PARSONS

FINAL

Vapor Intrusion/Indoor Air Guidance Survey

July 2010

Prepared for:

MassDEP

Massachusetts Department of Environmental Protection

Prepared by:

PARSONS

Final Report

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Indoor Air Guidance Survey

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GLOSSARY

ASTM	American Society for Testing and Materials
BTEX	Benzene, toluene, ethylbenzene, and xylenes
BWSC	Bureau of Waste Site Cleanup
DTSC	Department of Toxic Substances Control
EC	Engineering Control
ELCR	Excess Lifetime Cancer Risk
HDPE	High Density Polyethylene
IA	Indoor Air
IAC	Indoor Air Criteria
IBC	International Building Code
IC	Institutional Control
ITRC	Interstate Technology and Regulatory Council
J&E	Johnson and Ettinger
LEP	Licensed Environmental Professional
LLDPE	Linear low-density polyethylene
LSP	Licensed Site Professional
MassDEP	Massachusetts Department of Environmental Protection
Parsons	Parsons Commercial Technology Group
PM	Project Manager
PVC	Polyvinyl Chloride
OHM	Oil and/or Hazardous Materials
O&M	Operations and Maintenance
RBCA	Risk Based Corrective Action
SGC	Soil Gas Criteria
SMD	Sub-Membrane Depressurization system
SSD	Sub-Slab Depressurization system
SVE	Soil Vapor Extraction
SVOC	Semi-volatile organic compounds
UECA	Uniform Environmental Covenants Act
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
VI	Vapor Intrusion
VOC	Volatile organic compound

1. INTRODUCTION

The Massachusetts Department of Environmental Protection (MassDEP) Bureau of Waste Site Cleanup's (BWSC's) Indoor Air Workgroup is in the process of developing guidance for addressing vapor intrusion (VI) at properties with soil or groundwater contamination. In order to inform their analysis and decision-making, MassDEP engaged Parsons Commercial Technology Group (Parsons) to conduct a national survey of available guidance and best practices for addressing vapor intrusion concerns in other states. The survey also included the guidance provided by United States Environmental Protection Agency (USEPA), Interstate Technology and Regulatory Council (ITRC), and American Society for Testing and Materials (ASTM). MassDEP also expressed specific interest in learning about the use of physical vapor barriers to mitigate vapor intrusion. As such, research on commercially available contaminated soil vapor barrier products and their use was included as a task in this project as well.

This report presents the results of the state and agency survey and the vapor barrier research. The report is organized as follows: **Section 2** discusses the survey of state and agency vapor intrusion practices; **Section 3** discusses the vapor barrier research and findings; and **Section 4** presents a summary of key findings.

2. STATE AND AGENCY VAPOR INTRUSION PRACTICES

2.1 Survey Approach, Methodology, and Scope

The objective of the national survey was to obtain information on requirements and best practices from other states, USEPA, ITRC, and ASTM for the investigation and management of potential vapor intrusion issues. This information was gathered over a short timeframe between February 15 and April 26, 2010 from vapor intrusion guidance documents available on state websites and through phone calls to state agency contacts. In most cases, state environmental regulations were not reviewed.

Based on discussions during the scoping meeting with MassDEP held on February 10, 2010 and a memo from MassDEP regarding Parsons' preliminary findings, dated April 6, 2010, the research topics of interest included:

- Use of vapor intrusion modeling;
- States' approval schemes;
- Types of engineering controls recommended and accepted;
- Site closeout requirements;
- Use of Institutional Controls (ICs) at sites where VI is a concern;

- If and how effectiveness of engineering controls is determined; and
- Monitoring of engineering and institutional controls.

Parsons began by reviewing the available on-line vapor intrusion guidance documents at State environmental agency websites. All 50 states (including Massachusetts) were reviewed, although Parsons found that some states have not developed any guidance on their own. In addition, environmental agencies in some states rely on guidance developed by USEPA, ITRC, or ASTM. Detailed information gathered during the survey was recorded on a matrix, which is included electronically on CD as **Appendices A** and **B** for states and agencies, respectively.

In conjunction with the on-line document survey, Parsons completed two separate phases of interviews; Phase I of interviews was completed between February 26 and March 15, 2010, and Phase II was completed between April 14 and April 23, 2010. The Phase II interviews were completed to gather additional information identified by MassDEP after reviewing the draft of this report Parsons contacted 28 state agencies and spoke with staff responsible for vapor intrusion and/or case management (these individuals are identified on the spreadsheet in **Appendix A**). The purpose of these interviews was to fill in gaps in written guidance, to learn about states' review and approval practices, to learn about relevant guidance and regulations not directly referenced in vapor intrusion guidance, and to obtain additional information on how states actually addresses vapor intrusion issues as a practical matter. These interviews reveal differences in style and approach among the states. Information from the first phase of interviews conducted between February 26 and March 15, 2010 is provided in **Appendix A** on the summary matrix and is highlighted in blue. Notes from the Phase II interviews conducted between April 14 and April 23, 2010 are included in **Appendix C**. Copies of the questionnaires used as guides for both sets of phone interviews are also provided in **Appendix C**. It is noted that eight states (i.e., Arizona, Kansas, Minnesota, Mississippi, Montana, Pennsylvania, Virginia, and Wisconsin) were contacted and were not able to respond to our request for an interview within the time frame of this survey.

Various other professional organizations have prepared guidance on vapor intrusion. These include USEPA, trade associations (i.e., State Coalition for Remediation of Drycleaners), a standards development organization (i.e., ASTM), the Department of Defense, and an intergovernmental/commercial advisory council (i.e., ITRC). On-line guidance from ASTM, ITRC, and USEPA was reviewed and included in this survey.

The information gathered in this survey is wide ranging, covering several different important topics of interest to MassDEP. **Appendices A**, **B**, and **C** are available as a reference for detailed information on Parsons' research. Significant details from the matrix in **Appendices A** and **C** have been summarized in **Tables 1** through **5** covering states' approval schemes, use of vapor intrusion models, engineering controls, operations and maintenance (O&M) requirements, site closure, and institutional controls.

2.1.1 States and Agencies Surveyed

For this survey, websites for the state environmental agencies of all 50 states (including Massachusetts) were reviewed. Of these, 29 were noted to have specific vapor intrusion guidance documents or other guidance with significant advice and direction for addressing the vapor intrusion issue. Our research indicated that 21 states did not have written vapor intrusion guidance, although eight of those states relied on guidance from USEPA, ASTM, and/or ITRC. In addition, seven states with state-specific guidance also recommend or require the use of guidance documents from USEPA, ASTM, and/or ITRC. Five of these states recommend the use of ASTM or ITRC guidance documents, and three states require the use of specific screening tables and input parameters values for modeling, as provided in USEPA guidance.

As part of this survey, we also reviewed multiple USEPA, ASTM, and ITRC guidance documents. No single USEPA or ASTM document covered all of the relevant methods for assessing and mitigating vapor intrusion. The specific recommendations in the USEPA guidance documents will be detailed in this report. Since ASTM and ITRC are not regulatory bodies, their guidance does not make specific recommendations and instead acts as a generalized information source for evaluating vapor intrusion by describing the various options available for vapor intrusion investigation and mitigation.

During the phone interviews, Parsons inquired as to whether a state's VI guidance was being updated. Eighteen of the 50 states surveyed are in the process of updating (or have recently updated) their VI guidance. Of the non-state entities, the USEPA is in the process of updating their guidance as well. USEPA's final guidance document is supposed to be released by November 2012.

2.1.2 States' Approval Scheme and VI Investigation Approval Process

The scope of Parsons' research included gaining an understanding of the regulatory scheme in each state. During the course of interviews conducted between April 14 and April 23, 2010 with 27 states, Parsons asked questions relating to regulatory oversight and the identification of which plans and/or actions may be reviewed and approved. Four states [i.e., Connecticut, Massachusetts, Michigan for non-underground storage tank (UST) sites, and Ohio for the voluntary action program] have an LSP-like system where environmental work is developed, conducted, overseen, and approved by a consultant certified by the state environmental agency. Under an LSP-type program, the state agency may retrospectively audit the work. New Jersey is in transition to an LSP-like system, which will be fully implemented by 2012.

As presented in **Table 2**, hazardous waste sites in 28 states are directly overseen by the state environmental agency. Note that Connecticut, Michigan, and Ohio are counted in this category as well, as 10% of Connecticut's work, Michigan's non-UST program, and Ohio's Remedial Response program operate with direct regulatory oversight. Typically under this system, scopes of work developed by consultants for the Potentially Responsible Party are submitted to the state environmental agency for review and approval prior to implementation. Agency review commonly consists of a state project manager and a member of their technical staff reviewing plans and proposed actions. As shown in **Table 2**, the majority of states with this approval scheme require review and approval of plans and proposed actions by the state agency.

For example in Indiana, the state project manager distributes the work plan to the different technical sections (i.e., Chemistry Services, Geological Services, Engineering and Data Services, and Risk Services) for review. The PM then compiles all the technical comments and makes a decision on the proposed work plan.

Of the states interviewed, 22 states require prior agency approval to conduct work, such as installing mitigation systems or conducting modeling. Five states (i.e., Alabama, Indiana, Kentucky, Michigan, and New Hampshire) do not require prior approval for work, although they recommend it in the best interest of the responsible party and use other mechanisms to be involved in the process. For example, Alabama typically does not review work plans, but does review reports; Alabama agency representatives stay engaged with the project by conducting numerous discussion meetings on the site and in the office prior to field work. Additionally, Alabama state staff is sent to inspect and supervise field work and hold progress meetings.

Kentucky encourages state involvement by providing an incentive "solvent fund" for petroleum sites that reimburses site owners for actions approved by the state. The remaining states require prior approval for either monitoring or modeling, but not both. This information is summarized in **Table 2**.

The degree to which states are involved in the modeling process varies. Guidance for Idaho and Maine indicates a more hands-off approach and tends to suggest rather than dictate specifics on modeling usage, model type, and input parameters, though the specifics must be defensible and presented to the agency for approval. States with more rigid modeling requirements check the modeling results to varying levels. For example, California reviews input parameters and may confirm the model results.

2.2 Vapor Intrusion Modeling

Our survey results indicate that 37 states reference the use of modeling as part of their VI guidance. It is noted that in the available guidance and in the course of phone interviews, most states impose limitations on how the model and modeling results can be applied to VI sites. ITRC, ASTM, and USEPA mention the use of modeling in support of VI investigations. ITRC provides guidance to states on issues relative to modeling; ASTM provides a modified version of the J&E model, and the November 2002 USEPA guidance supports the use of the J&E model (with conservative parameter inputs) to complement data collected directly from sites. Note that the USEPA guidance is currently under revision.

More details on state research is presented in the matrix in **Appendix A**, information on non-agency guidance documents reviewed, and their specifications, are found in **Appendix B**, and the notes for state interviews conducted between April 14 and April 23, 2010 are found in **Appendix C**. A summary of the role of modeling in VI investigations is provided in **Table 3**.

Role of Modeling

Despite the widespread references to modeling across the surveyed states, the use of models, most commonly the use of the J&E model, is often restricted to specified circumstances and subject to limitations. Amongst the states that allow modeling to be used as a tool at VI sites, the permissible uses of modeling vary:

- **Eleven** states allow modeling to be used as the sole basis for determining the absence of risk and for ruling out further consideration of the VI pathway;
- **Seven** states allow modeling results to be used only as a line of evidence in the VI investigation; and
- **Eight** states do not allow modeling to be used as the only piece of evidence to rule out the VI pathway. Either the VI model cannot be used to predict indoor air concentrations (and to calculate risks), or it cannot be used to rule out further consideration of the VI pathway.

The states that fall under each modeling usage category are listed in **Exhibit 1**.

Exhibit 1 Role of Modeling		
Sole basis for ruling out risk and VI pathway	**A Line of Evidence**	**Not used to rule out VI pathway**
Alabama	Alaska	Connecticut
California	Colorado	Delaware
Idaho	Kentucky	Indiana
Illinois	Maine	Nebraska- UST
Michigan	Maryland	New Hampshire
Missouri	Massachusetts	Oregon
Nebraska – Superfund	New Mexico	South Dakota
New Jersey		Tennessee
Ohio		
Washington		
Wyoming		

Fifteen of the states that allow modeling require indoor air sampling to validate modeling results. This often is required when the risks are determined to be unacceptable [e.g., greater than an Excess Lifetime Cancer Risk (ELCR) of 10^{-6}].

A review of state guidance and notes from the interviews indicate that ten states have a preference for the use of indoor air sampling data over modeling. In these states, modeling results are viewed as lacking sufficient certainty. Modeling is either not recommended or is not given as much weight as other lines of evidence. For example, Colorado does not encourage the use of modeling; it will evaluate results if submitted, but only as a line of evidence to indicate the relative magnitude of the potential problem. Indiana allows modeling to tailor investigations, but the modeling results cannot be used for screening out a VI concern or to determine the suitability of site closure. Michigan is currently undergoing a redesign of its VI program and in the future will place a greater emphasis on the use of screening levels, including Soil Gas Criteria (SGC), Indoor Air Criteria (IAC), and new groundwater screening levels that are not dependent on modeling. Guidance from states such as Washington, Minnesota, and Oregon indicate that they prefer empirically-derived sampling data.

The most common limitations among the states that permit modeling are on the selection of input parameters and allowable modifications. New Jersey is an example of a state with guidance that details allowable parameter modifications; specific modifications are detailed in **Appendix A**. Ten states prohibit the use of volatile organic compounds (VOCs) soil concentration data to model vapor intrusion, seven states require site-specific parameters as compared to default parameters, and three states require the default soil gas entry rate (Q_{soil}) of 5 L/min to be used. The use of soil concentration data in modeling is limited because it requires estimating soil vapor concentrations using equilibrium partitioning. In the states' past experience, equilibrium partitioning does not accurately estimate soil vapor concentrations, especially for some SVOCs like naphthalene. To eliminate uncertainty, states that allow vapor intrusion modeling have generally elected to reduce the uncertainty associated with equilibrium partitioning by using soil gas data instead of soil data.

In general, the J&E model should not be used for buildings with earthen floor basements, wet basements, crawl spaces, and preferential pathways that facilitate vapor intrusion (e.g., sumps in contact with groundwater, drywells or wells within the building, or contaminated utility conduits), or to model vapor intrusion when there is fractured bedrock or karst between the vapor intrusion source and the overlying building. ITRC and ASTM do not detail parameter limitations and modifications.

Throughout the guidance for states that require the use of site-specific input parameters, the guidance stresses accountability. These states (i.e., California, South Dakota, and Virginia) require that input parameters be "reasonable", and that the rationale for the parameters and assumptions be stated.

Fifteen states have numeric groundwater standards that are protective of the groundwater to indoor air VI pathway. There was no trend between states allowing VI modeling and whether the state had numeric groundwater standards. In several states, such as Connecticut, Hawaii, Illinois, and Massachusetts, the groundwater standards protective of VI were based on modeling. Of the states that have numeric groundwater standards, some allow modeling and some do not.

Updated Guidance on Modeling

Of the states updating their VI guidance, seven states are re-evaluating modeling:

- **Three** states are debating whether to allow the use of modeling as a tool in VI investigations (i.e., Idaho, Indiana, and Tennessee);

- **One** state is modifying the VI modeling input parameters (i.e., Missouri);
- **One** state is shifting to emphasizing the use of screening level criteria above modeling (i.e., Michigan); and
- **Three** states are discussing the significance and role of VI modeling results (i.e., Alabama, Idaho, and Tennessee).

Idaho and Tennessee are debating whether future guidance will allow the use of modeling, which models to potentially use, and finally, how the modeling results will impact VI investigations. Indiana is considering limiting the use of the J&E model to apply only to industrial facilities to calculate non-default sub-slab to indoor air attenuation factors. Missouri, Illinois, and Michigan are modifying VI modeling to more accurately incorporate site input parameters and to overcome the weaknesses of the past modeling results. Missouri and Illinois are currently using the ASTM Risk Based Corrective Action (RBCA) model. The ASTM RBCA model does not incorporate advection and Missouri and Illinois are reassessing whether the ASTM RBCA model should be modified to include the advection component. Michigan is proposing to use media-specific criteria based on generic USEPA attenuation factors instead of VI modeling, due to the limitations of the J&E model.

Sensitivity Analysis

In the course of the interviews with state agency representatives, four states indicated that they use a "sensitivity analysis" to refine the model and improve the accuracy of the results.

- **Four** states that were interviewed require a sensitivity analysis to validate modeling results (i.e., California, Indiana, New Hampshire, and Wyoming).
- **Three** states may require a sensitivity analysis on a situational basis: 1) the project manager decides whether to require a sensitivity analysis on a case-by-case basis in Maine, 2) if site-specific modeling is allowed, a sensitivity analysis is required in Michigan, and 3) if site-specific parameter values are out of normal range a sensitivity analysis is required in Ohio.
- USEPA and ITRC mention the use of a sensitivity analysis but do not state that it is required.

Most commonly, (e.g., in California, New Hampshire, and Maine) a sensitivity analysis identifies the most sensitive parameters, and then varies one parameter at a time to determine the parameter's effect on the model. In addition, New Hampshire requires that inputs are representative of site conditions.

Indiana requires that a sensitivity analysis be submitted with the modeling results, but does not have formal guidance on which parameters should be evaluated. Research shows that the J&E model is most sensitive to the air exchange rate, soil moisture content, building height, source depth, total soil porosity, and pressure driven soil gas flow rate (i.e., Q_{soil}), and that sensitivity analyses should investigate the effects of these parameters. Unlike most states, Indiana supports a synergistic sensitivity analysis, rather than one-at-a-time, to give a more realistic assessment of uncertainty in the model.

In Wyoming, a sensitivity analysis is run on a range of inputs for the worst case, average case, and the best case scenario for the most sensitive parameters. Indoor air sampling is required if the risks from the worst case scenario are greater than an ELCR of 1 x 10^{-6} and the average case is less than an ELCR of 1 x 10^{-6}.

2.3 Engineering Controls

An engineering control (EC) is a physical barrier or passive mechanism designed to reduce, contain, or eliminate the exposure pathway from any contaminated medium. The use of ECs is mentioned in each of the 29 state VI guidance documents reviewed. An additional nine states without VI guidance refer to ASTM, ITRC, or USEPA guidance on ECs. Five states address ECs by providing a list of both their state-specific document and ASTM, ITRC, or USEPA guidance that should be followed. A summary of common EC state VI guidance recommendations is presented in **Table 4**. Detailed EC information for all 50 states surveyed is presented in **Appendix A**. USEPA, ITRC, and ASTM guidance also mention the most common ECs listed in **Table 4**, and further agency EC information is presented in **Appendix B**.

ECs related to vapor intrusion often include barriers, venting, pressurization, or some combination of these approaches. ECs are also identified as active or passive controls. The most commonly recommended ECs are presented in **Exhibit 2**.

Exhibit 2
Commonly Recommended ECs in state VI Guidance

Passive EC	# of States	Active EC	# of States
Vapor barriers	18	Active venting	19
Passive venting	17	Sub-slab Depressurization (SSD) system	17
Sealing	13	Sub-Membrane Depressurization (SMD) system	10

Some states' guidance also recommends building pressurization (8 states), HVAC modification (8 states), and indoor air treatment (5 states).

Active versus Passive ECs

Sub-Slab Depressurization systems (SSDs), venting (active and passive), and vapor barriers are the most commonly recommended ECs, and they are discussed in guidance states', as well in USEPA, ITRC, and ASTM guidance. However, SSD systems are more extensively documented and advocated in state VI guidance than vapor barriers. Multiple states dedicate sections solely to SSD usage, monitoring, and operation and maintenance requirements separately from the rest of the ECs. The other recommended EC options are covered by broader monitoring and O&M language which is described in the following section.

Active ECs are recommended by state guidance approximately 50% more frequently than passive ECs. However, state VI guidance typically does not indicate a preference for active versus passive ECs. The USEPA and ITRC documents do not explicitly recommend an EC, but they do lean toward the use of active over passive ECs. When this topic was discussed in telephone interviews with 14 states, the following information was gathered:

- **Five** states prefer the use of active over passive ECs;
- **Four** states would consider passive ECs, but EC selection is on a case-by-case basis; and,
- **Three** states allow the use of passive ECs with no further guidance offered.

The preferential use of active ECs is attributed to a lack of experience with or previous negative experiences with passive ECs. For example, all systems currently in use in Connecticut and Colorado are active ECs. New York generally would not accept a vapor barrier as the sole EC, but may request the installation of a vapor barrier in addition to an SSD. New York found that some vapor barriers do not work well for suppressing VI and that vapor barrier effectiveness can depend on the polarities of the vapor barrier and chemical contaminants.

Monitoring EC Effectiveness

State VI guidance varies widely on monitoring requirements to ensure EC effectiveness. Eighteen states require ECs to be monitored with specific frequencies. An additional seven states indicate that the monitoring frequencies are determined on a case-by-case basis. USEPA and ASTM guidance indicates that ECs should be monitored at intervals that take into account the lifespan of the EC and provide provisions for modifying the monitoring frequency based on periodic sampling data. The types of monitoring may include, but are not limited to, visual inspections, indoor air sampling, smoke tests, and measuring pressure gradients. Monitoring requirements, as determined during the state interviews, are as follows:

- **Ten** states require EC systems to be visually inspected. **Four** states require visual inspection on a case-by-case basis;
- **Fifteen** states require confirmatory indoor air monitoring samples to ensure that the ECs are effectively addressing the VI issue. **Eight** states require indoor air sampling on a case-by-case basis; and,
- As an additional step, **ten** states (i.e., California, Connecticut, Idaho, Maryland, Minnesota, Nebraska, New Jersey, New York, Ohio, and Washington) require the development of an O&M plan to outline EC maintenance and compliance. Examples of states with specific O&M plan guidance are presented in **Appendix A** under New York and Nebraska.

Specific monitoring requirements are commonly determined by either risk levels, the types of EC systems installed, or on a site-specific basis. There was a wide range of monitoring frequencies mentioned in guidance documents, and the most common monitoring frequencies are listed below:

- **Ten** states and USEPA require EC monitoring on a quarterly basis;
- **Five** states required monitoring on a case-by-case basis; and
- **Nine** states and USEPA allow a reduced EC monitoring frequency once the system is determined to be operating successfully.

The majority of states that require indoor air sampling as part of monitoring EC effectiveness do not specify the frequency required for indoor air sampling:

- **Fourteen** states require indoor air monitoring until the concentration in groundwater and/or soil gas, as appropriate, reaches acceptable levels;
- **Three** states require indoor air monitoring after an initial indoor air sample to determine frequency;
- **Three** states require indoor air monitoring on a case-by-case basis; and
- **Two** states require indoor air monitoring until the groundwater and/or soil source, as appropriate, is removed.

Further details on the state's EC monitoring requirements, obligation to sample ECs, general monitoring/sampling frequencies, indoor air monitoring durations and frequencies, and state documentation details are found in **Table 4**.

Impact of ECs on Site Closure

A review of state requirements regarding site closure while ECs are in operation provided no clear trend. Further guidance on site closure requirements was requested in phone discussions with 14 state environmental agencies. Additional site closure requirements are sometimes located in documents outside of state VI guidance; these were not reviewed as part of this survey. Survey results showed:

- **Seven** states would consider issuing No Further Action findings or allow site closure with engineering controls still in place as long as institutional controls were implemented.
- **Six** states and USEPA do not permit site closure while engineering controls are still in operation. Three of these five states (i.e., California, New Jersey, and New York) are considered among the leaders in VI guidance.
- **Three** states have not previously closed VI sites or are still developing guidance for site closure.

The remainder of the states and non-state agencies either did not have site closure information in their VI guidance or did not mention ECs in their site closure requirements. **Exhibit 3** lists the monitoring frequencies and site closure information for a selection of states. A summary of information on site closure requirements is presented in **Table 5**.

Exhibit 3
State EC Monitoring Requirements

State	Frequency	Site Closure
Arizona	Inspection at least once each calendar year. Within thirty days after the inspection, the owner must submit a written report containing the following information: a description of the current condition of the engineering control.	Remediated to meet the requirements.
Colorado	Quarterly for at least one year, if indoor air concentrations are acceptable. After that, frequency would be reduced to semi-annually, then annually, and then every 2-3 years. May decrease as more data becomes available and confidence is gained that conditions will either remain the same or improve with the passage of time.	Contamination has either been completely removed from the affected media or reduced to a level suitable for unrestricted use (when there is no longer a risk greater than 1E-5). All established standards and cleanup objectives have been achieved. OR The contamination that may still be present in the environment (at concentrations that are not safe for all uses) has been adequately controlled and will not present an unacceptable risk to human health and the environment, based on the existing, and potentially future, land use.
Hawaii	Quarterly for soil gas. Weekly to monthly for indoor air. After functioning properly for awhile, RP could propose semi-annual or annual monitoring.	If soil gas and indoor air levels are below action levels, can close site. Can grant NFA with ICs/ECs in place, but requires that RP maintains EC/IC.
Indiana	Periodic inspection and maintenance. Inspection on quarterly basis is recommended. Typically requires indoor air testing 60 days after installation of an EC.	IDEM has not closed a single VI site. IDEM contact expects that long-term monitoring would be required plus a deed restriction for the property.
New Jersey	After the remedial system is operational, confirmatory indoor air sampling should be conducted two to four weeks after. An inspection should be conducted semiannually.	When it can be demonstrated that the source has been eliminated. Sub-slab and indoor air samples must be collected to show no impact when the EC turned off.
New York	Usually require at least one round of post installation indoor air testing Sometimes DOH requests a second test. NY requires O&M Plan, annual monitoring at a minimum.	Owner has responsibility to maintain mitigation system until the site is clean. To reach complete closure, owner would have to temporarily shut down the system and do measurements to prove the problem is gone.

2.4 Institutional Controls

An IC is a legal restriction on land use and activities to prevent exposure. ICs are implemented to prevent or limit exposure to hazardous substances by preventing activities that would result in exposure to oil and/or hazardous materials (OHM) and/or ensuring maintenance of measures that prevent exposure.

- **Seventeen** states and all **three** non-state agencies discuss the use of ICs in their VI guidance;
- **Twelve** states discuss ICs in other state documents since they either do not have state VI guidance and/or ICs are not discussed within their state VI guidance;
- **Twenty-one** states with VI guidance are Uniform Environmental Covenants Act (UECA) members and have provisions for institutional controls covered by environmental covenants; and
- From the Phase I interviews with **14** state agencies, Parsons identified that IC guidance is sometimes found in Dry Cleaner guidance documents, Brownfield's user guides, Voluntary Cleanup Program documents, and other state documents.

A summary of IC details are presented in **Table 5**.

The most common types of ICs in VI guidance are deed restrictions and restrictive covenants. The three non-state agencies mention the use and types of ICs, but do not recommend any specific ICs. Nineteen states allow site closure without cleaning up the site to an unrestricted use level as long as the proper ICs are established. Using Ohio as a representative example of the 19 states, though contamination may still exist on-site, Ohio's ICs apply activity and land use restrictions such that a specific exposure pathway is broken. ICs required in Ohio restrict the types of inhabitable structures allowed on contaminated property.

Only two of the surveyed states, Hawaii and Missouri, distinguish between ICs in future versus existing buildings. Missouri allows the use of vapor barriers as an EC only in tandem with an IC to ensure the system's integrity and maintenance in existing and future buildings. In Hawaii, a site can be closed with ECs or ICs in place, but the future maintenance of both control types has to be addressed in the remediation plan.

Ten of the states recommended that ICs be reviewed on a periodic basis. Review frequencies fall into two categories; 1) states with quantitative review frequencies ranging from semi-annually to every 5 years, and 2) states with qualitative review frequencies, such as on a 'regular basis' or 'random monitoring'. Additional information is found in **Exhibit 4.**

Exhibit 4
Frequency of IC Review by State

State	Frequency
Alabama	5 years
Arizona	1 year
Arkansas	Random Audit
California	5 years
Colorado	5 years
Delaware	Regular Basis
Georgia	% of properties each year
New Jersey	Semi-annually
New York	1 year
Oregon	Random Monitoring

3. VAPOR BARRIERS TO MITIGATE VAPOR INTRUSION

Parsons conducted research on the use of passive soil moisture vapor barriers to prevent vapor intrusion in new buildings. This research involved the review of building codes, literature on vapor barrier products, and manufacturers' product information to understand typical requirements and specifications for sub-slab or sub-foundation vapor barriers. Our discussion of the specifications for and use of vapor barriers also reflects Parsons' experience in design and construction of new buildings.

In addition, Parsons reviewed and evaluated if information on installation methods and effectiveness measures of methane barriers are applicable to soil vapor barriers used to mitigate vapor intrusion.

3.1 Inclusion of Water Vapor Barriers in Building Codes

Water vapor barriers are included in the building codes used by most states. While individual states have historically had their own building codes, 46 of the 50 states have adopted the International Building Code (IBC) to govern construction and renovation of buildings, according to the International Code Council®, the originator of the IBC. This includes states that have adopted the 2000, 2003, 2006, or 2009 versions the IBC statewide. Therefore, the IBC was reviewed for its requirements for water vapor barrier requirements.

The IBC permits the use of a water vapor barrier for all buildings. The specified water vapor barrier consists of a HDPE barrier, a minimum of 6-mm thick with 6-inches of overlap at the seams or a liquid bitumen product not less than 4-mm in thickness.

A number of states have adopted the IBC with revisions. Parsons' review included investigation of IBC revisions in New York and California. The building codes for these states were reviewed and found to contain no amendments to the water vapor barrier portion. Based on this research as well as Parsons' experience in the construction field, very few, if any, states that have adopted the IBC have amended the water vapor barrier portion of the code. In Parsons' experience it is standard practice to specify vapor barriers equal to the requirements included in the IBC. More stringent specifications might be applied to water vapor barriers used for unusual building site conditions (e.g., sites with an unusually high soil moisture content or high water table); however, Parsons staff involved with this project do not recall seeing this in practice.

The role of water vapor barriers in the context of the IBC is specific to mitigation of non-contaminated water vapor intrusion. While the products specified by the IBC are also used as a contaminated soil vapor barriers, the intent of the IBC is to prevent damage to the building as a result of water vapor intrusion. Where a water vapor barrier product may be used for the prevention of contaminated soil vapor intrusion, the product manufacturer typically includes specifications that are more stringent than those included in the IBC. The inference is that a higher level of impermeability is required to prevent soil gas intrusion versus reducing water vapor intrusion in the IBC.

3.2 Products Used as Soil Vapor Barriers

There most common types of vapor barrier products used to prevent water vapor or contaminated soil vapor intrusion are spray-applied membranes (e.g., Liquid Boot® or Geo-Seal™). The use and specifications for each of these products is discussed below, and specifications and product information is provided in **Appendix D**. Other less commonly used types of vapor barriers used include PVC, PVC alloy, linear LLDPE with an aluminum layer, and polyolefin (i.e., STEGO® wrap). A review of Parsons recent experience indicated that HDPE products are currently less frequently used since the spray-applied membranes are easier to apply and provide better protection.

The specifications for the application of a spray-applied membrane are typically more stringent in the case of a contaminated soil vapor intrusion site than are specified by the IBC. Two spray-applied membrane products were researched as part of this survey: Liquid Boot® manufactured by CETCO; and Geo-Seal™ manufactured by Land Science Technologies. The installation process of these two products is very similar and in general involves:

- Constructing a 3-inch thick base of pea gravel on top of the finished subgrade;
- Installing a proprietary passive venting system which collects contaminated soil vapor through the pea gravel layer and vents through a stack to prevent accumulation of soil vapor under the building;
- Placing a proprietary fabric over the pea gravel. This layer is the base against which the membrane is applied. In the case of Geo-Seal™ this fabric also acts as a preliminary barrier;
- The membrane is then spray applied to the fabric surface; and
- A second fabric is placed over the spray applied membrane.

Once installed, the thickness of the vapor barrier varies according to the requirements of the application. For both Liquid Boot® and Geo-Seal™, the standard thickness of the spray-applied membrane is 60 mil (1.52 mm). Product information is provided in **Appendix D**. The results of inquiries made to Land Science Technologies indicated that the exact thickness of the barriers varies based on the contaminants and concentrations present in the soil below the buildings.

Both manufacturers have a number of standard details and specifications regarding penetrations of the barrier, sealing vertical surfaces, termination of the barrier, etc. Additionally, each manufacturer also produces different spray-applied membranes recommended for vertical surfaces.

A number of manufacturers of passive vapor barriers, both HDPE and spray-applied membrane types, recommend or require the use of an approved installer. Typically, these installers have been trained or certified by the manufacturer in the specific installation requirements of that product. The use of these certified installers is intended to help ensure the proper installation of the barrier.

3.3 Effectiveness of Vapor Barriers

A number of standard methods exist for the evaluation of passive vapor barrier products. These include ASTM Method D1434 which tests the permeability of the material or product to specific gases, including radon, methane, and hydrogen sulfide. This test can also be used to test the permeability of VOCs. Additionally, there are ASTM standards that can be used to evaluate the following aspects of passive vapor barriers: tensile strength, puncture resistance, elongation, freeze-thaw resistance, chemical resistance, etc. Standard test methods serve an important role in the specification of construction products allowing equivalent products to be specified and new products to be evaluated using a consistent method.

Technical specifications from the manufacturers indicate that vapor barrier effectiveness can be affected by chemical compatibility. Liquid Boot® has been tested for its resistance to unspecified VOCs, BTEX, sodium sulfate, sulfuric acid, microorganisms, oil, heat, and cold. Geo-Seal™ requests a list of chemicals present at each site where it will be applied, and tests the barrier's compatibility with those chemicals before issuing a warranty. Geo-Seal™ has been tested for its resistance to acetic, sulfuric, and hydrochloric acids, microorganisms, oil, heat, and cold.

3.4 Vapor Barrier Warranty Information

To ensure the effectiveness of their respective vapor barrier products, Geo-Seal™ and Liquid Boot® offer warranties that state that their product will be free of defects for the specified warranty period. Both companies have a specified set of requirements to obtain a warranty for their products. Geo-Seal™ offers a material warranty or a system warranty, which covers both the material and installer's work. The material warranty is valid for 1-30 years, and the system warranty is valid for 5-20 years. Both types of Geo-Seal™ warranties require that a manufacturer's representative or certified 3rd party inspector checks that the membrane is installed to the manufacturer's recommendations, a soil report with groundwater or soil gas data is submitted, and a smoke test is conducted to confirm the absence of leaks in the barrier.

Liquid Boot® offers a 20 year manufacturer and a 5 year installer warranty. The manufacturer warranty does not have any specific requirements, while the installer warranty requires that the installer complies with contract documents and a smoke test is performed. Warranty requirements and warranty lengths are summarized in **Exhibit 5**.

Exhibit 5
Summary of Vapor Barrier Warranties

Warranty	Length of Warranty	Requirements
Geo-Seal™ Material Warranty	1-30 years	• A manufacturer's representative or certified 3rd party inspector to inspect and verify that the membrane has been installed per the manufacturer's recommendations. • Require a smoke test. • Notice in writing of desired warranty prior to the start of installation • Soils report or other document with ground water or soil gas data
Geo-Seal™ System (material & labor) Warranty	5-20 years	• A manufacturer's representative or certified 3rd party inspector to inspect and verify that the membrane has been installed per the manufacturer's recommendations. • Require a smoke test. • Notice in writing of desired warranty prior to the start of installation • Soils report or other document with ground water or soil gas data • Comprehensive review of project drawings prior to bid date • Implementation of project specific details into the mitigation plans or project drawings system
Liquid Boot® Manufacturer Warranty	20 years	• No specified warranty requirements
Liquid Boot® Installer Warranty	5 years	• The installer shall comply with the Contract Documents (this Specification Section and the Drawings) for installation requirements. • Completion of the smoke test inspection shall be documented and signed off by the Contractor's Professional Engineer

Challenges in Installing Passive Vapor Barriers

There are a number of challenges in installing passive vapor barriers that generally arise because the barriers are installed below the floor slab (i.e., foundation) of the building. The challenge in all vapor barrier installations is avoiding damage to the barrier during construction of the slab. After the vapor barrier is installed, foot traffic at a minimum would be required to pass over the barrier in order to install the slab and related rebar. A number of products have been developed in response to this challenge. For example, Viper VaporCheck® by Insulation Solutions, Inc. is an HDPE product that is specifically designed for high puncture and shear resistance (note that the effectiveness of this product was not evaluated as part of this survey). The specifications for the installation of both spray-applied membrane and HDPE vapor barriers generally contain language that discourages excess travel across the installed barrier and provisions for fixing accidental penetrations of the barrier before pouring the slab.

If a sub-slab ventilation layer is utilized in construction, punctures or defects in the installation of the vapor barrier may be located prior to pouring the concrete slab by forcing smoke under the barrier through the ventilation layer. This practice is common in the installation of Liquid Boot® spray-applied membranes.

An additional challenge in the installation of vapor barriers for contaminated soil vapor is preventing and mitigating damage to the vapor barrier after the installation of a slab. The vapor barrier may be damaged if the foundation settles, and inspection of the vapor barrier after the installation of the slab is impractical. Typically, foundation settlement becomes apparent through visible cracks in the floor slab. In Parsons' experience at sites with actively monitored soil vapor control systems, the floor slab may be periodically inspected for cracking and visible cracks may be repaired with epoxy or similar materials. This type of visual monitoring may be effective for new buildings with vapor barriers.

Effectiveness of Methane Barriers and Applicability to VI

Parsons reviewed information on measures of effectiveness of methane barriers and their potential applicability to vapor intrusion. Parsons first compared the California Department of Toxic Substances Control's (DTSC) guidance for methane and vapor intrusion mitigation. These two guidance documents, *Advisory on methane assessment and common remedies at school sites* (2005) and *Vapor Intrusion Mitigation Advisory* (2009), specified identical materials (i.e., high density polyethylene at least 60 mil (1.52 mm) thick or rubberized asphalt at least 100 mil (2.54 mm) thick for methane barriers and 60 mil for VOCs and specified the same placement, layering, and sealing requirements. Therefore, methane barriers that meet DTSC's standards would also be acceptable for use as vapor barriers at VOC sites. However, it should be noted that DTSC does not specify acceptable permeability testing methods or ratings for either methane barriers or vapor intrusion barriers.

Parsons researched whether information was available on the effectiveness of methane barriers. The City of Los Angeles has developed criteria for determining whether products are suitable for use as methane barriers (see **Appendix E**). These criteria include testing the bonded seam strength (ASTM D882), dead load seam strength, resistance to microorganisms (ASTM D4068), resistance to oil (ASTM D543), environmental stress cracking (ASTM D1693), heat aging (ASTM D4068), and methane permeability (ASTM D1434).

All of these tests would be applicable to vapor barriers for VOCs and it is assumed that the acceptance criteria for these tests would also be applicable for vapor barriers for VOCs. Notably, the City of Los Angeles has an acceptance criterion for methane permeability of 40 $ml/day \cdot m^2 \cdot atm$. Unfortunately, no rationale for this criterion was presented.

Before methane barriers are used as soil vapor barriers for VOCs, it is recommended that additional testing be conducted. Specifically, resistance to the chemicals present at vapor intrusion sites (e.g., PCE, TCE, and BTEX) should be tested using ASTM D543, the permeability of those chemicals should be tested using ASTM D1434, and the life expectancy when buried should be tested using ASTM D4068/E154. As part of this, however, acceptance criteria will need to be developed, especially for the permeability or transmission rates of the VOCs. Additional tests/measurements that may be useful for in soil vapor intrusion barriers include the air infiltration rate through the barrier (ASTM E283) and resistance to chromate (ASTM E96) and acids (ASTM D543). When Parsons contacted methane barrier manufacturers, some readily indicated that they would perform additional testing as required. Further, testing information is already available for some vapor intrusion barriers VOC permeabilities, even though acceptance criteria for VOC permeabilities are not available.

It is expected that the permeabilities for VOCs such as PCE, TCE, and BTEX should be lower than methane, since these VOCs are larger molecules than methane and would, therefore, diffuse more slowly through the same substance. However, methane permeabilities are not available for most methane barriers, as the technical specification sheets merely state "passed."

The life spans of methane and vapor intrusion for VOCs barriers have not yet been determined. It has been estimated that asphalt based vapor barriers should have a lifespan of at least 100 years (see attached memo from Western Emulsions). However, no testing data was found. The product warranties were the only other source identified that provided any information on a vapor barrier's longevity or durability.

Field data demonstrating the effectiveness of methane and vapor intrusion barriers was not available from the methane and vapor barrier manufacturers contacted; however, it is likely to be available in site-specific remediation reports. These reports will require more effort to obtain. However, the manufacturer of Geo-Seal™ (Land Sciences Technology) provided a paper titled *Chemical Compatibility, Testing, and Advances in Materials Science*. This (non-peer reviewed) paper (see **Appendix D**) indicates that Liquid Boot®

has a higher steady state PCE permeation rate than Geo-Seal™. It should be noted that criteria for acceptable permeation rates for VOCs through soil vapor barriers have not yet been developed.

4. SUMMARY OF FINDINGS

In Summary, 29 states have VI guidance, and 18 of those states are in the process of updating their guidance documents. USEPA has drafted technical issue paper updates to their VI guidance that are currently under review and anticipates updating its guidance by November 2012. The scope of this survey included the review of state VI guidance available online, interviews with 28 state agencies, and review of ASTM, ITRC, and USEPA guidance. The interviews conducted revealed that many state agencies are evaluating the same issues identified by MassDEP BWSC's Indoor Air Workgroup.

Key findings are summarized below:

- Guidance for the majority of states reference the use of models to evaluate vapor intrusion, however the role that modeling plays in the final decision is often limited. States that allow modeling allow soil gas and groundwater concentration data as input terms in the model, but not soil concentration data.
- Eleven states allow modeling to be used as the sole basis for determining the absence of risk, and seven states may allow modeling results to be used as a line of evidence. In all but two of these 17 states, waste site assessment and cleanup work are reviewed and approved by the state environmental agency prior to implementation. Eight states do not allow modeling to be used as the only piece of evidence to rule out a VI pathway.
- Most states have specific EC monitoring and frequency requirements and for a few states these requirements are determined "on a case-by-case" basis.
- Monitoring and maintenance of VI sites with ECs usually consists of an initial inspection and sampling (at a minimum, indoor air should be sampled). The most common monitoring frequencies were annual or 5-year events.
- Although some states allow sites to be closed with ECs in operation, most do not.
- Although all states will allow passive ECs, active ECs or a combination of active and passive (e.g., a SSD and vapor barrier) are preferred.
- ICs are allowed in most states but not implemented in all states.

- Installation of vapor barriers for the mitigation of VI is based on the specifications provided by the product manufacturer, which are more stringent than IBC requirements for water vapor barriers.
- The construction process has the potential to damage the vapor barrier. New products are available that claim to prevent or minimize damage, but this remains a challenge in maintaining the effectiveness of vapor barriers.
- ASTM tests can be used to test a range of properties for a soil vapor barrier, but "passing" criteria is not readily available.
- Information (beyond basic warranty details) on the longevity and durability of vapor barriers is not readily available.

Tables 1 through **5** provide more details of the key findings. Additional information is available in **Appendices A** through **E**.

Tables

Table 1
Vapor Intrusion Guidance Survey Summary
MassDEP Vapor Intrusion Survey Report

State	Does State Have a VI Guidance? (Y/N)	Date of State's VI Guidance	In process of updating guidance? (Y/N)	Follow another VI guidance? (Y/N)	Which other VI guidance is referenced?	Interviewed via phone/email?	Contact: Agency	Contact: Name	Contact: Phone	Contact: Email
Alabama AL	Y	April 2008	Y	Y	ASTM	Y	Alabama Department of Environmental Management	Brian Espy	334-721-7749	bespy@adem.state.al.us
Alaska AK	Y	July 2009	Y	Y	ITRC	Y	Department of Environmental Conservations	Denise Elston Janice Wiergers	907-465-5207 907-451-2127	denise.elston@alaska.gov janice.wiegers@alaska.gov
Arizona AZ	N	-	N	N	-	DNR	Arizona Department of Environmental Quality	Richard Olm	602-771-4223	olm.richard@azdeq.gov
Arkansas AR	N	NA	N	Y	EPA	N	Arkansas Department of Environmental Quality	Ashley Whitlow	501-682-0869	whitlow@adeq.state.ar.us
California CA	Y	February 2005	Y	N	-	Y	Department of Toxic Substances Control	Dan Gallagher	916-255-6536	DGallagh@dtsc.ca.gov
Colorado CO	Y	September 2004	N	N	-	Y	Colorado Department of Public Health and Environment	Walter Avramenko	303-692-3362	walter.avramenko@state.co.us
Connecticut CT	Y	September 2007	Y	N	-	Y	State of Connecticut Department of Environmental Protection	Carl Gruszczak Ken Feathers	860-424-3948 860-424-3770	Carl.Gruszczak@ct.gov Kenneth.Feathers@ct.gov
Delaware DE	Y	December 2009	N	N	-	Y	Delaware Department of Natural Resources and Environmental Control	Rick Galloway Steve Johnson	302-395-2614 302-395-2600	rick.galloway@state.de.us Stephen.johnson@state.de.us
Florida FL	N	-	N	N	-	N	Florida Department of Environmental Protection	Thomas Conrardy	850-245-8899	tom.conrardy@dep.state.fl.us
Georgia GA	N	NA	N	Y	EPA	N	NA	NA	NA	NA
Hawaii HI	Y	June 2009	Y	N	-	Y	Evaluation and Emergency Response Office	John Peard	808-933-9921	john.peard@doh.hawaii.gov
Idaho ID	Y	July 2004	Y	N	-	Y	Idaho Department of Environmental Quality	Bruce Wicherski	208-373-0246	bruce.wicherski@deq.idaho.gov
Illinois IL	N	Upcoming	Y	Y	EPA	Y	Illinois Environmental Protection Agency	Heather Nifong	217-785-4729	Heather.Nifong@illinois.gov
Indiana IN	Y	April 2006	Y	N	-	Y	Indiana Department of Environmental Management	Megan Hamilton Bob Moran	317-234-3928 317-232-4419	megan.hamilton@idem.in.gov bmoran@idem.in.gov
Iowa IA	N	-	N	N	-	N	Iowa Department of Natural Resources	Elaine Douskey	515-281-8011	elaine.douskey@dnr.state.ia.us
Kansas KS	Y	June 2007	N	Y	ITRC	DNR	Kansas Department of Health and the Environment	Chris Carey	785-296-0225	ccarey@kdheks.gov
Kentucky KY	N	-	Y	Y	ASTM, ITRC	Y	Kentucky Environmental Protection Agency	Sarah Gaddis	502-564-5981	sarah.gaddis@ky.gov
Louisiana LA	N	October 2003	N	N	-	N	Louisiana Department of Environmental Quality	Dana Shepard	225-214-3421	dana.shepard@la.gov
Maine ME	Y	Jan-10	N	Y	ITRC	Y	Maine Department of Environmental Protection	Pete Eremita	207-822-6300	pete.m.eremita@maine.gov
Maryland MD	Y	August 2008	N	Y	EPA	Y	Maryland Department of Environment	Mark Mank	410-537-3493	mmank@mde.state.md.us
Massachusetts MA	Y	August 2007	Y	-	-	Y	Massachusetts Department of Environmental Protection	Paul Locke	617-556-1160	paul.locke@state.ma.us
Michigan MI	Y	May 2007	Y	N	-	Y	Michigan Department of Environmental Quality	Amy Salisbury	517-241-3584	salisburya@michigan.gov
Minnesota MN	Y	September 2008	N	N	-	DNR	Minnesota Pollution Control Agency	Rick Jolley	651-757-2475	rick.jolley@pca.state.mn.us
Mississippi MS	N	NA	N	N	-	DNR	Mississippi Department of Environmental Quality	Willie McKercher	601-961-5731	willie_mckercher@deq.state.ms.us
Missouri MO	Y	June 2004	Y	N	-	Y	Missouri Department of Natural Resources	Tim Chibnall	573-751-8629	tim.chibnall@dnr.mo.gov
Montana MT	Y	September 2009	N	N	-	DNR	Montana Department of Environmental Quality	Catherine LeCours	406-841-5040	clecours@mt.gov
Nebraska NE	Y	May 2009	N- UST Y-Superfund	N	-	Y	Nebraska Department of Environmental Quality	Scott McIntyre/David Chambers Jim Borovich	402-471-2668 402-471-4258 402-471-2223	scott.mcintyre@nebraska.gov David.Chambers@nebraska.gov jim.borovich@nebraska.gov
Nevada NV	N	NA	N	N	-	Y	Nevada Department of Environmental Protection	Mary Siders	775-687-9496	msiders@ndep.nv.gov
New Hampshire NH	Y	June 2009	N	N	-	Y	New Hampshire Department of Environmental Services	Robin Monegeon	603-271-7278	rmongeon@des.state.nh.us
New Jersey NJ	Y	September 2005	N	N	-	Y	New Jersey Department of Environmental Protection	Diane Groth	609-984-9782	diane.groth@dep.state.nj.us
New Mexico NM	N	NA	N	Y	EPA	Y	New Mexico Environment Department	Dana Bahar	505-827-2908	dana.bahar@state.nm.us
New York NY	Y	October 2006	Y	N	-	Y	New York State Department of Health	Charlotte Bethony	518-402-8755	cmb18@health.state.ny.us
North Carolina NC	N	-	N	N	-	N	North Carolina Department of Environment and Natural Resources	Delonda Alexander	919-508-8444	delonda.alexander@ncmail.net
North Dakota ND	N		N	N	-	N				
Ohio OH	Y	December 2009	Y	N	-	Y	Ohio Environmental Protection Agency	Audrey Rush	614-644-2286	audrey.rush@epa.state.oh.us
Oklahoma OK	N	NA	N	Y	EPA, ITRC	N	Oklahoma Department of Environmental Quality	Evelina Morales	405-702-5108	evalina.morales@deq.state.ok.us
Oregon OR	Y	Mar-10	N	N	-	Y	Oregon Department of Environmental Quality	Mary Camarata	541-686-7839	camarata.mary@deq.state.or.us
Pennsylvania PA	Y	January 2004	N	N	-	DNR	Pennsylvania Department of Environmental Protection	Ramesh Belani	484-250-5766	rbelani@state.pa.us
Rhode Island RI	N	NA	N	Y	EPA	N	Rhode Island Department of Environmental Management	Paul Kulpa	401-222-2797	
South Carolina SC	N		N	N	-	N				
South Dakota SD	Y	March 2003	N	N	-	Y	South Dakota Department of Environment and Natural Resource	Joane Lineburg	604-773-6476	Joane.Lineburg@state.sd.us
Tennessee TN	N	September 2006	Y	N	-	Y	Tennessee Department of Environment and Conservation	Steve Goins	615-532-8599	steve.goins@tn.gov
Texas TX	N	NA	N	Y	EPA	N	Texas Commission on Environmental Quality	Nathan Pechacek	512-239-1336	npechacek@tceq@state.tx.us
Utah UT	N	NA	N	N	-	N	Utah Department of Environmental Quality	John Menatti	801-536-4159	jmenatti@utah.gov
Vermont VT	N	NA	N	N	-	N	Vermont Department of Environmental Protection	Michael Smith	NA	michael.smith@anr.state.vt.us
Virginia VA	Y	January 2010	N	Y	EPA, ITRC	DNR	Virginia Department of Environmental Quality	Patricia McMurray	804-698-4186	pamcmurray@deq.virginia.gov
Washington WA	Y	October 2009	Y	N	-	Y	Washington State of Ecology	Martha Hankins	360-407-6864	mhan461@ecy.wa.gov
West Virginia WV	N	NA	N	N	-	N	West Virginia Department of Environmental Protection	Lawrence Sirinek	304-238-1220	Lsirinek@wvdep.org
Wisconsin WI	Y	February 2003	N	N	-	DNR	State of Wisconsin Division of Public Health	Henry Nehls-Lowe	608-266-3479	nehlshl@dhfs.state.wi.us
Wyoming WY	Y	May 2007	Y	Y	EPA	Y	Wyoming Department of Environmental Quality	Vickie Meredith	307-332-6924	vmered@wyo.gov

Total number of states with state-specific vapor intrusion guidance: 29

Notes:
ITRC = Interstate Technology and Regulatory Council
ASTM = American Society for Testing and Materials
EPA = United States Environmental Protection Agency
DNR = Did Not Respond

Table 2
States' Approval Scheme and VI Investigation Approval Process
MassDEP Soil Vapor Survey Report

State	Direct State Oversight of the Hazardous Waste Sites?	LSP develops/ implements required plans?	Work (installing mitigation system or conducting modeling) requires prior approval?	Agency reviews/ approves plan?
Alabama AL	Y	N	N	Y
Alaska AK	Y	N	Y	Y
California CA	Y	N	Y	Y
Colorado CO	Y	N	Y	Y
Connecticut CT	Y[1]	Y	Y	N
Delaware DE	Y	N	Y	Y
Hawaii HI	Y	N	Y	Y
Idaho ID	Y	N	Y[2]	Y
Illinois IL	Y	N	Y	Y
Indiana IN	Y	N	N[3]	Y
Kentucky KY	Y	N	N[3]	Y
Maine ME	Y	N	Y	Y
Maryland MD	Y	N	Y	Y
Massachusetts	Y	Y	N	N
Michigan MI	Y, non-UST sites	Y - UST sites	Y, modeling N, mitigation not required but preferred	Y, non-UST sites
Missouri MO	Y	N	Y[4]	Y
Montana MT				
Nebraska NE - UST	Y	N	Y	Y
Nebraska NE - Superfund	Y	N	Y	Y
New Hampshire NH	Y	N	N	N[3]
New Jersey NJ	Y[5]	N	Y	Y
New Mexico NM	Y	N	Y	Y
New York NY	Y	N	Y	Y
Ohio OH	Y	Y	NU[6]	NU[6]
Oregon OR	Y	N[7]	Y	Y
South Dakota SD	Y	N	Y	Y
Tennessee TN	Y	N	UY[9]	Y
Virginia VA				
Washington WA	Y	N	Y	Y
Wisconsin WI				
Wyoming WY	Y	N	Y[8]	Y
Totals Y	28	4	22	24
Totals N	1	24	7	5

Notes:
1) 90% of work uses LEP model, 10% of work is overseen by state agency.
2) Idaho does require prior approval for installing mitigation systems, vapor intrusion modeling does not.
3) Not required, but recommended.
4) For modeling, if using Tiers 1 and 2 of the standard RBCA models, do not require approval.
If using Tier 3, where there are significant modifications to input parameters.
or using a different model, then the workplan must be reviewed and approved first.
5) Transitioning to LSP-like system in 2012.
6) Approval not usually required, unless in Voluntary action program Memorandum of Agreement (MOA) track, in which public notice and Rap approval are required.
State approval required if covenant not to sue is issued before a building is put up on the site.
7) LSP-like system exists for independent cleanup program, which usually excludes VI sites.
8) Approval for modeling is required, but approval for mitigation is not neccessary.
9) Approval for modeling is required, but approval for mitigation is only necessary is state is paying to install the mitigation system.

