United States Environmental Protection Agency

This document contains the draft guidance without the tables and appendices from the EPA "OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance)," published in November 2002. The reference number is EPA 530-D-02-004. You can find the entire document at http://www.epa.gov/epaoswer/hazwaste/ca/eis/vapor.htm.

OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance)

Draft Guidance
[without Tables and Appendices]

November 2002

DRAFT GUIDANCE
FOR
EVALUATING THE VAPOR INTRUSION TO INDOOR AIR PATHWAY FROM GROUNDWATER AND SOILS

(Subsurface Vapor Intrusion Guidance)

I. INTRODUCTION

A. General

One of the primary objectives of the Office of Solid Waste and Emergency Response (OSWER) under EPA's Strategic Plan is stated as:

> "By 2005, EPA and its state, tribal and local partners will reduce or control the risk to human health and the environment at more than 374,000 contaminated Superfund, RCRA, underground storage tank (UST), brownfields and oil sites, and have the planning and preparedness capabilities to respond successfully to all known emergencies to reduce the risk to human health and the environment."

In order to effectively "reduce or control the risk to human health and the environment," it is necessary to determine if specific exposure pathways exist. If an exposure pathway exists, we need to evaluate the site to determine whether contamination is present at levels that may pose a significant risk to human health or the environment.

B. What Is The Intent Of This Guidance?

This draft guidance specifically addresses the evaluation of a single exposure pathway – the "vapor intrusion pathway." The intent of this draft guidance is to provide a tool to help the user conduct a screening evaluation as to whether or not the vapor intrusion exposure pathway is complete and, if so, whether it poses an unacceptable risk to human health. A complete pathway means that humans are exposed to vapors originating from site contamination. The approach suggested in this draft guidance begins with simple and generally reasonable conservative screening approaches and gradually progresses toward a more complex assessment involving increasingly greater use of site-specific data. For those sites determined to have an *incomplete* vapor intrusion pathway, EPA generally recommends that further consideration of the current site situation is not needed. For those sites determined to have a *complete* pathway, recommendations are provided on how to evaluate whether the pathway does or does not pose a potential significant risk to human health.

This guidance is not intended to provide recommendations on how to delineate the extent of risk or how to eliminate the risk, only to determine if there is a potential for an unacceptable risk. We generally recommend that a reevaluation of a screened-out site be carried out if site conditions or building/facility uses change in a way that might change

the screening-out decision or other new information suggests greater conservatism is warranted in assessing this exposure pathway.

Please recognize that this is a guidance document, not a regulation. This document presents current technical and policy recommendations of the Office of Solid Waste and Emergency Response, based on our current understanding of the phenomenon of subsurface vapor intrusion. EPA personnel (and of course, states) are free to use and accept other technically sound approaches, either on their own initiative, or at the suggestion of responsible parties or other interested parties. In addition, personnel who use this guidance document are free to modify the approach recommended in this guidance. This guidance document does not impose any requirements or obligations on EPA, states, or the regulated community. Rather, the sources of authority and requirements for addressing subsurface vapor intrusion are the relevant statutes and regulations (e.g., RCRA, CERCLA and the NCP).

C. At What Sites Are We Currently Suggesting You Use This Guidance?

The draft guidance is suggested for use at RCRA Corrective Action, CERCLA (National Priorities List and Superfund Alternative Sites), and Brownfields sites, but is not recommended for use at Subtitle I Underground Storage Tank (UST) sites at this time. The draft guidance recommends certain conservative assumptions that may not be appropriate at a majority of the current 145,000 petroleum releases from USTs. As such, the draft guidance is unlikely to provide an appropriate mechanism for screening the vapor pathway at UST sites.

We recommend that State and Regional UST corrective action programs continue to use a risk based decision making approach as described in OSWER Directive 9610.17: *Use of Risk-Based Decision Making in UST Corrective Action Program* to address this pathway. A majority of State programs are successfully implementing this directive at their UST cleanups and use the recommended approaches where appropriate, to prioritize and remediate their sites, including risk associated with vapor migration to indoor air in a manner that is protective of human health and the environment.

EPA also acknowledges that there are many unique issues specific to petroleum releases from underground storage tanks. EPA is forming an EPA-State working group to further study the behavior of petroleum and petroleum products in the subsurface associated with the vapor intrusion pathway.

D. What Is The Scope Of The Guidance?

This draft guidance is intended to address the incremental increases in exposures and risks from subsurface contaminants that may be intruding into indoor air. The approaches suggested in this draft guidance are primarily designed to ensure protection of the public in residential settings but may be adjusted for other land uses (e.g., commercial/industrial, recreational), so that human exposures in non-residential settings may also be considered under this guidance, as described below.

1) Occupational settings where persons are in a working situation.

There may be occupational settings where persons present are employees and hazardous constituents may be intruding into the air space from the vapor intrusion pathway. Such settings could include workplaces where workers are handling hazardous chemicals (e.g., manufacturing facilities) similar to or different from those in the subsurface contamination, as well as other workplaces, such as administrative and other office buildings where chemicals are not routinely handled in daily activities. OSHA and EPA have agreed that OSHA generally will take the lead role in addressing occupational exposures. Workers will generally understand the workplace (e.g., Occupational Safety and Health Administration, OSHA) regulations (and monitoring, as needed) that already apply and provide for their protection. For example, workplaces are subject to a written Hazard Communication and Monitoring Plan.

In general, therefore, EPA does not expect this guidance be used for settings that are primarily occupational.[1] However, employees and their employers may not be aware of subsurface contaminants that may be contributing to the indoor air environment of their workplaces, particularly since vapor intrusion may include constituents that are no longer or were never used in a particular workplace, may originate from elsewhere, or be modified by bio-degradation or other subsurface transformation processes. Therefore, we recommend that regional or State authorities notify the facility of the potential for this exposure pathway to cause a hazard or be recognized as a hazard and suggest that they consider any potential risk that may result. Any change in the future use of the building/facility might suggest a need to reevaluate the indoor air pathway.

2) Non-residential settings where persons are in a non-working situation.

Non-residential buildings may need to be evaluated where people (typically non-workers – see above) may be exposed to hazardous constituents entering into the air space from the subsurface. This would include for example buildings where the general public may be present, e.g., schools, libraries, hospitals, hotels, and stores. EPA recommends the appropriate environmental (public health protection) screening levels be applied to these situations.

The recommendations in this guidance may be appropriate for such situations, although we recommend adjustments appropriate for non-residential exposure durations, the building specific air volumes and air exchange rates, as well as other relevant factors be considered. The model used in this guidance accommodates the inclusion of these kinds of variables and for comparison of computed values with the recommended numerical criteria in Tables 2 and 3.

[1]It should be noted that at CERCLA sites, the cleanup levels are generally determined either by ARARs or risk range considerations; the OSHA standards are not ARARs under the CERCLA statute and regulations. Therefore, there may be instances (under CERCLA and other cleanup programs) where standards other than the OSHA standards are used to determine whether the exposure pathway presents a risk to human health.

E. Will This Guidance Supersede Existing Guidance?

This draft guidance supersedes the draft RCRA EI Supplemental Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway (December 2001). It does not supersede State guidance. However, we believe that States will find this guidance useful and States will consider this guidance in making Current Human Exposures Under Control EI determinations. Additionally, the lead regulatory authority for a site may determine that criteria other than those recommended herein are more appropriate for the specific site or area. For example, site-specific indoor air criteria may differ from the generic indoor air criteria generally recommended in this guidance and, consequently, the corresponding soil gas or groundwater screening levels may differ. Also, the site-specific relationship between indoor air concentrations and subsurface soil gas or groundwater concentrations may differ from that assumed in developing this guidance. Therefore, we suggest that the first step generally be to consult with the lead regulatory authority to identify the most appropriate approach for evaluation of any potential vapor intrusion to indoor air pathway.

F. Will We Continue To Evaluate Data And Revise This Document Accordingly?

Vapor intrusion is a rapidly developing field of science and policy and this draft guidance is intended to aid in evaluating the potential for human exposure via this pathway given the state-of-the-science at this time. EPA will continue to explore this area and improve our understanding of this complex exposure pathway. As our understanding improves, this guidance will be revised as appropriate. EPA and State site managers are encouraged to provide OSWER with relevant site information that can be added to the OSWER database to facilitate EPA's efforts (for more information see Site-Specific Investigations).

II. EXPLANATION OF VAPOR INTRUSION

Vapor Intrusion is the migration of volatile chemicals from the subsurface into overlying buildings. Volatile chemicals in buried wastes and/or contaminated groundwater can emit vapors that may migrate through subsurface soils and into indoor air spaces of overlying buildings in ways similar to that of radon gas seeping into homes, as shown in Figure 1. (However, this guidance is not intended for evaluation of intrusion of radon gas.) As the figure illustrates, this vapor intrusion pathway may be important for buildings both with and without a basement.

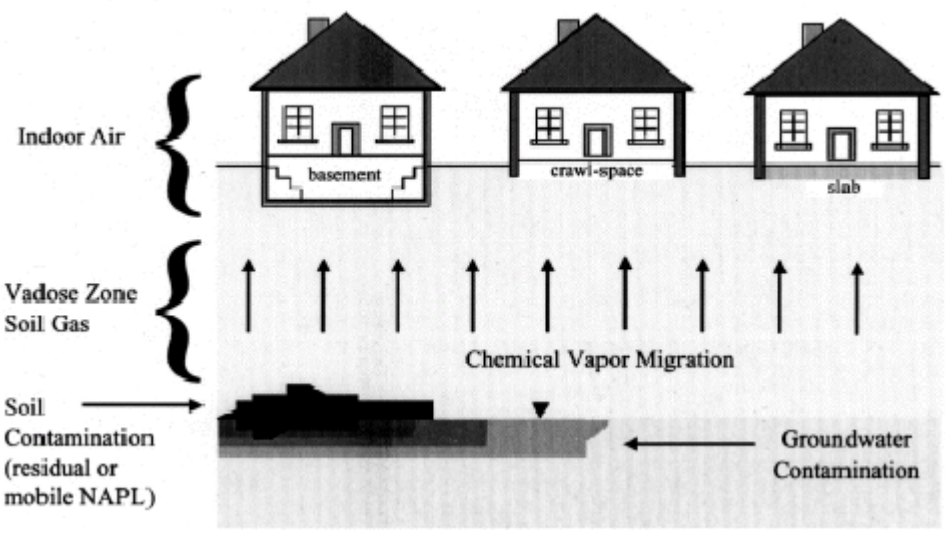


Figure 1: Generalized schematic of the pathway for subsurface vapor intrusion into indoor air.

A. Why Should You Be Concerned With This Pathway?

In extreme cases, the vapors may accumulate in dwellings or occupied buildings to levels that may pose near-term safety hazards (e.g., explosion), acute health effects, or aesthetic problems (e.g., odors). Typically however, the chemical concentration levels are low or, depending on site-specific conditions, vapors may not be present at detectable concentrations. In residences with low concentrations, the main concern is whether the chemicals may pose an unacceptable risk of chronic health effects due to long-term exposure to these low levels. A complicating factor in evaluating the potential chronic risk from vapor intrusion is the potential presence of some of the same chemicals at or above background concentrations (from the ambient (outdoor) air and/or emission sources in the building e.g., household solvents, gasoline, cleaners) that may pose, separately or in combination with vapor intrusion, a significant human health risk.

B. How Is This Exposure Pathway Different From Other Pathways?

The inhalation exposure pathway from vapor intrusion differs from other pathways in several respects. First, there is much less experience for risk assessors to draw upon when assessing the subsurface vapor to indoor air pathway than there is for the assessment of other pathways (e.g., groundwater ingestion and direct exposure to contaminated soils). Consequently, the key issues and technical challenges are not as fully understood. Second, response options will typically be different. For example, where groundwater used as drinking water is found to be highly contaminated, the groundwater plume may be cleaned up or its volume/concentration reduced, or people may drink bottled water, or they can be connected to other potable sources. In the case of significant vapor intrusion, ventilation is likely the most appropriate approach. Third, assessing the vapor intrusion pathway can be more complex than assessing other pathways because it typically involves the use of indirect measurements and modeling

(e.g., using soil gas or groundwater data) to assess the potential for indoor inhalation risks. Fourth, it is our judgment that indoor air sampling results can be misleading because it is difficult and sometimes impossible to eliminate or adequately account for contributions from "background" sources.

III. SUMMARY OF DRAFT GUIDANCE

This draft guidance employs a tiered approach to assist the user in determining whether the exposure pathway is complete (i.e., subsurface vapors intrude into indoor air spaces); and, if so, whether the vapors are present at levels that may pose an unacceptable exposure risk. Although vapors may be present in soils beneath a building, the vapors may or may not pose a risk to human health. It may also be predicted that a plume would reach a development or that future construction may occur over a plume that would result in a potential for exposure via this pathway. Estimating human health risk from indoor air exposure depends upon human exposure to the vapors. If contaminant vapors do not enter the building, the exposure pathway from the source of contamination to a person (receptor) is not "complete," and in such circumstances the person cannot be considered to be at risk from indoor air exposure due to vapor intrusion. In other situations, vapors may enter the building, but be present at such low levels that the risk is considered negligible. However, in some cases, vapors may seep into a building and accumulate at levels that may pose an unacceptable risk to human health.

