Question from the SAB Work Group on EPA Planned Actions for SAB Consideration of the Underlying Science Work Group Question for OSWER and the OSWER Response

Question: Addition of Subsurface Component to the Hazard Ranking System (HRS) (AG67)

- What were the charge questions asked of the peer reviewers mentioned in the Agency's description?
- Are the peer reviewers' reports available to the SAB work group for review to help determine whether it believes an SAB review is necessary? Could any other information be made available?

OSWER Response

The attached document is a modified version of the "External Peer Review Record" which was written by the peer review contractor (modified to remove the actual draft rule) for the HRS SsI proposed rulemaking. The document includes:

1. Title page with Table of Contents (modified)
2. Peer review charge questions
3. Summary matrix with comments on preamble (modified)
4. Summary matrix with comments on charge questions and rule (matrix does include reference to rule section number, line number and page number)
5. Each peer reviewer's comments on charge questions, their resume and COI certification

Proposed Rule: Addition of a Subsurface Intrusion Component to the Hazard Ranking System; 40 CFR Part 300; EPA-HQ-SFUND-2010-1086; FRL_XXXX-X (review draft)

External Peer Review Record (modified)
November 21, 2011 – February 20, 2012

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- Paul Johnson
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Peer Review Charge Questions

Peer Review Charge for:
U.S. Environmental Protection Agency (EPA). *Proposed Rule: Addition of a Subsurface Intrusion Component to the Hazard Ranking System*; 40 CFR Part 300; EPA-HQ-SFUND-2010-1086; FRL_XXXX-X (review draft).

Background
The U.S. Environmental Protection Agency (EPA) is proposing to include a subsurface intrusion (SsI) component to the Hazard Ranking System (HRS). Subsurface intrusion is the migration of hazardous substances from the unsaturated zone and/or the surficial ground water into overlying structures. The HRS is the principal mechanism the EPA uses to evaluate sites for placement on the National Priorities List (NPL). The subsurface intrusion component addition (this addition) would primarily expand the number of available options for EPA and state and tribal organizations performing work on behalf of EPA to evaluate potential threats to public health and the environment from releases of hazardous substances.

This addition will allow the HRS evaluation to directly consider human exposure to hazardous substances that enter building structures through subsurface intrusion, and thus enable sites with subsurface intrusion contamination to be evaluated for placement on the NPL. This addition will make the HRS more accurate in assessing a site's relative potential risk. The Agency is not considering changes to the remainder of the HRS except for minor updates reflecting changes in terminology related to revised toxicological parameters. This proposed regulatory change does not affect the status of sites currently on or proposed to the NPL.

Expertise Required
The peer review panel for U.S. EPA's *Proposed Rule: Addition of a Subsurface Intrusion Component to the Hazard Ranking System* should include expertise in:

***Federal Agency Panelist**:* Panelist must have a strong working knowledge of policy and technical issues related to topic of vapor intrusion. Knowledge of recent developments in vapor intrusion technologies and research is required, in addition to working knowledge of federal vapor intrusion response programs. Expertise in hydrogeology, chemistry, knowledge of public health risks associated with indoor air threats, and the subsurface migration of volatile hazardous substances is necessary. Field experience conducting vapor intrusion investigations, while not required, is highly desirable. Experience conducting field investigations for the purpose of listing sites on the NPL and/or experience working with the HRS to evaluate sites for inclusion on the NPL is highly recommended, but not necessary.

State Environmental Program Panelist: Panelist must have strong technical experience and working knowledge of policy and technical issues (e.g., mitigation and remediation) related to the topic of vapor intrusion. Expertise in hydrogeology, chemistry, knowledge of public health risks associated with indoor air threats, and the subsurface migration of volatile hazardous substances is necessary. Knowledge of recent developments in vapor intrusion technologies and research is required, in addition to working knowledge of state vapor intrusion response programs. Field experience conducting vapor intrusion investigations, while not required, is highly desirable. Experience related to conducting field investigations for the purpose of listing sites on the NPL and/or experience working with the HRS to evaluate sites for inclusion on the NPL is highly recommended, but not necessary.