Table 3
Summary of Role of Modeling
MassDEP Soil Vapor Intrusion Survey Report

State[1]	Does the State Allow Modeling? (Y/N)[2]	Prefer Data to Modeling?	Use Site Specific Parameters?	State Provides Values or Spreadsheets?	State Uses Screening Values?	Re-evaluating the use/role of modeling?	Can path forward be determined solely by modeling?	If state has numeric GW standards, are they protective of the GW to indoor air VI pathway?	Validate modeling with IA sampling?
Alabama AL	Y					Y	Y	N	cBc
Alaska AK [6]	Y					N	LoE	N	
Arkansas AR	Y								
California CA	Y			Y		N	Y	N	Y[16]
Colorado CO	Y	Y	Y	N		N	LoE	Y	-
Connecticut CT	N	Y			Y	N	N	Y	NA
Delaware DE	Y					N	N	Y	Y[16]
Georgia GA	Y								
Hawaii HI	N					N	NA	Y	NA
Idaho ID	Y					Y[11]	Y	Y[14]	
Illinois IL	Y					N	Y	N	Y[16]
Indiana IN	Y					Y	N	Y	Y
Kansas KS	Y	Y							
Kentucky KY	Y	Y				N	LoE	N	
Maine ME [9]	Y	Y				N	LoE	N	Y
Maryland MD	Y					N	LoE	N	Y
Massachusetts MA	Y	Y	Y			Y	LoE	Y	Y[18]
Michigan MI	Y	Y				Y	Y	Y	Y[16]
Minnesota MN	Y	Y							
Missouri MO	Y					Y[12]	Y	Y	Y[16]
Montana MT [9]	Y								
Nebraska -UST NE 3	Y					N	N	Y	Y[17]
Nebraska -Superfund NE [3]	Y					N	Y	N[15]	Y
Nevada NV [4, 9]	Y		Y[5]						
New Hampshire NH	Y		Y	N		N	N	Y	cBc
New Jersey NJ	Y			Y		N	Y	Y	
New Mexico NM	Y					N	LoE	N	Y
New York NY N	N	Y	Y	N		N	NA	N	NA
North Carolina NC	Y								
Ohio OH	Y					N	Y	N	Y[16]
Oklahoma OK	Y								
Oregon	Y	Y			Y	N	N	Y	Y
Pennsylvania PA	Y								
Rhode Island RI	Y								
South Dakota SD [10]	Y					N	N	Y	
Tennessee TN	Y					Y	N	N	
Texas TX	Y								
Virginia VA	Y		Y[6]						
Washington WA	Y		Y[7]	N		N	Y	Y	Y[16]
Wisconsin WI	Y			N					
Wyoming WY	Y					N	Y[13]	N	Y[16]
Totals Yes	37	10	7	2	2	7	11	15	15
Totals No	3	0	0	5	0	20	8	13	0
Totals cBc	0	0	0	0	0	0	0	0	2
Totals LoE							7		

Notes:
cBc = case-by-case
LoE = Line of Evidence
Nebraska's two state programs (UST and superfund) are counted as one state in the totals.
1) Only states with VI guidance or other references to modeling are included in this table.
2) Note that most states that allow modeling have limitations on the use of modeling.
3) The Nebraska DEQ also allows the use of the J/E model and other models with state approval at chlorinated solvent sites.
4) The USEPA version of the Johnson-Ettinger Model has been applied using some of the default parameters, along with some site-specific parameters (e.g., shallow groundwater in Las Vegas is typically about 25 C).
5) No formal written guidance is available; however, Nevada DEP will be involved in projects and provide verbal guidance and oversight.
6) A rational must be provided for the site-specific parameter used in the model.
7) It is recommended to use the model in default mode, with conservative and generic inputs, but empirically-derived site-specific attenuation factors are allowed.
8) Alaska will use other models if they are publicly available, peer-reviewed, and approved by DEC.
9) Delaware, Maine, Montana, and Nevada will consider using models on a case-by-case basis.
10) South Dakota will accept the use of the computer modeling system developed by Groundwater Services Inc.
11) Idaho is discussing the use and role of J&E model, and use of others possibly API Biovapor.
12) Missouri is currently using the ASTM RBCA model. They are re-evaluating the advection component of vapor intrusion modeling.
13) If model indicates no risk.
14) Idaho has rule-based GW screening levels protective of vapor intrusion for 18 petroleum related chemicals.
15) Nebraska currently has MCLs and are developing GW screening levels protective of vapor intrusion.
16) If risk levels are unacceptable.
17) This is site-specific, and confirmation by indoor air sampling may be required. This is recommended for sites where the source is near to a building.
18) If other lines of evidence inditcate indoor air is potentially impacted, collection of IA samples required

Table 4
Summary of Engineering Controls for VI
MassDEP Soil Vapor Survey Report

				Confirmation of Effectiveness				
State[1]	Use of ECs mentioned in state VI guidance?	Proposed ECs require approval?[4]	Recommended ECs	General EC Monitoring Requirements	EC System-specific Monitoring Requirements	Frequency of EC Monitoring/Sampling	Indoor Air Duration/ Frequency?	Where does the sampling obligation get established?
Alabama AL	Y	Y		monitoring cBc, Yearly Report, visual inspections, IA sampling	N/A	Quarterly, or Semi-annually	Until source removed, or steady state with acceptable risk is achieved	In the permit and may be part of the environmental covenant.
Alaska AK	Y	Y	Vapor Barrier, Passive Venting, Active Venting, SSD, Sealing	monitoring cBc, most likely IA sampling, leak testing, and pressure measurements.	NA	cBc	cBc	Closure document, ROD, or a cleanup plan.
Arkansas AR	N	NA						
California CA[3]	Y	Y	Vapor Barrier, Passive Venting, Active Venting, Sealing, Building Pressurization, Indoor Air Treatment	O&M plan, IA sampling if risks unacceptable, visual inspections, and smoke test.	SSD/SSV - pressure measurements	cBc	Until source term reaches acceptable conditions. Could stop sampling and go with inspections if have enough data to show the system in operating correctly and stable.	Land covenant attached to the property title
Colorado CO	Y	Y	Vapor Barrier, Passive Venting, Active Venting, SSD, SMD	Indoor Air Sampling	SSD - pressure measurements	Quarterly, for at least a year until IA concentrations are acceptable. Frequency then reduced to semi-annually, then annually, then every 2-3 years.	Until the source term reaches acceptable concentrations.	Workplans pursuant to compliance order
Connecticut CT	Y	N	Vapor Barrier, Passive Venting, Active Venting	O&M plan, typically visual inspections. and pressure measurements	NA	Monthly, to be reduced if system is successfully operating	Until source removed, or steady state with acceptable risk is achieved	DEP approval letter of O&M plan
Delaware DE	Y	Y	Vapor Barrier, Passive Venting, Active Venting, SSD	Visual inspections required, indoor air sampling cBc	SSD - pressure measurements	At least annually, although could be more often	Until the source term teaches acceptable concentrations.	In long term stewardship plan, referenced in the RAP
Georgia GA	N	NA						
Hawaii HI	Y	Y	Vapor Barrier, Caps, Active Venting	Significant Risk - visual inspections, indoor air monitoring	SSD - pressure measurements	Indoor Air weekly-monthly	Until acceptable risk is achieved	Depends on site risk level. For high risk, in an IC and deed covenant. For medium risk site, in the work plan.
Idaho ID	Y	Y	Caps	Unacceptable risk - IA sampling	SVE - system effluent, visual inspections, and groundwater monitoring	Monthly for operational parameters, Quarterly for progress	For IA sampling, until GW or Soil cleanup criteria have been achieved. Post-remediation monitoring to demonstrate no "rebound" after system turned off (typically 4 quarters for GW). No set criteria for IA monitoring.	Corrective Action Plan
Illinois IL	N	Y		cBc, visual inspections	NA	Every 2 years.	Until source term reaches acceptable concentrations.	No Further Action Letter
Indiana IN	Y	Y	Vapor Barrier, Passive Venting, Active Venting, SSD, Sealing	cBc, may include IA sampling and pressure measurements	NA	At least initial sampling event, and then regular pressure gauge measurements	At least initial sampling event	Workplan
Kansas KS	Y	--	Vapor Barrier, Passive Venting, Active Venting, SSD, SMD, Sealing, Building Pressurization, Indoor Air Treatment					
Kentucky KY	Y	Y	Vapor Barrier, Passive Venting, Active Venting, SSD, SMD, Sealing, Building Pressurization, Indoor Air Treatment	Indoor air sampling and visual inspection	NA	Periodic, usually quarterly	Indoor air sampling very 2 weeks, if system determined to be effective then quarterly. After 4 quarters, reduce to annual.	For superfund sites, in managed remediation plan. For petroleum sites, in written individual directives.
Maine ME	Y	Y	SSD, SMD, Building Pressurization, Indoor Air Treatment	cBc, may include pressure measurements and IA sampling	NA	No definitive guide, but would decrease over time once under control		-
Maryland MD	Y	Y	Passive Venting, Active Venting, SSD, SMD, HVAC Modification	O&M plan, Indoor air sampling, visual inspections, pressure measurements	NA	Quarterly, decreased to every 6 months once system determined acceptable, until termination.	-	-
Massachusetts MA	Y	N	Vapor Barrier, Passive Venting, Active Venting, SSD, SVE, HVAC Modification	IA sampling	SSD - pressure measurements SSV - IA monitoring	If an EC was used as part of the active remedy at the site, monitoring is required and documented through Remedial Monitoring Reports (submitted every six months) until site closure can be achieved.	No required time frame for indoor air sampling, but typically groundwater is sampled over four seasons prior to closing a site so it is reasonable to expect that the indoor air be samples multiple times over a long period of time to demonstrate that significant fluctuations are not likely.	In the work plan for remedial alternative selected, for an active system. Activity and Use Limitations for a passive system if required to maintain No Significant risk after site closure
Michigan MI	N	Y, non-UST sites		cBc, all require monitoring, O&M plan, and restrictive covenants	System-dependent	-	-	Restrictive covenant, RAP
Minnesota MN	Y	Y	Vapor Barrier, Passive Venting, Active Venting, SSD, SMD, Sealing, Building Pressurization, HVAC Modification	O&M Plan, IA sampling, Visual Inspections	NA	Quarterly, increased or decreased as appropriate	Until source term reaches acceptable concentrations.	Remedial Action Work plan
Missouri MO	Y	Y	Vapor Barrier, Active Venting	Indoor air sampling (except for with new vapor barrier), visual inspections	Active systems - IA sampling, environmental covenant SSV- sample effluent	Quarterly for a year. Frequency to be reduced after system demonstrated to functioning properly.	For 1st year, then move to visual inspection and reduce frequency to annually. until source term reaches acceptable concentrations.	Environmental covenant
Montana MT	N	NA			NA			
Nebraska NE -UST		Y		cBc, typically Indoor air sampling and sub-slab sampling	NA	cBc, but Quarterly, or Semi-annually	Until source term reaches acceptable concentrations.	In the work plan and approval process. May go into deed restriction or land use covenant, but NEP
Nebraska NE - Superfund	Y	Y		cBc, O&M plan, visual inspections, subsurface sampling, likely indoor air sampling	SSD - pressure differentials SSV - effluent sampling	Weekly for 1st month, monthly for 1st 6 months, then quarterly once system is operating properly.	Until source term reaches acceptable concentrations.	RA Workplan
Nevada NV	Y	--	Vapor Barrier, SSD, Sealing	Indoor air sampling	NA			
New Hampshire NH	Y	N	Vapor Barrier, Passive Venting, Active Venting, SSD, Sealing, Building Pressurization, HVAC Modification, Indoor Air Treatment	cBc	SSD - Indoor air sampling, and possible annual monitoring	cBc	Initial round, then cBc	Letter to responsible party, GW management permit
New Jersey NJ	Y	Y	Vapor Barrier, Passive Venting, Active Venting, SSD, SMD, Sealing, HVAC Modification	Indoor air sampling, visual inspection, pressure measurements, O&M plan	NA	Visual inspection semi-annually, with reduced frequency after 1 year.	-	-
New York NY	Y	Y	Vapor Barrier, Passive Venting, Active Venting, SSD, SMD, Sealing, Building Pressurization, HVAC Modification	Depends on type of system, O&M plan, at least one indoor air sampling event	SSD - monitoring requires annual monitoring HVAC - requires annual certification. At least one indoor air sample required	1-3 months after installation, if successful then yearly monitoring	Must take 1 successful IA sample. To turn off or remove system, 1 additional sampling event req to demonstrate acceptable conditions	IC within Site Management Plan.
North Carolina NC	Y	--						
Ohio OH	Y	UN[5]	Vapor Barrier, Passive Venting, SSD, SMD, Sealing, HVAC Modification	cBc, O&M plan	SSD - pressure measurements	Quarterly	Quarterly, includes visual inspections	O&M Plan
Oklahoma OK	N	NA						
Oregon	Y	Y	Passive Venting, Active Venting, Sealing, HVAC Modification	Indoor air sampling, visual inspection	Vapor barrier - smoke test SSD - Pressure measurements SSV - sample effluent	1st sample taken after installation, then at least yearly.	Until source term reaches acceptable concentrations.	ROD
Pennsylvania PA	Y	--	Active Venting, Sealing	Indoor air sampling				
Rhode Island RI	N	NA						
South Dakota SD	Y	Y	Building Pressurization	cBc, Indoor air sampling	cBc	Quarterly, reduced is results are acceptable.	Until source term reaches acceptable concentrations.	Letter to responsible part and in project file.
Texas TX	N	NA						
Virginia VA	N	NA						
Washington WA	Y	Y	SSD, SMD	O&M plan, cBc monitoring, cBc Indoor air sampling	cBc	Not specified in regulations.	cBc	Part of or attached to order or decree.
Wisconsin WI	Y	--	Vapor Barrier, Passive Venting, Active Venting, SSD					
Wyoming WY	Y	Y		Indoor air sampling, cBc visual inspections	Vapor barrier - smoke test SSV - sample effluent	cBc	Until demonstrated that the system is operating properly.	For sites with RPs: Remedy agreement, permit, or order. For Orphan sites: easement attached to deed.
Totals Yes	29	22						
Totals No	9	3						
Totals --	0	0						
Totals NA	0	7						

Notes:
NA = Not Applicable
O&M = Operation and Maintenance
SSD = Sub-slab Depressurizatior
SMD = Sub-Membrane Depressurizatior
IA= Indoor Air

1) Only states with VI guidance or other references to modeling are included in this tabl
2) This table provides the most common engineering controls; other engineering controls were also recommended and documented in Appendix
3) The California DEP recommended trench dams and sensors/alarms as possible engineering contro
4) Approval process information was collected through phone calls to state agencie
5) Approval not usually required, unless in Voluntary action program Memorandum of Agreement (MOA) track, in which public notice and RAP approval are requir
State approval required if covenant not to sue is issued before a building is put up on the si

Table 5
Summary of Institutional Controls and Site Closure Requirements for Vapor Intrusion Sites
MassDEP Soil Vapor Intrusion Survey Report

		Institutional Controls[2]									
State[1]	Does VI Guidance Discuss ICs? (Y/N)	If State has no VI Guidance and/or VI Guidance Does not Discuss ICs, are ICs Discussed Elsewhere? (Y/N)	Source of Additional Information on VI	Key Terms for ICs	Does State Differentiate ICs for Existing vs. Future Buildings? (Y/N)	Does State Provide Guidance on IC Review? (Y/N)	If State Provides guidance on IC Review, then what is the suggested review frequency? (Years)	Does State Enact the UECA (Uniform Environmental Covenants Act)? (Y/N)	Site can be closed without cleaning to unrestricted level	Possible to close site with EC in place	LTM or O&M Plan Required
Alabama AL	Y	--	--	Land Use Controls	N	Y	5	Y	Y		
Alaska AK	Y	--	--	Closure Letters, Deed Notices	Y	N	NA	N	N	Y	
Arkansas AR	N	Y	Brownfields Program User's Guide	Deed Restrictions	N	Y	Random Audit	N			
California CA	Y	--	--	Land Use Covenants, Deed Restrictions	N	Y	5	N	N		
Colorado CO	N	Y	Dry Cleaner Remediation Guidance Document	Environmental Covenants	N	Y	5	N	N	Y	
Connecticut CT	N	Y	Phone Interview, State Regulations	Environmental Land Use Restrictions	N	N	NA	N		Y	
Delaware DE	N	Y	Delaware Brownfield Program Fact Sheet	Uniform Environmental Covenants	N	Y	Regular Basis	Y	Y		
Georgia GA	N	Y	Georgia's Brownfields Law	Restrictive covenants, Property Notices	N	Y	A percentage of properties each year	Y	Y		
Hawaii HI	Y	--	--	Environmental Covenant	Y	N	NA	Y	Y	Y	
Idaho ID	Y	Y	Phone Interview	Uniform Environmental Covenants Act	N	N	NA	Y	Y	Y	
Illinois IL	N	--	--	--	--	--	--	Y	Y		
Indiana IN	N	Y	Phone Interview	Environmental Restrictive Covenants	N	N	NA	N	Y	cBc	Y
Kansas KS	N	--	--	--	--	--	--	N			
Kentucky KY	N	--	--	--	--	--	--	Y	Y		
Maine ME	Y	--	--	Environmental Covenants	N	N	NA	Y	Y	cBc	
Massachusetts MA	Y		--	Activity and Use Limitations (AULs)	N	Y	--	N	N	N	
Maryland MD	Y	--	--	Institutional Controls	N	N	NA	Y	Y		
Michigan MI	N	Y	Cleanup and Redevelopment Program	Environmental Covenants	N	N	NA	N	N		
Minnesota MN	N	--	--	--	--	--	--	Y	Y		
Missouri MO	Y	--	--	Activity and Use Limitations, Deed Notice, Restrictive Covenant	Y	N	NA	Y	N		Y
Montana MT	N	--	--	--	--	--	--	N			
Nebraska NE	N	Y	Voluntary Cleanup Program	Uniform Environmental Covenants Act	N	N	NA	Y	Y	Y	
Nevada NV	N	--	--	--	--	--	--	Y	Y		
New Hampshire NH	N	--	--	--	--	--	--	N			
New Jersey NJ	Y	--	--	Institutional Controls	Y	Y	Semi-annual	N		Y/N[4]	
New Mexico NM	N	--	--	--	--	--	NA	N			
New York NY	Y	Y	Phone Interview	Environmental Easement	N	Y	1	N	N	N	
North Carolina NC	N	--	--	--	--	--	--	N			
Ohio OH	Y	--	--	Institutional Controls	Y	N	NA	Y	Y		
Oklahoma OK	N	--	--	--	--	--	--	Y	Y		
Oregon	Y	Y	Guidance for Use of ICs	Easements, Equitable Servitudes, DR, PPA	N	Y	Random monitoring of the IC	N	N	N	
Pennsylvania PA	Y	--	--	DR	N	N	NA	Y	Y	N	
Rhode Island RI	N	--	--	--	--	--	--	N	Y		
South Dakota SD	N	--	--	--	--	--	--	Y	Y		
Tennessee TN	Y	--	--	Land Use Restrictions	N	N	NA	N			
Texas TX	N	--	--	--	--	--	--	N			
Virginia VA	N	--	--	--	--	--	--	N			
Washington WA	Y	Y	Phone Interview	Uniform Environmental Covenants Act	Y	N	NA	Y	Y	N	
Wisconsin WI	N	--	--	--	--	--	--	N			
Wyoming WY	Y	--	--	Institutional Controls	N	N	NA	N			
Totals NA	0	0	0	0	0	0	NA	0	0	0	0
Totals No	23	0	NA	NA	19	15	NA	22	8	6	0
Totals --	0	27	NA	NA	12	12	NA	0	0	0	0
Totals Yes	17	12	NA	NA	6	10	NA	18	19	6	2

Notes:
cBc = Case-by-case Basis
DR = Deed Restrictions
NA = Not Applicable
-- = No information available in the state guidance document
PPA = Prospective Purchaser Agreements
1) Only states with VI guidance or other references to modeling are included in this table.
2) ICs were investigated beyond the VI guidance in other state documents or via phone
3) UECA information can be found at http://www.environmentalcovenants.org/
4) Source must be eliminated.

Appendices

Appendix A:

Vapor Intrusion Guidance Survey Information - States

Appendix A
Vapor Intrusion Guidance Survey Information - States
MassDEP Soil Vapor Intrusion Report

State	Date of Guidance Update	Guidance Title	Pathway to Guidance	Agency	Contact	Do they allow modeling?	Model Type(s)	Model Modifications	Type of Approval
Alabama	April 2008 Revision 2	Alabama Risk-Based Corrective Action Guidance Manual	Vapor intrusion is covered here: http://www.adem.state.al.us/programs/land/landforms/ARBCAApril2008final.pdf Land use controls and remediation discussed here: http://www.adem.state.al.us/programs/land/landforms/AEIRGInvestigation.pdf	Alabama Department of Environmental Management	Brian Espy 334-271-7749 bespy@adem.state.al.us	Yes	ASTM	Non-specific.	Non-specific.
Alaska	July 2009	Draft Vapor Intrusion Guidance for Contaminated Sites DEC recommends use of "Vapor Intrusion Pathway: A Practical Guideline" published by the ITRC.	http://www.dec.state.ak.us/spar/csp/vi.htm	DEPARTMENT OF ENVIRONMENTAL CONSERVATION Division of Spill Prevention and Response Contaminated Sites Program	Vapor intrusion is a rapidly developing field, and we expect to update this guidance as new information becomes available. If you have any questions or comments, please contact Denise Elston, 907-465-5207.	Yes	Johnson and Ettinger (1991). Other models may be used if they are publicly available, peer-reviewed, and approved by DEC for predicting risk to building occupants.	The soil and NAPL Johnson and Ettinger (1991) EPA provided spreadsheets should not be used...Also the J/E model should not be used for evaluating petroleum-hydrocarbon spills unless adjusted for attenuation factors or biodegradation. (VI. INVESTIGATIVE STRATEGIES – SPECIAL CONSIDERATIONS, Predictive Modeling) Do not use soil data for modeling vapor transport... (III. KEY RECOMMENDATIONS)	Need approval if model is not J/E.
	Phone interview with: Denise Elston, Janice Wiergers, and Marty Brewer on 3/1/10	D: The guidance is still being updated and won't leave the draft phase for at least a year			D = Denise Elston @ 907-465-5207 J = Janice Wiergers @ 907-451-2127 M = Marty (Marlena) Brewer @ 907-269-3084	D: yes	J/E	D: The soil and NAPL Johnson and Ettinger (1991) spreadsheets from USEPA should not be used. Also, the J/E model should not be used for evaluating petroleum-hydrocarbon spills unless adjusted for biodegradation.	M: Alaska confirms the calculations; however, this is typically not a 100% of all calculations.
Arizona	Continuously Updated on website	Declaration of Environmental Use Restriction (DEUR)	http://www.azdeq.gov/environ/waste/cleanup/deur.html	Arizona Department of Environmental Quality	Richard Olm 602-771-4223 olm.richard@azdeq.gov Jeanene Hanley 602-771-43414 hanley.jeanene@azdeq.gov	Yes. See: http://www.azdeq.gov/environ/waste/ust/lust/tier2.html	Johnson and Ettinger (1991). See: http://www.azdeq.gov/environ/waste/ust/lust/tier2.html		
Arkansas	NA	There are currently no Guidance Documents available for Arkansas		Arkansas Department of Environmental Quality	Ashley Whitlow 501-682-0869 whitlow@adeq.state.ar.us	The ASTSWMO review states the following "The Arkansas Department of Environmental Quality utilizes the USEPA's guidance document entitled OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance), EPA530-D-02-0004, November 2002. They do not have their own guidance document or regulations on this issue. There are no immediate plans to promulgate regulations or prepare guidance."			

State	Recommended Engineering Controls (EC) or Corrective Actions Existing Buildings	Recommended Engineering Controls (EC) or Corrective Actions Future Buildings	EC Effectiveness/Operation and Maintenance	Site closure requirements	Institutional Controls and Deed Restrictions	Vapor/Gas Barriers?	Summary/Notes
Alabama	The site should install engineering controls in addition to any other land use controls to limit the exposure time below the period of time used in the RM-2 evaluation (from 7.3 Risk Management Recommendations).	The site should install engineering controls in addition to any other land use controls to limit the exposure time below the period of time used in the RM-2 evaluation (from 7.3 Risk Management Recommendations).	These additional controls should be maintained until such time that the cumulative risk level within each exposure domain is reduced to an acceptable level (from 7.3 Risk Management Recommendations).	ADEM may grant an NFA status (with or without restrictions) to the site when the responsible party has demonstrated the following: • The site has been adequately characterized.• Target cumulative risk levels have been achieved...The site concentrations have met the risk-based target levels...while no further investigative or remedial actions may be required for a site, Land Use Controls may be necessary...including engineering controls, institutional controls, etc. (from 2.10 No Further Action Under the ARBCA Program).	If land use other than unrestricted residential use is applied, the Department may require that the facility be required to implement and maintain land-use controls in perpetuity. LUCs (non-engineered controls instruments such as administrative and/or legal controls that minimize the potential for human exposure to contamination by limiting land or resource use.) may include, but are not limited to: • Engineering controls • Institutional controls • Water use restrictions • Deed restrictions • Restrictive covenants • Access controls • Usage restrictions • Protective cover maintenance • The listing of sites (e.g. State Cleanup Inventory List) (from 2.9 Land-Use Controls), e.g., a CERCLA 5-year review, the site manager should: (a) Evaluate both the administrative/legal components as well as the physical evidence to ensure that LUCs are both implemented and fully effective; (b) Ensure that any LUCs are available for inspection by any person performing a standard title search on the property and that the objectives of the LUCs are clearly (5.5.4 During Post-Remediation activities of this document:(http://www.adem.state.al.us/programs/land/landforms/AEIRGInvestigation.pdf)	None.	Alabama does not have VI Guidance but does address vapor intrusion.
Alaska	Sub slab depressurization systems, soil gas venting systems, vapor barriers. Other engineered mitigation systems may be proposed.	Sub slab depressurization systems, soil gas venting systems, vapor barriers. Other engineered mitigation systems may be proposed.	The responsible party must demonstrate to the DEC that the system is effective at controlling vapor migration into that building. Demonstrating abatement may include smoke tests or tracer gas tests, sub slab soil gas or indoor air sampling, or other measurements that characterize how the system interacts with building characteristics, such as sub slab pressure differentials.	Once DEC determines that all exposure pathways have been evaluated and the cleanup is protective of human health and the environment, the DEC will issue a closure decision. Institutional controls for the vapor intrusion pathway may remain after cleanup is complete until contaminant concentrations diminish to safe levels (from VIII Institutional Controls at Vapor Intrusion Sites).	Typically, institutional controls are necessary when: - Physical or mechanical barriers, such as remediation systems, ventilation systems, and vapor barriers, are used or relied on to reduce vapor intrusion Institutional controls should be established to ensure these mitigation measures are maintained and operated correctly. - New construction or changes to the existing structures could result in new vapor intrusion pathways. Institutional controls should be established to ensure that the vapor intrusion pathway is re-evaluated following any new construction and/or structure remodeling. - The site has been evaluated for commercial or industrial use, but not for residential use. Institutional controls should be established to restrict land use changes or to ensure the risk of residential use is evaluated.	The vapor barrier should be impermeable to the contaminants of concern and adequate sealing of the barrier along with any cracks or perforations in the foundation must be done. A smoke test may be required to confirm that the barrier is not leaking (from VII Mitigating a Vapor Intrusion Problem).	
	Passive Ekes are allowed but the state prefers active controls.	Passive Ekes are allowed but the state prefers active controls.	For ECs this is determined on a case by case basis. For passive ECs, a cleanup plan will be required and monitoring may also be required monitoring; however, this is determined on a case by case basis	Closure is achieved when concentrations in soil gas/GW are below target levels. A site can be closed with either/or ECs/ICs in place.	In Alaska, institutional controls can be established at a site, which allows the site to go into a cleanup complete status. ICs are documented in closure letters and in our database. Other methods (deed notices, regular reporting, etc.) can also be required to ensure that land users will be aware of and adhere to the ICs in the future. ICs for vapor intrusion are developed on a site-specific basis, although there is a little assistance on this topic in our VI Guidance.		The agency reviews the mitigation plans. Other guidance's: None specifically about vapor intrusion or methane/radon. DEC has developed some guidance for methamphetamine labs that required some limited indoor air sampling by the landowner.
Arizona	Declaration of environmental use restriction (DEUR) is a restrictive covenant designed to ensure appropriate future use of the contaminated site including the use of barriers or caps.	Declaration of environmental use restriction (DEUR) is a restrictive covenant designed to ensure appropriate future use of the contaminated site including the use of barriers or caps.	Required to inspect the engineering control at least once each calendar year. Within thirty days after the inspection, the owner must submit a written report containing the following information: a description of the current condition of the engineering control, and certification that the financial assurance mechanism(s) is being maintained.	Declaration of environmental use restriction (DEUR) is a restrictive covenant designed to allow closure of a site with contamination above residential soil remediation level. ADEQ will determine that a release of the DEUR is appropriate if the area of the property subject to the DEUR has been remediated to meet the requirements.	Declaration of environmental use restriction (DEUR) is a restrictive covenant designed to: 1. Document institutional and engineering controls; required to submit to ADEQ a written report once each calendar year regarding the status of the institutional control; designed to protect public health by limiting the use of contaminated areas including limiting any post remediation activity that might interfere with the residual contamination.	None.	Website with information that gives hard and fast requirements on O&M reds for ECs, this is a website and not a document which is strange.
Arkansas					See: http://www.adeq.state.ar.us/hazwaste/bf/pdfs/bf_users_guide.pdf		

State	Date of Guidance Update	Guidance Title	Pathway to Guidance	Agency	Contact	Do they allow modeling?	Model Type(s)	Model Modifications	Type of Approval
California	February 2005	Interim Final Guidance the evaluation and mitigation of subsurface vapor intrusion to indoor air	http://www.dtsc.ca.gov/AssessingRisk/upload/HERD_POL_Eval_Subsurface_Vapor_Intrusion_interim_final.pdf	Department of Toxic Substances Control (DTSC) The DTSC is a sub-agency of the California EPA.	Regulatory Assistance Officers (800) 728-6942	Yes	USEPA (2004) version of the Johnson and Ettinger (J/E) (1991) model used. The state provides GW-Screen and SG-Screen. Advanced versions are allowed but not encouraged.	DTSC has modified the USEPA J/E spreadsheets by including California specific toxicity factors. Uses CA specific air exchange rates Uses Qsoil of 5 L/min (as adjusted for slab area) Use default "crack to area ratio" of 0.005	DTSC reviews input parameters; may check model results
	April 2009	Department of Toxic Substances Control, California EPA Vapor Intrusion Mitigation Advisory is an extension for projects at Step 11 in the Vapor Intrusion Guidance; DTSC, 2005a above, to be used after 1. risk due to vapor intrusion has been estimated by modeling or indoor air sampling and 2. mitigation has been proposed as part of a response action.	http://dtsc.ca.gov/SiteCleanup/upload/VI_Mitigation_Advisory_Apr09r.pdf	Department of Toxic Substances Control (DTSC)	Kate Burger Department of Toxic Substances Control 8800 Cal Center Drive Sacramento, California 95826 kburger@dtsc.ca.gov	See above.	See above.	See above.	See above.
	Phone interview with Dan Gallagher on 3/3/2010	There is no time frame on updating the "Interim final guidance for the evaluation and mitigation of subsurface vapor intrusion to indoor air" AIR" but the "Active Soil Gas Investigation Advisory" was supposed to be published March 1, 2010 but is delayed a week.		Department of Toxic Substances Control (DTSC)	Dan Gallagher	Yes	J/E	The use of J/E is constrained to use CA toxicity factors and that if attenuation factors smaller than 1/10,000 are not realistic.	Use screening numbers and the data should be reasonable and based on site specifics, i.e., must duplicate site in the model.
	Phone interview with Dan Gallagher and Loraine Larson-Hallock on 3/9/2010			Department of Toxic Substances Control (DTSC)	Dan Gallagher and Loraine Larson-Hallock				

Appendix A
Vapor Intrusion Guidance Survey Information - States
MassDEP Soil Vapor Intrusion Report

State	Recommended Engineering Controls (EC) or Corrective Actions Existing Buildings	Recommended Engineering Controls (EC) or Corrective Actions Future Buildings	EC Effectiveness/Operation and Maintenance	Site closure requirements	Institutional Controls and Deed Restrictions	Vapor/Gas Barriers?	Summary/Notes
California	1. Excavation of VOC Sources 2. Existing Building Retrofit - VOC Collection and Passive Vent Systems etc. plus soil gas monitoring, subsurface vapor extraction, sensors, alarms, conduit seals, slab crack sealing, utility trench dams, and enhanced ventilation systems (from Step 11: Mitigate Indoor Air Exposure, Monitoring, and Implementation of Engineering Controls-Mitigation Measures).	1. Future Building Construction - VOC Collection, Membrane, and Passive Vent Systems 2. Future Building Construction - VOC Collection, Membrane, and Active Vent Systems plus soil gas monitoring, subsurface vapor extraction, sensors, alarms, conduit seals, slab crack sealing, utility trench dams, and enhanced ventilation systems (from Step 11: Mitigate Indoor Air Exposure, Monitoring, and Implementation of Engineering Controls-Mitigation Measures).	1. A one-time initial indoor air testing of all newly vented buildings 2. Routine inspection of the area of concern 3. Routine monitoring of air 4. Routine monitoring of vent risers for flow rates and gas concentrations 5. Routine maintenance, calibration, and testing of functioning components of the VOC venting systems (from Step 11: Mitigate Indoor Air Exposure, Monitoring, and Implementation of Engineering Controls-Operation and Monitoring (O&M) Requirements for Venting Systems).	None.	When the removal of all volatile chemicals from the subsurface is not possible, institutional controls with their prescribed notifications, prohibitions, and engineering controls must be utilized to prevent exposure due to vapor intrusion (from Step 11: Mitigate Indoor Air Exposure, Monitoring, and Implementation of Engineering Controls-Institutional Controls and Deed Restrictions).	Gas Barrier/Membrane System should meet the following requirements: 1. Gas membranes should be constructed of appropriate materials and thicknesses. 2. Gas membranes should be placed a maximum of one foot below the foundation 3. Protective layers consisting of at least two inches or more of sand and/or geotextile 4. Without an engineering evaluation and confirmation data to support the beneath footing passage, the membrane should not pass below footings 5. Gas tight seals (e.g., boots) should be provided at all pipe or conduit penetrations 6. A smoke test of the membrane system should be conducted (from Step 11: Mitigate Indoor Air Exposure, Monitoring, and Implementation of Engineering Controls-Mitigation Measures and III. Future Building Construction-VOC Collection, Membrane, and Passive Vent Systems).	
	1. Removal of VOC sources 2. sub-slab depressurization system 3. sub membrane depressurization system 4. Building Pressurization 5. Sealing Cracks and Openings and 6. Indoor Air Treatment.	1. Removal of VOC sources 2. sub-slab depressurization system 3. sub membrane depressurization system 4. Building Pressurization 5. sub-slab venting system podium building 6. Sealing Cracks and Openings 7. Vapor Barriers Indoor Air Treatment	1. Collecting vapor samples to demonstrate the effectiveness of the mitigation 2. For SSD systems, collecting pressure data to demonstrate the presence of a negative pressure field below the entire building foundation 3. For HVAC systems, measuring differential pressures and air exchange rates as well as monitoring of system operations 4. Ensuring continuous operation of the mitigation system 5. Ensuring operation in accordance with the manufacturer's specifications 6. Ensuring that site conditions have not changed in a way that will impact the function or measurement of the mitigation system 7. Monitoring of changes in ownership, tenant, and/or building conditions and, depending on requirements cited in the LUC, modifying the enforceable mechanism and 8. a contingency plan.	Subsurface remediation efforts will eventually reduce VC concentrations in soil, soil gas, and/or groundwater to levels that no longer require remediation. At this point, vapor mitigation systems may be shutdown and/or removed, depending on the preferences of the building owners and obligations of responsible parties, and O&M requirements would cease.	When vapor intrusion mitigation at a structure is necessary, as an interim response action or in conjunction with a final response action, the mitigation requirement should be included in a LUC (i.e., Covenant to Restrict Use of Property, Environmental Restriction). The LUC may include other ICs with their prescribed notifications, prohibitions, restrictions and requirements that must be utilized to ensure O&M and disclosure of the risks, restrictions, and requirements to future buyers and occupants. If existing conditions without mitigation may cause unacceptable future risk to receptors, effective legal notification to future buyers of the property, occupants of future developments, or re-developments on the property will be required.	Have traditionally been used to prevent moisture from accumulating behind drywall walls, thus giving rise to the name "vapor barrier." Sub-slab liners ideally cause soil gas that would otherwise enter the building to migrate laterally beyond the building footprint. However, in practice, sub-slab liners are not able to completely eliminate vapor intrusion due to the likelihood of punctures, perforations, tears, and incomplete seals. Thus, sub-slab liners by themselves are not an acceptable vapor intrusion mitigation system to DTSC for indoor air risks greater than or equal to 1 x 10-6 and a HI greater than or equal to 1 (see Chapter 2 for further discussion of the risk management framework), and should be used only in combination with a SSV, SSD, or SMD system.	
			Take one set of measurements in not reasonable, need a long term monitoring plan to show the VI pathway is incomplete, i.e., in SSD sampling and visual inspections should be performed. Annually, a land use covenant coupled with annual monitoring and sampling done by the department or an LSP or PE is acceptable. Dan notes that no special O&M is required for passive ECs.	Total site closure can be achieved if land has unrestricted use and a risk of less than $10^{-6.}$	If a site doesn't meet residential standards then do an institutional control like restricting buildings on area, i.e., no building over the plume. Also, Land Use Covenants can be used if signed by a reasonable party.		Mitigation plans are approved by the department.
				Site can be certified remedy complete with active EC's (like SSD) but will not be closed due to long term O&M requirements, use the term "complete with waste in place", but no, no full closure until site is deemed unrestricted use.	LUCs are used (started about 15 years ago) if waste is in place in order to indentify site conditions, prohibitions, and is filed with that local government and stays with the parcel until land is deemed for unrestricted use. LUC can have ICs, deed restrictions, etc, it's a comprehensive document that calls out responsible parties and is subject to a 5-year review. Note that the LUC rests on living documents referenced within itself like O&M plans of which can change and thus change the LUC. LUCs were born from a need for developers to avoid cleaning to unrestricted use and thus cleaning to C/I use and continue property development.		

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State	Date of Guidance Update	Guidance Title	Pathway to Guidance	Agency	Contact	Do they allow modeling?	Model Type(s)	Model Modifications	Type of Approval
Colorado	September 2004	Indoor Air Guidance	http://www.cdphe.state.co.us/hm/indoorair.pdf	Colorado Department of Public Health and Environment	Susan Newton 303-692-3321 susan.newton@state.co.us	Yes	Models can be used as a line of evidence to evaluate the likelihood that contamination will migrate into a building. The many uncertainties associated with modeling a complex and poorly understood physical system results in predictions that may be off by an order of magnitude. Where possible, the model should be calibrated with site-specific data, or run with conservative default parameters (from 4.1 Multiple Lines of Evidence).	CO does not provide model spreadsheets nor does it recommend any modifications.	
	March 2006	Dry Cleaner Remediation Guidance Document	http://www.cdphe.state.co.us/hm/drycleanerguidance.pdf						
	March 2002	Senate Bill 01-145 Public Guidance Document "Environmental Covenants" March 2002	http://www.cdphe.state.co.us/hm/covenant/envcovntguide.pdf						
	December 2007	Petroleum Hydrocarbon Vapor Intrusion Guidance Document	http://oil.cdle.state.co.us/oil/Technical/Guidance%20Documents/Colo%20VI%20Doc%2012-11-07.pdf	The Colorado Department of Labor and Employment, Division of Oil and Public Safety	Greg Johnson 303-318-8536 greg.johnson@state.co.us Marilyn Hajicek 303-318-8530 marilyn.hajicek@state.co.us	Wells should be installed and sampled along with ambient air. No mention of modeling.			Must follow sampling steps in guidance
	Phone interview with Walter Avramenko on 3/4/2010	No, there is no pressing need to update guidance		Hazardous Waste Corrective Action Unit Solid and Hazardous Waste Program Hazardous Materials and Waste Management Division Colorado Department of Public Health and Environment	Walter Avramenko, Unit Leader 303-692-3362 walter.avramenko@state.co.us	Do not encourage its use. Will evaluate results if submitted, but only as a line of evidence used to indicate the magnitude of the potential problem. Usually just use indoor air samples.	J/E		Do not have technical reviewers for J/E model. Project manager would look at and evaluate whether results look ok, but can't check evaluate whether the model was properly set up.

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Colorado	1. temporary relocation 2. sub-slab depressurization system 3. Buildings with crawl spaces may be remediated using a sub-membrane depressurization system cleanup of soil and/or ground water.	1. sub-slab depressurization system 2. Buildings with crawl spaces may be remediated using a sub-membrane depressurization system 3. cleanup of soil and/or ground water.	Buildings with indoor air mitigation systems should be routinely monitored to verify the effectiveness of a mitigation system. This type of monitoring starts on a quarterly frequency, but may decrease as more data becomes available and confidence is gained that conditions will either remain the same or improve with the passage of time.	No additional air sampling is required at locations where test results show that measured concentrations do not exceed chemical specific remediation goals. Site-specific conditions will dictate whether this decision is based on a single sample or multiple samples collected over a set period of time.			Assessment of the vapor intrusion pathway has a much shorter history than the assessment of other pathways. Consequently, the key issues and technical challenges are not as well understood. Vapor intrusion pathway should be conducted in direct consultation with Department representatives.
					ICs are legal mechanisms that impose some restriction on land use to render actual and potential human exposure pathways incomplete. They can also obligate the facility owner to conduct certain activities to maintain protectiveness (e.g., maintain a cover or a hydraulic containment system). These restrictions may include zoning restrictions, structure-use restrictions, excavation restrictions, land-use restrictions and natural resource-use (e.g., ground water) restrictions. Depending on site-specific circumstances, institutional controls may be the only practical mechanism to afford an adequate level of long-term protection of human health by, for instance, eliminating pathways to contaminants. Environmental covenants are enforceable agreements voluntarily initiated by the property owner, and once approved by the Department, are recorded with the property deed and run with the land in perpetuity, or until the conditions requiring the environmental covenant are resolved. The environmental covenant binds the owner of the land, all successors, and any persons using the land to comply with the use restrictions listed in the covenant to maintain the required level of protection. It may only be		More on ICs can be found at: http://www.cdphe.state.co.us/hm/envcovenants.asp.
					The environmental covenant provides the Department with an enforceable mechanism to insure that engineering/institutional controls that are part of environmental remediation projects are properly implemented and maintained, so that implemented remedies continue to be protective of human health and the environment.		
					Based on resource constraints, the department plans to perform only limited independent verification inspections of the properties, most of which will be part of other program responsibilities (e.g., Superfund 5-year reviews or RCRA permit inspections).		
	Passive and active venting systems, and sub-slab depressurization and pressurization systems.	Passive and active venting systems using gas barrier/membrane technology.	None.	None.		For future buildings, a recommended mitigation measure is "passive and active venting systems using gas barrier/membrane technology."	Addresses vapor intrusion as a result of petroleum products only, want you to drill wells and sample, no mention of modeling.
	All systems currently in use are active controls. If proponent wants to use passive system only, would need to provide data that target levels have been reached in indoor air and source would need to be remediated.	All systems currently in use are active controls. If proponent wants to use passive system only, would need to provide data that target levels have been reached in indoor air and source would need to be remediated.	No	When the source term is remediated to point that there is no longer a risk greater than 10E-6 or an HI of 1 without active mitigation. Do not have any sites that use only passive controls.	Colorado uses environmental covenants which remain on the property in perpetuity until removed. The covenant is signed by CO and the property owner then filed with the county. Environmental covenants are tracked by the state (currently about 60) and are enforceable. Environmental covenant is not in the deed and cannot be altered by the property owner. Inspections are included in the framework, but CO is still trying to work out the mechanics of those inspections. UECA is being considered but the Colorado Attorney General thinks that it is weaker than what CO currently has in place, so it is not likely that the UECA will be used.		The mitigation work plan is directly reviewed by the agency. Other important documents from the radon group are available.

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Connecticut	September 2007	Site Characterization Document	http://www.ct.gov/dep/lib/dep/site_clean_up/guidance/Site_Characterization/Final_SCGD.pdf	State of Connecticut Department of Environmental Protection	Graham Stevens 860-424-4166 graham.stevens@po.state.ct.us	Yes	non-specific	non-specific	model analysis...fully supported by quantitative data...purpose of model must be clearly stated. Properly constructed, calibrated, and validated models are useful...Sensitivity analysis should be performed...every model has its limitations...(5.2.6 Analytical and Numerical Modeling) If the environmental professional determines that there is a risk of vapor intrusion, soil vapor data should be of sufficient quality to assess such potential risk. Supplemental guidance provides more detail on soil vapor sampling. (5.2.5.3 Soil Vapor)
	January 1996	Remediation Standard Regulations	http://www.ct.gov/dep/lib/dep/regulations/22a/22a-133k-1through3.pdf	State of Connecticut Department of Environmental Protection					
	March 2003	Proposed Revisions - Connecticut's Remediation Standard Regulations Volatilization Criteria	http://www.ct.gov/dep/lib/dep/site_clean_up/remediation_regulations/RvVolCri.pdf	State of Connecticut Department of Environmental Protection	Carl.Gruszczak@ct.gov 860-424-3705 He's in a newly appointed position due to Graham Stevens promotion. Nice guy, open to questions.	Yes	Johnson and Ettinger (1991)	incorporating its extensions developed in 1998 and 1999 (Johnson et al. 1998 and Johnson et al. 1999),	
	Phone interview with Carl Gruszczak on 2/26/2010	When asked about when this guidance (Proposed Revisions - Connecticut's Remediation Standard Regulations Volatilization Criteria) would be finalized Carl's paraphrased response was, "The RSR in 2008 got bogged down in legislation and this had the proposed revisions to the Volatile Criteria in it. The department is going to try and push the RSR through again in the next year or two when a new governor is in office. However, the department still holds people to the 2003 document even in it's current proposed status"	http://www.ct.gov/dep/lib/dep/site_clean_up/remediation_regulations/RvVolCri.pdf	State of Connecticut Department of Environmental Protection, Permitting, Enforcement and Remediation Division Bureau of Water Management	Carl.Gruszczak@ct.gov 860-424-3705 He's in a newly appointed position due to Graham Stevens promotion. Nice guy, open to questions.	Yes	Johnson and Ettinger (1991)		J/E is used but not much. The department generally uses published numbers in the 2003 document.
	Phone interview with Jan Czeczotka on 3/3/2010	When asked about when this guidance (Proposed Revisions - Connecticut's Remediation Standard Regulations Volatilization Criteria) would be finalized Jan's paraphrased response was, "Could move forward independently, no time table, economy confuses the matter because they don't want to kill business, can't expect to make changes in this financial environment" Also, Jan says they don't regulate by guidance, regulate by professional judgment that shows equal or better protection of regulations.	http://www.ct.gov/dep/lib/dep/site_clean_up/remediation_regulations/RvVolCri.pdf	State of Connecticut Department of Environmental Protection, Permitting, Enforcement and Remediation Division Bureau of Water Management		Yes	Johnson and Ettinger (1991)	The agency claims that J/E is flawed and to use 2003 volatilization numbers but 2008 numbers are different to actively predict transport. Still advices to use 2003 numbers but by law must use "96 RSR's", if someone is LEP, says 96 model underestimates. Describes LEP's role is to protect human health and to provide verification that conforms to RSRs.	Criteria numbers must be used but must be site specific. Target air concentrations shown in table C1 or 2003 document "Proposed Revisions - Connecticut's Remediation Standard Regulations Volatilization Criteria" must be used as well.
Delaware	March 2007	Policy concerning the investigation, risk determination and remediation for the Vapor Intrusion pathway	http://www.dnrec.state.de.us/dnrec2000/Divisions/AWM/sirb/policy%20concern07008.pdf	Delaware Department of Natural Resources and Environmental Control, Site Investigation and Restoration Branch, Policy and Procedures	Rick Galloway 302-395-2614 rick.galloway@state.de.us	Yes, (Step 5)	J/E (EPA 2003), but other models will be considered on a site-by-site basis (Step 5).	Can use either advanced or generic based on amount of data available but must be either groundwater or soil gas data, soil data should not be used; worst case values should be used.	J/E can not be used if: preferential pathway exists, building foundations is in contact with groundwater...."goes on to list several other stipulation....however, another model may be used if approved by DNREC and you can conduct a field investigation if work plan is approved by DNREC (Step 5).

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Connecticut	None.	None.	None.	None.	None. See: http://www.ct.gov/dep/cwp/view.asp?a=2715&q=438254&depNav_GID=1626	When an environmental professional conducts indoor air sampling and analysis, he/she must consider potential sources of off-gassing, preferential vapor intrusion pathways, the presence of temporary and permanent barriers, building usage/occupancy, ventilation/air conditioning systems, indoor sources of VOCs, seasonal conditions, building construction, and background conditions. Additional information on indoor air sampling can be found in supplemental guidance.(5.2.5.4 Indoor Air)	NOT a vapor intrusion guidance but does talk generically about modeling to determine risk...mentions vapor intrusion analysis should be supported by sampling data
					When the Commissioner approves a request pursuant to this subsection to use an engineered control he may require that such control incorporate any measures which he deems necessary to protect human health and the environment. Any person implementing an engineered control under this subsection shall perform all actions specified in the approved engineered control proposal including the recordation of the environmental land use restriction and posting of the surety, and any additional measures specified by the Commissioner in his approval of such plan. Nothing in this subdivision shall preclude the Commissioner from taking any action he deems necessary to protect human health or the environment if an approved engineered control fails to prevent the migration of pollutants from the release area or human exposure to such pollutants.		
		See Recommended Engineering Controls Existing buildings	See next.	Site closure requirements are site specific but you'll need LEP (maybe he said LSP) verification, you'll need to show you broke the VI pathway, and you'll need to draft a Maintenance Plan prior to closure to ensure the EC effectiveness and proper O&M.		Prefer active, not passive systems.	
		Suggests passive ECs for future buildings.	A long term plan must include initial and perhaps quarterly monitoring or annual monitoring depending on the site and the DEP can approve or deny the is plan but there is no hard and fast template for O&M requirements, this holds true for both active and passive ECs.	A site can be closed with EC still operating, once everything is in place, provided O&M requirements are met the site can be closed contingent upon maintaining the Ecs.	Environmental Land Use Restrictions are used and that the commissioner takes interests to render sites inaccessible, etc, however, the department does not issue deeds but wants to look into deeds for the future.		LSPs handle 80% of mitigation work plans, but, it depends on who is lead.
Delaware	Sub slab depressurization and/or Vapor barrier with passive venting, but other remedial options will be considered on a case by case basis. Guidance goes on to list vapor barrier specs in accordance with ASTM and the system(s) must be approved prior to installation (Step 12).	Sub slab depressurization and/or Vapor barrier with passive venting, but other remedial options will be considered on a case by case basis. Guidance goes on to list vapor barrier specs in accordance with ASTM and the system(s) must be approved prior to installation (Step 12).	to determine the vapor barrier with passive venting system effectiveness, a case by case periodic indoor sampling event that shows a risk above 1x10-5 still existing in the building even with the passive venting will result in a "ineffective determination" (Step 12)	None.	None. See: http://www.google.com/search?q=DELAWARE+BROWNFIELD+PROGRAM+FACT+SHEET.docx\&ie=utf-8&oe=utf-8&aq=t&rls=org.mozilla:en-US:official&client=firefox-a	Sub slab depressurization and/or Vapor barrier with passive venting, but other remedial options will be considered on a case by case basis...guidance goes on to list vapor barrier specs in accordance with ASTM and the system(s) must be approved prior to installation (Step 12)	Outlines the steps to evaluate the vapor intrusion risk from investigation to remediation stage.

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Florida	December 2008	Vapor Intrusion is considered on a site-by-site basis only. The vapor intrusion pathway is not considered in default Groundwater cleanup target levels (GCTLs) and Soil cleanup target levels (SCTLs).	State is currently assessing how to tackle VI in the state: http://www.dep.state.fl.us/waste/quick_topics/publications/shw/HWRegulation/Workshop2008/Vapor_Intrusion_Study.pdf	Florida Department of Environmental Protection	Thomas Conrardy, FDEP Bureau of Petroleum Storage Systems (850) 245-8899 Tom.Conrardy@dep.state.fl.us (wrote pre-guidance document here: ftp://ftp.dep.state.fl.us/pub/reports/globalrbca/IndoorVaporIntrusionBWCconf-final.pdf)	No guidance.	No guidance.	No guidance.	No guidance.
	No guidance.	No guidance.	Guidelines for Vapor Monitoring: http://www.dep.state.fl.us/waste/quick_topics/publications/pss/tanks/Guidelines_for_Vapor_Monitoring.pdf	No guidance.	No guidance.	No guidance.	No guidance.	no guidance	No guidance.
Georgia	NA	There are currently no Guidance Documents available for Georgia; the state defers to OSWER 2002.	http://www.atsdr.cdc.gov/HAC/pha/rummelfibre/rfc_p1.html	USEPA	No guidance.	No guidance.	No guidance.	No guidance.	No guidance.
Hawaii	June 2009	On June 21, 2009 the Hawaii Department of Health posted an interim final document "Technical Guidance Manual for the Implementation of the Hawai'i State Contingency Plan". Section 7 of that document is "Soil Vapor and Indoor Air Sampling Guidance". See the guidance at (right)	http://www.hawaiidoh.org/tgm-pdfs/HTGM%20Section%2007.pdf	Evaluation and Emergency Response Office		No guidance.	No guidance.	No guidance.	No guidance.
	June 2009	Technical Guidance Manual for the Implementation of the Hawai'i State Contingency Plan	http://www.hawaiidoh.org/tgm-pdfs/HTGM%20Section%2016.pdf	Evaluation and Emergency Response Office		No guidance.	No guidance.	No guidance.	No guidance.
	Phone interview with John Peard on 3/3/2010	Current guidance is designed to be a "living document." Will be updated for small things on a continuous basis. Major revision for new soil vapor sampling methods in 2011. Expect revisions every 1-2 years.			Main Contact Roger Brewer, roger.brewer@doh.hawaii.gov on vacation for next 2 weeks Contacted on 3/3/2010 John Peard, john.peard@doh.hawaii.gov, 808-933-9921	John Peard: yes, use J&E model	J/E	John Peard: don't use soil model	John Peard: Roger Brewer would review
Idaho	July 2004	Idaho Risk Evaluation Manual. Appendices C and F gives specific guidance regarding SVI. Login as gianna.leandro@parsons.com	http://www.deq.idaho.gov/applications/brownfields/download/maindocument.pdf http://www.deq.state.id.us/Applications/Brownfields/index.cfm?site=register.cfm	Idaho DEQ.	Bruce Wicherski 208-373-0246 bruce.wicherski@deq.idaho.gov	Yes. The investigator can perform the calculation of risks using soil, ground water, or soil vapor data can typically be completed using the REM computational software or other models approved by DEQ. Note: investigator must register with the state to get access to the REM, I don't know what models are in this document (C.3 STEPS TO EVALUATE THE INDOOR INHALATION PATHWAY), Yes, the department uses an emission model and an indoor air-mixing model. These models are combined together and included in the Johnson and Ettinger Model (EPA, 2003). to calculate target levels. (3.7.6 Mathematical Models)	Investigator uses (REM) Department uses J/E (1991)		
	Phone interview with Bruce Wicherski on 3/15/2010	Idaho Risk Evaluation Manual. Appendices C and F gives specific guidance regarding SVI, note that a document titled, "Guidance on Petroleum Specific Risk Evaluation" along with a revision of Appendix. C in the "Idaho Risk Evaluation Manual" is in the works and is expected to be published in the summer of 2010. This document will likely decrease the minimum distance from building to contamination from 100 feet to 30 feet as per ASTM guidance.		Idaho DEQ.	Bruce Wicherski 208-373-0246 bruce.wicherski@deq.idaho.gov	Yes	J/E has been used since 2004, and any other model in which input parameters can be justified by the investigator can be used as well, although no one has used a model other than J/E	Department does not force attenuation factors or input parameters on the investigator but, the values used in the model must be defensible.	the department approves modeling on a site specific basis, dept. doesn't have boiler plate parameters, attenuation factors, etc.