A. How Should You Use This Draft Guidance?

The overall approach presented here is similar to that used in the February 5, 1999, RCRA Corrective Action Current Human Exposures Under Control EI Guidance. Record sheets containing a series of questions guide users through a recommended series of analytical steps to help determine if the subsurface vapor intrusion into indoor air pathway is complete and may present unacceptable risks. The record sheets encourage documentation of the facts and considerations that typically drive responses. Documentation is important to ensure clarity and transparency of the decisions. We recommend those who use this guidance consider the technical objectives, apply professional judgment, and attempt to assess the completeness of the vapor intrusion pathway in a technically defensible fashion. Users may find the discussions included in the attached Appendices to be useful in applying professional judgment to the evaluation of the vapor intrusion pathway.

B. How Do I Start And What Are The Different Tiers?

OSWER's fundamental approach to evaluating contaminated sites uses ***Guidance for the Data Quality Objectives (DQO) Process, EPA QA/G-4*** (EPA/600/R-96/055;August 2000); (URL = http://www.epa.gov/quality/qs-docs/g4-final.pdf) which calls for proceeding in a careful stepwise fashion. We recommend that site investigators use the specific sequential approach outlined in the DQO process to adequately determine the nature and extent of contamination, and identify potential exposure pathways and receptors that may be at risk (see Appendix A for more information). The first step in the

DQO process is to develop a Conceptual Site Model (CSM). A CSM is a three-dimensional "picture" of site conditions illustrating the contaminant sources, their movement of contaminants in the environment, their exposure pathways and the potential receptors (see Appendix B for more information).

The flowchart presented in Figure 2 summarizes the evaluation approach presented in this draft guidance. There are three tiers of assessment that involve increasing levels of complexity and specificity.

- Tier 1 - Primary Screening is designed to be used with general knowledge of a site and the chemicals known or reasonably suspected to be present in the subsurface; it does not call for specific media concentration measurements for each constituent of concern;
- Tier 2 - Secondary Screening is designed to be used with some limited site-specific information about the contamination source and subsurface conditions (e.g., measured or reasonably estimated concentrations of target chemicals in groundwater or soil gas, and depth of contamination and soil type); and
- Tier 3 - Site-Specific Pathway Assessment involves collecting more detailed site-specific information and conducting confirmatory subslab and/or indoor air sampling.

The evaluation process shown in Figure 2 presents a logical and linear progression designed to screen out sites ordinarily not needing further consideration and focuses attention on those sites that generally need further consideration of the vapor intrusion pathway or action. We suggest that a user of this guidance start at tier 1. However, the user does not need to begin with tier 1 and may proceed directly to tier 2 or 3 if they so choose. In addition, as noted earlier, the user may use other technically sound approaches in evaluating the vapor intrusion pathway.

C. What Are The Steps Associated With Each Tier And How Do I Use Them?

Tier 1 - Primary Screening: This step is designed to help quickly identify whether or not a potential exists at a specific site for subsurface vapor intrusion, and, if so, whether immediate action may be warranted. Criteria recommended for making these determinations under the guidance are presented in Questions 1 through 3, which focus on identifying:

a) if chemicals of sufficient volatility and toxicity are present or reasonably suspected to be present (Question 1);
b) if inhabited buildings are located (or will be constructed under future development scenarios – except for Environmental Indicator determinations, see section IV.C below) above or in close proximity to subsurface contamination (Question 2); and
c) if current conditions warrant immediate action (Question 3).

If the Primary Screening does not support a conclusion that the pathway is incomplete, or that immediate action is warranted to mitigate risks, we recommend the user proceed to Secondary Screening.

Tier 2 - Secondary Screening: This analysis involves comparing measured or reasonably estimated concentrations of target chemicals in various media (groundwater, soil gas, and/or indoor air) to recommended numerical criteria identified in Questions 4 and 5. These "generic criteria" reflect generally reasonable worst-case conditions. Question 4 provides a conservative first-pass screening of groundwater and soil gas data. Question 5 (based on a mathematical model) considers the relationship (if any) between groundwater and soil gas target criteria to such site-specific conditions as depth of contamination and soil type. Under the guidance, the site risk manager may choose to select media-specific target concentrations for screening at three cancer risk levels: 10^{-4}, 10^{-5}, and 10^{-6}, or a hazard quotient of 1 for non-cancer risk, whichever is appropriate. When results from secondary screening do not support a determination that the pathway is incomplete, we recommend the user proceed to the Site-Specific Pathway Assessment.

Tier 3 - Site-Specific Pathway Assessment: This tier specifically examines vapor migration and potential exposures in more detail (Question 6). At this level of assessment, the guidance generally recommends direct measurement of foundation air and/or indoor air concentrations from a subset of the potentially affected buildings and complementary site-specific mathematical modeling as appropriate. Modeling is considered to be useful for determining which combination of complex factors (e.g., soil type, depth to groundwater, building characteristics, etc.) lead to the greatest impact and, consequently, aid in the selection of buildings to be sampled. It is recommended that sampling of subslab or crawlspace vapor concentrations and/or sampling of indoor air concentrations be conducted before a regulator makes a final decision that there is not a potential problem with respect to vapor intrusion. When indoor air sampling is conducted to determine if a significant risk exists, we recommend that it be conducted more than once and the sampling program be designed to identify ambient (outdoor) and indoor air emission sources of contaminants.

IV. USE OF THIS GUIDANCE

A. Under What Conditions Do We Recommend You Consider This Pathway/Guidance?

We recommend that you consider the possibility of exposure by this pathway if you have or suspect the presence, in soil or groundwater, of volatile chemicals (Henry's Law Constant > 10^{-5} atm m^3/mol) at your site as follows:

- located 100 ft or less in depth or
- located in close proximity to existing buildings or future buildings (see Primary Screening Question #2 for definition of close proximity) or
- To the expected footprint of potential future buildings (for non-EI determinations).

B. Does This Guidance Address Setting Risk Management Goals?

No. The tiered approach to evaluating the vapor intrusion pathway described in this guidance uses computed target media-specific concentrations generally based on consensus toxicity values, where available, to aid in determining whether an unacceptable inhalation exposure risk is posed by the site contamination. The tables in this guidance provide target media-specific concentrations that may be used (where appropriate) for those contaminants for which a determination has been made that a pathway is complete. An adequate site evaluation demands careful consideration of all relevant chemical and site-specific factors as well as appropriate application of professional judgment. Risk management action decisions may need to consider other factors depending on the regulatory program that applies and/or site-specific circumstances. We recommend that the lead regulatory authority select the most appropriate value to consider for site evaluation purposes.

C. How Is The Guidance To Be Used In Making Current Human Exposures Under Control Environmental Indicator (EI) Determinations?

We recommend that the approaches suggested in this guidance be used, where appropriate, to support Current Human Exposures Under Control EI determinations. However, we do not believe that confirmatory sampling will generally be necessary in that context. Current Human Exposures Under Control EI determinations are intended to reflect a reasonable conclusion by EPA or the State that current human exposures are under control with regard to the vapor intrusion pathway and current land use conditions. We believe that not recommending confirmatory sampling is appropriate because of the conservative nature of the assumptions made. Additionally, the recommended approaches are designed to help site decision makers to differentiate those sites for which there is more likely to be unacceptable vapor intrusion from those where unacceptable vapor intrusion exposures are less likely.

Finally, this guidance provides targeted indoor air concentrations set at 10^{-4}, 10^{-5}, and 10^{-6} (incremental individual lifetime cancer risk) levels and a Hazard Quotient (HQ) of 1 for non-cancer risk. For the purposes of making Current Human Exposures Under Control EI determinations with respect to vapor intrusion under RCRA and CERCLA, EPA generally recommends the use of 10^{-5} values. This level, in EPA's view, serves as a generally reasonable screening mechanism for the vapor intrusion pathway. Additionally, it takes into account practical issues associated with the analytical difficulties in taking air measurements and the possible presence of many constituents of concern due to contributions from "background" sources, including ambient (outdoor) air and/or emitted from indoor sources.

D. How Will This Guidance Be Used In The RCRA And CERCLA (Superfund) Programs?

We recommend that this draft guidance be used in making Current Human Exposures Under Control EI determinations at RCRA and NPL sites, as well as in CERCLA remedial investigations and RCRA facility investigations. It is not designed to help the site decision makers conduct a more detailed (e.g., site-specific) assessment of current and future risks at NPL sites and it does not address cumulative risk that includes other exposure pathways.[2] Likewise, this draft guidance is not designated to be used during the process for determining whether, and to what extent, cleanup action is warranted at these sites.

E. What Has Changed From Previous Guidance Related To Vapor Intrusion That I Should Be Aware Of?

This draft guidance provides improved methodologies designed to be used at any site evaluation involving a potential vapor intrusion pathway. Much work has been done to improve methodologies and coordinate various cleanup programmatic interests, especially the major OSWER regulatory programs, in developing this vapor intrusion guidance. EPA believes that this guidance should prove useful and beneficial to these programs as well as to others by providing the most up-to-date recommended approach for use in evaluating potential exposures via the vapor intrusion pathway. Specifically, it should be noted that:

- The Johnson and Ettinger Model (1991) is used in Questions 5 and 6 of this draft guidance. EPA/OSWER re-evaluated the strengths and limitations of the model which led to revisions of the previous spreadsheets developed by the Superfund Program in 1997. The revisions include new default parameters that EPA generally recommends be used in vapor intrusion pathway evaluations. The new spreadsheets are available on the following website at: http://www.epa.gov/superfund/programs/risk/airmodel/johnson_ettinger.htm

- EPA is also issuing *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (SG) (OSWER 9355.4-24) which updates the 1996 Soil Screening Guidance and includes non-residential exposure scenarios. The site-specific methodologies and tools presented in the SG are consistent with this vapor intrusion guidance.

- As further improvements in practice are developed, for example sampling techniques described in Appendix E, they will be further evaluated and considered for updating of this vapor intrusion guidance and notification on the OSWER website.

[2] The draft guidance does not specifically address the issue of "additive risk." At sites where there are a limited number of constituents in the subsurface environment, this likely is not an issue. However, at those sites where a number of contaminants are identified in the subsurface environment, the Regions and states may want to consider the additively of these contaminants. For further guidance on additively, you could review Section 2.1.1 of the Soil Screening Guidance: Technical Background Document, EPA/540/R-95/128, May 1996.

F. If I Have Indoor Air Measurements Do I Need To Follow All The Steps Described In This Guidance?

We do not recommend that indoor air quality monitoring be conducted prior to going through the steps recommended in this guidance. In those cases where indoor air quality data are available at the beginning of the evaluation, however, we generally recommend that these data be considered. We recommend that a site-specific evaluation be performed simultaneously with the subsurface assessment if indoor air concentrations exceed target levels. In some cases, the responsible party or others may decide to proactively eliminate exposures through avoidance or mechanical systems as a cost-effective approach. This option may be appropriate at any time in the assessment.

In addition, there may be circumstances in which a lead authority or a responsible party elects to initiate indoor air quality monitoring to determine whether there are any potential risks rather than pursue assessment of the pathway via the steps recommended in this guidance. If a responsible party decides to initiate indoor air monitoring, coordination and approval of air monitoring plans with the lead regulatory authority is recommended.[3]

G. What Else Might I Consider If I Have Indoor Air Concentrations Data?

Using other information in conducting a screening evaluation of the vapor intrusion pathway beyond the guidance presented in this document may be appropriate and would be consistent with the need to consider all relevant data/information in screening and/or assessing vapor intrusion to a building. For example, in some cases, a building may be positively pressurized as an inherent design of the heating, ventilation, and air conditioning system. It may be possible to show that the pathway, in this case, is incomplete, at the current time, by demonstrating a significant pressure differential from the building to the subsurface.

H. How Should "Background" Be Considered In Evaluating The Contribution Of Subsurface Contamination To Indoor Air Contamination?