Academia: Panelist must have experience working, researching, and developing opinions on the topic of vapor intrusion. Expertise in the history and recent developments of vapor intrusion research and development, remediation, and mitigation technologies is required. Expertise in hydrogeology, chemistry, knowledge of public health risks associated with indoor air threats, and the subsurface migration of volatile hazardous substances is necessary. Experience working on Superfund issues is highly recommended, but not necessary.

Panelist from non-specified sector: Panelist must have a strong working knowledge of policy and technical issues related to the topic of vapor intrusion. Knowledge of recent developments in vapor intrusion technologies and research is required, in addition to working knowledge of federal vapor intrusion response programs. Expertise in hydrogeology, chemistry, knowledge of public health risks associated with indoor air threats, and the subsurface migration of volatile hazardous substances is necessary. Field experience conducting vapor intrusion investigations, while not required, is highly desirable. Experience conducting field investigations for the purpose of listing sites on the NPL and/or experience working with the HRS to evaluate sites for inclusion on the NPL is highly recommended, but not necessary.

Peer Review Charge Questions

1. Potential for subsurface exposure (intrusion) into occupied structures

Background: The current HRS evaluates the likelihood of a release of a hazardous substance when an actual release has occurred through either chemical analysis or direct observation. The current HRS also evaluates the potential for a release to occur within the ground water, surface water and air pathways (see section 2.3 of the current HRS). The potential for a release is determined by the consideration of pathway specific factors that aid the site evaluator in predicting whether a release to the pathway is likely to occur. These factors are based on containment features of the source of contamination (whether or not hazardous substance can get out), route characteristics specific to each pathway (how far hazardous substances could migrate based on knowledge of site conditions) and include physical/chemical properties of the hazardous substances being evaluated (how the hazardous substances act in the environment).

Proposed Approach: EPA is proposing a parallel approach for evaluating potential and actual exposure of intruded hazardous substances for the subsurface intrusion addition to the HRS. In determining which route characteristics are appropriate for evaluating potential exposure to subsurface contaminants, EPA examined present modeling methods such as the Johnson-Ettinger model and also considered multiple lines of evidence approaches which estimate the levels of contaminant exposure based on numerous route characteristics. In addition, EPA examined the relationship between these factors to determine which have the greatest influence on the likelihood that an exposure would occur, and then incorporated these factors within its proposed approach. EPA also gave careful consideration to ensure that the data necessary to obtain route characteristic factors could be measured or calculated on a site-specific basis and in a manner consistent with current HRS evaluations. Based on the Agency's analysis, the following three factors for which sufficient site-specific information could be collected during a site inspection represented the greatest impact on the potential for exposure: (1) depth to contamination; (2) vertical migration; and (3) vapor migration potential (see Figure 1).