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Florida	no guidance	No guidance.	No guidance.	No guidance.	discussed here: http://www.dep.state.fl.us/waste/quick_topics/publications/wc/csf/icpg.pdf	No guidance.	No guidance.
	no guidance	No guidance.	No guidance.	No guidance.	No guidance.	No guidance.	No guidance.
Georgia	no guidance	No guidance.	No guidance.	No guidance.	http://www.gaepd.org/Files_PDF/outreach/BFInstCnt.pdf	No guidance.	No guidance.
Hawaii	no guidance	No guidance.	No guidance.	No guidance.	No guidance.	At sites where Shallow Soil Gas Action Levels are approached or exceeded, collect indoor-air samples and compare results to Indoor Air Action Levels (HDOH, 2008a, Table C-3 in Appendix 1) and known or anticipated background levels in indoor air. In the case of anticipated future construction, remediation of the soil vapor source or incorporation of vapor barriers in the design of future buildings may be required.	
	An active vapor mitigation system to prevent subsurface vapor intrusion into indoor air spaces, Capping systems, Vapor barriers (19.7.2 Engineering Controls).	An active vapor mitigation system to prevent subsurface vapor intrusion into indoor air spaces, Capping systems, Vapor barriers (19.7.2 Engineering Controls).	See Below	See Below	Environmental covenant to prohibit disturbance of contaminated soil. 1) Establishment of a monetary trust to fund environmental response efforts if contamination left in place is disturbed in the future, 2) Long-term monitoring of a "stable" groundwater contaminant plume, and 3) Public notices and advisories against consumption of contaminated foodstuffs (16.2.2.1 Hierarchy of Remedial Alternative Selection).		See: http://www.hawaiidoh.org/tgm.aspx http://hawaii.gov/health/environmental/hazard/eal2005.html
	ALLOW PASSIVE EC'S? John Peard: yes	ALLOW PASSIVE EC'S? John Peard: yes	BOTH ACITVE AND PASSIVE: John Peard: indoor air and subsurface samples would be collected. In SVE systems, monitors would be installed in the piping. Required to have a maintenance program. Initially, monitoring and inspections would be quarterly. After functioning properly for awhile, could RP propose semi-annual or annual monitoring.	John Peard: if soil gas and indoor air levels are below action levels, can close site. Can grant NFA with institutional controls/ECs in place, but requires that RP maintains EC/IC.	John Peard: follow Uniform Environmental Covenants Act, can use either a deed restriction or a formal Uniform Environmental Act Covenant. Sites with ICs are tracked and provide info to EDR and other consultants. Reviewing at how ICs should be investigated/checked in the future, but currently do not have requirement for inspection of sites with ICs only.		Mitigation work plan is reviewed in house. Guidance is provided here: http://www.hawaiidoh.org/tgm.aspx http://hawaii.gov/health/environmental/hazard/eal2005.html (see volume 1 of EHE guidance)
Idaho	engineering controls such as a paved site	Engineering controls (e.g., such as a paved site).	None specified.	If pathway is incomplete the you can close then site (Figure C-2. Flowchart for Indoor Inhalation Evaluation)	Risk management plans must include provisions, as practicable, to implement ICs during remediation throughout the plume area that has migrated off site where concentrations exceed the RATL-1/RATL-2 concentrations for GW ingestion in Table 3-3. These controls must remain in place until remediation is complete and concentrations do not exceed the target levels described in Table 3-3. (3.8.3.1 Ground Water with Current Use or Reasonably Likely Future Use as Drinking Water). The tool used by DEQ as a remedial action IC to restrict property uses is an Equitable Servitude and Conservation Easement, which is a written agreement entered into by the responsible party and DEQ for on-site use restrictions. Such non-remedial action ICs include City/County Zoning Ordinances, Source Water Protection Areas.	None specified.	Appendix C is more of a guidance to investigate and evaluate VI pathway, not to mitigate, but body of text goes to lengths to discuss the need for remedial actions (although none specified) and institutional controls to protect human health, also, body discusses at length the use of modeling to calculate the departments target levels of COCs.
	the department approves all EC's on a site specific basis, Bruce did not promote any specific EC's	The department approves all ECs on a site specific basis.	Bruce did not promote any specific O&M requirements but insisted that these matters are site specific and must be defensible and justified.	Idaho is a member of the UECA (Uniform Environmental Covenants Act) and all terminations/closures of sites are included in the covenant. A site can be closed without cleaning to unrestricted use if proper IC's are included in the covenant.	Idaho is a member of the UECA (Uniform Environmental Covenants Act) and all terminations/closures of sites are included in the covenant. A site can be closed without cleaning to unrestricted use if proper IC's are included in the covenant.	Bruce does not provide specifics on barriers, but, barriers can be part of a mitigation plan and may be approved by the department, again, all mitigation plans are approved on a site specific basis, the dept. does not provide specs on barriers nor does it promote barriers.	Idaho does not provide specifics on modeling, ECs, ICs, Barriers, etc, insists that all mitigation plans will be approved on a site specific basis.

State	Date of Guidance Update	Guidance Title	Pathway to Guidance	Agency	Contact	Do they allow modeling?	Model Type(s)	Model Modifications	Type of Approval
Illinois	Upcoming	Currently Illinois uses OSWER (2002) but is in the process of amending their Tiered Approach to Corrective Action Objectives (TACO) to specifically address vapor intrusion. Currently, this amendment process is in progress (see website).	http://www.ipcb.state.il.us/COOL/External/CaseView.aspx?case=13524	Illinois Pollution Control Board (IPCB)	No guidance.	No guidance.	No guidance.	No guidance.	No guidance.
		TACO as it stands currently (does not address VI): Title 35: Environmental Protection Subtitle G: Waste disposal, Chapter I: pollution control board, Subchapter F: risk based cleanup objectives, part 742: tiered approach to corrective action objectives	http://www.ipcb.state.il.us/documents/dsweb/Get/Document-38408/	no guidance	No guidance.	No guidance.	No guidance.	No guidance.	No guidance.
Indiana	April 2006	Draft Vapor Intrusion Pilot Program Guidance	http://www.in.gov/idem/files/la-073-gg.pdf	Indiana Department of Environmental Management	Rob B Thompson 317-233-1514 rthompso@dem.state.in.us	No, but certain parameters are given in the guidance, such as screening levels, which are derived from J/E (Version 3.0) model from EPA. (Section 2.0)	NA	NA	NA
	10/19/2007	Addendum to the Draft Vapor Intrusion Pilot Program Guidance	http://www.in.gov/idem/4340.htm	Indiana Department of Environmental Management		No, IDEM has reviewed the recent literature on the use of the Johnson & Ettinger (J&E) model for evaluation of the vapor intrusion pathway. Based on this evaluation, the IDEM Vapor Intrusion Workgroup does not recommend that the results of site-specific vapor intrusion modeling be accepted without appropriate site-specific data for sensitive model parameters, and actual sub-slab/soil gas and indoor air data to calibrate and validate the model. Soil gas, sub-slab, and/or indoor air samples should be collected to determine if contaminant concentrations exceed health-protective levels, particularly in residential areas where soil or groundwater contaminant concentrations exceed IDEM's screening levels (IDEM 2006).Site closure requests based only on modeling in the absence of site-specific parameter data and confirmatory sub-slab/soil gas and indoor air samples will not be accepted.			
	Phone interview with Megan Hamilton and Bob Moran on 3/4/2010	Guidance is going to be updated. IDEM has been working on completing its VI guidance and also updating its RISC Technical Guidance (2001). The VI guidance will be pulled into the larger RISC guidance, as opposed to being issued separately. Megan estimates a Draft for Public Comment of the RISC Technical Guidance will issued by the end of the year.			Megan Hamilton, IDEM, Office of Land Quality, Risk Services Section (317) 234-3928, megan.hamilton@idem.in.gov Bob Moran, IDEM, Office of Land Quality, Risk Services Section (317) 232-4419, bmoran@idem.in.gov	Yes	The J&E model is allowed to be used only to tailor investigations (screen locations for testing). It cannot be used for screening out VI or for closure demonstrations.	NA	NA
Iowa	November 1996 Version 1	Tier 1 and 2 Site Cleanup Report Guidance for Assessing Leaking Underground Storage Tanks (LUST) Using Risk-Based Corrective Action (RBCA)	http://www.iowadnr.gov/land/ust/technicalresources/lustsiteassessment/documents/tier2guide.pdf	Iowa Department of Natural Resources	Elaine Douskey 515 -281-8011 elaine.douskey@dnr.state.ia.us	No guidance.	No guidance.	No guidance.	No guidance.
Kansas	June 2007	Kansas Vapor Intrusion Guidance Chemical Vapor Intrusion And Residential Indoor Air	http://www.kdheks.gov/ber/download/Ks_VI_Guidance.pdf	Kansas Department of Health and Environment.		Yes, but prefer not to: It is important to note that models do not incorporate preferential migration pathways such as foundation drain tile and sumps, utility corridors, or various older foundations types. Due to these limitations, direct measurements (e.g., indoor air samples, crawlspace, sub-slab, soil vapor, etc.) are the preferred method of determining vapor intrusion concentrations. (7. Vapor Intrusion Modeling)	None specified.	None specified.	None specified.

State	Recommended Engineering Controls (EC) or Corrective Actions Existing Buildings	Recommended Engineering Controls (EC) or Corrective Actions Future Buildings	EC Effectiveness/Operation and Maintenance	Site closure requirements	Institutional Controls and Deed Restrictions	Vapor/Gas Barriers?	Summary/Notes
Illinois	No guidance.	No guidance.	No guidance.	No guidance.	No guidance.	No guidance.	No guidance.
	No guidance.	No guidance.	No guidance.	No guidance.	No guidance.	No guidance.	No guidance.
Indiana	sub-slab depressurization system or a sub-slab ventilation system, sealing cracks or openings in foundation walls or slabs, sealing open sump pits, and installation of vapor barriers in crawl spaces or over earthen basement floors. (9.0 Corrective Action)	sub-slab depressurization system or a sub-slab ventilation system, sealing cracks or openings in foundation walls or slabs, sealing open sump pits, and installation of vapor barriers in crawl spaces or over earthen basement floors. (9.0 Corrective Action)	"periodic inspection and maintenance to ensure that the systems are operating safely and effectively, and that potential receptors are protected. Inspection of the systems on a quarterly basis is recommended"	None	None	See EC and Corrective Actions	not much of a guidance...refer to Radon based guidance documents throughout guidance
				Site closure requests based only on modeling in the absence of site-specific parameter data and confirmatory sub-slab/soil gas and indoor air samples will not be accepted.			Based on a review of the recent literature on vapor intrusion and modeling, IDEM has concluded that the use of modeling in the absence of confirmatory indoor air samples is an unacceptable method to demonstrate that the vapor intrusion pathway is incomplete. The results of vapor intrusion modeling without appropriate site-specific data for model parameters and actual soil gas and indoor air data to calibrate and validate the model will not be accepted as a stand-alone justification for site closure. For sites where contaminant concentrations exceed screening levels, soil gas, sub-slab, and/or indoor air samples should be collected to determine if contaminant concentrations exceed health-protective levels, particularly in areas where residential exposure is possible.
	IDEM does not prefer passive ECs; they have found that they often don't work. There are no specific O&M requirements for passive ECs. IDEM prefers active over passive controls, although they are not allowed to dictate the specific control used at a site.	IDEM does not prefer passive ECs; they have found that they often don't work. There are no specific O&M requirements for passive ECs. IDEM prefers active over passive controls, although they are not allowed to dictate the specific control used at a site.	There is no formal requirement for monitoring right now; this is done on a site-specific basis. IDEM typically requires indoor air testing 60 days after installation of an EC. They are working on monitoring guidance now. IDEM does not prefer passive ECs; they have found that they often don't work. There are no specific O&M requirements for passive ECs.	IDEM has not closed a single VI site. Megan expects that long-term monitoring would be required plus a deed restriction for the property.	Megan referred me to Bob Moran in her group who is working on institutional controls. No reply yet. IDEM has Environmental Restrictive Covenants, has Environmental Restrictive Ordinances and Voluntary Remediation Program (VRP) Covenants – these are discussed in the December 7, 2009 House Enrolled Act 1162 Interim Implementation Document (HEA 1162). From HEA 1162: If no structures exist on the impacted property the ERC may need to require active or passive vapor mitigation for future buildings. Also from HEA 1162: The VRP does not currently grant closure to applicants where the	NA	9. How are mitigation work plans and solutions approved? (All sites reviewed directly by agency, LSP-type "privatization" program, other?) IDEM reviews and approves all plans. The IDEM site project manager does all approvals with support from technical sections that review and comment on plans. Might want to check this doc out: December 7, 2009 House Enrolled Act 1162 Interim Implementation Document (HEA 1162).
Iowa	No guidance.	No guidance.	No guidance.	No guidance.	No guidance.	No guidance.	The pathways to be evaluated at Tier 1 are...groundwater vapor/soil vapor to enclosed space pathway...(General Tier 1 Procedure.)...a confined(I think they use enclosed and confined interchangeably) space is a basement in a building occupied by humans. Buildings constructed with a concrete slab on grade or buildings constructed without a concrete slab, but with a crawl space are not considered confined spaces.(3.3 Groundwater vapor to enclosed space pathway assessment). Charlie Paradis: It appears that soil and groundwater vapors are addressed in these documents, however, this is only for enclosed/confined spaces, not residential basements or crawl spaces.
Kansas	seal any gross openings, for structures with crawlspaces, installation of a vapor barrier is recommended, If odors are apparent, the basement/crawlspace air should be ventilated separately, sub-slab depressurization (9. Preventing Vapor Intrusion) sub-slab depressurization, sub membrane depressurization, building pressurization, indoor air treatment, sealing the building envelope (ITRC 2007 Table 4-1. Comparison of mitigation methods)	building design can be modified to accommodate residual contamination left in place...vapor mitigation system elements into the building construction...Useful information on pre-construction mitigation techniques (a.k.a. Radon Resistant New Construction - RRNC) is available on the following EPA website and in related documents such as "Building Radon Out": http://www.epa.gov/iaq/radon/contruc.html. (10. Vapor Intrusion and Property/Brownfields Redevelopment)				For structures with crawlspaces, installation of a vapor barrier is recommended (9. Preventing Vapor Intrusion)	Doc refers to this "A comprehensive review of mitigation strategies can be found in Chapter 4 of the ITRC Technical and Regulatory Guidance document, Vapor Intrusion Pathway: A Practical Guide (VI-1, 2007)." for existing buildings, and refers to this, "(a.k.a. Radon Resistant New Construction - RRNC) is available on the following EPA website and in related

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Kentucky	Sep-09	In the process of developing regulation for SVI. Make decisions based on ITRC guidance currently. From phone call to Sarah Gaddis: Superfund using ASTM guidance. Accept results of modeling as a line of evidence. If using modeling the GW and soil data must logically support your results. We deal with Karst geology a lot, which is not accounted for in J&E. Not allowed in every circumstance. Have established end of investigation numbers - outdoor air (can't clean past point of outdoor contamination) and emergency threshold values - indoor air, evacuate if at or above these numbers. Loosely considered cleanup numbers but in KY clean up to 1/1000000 cancer risk.	http://www.dep.ky.gov/NR/rdonlyres/0B9284F4-BA60-4A58-97C5-F4E51F041AE1/0/DWMannualreport2009FINAL.pdf	Kentucky Environmental Protection Agency. Waste Management Division.	Jerry Higgenbasum 502-564-6716 Sarah Gaddis (UST Division) 502-564-5981	Yes.	Currently, we are using the Johnson-Ettinger Model for Intrusion into buildings from soils/water and Schaum et al. Whole House Model for VOCs from domestic water use during RCRA/CERCLA type cleanups. We require it to be included if VOCs are present in soils or groundwater. From website below:	None specified.	None specified.
		Discussion of upcoming guidance as per KY DEP website.	http://www.dep.ky.gov/NR/rdonlyres/0B9284F4-BA60-4A58-97C5-F4E51F041AE1/0/DWMannualreport2009FINAL.pdf				http://www.itrcweb.org/vaporintrusionresources/ITRC_VI_Survey_8-17-05/ITRC_VI_Survey_pages/Q026.htm		
Louisiana	October 2003	Risk Evaluation / Corrective Action Plan (RECAP)	http://www.deq.louisiana.gov/portal/LinkClick.aspx?fileticket=66pH5o5gR6E%3d&tabid=2930	Louisiana Department of Environmental Quality, Corrective Action Group	Ms. Dana Shepherd 225-214-3421 dana.shepherd@la.gov	It appears that the J&E model is not used in its entirety but rather a series of hand calculations using some of the J&E parameters. Equations here: http://www.deq.louisiana.gov/portal/LinkClick.aspx?fileticket=kboCl%2bXgolQ%3d&tabid=2930 Charlie Modeling with Domenico and J/E was used to develop screening criteria by the department, no mention of allowing investigator to use modeling during site assessments.	See previous.	No guidance.	No guidance.
Maine	January 2010	Vapor Intrusion Evaluation Guidance	http://www.maine.gov/dep/rwm/publications/guidance/rags/vi1-14-2010/1-VI_Guide_1_13_10Final.pdf		Pete Eremita (207) 822-6300, pete.m.eremita@maine.gov Jean Firth (207) 287-2651	Yes, but emphases is on data collection	No specific models used, ME DEP approval required. Would allow use of J/E model. Use target levels to evaluate vapor intrusion including the Indoor Air Target (IAT) used for indoor air results and Soil Gas Targets (SGTs) used in the evaluation of representative and appropriate sub slab and soil gas analytical results. SGTs are derived by dividing the IAT by an attenuation factor (The Department uses an attenuation factor of 0.02 and SGTs are calculated by multiplying the applicable IAT by the inverse of 0.02 which is 50). SGTs for the chronic residential multi-contaminant scenario are provided in Table B10 of the Department's BRWM web site. Attenuation factors are derived from empirical studies15 which should be reviewed in order to properly apply SGTs.	Not specified.	ME DEP handles on case-by-case basis.
	Phone interview with Peter Eremita on 3/11/2010						Guidance is driven more by data collection and less weight is placed on modeling.	Left modeling and EC specifics up to the other documents out there that already detail the options well (like ITRC). No limitations, but would have to get Maine DEP approval first.	It is up to the project manager of the site if modeling is to be used or not. Modeling could be used at any point in time if project manager says so.

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State	Recommended Engineering Controls (EC) or Corrective Actions Existing Buildings	Recommended Engineering Controls (EC) or Corrective Actions Future Buildings	EC Effectiveness/Operation and Maintenance	Site closure requirements	Institutional Controls and Deed Restrictions	Vapor/Gas Barriers?	Summary/Notes
Kentucky	Sub-slab depressurization, sub membrane depressurization, building pressurization, indoor air treatment, sealing the building envelope (ITRC Table 4-1. Comparison of mitigation methods).	Passive barriers, passive venting, sub-slab depressurization, sub slab pressurization, building pressurization, indoor air treatment, sealing the building envelope (ITRC Table 4-1. Comparison of mitigation methods).	Periodic inspections and monitoring may be required to ensure that engineering controls are operated and maintained over time to retain their effectiveness (ITRC 4.2 Institutional Control Remedies).	None specified.	for example, restrictions could be established to allow only those land/building uses that would be associated with acceptable health risks. These legal actions can take many forms, including restrictive covenants, zoning, excavation prohibitions, and groundwater advisories (ITRC 4.2 Institutional Control Remedies)	Passive barriers are materials or structures installed below a building to physically block the entry of vapors...passive barriers are generally not recommended by themselves for vapor intrusion control, although they may enhance or increase the efficiency of other technologies, such as sub slab depressurization (SSD) systems. (ITRC 4.3.1.1 Passive Barriers).	ITRC does not discuss limitations or approval for J/E and does not discuss site closure but goes to lengths on discussing EC's, and IC's, very useful document.
Louisiana	No guidance.	No guidance.	No guidance.	No guidance.	No guidance.	No guidance.	Document addresses VI pathway to Enclosed structures - an occupied (or potentially occupied) [i.e., one or more receptors spend a significant portion of the day (or workday) within the enclosed structure] structure on a slab foundation that has a roof and walls on all sides which prevent the free exchange of indoor air with outdoor (ambient) air.
Maine	If point of entry mitigation is indicated, sub slab depressurization systems (SSDS) are generally considered an effective and reliable technology if the point of entry is through the basement floor. If the assessment determines that the pathway is complete, source remediation can then be considered as an alternative to conventional mitigation strategies such as sub-slab depressurization at the receptor. Since remedial and mitigation investigations and strategies are site and contaminant specific and as they are addressed elsewhere, site remediation and mitigation are not developed in this guidance. Then elsewhere refers to the ITRC guidance (ITRC "Vapor Intrusion Pathway: A Practical Guideline" Technical and Regulatory Guidance, January, 2007, Chapter 4 and Appendix D, http://www.itrcweb.org/Documents/VI-1.pdf) ITRC: sub-slab depressurization, sub membrane depressurization, building pressurization, indoor air treatment, sealing the building envelope	This guidance is intended to evaluate risks associated with current development conditions and it is not intended to evaluate VI risk posed by future development. However, changes to the subsurface infrastructure or future development in the area may warrant a re-examination of the VI pathway. Options to address changes in VI potential arising from future development include...-Plan to install mitigation systems as a component of future construction ITRC: passive barriers, passive venting, sub-slab depressurization, sub slab pressurization, building pressurization, indoor air treatment, sealing the building envelope	ITRC: periodic inspections and monitoring may be required to ensure that engineering controls are operated and maintained over time to retain their effectiveness.	Not covered by guidance document.	Require environmental covenants at properties considered vulnerable to VI as a result of development	ITRC: Passive barriers are materials or structures installed below a building to physically block the entry of vapors...passive barriers are generally not recommended by themselves for vapor intrusion control, although they may enhance or increase the efficiency of other technologies, such as sub slab depressurization (SSD) systems.	Only mentions that "mitigation systems are relatively low cost in comparison to a VI investigation, quick to implement and protective against other indoor air quality problems (moisture and radon)."
	ME DEP handles on case-by-case basis.	ME DEP handles on case-by-case basis.	ME DEP handles on case-by-case basis.	ME DEP handles on case-by-case basis.	ME DEP handles on case-by-case basis.	ME DEP handles on case-by-case basis.	

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Maryland	August 2008	Land Restoration Program: Vapor Intrusion	http://www.mde.state.md.us/assets/document/MDE%20VCP%20Vapor%20Intrusion%20080708.pdf	MD Department of Environment	Mark Mank, 410-537-3493 mmank@mde.state.md.us	Yes	Johnson and Ettinger (J/E) model	Also allow OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air from Groundwater and Soils (11/2002) and TCE/PCE New Screening Table http://www.epaprgs.ornl.gov/chemicals/download.shtml	Not mentioned.
	March 2006	VCP Guidance Document	http://www.mde.state.md.us/assets/document/Guidance%20Document%202-1-07(2).pdf	MD Department of Environment		Yes	Johnson and Ettinger (J/E) model	To evaluate the potential for vapor intrusion, a comprehensive characterization of foundation air must be performed, which may include sampling of the groundwater, soil, soil gas, and indoor air. Typically, this characterization is performed in a systematic manner utilizing - 30 - MDE VCP Guidance Document Revision Date: 3/17/2006 the U.S. EPA Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (http://www.epa.gov/correctiveaction/eis/vapor.htm). This guidance recommends using the Johnson & Ettinger model to evaluate the potential for vapor intrusion.	Prior to rendering any decision on a property, MDE reserves the right to review the Johnson & Ettinger results. To confirm the results of the Johnson & Ettinger model, MDE requires that sub-slab soil gas samples be collected beneath existing buildings, including possibly impacted tenant spaces.
Massachusetts	(1) August 2007 (2) April 2002	Several: (1) Standard Operating Procedure for Indoor Air Contamination (2) BWSC Policy #02-430, Indoor Air Sampling and Evaluation Guide (3) Indoor Air Threshold Values for the Evaluation of a Vapor Intrusion Pathway (4) Guidance on Implementing Activity and Use Limitations	http://www.mass.gov/dep/cleanup/laws/policies.htm	MA Department of Environmental Protection	Gerard Martin, 508-946-2799 gerard.martin@state.ma.us	Yes, as a "optional" or "secondary" Line of Evidence. GW-2 standards were calculated by MA DEP using the J & E model with agency-selected conservative input parameters.	Johnson and Ettinger (J/E) model	Collect and use site-specific information on soil/building conditions.	
Michigan	May 2007	Evaluation of the Michigan Department of Environmental Quality's Generic Groundwater and Soil Volatilization to Indoor Air Inhalation Criteria	http://www.michigan.gov/documents/iirept_3693_7.pdf	MI DEQ	Amy Merricle 517-241-3584 merricla@michigan.gov		Johnson and Ettinger (J/E) model	Vapor equilibrium modeling is only applicable at concentrations less than free-phase, where the chemical is sorbed to organic carbon in the soil, dissolved in soil moisture, and present as a gas in the air-filled pore spaces of the soil.	Not mentioned.
	September 2009	Program Redesign: The Vapor Intrusion to Indoor Air Pathway	http://www.michigan.gov/documents/deq/deq-rrd-PART201-VaporIntrusionProgramRedesign2009Presentation-9-24-09_293425_7.pdf				Michigan is undergoing a VI program redesign due to limitations of J&E model. SVIIC and GVIIC would no longer be used, and instead the emphasis will be on screening-level evaluations including SGC, IAC, and new groundwater screening levels that are NOT dependant on modeling. J&E becomes one of the last steps in the VI assessment process.	Soil gas criteria (SGC) is calculated with a fixed attenuation coefficient of .02 for sub-slab SGC and .002 for deep SGC (data collected from a depth >5 ft bgs).	Not mentioned.
Minnesota	Sep-08	Risk-Based Guidance for the Vapor Intrusion Pathway	http://www.pca.state.mn.us/publications/c-s4-06.pdf	MN Pollution Control Agency	Rick Jolley, 651-757-2475	Prefer data over modeling	"This guidance emphasizes the use of empirical field data rather than the use of fate and transport modeling." Petroleum Remediation Program (PRP) vapor intrusion assessment is a field-based procedure used to identify vapor sources, receptors and subsurface migration routes associated with a petroleum release	The MPCA in cooperation with the Minnesota Department of Health have developed compound-specific inhalation risk screening values, referred to as Intrusion Screening Values (ISVs), for volatile compounds commonly evaluated during vapor investigation…Media-specific soil vapor, sub-slab and ground water screening values, based on conservative attenuation factors, are also provided in this guidance...Screening values are then calculated using the compound-specific ISV and the media-specific attenuation factor. Screening values for soil gas and sub-slab soil vapor samples are thus described as a factor of the ISVs (i.e., 10 or 100 times the ISVs) and are provided in Table 1 for reference. Ground water screening values are provided in Table 2 and are based on the compound's potential to volatize from ground water to the overlying soil vapor phase and the compound specific ISV.	NA
Mississippi	NA	No SVI guidance document.	NA	MS DEQ,	Williw McKercher 601-961-5731 williw_mckercher@deq.state.ms.us	NA	Not mentioned.	Not mentioned.	Not mentioned.

State	Recommended Engineering Controls (EC) or Corrective Actions Existing Buildings	Recommended Engineering Controls (EC) or Corrective Actions Future Buildings	EC Effectiveness/Operation and Maintenance	Site closure requirements	Institutional Controls and Deed Restrictions	Vapor/Gas Barriers?	Summary/Notes
Maryland	Passive barriers, SSD, SMD, passive venting, active venting, indoor air treatment, HVAC modifications	Not mentioned.	Not mentioned.	Thorough investigation, follow the guidelines, involve regulators early, define responsibilities early in process, define mitigation strategies and cleanup objectives	Mentioned as mitigation option, but no specific method pinpointed.	Not mentioned.	Not mentioned.
	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.
Massachusetts	Sealing cracks/annular spaces around utilities and where the floor meets the wall, and/or cracks in basement floor, Sealing and venting groundwater sumps, Vapor barriers, Reducing basement depressurization by ducting in outside air for furnace combustion/draft, Overpressurization of the basement using air/air heat exchangers, where appropriate, Passive or active sub-slab depressurization systems, Groundwater treatment, Soil vapor extraction.	Not mentioned; guidance is for existing buildings.	Not mentioned.	Not mentioned.	Activity and Use Limitations (AULs) can be used as part of temporary or permanent solution. For RAO that depends on an AUL, the AUL must be recorded at the Registry of Deeds or Land Registration Office. Deed notice or restriction can be used prior to Response Action Outcome (RAO). Grant of Environmental Restriction is a legally enforceable contract which conveys property interests to DEP.	Simple mention as a potential mitigation measure in Indoor Air Sampling Guide.	
Michigan	Not mentioned.	Not mentioned.	Not mentioned.	Michigan has soil gas, indoor air, and groundwater criteria (protective of VI). If a site meets all of the criteria then there should be closure See: http://www.michigan.gov/documents/deq/deq-rrd-PART201-IndoorAirAndSoilGasCriteria-9-24-09_293422_7.pdf	Not mentioned.	Not mentioned.	Not mentioned.
	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Environmental covenants are mentioned in Part 201 & Part 213 Cleanup and Redevelopment Program Redesign Section 324 http://www.michigan.gov/documents/deq/deq-rrd-PART201-EnvironmentalCovenants8-20-09_Revised_10-29-09_303659_7.pdf	Not mentioned.	Not mentioned.
Minnesota	Source area remediation is the remediation of the contaminated soil, ground water or NAPL vapor sources. Source remediation can be effective to eliminate long term risks, although building mitigation or pathway interruption (e.g. sealing vapor entry points) may be necessary in the short term in order to eliminate risks to human health. Building mitigation technologies include: a) exposure pathway interruption such as sealing potential points of vapor entry; b) active building vapor mitigation systems such as sub-slab depressurization or sub-membrane depressurization (i.e. for crawl spaces); d) installation of a passive venting system and vapor barrier for new construction, and; d) the use of building pressurization or HVAC modification at commercial and industrial buildings or a combination of remedial strategies. The selection of the appropriate response actions will be site specific and the proposed response action plan should be provided to MPCA staff for review and approval.	"installation of a passive venting system and vapor barrier for new construction"	Remediation systems should include appropriate maintenance and post-remedial verification monitoring. The specific monitoring and maintenance requirements for remedial systems will be site specific and depend on the type of remedial system used. Mitigation systems installed in buildings should be inspected after they are installed and during the first several months of operation to document that they are working effectively. Long term monitoring may be required for sites where risks to receptors would be potentially greater in the event of system failure or in cases where passive technologies rather than active remediation are employed. An Operations and Maintenance Plan should be prepared which outlines the responsibilities of various parties (i.e. developer, homeowner, landlord, etc.), action steps, and closure criteria.	Not mentioned.	Not mentioned.	"installation of a passive venting system and vapor barrier for new construction"	Not mentioned.
Mississippi	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.

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State	Date of Guidance Update	Guidance Title	Pathway to Guidance	Agency	Contact	Do they allow modeling?	Model Type(s)	Model Modifications	Type of Approval
Missouri	January 2004	MISSOURI RISK-BASED CORRECTIVE ACTION (MRBCA) PROCESS FOR PETROLEUM STORAGE TANKS	http://www.dnr.mo.gov/env/hwp/tanks/mrbca-pet/docs/mrbca-pet-sect6.pdf	MO Department of Natural Resources	MO Department of Natural Resources, Michael Storh 573-751-8629, michael.stroh@dnr.mo.gov MO Petroleum Storage Tank Insurance Fund, David Pate 800-765-2765 dlp@willconsult.com	Yes	Johnson and Ettinger (J/E) model	For the calculation of DTLs, Tier 1, and Tier 2 target levels, Indoor Inhalation of Volatile Emissions from Soil and Water: This pathway requires (i) an emission model and (ii) an indoor air mixing model. These models are combined together and included in the Johnson and Ettinger Model (US EPA, 2001) and are used in the MRBCA process. Note that the model used in the MRBCA process does not include advective transport of vapors.	Not mentioned.
Montana	Sep-09	Montana Tier 1 Risk-Based Corrective Action Guidance for Petroleum Releases	http://www.deq.state.mt.us/statesuperfund/PDFs/rbca/rbca_guide.pdf	MT DEQ	Catherine LeCours 406-841-5040 clecours@state.mt.us		None specified. If volatile compounds are present in the vicinity of inhabitable structures, then the VI pathway should be evaluated either qualitatively or quantitatively. The DEQ is developing VI guidance for Montana, but until that guidance document is completed currently available VI guidance documents should be used to assess and evaluate VI risks. The DEQ will approve specific evaluation procedures on a site-by-site basis. The EPA has recommended using the vapor intrusion guidance developed by the Interstate Technology & Regulatory Council (ITRC).	Not mentioned.	Not mentioned.
Nebraska	May 2009	Risk-Based Corrective Action (RBCA) at Petroleum Release Sites: Tier1/Tier 2 Assessments & Reports	http://www.deq.state.ne.us/Publica.nsf/0/66fdec793aefc4b286256a93005b8db8/$FILE/RBCA_GD_MAY_2009.pdf	NE DEQ	Scott McIntyre 402-471-2668 scott.mcintyre@nebraska.gov	Yes	Farmer's Model	Not mentioned.	Not mentioned.
	Phone interview with Scott McIntyre on 3/3/2010				Scott McIntyre 402-471-2668 scott.mcintyre@nebraska.gov	Yes	Farmer's Model	NE DEQ will do the modeling based on data collected by responsible party. For petroleum sites only, a source to building separation of 15 feet is assumed to mean that the pathway is incomplete and modeling is not necessary.	NE DEQ does the modeling.
	Phone interview with Jim Borovich on 3/3/2010	Voluntary Cleanup Program (currently under revision to include remediation goals for vapor intrusion, available "any time" now)			Jim Borovich 402-471-2223 jim.borovich@nebraska.gov	Yes	Johnson and Ettinger (J/E) model Other models may be allowed	J&E can be used to calculate remedial goals and site-specific cleanup levels. Vapor intrusion modeling from soils is not allowed	Modeling is done by the Potentially Responsible Party, and the DEQ runs the model to check the numbers.

State	Recommended Engineering Controls (EC) or Corrective Actions Existing Buildings	Recommended Engineering Controls (EC) or Corrective Actions Future Buildings	EC Effectiveness/Operation and Maintenance	Site closure requirements	Institutional Controls and Deed Restrictions	Vapor/Gas Barriers?	Summary/Notes
Missouri	Active remedial actions to reduce COC concentrations and eliminate pathways are mentioned. To address the vapor exposure pathway, one or more of the following must be used, upon department approval, as part of the RMP: a substantial and reasonably durable "engineering control,"...that is expected to remain in place and functional for at least as long as the residual contamination poses an elevated risk through the identified pathway(s). If all affected and potentially affected existing and planned future buildings include a vapor barrier that prevents the intrusion of vapors into a building or a passive or active venting system that prevents the buildup of vapors into a building, the indoor inhalation pathway shall be considered incomplete	If all affected and potentially affected existing and planned future buildings include a vapor barrier that prevents the intrusion of vapors into a building or a passive or active venting system that prevents the buildup of vapors into a building, the indoor inhalation pathway shall be considered incomplete	Note, however, that the use of barrier or venting systems will be approved by MDNR only in combination with an appropriate activity and use limitation (AUL) that will ensure the long term operation and maintenance of the system.	When the MRBCA evaluation has been performed, the evaluation has been approved by MDNR, and the approved RMP has been successfully implemented, the evaluator may submit a request for issuance of a NFA letter to MDNR.	Activity and Use Limitations (AULs), Deed Notice, Restrictive Covenant (Chapter 11)	If all affected and potentially affected existing and planned future buildings include a vapor barrier that prevents the intrusion of vapors into a building or a passive or active venting system that prevents the buildup of vapors into a building, the indoor inhalation pathway shall be considered incomplete. Note, however, that the use of barrier or venting systems will be approved by MDNR only in combination with an appropriate activity and use limitation (AUL) that will ensure the long term operation and maintenance of the system.	Not mentioned.
Montana	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.
Nebraska	Specific ECs for SVI are not mentioned, but if an engineering control is the proposed remedial action, the DEQ requires a narrative that discusses why the engineering control is appropriate for the site, describes/illustrates the area to be addressed, and explanation of the type of engineering control to be used.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.
	ECs have not been used to date, and would be determined on a case-by-case basis.	Not mentioned.	Would be determined on a case-by-case basis.	Site closure as long as soil gas/groundwater/soil concentrations are below target levels calculated by state. Would consider closing a site with EC still operating, but there is no guidance on that.	Not mentioned.	DEQ would consider passive controls if proposed ,and would review on a case-by-case basis.	Not mentioned.
	Specific ECs for SVI are not mentioned, but if an engineering control is the proposed remedial action, the DEQ requires a narrative that discusses why the engineering control is appropriate for the site, describes/illustrates the area to be addressed, and explanation of the type of engineering control to be used.	Not mentioned.	To demonstrate compliance would need indoor and subsurface air measurements . Mitigation system inspection required annually. Performance monitoring plan that includes a description of the RAOs, locations, frequency, type and quality of samples, techniques, measurements that will be used to assess the performance of the remedial action, and a schedule for submittal of periodic monitoring reports. The O&M plan should include: • A description of the inspection procedures and tasks to be completed as part of the routine operation and maintenance of the system. • A general description of the contingencies that will be used in the event the performance monitoring system requires repair or modification beyond the scope of routine operation and maintenance. • An outline of the expected remediation time frame.	NFA granted when remedial action objectives are met. Could grant NFA when ECs are still in operation.	There are four categories of institutional controls; governmental, proprietary, Enforcement and permit tools with institutional control component, and Informational devices. (More info in 2.3.3.5 Institutional Controls). The RAWP should list the category and type of each proposed institutional control. The narrative should describe how the institutional control will minimize the potential for human exposure to contamination and protect the integrity of the remedy. Applicants may choose to use an environmental covenant pursuant to the Nebraska Uniform Environmental Covenants Act (Attachment 2-7). Environmental covenants established pursuant to the Act must include written documentation providing, among other things, the nature of the activity and use limitations, and information on where the administrative record documenting the remedial action may be found. A copy of the control must be recorded with the county where the property is located, as well as a copy provided to NDEQ.	DEQ would consider passive controls if proposed ,and would review on a case-by-case basis.	Not mentioned.

Appendix A
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State	Date of Guidance Update	Guidance Title	Pathway to Guidance	Agency	Contact	Do they allow modeling?	Model Type(s)	Model Modifications	Type of Approval
Nevada	NA	Nevada has not developed a SVI guidance document, and SVI is handled on a case-by-case basis. Nevada statutes and regulations do not specifically address SVI, but do consider soil contaminant vapors as a hazard to be considered for corrective action. The individual case officer would require a VI study if an owner/operator asks to close a site using a risked based approach. If the impacted groundwater and/or soil contain levels that may pose a VI risk, and is within a commercial or residential area, then the Bureau would ask for a VI study. The case officer would also assess what risk the VI will pose.		NV DEP	Sara Piper 702-486-2868 spiper@ndep.nv.gov	Yes	When assessing a VI issue, the Nevada Division of Environmental Protection uses the USEPA Johnson and Ettinger Model for Subsurface Vapor Intrusion into Buildings as a guidance document	Not mentioned.	Not mentioned.
	Phone interview with Mary Siders on 3/9/2010	The Nevada Division of Environmental Protection (NDEP) does not currently have state guidance for assessing the vapor intrusion pathway. The NDEP relies on guidance from USEPA (2002), ITRC (2007), and certain states, such as MA, NY, and NJ, who have longer experience with VI issues. Cases in Nevada are addressed on a site-specific basis with regard to VI issues.			Mary Siders 775-687-9496; msiders@ndep.nv.gov		The NDEP has employed the J&E model as part of "multiple lines of evidence" when assessing the potential for VI at a site. Data for samples of groundwater and soil gas have been used as input for the J&E model. The USEPA version of the J&E model has been applied using some of the default parameters, along with some site-specific parameters (e.g., shallow groundwater in Las Vegas is typically about 25^{o}C).	Guidance documents seem to indicate that data for soil samples are not reliable as input into the J&E model. The NDEP has used data for samples of groundwater and soil gas as input for the J&E model.	The results of the J&E modeling have been used by NDEP staff to assist with determining what additional work may be required at a site. If a responsible party provides J&E model output as part of a submittal, the case officer would check the calculations and would require that all parameters be provided, with any changes from the USEPA default parameters noted.
New Hampshire	June 2009	Vapor Intrusion Guidance	http://des.nh.gov/organization/divisions/waste/hwrb/sss/hwrp/guidance_documents.htm	New Hampshire Department of Environmental Services	Robin Mongeon 603-271-7378 rmongeon@des.state.nh.us	Yes	Johnson and Ettinger (J/E) model	Modeling can assist in evaluating the potential for vapor intrusion from subsurface contamination...when using the J/E model, input parameters for a given site should match site-specific conditions. It is important to understand the sensitivity of the input parameters on the results of the model and therefore DES recommends that vapor intrusion evaluations that involve modeling include a sensitivity analysis. NH guidance specifically allows the following: *Determination of a site-specific soil gas attenuation factor using a conservative tracer *Indoor/sub-slab differential pressure measurements NH does not provide the spreadsheets	DES recommends that a work plan be submitted to the department for comment prior to completing a site specific vapor intrusion pathway assessment (the model is a tool when conducting a site specific vapor intrusion pathway assessment).

State	Recommended Engineering Controls (EC) or Corrective Actions Existing Buildings	Recommended Engineering Controls (EC) or Corrective Actions Future Buildings	EC Effectiveness/Operation and Maintenance	Site closure requirements	Institutional Controls and Deed Restrictions	Vapor/Gas Barriers?	Summary/Notes
Nevada	SSD and sealing cracks. (http://ndep.nv.gov/pce/pce_cleanup.htm)	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.
	Not mentioned.	Not mentioned.	Visual inspections and collection of post-mitigation samples of indoor air have been conducted at a site where SSD systems were installed.	The closure process for VI concerns/sites has not yet been formalized	The NDEP has not yet instituted ICs directly due to VI issues.	Passive systems have not yet been employed as a mitigation strategy. Again, such decisions would be made on a site-specific basis.	Thus far, the state health department has determined that indoor air affected by environmental contamination falls under the NDEP's jurisdiction. Radon issues, which are related to naturally occurring conditions, are handled by the state health department.
New Hampshire	Sealing of cracks, utility conduits, sumps etc. in the basement, or crawl space, Passive Barriers, i.e. thin plastic liners, heavy HDPE liners, spray on elastomers, etc, SSD, or radon system, Natural ventilation, Heating recovery ventilation, Building pressurization, Soil pressurization, or Indoor air treatment.	for a future building, "...at a minimum that a passive venting system be installed, that can be modified to an active system at a later date if necessary." (9.0 VAPOR INTRUSION ABATEMENT STRATEGIES)	Not mentioned	Not mentioned	Not mentioned	"Passive Barriers, i.e. thin plastic liners, heavy HDPE liners, spray on elastomers, etc"	Not mentioned

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New Jersey	September 2005	Vapor Intrusion Guidance, and NJ Soil Gas Survey Guidance currently under revision	http://www.nj.gov/dep/srp/guidance/vaporintrusion/vig.htm	New Jersey DEP	John Boyer, 609-984-9751, john.boyer@dep.state.nj.us	Yes, with limitations	Johnson and Ettinger (J/E) model	Only Version 3.1 (or later versions), available from the USEPA Office of Solid Waste and Emergency Response, may be utilized. For the J&E spreadsheets, USEPA guidance should be consulted (USEPA 2004d). See table 5-1 for Site-Specific J&E Model Parameters. Allowable modifications: *Assessment of biodegradation for petroleum hydrocarbons (oxygen levels in subsurface soils, depth to ground water table); *Development of alternate attenuation factors (with sub-slab or near slab soil gas); *Modifications to the J&E Model (depth to vapor source and overlying unsaturated zone soil type) NJ provides GW-SCREEN and GW-ADV. Modifications made by NJ: *can only use Qsoil of 5 L/min (as adjusted for building size) *updated toxicity data	Site-specific adjustments to the J&E model (including specific building parameters) may be submitted to the Department for review and approval.
	Phone interview with John Boyer on 3/4/2010	Vapor Intrusion Guidance, and NJ Soil Gas Survey Guidance (Currently under review, estimated to be published before the end of the year)	http://www.nj.gov/dep/srp/guidance/vaporintrusion/vig.htm	New Jersey DEP	John Boyer, 609-984-9751, john.boyer@dep.state.nj.us	Yes, with limitations	Johnson and Ettinger (J/E) model	Only Version 3.1 (or later versions), may be utilized. For the J&E spreadsheets, USEPA guidance should be consulted (USEPA 2004d). See table 5-1 for Site-Specific J&E Model Parameters. The only J&E parameters allowed to be adjusted site-specifically are soil texture, depth to groundwater, depth of foundation, building air exchange rate, and the building perimeter. NJ provides guidelines for these site-specific adjustments. (http://www.state.nj.us/dep//srp/guidance/vaporintrusion/njje.htm) Allowable modifications: *Assessment of biodegradation for petroleum hydrocarbons (oxygen levels in subsurface soils, depth to ground water table); *Development of alternate attenuation factors (with sub-slab or near slab soil gas); *Modifications to the J&E Model (depth to vapor source and overlying unsaturated zone soil type) NJ provides GW-SCREEN and GW-ADV. Modifications made by NJ: *can only use Qsoil of 5 L/min (as adjusted for building size) *updated toxicity data *default soil/groundwater temperature and depth to groundwater was set Screening values are based on fixed attenuation factor of .02 for groundwater.	NJ recently started a "privatized" remediation management program called Licensed Site Remediation Professionals (LSRP), modeled after MA DEP program. Program is just getting started; NJDEP will review everything until LSRP is established.
New Mexico	NA	New Mexico does not have State guidance, but been accepting use of the Johnson and Ettinger model	http://www.astswmo.org/files/publications/federalfacilities/2009.07_Final-VI-Pathway-Guide.pdf	NM Environment Department	Dana Bahar 505-827-2908, dana_bahar@nmenv.state.nm.us	Yes	New Mexico follows USEPA's guidance document entitled OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance), EPA530-D-02-0004, released in November 2002. The draft EPA Guidance document is available at: http://www.epa.gov/correctiveaction/eis/vapor/complete.pdf	Not mentioned.	Not mentioned.

State	Recommended Engineering Controls (EC) or Corrective Actions Existing Buildings	Recommended Engineering Controls (EC) or Corrective Actions Future Buildings	EC Effectiveness/Operation and Maintenance	Site closure requirements	Institutional Controls and Deed Restrictions	Vapor/Gas Barriers?	Summary/Notes
New Jersey	Sealing openings and cracks with caulk or expanding foam (preferably volatile-free), Repairing compromised areas of the slab or foundation, Covering and sealing exposed earth and sump pits, Installing a sealed vapor barrier (e.g., plastic sheeting, liquid membrane) over earthen, gravel, etc. floors or crawlspaces, Utilizing natural ventilation, Installing a SSD, SMD, Block-Wall Depressurization, or Drain Tile Depressurization system, Installing a pressurized air curtain, Utilizing heat recovery ventilation, Installing a SVE system	"...if a property designated for development has a potential for vapor intrusion risk, the Department recommends that proactive measures (vapor barrier, vapor barrier with passive depressurization system, active depressurization system, etc.) be designed into the building."	After the remedial system is operational, confirmation indoor air sampling should be conducted. approximately two to four weeks after the remedial system is operational to verify the effectiveness of the system (10.3.2 Remedial Action System Verification Sampling, Monitoring and Maintenance) A monitoring and maintenance plan shall be submitted for NJDEP review and approval. For SSD systems, the pressure gauge should be monitored quarterly to … A reduced monitoring frequency may be appropriate after one year of successful operation of the remedial system. The pressure gauge measurements should be recorded over time in tabular format and updated with each submittal to NJDEP. An inspection should be conducted semiannually to determine if any new or existing areas (e.g., cracks, holes, sump pit covers, earthen crawlspaces) need to be sealed, caulked, and/or covered, etc.	For undeveloped properties/parcels that contain source concentrations above the generic screening levels (GWSL or SGSL), official notification of the property owner is necessary. Institutional controls will be required upon request for closure by the responsible party.	Consult the Technical Requirements for Site Remediation (N.J.A.C. 7:26E-8) for detailed institutional and engineering control requirements. An institutional control on the property and regular monitoring to protect against changes in future use/building construction may be required. Depending on the type of institutional control employed, the responsible party may have to monitor change in ownership and building conditions every six months and inform the NJDEP of these observations periodically through RA Progress Reports, biennial certification, or other appropriate mechanisms.	A remediation option is to Install a sealed vapor barrier (e.g., plastic sheeting, liquid membrane) over earthen, gravel, etc. floors or crawlspaces	See: http://www.nj.gov/dep/rpp/radon/
	New guidance will deal with mitigation methods much more than existing guidance. NJDEP typically requires SSD. Indoor air testing is required one month after system start-up to demonstrate the system is functional, then quarterly monitoring (can be as little as visual inspection to indicate system operation), and then annual monitoring thereafter.	"...if a property designated for development has a potential for vapor intrusion risk, the Department recommends that proactive measures (vapor barrier, vapor barrier with passive depressurization system, active depressurization system, etc.) be designed into the building."	Monitoring will be addressed in upcoming guidance.	The site cannot be closed out until it's demonstrated that the source has been eliminated. Sub slab and indoor air samples must be collected to show no impact when the EC turned off.	Use of institutional controls (ICs) is currently voluntary. Owners will add a "deed notice" that restricts site use, or requires later VI investigation if site is developed. There are Classification Exception Areas (CEAs) for groundwater – ICs can get implemented via agreements for a CEA. NJDEP is still working on implementation of ICs as a legal matter.	These have only been allowed at Brownfield sites and NJDEP has required both a vapor barrier and passive venting. NJDEP prefers active systems (e.g., SSD).	See: http://www.nj.gov/dep/rpp/radon/
New Mexico	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.

State	Date of Guidance Update	Guidance Title	Pathway to Guidance	Agency	Contact	Do they allow modeling?	Model Type(s)	Model Modifications	Type of Approval
New York	October 2006	Guidance for Evaluating Soil Vapor Intrusion in the State of New York	http://www.health.state.ny.us/environmental/investigations/soil_gas/svi_guidance/	New York State Department of Health	Email: BEEI@health.state.ny.us Telephone: 1-800-458-1158, extension 27850, or Jim Harrington 518-402-8755, jbhamin@gw.dec.state.nys.us	Yes	Modeling should not be the only means of evaluating SVI. It may, however, be used as a tool in the evaluation process... (2.12 Role of Modeling)	Model should incorporate site-specific parameters (e.g., attenuation factors, soil conditions, concentrations of volatile chemicals, depth to subsurface source, characteristics of subsurface source, and foundation slab thickness) as much as possible...both the limitations of the model (e.g. exclusion of preferential migration pathways) and the sensitivity of the variables in the model should be understood and identified. (2.12) NYDOH does not provide model spreadsheets; No modifications recommended	Use of any model at a site should be discussed with the agencies prior to the model's development and application (2.12)
		DOH is currently updating its VI guidance. Currently in pre-draft stage (Ms Bethany has not seen it yet) under internal review. Will not go public for at least 3-4 months, maybe longer depending on comments.			Charlotte Bethany, Public Health Specialist, NYDOH (518) 402-7860		NY does not rely on modeling; they have found many cases that don't fit the models or models don't accurately predict. NY's use of modeling is much less than many other states. For example, you can't screen out a site from further VI investigation based on modeling.	Not mentioned.	NYSDEC/DOH do all approvals for actions under NYSDEC managed programs. Sometimes there is County involvement in conjunction with DEC; depends on County's resources. Some locations DEC district office takes lead.
North Carolina	May 2007	North Carolina Dry-Cleaning Solvent Cleanup Act (DSCA) Program's Risk-Based Corrective Action (RBCA)	http://www.ncdsca.org/download/risk/dscariskguidancemay2007.pdf	NC Department of Environment and Natural Resources	Delonda Alexander 919-508-84444 delonda.alexander@ncmail.net	Yes	Not specified, different Tiers (1,2, or 3 depending on target risk level) of "mathematical models are used to estimate the soil, groundwater, or soil vapor risk-based concentrations protective of indoor inhalation" (6.2.3.1 Pathways for Inhalation)	Not mentioned.	The use of engineering controls is mentioned, but none are specified.
North Dakota	NA	No formal guidance document has been issued, and situations are handled on a case-by-case basis.			Vapor intrusion issues are jointly addressed on a case-by-case basis by the Department of Health's Division of Air Quality and Waste Management		Not mentioned.	Not mentioned.	Not mentioned.
Ohio	December 2009	Sample Collection and Evaluation of Vapor Intrusion to Indoor Air		Ohio EPA	Manager, DERR-CO Remedial Response Section, Ohio EPA, 614-644-2924.	Yes	Johnson and Ettinger (J/E) model	Review CSM to ensure J&E model is appropriate. Tables 4 and 5 of the guidance summarize the acceptable J&E Model input parameters for bulk soil and soil gas and ground water, respectively.	Not mentioned.
	Phone interview with Audrey Rush on 3/4/2010	Audrey is coordinator of new Vapor Intrusion guidance for Ohio. This guidance is specifically for two Ohio programs: (1) CERCLA cleanups under consent orders - Ohio EPA chooses the remedy; (2) Voluntary Action Program (VAP) - site owner led cleanup, overseen by Certified Professional (CP), similar to MA LSP.	Guidance is patterned after CA guidance and resembles ITRC. "Cookbook on how to sample and weight of evidence."		Audrey Rush, OEPA DERR, Vapor Intrusion Guidance Coordinator 614-644-2286		Not mentioned.	OH Guidance allows use of J/E model for contaminated soil (many other states don't allow this). Audrey emphasized their use of "weight of evidence".	CP directs analysis, OEPA reviews and approves.
Oklahoma	NA	No guidance document, but uses ITRC and EPA guidance documents.	http://iavi.rti.org/attachments/WorkshopsAndConferences/07_Morales_yes.pdf	Oklahoma DEQ	Evelina C. Morales 405-702-5108 evalina.morales@deq.state.ok.us	Yes	Johnson and Ettinger (J/E) model	Guided by the: • ITRC 2007 Vapor Intrusion Pathway: A Practical Guideline • EPA 2002 Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance)	Not mentioned.

State	Recommended Engineering Controls (EC) or Corrective Actions Existing Buildings	Recommended Engineering Controls (EC) or Corrective Actions Future Buildings	EC Effectiveness/Operation and Maintenance	Site closure requirements	Institutional Controls and Deed Restrictions	Vapor/Gas Barriers?	Summary/Notes
New York	Mitigation systems defined as any physical barrier or method employed to 1. actively or passively contain, stabilize, or monitor hazardous waste 2. restrict the movement of hazardous waste to ensure the long-term effectiveness of remedial actions, or 3. eliminate potential exposure pathways to hazardous waste. (4.6)... most effective mitigation methods involve sealing infiltration points and actively manipulating the pressure differential between the building's interior and exterior (on a continuous basis)...the appropriate method to use will largely depend upon the building's foundation design. (4.1) These systems could include a sub-slab depressurization system, HVAC modification, soil vapor retarder with sub-membrane depressurization, crawl space ventilation with sealing, Soil Vapor Extraction system, sealing, room pressurization, passive ventilation systems, or vapor barriers.	Use of institutional controls is recommended for future site usage. See Institutional controls and deed restrictions. "If sampling results indicate a mitigation system is recommended to address exposures in buildings that may be constructed, then a SSD system with sealing, or a SMD system with a soil vapor retarder, or a combination of these methods is recommended"	When mitigation systems are implemented at a site, the operation, maintenance and monitoring (OM&M) protocols for the systems should be included in a site-specific site management plan. For SMD and SSD, routine maintenance should commence within 18 months after the system becomes operational, and should occur every 12 to 18 months thereafter. During routine maintenance...a. a visual inspection of the complete system (e.g., vent fan, piping, warning device or indicator, labeling on systems, soil vapor retarder integrity, etc.), identification and repair of leaks , and c. inspection of the exhaust or discharge point to verify no air intakes have been located nearby. As appropriate, preventative maintenance (e.g., replacing vent fans), repairs and/or adjustments should be made...depend upon the life expectancy and warranty for the specific part. For other systems...visual inspection of the complete system, and identification and repair of leaks...air stream velocity measurements of ventilation systems	None that I could find	If investigation of a parcel that is undeveloped or contains unoccupied buildings is being delayed until the site is being developed or occupied, measures should be in place that assure the State that no development or occupation will occur without addressing the exposures. Institutional controls may be used for this purpose.	"To retard the infiltration of subsurface vapors into the building and enhance the performance of a SMD system, a minimum 6 mil (or 3 mil cross-laminated) polyethylene or equivalent flexible sheeting material should be used. 2. The sheet should cover the entire floor area and be sealed at seams (with at least a 12 inch overlap) and penetrations, around the perimeter of interior piers and to the foundation walls. 3. Enough of the sheeting should be used so it will not be pulled away from the walls when the depressurization system is turned on and the sheet is drawn down."	While soil vapor intrusion can also occur with "naturally-occurring" subsurface gases (e.g., radon, methane and hydrogen sulfide), the document discusses soil vapor intrusion in terms of environmental contamination only.
	Not mentioned.	Not mentioned.	Usually require at least one round of post installation indoor air testing to demonstrate effectiveness. Sometimes DOH requests a second test. NY requires O&M Plan, annual monitoring at a minimum.	Owner has responsibility to maintain mitigation system until the site is clean. To reach complete closure, owner would have to temporarily shut down the system and do measurements to prove the problem is gone.	NY places an Environmental Easement on property to ensure maintenance of control systems or ensure future investigation and installation of controls if site use changes. Requires annual review to document no change in site/building use. Look at 6 NYCRR Part 375 for regulations.	NYSDEC generally does not accept vapor barrier alone as a remedy. They sometimes request vapor barrier installation in addition to SSD. They have found that some vapor barriers don't work well for suppressing organic vapors - moisture barriers not usually effective and can depend on polarity of barrier and polarity of compounds.	Not mentioned.
North Carolina	The use of engineering controls is mentioned, but none are specified.	The use of institutional controls is mentioned, but none are specified.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.
North Dakota	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.
Ohio	Table 6 of the guidance document compares various mitigation methods. Removing VOC contamination through site remediation, source removal, design of ventilation systems to mitigate indoor air concentrations (HVAC), SSD, SMD,SSP, building pressurization, indoor air treatment, sealing the building envelope. Installing passive or active vent systems	Installing passive and/or active vent systems/membrane system	Monitoring of engineered controls must continue until risk-based clean-up levels as measured in environmental media have been met. For any remedy chosen for a site, long-term monitoring of soil gas and indoor air may be necessary. The frequency of the monitoring will depend upon site-specific conditions and the degree of VOC contamination	Not mentioned.	Restrict structures or types of structures on contaminated property. Institutional controls are restrictions that are recorded in the same manner as a deed which limits access to or use of the property such that exposure is reliably eliminated. Examples of institutional controls include prohibition of inhabitable structures in areas where vapor intrusion risk goals would otherwise be exceeded, or building-specific conditions, such as prohibition of basements. At undeveloped sites, or at sites where land use may change in the future, institutional controls	Yes, membrane systems are an engineering control option in future buildings.	In areas where radon gas is common, a radon detection meter may provide a means to evaluate where vapors are entering a structure. Locations where radon gas is detected should be considered for sub slab or indoor air sampling for VOCs of concern.
	Guidance does not offer much on remedies. OH relies on USEPA guidance on remedies for VI.	Not mentioned.	O&M Plan may be required per regulations (OAC 3745 300-11).	Owner needs to demonstrate that remedy is effective. CP submits "no further action" letter. If OEPA agrees, they issue a "covenant not to sue" for the site.	Look at regulations: OAC 3745 300-07 through -11.	Not mentioned.	Not mentioned.
Oklahoma	Remediation and mitigation is the next step after data evaluation, but no specific remedies are mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.