We believe that it is critical to consider the presence of background concentrations in assessing the vapor intrusion pathway. Background concentrations may be impacted by volatile chemicals commonly found in the home or found in local atmospheric emissions. For example, in urban areas air quality is often affected by multiple atmospheric emission sources. In addition, human activities (e.g., smoking, craft hobbies) or consumer products (e.g., cleaners, paints, and glues) typically found in the home provide additional indoor vapor emission sources that can contribute to increased indoor air concentrations of some chemicals. In fact, there may be dozens of detectable chemicals in indoor air even absent subsurface contribution. These two types of sources can contribute to background indoor air levels of VOCs, and we recommend they be considered in

[3] While proactive indoor air monitoring may be initiated at any time, EPA recommends that it is generally not necessary if the pathway can be confirmed to be incomplete considering other site-specific data and factors.

evaluating the contribution of subsurface contamination to indoor air contamination in dwellings at a cleanup site. Additionally, we recommend that: 1) an inspection be conducted of the residence, 2) an occupant survey be completed to adequately identify the presence of (or occupant activities that could generate) any possible indoor air emissions of target VOCs in the dwelling (see appendices E, H and I), 3) all possible indoor air emission sources be removed, and 4) ambient (outdoor) air samples be collected in conjunction with any indoor air samples. We recommend the evaluation of existing indoor air data focus on constituents (and any potential degradation products) present in subsurface sources of contamination. We recommend the relative contributions of background sources be carefully considered (see Appendix I) in order to properly assess the potential inhalation exposure risks that can be attributed to the vapor intrusion pathway.

It may be a challenge to distinguish "background" (ambient outdoor and indoor air) sources of vapors from site-related contamination. However, we recommend vapors attributable to background sources be accounted for during the "Site Specific Assessment" to properly assess the potential risk posed by exposures via the vapor intrusion pathway. To the extent practicable, we recommend that background sources of contamination be removed or excluded from the site dwellings or occupied buildings selected for sampling before any indoor air sampling is conducted. If this is not possible, then we recommend the contribution from these sources be carefully considered when evaluating any indoor air sampling results. (See Site-Specific Question # 6)

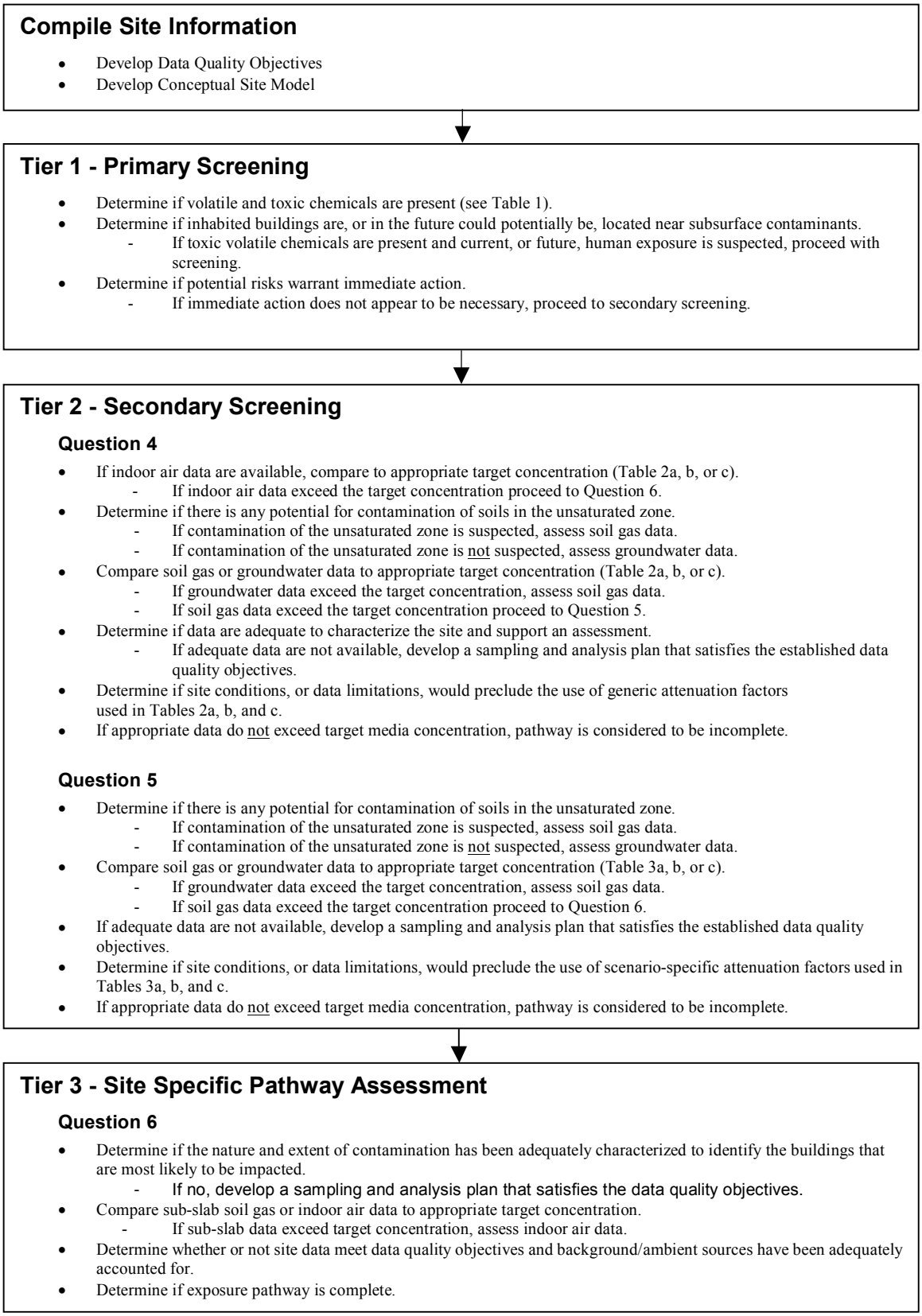


Figure 2. Schematic flow diagram: evaluation process recommended in guidance.

IV. TIER 1 - Primary Screening

Primary Screening is designed to help quickly screen out sites at which the vapor intrusion pathway does not ordinarily need further consideration, and point out the sites that do typically need further consideration. This evaluation involves determining whether any potential exists at a specific site for vapor intrusion to result in unacceptable indoor inhalation risks and, if so, whether immediate action may be warranted. Recommended criteria for making these determinations are presented in Questions 1 through 3, which focus on identifying:

a) if chemicals of sufficient volatility and toxicity are present or reasonably suspected to be present (Question 1);
b) if inhabited buildings are located (or will be constructed under future development scenarios – except for Environmental Indicator determinations, see section IV.C below) above or in close proximity to subsurface contamination (Question 2); and
c) if current conditions warrant immediate action (Question 3).

This primary screening process is illustrated in a flow diagram included in Appendix C.

A. Primary Screening – Question #1

Q1: Are chemicals of sufficient volatility and toxicity known or reasonably suspected to be present in the subsurface (e.g., in unsaturated soils, soil gas, or the uppermost portions of the ground water and/or capillary fringe – see Table 1)? (We recommend this consideration involve DQOs (see Appendix A) used in acquiring the site data as well as an appropriately scaled Conceptual Site Model (CSM) for vapor intrusion (see Appendix B).)

_____ If **YES** - check here, check off the relevant chemicals on Table 1, and continue with Question 2. The chemicals identified here (and any degradation products) are evaluated as constituents of potential concern in subsequent questions.

_____ If **NO** - check here, provide the rationale and references below, and then go to the Summary Page to document that the subsurface vapor to indoor air pathway is incomplete (i.e., no further consideration of this pathway is needed); or

_____ If sufficient data are not available, go to the Summary Page and document the need for more information. After collecting the necessary data, Question 1 can then be revisited with the newly collected data to re-evaluate the completeness of the vapor intrusion pathway.

1. What is the goal of this question?

This question is designed to help quickly screen out sites at which the vapor intrusion pathway generally does not need further consideration. This evaluation involves determining whether or not any potential exists at a specific site for the vapor intrusion

pathway to result in unacceptable indoor air inhalation risks. Table 1 lists chemicals that may be found at hazardous waste sites and indicates whether, in our judgment, they are sufficiently volatile (Henry's Law Constant > 10^{-5} atm m^3/mol) to result in potentially significant vapor intrusion and sufficiently toxic (either an incremental lifetime cancer risk greater than 10^{-6} or a non-cancer hazard index greater than 1, or in some cases both) to result in potentially unacceptable indoor air inhalation risks. The approach used to develop Table 1 is documented in Appendix D and can be used, where appropriate, to evaluate volatile chemicals not included in the Table. We recommend that if any of the chemicals listed in Table 1 that are sufficiently volatile and toxic are present at a site, those chemicals become constituents of potential concern for the vapor intrusion pathway and are evaluated in subsequent questions in this guidance. If the chemicals listed in Table 1 are not present at a site, and no other volatile chemicals are present, we suggest that the vapor intrusion pathway be considered incomplete and no further consideration of this pathway is needed.

2. What should you keep in mind?

In evaluating the available site data, we recommend the DQOs used in collecting the data be reviewed to ensure those objectives are consistent with the DQOs for the vapor intrusion pathway (see Appendix A). We recommend the detection limits associated with the available groundwater data be reviewed to ensure they are not too high to detect volatile contaminants of potential concern. Also, we suggest that the adequacy of the definition of the nature and extent of contamination in groundwater and/or the vadose zone be assessed to ensure that all contaminants of concern and areas of contamination have been identified. Additionally, we recommend groundwater concentrations be measured or reasonably estimated using samples collected from wells screened at, or across the top of the water table. We recommend users read Appendices B (Conceptual Site Model for the Vapor Intrusion Pathway) and E (Relevant Methods and Techniques) to obtain a greater understanding of the important considerations in evaluating data for use in screening assessments of the vapor intrusion pathway.

3. Rationale and References:

B. Primary Screening – Question #2

Q2: Are currently (or potentially) inhabited buildings or areas of concern under future development scenarios located *near* (see discussion below) subsurface contaminants found in Table 1?

_____ If **YES** – check here, identify buildings and/or areas of concern below, and document on the Summary Page whether the potential for impacts from the vapor intrusion pathway applies to currently inhabited buildings or areas of concern under reasonably anticipated future development scenarios, or both. (Note that for EI considerations, we recommend only current risks be evaluated.) Then proceed with Question 3.

_____ If **NO** – check here, describe the rationale below, and then go to the Summary Page to document that there is no potential for the vapor intrusion pathway to impact either currently inhabited buildings or areas of concern under future development scenarios (i.e., no further evaluation of this pathway is needed). (Note that for EI considerations, only current risks are evaluated.); or

_____ If sufficient data are not available – check here and document the need for more information on the Summary Page. After collecting the necessary data, Question 2 can then be revisited with the newly collected data to re-evaluate the completeness of the vapor intrusion pathway.

1. What is the goal of this question?

The goal of this question is to help determine whether inhabited buildings currently are located (or may be reasonably expected to be located under future development scenarios) above or in close proximity to subsurface contamination that potentially could result in unacceptable indoor air inhalation risks. If inhabited buildings and/or future development are not located "near" the area of concern, we suggest that the vapor intrusion pathway be considered incomplete and no further consideration of the pathway should be needed.

For the purposes of this question, **"inhabited buildings"** are structures with enclosed air space that are designed for human occupancy. Table 1, discussed above in Question 1, lists the **"subsurface contaminants demonstrating sufficient volatility and toxicity**" to potentially pose an inhalation risk. We recommend that an inhabited building generally be considered **"near"** subsurface contaminants if it is located within approximately 100 ft laterally or vertically of known or interpolated soil gas or groundwater contaminants listed in Table 1 (or others not included in table 1 – see Question 1) and the contamination occurs in the unsaturated zone and/or the uppermost saturated zone. If the source of contamination is groundwater, we recommend migration of the contaminant plume be considered when evaluating the potential for future risks. The distance suggested above (100 feet) may not be appropriate for all sites (or contaminants) and,

consequently, we recommend that professional judgment be used when evaluating the potential for vertical and horizontal vapor migration.

2. How did we develop the suggested distance?

The recommended distance is designed to allow for the assessment to focus on buildings (or areas with the potential to be developed for human habitation) most likely to have a complete vapor intrusion pathway. Vapor concentrations generally decrease with increasing distance from a subsurface vapor source, and eventually at some distance the concentrations become negligible. The distance at which concentrations are negligible is a function of the mobility, toxicity and persistence of the chemical, as well as the geometry of the source, subsurface materials, and characteristics of the buildings of concern. Available information suggests that 100 feet laterally and vertically is a reasonable criterion when considering vapor migration fundamentals, typical sampling density, and uncertainty in defining the actual contaminant spatial distribution. The recommended lateral distance is supported by empirical data from Colorado sites where the vapor intrusion pathway has been evaluated. At these sites, no significant indoor air concentrations have been found in residences at a distance greater than one house lot (approximately 100 feet) from the interpolated edge of ground water plumes. Considering the nature of diffusive vapor transport and the typical anisotropy in soil permeability, in our judgment a similar criterion of 100 feet for vertical transport is generally conservative. These recommended distances will be re-evaluated and, if necessary, adjusted by EPA as additional empirical data are compiled.