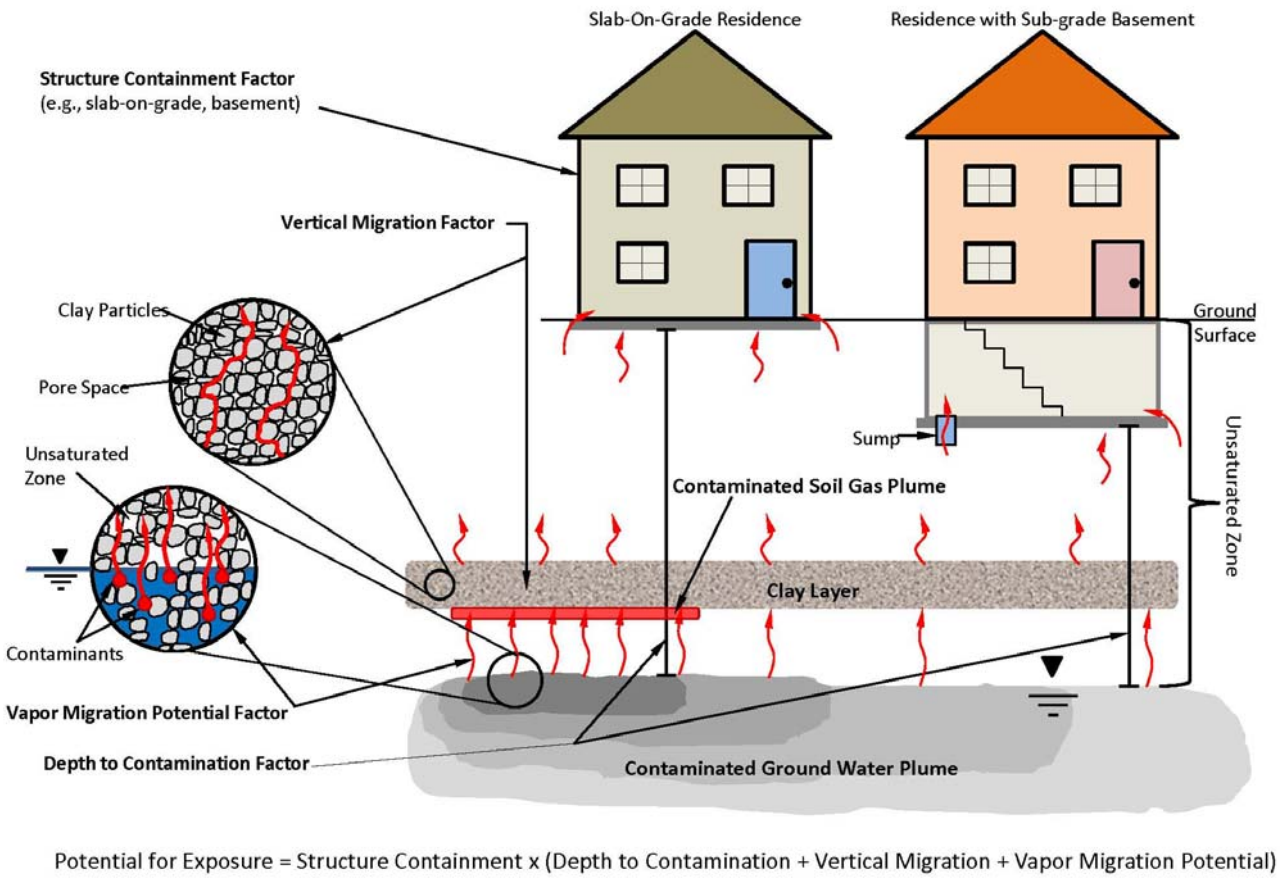

Figure 1

Charge Question #1 : Is EPA's proposed approach scientifically reasonable for evaluating and assigning proportional weightings for the following when evaluating potential for exposure? If no, what alternative approach would you recommend?

a. Consideration of the construction/structure type for which sufficient site-specific information could be collected during a site inspection for the occupied structure;
b. Distance between occupied structure and depth of contamination; and
c. Evaluation of the vertical migration factor based on the thickness and porosity/permeability of geologic materials in the interval between the lowest point of an occupied structure and the highest known point of hazardous substances in the subsurface.

2. Hazardous Waste Quantity

Background: In the current HRS, the hazardous waste quantity factor reflects the risk consideration related to the magnitude and duration of either the release for ground water, surface water, and air pathways, or the exposure for the soil exposure pathway (see section 2.4.2 of the current HRS). Hazardous waste quantity is evaluated for all four pathways. At each site evaluated, EPA uses a four-tiered hierarchy for calculating the hazardous waste quantity that is based on (1) constituent quantity; (2) waste stream; (3) volume; and (4) area of the sources of hazardous waste at the site. EPA uses minimum waste quantity factors when there is insufficient information to estimate hazardous waste quantity. In the ground water, surface water, and air pathways, the HRS evaluates the total quantity of hazardous substances available to migrate from the original sources (how much has migrated and how much can be released in the future). In the soil exposure pathway, the hazardous waste quantity does not include the total amount of hazardous substances in all site sources, but rather is based on the amount of hazardous substances to which a receptor can be exposed where actual contamination has been documented. In other words, for the soil exposure pathway, the risk posed by a release of hazardous substances is directly related to the amount of hazardous substances that receptors are exposed to, as opposed to how much of the hazardous substances from the original sources may migrate to the receptors.