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State	Date of Guidance Update	Guidance Title	Pathway to Guidance	Agency	Contact	Do they allow modeling?	Model Type(s)	Model Modifications	Type of Approval
Oregon	September 2009	Guidance for Assessing and Remediating Vapor Intrusion in Buildings	http://www.deq.state.or.us/lq/pubs/docs/cu/DRAFTVaporIntrusionGuidance.pdf	Oregon Department of Environmental Quality	1-800-742-7878, hotinfo@deq.state.or.us, or Mary Camarata 541-686-7839 x259 camarata.mary@deq.state.or.us	No	None	Modeling not allowed	None
	Phone interview with Mary Camarata on 3/4/2010	The current vapor intrusion guidance document is in draft form. Oregon is currently getting comments. The document should be finalized within 6 months..			Mary Camarata 541-686-7839 x259 camarata.mary@deq.state.or.us		Not mentioned.	Yes. DEQ developed soil gas screening values based empirical USEPA (2008) attenuation factors. When USEPA releases new empirical attenuation factors, this attenuation factors used will likely be updated. The J/E can be used, but is not recommended. Consultants need to work with DEQ prior to submitting modeling results. Past experience has indicated that it is not accurate. If J/E is used, would want detailed inputs and soil parameters from samples collected at the site.	Any modeling performed will be reviewed in house by DEQ hydrogeologists.
Pennsylvania	January 2004	Vapor Intrusion into Buildings from Groundwater and Soil under the Act 2 Statewide Health Standard	http://www.portal.state.pa.us/portal/server.pt?open=514&objID=552025&mode=2	Pennsylvania DEP and PA DEP Land Recycling Program	Ramesh Belani 484-250-5756 rbelani@state.pa.us Randy Roush 717-783-7816 raroush@sate.pa.us	Yes	Johnson and Ettinger (J/E) model	PA does not provide model spreadsheets; No modifications recommended	Not mentioned.
Rhode Island	NA	Rhode Island does not have state SVI guidance, and handles SVI on a case-by-case basis.	NA	Rhode Island Department of Environmental Management	Paul Kulpa , 401-222-2797, paul.kulpa@dem.ri.gov		Not mentioned.	Rhode Island loosely follows USEPA's guidance document entitled OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance), EPA530-D-02-0004, released in November 2002.	Not mentioned.
South Carolina	NA	No SVI Guidance.	NA	SC Department of Health and Environmental Control, Bureau of Land and Waste Management	Craig Dukes, 803-896-4057 dukescv@dhec.sh.gov		Not mentioned.	Not mentioned.	Not mentioned.
South Dakota	March 2003	Handbook for investigation and corrective action requirements for discharges from storage tanks, piping systems, and other releases	http://denr.sd.gov/des/gw/Spills/Handbook/Hand_Book.aspx, See Chapter 3, 4, 5, 7	South Dakota Department of Environment and Natural Resources	Ground Water Quality Program at 605-773-3296	Yes	The department will accept the use of the computer modeling system developed by Groundwater Services Inc., titled "Tier 1/Tier 2 RBCA Spreadsheet System."	When modeling is used to determine a site specific target level, the department will require that a list of the assumptions and values used be included in the report. Other models may also be accepted based on department approval.	By the department
Tennessee	September 2006	Risk-Based Procedure to Determine Clean-up Levels	http://tennessee.gov/environment/ust/guidance/tgd017.pdf	TN Department of Environment and Conservation	TN Department of Environment and Conservation, Division of Superfund (Dry-cleaning) Brad Parman 615-532-0926 brad.parman@state.tn.us, TN Department of Environment and Conservation, Underground Storage Tank Program, Mohammad Naqvi 615-253-6340 Mohammad.Naqvi@state.tn.us	Yes	The soil gas screening levels are calculated using the standard USEPA (2004) J&E equations. See: http://tennessee.gov/environment/ust/guidance/tgd018lt.xls For off-site SSCLs, the domenico model is used. More details on the risk analysis inputs is discussed in the cited document.	For contamination that exceeds the on-site and/or off-site SSCLs, option six consists of the application of an advanced risk-based model which incorporates detailed site-specific data. The general site information and current COC concentrations that are inputted into the RBCL Report will be used in the comparison to Division established RBCLs and are based in part on ASTM Designation: 1739-95 (Reapproved 2002).	Not mentioned.

State	Recommended Engineering Controls (EC) or Corrective Actions Existing Buildings	Recommended Engineering Controls (EC) or Corrective Actions Future Buildings	EC Effectiveness/Operation and Maintenance	Site closure requirements	Institutional Controls and Deed Restrictions	Vapor/Gas Barriers?	Summary/Notes
Oregon	Engineering controls can be either a removal or remedial action for VI and may include modifications to HVAC systems, vapor venting systems, soil vapor extraction systems, or other building modifications such as the sealing of floor joints and cracks, passive or active sub-slab depressurization, impermeable building foundation membranes, soil venting and source removal techniques such as soil excavation or in-situ treatment	Same as for existing buildings.	Define performance objectives in the remedy selection process, and develop clear and obtainable Data Quality Objectives. I...Seasonal fluctuations of soil vapor concentrations should be fully understood prior to the selection of remedial performance objectives. An EPA Engineering Bulletin titled Indoor Air Vapor Intrusion Mitigation Approaches contains a good discussion of performance monitoring and can be found at http://www.clu-in.org/download/char/600r08115.pdf . (5.4 Performance Monitoring of Selected Controls)		Use restrictions, environmental monitoring requirements, and site access and security measures...Easements and Equitable Servitudes, Deed Restrictions and Prospective Purchaser Agreements.	Allows use of "impermeable building foundation membranes." However, DEQ does not recommend specific mitigation or remedial techniques, but instead asks for an appropriate evaluation and a remedy proposal for its review and approval. (5. Vapor Intrusion Mitigation)	None
	Not mentioned.	Not mentioned.	It depends on what the EC is. If a vapor barrier is installed in a crawl space, we would monitor above the vapor barrier in the crawl space. We prefer not sampling in homes unless there is no way around it. We have gotten hits from products used in the house and not related to site contamination. Yes, we want the vapor barriers checked annual for tears or holes. We have had rats in some crawl spaces that have chewed holes in the vapor barriers.	If we need a EC, than the site is not closed. We will asked for monitoring of the soil gas until it is below cleanup levels.	We place deed restriction on properties. We also review site construction plans to see if institutional controls are included in the document. We put the property in our database and monitor that the institution control stays in place.	Yes, depending on the housing construction, the chemical, and the concentration.	Not mentioned.
Pennsylvania	The use of engineering controls is mentioned, but none are specified.	The use of engineering controls is mentioned, but none are specified.	A schedule of operation and maintenance of the controls. Include a description of the planned maintenance activities and frequencies at which they will be performed and future plans for submission of proposed changes.	When the site-specific standard can be maintained without engineering controls operating and mitigation measures have been successfully sustained, document this to the Department and receive approval to end the post remediation care program.	"If a property does not currently have occupied buildings or structures containing enclosed spaces that could retain vapors and it is possible that future development will consist of occupied buildings or structures containing enclosed spaces (residential or nonresidential), the deed acknowledgment requirements shall apply pursuant to Act 1995-2, 303(g)." Deed restrictions: one of a number of institutional control measures which may be applied in conjunction with the Act 2 remediation	See: http://www.portal.state.pa.us/portal/server.pt?open=514&objID=552017&mode=2	See: http://www.portal.state.pa.us/portal/server.pt?open=514&objID=552017&mode=2
Rhode Island	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.
South Carolina	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.
South Dakota	If the RBCA model predicts potential impacts to the receptor, the department will require corrective action or engineering controls to prevent impacts. Installation of VE system around a building foundation, apply positive pressure to the structure, Install explosion-proof fans to remove the vapors from the structure or utility, replacement of basement concrete walls, or other technologies as approved by the department. (Chapter 5.7.2) Regardless of the type of remedial activity proposed, the department must give approval prior to Installation.	No specific ECs for future "the soil remediation rules require corrective action if data indicate petroleum vapors have adversely affected structures or utilities, or in the opinion of he department, have the potential to do so in the future" (Chapter 5)	A vapor monitoring program may be needed prior to and during implementation of corrective action/engineering controls and to verify the actions have mitigated the problem. (Chapter 7)	Chapter 10 of handbook discusses site closure. "A site may receive no further action status if ground water contamination remains above state standards, but the site meets the criteria detailed below. The department may return a site to "active" or "monitoring" status if a problem arises from contamination left on the site. Note: The department is still developing this section and additional information will be provided."	Not mentioned.	Not mentioned.	Not mentioned.
Tennessee	For contamination that exceeds the on-site and/or off-site SSCLs, option five consists of engineering controls (i.e., design and installation of a vapor barrier, ventilation system, etc.).	Not mentioned.	Not mentioned.	Not mentioned.	For contamination that exceeds the on-site and/or off-site SSCLs, option four consists of institutional controls (i.e., filing a Notice of Land Use Restrictions in the register of deeds office in the appropriate county).	Vapor barriers are mentioned as a possible engineering control.	Not mentioned.

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State	Date of Guidance Update	Guidance Title	Pathway to Guidance	Agency	Contact	Do they allow modeling?	Model Type(s)	Model Modifications	Type of Approval
Texas	NA	No SVI Guidance document	NA	TX Commission on Environmental Quality	Nathan Pechacek 512-239-1336 npechace@tceq.state.tx.us		Not mentioned.	The Department also uses the USEPA Draft Guidance (OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance), EPA530-D-02-0004, released in November 2002). The USEPA Draft Guidance document (12/29/02) is available online at: http://www.epa.gov/epaoswer/hazwaste/ca/eis/vapor.htm	Not mentioned.
Utah	NA	Vapor intrusion is mentioned in their UST program, but no guidance details are given.	http://www.undergroundtanks.utah.gov/docs/correctiveActionProcessGuide.pdf	Utah DEQ	John Menatti 801-536-4159 jmenatti@utah.gov	Yes	Johnson and Ettinger (J/E) model has been used in the past.	J/E model has been used without modifications in the past.	Not mentioned.
Vermont	NA	Could not find any specific VI guidance.		VT DEP	Michael B. Smith michael.smith@anr.state.vt.us		Not mentioned.	Not mentioned.	Not mentioned.
Virginia	January 2010	Voluntary Remediation Program Risk Assessment Guidance	http://www.deq.virginia.gov/vrprisk/raguide.html	Virginia DEQ	Office of Remediation Program, Patricia McMurray 804-698-4186 pamcmurray@deq.virginia.gov	Yes	Johnson and Ettinger (J/E) model	Documentation of the model inputs should also be provided along with a rationale for any site-specific parameters used. The participant should record the results of exposure point concentration calculations in the appropriate table for the medium of concern (Table 3.6)	Then defers to EPA guidance on J/E Model, and ITRC documents for other related SVI guidance
Washington	October 2009	Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action	http://www.ecy.wa.gov/programs/tcp/policies/VaporIntrusion/VI%20guid%20rev5%20final%2010-9-09%20.pdf	Washington State Department of Ecology	Ed Jones (425) 649-4449 ed.jones@ecy.wa.gov,	Yes	Johnson and Ettinger (J/E) model	WA does not provide model spreadsheets Recommends following modification: use Qsoil of 5 L/min (as adjusted for building size)	Not mentioned.
	Phone interview with Martha Hankins on 3/4/2010	Washington is in the process of updating and amending the Model Toxics Control Act (MTCA, which governs risk assessment and remediation) and is currently reviewing comments on the draft vapor intrusion guidance document. The vapor intrusion guidance document will be updated to be consistent with the updated version of the MTCA and to account for the comments received on the guidance document.			Martha Hankins 360-407-6864 mhan461@ecy.wa.gov	Yes	Johnson and Ettinger (J/E) model, and empirically-derived site-specific attenuation factors are allowed.	Modeling vapor intrusion from soil sources not allowed. Recommended to use model in default mode; i.e., with conservative, generic inputs.	Per site manager request, the state will staff review and check any modeling submitted.

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State	Recommended Engineering Controls (EC) or Corrective Actions Existing Buildings	Recommended Engineering Controls (EC) or Corrective Actions Future Buildings	EC Effectiveness/Operation and Maintenance	Site closure requirements	Institutional Controls and Deed Restrictions	Vapor/Gas Barriers?	Summary/Notes
Texas	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.
Utah	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.
Vermont	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.
Virginia	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.	Not mentioned.
Washington	"For residences, sub-slab or sub-membrane depressurization systems may be considered presumptive mitigation approaches, and should not typically require feasibility study-type evaluation prior to selection" "Soil vapor extraction (SVE) can often be effective as an interim action to reduce soil gas concentrations. Depending on the design of the system, SVE may be able to not only decrease soil gas contamination but also de-pressurize the sub-slab zone beneath buildings of concern. Removal of the contaminated soils may also be an option. Some quick-acting groundwater treatment systems may additionally be alternatives to mitigation."	"For residences, sub-slab or sub-membrane depressurization systems may be considered presumptive mitigation approaches, and should not typically require feasibility study-type evaluation prior to selection" "Soil vapor extraction (SVE) can often be effective as an interim action to reduce soil gas concentrations. Depending on the design of the system, SVE may be able to not only decrease soil gas contamination but also de-pressurize the sub-slab zone beneath buildings of concern. Removal of the contaminated soils may also be an option. Some quick-acting groundwater treatment systems may additionally be alternatives to mitigation."	Not mentioned.	Not mentioned.	"Regulatory requirements for establishing protective institutional controls are contained in WAC 173-340-440." In general, institutional controls will commonly be needed when subsurface contamination poses a potential VI threat, and a) actions to reduce source concentrations will either not be implemented quickly, or will take a relatively long time to reach cleanup goals, b) mitigation is required, c) Ecology concludes continued operation of, and/or access to, the mitigation system is needed d) no buildings currently exist in the area of the contamination, but could be constructed there in the future. In addition, controls are also likely to be needed when subsurface contamination does not currently pose a potential VI threat to a particular structure, but the threat might become unacceptable were: a) the use of that structure to change (the types of receptors or exposure durations, for example), b) the building to be re-modeled or a different building constructed, or c) the ability of that structure to protect indoor air quality to change (due to changes in ventilation rates, or the installation of sumps, for example).	Not mentioned.	Not mentioned.
	Not mentioned.	Not mentioned.	EC monitoring, at present, is a site-specific determination. Currently, this is being evaluated and will be updated in the MTCA. Currently the MTCA does not contain compliance monitoring specifications for vapor intrusion. The MTCA does contain general O&M requirements for engineering controls (http://apps.leg.wa.gov/WAC/default.aspx?cite=173-340-400) that include "Procedures for the maintenance of the facility after completion of the cleanup action, including provisions for removal of unneeded appurtenances, and the maintenance of covers, caps, containment structures, and monitoring devices."	To close a site, indoor air would be sampled and compared to indoor air cleanup levels in the MTCA. If concentrations of VOCs meet the MTCA indoor air cleanup levels, the site can be closed. A site cannot be closed with an EC still in operation, and that situation would require an IC.	ICs can be implemented. Washington has recently passed the Uniform Environmental Covenants Act (UECA). Prior to the UECA, Washington had been using deed restrictions. Currently, Washington is updating their template documents to be consistent with UECA. Washington maintains a database of properties with ICs.	Passive ECs are allowed. Whether a passive EC can be used alone or must be used in combination with an active system (e.g., SVE + vapor barrier) would be a site-specific determination, dependent upon conditions and the contaminants at the site.	Not mentioned.

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State	Date of Guidance Update	Guidance Title	Pathway to Guidance	Agency	Contact	Do they allow modeling?	Model Type(s)	Model Modifications	Type of Approval
West Virginia	NA	Vapor Intrusion is mentioned as a pathway that needs to be evaluated in state documents, but no guidance exists.	http://www.dep.wv.gov/dlr/oer/voluntarymain/Documents/VRRA%20GuidanceVersion2-1.pdf	WV DEP	Lawrence P. Sirinek 304-238-1220 lsirinek@wvdep.org		Not mentioned.	Not mentioned.	Not mentioned.
Wisconsin	February 2003	Chemical Vapor Intrusion and Residential Indoor Air: Guidance for Environmental Consultants and Contractors	http://dhs.wisconsin.gov/eh/Air/pdf/VI_guide.pdf	State of Wisconsin Division of Public Health, Department of Health and Family Services	Henry Nehls-Lowe NehlsHL@dhfs.state.wi.us, (608) 266-3479	Yes	Mentions Johnson and Ettinger (J/E) model, and deterministic models with site-specific criteria	WI does not provide model spreadsheets; No modifications recommended	Not mentioned.
Wyoming	May 2007	Fact Sheet #25: Using Fate and Transport Models to Evaluate Cleanup Levels	http://deq.state.wy.us/volremedi/downloads/Current%20Fact%20Sheets/FS_25.pdf	WY DEQ	Voluntary Remediation Program (VRP) 307-777-7752	Yes	Johnson and Ettinger (J/E) model	DEQ accepts the use of the most current version of the JE Model on the EPA OSWER website (www.epa.gov/oswer/riskassessment/airmodel/johnson_ettinger.htm) at the time of the evaluation, and specifies default values for input parameters as provided in the EPA draft *Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils*. Also, the DEQ require sensitivity analyses when using the JE Model	Use of other versions or models must be approved in advance by DEQ.

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State	Recommended Engineering Controls (EC) or Corrective Actions Existing Buildings	Recommended Engineering Controls (EC) or Corrective Actions Future Buildings	EC Effectiveness/Operation and Maintenance	Site closure requirements	Institutional Controls and Deed Restrictions	Vapor/Gas Barriers?	Summary/Notes
West Virginia	Not mentioned.	Engineering controls can be incorporated into building designs to reduce the potential for future IAQ problems associated with buildings planned for areas with elevated radon and/or volatile organic compounds (VOC) containing soils. (2.4.9 Indoor Air Quality)	Not mentioned.	Not mentioned.	Information on land use covenants can be found here: http://www.dep.wv.gov/dlr/oer/voluntarymain/Documents/LUC%20template%20VRA%2011-24-09.doc	Not mentioned.	Not mentioned.
Wisconsin	Close off any openings that allow for direct SVI. These include openings in the slab, major cracks in walls, gaps around utility lines, sumps lids that do not fit tightly, compromised floor drains, etc. If odors are apparent, the basement air should be ventilated separately, as much as possible, from the remaining occupied portions of the building (closing cold air returns and heat vents in the impacted area). Installing a SSD system.	Prior or redevelopment, consider installing a basement construction with passive or active mitigation, or a slab-on-Grade with passive or active mitigation. When the vapor intrusion pathway is ruled out contingent upon maintaining a specific engineering control or land use for the property, changes in land use should trigger a reassessment of the pathway.	Construction requiring active mitigation also requires ongoing monitoring and maintenance of mitigation system	Not mentioned.	Not mentioned.	Passive mitigation is composed of two components, 1) creating a competent vapor barrier, and 2) providing an alternate route for vapors to vent to the atmosphere. In most current construction a gravel base beneath the concrete floor provides a preferential flow path for soil vapors. Adding a layer of plastic sheeting is also recommended to prevent concrete mixture from clogging the gas permeable gravel layer and to provide additional barrier to soil vapor migration. This construction is appropriate for residual VOCs unlikely to contribute to unacceptable air impacts (e.g. soil vapor concentrations already below levels of health concern).	See: http://dhs.wisconsin.gov/dph_beh/RadonProt /
Wyoming	Engineering controls are mentioned but none are specified.	Engineering controls are mentioned but none are specified.	Engineering controls are mentioned but none are specified.	Following completion of remedial actions, the Volunteer may seek either a certificate of completion or no further action from the DEQ.	There are four categories of institutional controls: governmental controls, proprietary controls, enforcement and permit tools, and informational devices. DEQ's preference is for remedies that are more permanent, have fewer operation and maintenance burdens, and, therefore, rely less on institutional controls.	Not mentioned.	Not mentioned.

Appendix B:

Vapor Intrusion Guidance Survey Information - Agencies

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Agency	Date of Guidance Update	Guidance Title	Pathway to Guidance	Contact	Do they allow modeling?	Model Type(s)	Model Modifications	Type of Approval	Recommended Engineering Controls (EC) or Corrective Actions Existing Buildings
USEPA	Feb-05	Johnson and Ettinger (1991) Model for Subsurface Vapor Intrusion into Buildings	http://www.epa.gov/oswer/riskassessment/airmodel/johnson_ettinger.htm	-	Yes	Johnson and Ettinger model	None - this is the standard upon which states base their guidance	Reviewed by USEPA	Not discussed
	Nov-02	OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance)	http://www.epa.gov/osw/hazard/correctiveaction/eis/vapor.htm	-	Yes	Johnson and Ettinger model	None	Reviewed by USEPA	subslab de-pressurization, soil vacuum extraction, building pressurization, indoor air purifiers
	Mar-08	Brownfields Technology Primer: Vapor Intrusion Considerations for Redevelopment	http://www.brownfieldstsc.org/pdfs/BTSC%20Vapor%20Intrusion%20Considerations%20for%20Redevelopment%20EPA%20542-R-08-0011.pdf	-	Yes	Johnson and Ettinger model	None	Reviewed by USEPA	sealing cracks, passive barriers, depressurization, Sub-slab Soil Pressurization, Building Pressurization
	Oct-08	Indoor Air Vapor Intrusion Mitigation Approaches	http://www.epa.gov/nrmrl/pubs/600r08115/600r08115.pdf	-	Yes	Recommends to follow ITRC and USEPA (2002)	None	Reviewed by USEPA	Active and Passive Sub-slab Ventilation, Sealing of Penetrations and Entryways, Passive Barriers (including Membranes), Natural Ventilation and HVAC Modification, Air Cleaning
Interstate Technology and Regulatory Council (ITRC)	January 2007	Vapor Intrusion Pathway: A Practical Guideline	http://www.itrcweb.org/guidancedocument.asp?TID=49	John Boyer 609-984-9751 john.boyer@dep.state.nj.us Robin Mongeon 603-271-7378 Robin.Mongeon@des.nh.gov	Yes	the USEPA J&E model can enable users to quickly screen sites for vapor intrusion risk....It is recommended that investigators (working with regulators) determine the critical parameters (Johnson et al. 2002) and conduct sensitivity analysis whenever predictive modeling is employed....For more complex sites, multidimensional numerical models can evaluate spatial and temporal processes in the vapor intrusion pathway.(3.7.2 Predictive Modeling)	none specified	none specified	passive venting, passive barriers, sub-slab depressurization, submembrane depresurization, subslab pressurization, building pressurization, indoor air treatment, sealing the building envelope (Table 4-1. Comparison of mitigation methods)
American Society for Testing and Materials (ASTM)	2008	ASTM E2600-08: Standard Practice for Assessment of Vapor Intrusion into Structures on Property Involved in Real Estate Transactions	http://www.astm.org/Standards/E2600.htm	Daniel Smith dsmith@astm.org 610-832-9727	Modeling may be using a tier 3, Vapor Intrusion Condition assessment	J&E is a model option	Table X8.1 lists select data required for direct assessment of the vapor intrusion pathway, as well as parameters expected to be incorporated into a modeling assessment of the vapor intrusion pathway, such as can be conducted using the U.S. EPA spreadsheet (http://www.epa.gov/oswer/riskassessment/airmodel/johnson_ettinger.htm) for the Johnson and Hettinger model (1991).	Not covered.	(1) source removal or treatment including contaminated soil excavation and removal, soil vapor extraction, in situ chemical oxidation, and groundwater pump and treat. (2) barriers and venting that block the migration of vapors from the subsurface into a building, including sealing, Vapor Barriers, Passive Vapor Collection/Venting Systems, Active Vapor Collection/Venting Systems (3) pressurization of building interiors and HVAC Modification; or (4) indoor air treatment systems.
	2005	ASTM E2435-05: Standard Guide for Application of Engineering Controls to Facilitate Use or Redevelopment of Chemical-Affected Properties	http://www.astm.org/Standards/E2435.htm	Daniel Smith dsmith@astm.org 610-832-9727	Not covered.	N/A	N/A	N/A	Specific ECs are not recommended. This document covers general, design, installation, monitoring, maintenance consideration when considering EC usage.
	2005	ASTM E2091 - 05: Standard Guide for Use of Activity and Use Limitations, Including Institutional and Engineering Controls	http://www.astm.org/Standards/E2091.htm	Daniel Smith dsmith@astm.org 610-832-9727	Not covered.	N/A	N/A	N/A	Engineering controls are briefly covered.
	2009	ASTM E1643-09: Standard Practice for Selection, Design, Installation, and Inspection of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs	http://www.astm.org/Standards/E1643.htm	Stephen Mawn smawn@astm.org 610-832-9726	Not covered.	N/A	N/A	N/A	N/A
	2009	ASTM E1745 - 09: Standard Specification for Plastic Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs	http://www.astm.org/Standards/E1745.htm	Stephen Mawn smawn@astm.org 610-832-9727	Not covered.	N/A	N/A	N/A	N/A
	1995	ASTM E1739 – 95: Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites	http://www.astm.org/Standards/E1739.htm		Yes	Simplified Johnson and Ettinger model	Qsoil =0	N/A	Specific ECs are not recommended.
	2000	ASTM E2081-00: Standard Guide for Risk-Based Corrective Action	http://www.astm.org/Standards/E2081.htm		Yes	Simplified Johnson and Ettinger model	Qsoil > 0	N/A	Specific ECs are not recommended.

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Agency	Recommended Engineering Controls (EC) or Corrective Actions Future Buildings	EC Effectiveness/Operation and Maintenance	Site closure requirements	Institutional Controls and Deed Restrictions	Vapor/Gas Barriers?	Summary/Notes
USEPA	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed
	subslab de-pressurization, soil vacuum extraction, vapor barriers, building pressurization, indoor air purifiers	Not discussed	Not discussed	Not discussed	Not discussed	Not discussed
	sealing cracks, passive barriers, passive venting, depressurization, Sub-slab Soil Pressurization, Building Pressurization	An O&M plan should be developed	Not discussed	Not discussed	Not discussed	Not discussed
	Active and Passive Sub-slab Ventilation, Sealing of Penetrations and Entryways, Passive Barriers (including Membranes), Natural Ventilation and HVAC Modification, Air Cleaning, pier construction	Develop an O&M plan; sample indoor air "shortly after start-up of the mitigation system; then, when sufficient reductions have been demonstrated, reducing the monitoring frequency to "every couple of years." May also sample air exchange rates, soil gas entry rates, sub-slab soil gas, pressure differentials, sub-slab to indoor air tracer testing	Addressed in a diagram that states "objectives reached"	Mentioned as possibilities	Yes	Not discussed
Interstate Technology and Regulatory Council (ITRC)	sub-slab depressurization, subslab pressurization, building pressurization, indoor air treatment (Table 4-1. Comparison of mitigation methods)	periodic inspections and monitoring may be required to ensure that engineering controls are operated and maintained over time to retain their effectiveness. (4.2 Institutional Control Remedies)	the decision to stop mitigation could be based on indoor air "confirmation tests," which would be conducted after temporarily shutting down the system. (4.5 Closure)	for example, restrictions could be established to allow only those land/building uses that would be associated with acceptable health risks. These legal actions can take many forms, including restrictive covenants, zoning, excavation prohibitions, and groundwater advisories (4.2 Institutional Control Remedies)	Passive barriers are materials or structures installed below a building to physically block the entry of vapors...passive barriers are generally not recommended by themselves for vapor intrusion control, although they may enhance or increase the efficiency of other technologies, such as sub-slab depressurization (SSD) systems. (4.3.1.1 Passive Barriers)	does not discuss limitations or approval for J/E but goes to lengths on discussing EC's, and IC's, very useful document
American Society for Testing and Materials (ASTM)	ICs might also include mechanisms to require the installation of vapor intrusion mitigation systems, such as vapor barriers or passive collection systems in new construction.	Proper operation and maintenance shall be performed as deemed appropriate and necessary by the user and qualified professional, based on information obtained during the VIA, to verify that any mitigation system(s) implemented to address a VIC.	Not covered.	Institutional Controls—Institutional controls (ICs) are generally legally enforceable conditions placed on a property to reduce the likelihood of exposure to unacceptable levels of contaminants, in this case indoor air vapors...ICs can take many forms, including restrictive covenants, zoning and land use restrictions, excavation prohibitions and groundwater advisories. ICs might also include mechanisms to require the installation of vapor intrusion mitigation systems, such as vapor barriers or passive collection systems in new construction. ...to ensure their long term effectiveness, ICs may require periodic inspections and monitoring. Mentions AULs.	Most passive barriers consist of an essentially impermeable high-density polyethylene (HDPE) sheet or a rubberized asphalt emulsion applied as a liquid that then hardens to form a barrier. In new structures, barriers are placed beneath the floor slab to prevent sub-slab vapors from entering the structure through cracks or construction joints in the slab. In existing structures, membranes can be used to retard the intrusion of vapors in crawl spaces or over dirt floors.	N/A
	Not specified.	In order to assess key performance criteria of the engineering control, monitoring programs may involve one or more of the following: visual inspection, physical measurements, or sampling and testing. The nature and frequency of such monitoring will depend on the type of engineering control employed. Repairs or replacements should be completed as indicated based on the results of periodic monitoring.	Not covered.	AULs are briefly mentioned.	Design considerations and specifications are outlined. Possible start-up, monitoring, and maintenance procedures are mentioned.	N/A
	Not specified.	N/A	Not specified.	Goes into great depth about AULs, Uniform Environmental Covenants Act ("UECA"), Deed Restrictions, Restrictive Covenants	Not covered.	N/A
	N/A	N/A	N/A	N/A	This practice covers procedures for selecting, designing, installing, and inspecting flexible, prefabricated sheet membranes in contact with earth or granular fill used as vapor retarders under concrete slab.	N/A
	N/A	N/A	N/A	N/A	This specification covers flexible, preformed sheet membrane materials to be used as vapor retarders in contact with soil or granular fill under concrete slabs.	N/A
	Not specified.	Not specified.	N/A	N/A	Not covered.	N/A
	Not specified.	Not specified.	N/A	AULs are briefly mentioned.	Not covered.	N/A

Appendix C:

- Phase I and II Phone Interview Templates
- Phase II Phone Interviews from April 14 to April 23, 2010

Phase I: Interviews conducted between February 26 and March 15, 2010

Questions for Phone Interviews with State Vapor Intrusion Experts

Information from the interviews conducted between these dates is provided in Appendix A in the summary matrix and is highlighted in blue.

1. Is guidance or program being updated? If yes, when will draft or final be issued?

2. Do you allow the use of modeling (e.g., J&E model) for vapor intrusion investigation?

3. Are there any limitations on use of the model and what, specifically, are your limitations?

4. How is the modeling (e.g., results, input, and/or use of) approved?

5. If an engineering control (EC) is installed to mitigate a VI problem, what do you require for monitoring? (air sampling, visual inspection, frequency of monitoring).

6. Are there any O&M requirements for passive ECs (e.g., passive vents or vapor barriers)?

7. How is site closure established for a VI site? When is the site/problem considered "closed," and what is required for monitoring? Can the site be closed out with an EC still operating?

8. Do you allow passive controls as a mitigation strategy?

9. Does your agency directly review mitigation work plans? (All sites reviewed directly by agency, LSP-type "privatization" program, other?)

10. Describe the role of institutional controls for existing or future buildings? How is this done, from a practical and regulatory standpoint?

11. Besides the available VI guidance, are there other documents, regulations or offices in your agency (e.g., brownfields) that we should be consulting or reviewing?

Phase II: Interviews conducted between April 14 and April 23, 2010

Phone Interview Template:

Notes from the interviews conducted between these dates are included in Appendix C.

A: If the state is updating its guidance

1. Have they (or do they plan to) re-evaluate the use/role of modeling?

2. If so, have you decided on any changes in regards to modeling?

B: If a state uses a sensitivity analysis

1. Describe what is involved in the sensitivity analysis. Is this a modeling exercise only? If so, which variables would be evaluated? Does this entail evaluating the effect of one variable at a time? How are the results used?

2. Does it require indoor air sampling?

C: Approval scheme

1. How are hazardous waste sites projects managed and monitored? There are several ways that regulatory bodies oversee environmental projects. These include 1) review by the regulatory body with a PM assigned to managed the site, 2) an LSP-like system where all environmental work is reviewed by a another consultant certified by the state environmental agency and 3) or a form of direct oversight.

2. How are actions or plans approved (e.g., selection of an EC, work plans, modeling input parameters, monitoring results, etc)

3. Does work, such as installing a mitigation system or conducting modeling, need prior approval?

4. What kind of follow up/confirmation, if any, is required when vapor intrusion modeling is used? What kind of follow up is required after implementation of a vapor intrusion mitigation system? (e.g., inspections, data review, etc)? Does it vary depending on the system? (i.e., SSV, SSD, vapor barrier)

D: Role of modeling

1. Can parties rely solely on modeling to predict/determine the indoor air concentration for the purpose of calculating risk?

2. Can model result be used to rule out further consideration of the VI pathway (e.g., demonstration of no significant risk)?

3. Does the state have numeric groundwater standards and if so, are the groundwater standards protective of (or do they screen for) the groundwater to indoor air VI pathway?

E: Monitoring

1. Is monitoring of an EC required?

2. If yes, what type of monitoring?

3. Does monitoring require/include indoor air sampling? Other types of air samples?

   Pressure measurements? Inspections?

4. What is the frequency of monitoring/sampling?

5. What is the duration (i.e., number of quarters, years) of indoor air sampling?

6. Where does the sampling obligation get established/memorialized (e.g., work plan, institutional control, approval/other)?

Alabama
Phone call with Brian Espy on 4/19/10 - notes of call reported by Parsons.
334-271-7749
bespy@adem.state.al.us

Note: Brian stated that AL expects the results of this survey to be made available to them. If not, AL will not participate in the future.

If the state is updating its guidance:

Yes, AL is in the process of updating its guidance.

1. Have they (or do they plan to) re-evaluate the use/role of modeling?
   AL is currently debating when to apply to the models, but not whether or not to use models.
2. If so, have you decided on any changes in regards to modeling?

Does your state use/require sensitivity analyses?

No.

If yes, ask the following:

1. Describe what is involved in the sensitivity analysis. Is this a modeling exercise only? If so, which variables would be evaluated? Does this entail evaluating the effect of one variable at a time? How are the results used?

2. Does it require indoor air sampling?

Approval scheme:

1. There are several ways that regulatory bodies oversee environmental projects. These include 1) scopes of work developed by consultants for the PRP are submitted to the state environmental agency for review and approval prior to implementation, or 2) an LSP-like system where environmental work is conducted, overseen and approved by a consultant certified by the state environmental agency; the state agency may or may not retrospectively audit the work.
   AL does not generally (80% of the time) review workplans; however, AL does review reports. AL uses a slightly different process. In general, AL has numerous meetings on-site and in the office prior to the implementation of field work to discuss the planned work. Additionally, the state sends staff to inspect and/or supervise field work and has meetings during field work to discuss progress.

2. How are actions or plans approved (e.g., selection of an engineering control, work plans, modeling input parameters, monitoring results, etc)?
   Work is reviewed by a PM. The PM will, as necessary, ask technical specialists for assistance. This same process applies to the meetings.

3. Does work, such as installing a mitigation system or conducting modeling, need prior approval?
   No.

4. What kind of follow up/confirmation, if any, is required when vapor intrusion modeling is used?
   This is decided on a case-by-case basis. The proponent can sample indoor air if desired to, but it is not required and decisions will not be based on indoor air data.

5. What kind of follow up is required after implementation of a vapor intrusion mitigation system (e.g., inspections, data review, etc)? Does it vary depending on the system (i.e., SSV, SSD, vapor barrier)?
   A yearly report is required. That which is monitored is negotiated beforehand and is not subject to fixed requirements. However, this would always include visual inspections and some sort of sampling by the proponents. Additionally, the State sends inspectors to perform visual inspections at least annually.

Role of modeling

1. Can parties rely solely on vapor intrusion modeling to predict/determine the indoor air concentration for the purpose of calculating risk?
   Yes.

2. Can vapor intrusion modeling be used to rule out further consideration of the VI pathway (e.g., demonstration of no significant risk)?
   Yes.

3. Does the state have numeric groundwater standards and if so, are the groundwater standards protective of (or do they screen for) the groundwater to indoor air VI pathway?
   Yes, AL has numeric groundwater criteria. The current criteria are not protective of vapor intrusion, but the State is are considering developing criteria protective of vapor intrusion in the next draft of its guidance.

Monitoring

1. Is monitoring of an engineering control required?
   Yes, this is specified in the Division 5 regulations.

2. If yes, what type of monitoring?
   Visual inspections and the collection of samples are required. The sampling plan is subject to negotiation.

3. Does monitoring require/include indoor air sampling? Other types of air samples? Pressure measurements? Inspections?
   Indoor air samples are not required; visual inspections are required. Other types of samples would are also required, as may be specified in the Division 5 regulations.

4. What is the frequency of monitoring/sampling?
   Generally, the frequency of monitoring/sampling is quarterly or semi-annually.

5. What is the duration (i.e., number of quarters, years) of indoor air sampling?

Indoor air sampling occurs until the source term has reached acceptable concentrations.

6. Where does the sampling obligation get established/memorialized (e.g., work plan, institutional control, approval/other)?
   The sampling obligation is established/memorialized in the permit and may be part of the environmental covenant that is filed with the county Judge of Probate at the county level.

Alaska
Phone call with Janice Wiegerson on 4/16/10 - notes of call reported by Parsons.
907-451-2127
Janice.wiegers@alaska.gov

If the state is updating its guidance:

1. Have they (or do they plan to) re-evaluate the use/role of modeling?
   New draft guidance was published in 2009. The state has solicited comments on the guidance, but has not received many; likely guidance will not change much.
2. If so, have you decided on any changes in regards to modeling?

If a state uses a sensitivity analysis:

No.

1. Describe what is involved in the sensitivity analysis. Is this a modeling exercise only? If so, which variables would be evaluated? Does this entail evaluating the effect of one variable at a time? How are the results used?

2. Does it require indoor air sampling?

Approval scheme:

1. How are hazardous waste sites projects managed and monitored? There are several ways that regulatory bodies oversee environmental projects. These include 1) scopes of work developed by consultants for the PRP are submitted to the state environmental agency for review and approval prior to implementation, or 2) an LSP-like system where environmental work is conducted, overseen and approved by a consultant certified by the state environmental agency; the state agency may or may not retrospectively audit the work.
   The state does not have an LSP; work should be done under a qualified person, as defined by the guidelines. Once the “qualified person” is hired, s/he is required to submit work plans that are then reviewed and approved. After work is conducted, a report is submitted and reviewed; closure cannot occur until the agency has approved the closure plan.

2. How are actions or plans approved (e.g., selection of an EC, work plans, modeling input parameters, monitoring results, etc)
   See above.

3. Does work, such as installing a mitigation system or conducting modeling, need prior approval?
   Yes, work like this must be approved in a work plan. Occasionally the work plan can be “abbreviated,”, but would still require state approval.

4. What kind of follow up/confirmation, if any, is required when vapor intrusion modeling is used? What kind of follow up is required after implementation of a vapor intrusion mitigation system (e.g., inspections, data review, etc)? Does it vary depending on the system (i.e., SSV, SSD, vapor barrier)?

The state reviews input parameters and the results of model. There are some requirements in guidance for modeling; Ms. Wiegerson noted that the guidance is not a regulation. Detailed requirements are setup on a site-specific basis.

Role of modeling

1. Can parties rely solely on modeling to predict/determine the indoor air concentration for the purpose of calculating risk?
   It is possible that parties could rely solely on modeling for predicting/determining indoor air concentrations since there is no formal method for indoor air sampling for this purpose. The state does not require any specific type of data.

2. Can model results be used to rule out further consideration of the VI pathway (e.g., demonstration of no significant risk)?
   It is possible that model results be used to rule out the VI pathway. If the modeling was part of a line-of-evidence approach, then the results can be used for this purpose.

3. Does the state have numeric groundwater standards and if so, are the groundwater standards protective of (or do they screen for) the groundwater to indoor air VI pathway?
   Yes, the state has numeric groundwater standards but the promulgated values are not protective, necessarily. There are "target groundwater levels" that are not regulation that are protective of VI; these "target groundwater levels" are based on air exposure and toxicity levels that are regulated by the State of Alaska. It follows the EPA 2002 RCRA guidance.

Monitoring

1. Is monitoring of an EC required?
   Monitoring of an EC is likely required. There are regulatory requirements for ICs, and monitoring would likely be required for active systems; however, the requirements are site-specific and may depend on the responsible party and what is possible at the site.

2. If yes, what type of monitoring?
   The type of monitoring is determined on a case-by-case basis. Most likely the state would require air sampling (Ms. Wiegerson was not certain if indoor air sampling is required), but it can vary. Monitoring could possibly include sampling of the subsurface soil gas, leak testing, pressure tests, and/or indoor air sampling.

3. Does monitoring require/include indoor air sampling? Other types of air samples?
   See above.

4. Pressure measurements? Inspections?
   See above.

5. What is the frequency of monitoring/sampling?
   The required monitoring/sampling frequency is not specified.

6. What is the duration (i.e., number of quarters, years) of indoor air sampling?
   The guidance does not specify the duration for indoor air sampling.

7. Where does the sampling obligation get established/memorialized (e.g., work plan, institutional control, approval/other)?
   The sampling obligation is established/memorialized in a closure document, ROD, or a cleanup plan (for an active site).

California
Phone call with Dan Gallagher on 4/19/2010- notes of call reported by Parsons.
916-255-6536
DGallagh@dtsc.ca.gov

If the state is updating its guidance:

CA is in the process of updating its guidance.

1. Have they (or do they plan to) re-evaluate the use/role of modeling?
   No. The use of modeling will not be re-evaluated and CA will continue to use modeling.

2. If so, have you decided on any changes in regards to modeling?

Does your state use/require sensitivity analyses?

Yes.

If yes, ask the following:

1. Describe what is involved in the sensitivity analysis. Is this a modeling exercise only? If so, which variables would be evaluated? Does this entail evaluating the effect of one variable at a time? How are the results used?
   Yes, this is a modeling exercise only. A sensitivity analysis is a modeling exercise in which one variable at a time is changed.

2. Does it require indoor air sampling?
   Indoor air sampling is not required as part of sensitivity analyses, but it is recommended if vapor intrusion modeling shows that risk is high.

Approval scheme:

1. There are several ways that regulatory bodies oversee environmental projects. These include 1) scopes of work developed by consultants for the PRP are submitted to the state environmental agency for review and approval prior to implementation, or 2) an LSP-like system where environmental work is conducted, overseen and approved by a consultant certified by the state environmental agency; the state agency may or may not retrospectively audit the work.
   Follows 1).

2. How are actions or plans approved (e.g., selection of an engineering control, work plans, modeling input parameters, monitoring results, etc)?
   Actions and/or plans are submitted to a PM who manages technical staff for review and approval.

3. Does work, such as installing a mitigation system or conducting modeling, need prior approval?
   Yes.

4. What kind of follow up/confirmation, if any, is required when vapor intrusion modeling is used?
   If the risks are not acceptable, indoor air sampling is recommended; if the risks are acceptable, no follow up is required.

5. What kind of follow up is required after implementation of a vapor intrusion mitigation system? (e.g., inspections, data review, etc)? Does it vary depending on the system? (i.e., SSV, SSD, vapor barrier)
   The installation of a mitigation system requires an O&M plan, including monitoring, to show that the system is working.

Role of modeling

1. Can parties rely solely on vapor intrusion modeling to predict/determine the indoor air concentration for the purpose of calculating risk?
   Yes.

2. Can vapor intrusion modeling be used to rule out further consideration of the VI pathway (e.g., demonstration of no significant risk)?
   Yes.

3. Does the state have numeric groundwater standards and if so, are the groundwater standards protective of (or do they screen for) the groundwater to indoor air VI pathway?
   CA has MCLs, but the CA does not have groundwater criteria/standards that are protective of vapor intrusion. However, one of the San Francisco Regional Board, a local water board, does have groundwater criteria/standards.

Monitoring

1. Is monitoring of an engineering control required?
   Yes.

2. If yes, what type of monitoring?
   Indoor air sampling is not necessary. Data must be collected to demonstrate that the system is running and working. It is possible to sample above/below the membrane in an SSD/SSV system and monitor vacuum. For SSV, effluent could be tested. Pressure differential could also be measured. Initial indoor air samples are required to demonstrate compliance.

3. Does monitoring require/include indoor air sampling? Other types of air samples? Pressure measurements? Inspections?
   Visual inspections are required.

4. What is the frequency of monitoring/sampling?
   The frequency of monitoring/sampling is determined on a case-by-case basis.

5. What is the duration (i.e., number of quarters, years) of indoor air sampling?
   Indoor air sampling occurs until the source term reaches acceptable concentrations. Parties can eventually stop sampling and use inspections only if there is enough data to show that the system is stable and operating correctly.

6. Where does the sampling obligation get established/memorialized (e.g., work plan, institutional control, approval/other)?
   The sampling obligation is usually established/memorialized in a land use covenant that is attached to a property title.

Colorado
Phone call with Walter Avramenko on 4/21/2010- notes of call reported by Parsons.
303-692-3362
walter.avramenko@state.co.us

If the state is updating its guidance:

CO is not currently updating it guidance.

1. Have they (or do they plan to) re-evaluate the use/role of modeling?

2. If so, have you decided on any changes in regards to modeling?

Does your state use/require sensitivity analyses?

CO might require sensitivity analyses, but it has not been required in the past.

If yes, ask the following:

1. Describe what is involved in the sensitivity analysis. Is this a modeling exercise only? If so, which variables would be evaluated? Does this entail evaluating the effect of one variable at a time? How are the results used?

2. Does it require indoor air sampling?

Approval scheme:

1. There are several ways that regulatory bodies oversee environmental projects. These include 1) scopes of work developed by consultants for the PRP are submitted to the state environmental agency for review and approval prior to implementation, or 2) an LSP-like system where environmental work is conducted, overseen and approved by a consultant certified by the state environmental agency; the state agency may or may not retrospectively audit the work.
   Follows 1).

2. How are actions or plans approved (e.g., selection of an engineering control, work plans, modeling input parameters, monitoring results, etc)
   Actions or plans are approved by a PM that who manages technical staff for review and approval.

3. Does work, such as installing a mitigation system or conducting modeling, need prior approval?
   Yes.

4. What kind of follow up/confirmation, if any, is required when vapor intrusion modeling is used?
   Modeling is used as one line-of-evidence. If all lines of evidence point towards vapor intrusion being an issue at a site, follow up may be required and the state will advocate the direct sampling of indoor air.

5. What kind of follow up is required after implementation of a vapor intrusion mitigation system (e.g., inspections, data review, etc)? Does it vary depending on the system (i.e., SSV, SSD, vapor barrier)?

Once a vapor intrusion mitigation system is installed, sampling indoor air will be required to show that the system is working

Role of modeling

1. Can parties rely solely on vapor intrusion modeling to predict/determine the indoor air concentration for the purpose of calculating risk?
   No.

2. Can vapor intrusion modeling be used to rule out further consideration of the VI pathway (e.g., demonstration of no significant risk)?
   No.

3. Does the state have numeric groundwater standards and if so, are the groundwater standards protective of (or do they screen for) the groundwater to indoor air VI pathway?
   Yes, CO has groundwater criteria protective of vapor intrusion.

Monitoring

1. Is monitoring of an engineering control required?
   Yes.

2. If yes, what type of monitoring?
   Indoor air sampling.

3. Does monitoring require/include indoor air sampling? Other types of air samples? Pressure measurements? Inspections?
   For an SSV system, sampling of the effluent from an SSV system is not required. However, this is being done on certain homes and the RP hopes to eventually show that the effluent may be sampled instead of indoor air. For an SSD system, the pressure gauges on an SSD system must be inspected annually.

4. What is the frequency of monitoring/sampling?
   Initially, the frequency of indoor air sampling will be quarterly. This will last for at least a year, if indoor air concentrations are acceptable. After that, the frequency of would be reduced to semi-annually, then annually, and then maybe once every two to three years. For SSD systems, annual inspections of the pressure gauges may be substituted for indoor air sampling.

5. What is the duration (i.e., number of quarters, years) of indoor air sampling?
   Indoor air sampling continues until the source term reaches acceptable concentrations.

6. Where does the sampling obligation get established/memorialized (e.g., work plan, institutional control, approval/other)?
   The sampling obligation is established/memorialized pursuant to a compliance order.

Connecticut
Phone call with Carl Gruszczak and Kenneth Feathers on 4/15/2010- notes of call reported by Parsons.
Carl Gruszczak, 860-424-3948, Carl.Gruszczak@ct.gov
Kenneth Feathers, 860-424-3770, Kenneth.Feathers@ct.gov

If the state is updating its guidance:

1. Have they (or do they plan to) re-evaluate the use/role of modeling?
   CT is currently evaluating whether guidance can be enforced legally and is now making decisions based on older guidance that has been promulgated into law. Although CT does intend to develop new guidance, the process is currently on hold. In general, modeling is not currently used as part of the site investigation process. Instead, data are compared to remediation standards, which are generally risk-based. For vapor intrusion, remedial standards were developed using the JE model.

2. If so, have you decided on any changes in regards to modeling?

Does your state use/require sensitivity analyses?
Modeling is not used.
If yes, ask the following:

1. Describe what is involved in the sensitivity analysis. Is this a modeling exercise only? If so, which variables would be evaluated? Does this entail evaluating the effect of one variable at a time? How are the results used?

2. Does it require indoor air sampling?

Approval scheme:

1. How are hazardous waste sites projects managed and monitored? There are several ways that regulatory bodies oversee environmental projects. These include 1) scopes of work developed by consultants for the PRP are submitted to the state environmental agency for review and approval prior to implementation, or 2) an LSP-like system where environmental work is conducted, overseen and approved by a consultant certified by the state environmental agency; the state agency may or may not retrospectively audit the work.
   Approximately 90% of work uses LEP (licensed environmental professional) model; the remaining 10% of work follows 1) because of a high public profile or extremely sensitive receptors; e.g., daycare centers.

2. How are actions or plans approved (e.g., selection of an engineering control, work plans, modeling input parameters, monitoring results, etc)
   Plans are developed and implemented by the LEP.

3. Does work, such as installing a mitigation system or conducting modeling, need prior approval?
   Plans are developed and implemented by the LEP.

4. What kind of follow up/confirmation, if any, is required when vapor intrusion modeling is used?
   Vapor intrusion modeling is not used.

5. What kind of follow up is required after implementation of a vapor intrusion mitigation system? (e.g., inspections, data review, etc)? Does it vary depending on the system? (i.e., SSV, SSD, vapor barrier)
   The type of follow up required depends on the system. All systems require an O&M plan; indoor air sampling is not encouraged. For systems based on pressure differentials, CT encourages the measurement of pressure differentials. CT does not have guidance on other types of systems. However, CT will probably eventually concur with ITRC guidance. In CT's experience, a vapor barrier by itself isn't effective.

Role of modeling

1. Can parties rely solely on vapor intrusion modeling to predict/determine the indoor air concentration for the purpose of calculating risk?
   No, evaluation is based on achievement of remedial goals for source media; e.g., groundwater and soil gas.

2. Can vapor intrusion modeling be used to rule out further consideration of the VI pathway (e.g., demonstration of no significant risk)?
   No.

3. Does the state have numeric groundwater standards and if so, are the groundwater standards protective of (or do they screen for) the groundwater to indoor air VI pathway?
   Yes, the state has numeric criteria; these are protective of VI.

Monitoring

1. Is monitoring of an engineering control required?
   Yes. This is usually expected.

2. If yes, what type of monitoring?
   See above.

3. Does monitoring require/include indoor air sampling? Other types of air samples? Pressure measurements? Inspections?
   Indoor air sampling is not encouraged due to numerous false positives in the past.
   Visual inspections are generally part of an O&M plan. If just a passive system is installed, air samples above the membrane but below the slab are collected.

4. What is the frequency of monitoring/sampling?
   The frequency of monitoring/sampling is not regulated by the state. Typically, use monthly sampling, but frequency can be reduced if the system is demonstrated to be operating successfully.

5. What is the duration (i.e., number of quarters, years) of indoor air sampling?
   Indoor air sampling occurs until the source is removed or until a stead state condition with an acceptable risk is achieved.

6. Where does the sampling obligation get established/memorialized (e.g., work plan, institutional control, approval/other)?
   The primary place would be in DEP approval letter of O&M plan.

Delaware
Phone call with Stephen Johnson on 4/21/10- notes of call reported by Parsons.
302-395-2600
Stephen.johnson@state.de.us

If the state is updating its guidance:

DE is not currently updating its guidance.

1. Have they (or do they plan to) re-evaluate the use/role of modeling?

2. If so, have you decided on any changes in regards to modeling?

Does your state use/require sensitivity analyses?

Mr. Johnson stated that he was unsure.

If yes, ask the following:

1. Describe what is involved in the sensitivity analysis. Is this a modeling exercise only? If so, which variables would be evaluated? Does this entail evaluating the effect of one variable at a time? How are the results used?

2. Does it require indoor air sampling?

Approval scheme:

1. There are several ways that regulatory bodies oversee environmental projects. These include 1) scopes of work developed by consultants for the PRP are submitted to the state environmental agency for review and approval prior to implementation, or 2) an LSP-like system where environmental work is conducted, overseen and approved by a consultant certified by the state environmental agency; the state agency may or may not retrospectively audit the work.
   Follows 1).

2. How are actions or plans approved (e.g., selection of an engineering control, work plans, modeling input parameters, monitoring results, etc)
   Workplans are submitted to a PM (who manages technical staff) for review and approval.

3. Does work, such as installing a mitigation system or conducting modeling, need prior approval?
   Yes.

4. What kind of follow up/confirmation, if any, is required when vapor intrusion modeling is used?
   If vapor intrusion modeling indicates that the risks are greater than 1×10^{-5}, may either sample indoor air or mitigate.

5. What kind of follow up is required after implementation of a vapor intrusion mitigation system? (e.g., inspections, data review, etc)? Does it vary depending on the system? (i.e., SSV, SSD, vapor barrier)
   Current practice: visual inspections would be required and indoor air sampling may be considered.

Role of modeling

1. Can parties rely solely on vapor intrusion modeling to predict/determine the indoor air concentration for the purpose of calculating risk?
   No.

2. Can vapor intrusion modeling be used to rule out further consideration of the VI pathway (e.g., demonstration of no significant risk)?
   Yes, as long as the Johnson and Ettinger model is applicable to the site.

3. Does the state have numeric groundwater standards and if so, are the groundwater standards protective of (or do they screen for) the groundwater to indoor air VI pathway?
   DE has groundwater standards protective of vapor intrusion pathway.

Monitoring

1. Is monitoring of an engineering control required?
   Yes.

2. If yes, what type of monitoring?
   Visual inspections would be required and indoor air sampling may be considered.

3. Does monitoring require/include indoor air sampling? Other types of air samples? Pressure measurements? Inspections?
   SSV – would not require effluent to be sampled, but could be done.
   SSD – would probably look at the pressure initially to demonstrate that the system is working.

4. What is the frequency of monitoring/sampling?
   The greatest frequency would be annually, though lower frequencies are also possible.

5. What is the duration (i.e., number of quarters, years) of indoor air sampling?
   Monitoring/inspections would continue until the source term reaches acceptable concentrations.

6. Where does the sampling obligation get established/memorialized (e.g., work plan, institutional control, approval/other)?
   In the “long term stewardship plan”, which might be referenced in the deed and would definitely be reference in the Plan of Remedial Action.

Hawaii
Phone call with Roger Brewer on 4/15/2010- notes of call reported by Parsons.
808-586-4328
roger.brewer@doh.hawaii.gov

If the state is updating its guidance:

1. Have they (or do they plan to) re-evaluate the use/role of modeling?
   Generally, HI does not run site-specific models. Instead, data collected at a site is compared to Hawaii's Environmental Action Levels (EALs). The EALs protective of vapor intrusion are based on field calibrated J&E model.

2. If so, have you decided on any changes in regards to modeling?
   No changes.

Does your state use/require sensitivity analyses?

No.

If yes, ask the following:

1. Describe what is involved in the sensitivity analysis. Is this a modeling exercise only? If so, which variables would be evaluated? Does this entail evaluating the effect of one variable at a time? How are the results used?