3. What should you keep in mind when evaluating this criterion?

It is important to consider whether **significant preferential pathways** could allow vapors to migrate more than 100 feet laterally. For the purposes of this guidance, a "significant" preferential pathway is a naturally occurring or anthropogenic subsurface pathway that is expected to have a high gas permeability and be of sufficient volume and proximity to a building so that it may be reasonably anticipated to influence vapor intrusion into the building. Examples include fractures, macropores, utility conduits, and subsurface drains that intersect vapor sources or vapor migration pathways. Note that naturally occurring fractures and macropores may serve as preferential pathways for either vertical or horizontal vapor migration, whereas anthropogenic features such as utility conduits are relatively shallow features and would likely serve only as a preferential pathway for horizontal migration. In either case, we recommend that buildings with significant preferential pathways be evaluated even if they are further than 100 ft from the contamination.

We also recommend that the potential for mobile "vapor clouds" (gas plumes) emanating from near-surface sources of contamination into the subsurface be considered when evaluating site data. Examples of such mobile "vapor clouds" include: 1) those originating in landfills where methane may serve as a carrier gas; and 2) those originating in commercial/industrial settings (such as dry cleaning facilities) where vapor can be released within an enclosed space and the density of the chemicals' vapor may result in

significant advective transport of the vapors downward through cracks/openings in floors and into the vadose zone. In these cases, diffusive transport of vapors is usually overridden by advective transport, and the vapors may be transported in the vadose zone several hundred feet from the source of contamination.

Finally, this guidance is intended to be applied to existing groundwater plumes as they are currently defined (e.g., MCLs, State Standards, or Risk-Based Concentrations). However, it is very important to recognize that some non-potable aquifers may have plumes that have been defined by threshold concentrations significantly higher than drinking-water concentrations. In these cases, contamination that is not technically considered part of the plume may still pose significant risks via the vapor intrusion pathway and, consequently, the plume definition may need to be expanded. Similarly, we recommend evaluating the technologies used to obtain soil gas and indoor air concentrations to determine if appropriate methods were used to ensure adequate data quality at the time analyses were conducted.

4. Identify Inhabited Buildings (or Areas With Potential for Future Residential Development) Within Distances of Possible Concern:

C. Primary Screening Stage-– Question #3

Q3: Does evidence suggest immediate action may be warranted to mitigate current risks?

_____ If **YES** – check here and proceed with appropriate actions to verify or eliminate imminent risks. Some examples of actions may include but are not limited to indoor air quality monitoring, engineered containment or ventilation systems, or relocation of people. The action(s) should be appropriate for the site-specific situation.

_____ If **NO** – check here and continue with Question 4.

1. What is the goal of this question?

This question is intended to help determine whether immediate action may be warranted for those buildings identified in Question 2 as located within the areas of concern. For the purposes of this guidance, "immediate action" means such action is necessary to verify or abate imminent and substantial threats to human health.

2. What are the qualitative criteria generally considered sufficient to indicate a need for immediate actions?

Odors reported by occupants, particularly if described as "chemical," or "solvent," or "gasoline." The presence of odors does not necessarily correspond to adverse health and/or safety impacts and the odors could be the result of indoor vapor sources; however, we believe it is generally prudent to investigate any reports of odors as the odor threshold for some chemicals exceeds their respective acceptable target breathing zone concentrations.

Physiological effects reported by occupants (dizziness, nausea, vomiting, confusion, etc.) may, or may not be due to subsurface vapor intrusion or even other indoor vapor sources, but, should generally be evaluated.

Wet basements, in areas **where chemicals of sufficient volatility and toxicity** (see Table 1) **are known to be present in groundwater and the water table is shallow enough that the basements are prone to groundwater intrusion or flooding.** This has been proven to be especially important where there is evidence of light, non-aqueous phase liquids (LNAPLs) floating on the water table directly below the building, and/or any direct evidence of contamination (liquid chemical or dissolved in water) inside the building.

Short-term safety concerns are known, or are reasonably suspected to exist, including: a) measured or likely explosive or acutely toxic concentrations of vapors in the building or connected utility conduits, sumps, or other subsurface drains directly connected to the

building and b) measured or likely vapor concentrations that may be flammable/combustible, corrosive, or chemically reactive.

3. Rationale and Reference(s):

V. TIER 2 - SECONDARY SCREENING

The vapor intrusion pathway is complex and, consequently, we recommend that a comprehensive assessment of this pathway using all available lines of evidence be conducted before drawing conclusions about the risks posed by this pathway. Users are encouraged to consider the evidence for vapor intrusion in sequential steps, starting with the source of vapors (contaminated groundwater or unsaturated soils), proceeding to soil gas in the unsaturated zone above the source, and upward to the exposure point (e.g., subslab or crawlspace vapor). Then, if indicated by the results of previous steps, collect and evaluate indoor air data. In our judgment, this sequential evaluation of independent lines of evidence provides a logical and cost-effective approach for identifying whether or not subsurface vapor intrusion is likely to contribute significantly to unacceptable indoor air quality. However, in those cases where indoor air quality data are available at the beginning of an evaluation, this guidance recognizes these data will generally be considered early in the process.

Collection of indoor air quality data without evidence to support the potential for vapor intrusion from subsurface sources can lead to confounding results. Indoor air quality can be influenced by 'background' levels of volatile chemicals. For example, consumer products typically found in the home (e.g., cleaners, paints, and glues) or occupant activities (e.g., craft hobbies, smoking) may serve as contributory sources of indoor air contaminants. Additionally, ambient (outdoor) air in urban areas often contains detectable concentrations of many volatile chemicals. In either case, the resulting indoor air concentrations can be similar to or higher than levels that are calculated to pose an unacceptable chronic inhalation risk in screening calculations. In fact, there may be dozens of detectable chemicals in indoor air even absent subsurface contributions. Thus, we recommend focusing the evaluation of existing indoor air data on constituents (and any potential degradation products) present in subsurface sources of contamination. We recommend considering the relative contributions of background sources (see Appendices E and I) in order to properly assess the potential inhalation exposure risks that can be attributed to the subsurface vapor intrusion pathway.

Using a sequential approach, the secondary screening suggested in this guidance involves comparing available measured or reasonably estimated concentrations of constituents of potential concern (identified in Question 1) in groundwater and/or soil gas to target concentrations identified in Questions 4 and 5. More detailed studies, including foundation and/or indoor air sampling and vapor intrusion modeling, are generally conducted in the site-specific assessment in Question 6. The sequential evaluation approach is illustrated in flow diagrams included in Appendix C. Question 4 uses conservative "generic" attenuation factors that reflect generally reasonable worst-case conditions for a first-pass screening of groundwater and soil gas data. Question 5 uses attenuation factors (based on a generally conservative use of the Johnson-Ettinger mathematical model) that relate groundwater and soil gas target concentrations to such site-specific conditions as depth of contamination and soil type. In performing the secondary screening assessment, the user will need to identify whether the contamination (source of vapors) occurs in groundwater or in the unsaturated zone. In our judgment, if

there is a contaminant source in the unsaturated zone, soil gas data are needed to evaluate the vapor intrusion pathway in the vicinity of the unsaturated zone source. However, we recommend that groundwater data still be evaluated, particularly if the plume extends beyond an unsaturated zone source of vapors, but only in conjunction with soil gas data. If the secondary screening indicates the vapor intrusion pathway is complete, the guidance recommends the user perform a site-specific assessment following the guidelines in Question 6. If the secondary screening indicates this pathway is incomplete and/or does not pose an unacceptable risk to human health, then no further assessment of the pathway is recommended, unless conditions change.

The media-specific target concentrations used in Questions 4 and 5 were developed considering a generic conceptual model for vapor intrusion consisting of a groundwater and/or vadose zone source of volatile vapors that diffuse upwards through unsaturated soils towards the surface. Under the model, the soil in the vadose zone is considered to be relatively homogeneous and isotropic, though horizontal layers of soil types can be accommodated. The receptors at the surface used in the model are residents in homes with poured concrete foundations (e.g., basement or slab on grade foundations or crawlspace homes with a liner or other vapor barrier). The underlying assumption for this generic model is that site-specific subsurface characteristics will tend to reduce or attenuate vapor concentrations as vapors migrate upward from the source and into structures. Thus, application of the secondary screening target concentrations necessitates at least rudimentary knowledge of the contamination source, subsurface conditions (e.g., measured or reasonably estimated concentrations of target chemicals in soil or groundwater, and depth of contamination and soil type), and building construction at the site (e.g., foundation type). Specific factors that may result in unattenuated or enhanced transport of vapors towards a receptor, and consequently are likely to render the use of the secondary screening target concentrations inappropriate, are discussed in each question below. Factors such as biodegradation that can result in accelerated attenuation of vapors are not considered in the conceptual model. In general, it is recommended that the user consider whether the assumptions underlying the generic conceptual model are applicable at each site, and use professional judgment to make whatever adjustments (including not considering the model at all) are appropriate.

A. Secondary Screening – Question #4: Generic Screening

Q4(a): Are indoor air quality data available? (Collection of indoor air quality data without evidence to indicate the potential for vapor intrusion from subsurface sources is not recommended at this level of screening, but if such data are available, we recommend they be evaluated along with the available subsurface data.)

_____ If **YES** - check here and proceed to **Question 4(b).**

_____ If **NO** – check here and proceed to **Subsurface Source Identification - Question 4(c**).

Q4(b): Do measured indoor air concentrations of constituents of potential concern identified in Question 1 (and any degradation products) exceed the target concentrations given in Tables 2(a), 2(b), or 2(c)?

_____ If **YES** - check here, document representative indoor air concentrations on Table 2, and **initiate a site-specific assessment** following the guidelines in Question 6. (We recommend the user also proceed with the subsurface evaluation to evaluate whether there is sufficient evidence to indicate the elevated indoor concentrations are due to vapor intrusion from subsurface sources, and not from background or other sources)

_____ If **NO** – check here and proceed to **Subsurface Source Identification - Question 4(c).** (Here, the recommendation to proceed with the subsurface evaluation is based on the assumption that only limited indoor air data are available and, therefore, the available subsurface data need to be evaluated to ensure that all possible areas potentially affected by the vapor intrusion pathway are evaluated. However, in our judgment, if the site has been adequately characterized and sufficient indoor air data are available (see Question 6 for a discussion of data needs), the **pathway is incomplete** and/or does not pose an unacceptable risk to human health, and no further assessment of the pathway is recommended. Document the finding as described in Question 6.)

Subsurface Source Identification:

Q4(c): Is there any potential contamination (source of vapors) in the unsaturated zone soil at any depth above the water table? (In our judgment, if there is a contaminant source in the unsaturated zone, soil gas data are needed to evaluate the vapor intrusion pathway in the vicinity of the source and, consequently, use of the groundwater target concentrations may be inappropriate. However, we recommend that groundwater data still be evaluated, particularly if a contaminant plume extends beyond the unsaturated zone source, but that the evaluation be performed only in conjunction with an evaluation of soil gas data. Other vapor sources that typically make the use of groundwater target concentrations inappropriate include: 1) those originating in landfills where methane may serve as a carrier gas; 2) those originating in commercial/industrial settings (such as dry cleaning facilities) where vapor can be released within an enclosed space and the density of the chemicals' vapor may result in significant advective transport of the vapors downward through cracks/openings in floors and into the vadose zone; and 3) leaking vapors from underground storage tanks. In these cases, diffusive transport of vapors is often overridden by advective transport and the vapors may be transported in the vadose zone several hundred feet from the source of contamination.)

_____ If **YES**-check here and skip to **Soil Gas Assessment - Question 4 (g)** below.

_____ If **NO**- check here and continue with **Groundwater Assessment - Question 4(d)** below.

Groundwater Assessment:

Q4(d): Do measured or reasonably estimated groundwater concentrations exceed the generic target media-specific concentrations given in Tables 2(a), 2(b), or 2(c)? (For more information on the use of data for this part, please see the sections below entitled "How should data be used in this question?" and "How do you know you have unusable data?".)

_____ If **YES** (or if the detection limit for any constituents of potential concern is above the target concentration) - check here and document representative groundwater concentrations on Table 2. If **soil gas data are available**, proceed to **Soil Gas Assessment - Question 4(g)** below, **otherwise** proceed to **Question 5.**

_____ If **NO** – check here and **proceed to Question 4(e).**

Q4(e): Is the **nature and extent of groundwater contamination adequately characterized** (see Appendices B & E) in areas with inhabited buildings (or areas with the potential for future development of inhabited buildings)?

_____ If **YES** - check here and continue with **Question 4(f)** below.

_____ If **NO** - check here, go to Summary Page and document that more information is needed. We recommend the next step be expeditious collection of the needed data in accordance with proper DQOs. Question 4 can then be revisited with the newly collected data to re-evaluate the completeness of the vapor intrusion pathway.

Q4(f): Are there site conditions and/or data limitations that make the use of the recommended generic groundwater attenuation factors inappropriate? We recommend this consideration involve comparison of the generic conceptual model to an appropriately scaled and updated Conceptual Site Model (CSM) for vapor intrusion (see Appendix B), as well as the proper DQOs (see Appendix A). We also recommend evaluation of the generic attenuation factors used to develop the media-specific attenuation factors (see the section below titled "What is in Tables 2(a), 2(b), and 2(c) and how did we develop them?" and Appendix F.)

Factors that, in our judgment, typically make the use of generic groundwater attenuation factors inappropriate include:

- Very shallow groundwater sources (e.g., depths to water less than 5 ft below foundation level); or
- Relatively shallow groundwater sources (e.g., depths to water less than 15 ft below foundation), and one or more of the following:

- buildings with significant openings to the subsurface (e.g., sumps, unlined crawlspaces, earthen floors), or
- significant preferential pathways, either naturally-occurring and/or anthropogenic (see discussion below under "What Should I Keep in Mind When Evaluating Data"), or
- buildings with very low air exchange rates (e.g., < 0.25/hr) or very high sustained indoor/outdoor pressure differentials (e.g., > 10 Pascals).

_____ If **YES** - check here, briefly document the issues below, and proceed to **Site-Specific Assessment - Question 6**.

_____ If **NO** - check here, briefly document the rationale below and document on the Summary Page that the groundwater data indicate the **pathway is incomplete** and/or does not pose an unacceptable risk to human health. In order to increase confidence in the assessment that the pathway is incomplete, we recommend that soil gas data **also** be evaluated (**Question 4(g)**).

_____ If sufficient data (of acceptable quality) are not available - check here, go to Summary Page and document that more information is needed. We recommend the next step be expeditious collection of the needed data in accord with proper DQOs. Question 4 can then be revisited with the newly collected data to re-evaluate the completeness of the vapor intrusion pathway.

Soil Gas Assessment:

Q4(g): Do measured or reasonably estimated soil gas concentrations exceed the generic target media-specific concentrations given in Tables 2(a), 2(b), or 2(c) (see Appendix D)? For more information on the use of data for this part, please see the section below entitled "How should data be used in this question?"

_____ If **YES** (or if the detection limit for any constituents of potential concern is above the target concentration) - check here. Document representative soil gas concentrations on Table 2 and proceed to **Question 5**.

_____ If **NO** – check here and proceed to **Question 4(h)**.

Q4(h): Is the **nature and extent of soil contamination adequately characterized** and has an adequate demonstration been made to show that the **soil gas sampling techniques used could reasonably detect an elevated concentration of vapors** if they were present in the site setting?

_____ If **YES** - check here and continue with **Question 4(i)** below.

_____ If **NO** - check here. Skip to Summary Page and document that more information is needed. We recommend the next step be expeditious collection of the needed

data in accord with proper DQOs. Question 4 can then be revisited with the newly collected data to re-evaluate the completeness of the vapor intrusion pathway.

Q4(i): Are there site conditions and/or data limitations that may make the use of generic soil gas attenuation factors inappropriate? (We recommend that this consideration involve an appropriately scaled and updated Conceptual Site Model (CSM) for vapor intrusion (see Appendix B), as well as the proper DQOs (see Appendix A). We also recommend evaluation of the generic attenuation factors used to develop the media-specific attenuation factors (see the section below titled "What is in Tables 2(a), 2(b), and 2(c) and how did we develop them?" and Appendix F.))

Factors that, in our judgment, typically make the use of generic soil gas attenuation factors inappropriate include:

- Shallow soil contamination vapor sources (e.g., less than 15 ft below foundation level), and one or more of the following:
  - buildings with significant openings to the subsurface (e.g., sumps, unlined crawlspaces, earthen floors), or
  - significant preferential pathways, either naturally-occurring and/or anthropogenic (see discussion below under "What Should I Keep in Mind When Evaluating Data"), or
  - buildings with very low air exchange rates (e.g., < 0.25/hr) or very high sustained indoor/outdoor pressure differentials (e.g., > 10 Pascals).

_____ If **YES** - check here, briefly document the issues below, and proceed to **Site-Specific Assessment - Question 6**.

_____ If **NO** - check here, briefly document the rationale below and document on the Summary Page that the soil gas data indicate the **pathway is incomplete** and/or does not pose an unacceptable risk to human health. In this case, no further assessment of the vapor intrusion pathway is recommended.

_____ If sufficient data (of acceptable quality) are not available - check here, go to Summary Page and document that more information is needed. We recommend the next step be expeditious collection of the needed data in accord with proper DQOs or proceed to **Question 5**. When additional data are collected, Question 4 can then be revisited with the newly collected data to re-evaluate the completeness of the vapor intrusion pathway.

1. What is the goal of this question?

Question 4 is intended to allow a rapid screening of available site data using measured or reasonably estimated groundwater and/or soil gas concentrations. The term "measured or

reasonably estimated" is used above (and throughout this document) in recognition of the fact that measurements adjacent to or in all buildings of concern may not be practical or necessary. For example, groundwater concentrations beneath buildings are commonly estimated from concentrations collected in wells distributed about a larger area of interest.

2. How should data be used in this question?

Question 4 calls for comparison of site data with generic target media-specific concentrations given in Tables 2(a), 2(b), and 2(c). These target media-specific concentrations correspond to indoor air concentrations associated with a specific incremental lifetime cancer risk of (a) 10^{-4}, (b) 10^{-5}, (c) 10^{-6} or a hazard quotient greater than 1 (whichever is more restrictive). Under this question, the user selects the appropriate screening risk level for the site and compares the soil gas and/or groundwater concentrations observed at the site to the corresponding target media concentrations in the table. If the detection limit for any constituent of potential concern is above its target screening level, we recommend the user continue the evaluation as though the target level is exceeded.

In order to select the appropriate target media concentrations for comparison, it is important to identify whether a source of vapors in an area occurs in the unsaturated zone (contaminated soil). This allows the site data to be segregated into two categories: a) data representing areas where contaminated groundwater is the only source of contaminant vapors, and b) data representing areas where the underlying unsaturated zone soil contains a source of vapors. In case (a) either the groundwater or soil gas target concentrations in Tables 2(a), 2(b), or 2(c) are generally appropriate to use. In case (b), we recommend that only soil gas target concentrations and soil gas samples collected above the vapor source zone be used. This is because the groundwater target concentrations have been derived assuming no other vapor sources exist between the water table and the building foundation. However, we recommend that groundwater data still be evaluated, particularly if a contaminant plume extends beyond the unsaturated zone source, but the evaluation be performed only in conjunction with an evaluation of soil gas data. In either case, because of the complexity of the vapor intrusion pathway, we recommend that professional judgment be used when applying the target concentrations.

This screening approach is based on a conceptual model that assumes diffusive transport of vapors in the unsaturated zone. Consequently, we recommend the target concentrations used in this secondary screening not be applied to data from sites in which advection significantly influences vapor transport. Thus, the exclusionary criteria listed above in Questions 4(f) and 4(i) are designed to identify those situations in which advective vapor transport may result in unattenuated or enhanced vapor intrusion (e.g., shallow vapor sources at depths less than 15 ft below foundation level and buildings with significant openings to the subsurface, or very high sustained pressure differentials, or significant vertical preferential pathways).

3. What is in Tables 2(a), 2(b), and 2(c) and how did we develop them?

Tables 2(a), 2(b), or 2(c) contain generally recommended target concentrations for indoor air, soil gas, and groundwater for each chemical listed. A separate table is provided for each of the three cancer risk levels considered (a) 10^{-4}, (b) 10^{-5}, and (c) 10^{-6} including non-cancer risk values where applicable for Hazard Quotient = 1. Details regarding the derivation of Tables 2(a), 2(b), and 2(c) are provided in Appendix D. The tabulated indoor air concentrations are risk-based screening levels calculated following an approach consistent with EPA's ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*** (EPA, 2002). These recommended target indoor air concentrations were calculated using toxicity information current as of the date indicated on the tables. The user is encouraged to visit the EPA web-page to determine whether updated tables are available.

The soil gas and groundwater target concentrations were calculated to correspond to the target indoor air concentrations using media-specific attenuation factors. Shallow soil gas (e.g., subslab gas and soil gas measured at 5 feet or less from the base of the foundation) is conservatively assumed to intrude into indoor spaces with an attenuation factor of 0.1. Note that in general samples taken less than 5 feet below the building foundation are not recommended unless the sample was taken from directly under the foundation slab or repeated sampling is performed to ensure a representative soil gas value. For deep soil gas (e.g., soil gas samples taken at depths greater than approximately 5 feet below the foundation level), an attenuation factor of 0.01 (generally considered reasonably conservative) is used to calculate target concentrations. For groundwater, an attenuation factor of 0.001 (generally considered reasonably conservative) is used in combination with the conservative assumption that the partitioning of chemicals between groundwater and soil vapor is assumed to obey Henry's Law. (Note that if the risk-based concentration calculated for groundwater falls below the chemical's MCL, the MCL is recommended as the target concentrations.) EPA generally considers the attenuation factors used in this guidance to be reasonable upper bound values based on data from sites where paired indoor air, soil gas and groundwater samples were available (see Appendix F), and also theoretical considerations.

4. How do you know if you have usable data?

In comparing available site data to the target media-specific target concentrations in Table 2, we recommend that DQOs used in collecting the data be consistent with DQOs for the vapor intrusion pathway and that the sampling issues specific to evaluating this pathway be considered (see Appendices A and E). Some examples of sampling issues that we recommend be considered are: 1) groundwater samples be taken from wells screened (preferably over short intervals) across the top of the water table (only volatile contaminants in the uppermost portions of an aquifer, including the capillary fringe, are likely to volatilize into the vadose zone and potentially migrate into indoor air spaces); 2) fluctuations in water table elevation can lead to elevated source vapor concentrations and thus, we recommend soil gas samples be considered in these areas; 3) we recommend soil

gas samples be taken as close to the areas of interest as possible and preferably from directly underneath the building structure; and 4) as vapors are likely to migrate upward through the coarsest and/or driest material, we recommend that soil gas samples be collected from these materials. More detail regarding considerations for using groundwater and soil gas data to evaluate the vapor intrusion pathway are provided in Appendix E.

5. What should I keep in mind when evaluating data?

It is important to consider whether **significant preferential pathways** could allow vapors to migrate farther and at greater concentrations than expected. For purposes of this guidance, a preferential pathway is a naturally-occurring and/or anthropogenic subsurface 'pathway' that is expected to have a high intrinsic gas permeability (vadose zone) or high conductivity (saturated zone) and thus influence the flow or migration of contaminated vapors or groundwater. A preferential pathway is likely to have a significant influence on vapor intrusion if it is of sufficient volume and proximity to a currently occupied building so that it may be reasonably anticipated to influence the migration of contaminants to, or into, the building. Significant vertical preferential pathways may result in higher than anticipated concentrations in the overlying near surface soils, whereas significant horizontal preferential pathways may result in elevated concentrations in areas on the periphery of subsurface contamination. Naturally occurring preferential pathways may include fractured vadose zone geology or very permeable soils located between a relatively shallow source of contamination and a building. Anthropogenic preferential pathways may include utility conduits or subsurface drains that are directly connected to a building and a source of vapors. In highly developed residential areas, extensive networks of subsurface utility conduits could significantly influence the migration of contaminants. EPA recommends that buildings with significant preferential pathways be evaluated closely even if they are further than 100 feet from the contamination.

6. What if I have bulk soil data?

Soil (as opposed to soil gas) sampling and analysis is not currently recommended for assessing whether or not the vapor intrusion pathway is complete. This is because of the large uncertainties associated with measuring concentrations of volatile contaminants introduced during soil sampling, preservation, and chemical analysis, as well as the uncertainties associated with soil partitioning calculations. Thus, bulk soil target concentrations were not derived and the use of bulk soil target concentration is not generally recommended. Note however, if a NAPL source is suspected, a soil sample may be necessary to determine whether a NAPL source is present. Also, bulk soil concentration data could be used in a qualitative sense for delineation of sources, where appropriate. For example, high soil concentrations would indicate impacted soils; unfortunately, the converse is not always true and it is our judgment that non-detect analytical results can not be interpreted to indicate the absence of a vapor source.

7. Rationale and Reference(s):

Document Risk Level Used (Circle One): (a) 10^{-4}, (b) 10^{-5}, or (c) 10^{-6}

B. Secondary Screening – Question #5: Semi-Site Specific Screening

Q5(a): Do groundwater and/or soil gas concentrations for any constituents of potential concern exceed target media-specific concentrations by a factor greater than 50? (Evaluation of limited site data in Question 5 allows the user to potentially screen sites using target concentrations that are higher by a factor of up to 50 times greater than the generic target concentrations used in Question 4. If observed concentrations are greater than 50 times the generic target concentrations, we recommend expeditious site-specific evaluation.)