2. Does it require indoor air sampling?

Approval scheme:

1. There are several ways that regulatory bodies oversee environmental projects. These include 1) scopes of work developed by consultants for the PRP are submitted to the state environmental agency for review and approval prior to implementation, or 2) an LSP-like system where environmental work is conducted, overseen and approved by a consultant certified by the state environmental agency; the state agency may or may not retrospectively audit the work.
   Follows 1).

2. How are actions or plans approved (e.g., selection of an engineering control, work plans, modeling input parameters, monitoring results, etc)
   Reviewed and approved by PM and technical staff.

3. Does work, such as installing a mitigation system or conducting modeling, need prior approval?
   Yes.

4. What kind of follow up/confirmation, if any, is required when vapor intrusion modeling is used?
   Vapor intrusion modeling is not used. However, if groundwater or soil EALs are exceeded, would require soil gas samples. If soil gas samples exceed EALs, indoor air sampling would be recommended (if building present).

5. What kind of follow up is required after implementation of a vapor intrusion mitigation system? (e.g., inspections, data review, etc)? Does it vary depending on the system? (i.e., SSV, SSD, vapor barrier)
   This varies depending upon the severity of the risk. For sites where there is a significant risk, Hawaii would require visual inspections, follow up soil gas monitoring underneath and/or above vapor barrier and, in some cases, indoor air monitoring. For sites where there is a medium risk, it would be recommend (but not required) that a vapor barrier be installed; however, no follow up would be required.

Role of modeling

1. Can parties rely solely on vapor intrusion modeling to predict/determine the indoor air concentration for the purpose of calculating risk?
   HI does not allow site specific modeling. However, parties can rely solely on soil gas and groundwater EALs.

2. Can vapor intrusion modeling be used to rule out further consideration of the VI pathway (e.g., demonstration of no significant risk)?
   HI does not allow site specific modeling. However, parties can rely solely on soil gas and groundwater EALs.

3. Does the state have numeric groundwater standards and if so, are the groundwater standards protective of (or do they screen for) the groundwater to indoor air VI pathway?
   Yes and yes.

Monitoring

1. Is monitoring of an engineering control required?
   At high risk sites, yes. Otherwise, no.

2. If yes, what type of monitoring?
   See above.

3. Does monitoring require/include indoor air sampling? Other types of air samples? Pressure measurements? Inspections?
   Monitoring is required immediately after mitigation measures are implemented at high risk sites for a short time. If an SSD is used, monitoring would require pressure differential measurements.

4. What is the frequency of monitoring/sampling?
   For soil gas, monitoring would be quarterly. For indoor air, sampling frequency would be weekly initially then monthly. If sampling demonstrates that mitigation has been successful, sampling would no longer be required.

5. What is the duration (i.e., number of quarters, years) of indoor air sampling?
   Until the source term reaches acceptable concentrations.

6. Where does the sampling obligation get established/memorialized (e.g., work plan, institutional control, approval/other)?
   For a high risk site, this would be in an IC and deed covenant. For a medium risk site, this would be in the work plan and a deed covenant would not be used.

Idaho
Phone call to Bruce Wicherski on 4/15/2010- notes of call reported by Parsons.
208-373-0246
Bruce.Wicherski@deq.idaho.gov

If the state is updating its guidance:

1. Have they (or do they plan to) re-evaluate the use/role of modeling?
   Yes.

2. If so, have you decided on any changes in regards to modeling?
   Nothing has been finalized. Discussions revolve around the use and role of the J&E model and potential use of other models; e.g., API's Biovapor. Revised process will likely include some role for modeling, although the exact role is not yet clear.

Does your state use/require sensitivity analyses?

No.

If yes, ask the following:

1. Describe what is involved in the sensitivity analysis. Is this a modeling exercise only? If so, which variables would be evaluated? Does this entail evaluating the effect of one variable at a time? How are the results used?

2. Does it require indoor air sampling?

Approval scheme:

1. There are several ways that regulatory bodies oversee environmental projects. These include 1) scopes of work developed by consultants for the PRP are submitted to the state environmental agency for review and approval prior to implementation, or 2) an LSP-like system where environmental work is conducted, overseen and approved by a consultant certified by the state environmental agency; the state agency may or may not retrospectively audit the work.
   Neither. Would not require prior approval for a workplan for a site investigation. However, for remediation work, ID follows 1).

2. How are actions or plans approved (e.g., selection of an engineering control, work plans, modeling input parameters, monitoring results, etc)
   Submitted to technical staff and PM for review and approval.

3. Does work, such as installing a mitigation system or conducting modeling, need prior approval?
   Mitigation systems: yes. Vapor intrusion modeling does not require prior approval to perform, but it is reviewed after it is performed.

4. What kind of follow up/confirmation, if any, is required when vapor intrusion modeling is used?
   If modeling indicates that risks from vapor intrusion are acceptable, indoor air sampling is not required. However, if modeling indicates that risks from vapor intrusion are unacceptable, can either clean up or do additional site characterization, which could include indoor air sampling.

5. What kind of follow up is required after implementation of a vapor intrusion mitigation system? (e.g., inspections, data review, etc)? Does it vary depending on the system? (i.e., SSV, SSD, vapor barrier)
   Have not had enough sites where mitigation systems were installed to have a standard. However, a monitoring plan would be required in which the level of monitoring would be specified.

Role of modeling

1. Can parties rely solely on vapor intrusion modeling to predict/determine the indoor air concentration for the purpose of calculating risk?
   At present, yes.

2. Can vapor intrusion modeling be used to rule out further consideration of the VI pathway (e.g., demonstration of no significant risk)?
   At present, yes.

3. Does the state have numeric groundwater standards and if so, are the groundwater standards protective of (or do they screen for) the groundwater to indoor air VI pathway?
   Yes, ID has groundwater standards. For 18 petroleum related chemicals, have rule-based GW screening levels protective of vapor intrusion.

Monitoring

1. Is monitoring of an engineering control required?
   Yes.

2. If yes, what type of monitoring?
   SVE – normally monitoring effluent from SVE system and monitoring groundwater and visual inspections. Indoor air sampling may be required if goal is to mitigate vapor intrusion risks.
   ID does not have a lot of experience with SSD and, therefore, can't make any recommendations for monitoring of SSD systems.

3. Does monitoring require/include indoor air sampling? Other types of air samples? Pressure measurements? Inspections?
   See above.

4. What is the frequency of monitoring/sampling?
   For operational parameters, inspections are typically performed on a monthly basis. Monitoring for progress is typically performed on a quarterly basis.

5. What is the duration (i.e., number of quarters, years) of indoor air sampling?
   Until it can be demonstrated that groundwater or soil (not soil vapor) cleanup criteria have been achieved. There will also be some post-remediation monitoring to demonstrate that there is no "rebound" after the remediation system is turned off. For groundwater, rebound monitoring is typically 4 quarters. Indoor air monitoring would not be as long, but there are no set criteria.

6. Where does the sampling obligation get established/memorialized (e.g., work plan, institutional control, approval/other)?
   Corrective action plan.

Illinois
Phone call with Heather Nifong on 4/16/2010- notes of call reported by Parsons.
217-785-4729
Heather.Nifong@illinois.gov

Note that the Illinois proposed vapor intrusion guidance in 2008. However, USEPA disagreed with the approach. Therefore, the Illinois' Tiered Approach to Corrective Action Objectives (TACO) program does not currently have an approved approach for dealing with vapor intrusion. However, Illinois is working with USEPA to resolve their differences in vapor intrusion guidance. Illinois should have new draft vapor intrusion guidance document in a matter of months. But it will take another year or more before guidance is promulgated.

If the state is updating its guidance:

1. Have they (or do they plan to) re-evaluate the use/role of modeling?
   No, will continue to use modeling.

2. If so, have you decided on any changes in regards to modeling?
   The previous draft vapor intrusion guidance document did not include the advection component. Advection is being put back in the forthcoming draft.

Does your state use/require sensitivity analyses?

No.

If yes, ask the following:

1. Describe what is involved in the sensitivity analysis. Is this a modeling exercise only? If so, which variables would be evaluated? Does this entail evaluating the effect of one variable at a time? How are the results used?

2. Does it require indoor air sampling?

Approval scheme:

1. There are several ways that regulatory bodies oversee environmental projects. These include 1) scopes of work developed by consultants for the PRP are submitted to the state environmental agency for review and approval prior to implementation, or 2) an LSP-like system where environmental work is conducted, overseen and approved by a consultant certified by the state environmental agency; the state agency may or may not retrospectively audit the work.
   Illinois uses option 1).

2. How are actions or plans approved (e.g., selection of an engineering control, work plans, modeling input parameters, monitoring results, etc)
   There are three tiers in Illinois TACO system. Plans that follow Tiers 1 + 2 (i.e., follow generic guidance) are approved by a project manager, which is also a technical person. Plans that follow Tier 3 would require review by a group of senior staff prior to approval.

3. Does work, such as installing a mitigation system or conducting modeling, need prior approval?
   Yes.

4. What kind of follow up/confirmation, if any, is required when vapor intrusion modeling is used?
   The work must be certified by a Licensed Registered Engineer (LRE). If the risks from vapor intrusion, as determined by modeling, are greater than 10^{-6}, further investigation or remediation will be necessary, which could include indoor air sampling. However, remediation or mitigation are preferred over indoor air sampling.

5. What kind of follow up is required after implementation of a vapor intrusion mitigation system? (e.g., inspections, data review, etc)? Does it vary depending on the system? (i.e., SSV, SSD, vapor barrier)
   This does not vary by system. The State issues a No Further Remediation letter, which contains all terms and conditions. This is filed with the county and attaches to the property title. Periodic inspections, but not monitoring, would be required.

Role of modeling

1. Can parties rely solely on vapor intrusion modeling to predict/determine indoor air concentration for the purpose of calculating risk?
   Yes.

2. Can vapor intrusion modeling be used to rule out further consideration of the VI pathway (e.g., demonstration of no significant risk)?
   Yes.

3. Does the state have numeric groundwater standards and if so, are the groundwater standards protective of (or do they screen for) the groundwater to indoor air VI pathway?
   Yes, the state currently has groundwater standards. The current standards are only protective of potable water use. However, the new draft vapor intrusion guidance document will include proposed groundwater standards protective of VI.

Monitoring

1. Is monitoring of an engineering control required?
   No, just visual inspections are required.

2. If yes, what type of monitoring?

3. Does monitoring require/include indoor air sampling? Other types of air samples? Pressure measurements? Inspections?
   Only visual inspections are required.

4. What is the frequency of monitoring/sampling?
   Frequency of inspections would be every two years.

5. What is the duration (i.e., number of quarters, years) of indoor air sampling?
   Until the source term reaches acceptable concentrations.

6. Where does the sampling obligation get established/memorialized (e.g., work plan, institutional control, approval/other)?
   In the No Further Remediation letter, which gets filed with the county.

Indiana
Sent via email to Megan Hamilton and Kevin Spindler, Returned on 4/21/10
317-234-3928
megan.hamilton@idem.in.gov

If the state is updating its guidance:

1. Have they (or do they plan to) re-evaluate the use/role of modeling?
   Yes.
2. If so, have you decided on any changes in regards to modeling?
   No changes have been officially accepted, but IDEM is considering allowing the limited used of the Johnson-Ettinger model at industrial facilities. If this proposal is accepted, modeling may be used to calculate a non-default sub-slab to indoor air attenuation factor. The only parameters that would be allowed to be adjusted would be the building volume/mixing height. Note that this would likely only apply to industrial buildings located on the property responsible for the release of contamination into the environment, and would still require the collection of an appropriate number of sub-slab vapor samples.

Does your state use/require sensitivity analyses?
If yes, ask the following:

1. Describe what is involved in the sensitivity analysis. Is this a modeling exercise only? If so, which variables would be evaluated? Does this entail evaluating the effect of one variable at a time? How are the results used?
   Currently, IDEM requires that a sensitivity analysis be submitted with the modeling results, but does not have formal guidance as to which parameters should be evaluated. However, research shows that models are most sensitive to the air exchange rate, water content, mixing height, source depth, porosity, and pressure driven soil gas flow rate (Qsoil), so any thorough sensitivity analysis would investigate the effects of these parameters. IDEM supports synergistic sensitivity analysis, rather than one-at-a-time, to give a more realistic assessment of uncertainty in the model, based on "Uncertainty in the Johnson-Ettinger Model for Vapor Calculations", by Weaver and Tillman, US EPA, September 2005.

2. Does it require indoor air sampling?

   Confirmatory indoor air samples are needed to verify the results of the model.

Approval scheme:

1. How are hazardous waste site projects managed and monitored? There are several ways that regulatory bodies oversee environmental projects. These include 1) scopes of work developed by consultants for the PRP are submitted to the state environmental agency for review and approval prior to implementation, or 2) an LSP-like system where environmental work is conducted, overseen and approved by a consultant certified by the state environmental agency; the state agency may or may not retrospectively audit the work.
   Hazardous waste site projects in Indiana are handled as suggested in example 1 above. IDEM's Office of Land Quality (OLQ) has a Remediation Branch made up of several program areas

(Voluntary Remediation, State Clean-up Program, LUST Program). The Project Managers (PM) in these sections manages a site through the entire investigation, characterization, remediation, and closure processes.

2. How are actions or plans approved (e.g., selection of an engineering control, work plans, modeling input parameters, monitoring results, etc)
   These plans are approved through the IDEM Project Manager for the specific site. OLQ has a Science Services Branch which is made up of several "Technical Sections" (Chemistry Services, Geological Services, Engineering and Data Services, and Risk Services). The PMs send out the site investigation or work plans, etc to the different Technical Sections for review. The PM then compiles all of the technical comments and makes a decision as to the adequacy of the proposed plan.

3. Does work, such as installing a mitigation system or conducting modeling, need prior approval?
   Installing a mitigation system or conducting modeling does not "require" prior approval; however, it is in the consultant's best interest to have these plans approved before implementation. If a consultant chooses to conduct work that has not been approved, they run the risk of IDEM rejecting the work afterwards. This results in wasted time and money. In general, most consultants seek approval of mitigation system installation prior to the work being done. Modeling in an attempt to screen out a site has been submitted several times without prior approval. Since IDEM does not allow modeling for the use of screening out sites, the consultant is usually advised to go back and conduct a VI investigation.

4. What kind of follow up/confirmation, if any, is required when vapor intrusion modeling is used?
   Indoor air samples are needed to validate the results of the model.

5. What kind of follow up is required after implementation of a vapor intrusion mitigation system? (e.g., inspections, data review, etc)? Does it vary depending on the system? (i.e., SSV, SSD, vapor barrier)
   Confirmatory requirements are site-specific. IDEM's current VI Guidance does not address confirmatory sampling requirements. In practice, IDEM generally asks for at least one indoor air sampling event during worst case conditions and regular monitoring of the mitigation system's pressure gauge. Confirmatory sampling requirements are being developed for IDEM's updated VI Guidance.

Role of modeling

1. Can parties rely solely on vapor intrusion modeling to predict/determine the indoor air concentration for the purpose of calculating risk?
   No.

2. Can vapor intrusion modeling be used to rule out further consideration of the VI pathway (e.g., demonstration of no significant risk)?
   Not without accompanying indoor air data to validate the results of the model.

3. Does the state have numeric groundwater standards and if so, are the groundwater standards protective of (or do they screen for) the groundwater to indoor air VI pathway?
   Yes, IDEM has VI Ground Water Screening Levels for a handful of contaminants. The levels are based on conservative assumptions and are protective of the groundwater to indoor air VI pathway. They can be found in Appendix VIII of IDEM's Draft VI Guidance found at: http://www.in.gov/idem/files/la-073-gg.pdf. Ground Water Screening Levels for other contaminants are available upon request. IDEM is in the process of revising this method for the updated VI Guidance. Right now, IDEM is considering publishing ground water screening levels for all contaminants considered volatile. Only screening levels protective of a chronic 25/30 year exposure duration will be used for purposes of this screening tool. We are still in the policy development stages, so this thought pattern could change before final guidance is published.

Monitoring

1. Is monitoring of an engineering control required?
   If this question is referring to a VI mitigation system, then monitoring requirements are currently being developed for the updated VI Guidance. See number 5 under the "Approval Scheme" section above.

2. If yes, what type of monitoring?

3. Does monitoring require/include indoor air sampling? Other types of air samples? Pressure measurements? Inspections?

4. What is the frequency of monitoring/sampling?

5. What is the duration (i.e., number of quarters, years) of indoor air sampling?

6. Where does the sampling obligation get established/memorialized (e.g., work plan, institutional control, approval/other)?

Kentucky
Sarah Gaddis, Environmental Scientist on 4/20/10
Kentucky Environmental Protection Agency, Waste Management Division
(502) 564-5981
Sarah.Gaddis@ky.gov

If the state is updating its guidance:

1. Have they (or do they plan to) re-evaluate the use/role of modeling?
   N/A
2. If so, have you decided on any changes in regards to modeling?
   N/A

If a state uses a sensitivity analysis:

1. Describe what is involved in the sensitivity analysis. Is this a modeling exercise only? If so, which variables would be evaluated? Does this entail evaluating the effect of one variable at a time? How are the results used? N/A

2. Does it require indoor air sampling? N/A

Approval scheme:

1. How are hazardous waste sites projects managed and monitored? There are several ways that regulatory bodies oversee environmental projects. These include 1) scopes of work developed by consultants for the PRP are submitted to the state environmental agency for review and approval prior to implementation, or 2) an LSP-like system where environmental work is conducted, overseen and approved by a consultant certified by the state environmental agency; the state agency may or may not retrospectively audit the work.
   KY EPA Project Manager (PM) has responsibility for all sites within a County. PM reviews Phase I reports and determines if conditions at the site indicate a potential vapor intrusion issue. If VI is a concern, the department VI specialist (Sarah) gets involved. The VI specialist is involved in all VI sites in the state.

2. How are actions or plans approved (e.g., selection of an EC, work plans, modeling input parameters, monitoring results, etc)
   PM and VI specialist review plans and reports, then work with responsible party on next steps (mitigation, monitoring).

3. Does work, such as installing a mitigation system or conducting modeling, need prior approval?
   No, but most responsible parties involve the agency in the review and mitigation process. For petroleum sites, the state has a "Solvent Fund" from which site owners are reimbursed for actions approved by the state. This is a strong incentive for involving the state early.

4. What kind of follow up/confirmation, if any, is required when vapor intrusion modeling is used? What kind of follow up is required after implementation of a vapor intrusion mitigation system? (e.g., inspections, data review, etc)? Does it vary depending on the system? (i.e., SSV, SSD, vapor barrier)
   Modeling: KY EPA is negative on modeling. They feel the J&E model is too conservative for petroleum sites and under predicts for sites with groundwater in bedrock/Karst (there is a lot of Karst in KY). Follow up after mitigation: Monitoring and data review.

Role of modeling

1. Can parties rely solely on modeling to predict/determine the indoor air concentration for the purpose of calculating risk?
   No. Modeling is usually done in Phase I by consultants to identify potential for vapor intrusion concern (pVIC) under ASTM Standard Practice. Modeling is allowed primarily as one line of evidence. KY likes to see other evidence as well (e.g., sampling).

2. Can model result be used to rule out further consideration of the VI pathway (e.g., demonstration of no significant risk)?
   No.

3. Does the state have numeric groundwater standards and if so, are the groundwater standards protective of (or do they screen for) the groundwater to indoor air VI pathway?
   State does not have its own standards – KY relies on screening values from OSWER 2002 guide (Table 2c – 10-6 risk level) which are protective of indoor air from VI.

Monitoring

1. Is monitoring of an EC required?
   Yes.

2. If yes, what type of monitoring?
   Indoor air sampling and visual operational monitoring.

3. Does monitoring require/include indoor air sampling? Other types of air samples?
   Yes.

4. Pressure measurements? Inspections?
   Periodic inspections – usually coordinated with quarterly groundwater monitoring.

5. What is the frequency of monitoring/sampling?
   Initially, indoor air sampling every 2 weeks. If all samples indicate system effectiveness, then reduce frequency to quarterly. After 4 quarters, reduce to annual.

6. What is the duration (i.e., number of quarters, years) of indoor air sampling?
   See above.

7. Where does the sampling obligation get established/memorialized (e.g., work plan, institutional control, approval/other)?
   For the state superfund program, obligations are written in the Managed Remediation Plan.
   For petroleum sites (USTs, spills, etc), the state issues written Individual Directives.

Maine
Phone call with Pete Eremita on 04/14/2010- notes of call reported by Parsons.
207-822-6300
pete.m.eremita@maine.gov

If the state is updating its guidance:

1. Have they (or do they plan to) re-evaluate the use/role of modeling?
   No update is currently planned; however, it is likely that the guidance will be updated within approximately 1.5 years.

2. If so, have you decided on any changes in regards to modeling?
   Currently, Maine does not rely heavily on modeling. This will be revaluated when the guidance is next updated.

If a state uses a sensitivity analysis:

1. Describe what is involved in the sensitivity analysis. Is this a modeling exercise only? If so, which variables would be evaluated? Does this entail evaluating the effect of one variable at a time? How are the results used?
   The use of a sensitivity analysis would be left up to the project manager. Generally, a sensitivity analysis should identify the most sensitive parameters, then one parameter at a time is varied to determine the effect on the model.

2. Does it require indoor air sampling?
   Yes, modeling must be accompanied by field data.

Approval scheme:

1. How are hazardous waste site projects managed and monitored? There are several ways that regulatory bodies oversee environmental projects. These include 1) review by the regulatory body with a PM assigned to manage the site, 2) an LSP-like system where all environmental work is reviewed by a another consultant certified by the state environmental agency and 3) or a form of direct oversight.
   Hazardous waste site projects are reviewed by the regulatory body with a PM assigned to manage the site.

2. How are actions or plans approved (e.g., selection of an EC, work plans, modeling input parameters, monitoring results, etc
   The state reviews everything using technical staff managed by a PM.

3. Does work, such as installing a mitigation system or conducting modeling, need prior approval?
   Yes.

4. What kind of follow up is required after implementation of vapor intrusion modeling?

The follow up would be determined on a project- and site-specific basis that is dependent on the level of confidence in the applicability of the model to the site. However, Maine would prefer to validate modeling with field data in any case and is likely to skip modeling entirely. This is because the majority of buildings in the state have groundwater either in contact with the foundation or very close to it, which violates the assumptions of the Johnson and Ettinger model.

Maine has not yet had to deal with properties where there are no buildings. However, for those properties, if modeling indicated that vapor intrusion was represented an acceptable risk, Maine would probably still recommend a passive mitigation system that could be converted to an active system in the future.

5. What kind of follow up is required after implementation of a mitigation system? (e.g., inspections, data review, etc)?
   The inspection would most likely consist of making sure that there was a vacuum associated with any depressurization system that was installed and sampling the exhaust from any venting system installed. However, this hasn't been formalized. Indoor air sampling may not really provide any useful data.

Role of modeling

1. Is modeling used for the sole purpose of calculating risk?
   No, but it can be used as a line of evidence. Indoor air sampling is preferred for estimating risks.

2. Can model result be used to rule out further consideration of the VI pathway (e.g., demonstration of acceptable risk)?
   No, but it can be used as a line of evidence. However, multiple lines of evidence would be required to rule out vapor intrusion; e.g., acceptable soil gas and sub-slab soil gas concentrations when using empirical/default attenuation factors. However, it was noted that some other PMs in the department may disagree.

3. Are the groundwater standards protective of (or do they screen for) the groundwater to indoor air VI pathway?
   No.

Monitoring

1. Is monitoring of an EC required?
   Yes.

2. What is the frequency of monitoring?
   There is currently no definitive guidance for Maine. Current practice for heating oil spills would probably be followed, which includes initial high frequency sampling; i.e., maybe every week for a month. Once things look under control, then sampling would shift to monthly, then quarterly, and finally to yearly.

Maryland
Phone call with Mark Mank on 4/15/2010- notes of call reported by Parsons.
410-537-3436
mmank@mde.state.md.us

If your state is updating its guidance:

1. Have you (or do you) plan to re-evaluate the use/role of vapor intrusion modeling?
   Maryland's guidance is updated approximately every 18 months to 2 years. The utility of models will be re-evaluated during every update.

2. If so, have you decided on any changes in regards to vapor intrusion modeling?
   At present, it is anticipated that modeling will continue to be used.

If your state uses sensitivity analysis to support vapor intrusion modeling:

1. Describe what is involved in the sensitivity analysis. Is this a modeling exercise only? If so, which variables would be evaluated? Does this entail evaluating the effect of one variable at a time? How are the results used?
   A sensitivity analysis is not required.

2. Does a sensitivity analysis require indoor air sampling?

Approval scheme:

1. How are hazardous waste site projects managed and monitored? There are several ways that regulatory bodies oversee environmental projects. These include 1) review by the regulatory body with a PM assigned to managed the site, 2) an LSP-like system where all environmental work is reviewed by a another consultant certified by the state environmental agency and 3) or a form of direct oversight. Which does your state use?
   Hazardous waste site projects are reviewed by the regulatory body with a PM assigned to managed the site.

2. How are actions or plans approved? For example, the selection of an EC, work plans, modeling input parameters, monitoring results, etc.
   Plans and actions are reviewed before they are implemented. Remedial actions require validation afterwards to demonstrate that remediation was successful; e.g., indoor air sampling.

3. Does work, such as installing a mitigation system or conducting modeling, need prior approval?
   Yes.

4. What kind of follow up is required after vapor intrusion modeling?
   If vapor intrusion modeling predicts that indoor air concentrations will be acceptable, no follow up will be required. However, if vapor intrusion modeling indicates that risks are too high, then indoor air sampling is recommended.

5. What kind of follow up is required after implementing a vapor intrusion mitigation system? For example, inspections, indoor air sampling, testing pressure differentials, etc.
   Indoor air will always have to be sampled to demonstrate successful implementation of the mitigation system. In addition, visual inspections of the mitigation system will be used. For all types of mitigation systems, an O&M plan is required, as well. As part of the O&M plan for an SSD system, the pressure gauges would be checked to ensure that the system is generating a vacuum.

Role of modeling

1. Is vapor intrusion modeling used for the sole purpose predicting of indoor air concentrations which are then used to calculate risks?
   Somewhat, but then the modeling is validated with indoor air sampling.

2. Can vapor intrusion modeling results be used to rule out further consideration of the VI pathway (e.g., demonstration of acceptable risk)?
   Yes.

3. Are your states groundwater standards protective of (or do they screen for) the groundwater to indoor air VI pathway?
   No.

Monitoring

1. Is monitoring of an engineering control (e.g., sub-slab depressurization system) required?
   Yes.

2. If so, what type of monitoring?
   See above.

3. If sampling is required, is it indoor air sampling or are other types of air samples collected? What about pressure measurements and visual inspections of system integrity/function?
   Indoor air sampling would be required for all types of mitigation systems to demonstrate successful implementation of the mitigation system. For an SVE system, it would not be required to sample the exhaust. When sampling indoor air, it is recommended that outdoor air be sampled at the same time.

4. What is the frequency of monitoring?
   The frequency of monitoring depends on the type of mitigation system. Generally, monitoring is initially quarterly. If the system is functioning properly and indoor air measurements are acceptable, monitoring will be decreased to every 6 months. Following a few rounds of successful monitoring every six months, it would cease.

   If a vapor barrier and SSD are installed, only initial inspections are necessary as these systems are doubly protective and do not fail often. For an SSD system by itself, after initial monitoring, would just make sure that the system is function but would not require sampling.

Massachusetts
Gerard Martin replied via email on 4/27/10
508-946-2799
Gerard.Martin@state.ma.us

If the state is updating its guidance:

Yes, MassDEP is updating their guidance.

1. Have they (or do they plan to) re-evaluate the use/role of modeling?
   MassDEP is currently re-evaluating the role of modeling in vapor intrusion assessments.
2. If so, have you decided on any changes in regards to modeling?
   MassDEP is in the process of finalizing its position regarding when and how models should be used at sites with potential vapor intrusion. Our interim position is that modeling can be used as one of the lines of evidence but not as the sole determinant of indoor air concentrations or risk where the potential for vapor intrusion exists. MassDEP's model-based Groundwater Category GW-2 Standards (applied to groundwater near occupied buildings and designed to be protective of indoor air) are a screening tool to identify sites where vapor intrusion may be a concern. MassDEP is of the opinion that the analytical models do not adequately predict concentrations of VOCs in indoor air and advocates for sampling if other lines off evidence indicate that the indoor air is potentially impacted.

If a state uses a sensitivity analysis:

1. Describe what is involved in the sensitivity analysis. Is this a modeling exercise only? If so, which variables would be evaluated? Does this entail evaluating the effect of one variable at a time? How are the results used?
   MassDEP is not directly involved in conducting sensitivity analysis.

2. Does it require indoor air sampling?
   As stated above, MassDEP advocates sampling if other lines of evidence indicate that the indoor air is potentially impacted.

Approval scheme:

1. How are hazardous waste sites projects managed and monitored? There are several ways that regulatory bodies oversee environmental projects. These include 1) scopes of work developed by consultants for the PRP are submitted to the state environmental agency for review and approval prior to implementation, or 2) an LSP-like system where environmental work is conducted, overseen and approved by a consultant certified by the state environmental agency; the state agency may or may not retrospectively audit the work.
   LSP oversight of work; reports filed with MassDEP by LSP; audits conducted by MassDEP on a percentage of those reports, usually within five years of submittal; and enforcement as appropriate.

2. How are actions or plans approved (e.g., selection of an EC, work plans, modeling input parameters, monitoring results, etc)
   Action plans are developed by the LSP. MassDEP has the authority to review and approve these plans if the situation warrants (e.g., evidence of exposure in schools, residences, daycares, Imminent Hazard concentrations present). Otherwise, the PRP/LSP implements the plan and the MassDEP may audit that work after it's conducted.

3. Does work, such as installing a mitigation system or conducting modeling, need prior approval?
   Same as above.

4. What kind of follow up/confirmation, if any, is required when vapor intrusion modeling is used? What kind of follow up is required after implementation of a vapor intrusion mitigation system? (e.g., inspections, data review, etc)? Does it vary depending on the system? (i.e., SSV, SSD, vapor barrier)
   As part of the guidance development effort, MassDEP is currently evaluating these issues and plans to better define it in the guidance.

Role of modeling

1. Can parties rely solely on modeling to predict/determine the indoor air concentration for the purpose of calculating risk?
   MassDEP advocates the use of multiple lines of evidence and the collection of samples over using a model to predict the indoor air concentrations where the potential for vapor intrusion is indicated.

2. Can model result be used to rule out further consideration of the VI pathway (e.g., demonstration of no significant risk)?
   If the other lines of evidence indicate that the indoor air is potentially impacted, MassDEP would require the collection of indoor air samples to determine the exposure point concentration.

3. Does the state have numeric groundwater standards and if so, are the groundwater standards protective of (or do they screen for) the groundwater to indoor air VI pathway?
   Yes, MassDEP's Groundwater Category GW-2 Standards are designed to be protective relative to the indoor air pathway at most sites.

Monitoring

1. Is monitoring of an EC required?
   As part of the guidance development effort, MassDEP is currently evaluating these issues and plans to better define it in the guidance.

   If an EC was used as part of the active remedy at the site, monitoring is required and documented through Remedial Monitoring Reports (submitted every six months) until site closure can be achieved. At this time site closure cannot be attained if an active EC is necessary to maintain No Significant Risk.

Currently, MassDEP's position on monitoring is as follows:

If an EC is used to address VI, it should be demonstrated that it is effective and the performance standards are met. Where passive (SSV) systems are used, *more post-installation monitoring of indoor air quality is typically needed* than would be necessary following the installation of an active (SSD) system to demonstrate the effectiveness, since passive systems are inherently less efficient and consistent in preventing vapor intrusion than active systems.

After initial post-installation indoor air testing to confirm the effectiveness of a SSD system, pressure testing may be used to monitor an SSD system that has been shown to be effective. When a passive SSV system is used to address vapor intrusion, post-installation indoor air testing is necessary (pressure testing is not applicable) to confirm effectiveness.

2. If yes, what type of monitoring?
   Indoor air sampling should be conducted (at least initially) to demonstrate that the EC is working. See above.

3. Does monitoring require/include indoor air sampling? Other types of air samples?

4. Pressure measurements? Inspections?
   For sub-slab depressurization systems an initial round of indoor air sampling should be conducted in conjunction with pressure testing. If the initial testing demonstrates that the system is effective in mitigating indoor air impacts subsequent monitoring may consist of inspections and assurance that adequate pressure conditions are maintained.

5. What is the frequency of monitoring/sampling?
   As part of the guidance development effort, MassDEP is currently evaluating these issues and plans to better define it in the guidance.

6. What is the duration (i.e., number of quarters, years) of indoor air sampling?
   Currently, MassDEP does not have a required time frame for indoor air sampling, but it is standard that groundwater be sampled over four seasons prior to closing a site so it is reasonable to expect that the indoor air be samples multiple times over a long period of time to demonstrate that significant fluctuations are not likely.

7. Where does the sampling obligation get established/memorialized (e.g., work plan, institutional control, approval/other)?
   The sampling requirements could be included in the work plan for the remedial alternative selected (Phase IV Remedial Implementation Plan) for an active system operated until the sites can be closed or in an Activity and Use Limitation for a passive system if it is necessary to maintain No Significant Risk after site closure.

Michigan
Phone call with Amy Salisbury on 4/20/2010- notes of call reported by Parsons.
517-241-3584
salisburya@michigan.gov

If the state is updating its guidance:

Currently MI is updating the guidance.

1. Have they (or do they plan to) re-evaluate the use/role of modeling?
   Yes.

2. If so, have you decided on any changes in regards to modeling?
   The current proposal includes changing the basis of media-specific criteria from the JE model to USEPA attenuation factors. Additionally, the current proposal would eliminate soil criteria protective of vapor intrusion, which are currently promulgated. The attenuation factors used in the current proposal are from values communicated to the state in 2006 by USEPA do not reflect USEPA's current draft attenuation factor database; i.e., 0.02 for sub-slab and 0.002 for deep soil gas.

Does your state use/require sensitivity analyses?

If site specific modeling is allowed, it would be required. However, USEPA attenuation factors would normally be used.

If yes, ask the following:

1. Describe what is involved in the sensitivity analysis. Is this a modeling exercise only? If so, which variables would be evaluated? Does this entail evaluating the effect of one variable at a time? How are the results used?
   Currently MI has no guidance.

2. Does it require indoor air sampling?

Approval scheme:

1. There are several ways that regulatory bodies oversee environmental projects. These include 1) scopes of work developed by consultants for the PRP are submitted to the state environmental agency for review and approval prior to implementation, or 2) an LSP-like system where environmental work is conducted, overseen and approved by a consultant certified by the state environmental agency; the state agency may or may not retrospectively audit the work.
   UST sites follow an LSP-like system called "qualified consultant." Non-UST sites follow 1).

2. How are actions or plans approved (e.g., selection of an engineering control, work plans, modeling input parameters, monitoring results, etc)
   Submitted to PM and technical staff for review and approval. For UST sites, the closure reports are reviewed as part of an audit.

3. Does work, such as installing a mitigation system or conducting modeling, need prior approval?

Mitigation systems: prior approval is preferred, but not required. Mitigation systems would be detailed in the Remedial Action Plan (RAP), but the mitigation system can be implemented before the RAP is approved. In that case, the consultant usually comes in and talks to the state to float their ideas and determine whether the state would approve the proposed mitigation system.
Modeling: site specific modeling does require approval.

4. What kind of follow up/confirmation, if any, is required when vapor intrusion modeling is used?
   When using generic screening values, no follow up is required. If measured concentrations exceed site-specific groundwater criteria (based on the JE model), would request that either soil gas data be collected or that mitigation be performed. If measured concentrations exceed soil gas criteria, a "site-specific evaluation" would be required. This could include many different things, but most RPs mitigate at this point.

5. What kind of follow up is required after implementation of a vapor intrusion mitigation system? (e.g., inspections, data review, etc)? Does it vary depending on the system? (i.e., SSV, SSD, vapor barrier)
   This will depend on the type of system. All systems require a permanent marker, monitoring, O&M plan, financial assurance on the part of the RP, and restrictive covenants. All of these can be negotiated as part of the RAP review, but all would generally be included, except for the permanent marker.

   Compliance monitoring is part of the proposed vapor intrusion guidance. This is currently being developed – so MI can't provide details as the details are evolving quickly.

Role of modeling

1. Can parties rely solely on vapor intrusion modeling to predict/determine the indoor air concentration for the purpose of calculating risk?
   Yes, as long as the existing criteria apply. For the proposed vapor intrusion guidance, no follow up is required, but vapor intrusion would be assessed using USEPA attenuation factors and not the JE model.

2. Can vapor intrusion modeling be used to rule out further consideration of the VI pathway (e.g., demonstration of no significant risk)?
   Yes. If data collected at the site are all below generic criteria, no follow up is required.

3. Does the state have numeric groundwater standards and if so, are the groundwater standards protective of (or do they screen for) the groundwater to indoor air VI pathway?
   MI has promulgated groundwater standards that are protective of VI.

Monitoring

3. Is monitoring of an engineering control required?
   Yes, in most cases.

4. If yes, what type of monitoring?

Matt Williams (517-373-4821) was referenced as a source for more information; however, he was not available for further input within the timeframe of the survey.

5. Does monitoring require/include indoor air sampling? Other types of air samples? Pressure measurements? Inspections?
   Matt Williams (517-373-4821) was referenced as a source for more information; however, he was not available for further input within the timeframe of the survey.

6. What is the frequency of monitoring/sampling?
   Matt Williams (517-373-4821) was referenced as a source for more information; however, he was not available for further input within the timeframe of the survey.

7. What is the duration (i.e., number of quarters, years) of indoor air sampling?
   Matt Williams (517-373-4821) was referenced as a source for more information; however, he was not available for further input within the timeframe of the survey.

8. Where does the sampling obligation get established/memorialized (e.g., work plan, institutional control, approval/other)?
   Could be in restrictive covenant and in RAP.

Minnesota
Phone call with Dana (pronounced like "Donna") Bahar on 4/19/2010- notes of call reported by Parsons.
505-827-2908
dana.bahar@state.nm.us

Dana works on federal superfund sites. Her answers do not necessarily reflect sites managed under the state superfund or petroleum programs.

If the state is updating its guidance:

MN is not currently updating its guidance.

1. Have they (or do they plan to) re-evaluate the use/role of modeling?

2. If so, have you decided on any changes in regards to modeling?

Does your state use/require sensitivity analyses?

Not required, but will accept if submitted.

If yes, ask the following:

1. Describe what is involved in the sensitivity analysis. Is this a modeling exercise only? If so, which variables would be evaluated? Does this entail evaluating the effect of one variable at a time? How are the results used?
   This is a modeling exercise only. Modifying one variable at a time acceptable.

2. Does it require indoor air sampling?
   Yes, generally requires indoor air sampling as verification.

Approval scheme:

1. There are several ways that regulatory bodies oversee environmental projects. These include 1) scopes of work developed by consultants for the PRP are submitted to the state environmental agency for review and approval prior to implementation, or 2) an LSP-like system where environmental work is conducted, overseen and approved by a consultant certified by the state environmental agency; the state agency may or may not retrospectively audit the work.
   Follows 1).

2. How are actions or plans approved (e.g., selection of an engineering control, work plans, modeling input parameters, monitoring results, etc)
   Reviewed and approved by technical staff and PM.

3. Does work, such as installing a mitigation system or conducting modeling, need prior approval?
   Yes.

4. What kind of follow up/confirmation, if any, is required when vapor intrusion modeling is used?
   Generally NM requires indoor air sampling as verification, although this depends on site specific conditions, including risks. If vapor intrusion modeling estimates that the risks are greater than $1x10^{-6}$, verification would be required.

5. What kind of follow up is required after implementation of a vapor intrusion mitigation system? (e.g., inspections, data review, etc)? Does it vary depending on the system? (i.e., SSV, SSD, vapor barrier)
   Once the mitigation system is installed, would require indoor sampling and visual inspections.

Role of modeling

1. Can parties rely solely on vapor intrusion modeling to predict/determine the indoor air concentration for the purpose of calculating risk?
   No.

2. Can vapor intrusion modeling be used to rule out further consideration of the VI pathway (e.g., demonstration of no significant risk)?
   Yes, depending upon site specific considerations.

3. Does the state have numeric groundwater standards and if so, are the groundwater standards protective of (or do they screen for) the groundwater to indoor air VI pathway?
   NM has groundwater criteria, but they are not intended to be protective of vapor intrusion.

Monitoring

1. Is monitoring of an engineering control required?
   Yes.

2. If yes, what type of monitoring?
   Must demonstrate that the mitigation system is functional, operational, and effective. Would require visual inspections and indoor air sampling. Other things may be measured, as appropriate.

3. Does monitoring require/include indoor air sampling? Other types of air samples? Pressure measurements? Inspections?
   Other types are subject to negotiation.

4. What is the frequency of monitoring/sampling?
   Initially, this would be performed quarterly. The frequency could be either increased or decreased, as appropriate. Can decrease frequency to semi-annual then to annual, if the system is demonstrated to be operating properly and results in acceptable indoor air concentrations.

5. What is the duration (i.e., number of quarters, years) of indoor air sampling?
   Required until source term reaches acceptable concentrations.

6. Where does the sampling obligation get established/memorialized (e.g., work plan, institutional control, approval/other)?
   In the Remedial Action Work Plan.

Missouri
Phone call with Tim Chibnall on 4/19/2010- notes of call reported by Parsons.
573-751-8629
tim.chibnall@dnr.mo.gov

If the state is updating its guidance:

Probably will start updating within next 12 months.

1. Have they (or do they plan to) re-evaluate the use/role of modeling?
   Yes, but not from a yes/no stand point. MO is currently using the ASTM RBCA model. MO will be revaluating the advection component of vapor intrusion modeling, which is not included in the RBCA model.

2. If so, have you decided on any changes in regards to modeling?

Does your state use/require sensitivity analyses?

No.

If yes, ask the following:

1. Describe what is involved in the sensitivity analysis. Is this a modeling exercise only? If so, which variables would be evaluated? Does this entail evaluating the effect of one variable at a time? How are the results used?

2. Does it require indoor air sampling?

Approval scheme:

1. There are several ways that regulatory bodies oversee environmental projects. These include 1) scopes of work developed by consultants for the PRP are submitted to the state environmental agency for review and approval prior to implementation, or 2) an LSP-like system where environmental work is conducted, overseen and approved by a consultant certified by the state environmental agency; the state agency may or may not retrospectively audit the work.
   Follows 1).

2. How are actions or plans approved (e.g., selection of an engineering control, work plans, modeling input parameters, monitoring results, etc)
   Submitted for review and approval to a PM who manages technical staff.

3. Does work, such as installing a mitigation system or conducting modeling, need prior approval?
   Generally, yes. For modeling, if using Tiers 1 and 2 of the standard RBCA models, do not require approval. However, if using Tier 3, where there are significant modifications to input parameters or using a different model, then the work plan must be reviewed and approved first.

4. What kind of follow up/confirmation, if any, is required when vapor intrusion modeling is used?
   For the most part, there is no follow up. However, if modeling indicates that the risks are unacceptable, the proponent may either collect indoor air samples or go straight to mitigation.

5. What kind of follow up is required after implementation of a vapor intrusion mitigation system? (e.g., inspections, data review, etc)? Does it vary depending on the system? (i.e., SSV, SSD, vapor barrier)
   The requirements vary depending on the regulatory program. But for most part, would expect periodic monitoring after installation of the mitigation system to verify that it is working. For active systems, would then use an environmental covenant that would stipulate the requirements for routine monitoring and maintenance.

Role of modeling

1. Can parties rely solely on vapor intrusion modeling to predict/determine the indoor air concentration for the purpose of calculating risk?
   Yes.

2. Can vapor intrusion modeling be used to rule out further consideration of the VI pathway (e.g., demonstration of no significant risk)?
   Yes.

3. Does the state have numeric groundwater standards and if so, are the groundwater standards protective of (or do they screen for) the groundwater to indoor air VI pathway?
   Yes, and yes.

Monitoring

1. Is monitoring of an engineering control required?
   Yes.

2. If yes, what type of monitoring?
   Indoor air sampling is required, except for new construction with a vapor barrier. Active systems would require initial indoor air sampling; i.e., quarterly sampling for year, although the frequency could be reduced, as determined on a case-by-case basis.

3. Does monitoring require/include indoor air sampling? Other types of air samples? Pressure measurements? Inspections?
   Monitoring would have to demonstrate the system is working, but how that is demonstrated is up to the project manager and RP. However, visual inspections would be a requirement, regardless.

   Pressure differential measurements not required, but is one means of verifying that the system is functioning effectively. SSV – sampling effluent is an option.

4. What is the frequency of monitoring/sampling?
   Routinely, have monitoring quarterly for a year. Although this could be more/less often, depending on site-specific conditions. After demonstrating that the system is functioning properly, the frequency could be reduced.

5. What is the duration (i.e., number of quarters, years) of indoor air sampling?
   Indoor air samples would be collected for the first year. After that, would move to visual inspections, with possibility of reduced frequency of indoor air sampling; e.g., annually. This would continue until the source term reaches acceptable concentrations.

6. Where does the sampling obligation get established/memorialized (e.g., work plan, institutional control, approval/other)?
   Environmental covenant.

Nebraska
Phone call with David Chambers of UST program on 4/16/2010- notes of call reported by Parsons.
402-471-4258
David.Chambers@nebraska.gov

Called Scott McIntyre of UST program. Stated was leaving in 2 minutes and would not be back until April 26th. Suggested I speak with David Chambers.

If the state is updating its guidance:

NE is not currently updating its guidance.

1. Have they (or do they plan to) re-evaluate the use/role of modeling?

2. If so, have you decided on any changes in regards to modeling?

Does your state use/require sensitivity analyses?

No.

If yes, ask the following:

1. Describe what is involved in the sensitivity analysis. Is this a modeling exercise only? If so, which variables would be evaluated? Does this entail evaluating the effect of one variable at a time? How are the results used?

2. Does it require indoor air sampling?

Approval scheme:

1. There are several ways that regulatory bodies oversee environmental projects. These include 1) scopes of work developed by consultants for the PRP are submitted to the state environmental agency for review and approval prior to implementation, or 2) an LSP-like system where environmental work is conducted, overseen and approved by a consultant certified by the state environmental agency; the state agency may or may not retrospectively audit the work.
   NE uses option 1).

2. How are actions or plans approved (e.g., selection of an engineering control, work plans, modeling input parameters, monitoring results, etc)
   Documents are submitted to the state and reviewed by technical staff that is managed by a PM.

3. Does work, such as installing a mitigation system or conducting modeling, need prior approval?
   Yes.

4. What kind of follow up/confirmation, if any, is required when vapor intrusion modeling is used?
   If modeling indicates that the risks are acceptable, no further action is required. However, if modeling indicates that the risks are not acceptable, further action would be required. This could include indoor air sampling or mitigation. But this is not specified in guidance and would be a case-by-case decision.

5. What kind of follow up is required after implementation of a vapor intrusion mitigation system? (e.g., inspections, data review, etc)? Does it vary depending on the system? (i.e., SSV, SSD, vapor barrier)
   This is not specified in guidance and would be a case-by-case decision. Philosophically, however, Nebraska wouldn't want to leave a mitigation system in place but would prefer to remediate the source term then remove the mitigation system. In general, some sort of monitoring or inspection would be required.

Role of modeling

1. Can parties rely solely on vapor intrusion modeling to predict/determine the indoor air concentration for the purpose of calculating risk?
   This is somewhat site specific. Confirmation with indoor air samples may be required. This is often recommended for sites where the source is near to a building.

2. Can vapor intrusion modeling be used to rule out further consideration of the VI pathway (e.g., demonstration of no significant risk)?
   No.

3. Does the state have numeric groundwater standards and if so, are the groundwater standards protective of (or do they screen for) the groundwater to indoor air VI pathway?
   Nebraska does have groundwater standards, including screening levels protective of vapor intrusion.

Monitoring

1. Is monitoring of an engineering control required?
   Yes.

2. If yes, what type of monitoring?
   This is not specified in guidance and would be a case-by-case decision. However, at a vapor intrusion site that the state is currently working on, this includes both indoor air sampling and sub-slab sampling.

3. Does monitoring require/include indoor air sampling? Other types of air samples? Pressure measurements? Inspections?
   While the state is unlikely to request that pressure be monitored, visual inspections would be required.

4. What is the frequency of monitoring/sampling?
   Quarterly or semi-annually, but that decision is made on a case by case basis.

5. What is the duration (i.e., number of quarters, years) of indoor air sampling?
   Until the source term reaches acceptable concentrations.

6. Where does the sampling obligation get established/memorialized (e.g., work plan, institutional control, approval/other)?
   Through the workplan and approval process. This may go into a deed restriction or land use covenant; however, an exact procedure has not yet been established.

Nebraska
Phone call with Jim Borovich on 4/19/2010- notes of call reported by Parsons.
jim.borovich@nebraska.gov
402-471-2223
Jim represents (essentially) the state superfund program

If the state is updating its guidance:

NE is currently updating its guidance.

1. Have they (or do they plan to) re-evaluate the use/role of modeling?
   No, NE does not plan to re-evaluate.

2. If so, have you decided on any changes in regards to modeling?

Does your state use/require sensitivity analyses?

Unknown, but that is probably a good idea.

If yes, ask the following:

1. Describe what is involved in the sensitivity analysis. Is this a modeling exercise only? If so, which variables would be evaluated? Does this entail evaluating the effect of one variable at a time? How are the results used?
   This would be a modeling exercise only evaluating the effect of one variable at a time.

2. Does it require indoor air sampling?
   Not required.

Approval scheme:

1. There are several ways that regulatory bodies oversee environmental projects. These include 1) scopes of work developed by consultants for the PRP are submitted to the state environmental agency for review and approval prior to implementation, or 2) an LSP-like system where environmental work is conducted, overseen and approved by a consultant certified by the state environmental agency; the state agency may or may not retrospectively audit the work.
   Follows 1).

2. How are actions or plans approved (e.g., selection of an engineering control, work plans, modeling input parameters, monitoring results, etc)
   Plans are submitted to technical staff supervised by a PM for review and approval.

3. Does work, such as installing a mitigation system or conducting modeling, need prior approval?
   Yes.

4. What kind of follow up/confirmation, if any, is required when vapor intrusion modeling is used?
   Would require sub-slab/subsurface profiling to verify modeling, could include indoor air sampling, but would not be solely indoor air sampling. Indoor air sampling is optional.

5. What kind of follow up is required after implementation of a vapor intrusion mitigation system? (e.g., inspections, data review, etc)? Does it vary depending on the system? (i.e., SSV, SSD, vapor barrier)
A monitoring program would be put in place that would include visual inspections, subsurface sampling, and likely indoor air sampling. This could vary depending on the type of mitigation system.

Role of modeling

1. Can parties rely solely on vapor intrusion modeling to predict/determine the indoor air concentration for the purpose of calculating risk?
Yes.

2. Can vapor intrusion modeling be used to rule out further consideration of the VI pathway (e.g., demonstration of no significant risk)?
Yes, but would prefer to have indoor air samples as well.

3. Does the state have numeric groundwater standards and if so, are the groundwater standards protective of (or do they screen for) the groundwater to indoor air VI pathway?
Currently have MCLs and are developing groundwater screening levels protective of vapor intrusion.

Monitoring

1. Is monitoring of an engineering control required?
Yes.

2. If yes, what type of monitoring?
See above.

3. Does monitoring require/include indoor air sampling? Other types of air samples? Pressure measurements? Inspections?
Probably require pressure differentials for SSD, probably require sampling of effluent from SSV.

4. What is the frequency of monitoring/sampling?
Start out with weekly for first month, then monthly for first 6 months, then quarterly (assuming that the system has been found to be operating properly).

5. What is the duration (i.e., number of quarters, years) of indoor air sampling?
Until the source term reaches acceptable concentrations.

6. Where does the sampling obligation get established/memorialized (e.g., work plan, institutional control, approval/other)?
In a Remedial Action Work Plan.

New Hampshire
Phone call with Robin Mongeon, Engineer (Vapor Intrusion Leader) on 4/20/2010- notes of call reported by Parsons.
New Hampshire Dept. of Environmental Services (NHDES)
(603) 271-7378
Robin.Mongeon@des.nh.gov

If the state is updating its guidance:

1. Have they (or do they plan to) re-evaluate the use/role of modeling?
   No.
2. If so, have you decided on any changes in regards to modeling?

If a state uses a sensitivity analysis:

1. Describe what is involved in the sensitivity analysis. Is this a modeling exercise only? If so, which variables would be evaluated? Does this entail evaluating the effect of one variable at a time? How are the results used?
   NHDES requires sensitivity analysis with modeling. The agency is concerned that people will misuse models for their sites. They require that model input parameters be documented and accompanied by an explanation of how the inputs are matched to (representative of) site conditions. Sensitivity analysis is the independent variation of individual parameters to test the sensitivity of model results to parameter value selection.

2. Does it require indoor air sampling?
   No.

Approval scheme:

1. How are hazardous waste sites projects managed and monitored? There are several ways that regulatory bodies oversee environmental projects. These include 1) scopes of work developed by consultants for the PRP are submitted to the state environmental agency for review and approval prior to implementation, or 2) an LSP-like system where environmental work is conducted, overseen and approved by a consultant certified by the state environmental agency; the state agency may or may not retrospectively audit the work.
   NHDES assigns a project manager to each new site. (There is no LSP-type program in NH.)

2. How are actions or plans approved (e.g., selection of an EC, work plans, modeling input parameters, monitoring results, etc)
   DES requests that responsible parties submit workplans to the project manager for review and comment before moving forward. The regulations don't require this, but most responsible parties follow this practice. DES reviews investigation results, model inputs and results, and remedy plans before implementation and monitoring after implementation. DES has an in-house vapor intrusion expert (Robin) and an indoor air risk assessor that participate in reviews only if asked by the project manager.

3. Does work, such as installing a mitigation system or conducting modeling, need prior approval?
   No, review and approval is recommended and usually done, but not required.

4. What kind of follow up/confirmation, if any, is required when vapor intrusion modeling is used? What kind of follow up is required after implementation of a vapor intrusion mitigation system? (e.g., inspections, data review, etc)? Does it vary depending on the system? (i.e., SSV, SSD, vapor barrier)
   There is no specific requirement for confirmation of modeling, although in practice modeling is seldom used solely for decision-making. Project manager evaluates on a case-by-case basis. For mitigation systems, such as SSD, DES usually requires one round of indoor air sampling to demonstrate system effectiveness. Minimum follow-up monitoring is annual thereafter.

Role of modeling

1. Can parties rely solely on modeling to predict/determine the indoor air concentration for the purpose of calculating risk?
   This is not typically done, and Robin was unaware of any such cases in NH. If properly documented, NH DES would accept this approach.

2. Can model result be used to rule out further consideration of the VI pathway (e.g., demonstration of no significant risk)?
   If properly documented and calculated risk are low enough (e.g., $< 1 \times 10^{-6}$), DES would accept this in some cases.

3. Does the state have numeric groundwater standards and if so, are the groundwater standards protective of (or do they screen for) the groundwater to indoor air VI pathway?
   Yes, NH has screening levels modeled after the MA program that include values for GW and soil vapor that are protective of indoor air due to VI.

Monitoring

1. Is monitoring of an EC required?
   Yes.

2. If yes, what type of monitoring?
   Usually an initial round of indoor air sampling; later (annual) monitoring may include only inspection for good operation of the system (in case of SSD).

3. Does monitoring require/include indoor air sampling? Other types of air samples?
   Yes – see above.
   Pressure measurements? Inspections?
   Yes – see above.

4. What is the frequency of monitoring/sampling?

Once initially following start up of EC, then annual.

5. What is the duration (i.e., number of quarters, years) of indoor air sampling?
   Case-by-case determination. This is not specified in guidance.

6. Where does the sampling obligation get established/memorialized (e.g., work plan, institutional control, approval/other)?
   DES documents requirements in a letter to the responsible party. If the site has a GW management permit (DES issues these for most GW sites), then requirements are documented there.

Institutional Controls

Discussion of this topic: There is a legal mechanism for applying institutional controls in the Contaminated Site Rules (NH regulations) that can be applied to VI sites. This is not addressed in the state's VI guidance.

New Jersey
Phone call with Diane Groth, Research Scientist on 4/21/10- notes of call reported by Parsons.
NJ Dept of Environmental Protection, Site Remediation Program
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If the state is updating its guidance:

1. Have they (or do they plan to) re-evaluate the use/role of modeling?
   No specific plans for this topic, but will be considered depending on stakeholder input.

2. If so, have you decided on any changes in regards to modeling?
   No.

If a state uses a sensitivity analysis:

1. Describe what is involved in the sensitivity analysis. Is this a modeling exercise only? If so, which variables would be evaluated? Does this entail evaluating the effect of one variable at a time? How are the results used?
   N/A.

2. Does it require indoor air sampling?
   N/A.

Approval scheme:

1. How are hazardous waste sites projects managed and monitored? There are several ways that regulatory bodies oversee environmental projects. These include 1) review by the regulatory body with a PM assigned to managed the site, 2) an LSP-like system where all environmental work is reviewed by a another consultant certified by the state environmental agency and 3) or a form of direct oversight.
   NJ is in transition to LSRP program – transition should be complete in 2012. In the past, a NJDEP Case Manager has been assigned to each site. Diane could provide no further detail on approval (she's a VI specialist).

2. How are actions or plans approved (e.g., selection of an EC, work plans, modeling input parameters, monitoring results, etc)
   See Technical Regulations for Site Remediation, NJAC 7:26E, Sections 1.14 and 1.18. These regulations specify the steps and schedules for evaluating and mitigating VI and reporting to the department.

3. Does work, such as installing a mitigation system or conducting modeling, need prior approval?
   See above comment.

4. What kind of follow up/confirmation, if any, is required when vapor intrusion modeling is used? What kind of follow up is required after implementation of a vapor intrusion mitigation system? (e.g., inspections, data review, etc)? Does it vary depending on the system? (i.e., SSV, SSD, vapor barrier)
   See Chapter 10 of VI Guidance Document.

Role of modeling

1. Can parties rely solely on modeling to predict/determine the indoor air concentration for the purpose of calculating risk?
   Yes, sometimes. Look at Chapter 5 of VI Guidance Doc for discussion of ongoing site conditions monitoring required. Here is a related statement from Sec. 5.2.5 "Note that adjustment of building parameters is an option that will result in an institutional control on the property and regular monitoring of the parameter by the responsible party to protect against future use modifications."

2. Can model result be used to rule out further consideration of the VI pathway (e.g., demonstration of no significant risk)?
   Yes, sometimes. Look at Chapter 5 of VI Guidance Doc for discussion of ongoing site conditions monitoring required. See above comment.

3. Does the state have numeric groundwater standards and if so, are the groundwater standards protective of (or do they screen for) the groundwater to indoor air VI pathway?
   Yes.

Monitoring

1. Is monitoring of an EC required?
   Yes.

2. If yes, what type of monitoring?
   See Chapter 10 of VI Guidance Doc. Section 10.3 is **"**Remedial Action Operation, Monitoring and Maintenance**." –** Indoor Air Monitoring, If subsurface depressurization systems are the chosen remedial system, in addition to indoor air sampling, it should be demonstrated, immediately after system startup, that a negative pressure field exists beneath the building, or appropriate portion of the building, of concern Pressure gauge should be measured quarterly, with reduced frequency after 1 year of successful operation.

3. Does monitoring require/include indoor air sampling? Other types of air samples?
   See Chapter 10 of VI Guidance Doc. – yes, confirmational indoor air sampling 2-4 weeks after operational. Indoor air sampling events that do not occur during the winter or early spring (November through March) should necessitate a second round of indoor air sampling during this timeframe. However, the Department will accept a single round of sampling (irrespective of the seasonal timing of the sample event) in those cases where the results are an order of magnitude below the appropriate screening level.

Pressure measurements? Inspections?
See Chapter 10 of VI Guidance Document.

4. What is the frequency of monitoring/sampling?
   See Chapter 10 of VI Guidance Doc. Visual inspection semi-annually, with reduced frequency after 1 year.

5. What is the duration (i.e., number of quarters, years) of indoor air sampling?
   See Chapter 10 of VI Guidance Document.

6. Where does the sampling obligation get established/memorialized (e.g., work plan, institutional control, approval/other)?
   In Remedial Action Workplan. DEP may use permits under the LSRP program.

New York
Phone call with Charlotte Bethony on 4/15/2010- notes of call reported by Parsons.
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If the state is updating its guidance:

1. Have they (or do they plan to) re-evaluate the use/role of modeling?
   No, the department has pretty much decided that modeling is not as useful as indoor air sampling.

2. If so, have you decided on any changes in regards to modeling?

Does your state use/require sensitivity analyses?

No.

If yes, ask the following:

1. Describe what is involved in the sensitivity analysis. Is this a modeling exercise only? If so, which variables would be evaluated? Does this entail evaluating the effect of one variable at a time? How are the results used?

2. Does it require indoor air sampling?

Approval scheme:

1. How are hazardous waste site projects managed and monitored? There are several ways that regulatory bodies oversee environmental projects. These include 1) scopes of work developed by consultants for the PRP are submitted to the state environmental agency for review and approval prior to implementation, or 2) an LSP-like system where environmental work is conducted, overseen and approved by a consultant certified by the state environmental agency; the state agency may or may not retrospectively audit the work.
   New York state uses the first option. New York City has an LSP-type system. However, they must still follow state guidance. Charlotte was not familiar with how New York City uses the LSP-type system.

   Following mitigation, certified professionals can sign off on O&M compliance monitoring and IC compliance inspection reports.

2. How are actions or plans approved (e.g., selection of an engineering control, work plans, modeling input parameters, monitoring results, etc)
   PM and technical staff review and approve.

3. Does work, such as installing a mitigation system or conducting modeling, need prior approval?
   Yes.

4. What kind of follow up/confirmation, if any, is required when vapor intrusion modeling is used?
   Indoor air sampling is generally requested instead of modeling.

5. What kind of follow up is required after implementation of a vapor intrusion mitigation system? (e.g., inspections, data review, etc)? Does it vary depending on the system? (i.e., SSV, SSD, vapor barrier)
   This varies on the type of system installed.
   - SSD – monitoring generally includes having the home owner check yearly that the system is still operating. Additionally, there is a yearly or periodic visit by the state to inspect the system to ensure that is still functioning properly. Generally, indoor air samples are not collected.
   - HVAC used to pressurize the building – annual certification that the HVAC system is working to create positive pressure.
   - These are specified in the O&M plan.

Role of modeling

1. Can parties rely solely on vapor intrusion modeling to predict/determine the indoor air concentration for the purpose of calculating risk?
   No.

2. Can vapor intrusion modeling be used to rule out further consideration of the VI pathway (e.g., demonstration of no significant risk)?
   No.

3. Does the state have numeric groundwater standards and if so, are the groundwater standards protective of (or do they screen for) the groundwater to indoor air VI pathway?
   New York has groundwater standards but they are not protective of VI.

Monitoring

1. Is monitoring of an engineering control required?
   Yes.

2. If yes, what type of monitoring?
   - See above for SSD and HVAC
   - For carbon filtration units – have a maintenance schedule for changing the filters + indoor air sampling
   - SVE – monitoring to ensure that there is a negative pressure field under the building

3. Does monitoring require/include indoor air sampling? Other types of air samples? Pressure measurements? Inspections?
   At least one indoor air sample is required to demonstrate that the mitigation system has been successfully implemented. If the mitigation system has not been successful at reducing indoor air concentrations, more sampling will be required after the system has been modified to demonstrate that it is successful.

4. What is the frequency of monitoring/sampling?

The initial sample is collected one to three months after installation. If the mitigation system is successful, then there is yearly monitoring.

5. What is the duration (i.e., number of quarters, years) of indoor air sampling?
   Just one successful indoor air sampling event is required. If the mitigation system is going to be turned off or removed, additional sampling is required to demonstrate that conditions are acceptable.

6. Where does the sampling obligation get established/memorialized (e.g., work plan, institutional control, approval/other)?
   As an institutional control within site management plan.

Ohio

Phone call with Audrey Rush on 4/20/2010- notes of call reported by Parsons.

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If the state is updating its guidance:

OH just finished updating its guidance and will be presenting the final updated guidance to management 4/21/2010 for final approval. The document should be posted a few days after that.

1. Have they (or do they plan to) re-evaluate the use/role of modeling?
   OH will continue to allow JE modeling.

2. If so, have you decided on any changes in regards to modeling?

Does your state use/require sensitivity analyses?

It is used, but is not in the guidance.

If yes, ask the following:

1. Describe what is involved in the sensitivity analysis. Is this a modeling exercise only? If so, which variables would be evaluated? Does this entail evaluating the effect of one variable at a time? How are the results used?
   Consultants are allowed to use site-specific parameter values, but if values that are out of normal range are use, they must provide documentation in support of that value. Other than that, OH doesn't really require a sensitivity analysis.

2. Does it require indoor air sampling?

Approval scheme:

1. There are several ways that regulatory bodies oversee environmental projects. These include 1) scopes of work developed by consultants for the PRP are submitted to the state environmental agency for review and approval prior to implementation, or 2) an LSP-like system where environmental work is conducted, overseen and approved by a consultant certified by the state environmental agency; the state agency may or may not retrospectively audit the work.
   - For the voluntary action program, which is most work in state, they use an LSP-like program; i.e., Certified Professionals. Under this scheme, CPs do not need to submit final report to the state unless they want a covenant not to sue. 25% of the NFA letters are audited by the state.
   - voluntary action program MOA (Memorandum of Agreement) track, which is a small number of sites: work up to the remedial action work plan can proceed without prior approval from the state.
   - Remedial response program: follows 1).
2. How are actions or plans approved (e.g., selection of an engineering control, work plans, modeling input parameters, monitoring results, etc)

The CP follows the guidance from the state and does not need approval, unless in MOA track, in which public notice and approval of RAP are required, but workplans are not required to be approved by the state.

3. Does work, such as installing a mitigation system or conducting modeling, need prior approval?
   The CP follows the guidance from the state and does not need approval, unless in MOA track, in which public notice and approval of RAP are required, but workplans are not required to be approved by the state.

   However, the CP will require approval from the state if the covenant not to sue is issued before a building is put up on the site and the building will require further mitigation efforts. This requirement may change in the future.

   For Remedial response program: yes

4. What kind of follow up/confirmation, if any, is required when vapor intrusion modeling is used?
   Can use either USEPA attenuation factors or the JE model. If cumulative risks from GW exceed 1×10^{-5}, can then sample soil gas or move on to mitigation. If the risks predicted from soil gas are greater than 1×10^{-5}, can either sample indoor air or move on to mitigation.

5. What kind of follow up is required after implementation of a vapor intrusion mitigation system? (e.g., inspections, data review, etc)? Does it vary depending on the system? (i.e., SSV, SSD, vapor barrier)
   The state requires verification that the remedy is working, although how exactly that is done is up to the CP.
   For SSV – collect sub-slab soil gas samples.
   For SSD - collect sub-slab soil gas samples and could also measure pressure differential.

Role of modeling

1. Can parties rely solely on vapor intrusion modeling to predict/determine the indoor air concentration for the purpose of calculating risk?
   Yes.

2. Can vapor intrusion modeling be used to rule out further consideration of the VI pathway (e.g., demonstration of no significant risk)?
   Yes.

3. Does the state have numeric groundwater standards and if so, are the groundwater standards protective of (or do they screen for) the groundwater to indoor air VI pathway?
   Ohio uses USEPA MCLs, does not have standards groundwater standards protective of vapor intrusion

Monitoring

1. Is monitoring of an engineering control required?
   Yes.

2. If yes, what type of monitoring?
   The state requires verification that the remedy is working, although how exactly that is done is up to the CP. Initially, the CP must prove that the system is working, which is usually done by collecting sub-slab soil gas samples. Thereafter, only visual inspections are required.

3. Does monitoring require/include indoor air sampling? Other types of air samples? Pressure measurements? Inspections?
   See above.

4. What is the frequency of monitoring/sampling?
   Quarterly, including visual inspections.

5. What is the duration (i.e., number of quarters, years) of indoor air sampling?
   Require quarterly sampling of sub-slab soil gas for 2 years. If that shows that the system is working, sampling can be replaced by inspections.

6. Where does the sampling obligation get established/memorialized (e.g., work plan, institutional control, approval/other)?
   Operation and Maintenance Plan.

Oregon
Phone Call with Mary Camarata on 4/19/2010- notes of call reported by Parsons.
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If the state is updating its guidance:

The guidance update was released March 25, 2010; not planning on further updates this year.

1. Have they (or do they plan to) re-evaluate the use/role of modeling?
   Current guidance uses comparison of measured concentrations to screening values that are based on Oregon-specific attenuation factors. Use of site-specific JE modeling needs to be confirmed with PM prior to use.

2. If so, have you decided on any changes in regards to modeling?

Does your state use/require sensitivity analyses?

Can do if wanted, but not required as OR prefers using screening values.

If yes, ask the following:

1. Describe what is involved in the sensitivity analysis. Is this a modeling exercise only? If so, which variables would be evaluated? Does this entail evaluating the effect of one variable at a time? How are the results used?
   This would be a modeling exercise using a one at a time analysis.

2. Does it require indoor air sampling?
   No.

Approval scheme:

1. There are several ways that regulatory bodies oversee environmental projects. These include 1) scopes of work developed by consultants for the PRP are submitted to the state environmental agency for review and approval prior to implementation, or 2) an LSP-like system where environmental work is conducted, overseen and approved by a consultant certified by the state environmental agency; the state agency may or may not retrospectively audit the work.
   Have two models:
   a) Independent cleanup program: consultant does all work without involvement of the state then submits a final report to DEQ for review and approval. This is designed for simple sites and usually excludes vapor intrusion sites.
   b) Voluntary cleanup + site response programs: follows 1).

2. How are actions or plans approved (e.g., selection of an engineering control, work plans, modeling input parameters, monitoring results, etc)
   Submitted to a PM who manages technical staff for review and approval.

3. Does work, such as installing a mitigation system or conducting modeling, need prior approval?
   Mitigation system: yes. Modeling: may or may not apply, prefer indoor air samples instead of JE modeling

4. What kind of follow up/confirmation, if any, is required when vapor intrusion modeling is used?
   Collect indoor air or flux chamber samples.

5. What kind of follow up is required after implementation of a vapor intrusion mitigation system? (e.g., inspections, data review, etc)? Does it vary depending on the system? (i.e., SSV, SSD, vapor barrier)
   Indoor air, or crawl space air, sampling is required. If a vapor barrier is installed, might do a smoke test, could even do yearly for buildings with crawl spaces. Visual inspections would be required.
   SSV: might sample effluent
   SSD: could measure pressure
   However, for SSV and SSD, since the compliance point is indoor air, would sample indoor air anyway.

Role of modeling

1. Can parties rely solely on vapor intrusion modeling to predict/determine the indoor air concentration for the purpose of calculating risk?
   If this means comparing measured concentrations to default risk-based concentrations, yes. But seasonal (i.e., winter and summer) soil gas sampling will be required. If this means the JE model: no.

2. Can vapor intrusion modeling be used to rule out further consideration of the VI pathway (e.g., demonstration of no significant risk)?
   If this means comparing measured concentrations to default risk-based concentrations, yes. If this means the JE model: no.

3. Does the state have numeric groundwater standards and if so, are the groundwater standards protective of (or do they screen for) the groundwater to indoor air VI pathway?
   Yes and yes.

Monitoring

1. Is monitoring of an engineering control required?
   Yes.

2. If yes, what type of monitoring?
   See above.

3. Does monitoring require/include indoor air sampling? Other types of air samples? Pressure measurements? Inspections?
   See above.

4. What is the frequency of monitoring/sampling?
   An initial sample would be collected after installation to confirm that the mitigation system is working. Thereafter, sampling would move to at least yearly. Frequency of visual inspections would also probably be the same. Under some conditions, the frequency could change.

5. What is the duration (i.e., number of quarters, years) of indoor air sampling?
   Until the source terms reaches acceptable concentrations.

6. Where does the sampling obligation get established/memorialized (e.g., work plan, institutional control, approval/other)?
   Record of Decision.

South Dakota
Phone call with Joane Lineburg on 4/22/2010- notes of call reported by Parsons.
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Joane.Lineburg@state.sd.us

Note that the guidance for SD consists of comparing measured concentrations in soil or groundwater to screening values. The JE model is allowed, but would require approval prior to use.

If the state is updating its guidance

No.

Have they (or do they plan to) re-evaluate the use/role of modeling?

1. If so, have you decided on any changes in regards to modeling?

Does your state use/require sensitivity analyses?

It might be used, but would not be required.

If yes, ask the following:

1. Describe what is involved in the sensitivity analysis. Is this a modeling exercise only? If so, which variables would be evaluated? Does this entail evaluating the effect of one variable at a time? How are the results used?
   SD has no guidance on the topic; it would be up to the consultant to propose a sensitivity analysis.

2. Does it require indoor air sampling?
   Not as part of the sensitivity analysis. If soil or groundwater measurements exceed screening levels, collect indoor air sampling. Modeling isn't necessary, but is allowed.

Approval scheme:

1. There are several ways that regulatory bodies oversee environmental projects. These include 1) scopes of work developed by consultants for the PRP are submitted to the state environmental agency for review and approval prior to implementation, or 2) an LSP-like system where environmental work is conducted, overseen and approved by a consultant certified by the state environmental agency; the state agency may or may not retrospectively audit the work.
   Follows 1).

2. How are actions or plans approved (e.g., selection of an engineering control, work plans, modeling input parameters, monitoring results, etc)
   Reports and workplans are submitted to a PM (who manages technical staff) for review and approval.

3. Does work, such as installing a mitigation system or conducting modeling, need prior approval?
   Mitigation systems: yes. Modeling is not normally performed, but could be done and would require approval

4. What kind of follow up/confirmation, if any, is required when vapor intrusion modeling is used?
   If measured values in groundwater or soils exceed screening values, indoor air sampling would be recommended, and in some cases required. The same applies to modeling.

5. What kind of follow up is required after implementation of a vapor intrusion mitigation system? (e.g., inspections, data review, etc)? Does it vary depending on the system? (i.e., SSV, SSD, vapor barrier)
   This would be determined on a site-by-site basis.

Role of modeling

1. Can parties rely solely on vapor intrusion modeling to predict/determine the indoor air concentration for the purpose of calculating risk?
   No.

2. Can vapor intrusion modeling be used to rule out further consideration of the VI pathway (e.g., demonstration of no significant risk)?
   Yes – this includes comparison to screening levels.

3. Does the state have numeric groundwater standards and if so, are the groundwater standards protective of (or do they screen for) the groundwater to indoor air VI pathway?
   SD has groundwater screening levels protective of vapor intrusion.

Monitoring

1. Is monitoring of an engineering control required?
   Some sort of monitoring would be required but the nature of the monitoring would be determined on a site-by-site basis.

2. If yes, what type of monitoring?
   This would be determined on a site-by-site basis.

3. Does monitoring require/include indoor air sampling? Other types of air samples? Pressure measurements? Inspections?
   All of these would be considered on a site-by-site basis, but are not required

4. What is the frequency of monitoring/sampling?
   Most PMs would start out with quarterly monitoring/inspections, which would be reduced if the results are found to be acceptable.

5. What is the duration (i.e., number of quarters, years) of indoor air sampling?
   Monitoring/inspections would continue until the source term reaches acceptable concentrations

6. Where does the sampling obligation get established/memorialized (e.g., work plan, institutional control, approval/other)?
   In a letter to the responsible party and in the project file.

Tennessee

Phone call with Steve Goins, State Superfund group, on 4/21/2010- notes of call reported by Parsons.

615-532-8599

steve.goins@tn.gov

If the state is updating its guidance:

Currently, the state superfund program does not have its own vapor intrusion guidance. However, they are in the early stages of developing their guidance.

1. Have they (or do they plan to) re-evaluate the use/role of modeling?
   TN will probably allow the use of modeling as a line of evidence in its forthcoming guidance.

2. If so, have you decided on any changes in regards to modeling?

Does your state use/require sensitivity analyses?

That decision has not yet been made.

If yes, ask the following:

1. Describe what is involved in the sensitivity analysis. Is this a modeling exercise only? If so, which variables would be evaluated? Does this entail evaluating the effect of one variable at a time? How are the results used?

2. Does it require indoor air sampling?

Approval scheme:

1. There are several ways that regulatory bodies oversee environmental projects. These include 1) scopes of work developed by consultants for the PRP are submitted to the state environmental agency for review and approval prior to implementation, or 2) an LSP-like system where environmental work is conducted, overseen and approved by a consultant certified by the state environmental agency; the state agency may or may not retrospectively audit the work.
   Follows 1).

2. How are actions or plans approved (e.g., selection of an engineering control, work plans, modeling input parameters, monitoring results, etc)
   Documents are submitted to a PM (who manages technical staff) for review and approval.

3. Does work, such as installing a mitigation system or conducting modeling, need prior approval?
   No current guidance or practice
   Mitigation system: approval required only if state is paying to install the mitigation system.
   Modeling: yes.

4. What kind of follow up/confirmation, if any, is required when vapor intrusion modeling is used?
   Current practice: if a vapor intrusion problem is indicated, indoor air sampling is recommend.

5. What kind of follow up is required after implementation of a vapor intrusion mitigation system? (e.g., inspections, data review, etc)? Does it vary depending on the system? (i.e., SSV, SSD, vapor barrier)
   Specifics and requirements are to be determined. However, Steve would assume that the site would have an institutional control and some sort of monitoring (i.e., at least visual inspections but would probably not sample indoor air) to ensure that system is operating properly.

Role of modeling

1. Can parties rely solely on vapor intrusion modeling to predict/determine the indoor air concentration for the purpose of calculating risk?
   The current practice is that this is not allowed.

2. Can vapor intrusion modeling be used to rule out further consideration of the VI pathway (e.g., demonstration of no significant risk)?
   The current practice is that this is not allowed.

3. Does the state have numeric groundwater standards and if so, are the groundwater standards protective of (or do they screen for) the groundwater to indoor air VI pathway?
   TN has groundwater standards, but they are not protective of vapor intrusion.

Monitoring

1. Is monitoring of an engineering control required?
   Yes.

2. If yes, what type of monitoring?
   Specifics and requirements are to be determined. However, Steve would assume that the site would have an institutional control and some sort of monitoring (i.e., at least visual inspections but would probably not sample indoor air) to demonstrate that system is operating properly.

3. Does monitoring require/include indoor air sampling? Other types of air samples? Pressure measurements? Inspections?
   SSV – would consider monitoring effluent
   SSD – would consider monitoring pressure
   The requirements depend on which program the site is in.

4. What is the frequency of monitoring/sampling?
   At least annually.

5. What is the duration (i.e., number of quarters, years) of indoor air sampling?
   Monitoring/inspections required until the source term reaches acceptable concentrations.

6. Where does the sampling obligation get established/memorialized (e.g., work plan, institutional control, approval/other)?
   In the Record of Decision and a deed restriction.

Washington
Phone call with Martha Hankins on 4/21/10- notes of call reported by Parsons.
360-407-6864
mhan461@ecy.wa.gov

If the state is updating its guidance:

WA is currently finalizing it vapor intrusion guidance and updating its cleanup regulation.

1. Have they (or do they plan to) re-evaluate the use/role of modeling?
   No, Washington will continue to use the screening level Johnson and Ettinger model.

2. If so, have you decided on any changes in regards to modeling?

Does your state use/require sensitivity analyses?

No.

If yes, ask the following:

1. Describe what is involved in the sensitivity analysis. Is this a modeling exercise only? If so, which variables would be evaluated? Does this entail evaluating the effect of one variable at a time? How are the results used?

2. Does it require indoor air sampling?

Approval scheme:

1. There are several ways that regulatory bodies oversee environmental projects. These include 1) scopes of work developed by consultants for the PRP are submitted to the state environmental agency for review and approval prior to implementation, or 2) an LSP-like system where environmental work is conducted, overseen and approved by a consultant certified by the state environmental agency; the state agency may or may not retrospectively audit the work.
   Follows 1).

2. How are actions or plans approved (e.g., selection of an engineering control, work plans, modeling input parameters, monitoring results, etc)
   At formal cleanup sites (those being cleaned up under an order or decree), reports and work plans are submitted to the Ecology site manager for prior review and approval. At sites undergoing independent cleanup, a final report is submitted for approval.

3. Does work, such as installing a mitigation system or conducting modeling, need prior approval?
   At formal sites – yes.

4. What kind of follow up/confirmation, if any, is required when vapor intrusion modeling is used?
   Case by case determination by the Ecology site manager.

5. What kind of follow up is required after implementation of a vapor intrusion mitigation system? (e.g., inspections, data review, etc)? Does it vary depending on the system? (i.e., SSV, SSD, vapor barrier)
   An O&M plan and compliance monitoring are required. What parameters are included in the compliance monitoring would be site dependent.

Role of modeling

1. Can parties rely solely on vapor intrusion modeling to predict/determine the indoor air concentration for the purpose of calculating risk?
   Case by case determination. From figures 4 and 5 of the draft guidance: If vapor intrusion modeling, or comparison to generic screening levels, indicate that the risks are acceptable, no further action is necessary. However, if vapor intrusion modeling indicates that the risks are unacceptable, then indoor air sampling is required. Site managers may require air sampling to confirm modeling.

2. Can vapor intrusion modeling be used to rule out further consideration of the VI pathway (e.g., demonstration of no significant risk)?
   From figure 4 of the draft guidance: yes Air sampling may be required to confirm.

3. Does the state have numeric groundwater standards and if so, are the groundwater standards protective of (or do they screen for) the groundwater to indoor air VI pathway?
   Washington's draft guidance includes groundwater screening levels protective of vapor intrusion.

Monitoring

1. Is monitoring of an engineering control required?
   Yes.

2. If yes, what type of monitoring?
   This is a site specific determination.

3. Does monitoring require/include indoor air sampling? Other types of air samples? Pressure measurements? Inspections?
   Site specific. All of these may be considered as options.

4. What is the frequency of monitoring/sampling?
   This is not specified in the regulations now.

5. What is the duration (i.e., number of quarters, years) of indoor air sampling?
   The duration of indoor air sampling is not in the regulations and would be a site-specific determination. Visual inspections of the mitigation system is generally required until the source term reaches acceptable concentrations.

6. Where does the sampling obligation get established/memorialized (e.g., work plan, institutional control, approval/other)?
   For sites undergoing formal cleanup, sampling requirements are part of (or attached to) the order or decree. For sites being cleaned up independently, sampling requirements are part of the sampling and analysis plan.

Wyoming
Phone call with Vickie Meredith on 4/20/2010- notes of call reported by Parsons.
307-332-6924
vmered@wyo.gov

If the state is updating its guidance:

WY is not currently updating its guidance.

1. Have they (or do they plan to) re-evaluate the use/role of modeling?

2. If so, have you decided on any changes in regards to modeling?

Does your state use/require sensitivity analyses?

Yes.

If yes, ask the following:

1. Describe what is involved in the sensitivity analysis. Is this a modeling exercise only? If so, which variables would be evaluated? Does this entail evaluating the effect of one variable at a time? How are the results used?
   Facilities collect site-specific soil physical properties data and then determine a range of inputs for the most sensitive parameters in the Johnson and Ettinger model. A sensitivity analysis is then run on a range of inputs for the worst case, average case, and the best case for the most sensitive parameters. The results are used as part of the risk management process. This could trigger indoor air sampling if the risks from the worst case are greater than 1×10^{-6} and the average case is less than 1×10^{-6}.

2. Does it require indoor air sampling?
   No, would only require indoor air sampling if vapor intrusion modeling (including worst case sensitivity analysis) showed that there was a potential for unacceptable risks.

Approval scheme:

1. There are several ways that regulatory bodies oversee environmental projects. These include 1) scopes of work developed by consultants for the PRP are submitted to the state environmental agency for review and approval prior to implementation, or 2) an LSP-like system where environmental work is conducted, overseen and approved by a consultant certified by the state environmental agency; the state agency may or may not retrospectively audit the work.
   Follows 1).

2. How are actions or plans approved (e.g., selection of an engineering control, work plans, modeling input parameters, monitoring results, etc)
   Review and approved by PM and technical staff.

3. Does work, such as installing a mitigation system or conducting modeling, need prior approval?
   Mitigation system: not necessarily. Modeling: yes.

4. What kind of follow up/confirmation, if any, is required when vapor intrusion modeling is used?

If the risks are unacceptable (including worst case sensitivity analysis), would recommend that indoor air and sub-slab soil gas are sampled for an existing building. For a site without an existing building, if the risks are unacceptable (including worst case sensitivity analysis), would recommend that a mitigation system be installed.

5. What kind of follow up is required after implementation of a vapor intrusion mitigation system? (e.g., inspections, data review, etc)? Does it vary depending on the system? (i.e., SSV, SSD, vapor barrier)
   Some follow up indoor air sampling would be required to ensure that the system is working.

Role of modeling

1. Can parties rely solely on vapor intrusion modeling to predict/determine the indoor air concentration for the purpose of calculating risk?
   It depends. If the risks are greater than 10^{-6} (including worst case in the sensitivity analysis) and indoor air concentrations are greater than background, indoor air sampling would be required.
   If the risks are less than 10^{-6} (including worst case in the sensitivity analysis), indoor air sampling would not be required.

2. Can vapor intrusion modeling be used to rule out further consideration of the VI pathway (e.g., demonstration of no significant risk)?
   Yes.

3. Does the state have numeric groundwater standards and if so, are the groundwater standards protective of (or do they screen for) the groundwater to indoor air VI pathway?
   WY only has MCLs.

Monitoring

1. Is monitoring of an engineering control required?
   Yes, it is typically required. There are some circumstances, although not typical where it may not be required.

2. If yes, what type of monitoring?
   An example was given of a building with a crawl space that had a vapor barrier and was positively pressurized. For that building, an annual smoke test was required. Indoor air sampling would be required, at least initially, to demonstrate that the mitigation system is working properly. Thereafter, it would be unlikely that indoor air sampling would be required.
   SSD systems – don't remember any specific requirements, but some verification is required
   SSV – would probably be required to test effluent initially but don't recall details
   Visual inspections would be required on a case by case basis.

3. Does monitoring require/include indoor air sampling? Other types of air samples? Pressure measurements? Inspections?
   See above.

4. What is the frequency of monitoring/sampling?
   This would be site dependent. Vapor barrier and SSD: would test initially, then subsequent inspections would be irregular, could be 1) annually, 2) every time ownership changes, or even 3) every five years.

5. What is the duration (i.e., number of quarters, years) of indoor air sampling?
   If collected, until it can be demonstrated that the system is operating properly
   After that, it is generally assumed that the system would continue to work and additional follow up would not be necessary, unless building owner/occupant called the state and told them that the system was no longer working.

6. Where does the sampling obligation get established/memorialized (e.g., work plan, institutional control, approval/other)?
   For sites with RPs: remedy agreement, permit, or order. Orphan sites: easement (access agreement) attached to the deed.

Appendix D:

Soil Vapor Barrier Product Information

- Geo-Seal™ Vapor Intrusion Barrier Specifications
- Geo-Seal™ Vapor Intrusion Cut Sheets
- Brownfields Vapor Barriers: Chemical Compatibility, Testing, and Advances in Materials Science
- Geo-Seal™ Vapor Warranty Information
- Liquid Boot Technical Data
- Liquid Boot Installation Process
- GeoKinetics Results of Solvent Diffusion Tests on Liquid Boot Membranes

Appendix D:

Soil Vapor Barrier Product Information

Geo-Seal™ Vapor Intrusion Barrier Specifications

Geo-Seal® Vapor Intrusion Barrier
02 56 19.13
Fluid-Applied Gas Barrier
Version 1.30

Note: If membrane will be subjected to hydrostatic pressure, please contact Land Science Technologies™ for proper recommendations.

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the contract, including general and supplementary conditions and Division 1 specification sections, apply to this section.

1.2 SUMMARY

A. This section includes the following:

1. Substrate preparation:
2. Vapor intrusion barrier components:
3. Seam sealer and accessories.

B. Related Sections: The following sections contain requirements that relate to this section:

1. Division 2 Section “Earthwork”, “Pipe Materials”, “Sub-drainage Systems”, “Gas Collection Systems”:
2. Division 3 Section “Cast-in-Place Concrete” for concrete placement, curing, and finishing:
3. Division 5 Section “Expansion Joint Cover Assemblies”, for expansion-joint covers assemblies and installation.

1.3 PERFORMANCE REQUIREMENTS

A. General: Provide a vapor intrusion barrier system that prevents the passage of methane gas and/or volatile organic compound vapors and complies with physical requirements as demonstrated by testing performed by an independent testing agency of manufacturer’s current vapor intrusion barrier formulations and system design.

1.4 SUBMITTALS

A. Submit product data for each type of vapor intrusion barrier, including manufacturer’s printed instructions for evaluating and preparing the substrate, technical data, and tested physical and performance properties.

B. Project Data - Submit shop drawings showing extent of vapor intrusion barrier, including details for overlaps, flashing, penetrations, and other termination conditions.

C. Samples – Submit representative samples of the following for approval:

1. Vapor intrusion barrier components.

D. Certified Installer Certificates – Submit certificates signed by manufacturer certifying that installers comply with requirements under the “Quality Assurance” article.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced installer who has been trained and certified in writing by the membrane manufacturer, Land Science Technologies™ for the installation of the Geo-Seal® System.

B. Manufacturer Qualification: Obtain vapor intrusion barrier materials and system components from a single manufacturer source Land Science Technologies.

C. Field Sample: Apply vapor intrusion barrier system field sample to 100 ft^2 (9.3 m^2) of field area demonstrate application, detailing, thickness, texture, and standard of workmanship.

1. Notify engineer or special inspector one week in advance of the dates and times when field sample will be prepared.

2. If engineer or special inspector determines that field sample, does not meet requirements, reapply field sample until field sample is approved.

3. Retain and maintain approved field sample during construction in an undisturbed condition as a standard for judging the completed methane and vapor intrusion barrier. An undamaged field sample may become part of the completed work.

D. Pre-installation Conference: A pre-installation conference shall be held prior to application of the vapor intrusion barrier system to assure proper site and installation conditions, to include contractor, applicator, architect/engineer, other trades influenced by vapor intrusion barrier installation and special inspector (if any).

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to project site as specified by manufacturer labeled with manufacturer's name, product brand name and type, date of manufacture, shelf life, and directions for storing and mixing with other components.

B. Store materials as specified by the manufacturer in a clean, dry, protected location and within the temperature range required by manufacturer. Protect stored materials from direct sunlight. If freezing temperatures are expected, necessary steps should be taken to prevent the freezing of the Geo-Seal CORE and Geo-Seal CORE Detail components.

C. Remove and replace material that cannot be applied within its stated shelf life.

1.7 PROJECT CONDITIONS

A. Protect all adjacent areas not to be installed on. Where necessary, apply masking to prevent staining of surfaces to remain exposed wherever membrane abuts to other finish surfaces.

B. Perform work only when existing and forecasted weather conditions are within manufacturer's recommendations for the material and application method used.

C. Minimum clearance of 24 inches is required for application of product. For areas with less than 24-inch clearance, the membrane may be applied by hand using Geo-Seal CORE Detail.

D. Ambient temperature shall be within manufacturer's specifications. (Greater than +45ºF/+7ºC.) Consult manufacturer for the proper requirements when desiring to apply Geo-Seal CORE below 45ºF/7ºC.

E. All plumbing, electrical, mechanical and structural items to be under or passing through the vapor intrusion barrier system shall be positively secured in their proper positions and appropriately protected prior to membrane application.

F. Vapor intrusion barrier shall be installed before placement of fill material and reinforcing steel. When not possible, all exposed reinforcing steel shall be masked by general contractor prior to membrane application.

G. Stakes used to secure the concrete forms **shall not penetrate** the vapor intrusion barrier system after it has been installed. If stakes need to puncture the vapor intrusion barrier system after it has been installed, the necessary repairs need to be made by a certified Geo-Seal applicator. To confirm the staking procedure is in agreement with the manufactures recommendation, contact Land Science Technologies.

1.8 WARRANTY

A. General Warranty: The special warranty specified in this article shall not deprive the owner of other rights the owner may have under other provisions of the contract documents, and shall be in addition to, and run concurrent with, other warranties made by the contractor under requirements of the contract documents.

B. Special Warranty: Submit a written warranty signed by vapor intrusion barrier manufacturer agreeing to repair or replace vapor intrusion barrier that does not meet requirements or that does not remain methane gas and/or volatile organic compound vapor tight within the specified warranty period. Warranty does not include failure of vapor intrusion barrier due to failure of substrate prepared and treated according to requirements or formation of new joints and cracks in the attached to structures that exceed 1/16 inch (1.58 mm) in width.

1. Warranty Period: 1 year after date of substantial completion. Longer warranty periods are available upon request to the manufacturer.

C. Labor and material warranties are available upon request to the manufacturer.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. Geo-Seal; Land Science Technologies™, San Clemente, CA. (949) 481-8118

1. Geo-Seal BASE sheet layer
2. Geo-Seal CORE spray layer and Geo-Seal CORE Detail
3. Geo-Seal BOND protection layer

2.2 VAPOR INTRUSION BARRIER SPRAY MATERIALS

A. Fluid applied vapor intrusion barrier system – Geo-Seal CORE; a single course, high build, polymer modified, asphalt emulsion. Waterborne and spray applied at ambient temperatures. A nominal thickness of 60 dry mils, unless specified otherwise. Non-toxic and odorless. Geo-Seal CORE Detail has similar properties with greater viscosity and is roller or brush applied. Manufactured by Land Science Technologies.

B. Fluid applied vapor intrusion barrier physical properties.

Geo-Seal CORE – TYPICAL CURED PROPERTIES

Properties	**Test Method**	**Results**
Tensile Strength - CORE only	ASTM 412	32 psi
Tensile Strength - Geo-Seal System	ASTM 412	662 psi
Elongation	ASTM 412	4140%
Resistance to Decay	ASTM E 154 Section 13	4% Perm Loss
Accelerated Aging	ASTM G 23	No Effect
Moisture Vapor Transmission	ASTM E 96	.026 $g/ft^2/hr$
Hydrostatic Water Pressure	ASTM D 751	26 psi
Perm rating	ASTM E 96 (US Perms)	0.21
Methane transmission rate	ASTM D 1434	Passed
Adhesion to Concrete & Masonry	ASTM C 836 & ASTM C 704	11 lbf./inch
Hardness	ASTM C 836	80
Crack Bridging	ASTM C 836	No Cracking
Heat Aging	ASTM D 4068	Passed
Environmental Stress Cracking	ASTM D 1693	Passed
Oil Resistance	ASTM D543	Passed
Soil Burial	ASTM D 4068	Passed
Low Temp. Flexibility	ASTM C 836-00	No Cracking at –20°C
Resistance to Acids:		
Acetic		30%
Sulfuric and Hydrochloric		13%
Temperature Effect:		
Stable		248°F
Flexible		13°F

Geo-Seal CORE Detail – TYPICAL CURED PROPERTIES

Properties	**Test Method**	**Results**
Tensile Strength	ASTM 412	32 psi
Elongation	ASTM 412	3860%
Resistance to Decay	ASTM E 154 Section 13	9% Perm Loss
Accelerated Aging	ASTM G 23	No Effect
Moisture Vapor Transmission	ASTM E 96	.026 $g/ft^2/hr$
Hydrostatic Water Pressure	ASTM D 751	28 psi
Perm rating (US Perms)	ASTM E 96	0.17
Methane transmission rate	ASTM D 1434	Passed
Adhesion to Concrete & Masonry	ASTM C 836	7 lbf./inch
Hardness	ASTM C 836	85
Crack Bridging	ASTM C 836	No Cracking
Low Temp. Flexibility	ASTM C 836-00	No Cracking at –20ºC
Resistance to Acids:		
Acetic		30%
Sulfuric and Hydrochloric		13%
Temperature Effect:		
Stable		248°F
Flexible		13°F

2.3 VAPOR INTRUSION BARRIER SHEET MATERIALS

A. The Geo-Seal BASE layer and Geo-Seal BOND layer are chemically resistant sheets comprised of a 5 mil high density polyethylene sheet thermally bonded to a 3 ounce non woven geotextile.

B. Sheet Course Usage

1. As foundation base layer, use Geo-Seal BASE course and/or other base sheet as required or approved by the manufacturer.

2. As top protective layer, use Geo-Seal BOND layer and/or other protection as required or approved by the manufacturer.

C. Geo-Seal BOND and Geo-Seal BASE physical properties.

Properties	Test Method	Results
Film Thickness		5 mil
Composite Thickness		18 mil
Water Vapor Permeability	ASTM E 96	0.214
Adhesion to Concrete	ASTM D 1970	9.2 $lbs/inch^2$
Dart Impact	ASTM D 1790	>1070 gms, method A
		594 gms, method B
Puncture Properties Tear	ASTM B 2582 MD	11,290 gms
	ASTM B 2582 TD	13,150 gms

2.4 AXILLARY MATERIALS

A. Sheet Flashing: 60-mil reinforced modified asphalt sheet good with double-sided adhesive.

B. Reinforcing Strip: Manufacturer's recommended polypropylene and polyester fabric.

C. Gas Venting Materials: Geo-Seal Vapor-Vent HD or Geo-Seal Vapor-Vent Poly, and associated fittings.

D. Seam Detailing Sealant Mastic: Geo-Seal CORE Detail, a high or medium viscosity polymer modified water based asphalt material.

1. Back Rod: Closed-cell polyethylene foam.

PART 3 – EXECUTION

3.1 AUXILIARY MATERIALS

A. Examine substrates, areas, and conditions under which vapor intrusion barrier will be applied, with installer present, for compliance with requirements. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 SUBGRADE SURFACE PREPARATION

A. Verify substrate is prepared according to manufacturer's recommendations. On a horizontal surface, the substrate should be free from material that can potentially puncture the vapor intrusion barrier. Additional protection or cushion layers might be required if the earth or gravel substrate contains too many jagged points and edges that could puncture one or more of the system components. Contact manufacturer to confirm substrate is within manufactures recommendations.

B. Geo-Seal can accommodate a wide range of substrates, including but not limited to compacted earth, sand, aggregate, and mudslabs.

1. Compacted Earth: Remove pieces of debris, gravel and/or any other material that can potentially puncture the Geo-Seal BASE. Remove any debris from substrate that can potentially puncture the Geo-Seal system prior to application.

2. Sand: A sand subgrade requires no additional preparation, provided any material that can potentially puncture the Geo-Seal BASE layer is not present.

3. Aggregate: Contact the manufacturer to ensure the aggregate layer will not be detrimental to the membrane. **The gravel layer must be compacted and rolled flat.** Ideally a ¾" minus gravel layer with rounded edges should be specified; however the Geo-Seal system can accommodate a wide variety of different substrates. Contact Land Science Technologies if there are questions regarding the compatibility of Geo-Seal and the utilized substrate. Exercise caution when specifying pea gravel under the membrane, if not compacted properly, pea gravel can become an unstable substrate.

4. Mudslabs: The use of a mubslab under the Geo-Seal system is acceptable, contact Land Science Technologies for job specific requirements.

C. Mask off adjoining surface not receiving the vapor intrusion barrier system to prevent the spillage or over spray affecting other construction.

D. Earth, sand or gravel subgrades should be prepared and compacted to local building code requirements.

3.3 CONCRETE SURFACE PREPARATION

A. Clean and prepare concrete surface to manufacturer's recommendations. In general, only apply the Geo-Seal CORE material to dry, clean and uniform substrates. Concrete surfaces must be a light trowel, light broom or equivalent finish. Remove fins, ridges and other projections and fill honeycomb, aggregate pockets, grout joints and tie holes, and other voids with hydraulic cement or rapid-set grout. It is the applicator's responsibility to point out unacceptable substrate conditions to the general contractor and ensure the proper repairs are made.

B. When applying the Geo-Seal CORE or Geo-Seal CORE Detail material to concrete it is important to not apply the product over standing water. Applying over standing water will result in the membrane not setting up properly on the substrate

C. Surfaces may need to be wiped down or cleaned prior to application. This includes, but is not limited to, the removal of forming oils, concrete curing agents, dirt accumulation, and other debris. Contact form release agent manufacturer or concrete curing agent manufacturer for VOC content and proper methods for removing the respective agent.

D. Applying the Geo-Seal CORE to "green" concrete is acceptable and can be advantageous in creating a superior bond to the concrete surface. To help reduce blistering, apply a primer coat of only the asphalt component of the Geo-Seal CORE system. Some blistering of the membrane will occur and may be more severe on walls exposed to direct sunlight. Blistering is normal and will subside over time. Using a needle nose depth gauge confirm that the specified mil thickness has been applied.

3.4 PREPARATIONS AND TREATMENT OF TERMINATIONS

A. Prepare the substrate surface in accordance with Section 3.3 of this document. Concrete surfaces that are not a light trowel, light broom or equivalent finish, will need to be repaired.

B. Terminations on horizontal and vertical surfaces should extend 6" onto the termination surface. Job specific conditions may prevent a 6" termination. In these conditions, contact manufacturer for recommendations.

C. Apply 30 mils of Geo-Seal CORE to the terminating surface and then embed the Geo-Seal BASE layer by pressing it firmly into the Geo-Seal CORE layer. Next, apply 60 mils of Geo-Seal CORE to the BASE layer. When complete, apply the Geo-Seal BOND layer. After the placement of the Geo-Seal BOND layer is complete, apply a final 30 mil seal of the Geo-Seal CORE layer over the edge of the termination. For further clarification, refer to the termination detail provided by manufacturer.

D. The stated termination process is appropriate for terminating the membrane onto exterior footings, pile caps, interior footings and grade beams. When terminating the membrane to stem walls or vertical surfaces the same process should be used.

3.5 PREPARATIONS AND TREATMENT OF PENETRATIONS

A. All pipe penetrations should be securely in place prior to the installation of the Geo-Seal system. Any loose penetrations should be secured prior to Geo-Seal application, as loose penetrations could potentially exert pressure on the membrane and damage the membrane after installation.

B. To properly seal around penetrations, cut a piece of the Geo-Seal BASE layer that will extend 6" beyond the outside perimeter of the penetration. Cut a hole in the Geo-Seal BASE layer just big enough to slide over the penetration, ensuring the Geo-Seal BASE layer fits snug against the penetration, this can be done by cutting an "X" no larger than the inside diameter of the penetration. There should not be a gap larger than a 1/8" between the Geo-Seal BASE layer and the penetration. Other methods can also be utilized, provided, there is not a gap larger than 1/8" between the Geo-Seal BASE layer and the penetration.

C. Seal the Geo-Seal BASE layer using Geo-Seal CORE or Geo-Seal CORE Detail to the underlying Geo-Seal BASE layer.

D. Apply one coat of Geo-Seal CORE Detail or Geo-Seal CORE spray to the Geo-Seal BASE layer and around the penetration at a thickness of 30 mils. Penetrations should be treated in a 6-inch radius around penetration and 3 inches onto penetrating object.

E. Embed a fabric reinforcing strip after the first application of the Geo-Seal CORE spray or Geo-Seal CORE Detail material and then apply a second 30 mil coat over the embedded joint reinforcing strip ensuring its complete saturation of the embedded strip and tight seal around the penetration.

F. After the placement of the Geo-Seal BOND layer, a cable tie should then be placed around the finished penetration. The cable tie should be snug, but not overly tight so as to slice into the finished seal.

OPTION: A final application of Geo-Seal CORE may be used to provide a finishing seal after the Geo-Seal BOND layer has been installed.

NOTE: Metal or other slick penetration surfaces may require treatment in order to achieve proper adhesion. For plastic pipes, sand paper may be used to achieve a profile, an emery cloth is more appropriate for metal surfaces. An emery cloth should also be used to remove any rust on metal surfaces.

3.6 GEO-SEAL BASE LAYER INSTALLATION

A. Install the Geo-Seal BASE layer over substrate material in one direction with six-inch overlaps and the geotextile (fuzzy side) facing down.

B. Secure the Geo-Seal BASE seams by applying 60 mils of Geo-Seal CORE between the 6" overlapped sheets and the geotextile down.

C. Visually verify there are no gaps/fish-mouths in seams.

D. For best results, install an equal amount of Geo-Seal BASE and Geo-Seal CORE in one day. Leaving unsprayed Geo-Seal BASE overnight might allow excess moisture to collect on the Geo-Seal BASE. If excess moisture collects, it needs to be removed.

NOTE: In windy conditions it might be necessary to encapsulate the seam by spraying the Geo-Seal CORE layer over the completed Geo-Seal BASE seam.

3.7 GEO-SEAL CORE APPLICATION

A. Set up spray equipment according to manufacturer's instructions.

B. Mix and prepare materials according to manufacturer's instructions.

C. The two catalyst nozzles (8001) should be adjusted to cross at about 18" from the end of the wand. This apex of catalyst and emulsion spray should then be less than 24" but greater than 12" from the desired surface when spraying. When properly sprayed the fan pattern of the catalyst should range between 65° and 80°.

D. Adjust the amount of catalyst used based on the ambient air temperature and surface temperature of the substrate receiving the membrane. In hot weather use less catalyst as hot conditions will quickly "break" the emulsion and facilitate the curing of the membrane. In cold conditions and on vertical surfaces use more catalyst to "break" the emulsion quicker to expedite curing and set up time in cold conditions.

E. To spray the Geo-Seal CORE layer, pull the trigger on the gun. A 42° fan pattern should form when properly sprayed. Apply one spray coat of Geo-Seal CORE to obtain a seamless membrane free from pinholes or shadows, with an average dry film thickness of 60 mils (1.52 mm).

F. Apply the Geo-Seal CORE layer in a spray pattern that is perpendicular to the application surface. The concern when spraying at an angle is that an area might be missed. Using a perpendicular spray pattern will limit voids and thin spots, and will also create a uniform and consistent membrane.

G. Verify film thickness of vapor intrusion barrier every 500 ft^2. (46.45 m^2), for information regarding Geo-Seal quality control measures, refer to the quality control procedures in Section 3.9 of this specification.

H. The membrane will generally cure in 24 to 48 hours. As a rule, when temperature decreases or humidity increases, the curing of the membrane will be prolonged. The membrane does not need to be fully cured prior the placement of the Geo-Seal BOND layer, provided mil thickness has been verified and a smoke test will be conducted.

I. **Do not penetrate** membrane after it has been installed. If membrane is penetrated after the membrane is installed, it is the responsibility of the general contractor to notify the certified installer to make repairs.

J. If applying to a vertical concrete wall, apply Geo-Seal CORE directly to concrete surface and use manufacturer's recommended protection material based on site specific conditions. If applying Geo-Seal against shoring, contact manufacturer for site specific installation instructions.

NOTE: Care should be taken to not trap moisture between the layers of the membrane. Trapping moisture may occur from applying a second coat prior to the membrane curing. Repairs and detailing may be done over the Geo-Seal CORE layer when not fully cured.

3.8 GEO-SEAL BOND PROTECTION COURSE INSTALLATION

A. Install Geo-Seal BOND protection course perpendicular to the direction of the Geo-Seal BASE course with overlapped seams over nominally cured membrane no later than recommended by manufacturer and before starting subsequent construction operations.

B. Sweep off any water that has collected on the surface of the Geo-Seal CORE layer, prior to the placement of the Geo-Seal BOND layer.

C. Overlap and seam the Geo-Seal BOND layer in the same manner as the Geo-Seal BASE layer.

D. To expedite the construction process, the Geo-Seal BOND layer can be placed over the Geo-Seal CORE immediately after the spray application is complete, provided the Geo-Seal CORE mil thickness has been verified.

3.9 QUALITY ASSURANCE

A. The Geo-Seal system must be installed by a trained and certified installer approved by Land Science Technologies.

B. For projects that will require a material or labor material warranty, Land Science Technologies will require a manufacturer's representative or certified 3rd party inspector to inspect and verify that the membrane has been installed per the manufacturer's recommendations.

The certified installer is responsible for contacting the inspector for inspection. Prior to application of the membrane, a notice period for inspection should be agreed upon between the applicator and inspector.

C. The measurement tools listed below will help verity the thickness of the Geo-Seal CORE layer. As measurement verification experience is gained, these tools will help confirm thickness measurements that can be obtained by pressing one's fingers into the Geo-Seal CORE membrane.

To verify the mil thickness of the Geo-Seal CORE, the following measurement devices are required.

1. Mil reading caliper: Calipers are used to measure the thickness of coupon samples. To measure coupon samples correctly, the thickness of the Geo-Seal sheet layers (18 mils each) must be taken into account. Mark sample area for repair.

2. Wet mil thickness gauge: A wet mil thickness gauge may be used to quickly measure the mil thickness of the Geo-Seal CORE layer. The thickness of the Geo-Seal sheet layers do not factor into the mil thickness reading.

   NOTE: When first using a wet mil thickness gauge on a project, collect coupon samples to verify the wet mil gauge thickness readings.

3. Needle nose digital depth gauge: A needle nose depth gauge should be used when measuring the Geo-Seal CORE thickness on vertical walls or in field measurements. Mark measurement area for repair.

To obtain a proper wet mil thickness reading, take into account the 5 to 10 percent shrinkage that will occur as the membrane fully cures. Not taking into account the thickness of the sheet layers, a freshly sprayed membrane should have a minimum wet thickness of 63 (5%) to 66 (10%) mils.

Methods on how to properly conduct Geo-Seal CORE thickness sampling can be obtained by reviewing literature prepared by Land Science Technologies.

D. It should be noted that taking too many destructive samples can be detrimental to the membrane. Areas where coupon samples have been removed need to be marked for repair.

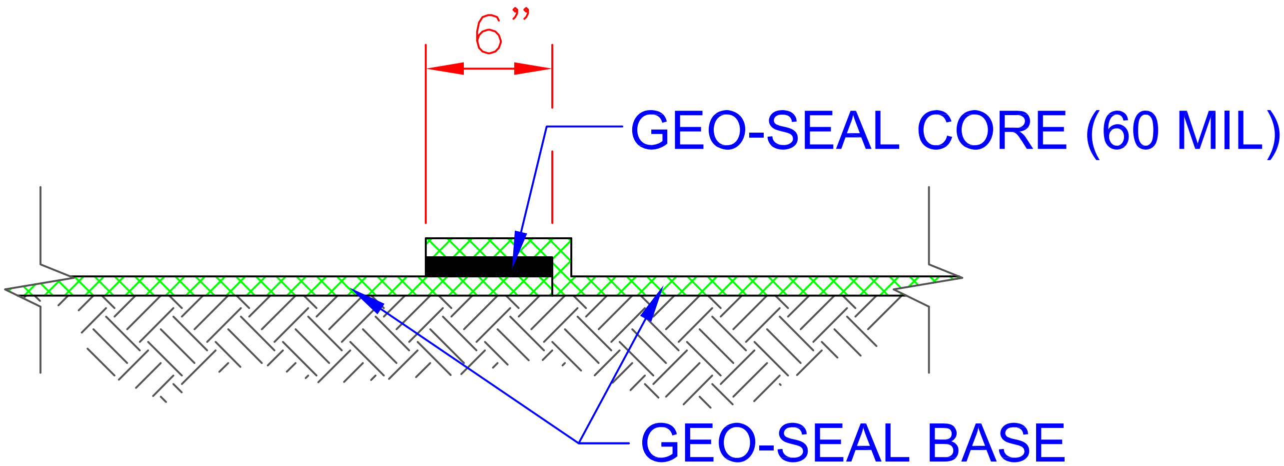
E. Smoke Testing is highly recommended and is the ideal way to test the seal created around penetrations and terminations. Smoke Testing is conducted by pumping non-toxic smoke underneath the Geo-Seal vapor intrusion barrier and then repairing the areas where smoke appears. Refer to smoke testing protocol provided by Land Science Technologies. For projects that will require a material or labor material warranty, Land Science Technologies will require a smoke test.

F. Visual inspections prior to placement of concrete, but after the installation of concrete reinforcing, is recommended to identify any punctures that may have occurred during the installation of rebar, post tension cables, etc. Punctures in the Geo-Seal system should be easy to indentify due to the color contrasting layers of the system.