_____ If **YES** - check here and briefly document the issues below and go to **Site-Specific Assessment - Question 6.**

_____ If **NO** - check here and continue with **Question 5(b)**.

Q5(b): Are there site conditions and/or data limitations under which we would not recommend the use of semi-site specific attenuation factors (based on the Johnson-Ettinger Model)? (To determine whether use of the Johnson-Ettinger model is appropriate, we recommend the user consider an appropriately scaled and updated Conceptual Site Model (CSM) for vapor intrusion (see Appendix B) and DQOs (see Appendix A). We also recommend users refer to Appendix G, which lists the limitations of the Johnson-Ettinger Model.)

Factors that, in our judgment, typically make the use of semi-site specific attenuation factors inappropriate include:

- Very shallow vapor sources (e.g., depths less than 5 ft below foundation level); or
- Relatively shallow vapor sources (e.g., depths less than 15 ft below foundation level), and one or more of the following:
  - buildings with significant openings to the subsurface (e.g., sumps, unlined crawlspaces, earthen floors), or
  - significant preferential pathways, either naturally-occurring and/or anthropogenic (see discussion in Question 4), or
  - buildings with very low air exchange rates (e.g., < 0.25/hr) or very high sustained indoor/outdoor pressure differentials (e.g., > 10 Pascals), or
  - soil types outside the range shown in Table 4, or
- Any other situation for which the Johnson-Ettinger Model is deemed inappropriate.

_____ If **YES** - check here and briefly document the issues below and go to **Site-Specific Assessment - Question 6.**

_____ If **NO** - check here and continue with **Question 5(c)**.

_____ If sufficient data (of acceptable quality) are not available - check here and skip to Summary Page and document that more information is needed. We recommend that the next step be expeditious collection of the needed data in accord with proper DQOs. Question 5 can then be revisited with the newly collected data to re-evaluate the completeness of the vapor intrusion pathway.

Q5(c): Are the **depth to vapor source and the overlying unsaturated zone soil type adequately characterized** in areas with inhabited buildings (or areas with the potential for future development of inhabited buildings)?

_____ If **YES** - check here and continue with **Question 5(d)** below.

_____ If **NO** - check here, go to Summary Page and document that more information is needed. We recommend the next step be expeditious collection of the needed data in accord with proper DQOs. Question 5 can then be revisited with the newly collected data to re-evaluate the completeness of the vapor intrusion pathway.

Subsurface Source Identification

Q5(d): **Is there any potential contamination (source of vapors) in the unsaturated zone soil at any depth above the water table?** (In our judgment, if there is a contaminant source in the unsaturated zone, soil gas data are needed to evaluate the vapor intrusion pathway in the vicinity of the source and, consequently, use of the groundwater target concentrations may be inappropriate. However, we recommend that groundwater data still be evaluated, particularly if a contaminant plume extends beyond the unsaturated zone source, but that the evaluation be performed only in conjunction with an evaluation of soil gas data. Other vapor sources that we believe typically make the use of groundwater target concentrations inappropriate include: 1) those originating in landfills where methane may serve as a carrier gas; 2) those originating in commercial/industrial settings (such as dry cleaning facilities) where vapor can be released within an enclosed space and the density of the chemicals' vapor may result in significant advective transport of the vapors downward through cracks/openings in floors and into the vadose zone; and 3) leaking vapors from underground storage tanks. In these cases, diffusive transport of vapors is often overridden by advective transport and the vapors may be transported in the vadose zone several hundred feet from the source of contamination.)

_____ If **YES** - check here and skip to **Soil Gas Assessment – Question 5(f)** below.

_____ If **NO** - check here and continue with Groundwater Assessment - **Question 5(e)** below.

Groundwater Assessment:

Q5(e):Do measured or reasonably estimated groundwater concentrations exceed the target media-specific concentrations given in Tables 3(a), 3(b), or 3(c) for the appropriate attenuation factor (given that the conditions listed above in 5(b) are not present and that sampling issues described Appendix E have been considered)?

_____ If **YES** - check here, document the soil type, depth to groundwater and attenuation factor used in the assessment on the summary page, and document the representative groundwater concentrations on Table 3. If **soil gas data are available**, proceed to **Soil Gas Assessment - Question 5(f)** below**, otherwise** proceed to **Site Specific Assessment - Question 6**.

_____ If **NO** – check here and document that the groundwater data indicate that the **pathway is incomplete** and/or does not pose an unacceptable risk to human health on the Summary Page. In order to increase confidence in the assessment that the pathway is incomplete, EPA recommends that soil gas data also be evaluated following the soil gas assessment guidelines below (**Question 5(f)**).

Soil Gas Assessment:

Q5(f): Do measured or reasonably estimated soil gas concentrations exceed the target media-specific concentrations given in Tables 3(a), 3(b), or 3(c) for the appropriate attenuation factor (given that the conditions listed above in 5(b) are not present, or that other site specific factors make consideration of this analysis inappropriate, and that sampling issues described in Appendix E have been considered)?

_____ If **YES** - check here, document the soil type, depth to source and attenuation factor used in the assessment on the summary page, document representative soil gas concentrations on Table 3 and proceed to **Site Specific Assessment - Question 6**.

_____ If **NO** – check here and document that the subsurface vapor to indoor air **pathway is incomplete** and/or does not pose an unacceptable risk to human health on the Summary Page. In this case, we recommend no further assessment of the vapor intrusion pathway.

1. What is the goal of this question?

The goal of this question is to provide a means of evaluating the vapor intrusion pathway using tables of generally recommended target media-specific concentrations that incorporate limited site-specific information. Specifically, Question 5 factors in consideration of soil type and depth to source in screening the available groundwater and soil gas data. Soil gas- and groundwater-to-indoor air attenuation factors generally

depend (as described in Appendix G) on building characteristics, chemical type, soil type, and depth of the source (which is defined as either a measured soil gas concentration at the specified sample collection depth below the building, or the ground water concentration at the depth of the water table). By using the Johnson and Ettinger Model (1991) and keeping all factors besides source depth and soil type constant (and reasonably conservative), a set of attenuation factors can be derived that allows for the selection of semi-site specific target media concentrations that are more representative of the user's site. The semi-site-specific target values provided in Question 5 are less conservative (higher by a factor of 2 to 50 times, depending on soil type and depth to source) than the generic screening values used in Question 4. The increase in target concentrations corresponds to a decrease in the calculated attenuation factors as depth to source increases and soil type becomes finer grained (see Figures 3(a) and (b) and Section 3 below). In our judgment, if observed concentrations are greater than 50 times the generic target concentrations provided in Question 4, there is no benefit in using the criteria in Question 5 and we recommend expeditious site-specific evaluation.

2. How do you use the Graphs and the Tables?

The user selects a representative attenuation factor for soil gas from Figure 3(a) and for groundwater from Figure 3(b) based on measured site-specific information about soil type and depth to source. The selected attenuation factors are then rounded up to the nearest attenuation factor shown in Figure 3. Then, the columns in Tables 3(a), 3(b), and 3(c) corresponding to the attenuation factors selected from Figure 3(a) or 3(b) can be used to determine the appropriate target media concentrations for this level of screening. The values in Tables 3(a), 3(b), and 3(c) were derived as discussed in Appendix D.

3. How did we develop the media-specific target concentrations?

The Johnson and Ettinger (1991) Model was used as described in Appendix G to calculate the attenuation factors shown in Figures 3(a) and 3(b). Generally reasonable building characteristics were selected and held constant in these calculations and the chemicals were assumed not to degrade. To capture the effect of changes in soil properties, the U.S. Soil Conservation Service (SCS) soil texture classifications were considered, and a subset of these was selected. This subset was chosen so that their relevant properties (porosity and moisture content) would collectively span the range of conditions most commonly encountered in the field. Then, plots of attenuation factor versus depth were calculated, and these results are presented in Figures 3(a) and 3(b). The two graphs are different because the soil gas attenuation factors (Figure 3(a)) do not have to account for transport across the capillary fringe whereas the groundwater attenuation factors (Figure 3(b)) do. Details of the input parameters and calculations used to derive the graphs are included in Appendix G.

4. What should you keep in mind when using the graphs?

The generally recommended depth to source used to select a scenario-specific attenuation factor is: 1) the vertical separation between the soil gas sampling point and the building

foundation for use of Figure 3(a), or 2) the vertical separation between the water table and the building foundation for use of Figure 3(b). Note that we recommend that groundwater or soil gas samples collected at depths less than 5 feet (1.5 m) below the building foundation not be evaluated with these graphs. If contaminated groundwater is within 5 feet of the foundation level, or if the only soil gas samples available for screening were obtained from depths less than 5 feet below foundation level and the soil gas concentrations are greater than target levels, we recommend the user perform a site specific assessment. If the depth to source across the site varies, we recommend that the minimum depth be used in this assessment.

We recommend that the soil type used to select a scenario-specific attenuation factor represent the material most permeable to vapors between the building foundation and the contaminant source (e.g., the coarsest and/or driest soils). The graphs below use the U.S. Soil Conservation Service system of soil classification, in which the soil texture classes are based on the proportionate distribution of sand, silt and clay sized particles in soil. The generally preferred method for determining the SCS soil class is to use lithological information combined with the results of grain size distribution tests on selected soil samples. Table 4 below has been developed to assist users in selecting an appropriate SCS soil type in cases where lithological and grain size information is limited. Note that in Table 4 there is no soil texture class represented as consisting primarily of clay. Exclusion of clay was deliberate since homogenous unfractured clay deposits are rare.

Table 4. Guidance for selection of soil type curves in Figures 3(a) and 3(b).

If your boring log indicates that the following materials are the predominant soil types …	Then we recommend the following texture classification when obtaining the attenuation factor.
Sand or Gravel or Sand and Gravel, with less than about 12 % fines, where "fines" are smaller than 0.075 mm in size.	Sand
Sand or Silty Sand, with about 12 % to 25 % fines	Loamy Sand
Silty Sand, with about 25 % to 50 % fines	Sandy Loam
Silt and Sand or Silty Sand or Clayey, Silty Sand or Sandy Silt or Clayey, Sandy Silt, with about 50 to 85 % fines	Loam

5. Rationale for Selecting Semi-Site Specific Attenuation Factor and Reference(s):

Document Risk Level Used (Circle One): 10^{-4}, (b) 10^{-5}, or (c) 10^{-6}

Figure 3a- DRAFT
Vapor Attenuation Factors - Soil Vapor to Indoor Air Pathway
Basement Foundations

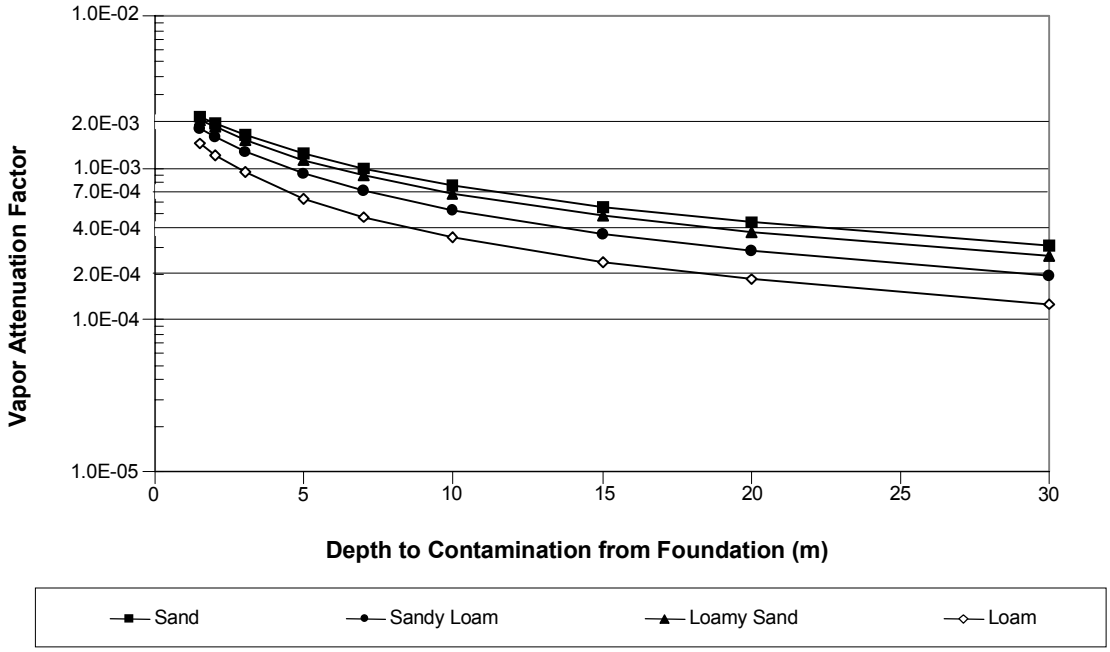
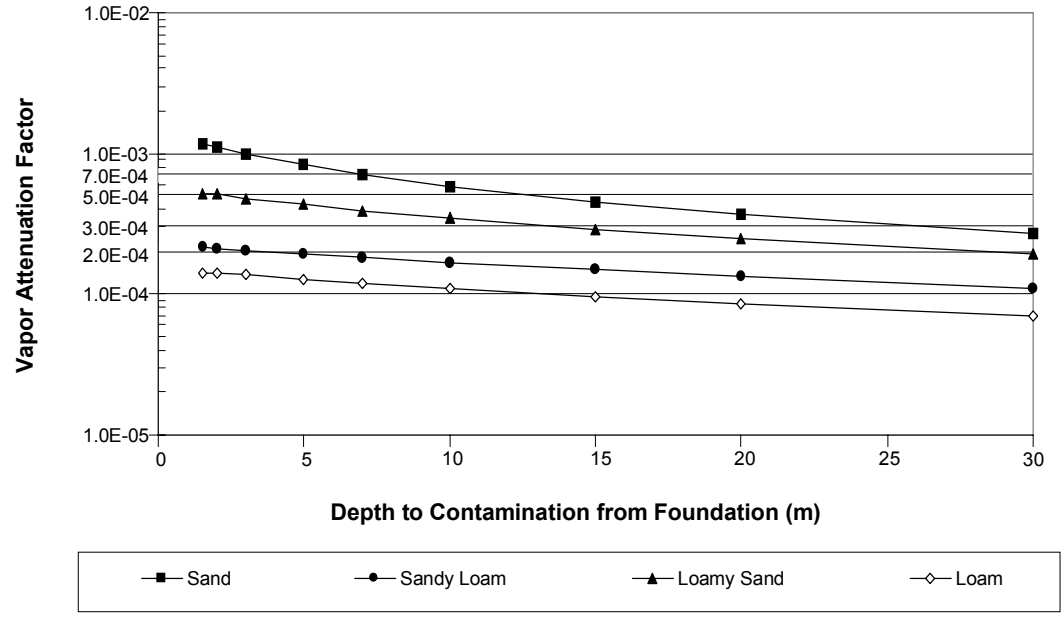