Appendix D:

Soil Vapor Barrier Product Information

Geo-Seal™ Vapor Intrusion Cut Sheets



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949.366.8000 OFFICE

Geo-Seal™ Advanced Vapor Management Technology

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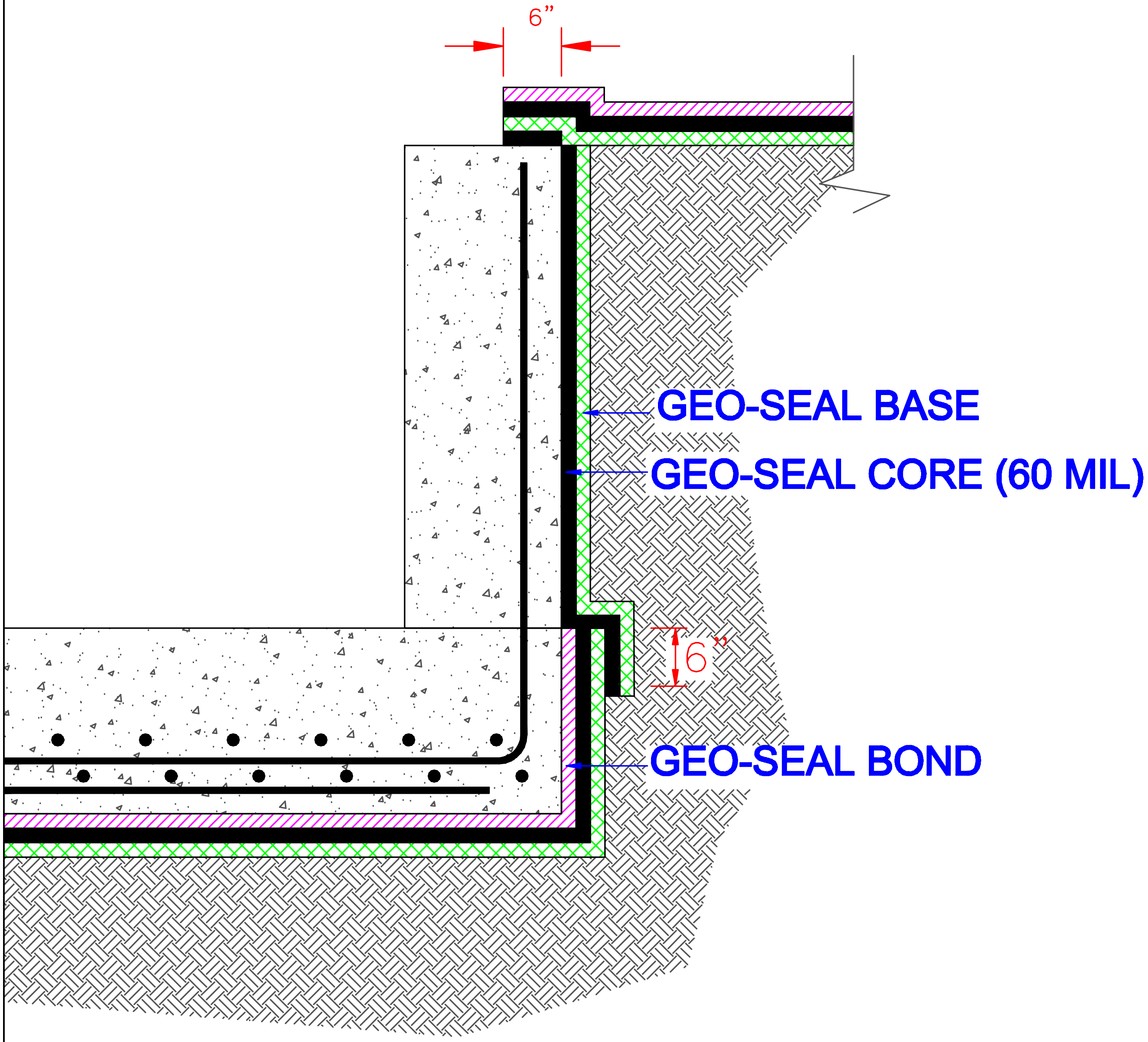
App by	
Date	
Scale	

BASE OVERLAP DETAIL

D-8



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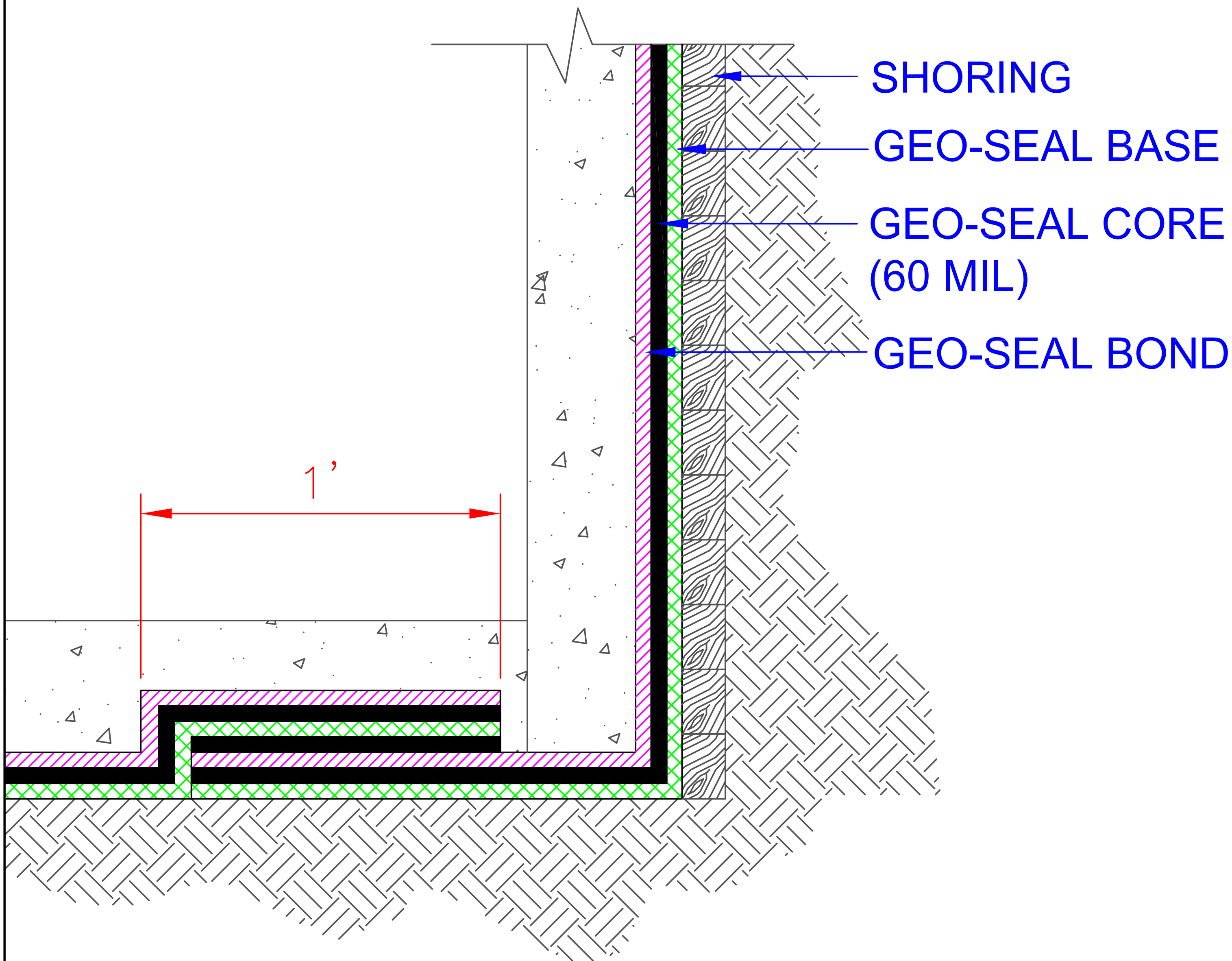
BELOW GRADE OVERLAP DETAIL



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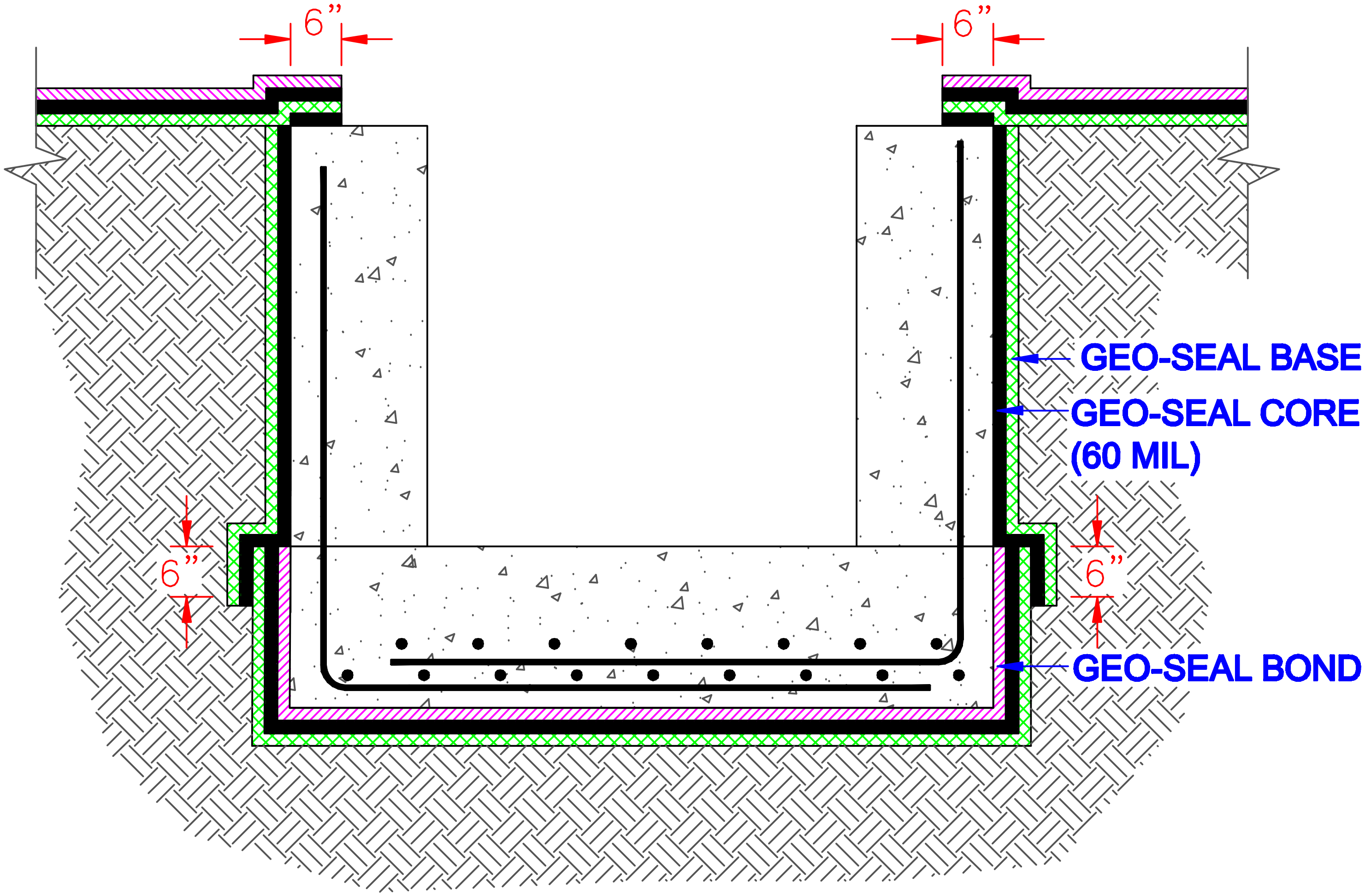
BELOW GRADE SHORING DETAIL

D-10



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ELEVATOR PIT DETAIL

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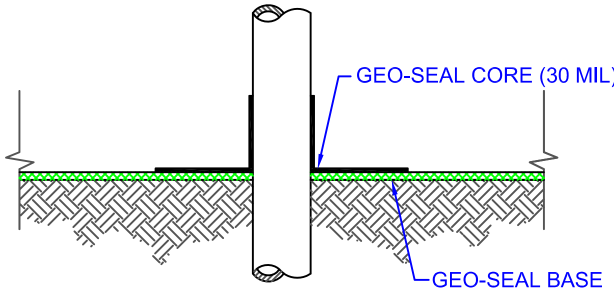
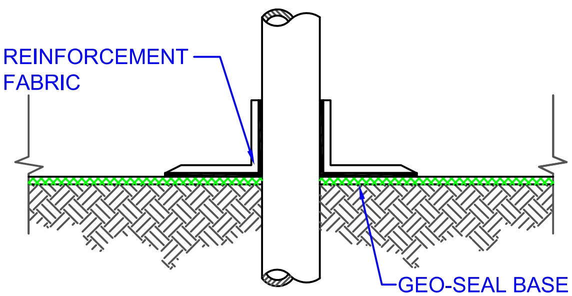
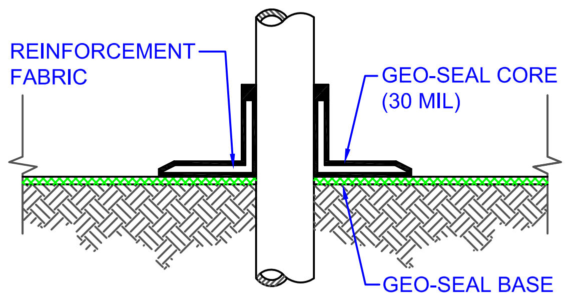


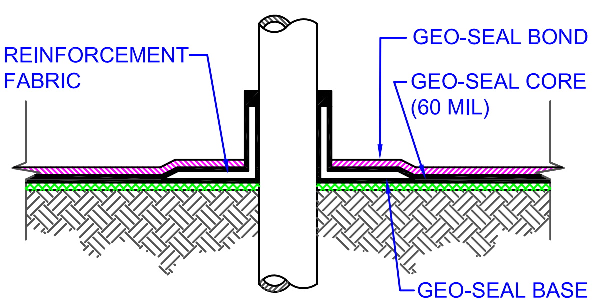
STEP 1



STEP 2



STEP 3



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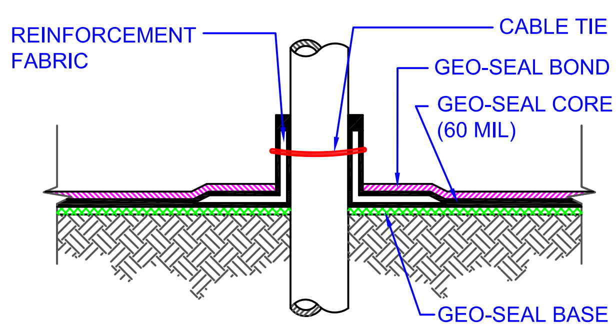

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PENETRATION SEQUENCE

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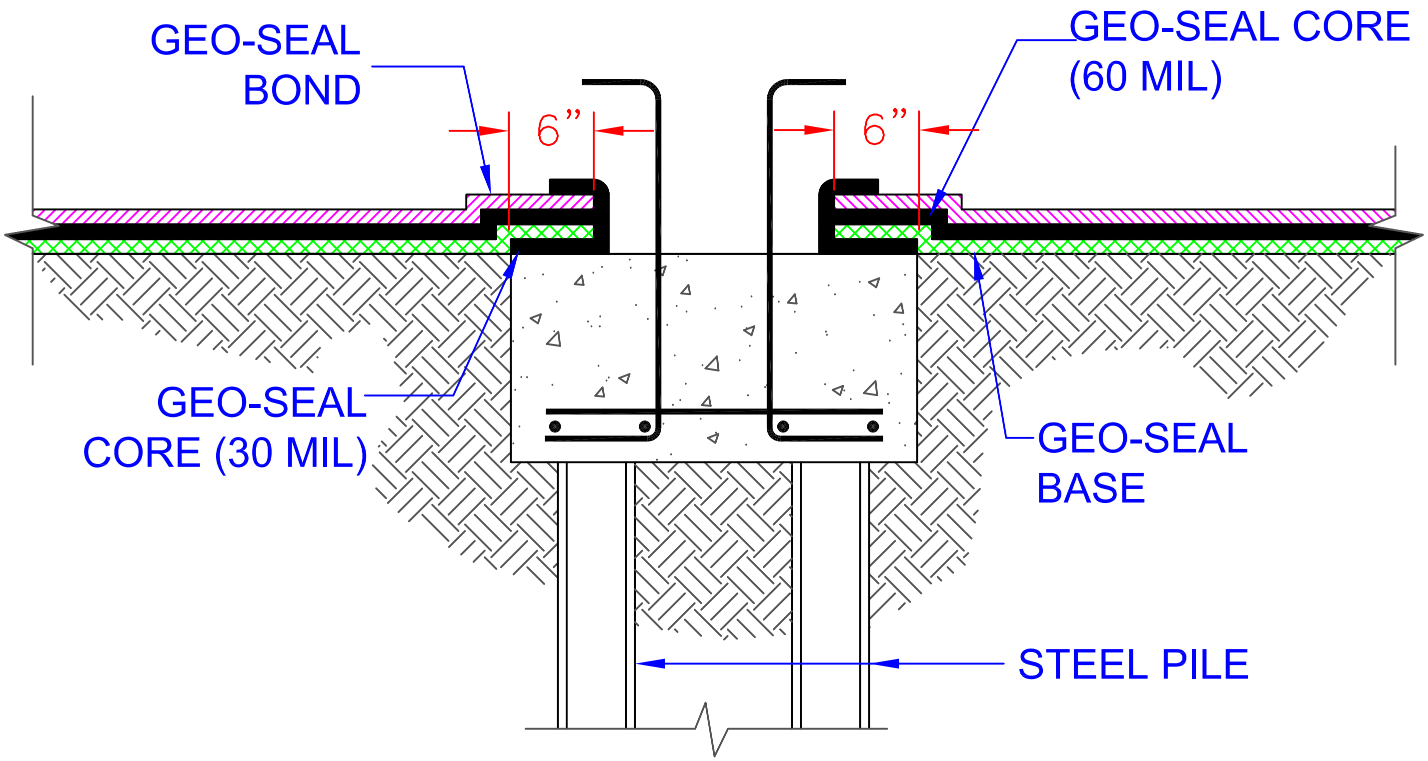

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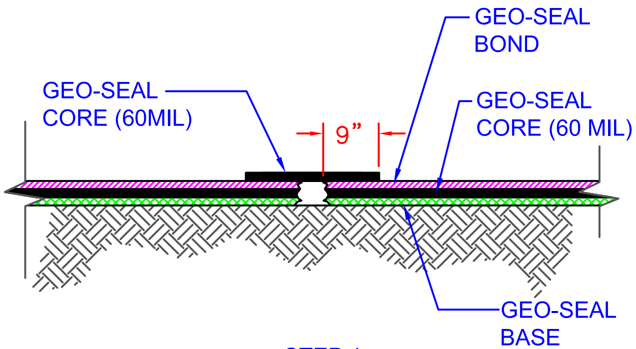

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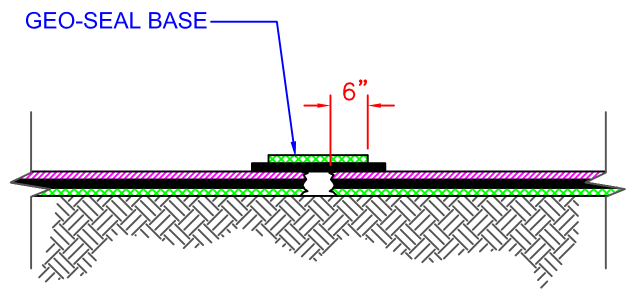

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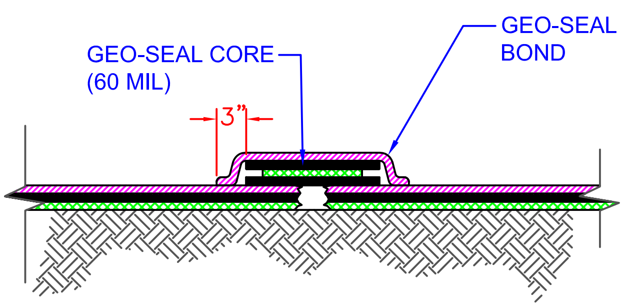

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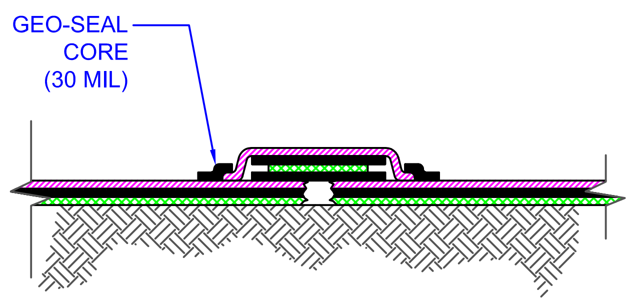

STEP 4

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REPAIR SEQUENCE

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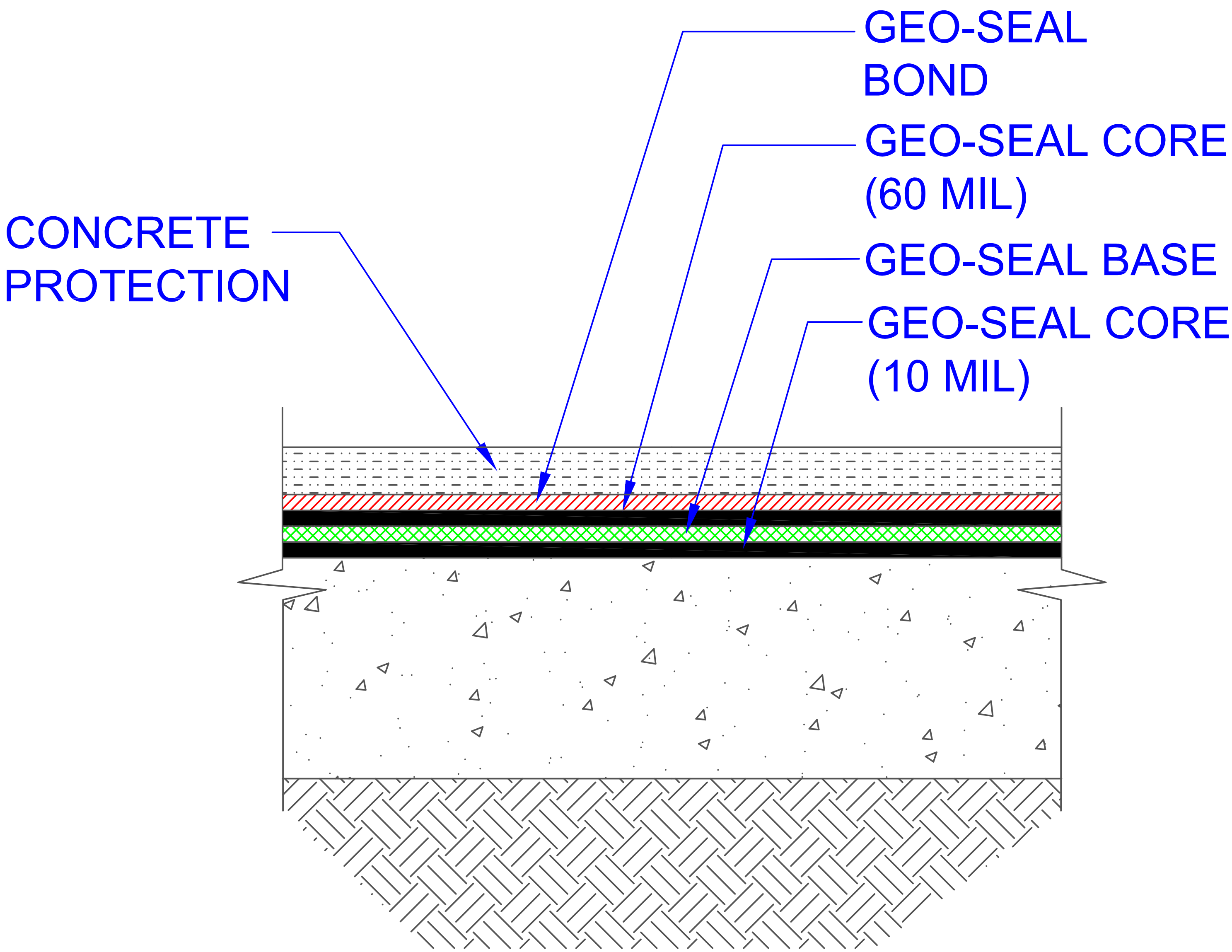

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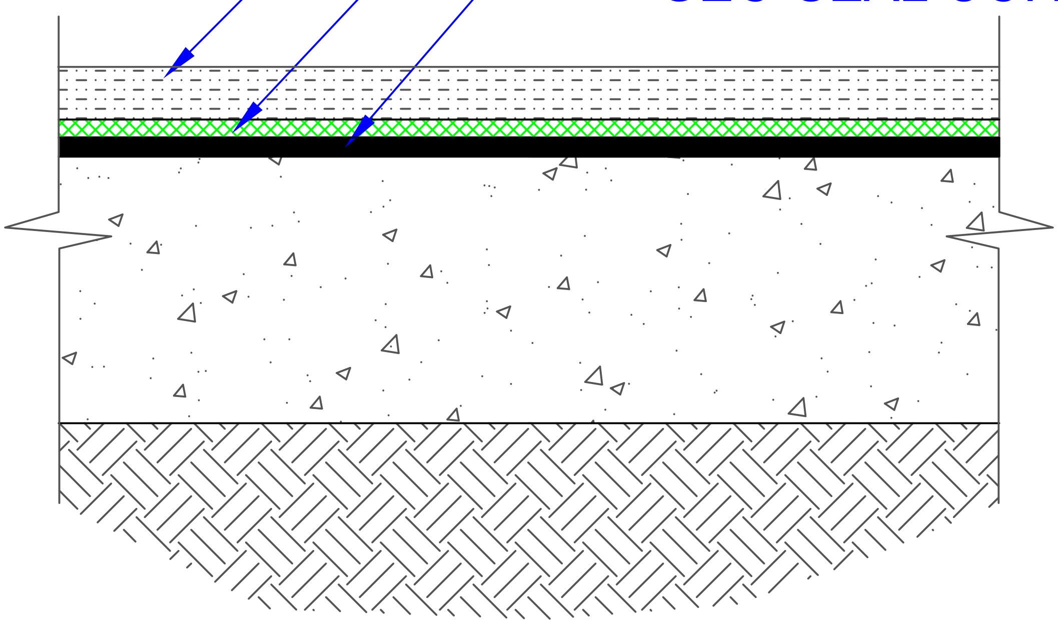
RETROFIT OVER EXISTING SLAB (OPTION 1)



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RETROFIT OVER EXISTING SLAB (OPTION 2)

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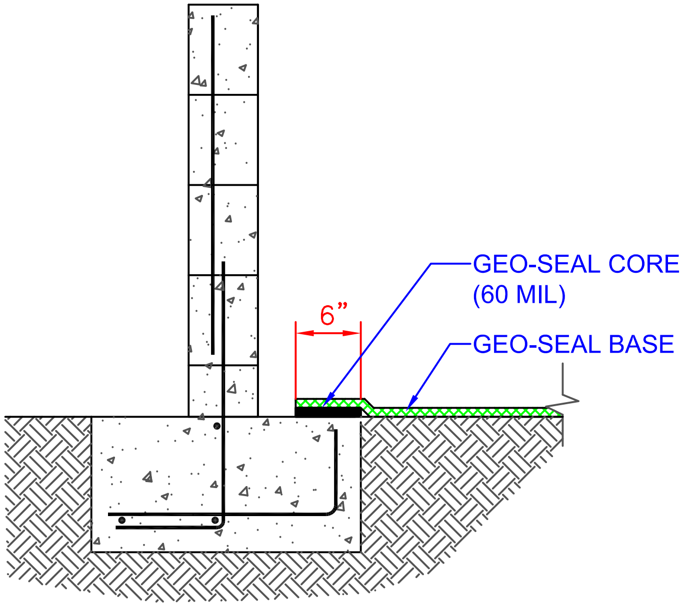

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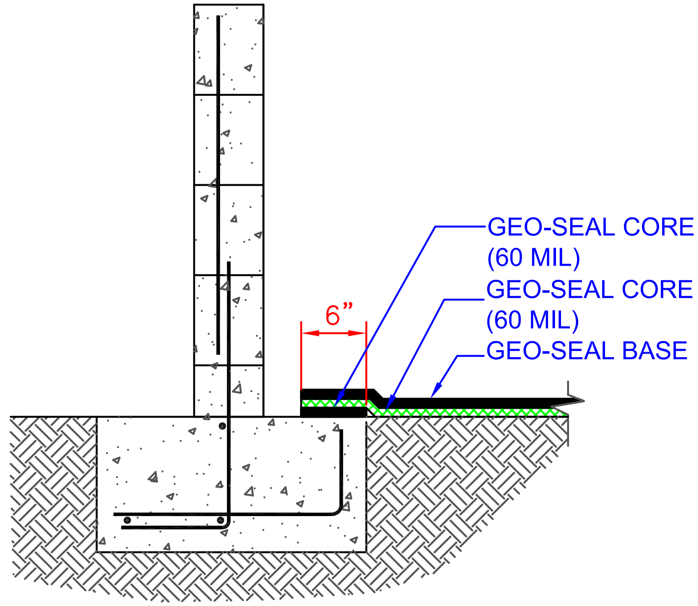

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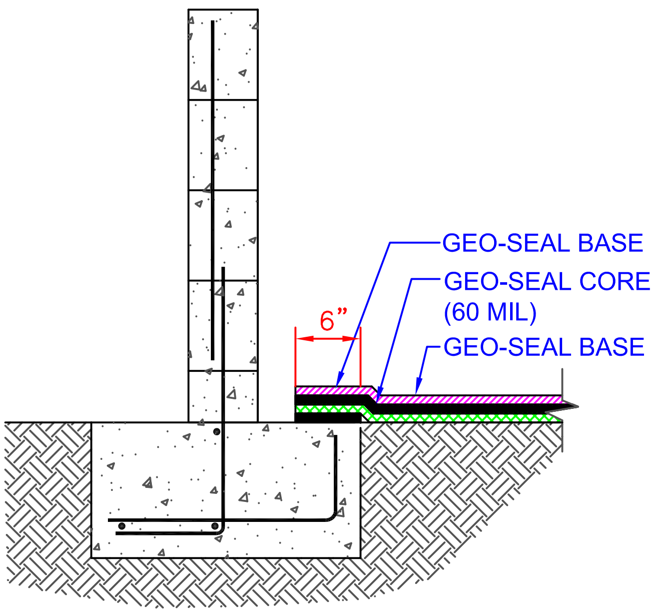

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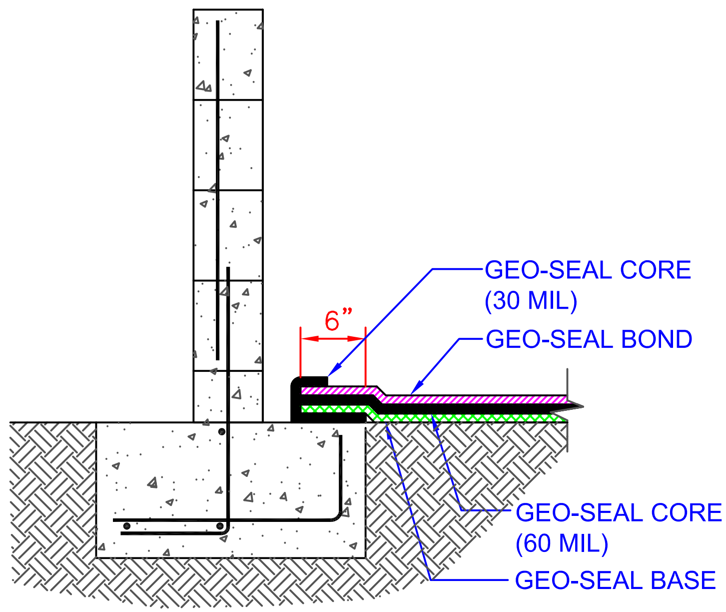

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TERMINATION SEQUENCE

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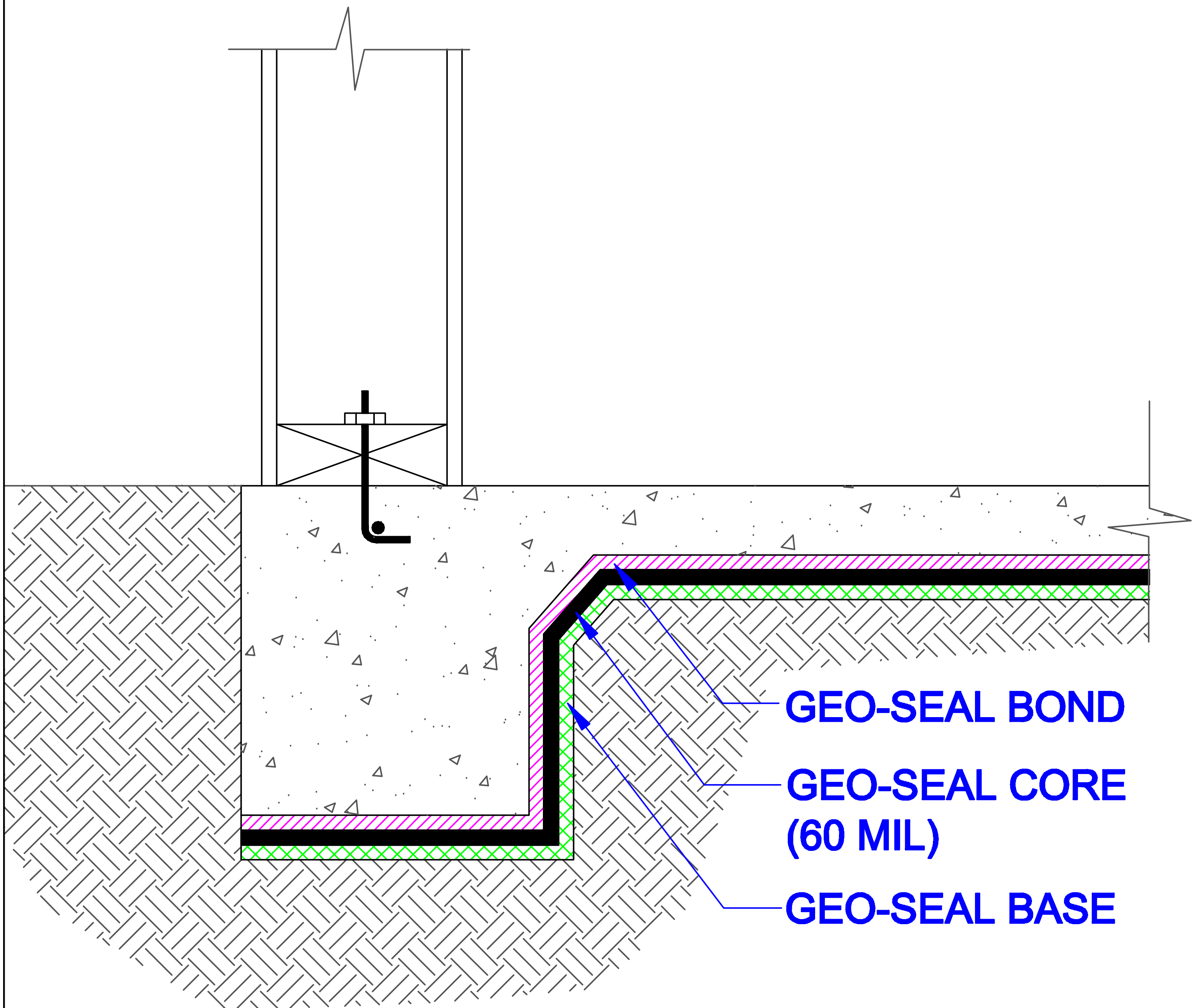

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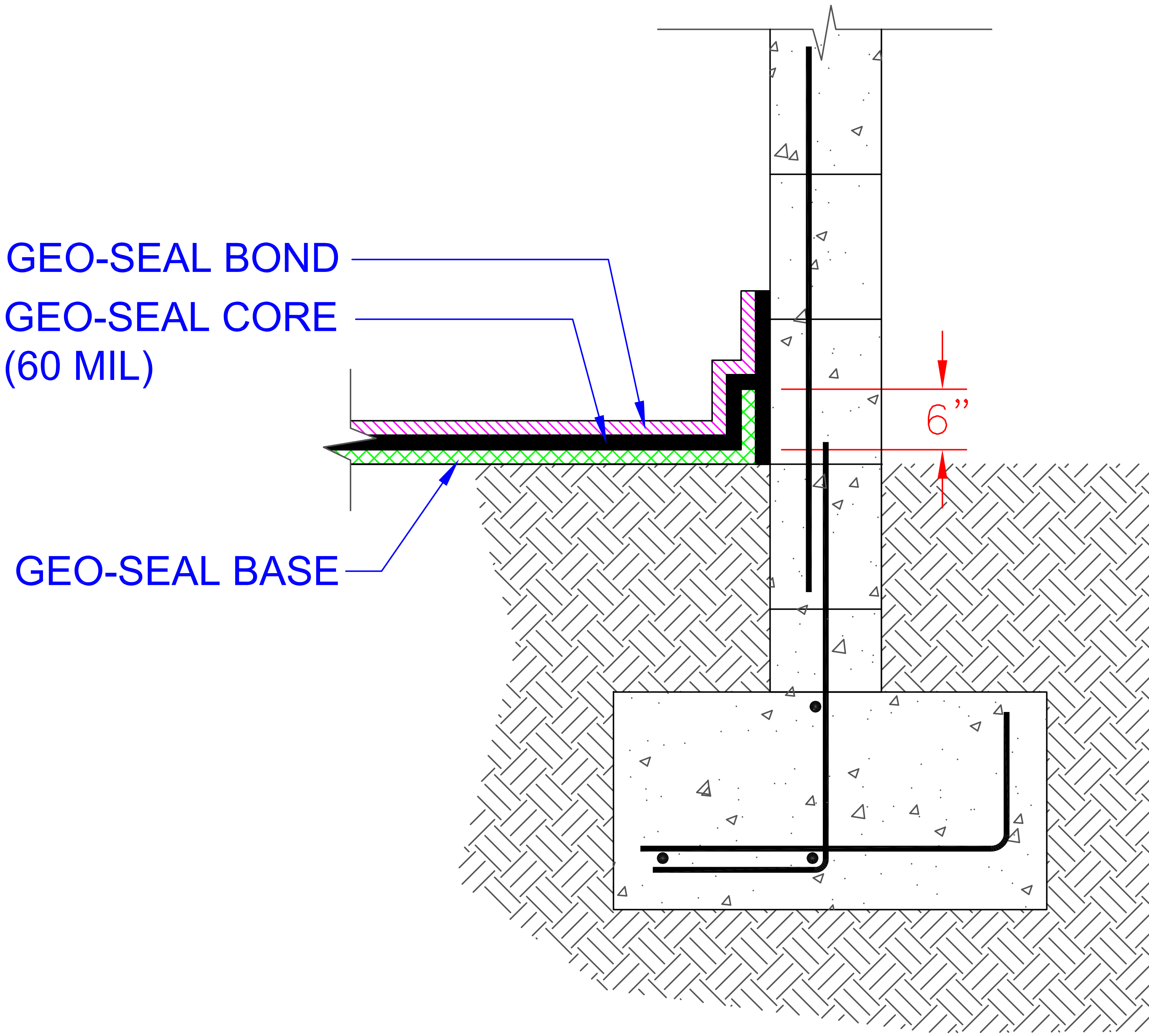
UNDER FOOTING DETAIL



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VERTICAL TERMINATION DETAIL

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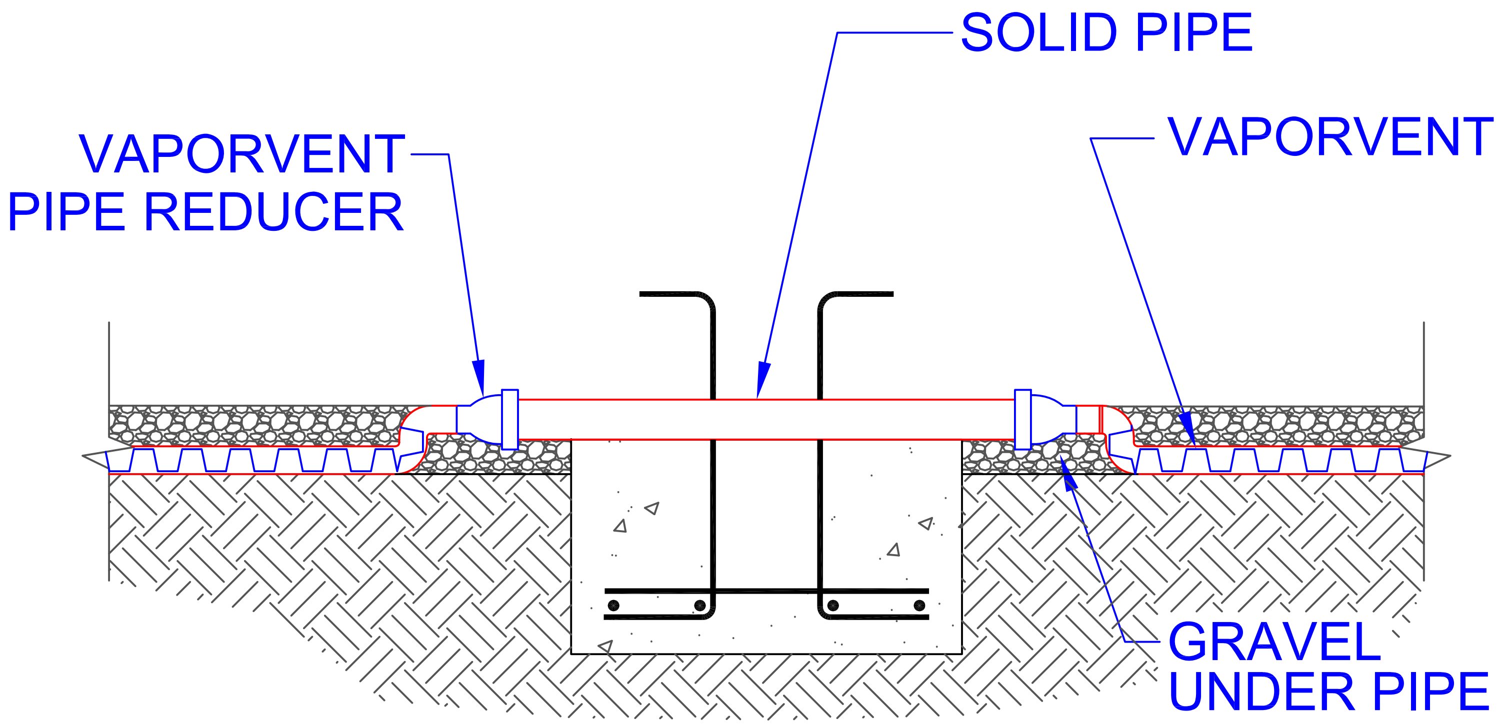

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VAPORVENT OVER FOOTING

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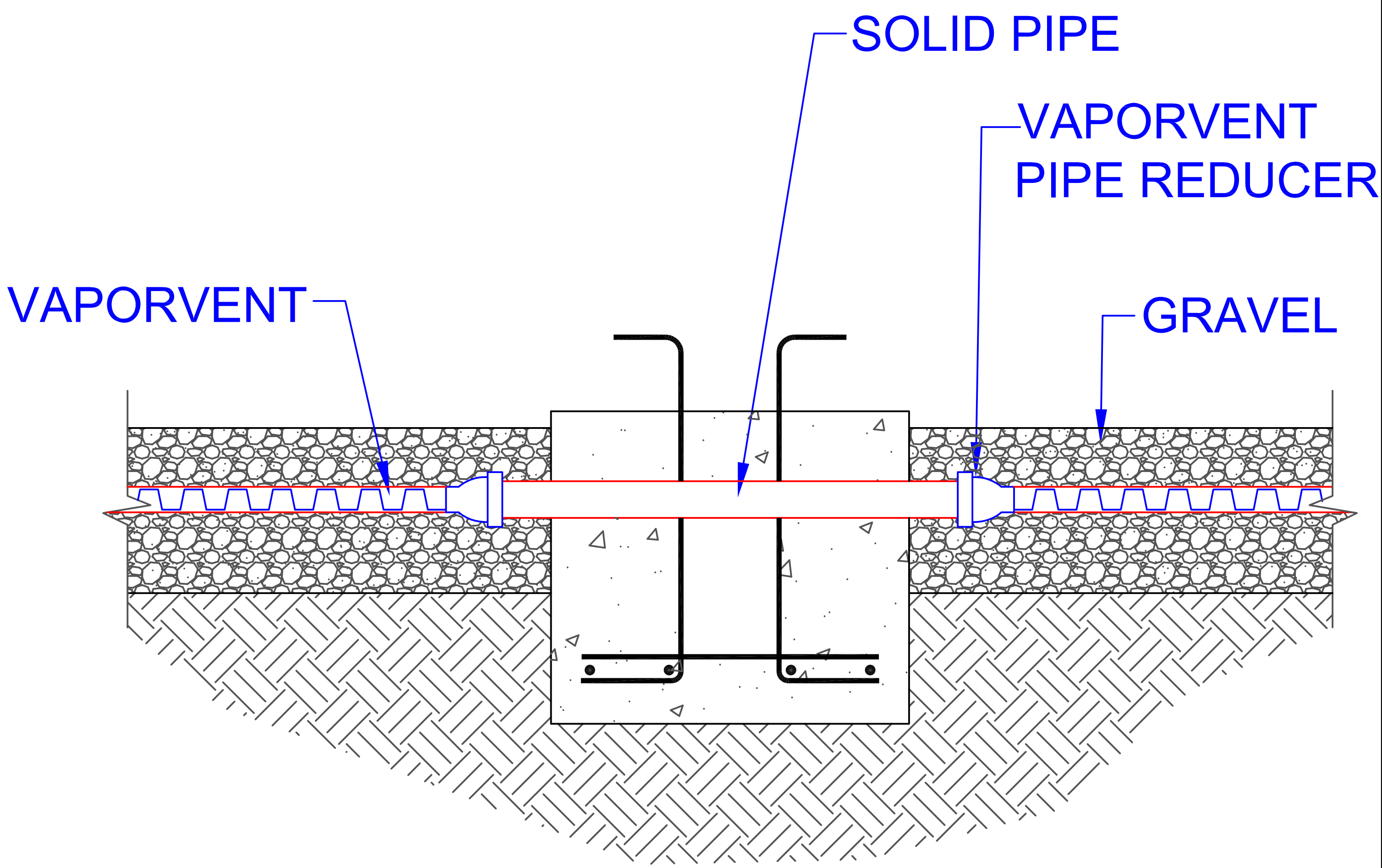

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VAPORVENT THROUGH FOOTING

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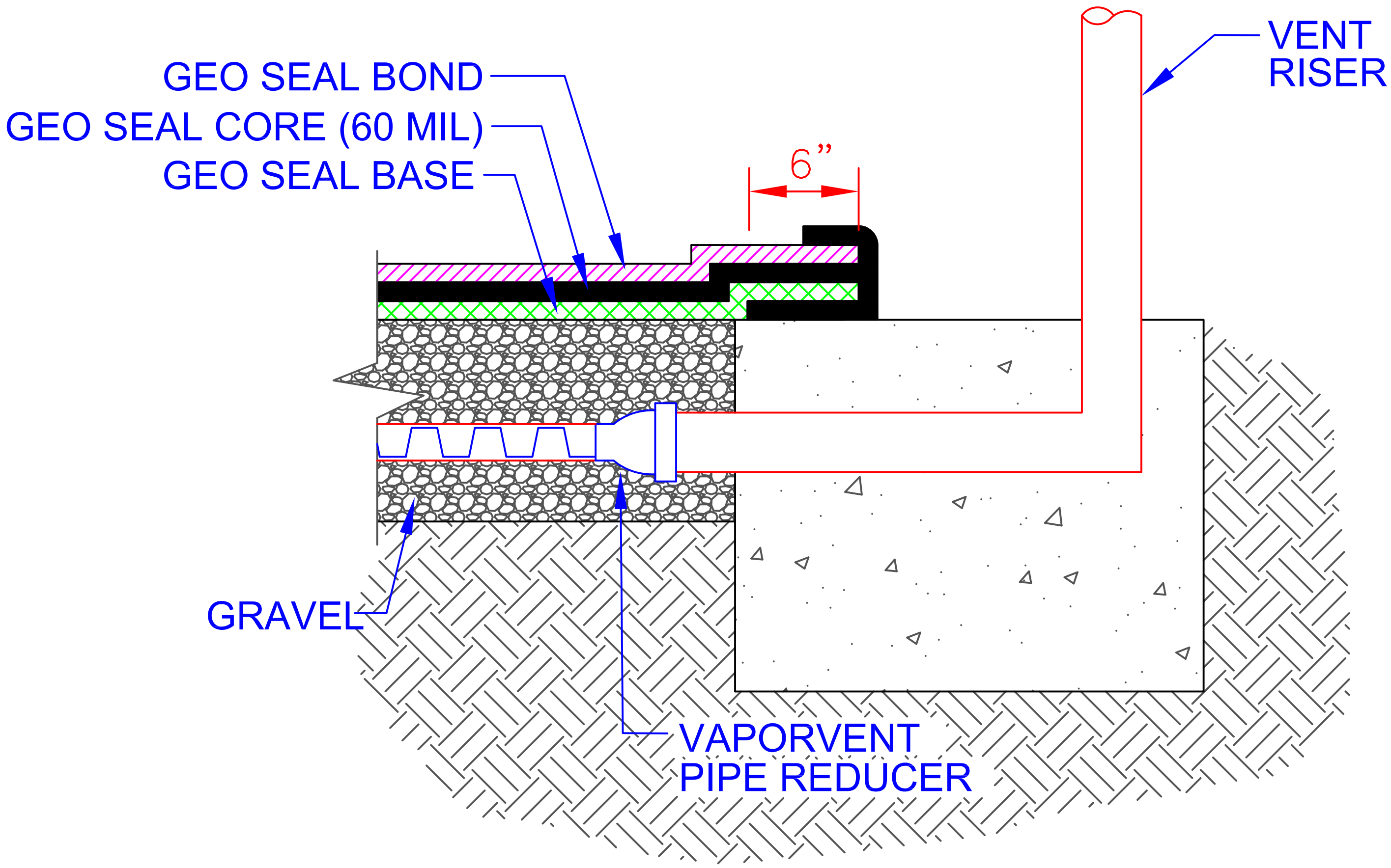

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VAPORVENT VENT RISER

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Appendix D:

Soil Vapor Barrier Product Information

Brownfields Vapor Barriers: Chemical Compatibility, Testing, and Advances in Materials Science

Brownfield Vapor Barriers:
Chemical Compatibility, Testing, and Advances in Materials Science

Scott Wilson (swilson@regenesis.com), Benjamin Mork, Ph.D. (Land Science Technologies, a division of Regenesis, San Clemente, CA)

ABSTRACT: A new composite membrane system, Geo-Seal™, has been developed that offers exceptional chemical resistance for use as a vapor barrier at brownfield sites. Data generated in controlled laboratory conditions indicate the composite membrane to have < 0.2X the volatile organic compound partitioning when compared to spray applied latex/asphalt vapor barriers. More importantly, data generated under both liquid and gas permeability tests indicate that the new composite membrane system limits the transmission of volatile organic vapors. Data indicated the Geo-Seal membrane to resist contaminant permeation breakthrough for a period 18X longer than that of simple asphalt/latex membranes and to allow for < 0.16X the rate of VOC permeance of the asphalt/latex membranes.

INTRODUCTION

Brownfield site development often requires the use of a contaminant vapor barrier to inhibit volatile organic contaminants remaining on-site from migrating into the newly constructed buildings, potentially impacting indoor air quality.

Historically plastic sheet materials such as high density polyethylene, known for chemical resistance, have been applied as contaminant vapor barriers. The use of these materials, however, requires labor-intensive cutting and seaming to ensure a continuous and cohesive barrier to vapor migration. This installation process can be intensive, difficult, and costly when applied to construction foundations with multiple penetrations (e.g. piping, electrical conduits).

In recent years "spray applied" latex/asphalt membrane-type waterproofing materials have been widely promoted for brownfield vapor barrier use. While easy to apply and proven to retard water migration through concrete, the use of these latex/asphalt materials for repelling volatile organic constituents (VOCs) such as benzene and chlorinated solvents may be complicated by the affinity of latex/asphalt for VOCs. It is widely recognized that asphalt/latex-based products are, in fact, highly susceptible to partitioning by VOCs, particularly chlorinated dry cleaning- type solvents.

BACKGROUND

Spray Applied Asphalt/Latex Membranes. Asphalt/latex membranes are chemically described as bitumen/polystyrene emulsions that are spray-applied in the presence of calcium chloride salt solutions. Simply put, the salt solution "breaks the emulsion" upon mixing when applied forming a continuous layer of bitumen-styrene as the material dries upon a surface. Depending on the exact formulation, the emulsion material may also have clay or calcium carbonate added as a "filler" or "builder" which allows for varying of key characteristics such as viscosity, flexibility, etc.

Proceedings of the **Sixth International Conference on Remediation of Chlorinated and Recalcitrant Compounds**, Barriers to VOC Intrusion into Buildings. 2008.Monterey, California, USA. Battelle Press, Columbus, Ohio, USA. *In Press*.

Geo-Seal™ Composition. Geo-Seal™ (Land Science Technologies, San Clemente, CA, USA) is a unique composite membrane (patent pending) that incorporates the ease of application associated with spray applied asphalt/latex membranes with the chemical resistance, low chemical permeability, and mechanical strength of high density polyethylene (HDPE). The Geo-Seal membrane incorporates all the positive aspects of 60 mil asphalt/latex membranes plus the two outer layers of proprietary HDPE.

Hydrophobic vs Lipophilic. All asphalt/latex membrane materials are hydrophobic (water repelling) due to the petroleum (bitumen) content. This is why these materials tend to have both low adsorptivity toward water (water does not partition into the membrane itself) and low permeance with regard to water vapors (very little water vapor moves through the membrane). Asphalt/latex membranes make for excellent water-proofing and damp-proofing materials.

Conversely, asphalt/latex membrane materials are lipophilic (oil attracting, or non-polar). When contacted with oils they absorb the oil. In the same fashion, non-polar VOCs like benzene or perchloroethene (PCE) tend to partition into the membrane itself. This is very well documented. In fact, this is why the "dry cleaning" industry has adopted the use of PCE to remove bitumen from clothes…the PCE partitions into the bitumen and extracts it from the fabric. Likewise gasoline is commonly used as a cleaner to remove tar.

SOLVENT EXPOSURE TESTING

Any solvent exposure testing relevant to the use of materials for under-slab VOC contaminant vapor barriers should test or model the true long term exposure of the barrier material to the specific contaminant of concern. In the case of testing latex/asphalt contaminant vapor barrier material for exposure to volatile organic contaminants (e.g. benzene, PCE, trichloroethene (TCE), etc.) the most important factor to consider is the long term adsorption of the contaminant into the membrane itself.

Over time the lipophilic membrane material will continue to absorb contaminant until some point in the future when it reaches equilibrium and/or becomes "saturated". The period of time required to reach saturation is dependent upon the contaminant type, its concentration in the soil pore gas, temperature, pressure, and its specific partitioning coefficient toward the specific asphalt/latex membrane under testing.

The standard analytical method for solvent exposure testing is generally considered to be ASTM D-543 (ASTM D-543-06). In this test the specific membrane material (latex/asphalt) is exposed to the specific contaminant of concern (e.g. PCE) within the specific medium of concern (air) for a period of 7 days. The amount of weight gained by the membrane is a direct measure of the absorption of the contaminant by the membrane material. When little absorption occurs it can be said that there is little reactivity or change of the membrane with exposure. This test however, will only indicate the absorption (partitioning) which occurs within the 7 day period when the membrane is subjected to the contaminant at the specific concentration tested. It does not indicate the total potential absorption (partitioning) that may occur over the lifespan of the membrane in an actual field application.

In order to understand the long term effects of a membrane's exposure to solvents one has to either 1) test the membrane under low volatile organic vapor (VOC) concentrations for an extended period of time- until the partitioning equilibrates (this could be many years depending on how low the vapor concentration is) or 2) run the test at very high concentrations to ensure saturation within the test period. At the point of saturation with VOCs, asphalt/latex membranes show very different characteristics, particularly with regard to VOC permeation, weight, dimensions, and tensile strength.

It is widely known that unprotected asphalt/latex membranes absorb significant contaminant vapors as the VOC partitions into the bitumen fraction of the membrane itself. Eventually this leads to saturation of the membrane, membrane swelling, softness, etc.

General Asphalt/Latex Solvent Exposure Testing. In work conducted by an independent laboratory experienced in asphalt/latex membrane formulation, ASTM D-543 was conducted on varying formulations in the presence of hexane vapors. Specific formulations and test results are presented below in Table 1. It is appropriate to note that in all of the varying formulations a weight gain of greater than 10% was observed indicating that asphalt/latex membranes by their very chemical makeup absorb (partition) VOC vapors when properly exposed to the VOC.

TABLE 1. VOC Solvent Exposure Testing of Various Asphalt/Latex Membranes By ASTM D-543 Employing Hexane Vapors*

Ingredient			(%)	
Bitumen	72.2	71.7	72.2	66.2
Polystyrene Latex	18.1	17.9	18.1	16.6
$CaCl_2$	0.7	1.4	0.7	0.7
$CaCO_3$	9.0	9.0	0.0	16.6
Bentonite	0.0	0.0	9.0	0.0
% Weight Gain	15.0	12.5	14.1	10.9

*Applied Power Concepts Laboratory, Anaheim, CA 2004, USA.

Comparative Solvent Exposure Testing. In an effort to confirm that in fact commercially available spray-applied asphalt/latex membranes behave just as other asphalt/latex membranes, a third party laboratory conducted testing upon a sample (60 mil thickness) of a commercially available spray applied asphalt/latex vapor barrier (Liquid Boot®, Santa Ana, California, USA) obtained directly from a manufacturer-certified applicator.. The identical test was conducted employing a sample of the Geo-Seal composite membrane. The method employed was a modified ASTM D-543 using PCE vapors on one side of the membrane and ambient air on the other. Results indicated

2.1% weight gain for Geo-Seal, compared to 10.8% weight gain of the commercially available asphalt/latex membrane sample. Data derived from this testing is presented in Table 2 below.