Figure 3b- DRAFT
Vapor Attenuation Factors - Ground Water to Indoor Air Pathway
Basement Foundations



VI. Tier 3 - Site-Specific Assessment

If primary and secondary screening results do not assist in excluding the existence of a vapor intrusion pathway, we recommend a site-specific assessment. In this case, this guidance recommends: (1) direct measurement of foundation air concentrations before any indoor air measurements; (2) direct measurement of indoor air concentrations coupled with a home survey (see Appendix H) and sampling to identify background sources of vapor in ambient (outdoor) and/or indoor air; 3) removal of all indoor air sources before sampling indoors; and (4) complementary site-specific mathematical modeling as appropriate. The sampling of foundation air (e.g., subslab and /or crawlspace air) and ambient (outdoor) air in conjunction with indoor air is intended to distinguish the exposures that originate from subsurface contaminant vapor intrusion from those due to background sources.

The recommended site-specific modeling is intended to be complementary to the more direct building-related measurements collected from a selected subset of the potentially impacted buildings. Considering the complexities involved in evaluating the vapor intrusion pathway (due to the sensitivity of attenuation factors to soil type, depth to source, and building characteristics), mathematical modeling may be useful in determining which combination of factors leads to the greatest impact and, consequently, aid in identifying appropriate buildings to be sampled. However, if an appropriate model is not available or cannot be modified to represent the conceptual site model, the only available option may be a site-specific assessment that relies entirely on direct measures of potential exposures.

We recommend that since site-specific assessments are based on direct evidence (confirmatory sampling of subslab or crawlspace vapor concentrations and/or indoor air concentrations), decisions made that "no further action with respect to vapor intrusion is needed", are likely to be "final decisions." Additionally, we recommend that the approaches suggested in the site-specific assessment be used, where appropriate, to support Current Human Exposures Under Control EI determinations. However, we do not believe that confirmatory sampling will generally be necessary in that context. Current Human Exposures Under Control EI determinations are intended to reflect a reasonable conclusion by EPA or the State that current human exposures are under control with regard to the vapor intrusion pathway and current land use conditions. We believe that not recommending confirmatory sampling to support Current Human Exposures Under Control EI determinations is appropriate because of the conservative nature of the assumptions made.

If buildings are not available or not appropriate for sampling, for example in cases where future potential impacts need to be evaluated, we recommend mathematical modeling be used to evaluate the potential for unacceptable inhalation risks due to the vapor intrusion pathway. Where modeling indicates there is the potential that vapor intrusion may result in unacceptable exposures, other more direct measures of potential impacts, such as emission flux chambers or soil gas surveys, may need to be conducted in areas underlain by subsurface contamination. Alternately, it may be appropriate to reduce potential

exposures with a mechanical ventilation system in the event buildings are constructed over subsurface vapor sources. EPA recommends that these sites be reevaluated when they are being developed, as appropriate, and that management decisions be made based on evaluation results at that time.

The data collected during site-specific evaluations of the vapor intrusion pathway can also serve to increase the level of understanding about key issues and important factors in the assessment of this pathway. Because the Agency is interested in improving the understanding of the modeling approach to evaluate the vapor intrusion pathway, EPA requests that the relevant data collected in site specific assessments be submitted electronically to an EPA repository that will be established by OSWER. EPA plans to develop a database structure specific to vapor intrusion evaluations to facilitate electronic entry of the relevant data and electronic submission to the repository. Once developed, EPA plans to make the database structure accessible through OERR's and OSW's web sites.

EPA plans to review and analyze these submitted data on an ongoing basis and consider appropriately refining this draft guidance for assessing the vapor intrusion pathway. EPA plans to post any revisions/addenda on the OSWER's website.

A. Site Specific Assessment – Question 6

Q6(a): Have the **nature and extent of contaminated soil vapor, unsaturated soil, and/or groundwater as well as potential preferential pathways and overlying building characteristics been adequately characterized to identify the most-likely-to-be-impacted buildings?** (Consider an appropriately-scaled Conceptual Site Model (CSM) for vapor intrusion (see Appendix B) and DQOs (see Appendix A)).

_____ If **YES** - check here, briefly document the basis below and **proceed to Question 6(b).** If a model was used, we recommend it be an appropriate and applicable model that represents the conceptual site model. If other means were used, document how you determined the potentially most impacted areas to sample.

_____ If **NO**, or if insufficient data (of acceptable quality) are available - check here, briefly **document the needed data** below, and skip to the Summary Page and document that more information is needed. After collecting the additional data, you can return to this question. However**, if indoor air data are available go to Question 6(e)**.

Q6(b): Are you conducting an EI determination and are you using an appropriate and applicable model?

_____ If **YES** - check here and continue with **Question 6(c)** below.

_____ If **NO** - check here and continue with **Question 6(d)**.

Q6(c): Does the model predict an unacceptable risk? (EPA recommends that predictive modeling can be used to support Current Human Exposures Under Control EI determinations without confirmatory sampling to support this determination. Current Human Exposures Under Control EI determinations are intended to reflect a reasonable conclusion by EPA or the State that current human exposures are under control with regard to the vapor intrusion pathway and current land use conditions.)

_____ If **YES** - check here and continue with **Question 6(d)** below.

_____ If **NO** - check here and document that the **Pathway is Incomplete** and/or does not pose an unacceptable risk to human health for EI determinations. However, this determination does not necessarily reflect a final decision that the site is clean without confirmatory sampling.

Q6(d): Are subslab soil gas data available?

_____ If **YES** - check here and continue with **Question 6(e)** below.

_____ If **NO** - check here and continue with **Question 6(g)**.

Q6(e): Do measured subslab soil gas concentrations exceed the target shallow soil gas concentrations given in Tables 2(a), 2(b), or 2(c)?

_____ If **YES** - check here, document representative subslab soil gas concentrations on Table 2, collect indoor air data and **go to Question 6(g).**

_____ If **NO** – check here and **continue to Question 6(f)**.

Q6(f): Is the subslab sampling data adequate? (We recommend doing subslab sampling before indoor air sampling) Some factors we recommend for consideration in this question include:

- Do analytical results meet the required detection thresholds?
- Do the data account for seasonal and/or temporal transience?
- Do the data account for spatial variability?
- Is there any reason to suspect random (sampling) or systematic (analytical) error?
- How do the data account for the site conceptual model?
- Was "background" ambient (outdoor) air or other vapor sources considered?

_____ If **YES** - check here and document that the **Pathway is Incomplete** and/or does not pose an unacceptable risk to human health.

_____ If **NO** or unsure - check here, briefly document the needed data below, and skip to the Summary Page and document that more information is needed. After collecting the additional data, return to Question 6(e).

Q6(g): Do measured indoor air concentrations exceed the target concentrations given in Tables 2(a), 2(b), or 2(c)? (We recommend that before any indoor air sampling occurs: 1) an inspection of the residence be conducted, 2) an occupant survey be completed to adequately identify the presence of (or occupant activities that could generate) any possible indoor air emissions of target VOCs in the dwelling (see appendix E, H and I), 3) all possible indoor air emission sources be removed, and 4) that the analysis be done only for the constitutes of potential concern found on the site.)

_____ If **YES** - check here, document representative indoor air concentrations on Table 2, and go to Question 6(i).

_____ If **NO** – check here and continue to Question 6(h).

Q6(h): Do the indoor air concentrations adequately account for seasonal variability and represent the most impacted buildings or area (see Appendix E)? Some factors we recommend for consideration in this question include:

- Do analytical results meet the required detection thresholds?
- Do the data account for seasonal and/or temporal transience?
- Do the data account for spatial variability?
- Is there any reason to suspect random (sampling) or systematic (analytical) error?
- How do the data account for the site conceptual model?

_____ If **YES** - check here, document that **Pathway is Incomplete** and/or does not pose an unacceptable risk to human health. If a model was used to predict the indoor air concentrations also document the relationship between the predicted concentrations and the measured concentrations.

_____ If **NO** - check here, go to the summary page and document that more information is needed. If the data do not account for seasonal variability, we recommend designing a sampling plan to account for seasonal variability, resample and return to Question 6(g). If the data do not represent most impacted building or area, skip to the Summary Page and document that more information is needed. After collecting the additional data, you can return to Question 6(g).

Q6(i): Have background sources of vapor in indoor air and ambient (outdoor) air been adequately accounted for?

_____ If **YES** - check here, document results and document that **Pathway is Complete**. If a model was used to predict the indoor air concentrations, also document the relationship between the predicted concentrations and the measured concentrations.

_____ If **NO** - check here, briefly document the needed data below, and skip to the Summary Page and document that more information is needed. After collecting the additional data, you can return to Question 6(g).

1. What is the goal of this question?

The Site-Specific Pathway Assessment is designed to be used where site-specific conditions warrant further consideration prior to concluding either that the pathway is incomplete, or that some form of exposure control may be needed. In general, this final step recommends direct measures of potential impacts (e.g., building-specific foundation vapor concentrations – subslab sampling and/or indoor air concentrations) coupled with site-specific mathematical modeling where an appropriate model is available. However, EPA recommends that predictive modeling can be used to support Current Human Exposures Under Control EI determinations without confirmatory sampling these determination. Current Human Exposures Under Control EI determinations are intended to reflect a reasonable conclusion by EPA or the State that current human exposures are under control with regard to the vapor intrusion pathway and current land use conditions. The purpose of this site-specific approach is to help assess whether or not the vapor intrusion pathway is a likely problem. It is not meant to provide detailed guidance on how to delineate the extent of impacted buildings.

2. How should you complete this evaluation?

We recommend that the first step in conducting the site-specific evaluation be to update the site-specific conceptual site model and determine what additional information (e.g., direct sampling) you may need to determine the most-likely-to-be-impacted buildings (e.g., professional judgment or a model such as the J&E model). Confirmatory subslab/crawlspace and/or indoor air sampling is recommended at a percentage of the buildings at each potentially affected site that you have determined to be the most-likely-to-be-impacted. If sampling confirms that unacceptable inhalation risks due to vapor intrusion do not occur at the site, we recommend that the vapor intrusion pathway be considered incomplete and/or does not pose an unacceptable risk to human health. If sampling confirms that any building is impacted on the site, we recommend that the pathway be considered complete. In such case, we recommend that further analysis be conducted to delineate the extent of the impacted building(s) and that mitigation or avoidance measures be considered for the impacted buildings. These tasks are critically important, but are outside the scope of this guidance.

3. Why do we recommend updating your conceptual site model?

A conceptual model of the site and potential subsurface vapor transport and vapor intrusion mechanisms will be needed to adequately support the Site-Specific Pathway Assessment recommended in this guidance. We recommend that the site-specific conceptual model be developed in the typical source-pathway-receptor framework, and that it identify how the site-specific conceptual model is similar to, and different from, the generic conceptual model used in this guidance (see Introduction and Secondary

Screening). Under the guidance approach, key components of the conceptual model need to be justified with site-specific data, including, but not limited to, the source (chemical constituents, concentrations, mass, phase distribution, depth, and aerial extent), pathway (soil texture, moisture, and layering) and building (building design, construction, and ventilation). Some of the necessary data might already be available from previous site characterization efforts, but if not, we recommend collecting or developing appropriate site-specific data for evaluating the vapor intrusion pathway.