TABLE 2. Solvent Exposure Testing – Modified ASTM D-543*			
	Pre-Test Weight (g)	Post-Test Weight (g)	Weight Gain
Asphalt/Latex+	4.24	4.70	10.8%
Geo-Seal™	3.87	3.95	2.1%

*Intertek Laboratories, Foxboro Mass. 2008
+Liquid Boot ®, Santa Ana, CA, USA

These data clearly indicate that commercially available asphalt/latex is subject to the same weakness as other simple spray applied asphalt/latex membranes- they do not repel VOC vapors. Instead they tend to absorb (partition) vapors. The Geo-Seal composite membrane, on the other hand, incorporates two layers of the very chemical resistant high density polyethylene in addition to the 60 mil spray applied copolymer modified bitumen/polystyrene core layer. These HDPE layers serve to limit exposure of the core layer to VOCs and to ensure mechanical integrity of the membrane.

PERMEATION TESTING

Permeation testing measures the rates of transport across membranes. Traditionally this has been conducted by simply placing the challenge gas or liquid on one side of the membrane and, after sealing, measuring the amount of the gas that emerges from the opposing side of the membrane over time. This method is the basis for several standard analytical techniques used in the testing of materials for waterproofing applications. However, this basic approach is flawed in testing VOC permeation through lipophilic membranes such as simple asphalt/latex membranes.

VOC Partitioning, Break-through and Permeation. Permeation of VOCs through a lipophilic membrane can be viewed as a three phase process where: 1) VOCs move into the membrane through absorption (partition) with only a fraction passing completely through, 2) partitioning of the VOCs into the membrane continues to the point of equilibrium saturation where break-through of higher concentrations occur, and 3) post saturation where VOCs are moving out of the membrane at significantly increased rates. This process is depicted in Figure 1, below.

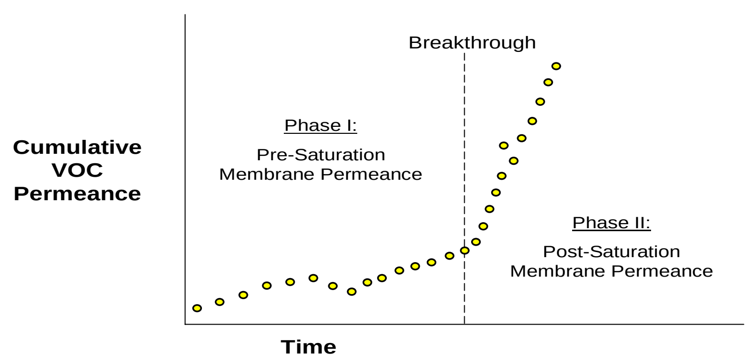


FIGURE 1. Permeation of VOCs through a Lipophilic Membrane

Asphalt/Latex Membrane Permeation Testing. When testing asphalt/latex membranes against VOCs one should not simply measure the flux of low concentrations of VOCs across the membrane as this approach does not take into account the concentration of VOCs absorbed (partitioned) by the membrane itself.

In the ASTM publication "Determination of Volatile Organic Compound Permeation Through Geomembranes" (Park, 1996) the authors state, in reference to the general testing method employed by vendors of asphalt/latex membranes:

> "The permeation rate was estimated solely on the amount of VOC that passed through the geomembrane surface area in a unit time. This estimation is incorrect for it does not account for partition and diffusion and assumes a constant concentration above the geomembrane".

In the permeation testing conducted by a vendor of asphalt/latex membranes (Cetco Liquid Boot, 2008), which was then used to generate a diffusion coefficient, the physical partitioning of the VOCs into the membrane was not taken into account. As noted by Park, et. al. (1996), this method is in error. The membrane in this testing was almost certainly not at the point of saturation after less than one year's time in contact with vapors from aqueous dissolved VOC. Thus, the testing was conducted under conditions where much of the VOCs were being partitioned into the membrane. Over time, however this lipophilic membrane would become saturated and the rate of VOC permeation would significantly increase.

Testing Permeation upon Pre-Saturation. An approach to understanding the capacity of a membrane to act as a long term barrier to VOC permeation is to first saturate the membrane with VOC. Once saturated, the membrane can then be subjected to the VOC in specific concentrations and the associated permeation rate can be measured. In this case, the impact of the VOC absorbance (partitioning) on the measurement of permeation is minimized if not eliminated altogether.

A series of tests were conducted by a third party laboratory in order to gain an understanding of the relative long term performance of the Geo-Seal composite membrane and the commercially available asphalt/latex membrane against VOC permeation.

Comparative Liquid VOC Challenge Post-Saturation. In order to understand the chemical permeation of VOCs through the two membrane systems a standard method ASTM F-739 was employed utilizing an open loop system permeation test cell (ASTM F739-07). The membranes were subjected to liquid VOC for 24 hours to ensure saturation followed by an 8 hour test of the materials toward VOC permeation from direct liquid VOC contact.

Results of this test represent "worst case" permeation rates, as it assumes maximum VOC concentration challenge after membrane saturation. Thus, the absolute VOC permeation rate numbers are very high. This test however serves to indicate the relative capacity for the two membranes to block permeation from the specific VOCs under identical controlled conditions. All tests were performed in triplicate under controlled laboratory conditions.

TABLE 3. Results of Comparative Permeation Testing under Liquid VOC Challenge*

Barrier Material	VOC Contaminant	Breakthrough Time (minutes)†	Steady-State Perm Rate ($\mu g/cm^2/min$)
Asphalt/Latex+	PCE	15	12.9
Geo-Seal™	PCE	270	2

*Intertek Laboratories, Foxboro MA, USA. 2008
+Liquid Boot®, Santa Ana, CA, USA
† Time when permeation rate reached 1.0 $\mu g/cm^2/min$

As can be seen from the results presented in Table 3, the Geo-Seal barrier after saturation was much more resistant to permeation than the asphalt/latex membrane . Geo-Seal held up breakthrough permeation for an 18X longer period when compared to Liquid Boot. Additionally, once steady state permeation was reached, Liquid Boot allowed for 6.45X the rate of permeation when compared to Geo-Seal. This is not surprising when considering the HDPE composite composition of Geo-Seal compared to the simple commercially available asphalt/latex membrane.

Comparative VOC Vapor Challenge Post-Saturation. In order to compare the relative performance of Geo-Seal and commercially available asphalt/latex membranes to act as a long term barrier to VOC vapor permeation, a series of test were conducted by a third party laboratory employing a double compartment apparatus in a modified ASTM-F739 test protocol (see Figure 2). Under this test the membranes were first subjected to the VOC for 24 hours to reach saturation then placed into the apparatus which subjected the membrane to VOC vapors for a period of 8 hours.

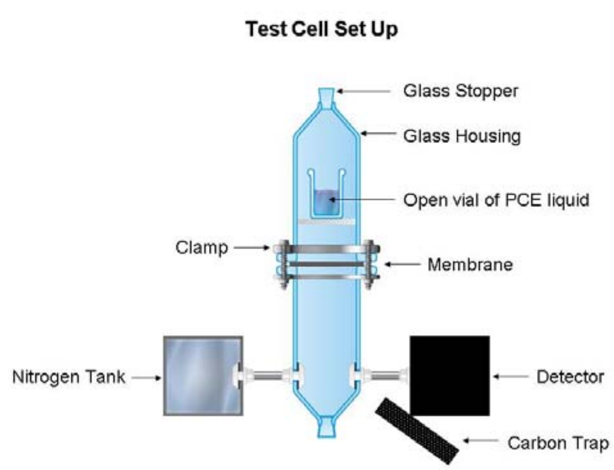


FIGURE 2. Double Compartment Apparatus

As can be seen from the results presented in Table 4, Geo-Seal did not break-through or allow detectable permeation of the VOC vapors within the testing period even after being saturated with the VOC prior to testing. The simple asphalt/latex membrane however, under the same conditions, reached break-through after 450 minutes and had reached a steady state permeation rate of 5 μg/cm^2/min.

TABLE 4. Results of Comparative Permeation Testing under VOC Vapor Challenge*			
Barrier Material	VOC Contaminant	Breakthrough Time (minutes)	Steady-State Perm Rate (μg/cm^2/min)
Asphalt/Latex+	PCE	450	5
Geo-Seal™	PCE	No Breakthrough	< 0.01

+Liquid Boot ®, Santa Ana, CA, USA

SUMMARY

Membrane materials for use as sub-slab contaminant vapor barriers are evolving. It is now becoming recognized that traditional waterproofing materials such as asphalt/latex membranes, while low in cost and easy to apply, are limited in their ability to block the permeation of volatile organic contaminants. Through recent advancements in membrane science a composite membrane (Geo-Seal™) is now available which encapsulates a spray applied asphalt/latex membrane with chemically resistant high density polyethylene. This technology is shown to have superior characteristics as a vapor barrier to VOC contamination when compared to traditional asphalt/latex membranes.

REFERENCES

ASTM D543-06: American Society for Testing and Materials method ASTM S543-06, "Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents" www.astm.org

ASTM F739-07: American Society for Testing and Materials method ASTM F 739, "Standard Test Method for Permeation of Liquids and Gases through Protective Clothing Materials under Conditions of Continuous Contact" www.astm.org

Cetco Liquid Boot. 2008. CETCO Liquid Boot Vapor Intrusion Seminar: Chemical Compatibility of Liquid Boot® Membranes with Respect to Vapor Barrier Application, Workbook April 29,2008.

Park, J.K., J.P. Sakti, and J.A. Hoopes. 1996. "Determination of Volatile Organic Compound Permeation Through Geomembranes". *Volatile Organic Compounds in the Environment, ASTM STP 126, W. Wang. J. Schoor, and J. Doi, Eds.*, American Society for Testing and Materials, 1996, pp. 245-258.

Appendix D:

Soil Vapor Barrier Product Information

Geo-Seal™ Vapor Warranty Information

Geo-Seal ™ Warranty Information

Land Science Technologies™ is pleased to offer the following warranty options for the Geo-Seal™ gas vapor management system. The warranty options below are approved on a project by project basis; to gain approval for a specific project please contact your local Land Science Technologies representative or our corporate office (949.366.8000).

Material Only Warranty

This warranty states that the Geo-Seal™ will be free of defects for the specified warranty period. We are able to offer this warranty for a period ranging from one to 30 years. To obtain a material warranty we will require the following:

- Manufacturer's representative inspection or inspection by 3rd party as approved by Land Science Technologies
- Notice in writing of desired warranty prior to the start of installation
- Soils report or other document with ground water or soil gas data

Material Only Warranty terms

- Material warranty up to 20 years is free of charge
- 25 year warranty is $0.07 per square foot
- 30 year warranty is $0.10 per square foot

System Warranty

This warranty option covers both the Geo-Seal material and the applicator's workmanship for the specified warranty period. We are able to provide this warranty for a 5 year period, and up to 20 years. To obtain this comprehensive warranty we will require the following:

- Manufacturer's representative inspection or inspection by 3rd party as approved by Land Science Technologies
- Notice in writing of desired warranty prior to the start of installation
- Soils report or other document with ground water or soil gas data
- Comprehensive review of project drawings prior to bid date
- Implementation of project specific details into the mitigation plans or project drawings

System Warranty terms

- System warranty up to 10 years is free of charge
- 15 year system warranty is $0.10 per square foot
- 20 year system warranty is $0.14 per square foot

Gas Vapor Barrier and Hydrostatic Pressure

Our relationship with Epro Services allows us to provide one system that provides both vapor intrusion and waterproofing protection. Hydrostatic conditions can present the most challenging conditions and can require additional products and project specific details for specific conditions. Similar warranty offerings are available for this condition; please contact Land Science Technologies for more information.

No Warranty

If no warranty is desired, a letter is required from the owner, or party acting on behalf of the owner, stating their desire. This letter must be received prior to beginning the Geo-Seal installation.

If circumstances are such that Land Science Technologies will not provide a material or system warranty, a letter will be issued to the owner or specifying engineer. The letter will be issued prior to beginning the Geo-Seal installation, but can also be issued during the installation if a change in site conditions prevent the proper installation of the membrane.

Appendix D:

Soil Vapor Barrier Product Information

Liquid Boot Technical Data

LIQUID BOOT®

SPRAY-APPLIED GAS VAPOR BARRIER

PRODUCT DESCRIPTION

Liquid Boot® is specially formulated for use as a:

- Gas Vapor Barrier
- Damp Proofing Membrane

Damp proofing membrane is intended to provide a barrier to water in non-hydrostatic incidental water conditions. Liquid Boot® has been specially designed as an impermeable vapor membrane/barrier for projects that are situated on sites with volatiles, gases or contaminants in the soil. Liquid Boot® is manufactured to meet or exceed the minimum average values listed in the chart below.

BENEFITS

- Spray application provides excellent sealing of penetrations
- Seamless, monolithic membrane means no mechanical fastening required
- Protection from methane gas, VOCs, chlorinated solvents and other contaminates
- Also protects against water vapor

INSTALLATION

Protect all adjacent areas not to receive gas vapor barrier. Ambient temperature shall be within manufacturer's specifications. All plumbing, electrical, mechanical and structural items to be under or passing through the gas vapor barrier shall be secured in their proper positions and appropriately protected prior to membrane application. Gas vapor barrier shall be installed before placement of reinforcing steel. Expansion joints must be filled with a conventional waterproof expansion joint material. Surface preparation shall be per manufacturer's specification. A minimum thickness of 60 dry mils, unless specified otherwise.

AVAILABILITY

Shipping is available from two convenient plant locations:

- CETCO, 1001 S Linwood Ave, Santa Ana, CA
- CETCO, 218 NE Industrial Park Rd, Cartersville, GA

Contact your local technical sales manager at:
714-384-0111 or 800-527-9948

PHYSICAL PROPERTIES

PROPERTIES	TEST METHOD	VALUE
Hydrogen Sulfide Gas Permeability	ASTM D1434	None Detected
Chemical Resistance: VOCs, BTEXs (tested at 20,000 ppm)	ASTM D543	Less than 1% weight change
Sodium Sulfate (2% water solution)	ASTM D543, D412, D1434	Less than 1% weight change
Acid Exposure (10% H2SO4 for 90 days)	ASTM D543	Less than 1% weight change
Radon Permeability	Tested by US Dept. of Energy	Ø permeability to Radon (222 Rn)
Chromate Exposure (10% Chromium6+ salt for 31 days)	ASTM E96	Less than 1% weight change
Air Infiltration	ASTM E283-91	0 cfm/sq. ft.
*Bonded Seam Strength Tests	ASTM D6392	Passed
*Micro Organism Resistance (Soil Burial)	ASTM D4068-88	Passed
*Methane Permeability	ASTM 1434-82	Passed
*Oil Resistance Test:	ASTM D543-87	Passed
*Heat Aging:	ASTM D4068-88	Passed
*Dead Load Seam Strength	City of Los Angeles	Passed
*Environmental Stress-Cracking	ASTM D1693-78	Passed
PCE Diffusion Coefficient	Tested at 6,000 mg/m3	2.74×10^{-14} m^2/sec
TCE Diffusion Coefficient	Tested at 20,000 mg/m3	8.04×10^{-14} m^2/sec
Benzene Diffusion Test	Tested at 43,000 ppm	2.90×10^{-11} m^2/day

* Required Tests for membranes in the City of Los Angeles Methane Zone

PROPERTIES cont'd	TEST METHOD	VALUE
Soil Burial	ASTM E154-88	Passed
Water Penetration Rate	ASTM D2434	<7.75 x 10^{-9} cm/sec
Water Vapor Permeability	ASTM E96	0.24 perms
Water Vapor Transmission	ASTM E96	0.10 grains/h-ft^2
Toxicity Test	22 CCR 66696	Passed
Potable Water Containment	ANSI/NSF 61	NSF Certified for tanks >300,000 gal
Coefficient of Friction (with geotextile both sides)	ASTM D5321	0.72
Cold Bend Test	ASTM D146	Passed. Ø cracking at -25°F
Freeze-Thaw Resistance (100 Cycles)	ASTM A742	Meets criteria. Ø spalling or disbondment
Accelerated Weathering and Ultraviolet Exposure	ASTM D822	No adverse effect after 500 hours
Hydrostatic Head Resistance	ASTM D751	Tested to 138 feet or 60 psi
Elongation	ASTM D412	1,332% Ø reinforcement, 90% recovery
Elongation w/8 oz. non-woven geotextile both sides	ASTM D751	100% (same as geotextile tested separately)
Tensile Strength	ASTM D412	58 psi without reinforcement
Tensile Strength w/8 oz. non-woven geotextile both sides	ASTM D751	196 psi (same as geotextile tested separately)
Tensile Bond Strength to Concrete	ASTM D413	2,556 lbs/ft^2 uplift force
Puncture Resistance w/8 oz. non-woven geotextile both sides	ASTM D4833	286 lbs. (travel of probe = 0.756 in)
Flame Spread	ASTM E108	Class A with top coat (comparable to UL790)
Electric Volume Resistivity	ASTM D257	1.91 x 10^{10} ohms-cm

LIMITED WARRANTY

CETCO warrants its products to be free of defects. This warranty only applies when the product is applied by Approved Applicators trained by CETCO. As factors which affect the result obtained from this product, including weather, equipment, construction, work-manship and other variables are all beyond CETCO's control, we warrant only that the material herein conforms to our product specifications. Under this warranty we will replace at no charge any product proved to be defective within 12 months of manufacture, provided it has been applied in accordance with our written directions for uses we recommend as suitable for this product. This warranty is in lieu of any and all other warranties expressed or implied (including any implied warranty of merchantability or fitness for a particular use), and the Manufacturer shall have no further liability of any kind including liability for consequential or incidental damages resulting from any defects or any delays caused by replacement or otherwise. This warranty shall become valid only when the product has been paid for in full.

PACKAGING

- 55 Gallon Drum
- 275 Gallon Tote

LIMITATIONS

- Do not allow materials to freeze in containers.
- Store Liquid Boot® at site in strict compliance with manufacturer's instructions.
- When applying material below 45°F, contact your local technical sales manager.

EQUIPMENT Contact CETCO for complete equipment specifications

- COMPRESSOR: Minimum output of 155-185 cubic feet per minute (CFM)
- PUMPS: For "A" drum, an air-powered piston pump of 4:1 ratio (suggested model: Graco, 4:1 Bulldog). For "B" drum, an air-powered diaphragm pump (0 -100 psi)
- HOSES: For "A" drum, ½" wire hose with a solvent resistant core (for diesel cleaning flush), hose rated for 500 psi minimum. For "B" drum, a 3/8" fluid hose rated at only 300 psi may be used.
- SPRAY WAND: Only the spray wand sold by CETCO is approved for the application of Liquid Boot®.
- SPRAY TIPS: Replacement tips can be purchased separately from CETCO.

Appendix D:

Soil Vapor Barrier Product Information

Liquid Boot Installation Process

LIQUID BOOT® Installation Process

STEP 1: LIQUID BOOT® GeoVent being installed for the passive venting layer

STEP 2: LIQUID BOOT® Base Fabric T-60 being laid out.

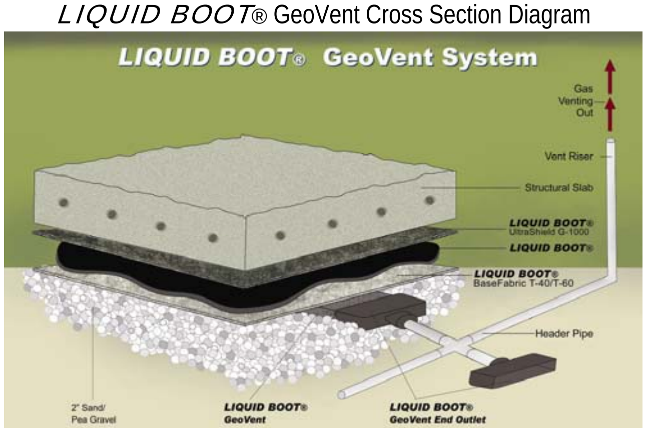
STEP 3: Penetrations being prepared with LIQUID BOOT® Trowel Grade before spraying.

STEP 4: LIQUID BOOT® Gas Vapor Barrier being sprayed.

STEP 5: LIQUID BOOT® Smoke Testing Process

STEP 6: LIQUID BOOT® UltraShield G-1000 protection course installation.

LIQUID BOOT® GeoVent Cross Section Diagram



Appendix D:

Soil Vapor Barrier Product Information

GeoKinetics Results of Solvent Diffusion Tests on Liquid Boot Membranes

GeoKinetics
Geotechnical &
Environmental Engineers

15510 Rockfield Blvd., Suite C3
Irvine, CA 92618

Tel 949.580.1818, Fax 949.580.1819
E-Mail: geokinetics@appliedgeokinetics.

November 11, 2004

Mr. Richard Cicoletti
LBI Technologies
3873 East Eagle Drive
Anaheim, CA 92807

SUBJECT: RESULTS OF SOLVENT DIFFUSION TESTS ON LIQUID BOOT MEMBRANES

Dear Mr. Cicoletti,

As requested, GeoKinetics has completed a series of vapor diffusion tests on Liquid Boot^R membranes. The tests were performed using the highly volatile chlorinated solvents tetrachloroethylene (PCE) and trichloroethylene (TCE) over a period of approximately four months. The membranes were subjected to relatively high solvent vapor concentrations (6,000 to 20,000 mg/m^3) to simulate severe exposure conditions. The tests were performed on 60-mil thick Liquid Boot^R membranes. The membranes were found to have very low diffusion coefficients for the solvents indicating they represent an effective barrier under the test conditions. The testing procedures and associated results are described in the attached report. We hope this information is helpful to you. Please do not hesitate to contact the undersigned if you have any questions or comments.

Sincerely,
GEOKINETICS, INC.

Glenn D. Tofani, GE/RCE/REA
Principal engineer

attachment

1.0 Introduction: GeoKinetics has performed solvent diffusion tests on a series of 60-mil thick Liquid Boot[R] membrane samples that were provided by your office. Tests were performed using the highly volatile chlorinated solvents tetrachloroethylene (PCE) and trichloroethylene (TCE) over a period of approximately four months. The purpose of these tests was to establish diffusion coefficients for use in estimating the rates at which the solvent vapors will migrate across a Liquid Boot[R] membrane under a concentration gradient. We are not aware of any ASTM or other standardized testing procedures for measuring the diffusion coefficients of organic solvents across gas membranes. However, standardized ASTM test procedures have been established for measuring water vapor transmission, or diffusion, across membranes (i.e. ASTM E96-00e1 and F1770-97e1). For the existing project, we have utilized the same experimental approach set forth in these standards but modified the measurement protocol so that it is suitable for quantification of the diffusion rate of the organic solvents that were tested.

2.0 Test Configuration & Protocol: The tests that were performed in conjunction with this project involved placing Liquid Boot[R] membranes between two chambers with different organic solvent vapor levels and measuring the rate of vapor transmission through the membrane over time. The test configuration that was utilized is illustrated in Figure 1. A series of two-piece, cylindrical, 6-inch diameter borosilicate glass test chambers were fabricated for the testing program. The lower test chamber was partially filled with a solution of distilled water and either PCE or TCE. The test cells were maintained at a constant temperature of 70° F throughout each test. The solvent solutions were prepared to provide specific vapor levels in the lower chamber based upon the test temperature and Henry's law constants for the solvents, as follows:

Solvent	Air-Water Partioning Coefficient	Solvent Concentration in Water	Solvent Vapor Concentration
PCE	0.605	9.92 mg/l	6 mg/l
TCE	0.410	48.8 mg/l	20 mg/l

A sufficient volume of the water / solvent solution was provided in the lower chamber to maintain a near steady-state vapor concentration within that chamber throughout the duration of the test. The vapor concentration in each of the lower test chambers was confirmed using a Photovac Photo-Ionization Detector (PID) at the start and completion of each test.

The membrane to be tested was sealed to the lower test chamber using a high quality silicone sealant. An upper test chamber was then placed above the membrane using the same procedure. As shown in Figure 1, both the upper and lower test cells were vented to the atmosphere to prevent the development of any pressure differential across the membrane. After the sealant had cured for 24-hours, the upper cell was purged with clean (filtered) air through the two integral ports. Immediately thereafter, one of the ports was connected to three in-line granular activated carbon filters while the other port was sealed. The upper chamber remained open to the atmosphere (through the carbon filters) throughout the duration of the test to prevent differential pressures across the membrane. Solvent vapors that diffused across the membrane from the lower to upper test chambers were absorbed by the primary activated carbon filter (GAC-1). The secondary in-line filter (GAC-2) provided a means of determining if solvent vapors migrated past the primary filter for quality assurance purposes. The tertiary activated carbon filter (GAC-3) prevented contamination of the secondary filter from background levels of solvents that may be present in the air within the testing laboratory. The primary and secondary activated carbon filters consisted of virgin granular activated carbon. The weight of the activated carbon used in the filters ranged from 1.8 grams up to 20 grams. The tertiary filter consisted of a 500 gram activated carbon canister filter. Photographs of the tests chambers are provided in Figure 2 for your reference.

The diffusion tests were performed for periods ranging from 11 to 123 days. At the termination of each test, the primary and secondary activated carbon filters were individually sealed and detached from the upper test chamber. The filters were then submitted to a state-certified analytical laboratory for analysis of volatile organic compounds (solvents) in accordance with EPA 8260B testing protocol. All of the activated carbon was removed from each of the filters at the laboratory. The organic compounds that had been absorbed by each filter were then extracted using a 1:1 ratio of methanol to activated carbon (5 ml : 5 g). The extract was analyzed using the above referenced gas chromatography / mass spectrometry (gc/ms) test procedure. The typical practical quantification limit (PQL) for this analytical procedure was 1 μg/kg. With the specific filter weights that were used for the tests, the method was able to determine the quantity of the target solvent in the filter with a resolution of approximately ± 0.002 μg to $\pm 0.02 \mu$g.

Two different solvents were evaluated in this program. Four identical samples were tested with both solvents resulting in a total of eight tests. A matrix summarizing the test configurations is provided below:

Membrane	Solvent	Vapor Concentration	Number of Tests
60-mil	PCE	6,000 mg/m^3	4
	TCE	20,000 mg/m^3	4
		Total:	**8**

All eight tests were initiated at the same time. Testing on the first sample for both solvents was terminated after 11 days. Testing on the second, third, and final sets of samples was terminated after 35, 70, and 123 days, respectively. The primary and secondary activated carbon filters for each test were immediately sealed and transported to the laboratory for analysis upon the completion of that test. The test designations and weights of the activated carbon filters are summarized in Table 1. Larger carbon filters were used for the longer duration tests for the membranes in anticipation of potentially higher solvent levels. It was intended that the 123 day sample for PCE and the 70 and 123 day samples for TCE would have the larger (20 gram) filters. However, one of the TCE samples with the larger filter was inadvertently terminated after 35 days of testing rather than after 70 days of testing as had been intended. As will be discussed in the subsequent section of this report, this deviation does not appear to have affected the test results.

The effective diffusion coefficient was determined for each of the three test series using Fick's law, as follows:

$$M / t = D_c * (\Delta C/\Delta X) * A$$

Where:

M = the quantity of solvent which diffused across the membrane during the test (mg)

t = the test duration (days)

D_c = the membrane diffusion coefficient (m^2 / day)

ΔC= the difference in the solvent vapor concentration between the lower and upper cells = the concentration in the lower cell (mg/m^3)

ΔX= the thickness of the membrane (m)

A = the membrane area (m^2)

The thickness of each membrane was measured at eight equally spaced locations around the perimeter of each sample before and after testing.

3.0 Test Results: The minimum, maximum, and average measured thicknesses of each of the eight membrane samples - both before and after testing - are summarized in Table 2. The localized thickness of the samples was found to range from 42½ mils (0.0425") to 88.5 mils (0.0885"). The average thickness of individual samples ranged from a minimum of 50.8 mils to a maximum of 78.8 mils. The average thicknesses of the membrane samples for both test series are shown below:

Solvent	Average Membrane Thickness for Test Series
PCE	66 mils
TCE	56 mils

The solvent vapor concentrations measured in the upper and lower test chambers at the beginning and end of each test are summarized in Table 3. As can be seen from these values, the vapor concentrations measured in the lower test chamber were consistent with the target values that were estimated using the established air / water partitioning coefficients for each solvent. Low concentrations of VOC's were detected in the upper test chambers at the start of each test (prior to connection of the test cells to the carbon filters). However, VOC's were typically not detected above background levels in any of the upper test chambers with the PID at the completion of the tests.

Copies of the laboratory testing results for each of the primary and secondary activated carbon filters are included in Attachment A for your reference. The reported solvent concentrations are summarized in Table 4 while graphs illustrating the rate of solvent diffusion across the membrane for each test are provided in Figures 3 and 4. We have made the following observations based upon our evaluation of these results:

- Variable concentrations of chlorinated solvents other than PCE and TCE were detected in the activated carbon filters. The presence of these compounds is likely attributable to background concentrations of solvents in the analytical laboratory. The presence of these solvents should not have impacted the identification and quantification of TCE and PCE in the filter media.

- TCE was detected in each of the four primary and four secondary filters for the PCE test samples. The average concentration of TCE in these samples was approximately 2,400 μg/kg. TCE is not a common laboratory solvent. It is therefore more likely that the "background" TCE was absorbed by the activated carbon prior to initiating the tests.

- Low levels of PCE were detected in four of the eight carbon filters for the TCE test series. The average PCE concentration in the filters was approximately 300 μg/kg. As with the TCE, the PCE was likely absorbed by the filters prior to the initiation of testing.

- The four data points for PCE series of tests show a relatively linear increase in the solvent concentration over time within the primary activated carbon filters, as shown in Figure 3. The average rate of PCE absorption by the filter during this test series was 0.12 μg / day.

- A small tear or puncture in the Liquid Boot^R membrane was identified in the 70 day sample in the TCE series of tests. This puncture was approximately 0.2" long with no measurable width. It appeared to extend entirely through the Liquid Boot^R membrane. The penetration appears to have been caused by excessive clamping pressure between the upper and lower test chambers. An anomalously high TCE level was detected in the primary filter for this test. The presence of the penetration is believed to account for the high TCE level that was measured in the primary filter for this sample. As shown in Figure 4, the TCE levels in the filters for the three remaining tests indicate a relatively linear TCE absorption rate of 1.22 μg / day.

The estimated solvent diffusion rates from the data presented in Figures 3 and 4 are summarized in Table 5 along with the other test parameters that were used to calculate the associated membrane diffusion coefficient. The membrane diffusion coefficients that were calculated for both test series are also presented in this table. As shown, the calculated diffusion coefficients range from 2.74×10^{-14} m^2 / sec up to 8.04×10^{-14} m^2 / sec. The lower diffusion rates were obtained for PCE and the higher rates for the more volatile TCE. In each instance, the calculated diffusion coefficients are relatively low and indicate the membrane represents a relatively effective barrier against diffusion of the solvents that were tested.

4.0 Closing: We have performed the observations and testing for this project with the degree of skill and care ordinarily exercised by engineers practicing in this, and similar, localities. No other warranty, expressed or implied, is given regarding the conclusions or professional opinions presented in this report. The scope of this report is limited to the matters expressly covered herein. This report is presented for the sole use of LBI Technologies and may not be relied upon by any other party without written authorization from the undersigned.

We hope this information is helpful to you. Please do not hesitate to contact the undersigned if you have any questions or comments.

Prepared by:
GEOKINETICS, INC.

Glenn D. Tofani, GE/RCE/REA
Principal Engineer

Reviewed by:
GEOKINETICS, INC.

S.V. Jagannath, Ph.D/GE
Project Engineer

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No. 044229
Exp. 6-30-05
CIVIL
STATE OF CALIFORNIA

REGISTERED PROFESSIONAL ENGINEER
GLENN D. TOFANI
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Exp. 6-30-05
GEOTECHNICAL
STATE OF CALIFORNIA

Table 1 - Test Designations and Activated Carbon Filter Weights

Test Conditions	Test Duration	Test Designation	Activated Carbon Filter Weights	
			Primary	Secondary
PCE Solvent With 60-mil Liquid Boot^R Membrane	11	D	1.8 g	1.8 g
	35	C	1.8 g	1.8 g
	70	B	1.8 g	1.8 g
	123	A	20.0 g	1.8 g
TCE Solvent With 60-mil Liquid Boot^R Membrane	11	L	1.8	1.8 g
	35	J	20.0	1.8 g
	70	K	1.8	1.8 g
	123	I	20.0	1.8 g

Table 2 - Summary of Membrane Thickness Measurements

Test Conditions	Test Duration	Test Designation	Measured Membrane Thickness (mils)		
			Minimum	Maximum	Average
PCE Solvent With 60-mil Liquid Boot^R Membrane	11	D	60.5	71.0	65.3
	35	C	62.0	82.5	70.1
	70	B	72.5	78.0	75.5
	123	A	46.5	60.0	51.7
TCE Solvent With 60-mil Liquid Boot^R Membrane	11	L	47.5	58.5	50.8
	35	J	56.0	67.0	61.9
	70	K	51.0	63.5	58.3
	123	L	47.5	58.5	50.8
		Average Values:	57.6	72.0	64.7

Table 3 - Summary of VOC Vapor Levels Measured in Test Chambers

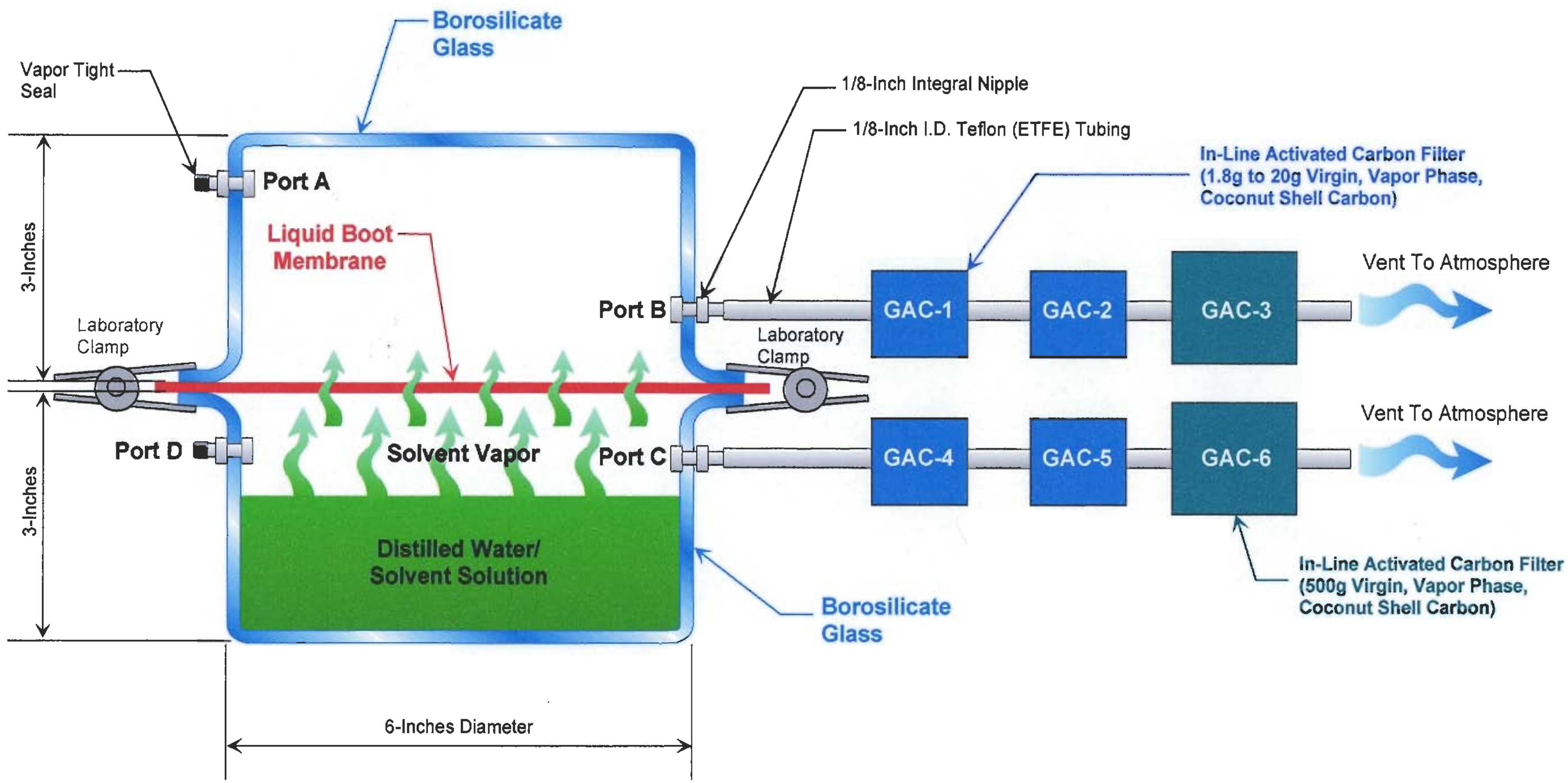
Test Condition	Solvent	[1]Measured VOC Levels (mg/m^3)							
		Series #1 (11 Days)		Series #2 (35 Days)		Series #3 (70 Days)		Series #4 (123 Days)	
		Start of Test	End of Test	Start of Test	End of Test	Start of Test	End of Test	Start of Test	End of Test
PCE Solvent With 60-mil Liquid Boot[R] Membrane	Upper Chamber	4	<0.7	2	<0.7	5	1	4	<0.7
	Lower Chamber	6,170	5,990	5,820	6,070	6,020	6,100	6,350	6,040
TCE Solvent With 60-mil Liquid Boot[R] Membrane	Upper Chamber	8	2	11	1	19	4	9	1
	Lower Chamber	18,600	19,850	20,230	19,850	20,100	18,350	20,200	19,270

Table 4 - Summary of Solvent Concentrations for Activated Carbon Filters

Test Condition	Solvent	Filter Solvent Concentrations ($\mu g/kg$) @ Indicated Test Durations							
		11 Days		35 Days		70 Days		123 Days	
		Primary Filter	Secondary Filter	Primary filter	Secondary Filter	Primary Filter	Secondary Filter	Primary Filter	Secondary Filter
PCE Solvent With 60-mil Liquid Boot[R] Membrane	TCE	1,500	1,100	2,500	750	4,200	1,500	5,800	1,900
	PCE	1,500	ND	ND	ND	5,100	ND	710	ND
	Carbon Tetrachloride	ND	ND	ND	ND	ND	870	7,600	8,000
	Trans-1,2 DCE	ND	ND	ND	ND	ND	ND	480	450
	1,1 Dichloropropane	8,500	8,500	2,600	2,400	ND	ND	ND	ND
	Methylene Chloride	630	620	ND	ND	ND	ND	ND	ND
TCE Solvent With 60-mil Liquid Boot[R] Membrane	TCE	17,000	1,200	2,800	1,200	94,000	2,700	7,500	43,000
	PCE	1,100	780	ND	ND	ND	ND	93	350
	Carbon Tetrachloride	ND	ND	ND	ND	580	830	7,700	8,700
	Trans-1,2 DCE	ND	ND	ND	ND	ND	ND	93	640
	1,1 Dichloropropane	6,300	5,800	3,100	3,000	ND	ND	ND	ND
	Methylene Chloride	560	530	420	480	ND	ND	ND	ND

Table 5 - Summary of Test Parameters and Calculated Membrane Diffusion Coefficients

Test Conditions	Average Solvent Diffusion Rate	Solvent Vapor Concentration Differential	Membrane Area	Membrane Thickness	Calculated Diffusion Coefficient
PCE Solvent With 60-mil Liquid Boot® Membrane	0.12 μg/day	6,000 mg/m^3	1.45 x 10^{-2} m^2	1.68 x 10^{-3} m	2.74 x 10^{-14} m^2/sec
TCE Solvent With 60-mil Liquid Boot® Membrane	1.22 μg/day	20,000 mg/m^3	1.48 x 10^{-2} m^2	1.57 x 10^{-3} m	8.04 x 10^{-14} m^2/sec



GeoKinetics
Geotechnical & Environmental Engineers

Project Name: Liquid Boot Diffusion Testing	
Project No.: 1163H	Date: November 2004

Membrane Diffusion Test Configuration

Figure 1

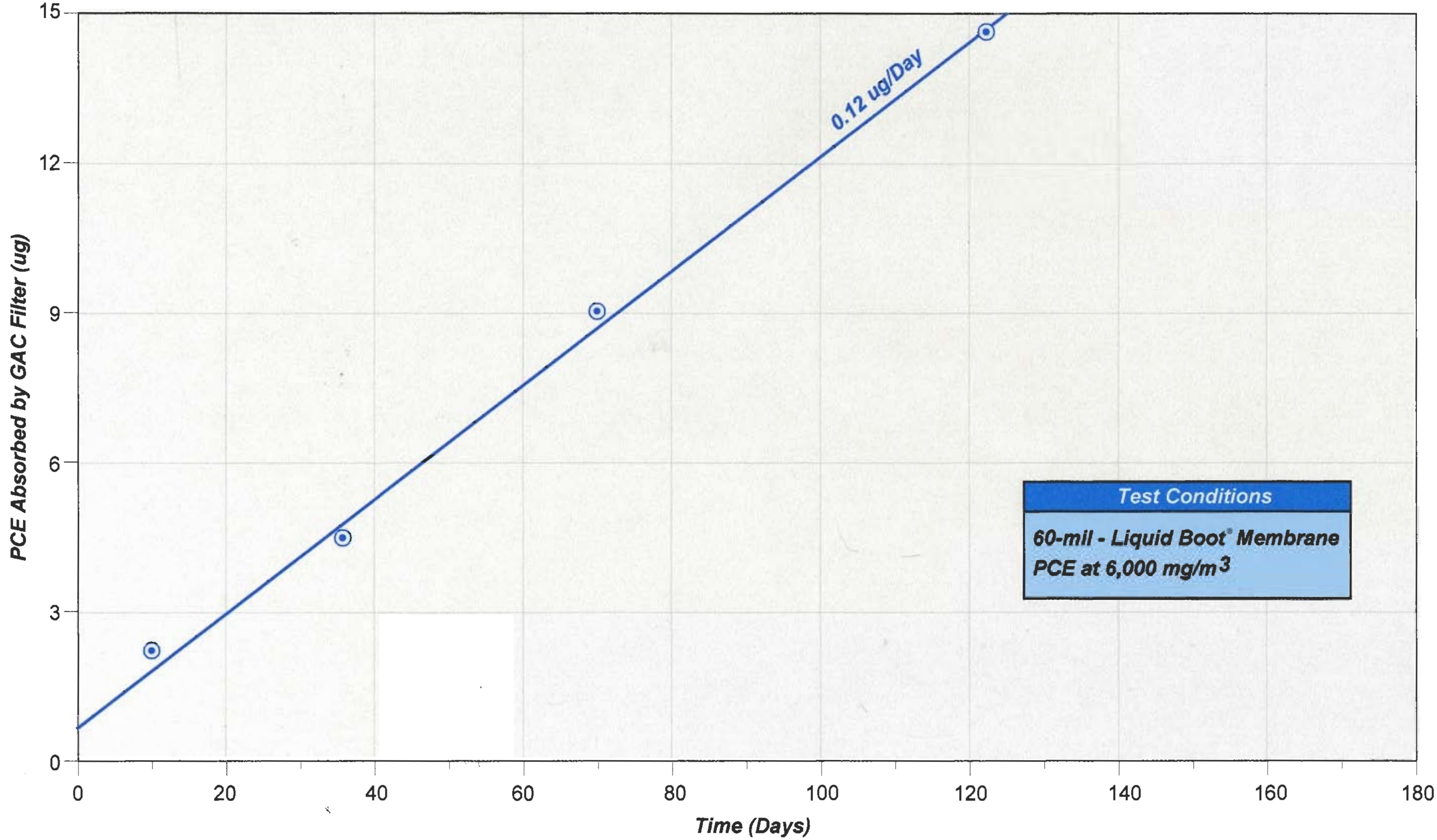
GeoKinetics
Geotechnical & Environmental Engineers

Project Name: Liquid Boot Diffusion Testing

Date: November 2004

Liquid Boot Diffusion Testing

Figure 2



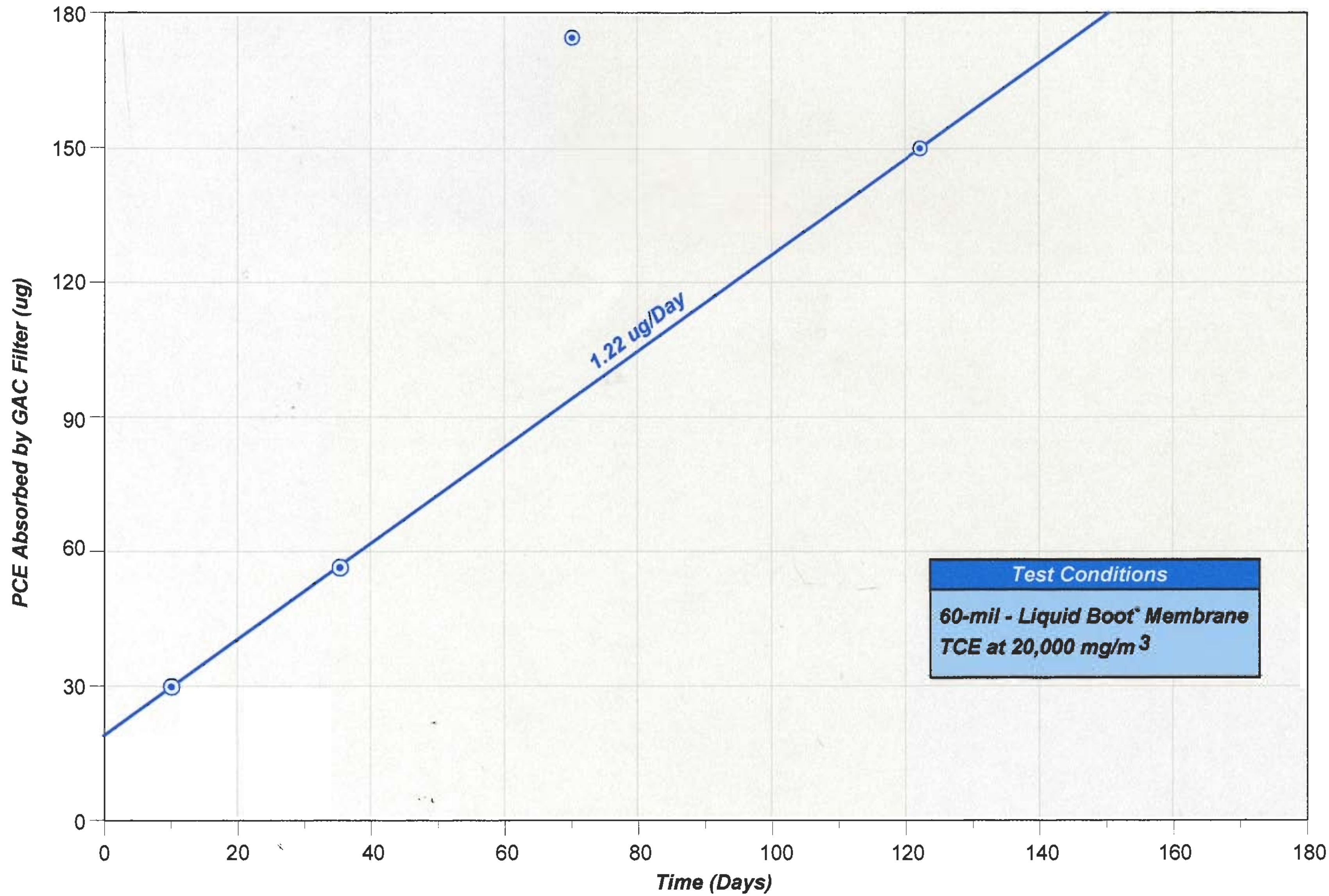
GeoKinetics
Geotechnical & Environmental Engineers

Project Name: Liquid Boot Diffusion Testing

Project No.: 1163H | Date: November 2004

Test Results for Liquid Boot® Membrane With PCE

Figure 3



GeoKinetics
Geotechnical & Environmental Engineers

Project Name: Liquid Boot Diffusion Testing

Project No.: 1163H | Date: November 2004

Test Results for Liquid Boot® Membrane With TCE

Figure 4

Appendix E:

City of Los Angeles Methane Barrier Test Criteria

METHANE BARRIER TEST CRITERIA

PART 1 - BONDED SEAM STRENGTH TESTS:

A. Seams shall be bonded using processes and materials representative of the field installation. The method of producing the seams that was used to pass this criteria shall be the only method approved for field installation.

B. A minimum of ten identically prepared specimens shall be tested.

C. Unsupported materials

1. Method A or B of ASTM D882-88 shall be used with the following modifications:

a. Specimens shall be 1 inch wide.

b. The grip separation shall be 4 inches plus the width of the seam with the seam centered between the clamps and oriented perpendicular to the length of the test specimen.

c. The rate of the grip separation shall be 20 inches per minute or as specified in the
material property tables. The rate of grip separation for HDPE liners shall be 2 inches per minute.

d. Conditioning of the sample seams shall be as described in Part E.

D. Supported Materials

1. The Grab Test method of ASTM D751-89 shall be used with the following modifications:

a. Specimens shall be 4 inches in width and not less than 9 inches plus width of the seam.

b. At the start of the test the sample shall be positioned such that the clamps are 3 inches clear from the closest edge of the seam.

c. Conditioning of the sample seams shall be as described in Part E of this test criteria.

d. The rate of loading shall be at the rate of 12 inches per minute.

E. Conditioning of seam specimens

1. Heat-sealed specimens shall be conditioned for 24 hours at 74 ± 4 degrees Fahrenheit. (23 ± 2EC).

2. Adhesive seamed specimens shall be conditioned for a minimum of 24 hours at 74 ± 4 degrees Fahrenheit (23 ± 2EC), or for any greather period of time as recommended by the manufacturer. The test report shall state the time period used for conditioning of the test samples.

F. Seams and bonding methods shall be deemed acceptable when none of the ten samples fail within the bonded overlapping portion of the test samples, such that the seams may be deemed as strong or stronger than the membrane as tested without seams.

G. The test report shall include the additional information as needed to specify the test seam. The length of the overlap, method of bonding the seam, and, if a bonding agent is used, the rate of dispersion of the bonding agent and curing time used to produce the test samples shall be reported.

Note that this test shall apply to liquid applied membranes also. Samples representative of the manufacturers recommended field repair guidelines shall be tested.

PART 2 - MICROORGANISM RESISTANCE (SOIL BURIAL)

A. Testing shall be performed according to Annex A of ASTM D4068-88 with the following changes:

1. Section A 1.2.1 is modified by omitting the three T-peel specimens and replacing them with two sets of five samples of appropriate dimensions as needed to test the Bonded Seam Strength in accordance with Part 1 of this test criteria for methane barriers. In addition a minimum of two sets of three specimens of the size needed to perform the methane gas permeability test according to ASTM D1434-82 shall be prepared.

2. Section A 1.3.3.1 shall be modified by substituting Bonded Seam Strength specimens for the T-peel specimens.

3. Section A 1.4.1 is amended by adding the requirement that both sets of the samples needed for testing Bonded Seam Strength and Methane Permeability be buried as prescribed in this section.

4. Section A 1.4.2 is amended by omitting the test requirement for the T-peel samples.

5. Section A 1.4.3 is amended by omitting the test requirement for the T-peel samples, and by adding the requirement that one set of the buried samples for Bonded Seam Strength and Methane Permeability be tested as prescribed in Parts 1 and 3 of this acceptance criteria. The second set of the Bonded Seam Strength and Methane Permeability shall be retained for future reference.

B. Acceptable materials must exhibit the following performance characteristics:

1. The average value of weight change ± 5%.

2. The average value of tensile strength change ± 10% maximum.

3. The average value of tensile stress at 100% elongation ± 10% maximum.

4. The average value of elongation change ± 10% maximum.

5. Seams shall not fail in the seam areas when tested to criteria of Part 1.

6. Methane Permeability shall neither increase beyond the values obtained from Part 3 nor shall they exceed the limit stated in Part 3 of this test criteria.

PART 3 - METHANE PERMEABILITY

A. Methane Permeability shall be tested using ASTM D 1434-82 with the following added requirements:

1. Testing shall be performed at a temperature of 74 ± 4 degrees Fahrenheit. (23 ± 2E C)

2. A minimum of 3 samples shall be tested and the average value of the Methane Gas Transmission Rate shall be reported. If the lower test value varies by more than 10% from the highest test value two additional samples shall be tested, and the Gas Transmission Rate shall be reported as an average of the five test values.

B. Materials exhibiting an average Methane Gas Transmission Rate not exceeding 40.0 ml/day.m^2.atm shall be acceptable.

PART 4 - OIL RESISTANCE TEST

A. Testing shall be performed according to ASTM D543-87 with the following specifications:

1. Section 10.2 is clarified to specify that the tests shall be run at a temperature of 74 ± 4 degrees Fahrenheit. (23 ± 2EC)

2. Section 10.4 shall be modified to require the test to be run for 28 days.

3. To Section 7 of this standard add the following test specimen requirement:

   Bonded Seam Strength Specimens shall be prepared in accordance to the guidelines of Part 1 of these standards. Five specimens shall be immersed in the test reagent and tested to failure as specified in the Bonded Seam

Strength test criteria.

B. The following reagent shall be used:

1. Standard 30 weight non detergent motor oil.

C. Materials will be judged acceptable if the average value of changes do not exceed:

1. Weight change ± 10%.

2. Tensile yield strength ± 10%.

3. Tensile breaking strength ± 10%.

4. Elongation at break ± 10%.

5. Testing of Bonded Seams shall not exhibit any failure in the bonded seams.

PART 5 - HEAT AGING

A. Heat aging shall be tested in accordance with ASTM D4068-88 with the following modifications:

1. Section 14.3 is modified to omit the weight change specimens and bonded T-peel specimens. This section is further amended to require five Bonded Seam Strength specimens of dimensions needed for testing in accordance with Part 1 of this acceptance criteria to be heat aged.

B. Tensile strength, tensile stress at 100% elongation, and ultimate elongation shall be tested per Section 14.1 and compared to unconditioned samples.

C. Bonded Seam Strength specimens shall be tested in accordance with the procedures outlined in Part 1 of this acceptance criteria.

D. Acceptable performance is obtained when the following is obtained:

1. No Bonded Seam Strength Samples shall fail in the seam locations.

2. The average values of the tensile strength change ± 10% maximum.

3. The average value fo the tensile stress at 100% elongation ± 10% maximum.

4. The average value of the elongation at break ± 10% maximum.

E. Liquid applied membranes shall use specimens representative of the field repair method recommended by the manufacturer for the Bonded Seam Strength Samples.

PART 6 - DEAD LOAD SEAM STRENGTH

A. Scope

To determine the ability of factory seam joints to withstand stress under load at room temperature (72 ± 4EF).

B. Test Specimens

The supported specimen size shall be 4-inch width of the seam joint and a 12-inch length, sufficient to fit in the clamps of the testing machine. The unsupported specimen size shall be 1 inch width of the seam joint and an 8 inch length. A total of five specimens shall be tested.

C. Procedure

The clamping mechanism will grip a 1 inch wide section and should be centered in the width of the test specimen, above and below the seam joint. The clamps shall not grip any portion of the overlap area of the seam joint.

1. Room Temperature Test: A load equivalent to 50% of the materials value for tensile stress at 100% elongation (modulus) shall be applied at the seam joint. The load shall be maintained for 4 hours at a temperature of 72 ± 4EF. The stressed sample must be closely observed. Excessive elongation may require clamp adjustment to maintain consistent loading. When elongation reaches 50% of the original jaw separation, no additional adjustment need be made. Retain existing load for balance of test duration.

2. A "failure" will be noted when seam joint separates entirely.

D. Reporting of Results

The results shall be reported by indicating the designated load, the temperature, the time duration of the test, the length of the overlap seam, and a "pass" or "fail" designation.

E. Seams shall be deemed acceptable when none of the five specimens fail.

PART 7 - ENVIRONMENTAL STRESS-CRACKING

A. Testing shall be performed using Condition B of ASTM D1693-70 with using the following modifications:

1. Use an agneous solution containing 10% igepal by volume.

2. The final product shall be tested as produced, regardless of thickness.

3. The notch depth shall be as stated in Condition B (.012 to 0.15) for all sheet thicknesses.

4. Cut five specimens with the length parallel to the roll direction (MD) and

five with the length parallel to the cross roll direction (TD).

5. Failure time shall be the time in hours to the first specimen failure.

B. The material will be deemed acceptable when the time to first failure exceed 500 hours.

/elcm - 09/23/02