4. What should you keep in mind when you conduct indoor air or subslab sampling?

Collection of indoor air quality data without evidence to indicate the potential for vapor intrusion from subsurface sources can lead to confounding results. Indoor air quality can be influenced by 'background' levels of volatile chemicals (e.g., due to indoor and/or outdoor ambient sources). For example, consumer products typically found in the home (e.g., cleaners, fuels, paints, and glues) may serve as ancillary sources of indoor air contaminants. Additionally, ambient outdoor air in urban areas often contains detectable concentrations of many volatile chemicals. In either case, the resulting indoor air concentrations can be similar to or higher than levels that are calculated to pose an unacceptable chronic inhalation risk. Thus, we recommend the evaluation of existing indoor air data focus on constituents (and any potential degradation products) present in subsurface sources of contamination and the relative contributions of background sources be considered (see Appendix I). Additionally, see Appendix E for other items to keep in mind when doing subslab sampling.

5. What direct measurements should be considered and what do they mean?

Direct measures of indoor air and building foundation air (e.g., subslab and/or crawlspace concentrations) are recommended to verify whether or not the vapor intrusion pathway is complete. We recommend that the building specific sampling program be designed to identify and account for background sources. Prior to indoor air sampling, it is recommended that an inspection of the residence be conducted and an occupant survey be completed to adequately identify the presence of (or occupant activities that could generate) any possible indoor air emission sources of target VOCs in the dwelling (see discussion above and Appendices E, H & I) and then, if possible remove these sources. The Massachusetts Department of Environmental Protection (MA DEP) has prepared a useful ***Indoor Air Sampling and Evaluation Guide (April 2002)*** which is available at the following URL: http://www.state.ma.us/dep/ors/files/indair.pdf.

In collecting indoor air samples, it is important to recognize that indoor air quality can be influenced by 'background' levels of volatile chemicals (e.g., due to indoor and/or outdoor ambient sources), as discussed in the above section. Thus, we recommend the evaluation of existing indoor air data focus on constituents (and any potential degradation products) present in subsurface sources of contamination and determine the relative contributions of background sources (see Appendix I) in order to properly assess the potential inhalation exposure risks that can be attributed to the subsurface vapor intrusion

pathway. Where air concentrations in upper level living spaces are greater than basement levels, intrusion is not likely to have occurred. Indoor air quality data also are subject to homeostatic fluctuations and temporal trends. Thus, to properly evaluate the indoor air data, we recommend that sufficient information be obtained to identify seasonal and spatial variations in indoor air concentrations. Additionally, we recommend careful consideration of subsurface data from the site in order to determine whether the most likely to be impacted structures were sampled.

Sampling of foundation air (e.g., subslab and/or crawlspace air) provides a direct measure of the potential for exposures from vapor intrusion. When collected in conjunction with indoor air sampling, foundation samples can be used to identify the exposures that originate from vapor intrusion and distinguish those due to background sources. Subslab vapor is defined as the soil gas in contact with the building envelope immediately beneath or within the sub-floor construction materials. Subslab samples are recommended to be, but do not need to be, collected via holes through the flooring as close to the center of the floor space as possible. Soil gas sampling using angled or horizontal borings from outside under the foundation also may be effective. Appendix E provides more detailed recommendations on subslab and soil gas sampling methodologies. The recommended attenuation factor for sub-slab soil gas samples in this step is 0.1 (see Appendix F). The recommended attenuation factor to apply for crawl-space air samples is 1.0 (i.e., the same as target indoor air concentrations).

6. Why should you consider using site-specific modeling at this time?

Site-specific modeling is intended to complement the evaluation of samples collected from a subset of the potentially impacted buildings. We recommend that only models appropriate for the site setting be used and that the direct evidence from the sampled buildings be used to verify the accuracy of the model's site-specific predictive capability. Where predictions and direct evidence from the indoor air sampling are consistent, the model can be used to direct the selection of buildings to be sampled. Considering the complex influence of soil type, depth to groundwater, and building characteristics on vapor attenuation factors, the model may help to determine which combination of factors leads to the greatest impact. Additionally, the model may be used to justify the decreased need for more direct evidence from the remaining contaminated area. We recommend that site-specific modeling be performed with inputs derived from direct measurements at the site. This may necessitate the collection of more detailed information regarding subsurface properties, nature and extent of contamination, and building construction characteristics.

EPA has developed a spreadsheet version of the Johnson and Ettinger (JE) Model (1991), which is one of the available screening level models for evaluating the vapor intrusion pathway. As described in Question 5, the JE Model was used to develop conservative attenuation factors linked to soil type and depth to source at a site. This model and documentation for the model are available at the following web site:

URL = http://www.epa.gov/superfund/programs/risk/airmodel/johnson_ettinger.htm

If the JE model is used in a site-specific assessment of the vapor intrusion pathway, we recommend that model inputs and assumptions that are different from the generic assumptions used in Question 5 and described in Appendix G be supported with site-specific information. If a model other than the JE Model is used, EPA recommends model inputs and outputs be identified and appropriately justified.

7. How do you appropriately involve the community when evaluating the vapor intrusion pathway?

Prior to conducting any direct sampling efforts, we recommend appropriately involving the community. It has been our experience that proper community involvement efforts are critical to the effective implementation of this level of screening. We recommend that users refer to the Community Involvement Guidance in Appendix H. Under the approach recommended in this guidance, we recommend the user consider the following: 1) getting to know the neighborhood, key stakeholders and the concerns of the community; 2) informing stakeholders of the situation; 3) developing a community involvement plan that highlights key community concerns; 4) obtaining written permission, and involving the property owner in identifying or removing potential indoor air sources, including inspection of residence and completing an occupant survey: 5) fully communicating sampling results (with visuals, maps etc.); and 6) a commitment to ongoing communications activities throughout site cleanup efforts. Appendix H contains and cites examples of guidance that could be considered for site-specific adaptation for interaction/involvement with building/dwelling occupants prior to indoor air sampling.

8. What do you do if the pathway is found to be complete?

If the pathway is judged to be complete during the Site-Specific Screening, the next recommended step is to identify the impacted buildings or areas of concern. This may result in some buildings or areas being included and some being excluded from the areas of concern. For these areas, we recommend that the pathway be considered to remain complete unless some action is taken to reduce occupants' exposure to the site contamination. Possible actions include:

- engineered containment systems (subslab de-pressurization, soil vacuum extraction, vapor barriers),
- ventilation systems (building pressurization, indoor air purifiers),
- avoidance (temporary or permanent resident relocation), or
- removal actions to reduce the mass and concentrations of subsurface chemicals to acceptable levels (i.e., remediation efforts).

This draft guidance is not intended to provide direction on how to fully delineate the extent of impacted buildings or what action should be taken after the pathway is confirmed. It is intended to be a quick screening process to help guide the user in determining if vapor intrusion is or is not a problem on the site.

9. Rationale and Reference(s):

Document Risk Level Used (Circle One): 10^{-4}, (b) 10^{-5}, or (c) 10^{-6}

VII. VAPOR INTRUSION PATHWAY SUMMARY PAGE

Facility Name: _____

Facility Address: _____

Primary Screening Summary

☐ *Q1: Constituents of concern Identified?*

_____ *Yes*

_____ *No* (If NO, skip to the conclusion section below and check NO to indicate the pathway is *incomplete.)*

☐ *Q2: Currently inhabited buildings near subsurface contamination?*

_____ *Yes*

_____ *No*

Areas of future concern near subsurface contamination?

_____ *Yes*

_____ *No* (If NO, skip to the conclusion section below and check NO to indicate the pathway is *incomplete.)*

☐ *Q3: Immediate Actions Warranted?*

_____ *Yes*

_____ *No*

Secondary Screening Summary

☐ *Vapor source identified:*

_____ *Groundwater*

_____ *Soil*

_____*Insufficient data*

☐ *Indoor air data available?*

_____ *Yes*

_____ *No*

☐ *Indoor air concentrations exceed target levels?*

_____ *Yes*

_____ *No*

- *Subsurface data evaluation: (Circle appropriate answers below)*

Medium	Q4 Levels Exceeded?	Q5 Levels Exceeded?	Data Indicates Pathway is Complete?
Groundwater	YES / NO / NA / INS	YES / NO / NA / INS	YES / NO / INS
Soil Gas	YES / NO / NA / INS	YES / NO / NA / INS	YES / NO / INS

NA = not applicable
INS = insufficient data available to make a determination

Site-Specific Summary

- *Have the nature and extent of subsurface contamination, potential preferential pathways and overlying building characteristics been adequately characterized to identify the most-likely-to-be-impacted buildings?*

  _____ *Yes*

  _____ *No*

  _____ *N/A*

  EPA recommends that if a model was used, it be an appropriate and applicable model that represents the conceptual site model. If other means were used, document how you determined the potentially most impacted areas to sample. EPA recommends that predictive modeling can be used to support Current Human Exposures Under Control EI determinations without confirmatory sampling to support this determination. Current Human Exposures Under Control EI determinations are intended to reflect a reasonable conclusion by EPA or the State that current human exposures are under control with regard to the vapor intrusion pathway and current land use conditions. Therefore, if conducting evaluation for an EI determination, document that the **Pathway is Incomplete** and/or does not pose an unacceptable risk to human health for EI determinations.

- *Are you making an EI determination based on modeling and does the model prediction indicate that determination is expected to be adequately protective to support Current Human Exposures Under Control EI determinations?*

  _____ *Yes*

  _____ *No*

  _____ *N/A*

- *Do subslab vapor concentrations exceed target levels?*

  _____ *Yes*

  _____ *No*

  _____ *N/A*

- *Do indoor air concentrations exceed target levels?*

  _____ *Yes*

  _____ *No*

Conclusion

Is there a Complete Pathway for subsurface vapor intrusion to indoor air?

Below, check the appropriate conclusion for the Subsurface Vapor to Indoor Air Pathway evaluation and attach supporting documentation as well as a map of the facility.

_____ NO - the "Subsurface Vapor Intrusion to Indoor Air Pathway" has been verified to be incomplete for the _____ facility, EPA ID #_____, located at _____. This determination is based on a review of site information, as suggested in this guidance, check as appropriate:

  _____ for current and reasonably expected conditions, or

  _____ based on performance monitoring evaluations for engineered exposure controls. This determination may be re-evaluated, where appropriate, when the Agency/State becomes aware of any significant changes at the facility.

_____ YES –The "Subsurface Vapor to Indoor Air Pathway" is Complete. Engineered controls, avoidance actions, or removal actions taken include: _____

_____

_____

_____ UNKNOWN - More information is needed to make a determination.

Locations where References may be found:

_____

_____

_____

_____

_____

Contact telephone and e-mail numbers:

(name) _____

(phone #) _____

(e-mail) _____

Reminder: As discussed above, this is a guidance document, not a regulation. Therefore, conclusions reached based on the approaches suggested in this guidance are not binding on EPA or the regulated community. If information suggests that the conclusions reached using the approaches recommend are inappropriate, EPA may (on it's own initiative or at the suggestion of interested parties) choose to act at variance with these conclusions.

References

Burning of Hazardous Waste in Boilers and Industrial Furnaces; Final Rule (58 FR 7135, February 21, 1991)

Draft Exposure Assessment Guidance for RCRA Hazardous Waste Combustions Facilities (April/May 1994)

Guidance for the Data Quality Objectives (DQO) Process, EPA QA/G 4. (EPA/600/R-96/055; August 2000);(URL = http://www.epa.gov/quality/qs_docs/g4_final.pdf)

Johnson and Ettinger (JE) Model (1991)
(URL = http://www.epa.gov/superfund/programs/risk/airmodel/johnson_ettinger.htm)

Massachusetts Department of Environmental Protection (MA DEP) Indoor Air Sampling and Evaluation Guide - WSC Policy#02-430 (April 2002) (URL = http://www.state.ma.us/dep/bwsc/finalpol.htm)

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RCRA draft Supplemental Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway (EPA/600/SR-93/140 - Dec 2001)
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Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites
(Peer Review Draft: March 2001) Office of Emergency and Remedial Response/EPA
(URL = http://www.epa.gov/superfund/resources/soil/ssgmarch01.pdf)
[final version will issue concurrently with the *Subsurface Vapor Intrusion Guidance*.]

Use of Risk-Based Decision Making in UST Corrective Action Programs. OSWER **Directive 9610.17 (EPA; Mar 1, 1995);(URL= http://www.epa.gov/swerust1/directiv/od961017.htm)**