Proposed Approach: EPA is proposing a parallel approach to the soil exposure pathway to calculate hazardous waste quantity for the subsurface intrusion addition to the HRS. Since the subsurface intrusion component also focuses on exposure, the waste quantity factor value for this component should also reflect only the amount of hazardous substances that people actually are exposed to (the amount present in occupied structures). EPA is proposing to use a similar four-tiered hierarchical approach to calculate hazardous waste quantity within occupied structures with contamination. In cases where no home is subject to actual contamination, EPA is proposing to use minimum waste quantity factors. In situations where there is an observed release within a structure above benchmarks (Level I), a default value of 100 is proposed for the hazardous waste quantity factor value. This value is not used in the current soil exposure pathway, but is consistent with the ground water, surface water, and air pathways and reflects the increased exposure risk of a release within an occupied structure.

Charge Question #2: Is EPA's approach of basing the hazardous waste quantity on the amount of contaminants that could be found in the intruded structures appropriate? If no, what alternative approach would you recommend?

3. Population score

Background: Within the current HRS, receptors are evaluated in two main categories: whether they are exposed to 1) actual contamination; or 2) potential contamination (see section 2.5 of the current HRS). If receptors are exposed to contaminant levels meeting observed release criteria, they are identified as actually contaminated; however, if the receptors are not exposed to contaminants that meet the observed release criteria but are within the target area being evaluated, they are considered potentially contaminated. Actual contamination is further divided into two sub-categories based on whether the hazardous substance is present at or above a health-based benchmark. If the concentration of the hazardous substance released at the receptor is greater than a health-based benchmark, the receptors are identified as Level I receptors and are weighted (multiplied by a factor of 10) in scoring. If the release concentrations are less than a health-based benchmark, the receptors are identified as Level II receptors and are not weighted (multiplied by a factor of 1). Potential receptors are distance/dilution weighted; in other words, the farther away a receptor is located from a source, the less the population contributes to the site score.

Proposed Approach: EPA is proposing to generally use the same receptor weighting structure in the subsurface intrusion component as the one used in the current HRS. Those receptors in the area(s) of observed exposure (AOE) are considered actually contaminated, and those in the area(s) of subsurface contamination (ASC) are considered potentially contaminated (See Figure 2). The receptors in an AOE are further differentiated based on whether the contaminant concentrations are at levels above identified benchmarks (Level I) or are at levels establishing a release but below identified benchmarks (Level II). The benchmarks that EPA is proposing to use for the subsurface intrusion component are:

- Screening concentration for cancer effects; and
- Screening concentration for non-cancer effects (systemic toxicants).

Consistent with the weighting of populations throughout the HRS, the proposed subsurface intrusion component will weight targets within the AOE subject to Level I contaminant concentrations by a factor of 10 and weight targets subject to Level II contaminant concentrations by a factor of 1.

EPA is proposing to evaluate the weighting of targets within the ASC based on sub-slab, soil gas, and/or ground water samples. Potential receptors within the ASC receive less weight (population multiplied by a factor of 0.1), except in cases where a sub-slab sample indicates contaminant levels are at least 10 times higher than a health-based benchmark (population is multiplied by a factor 0.75). The value of 0.75 was determined based on an evaluation of paired data when both a sub-slab and indoor air sample were collected. The 0.75 weighting reflects the observation that for approximately 80 percent of the sampling events where contamination was detected in the sub-slab, contamination was also detected in the indoor air sample. The order of magnitude adjustment applied to the health-based benchmark reflects EPA's finding that, in such paired sampling events, the indoor air sample concentration is, on average, 10 times lower than the sub-slab sample concentration.

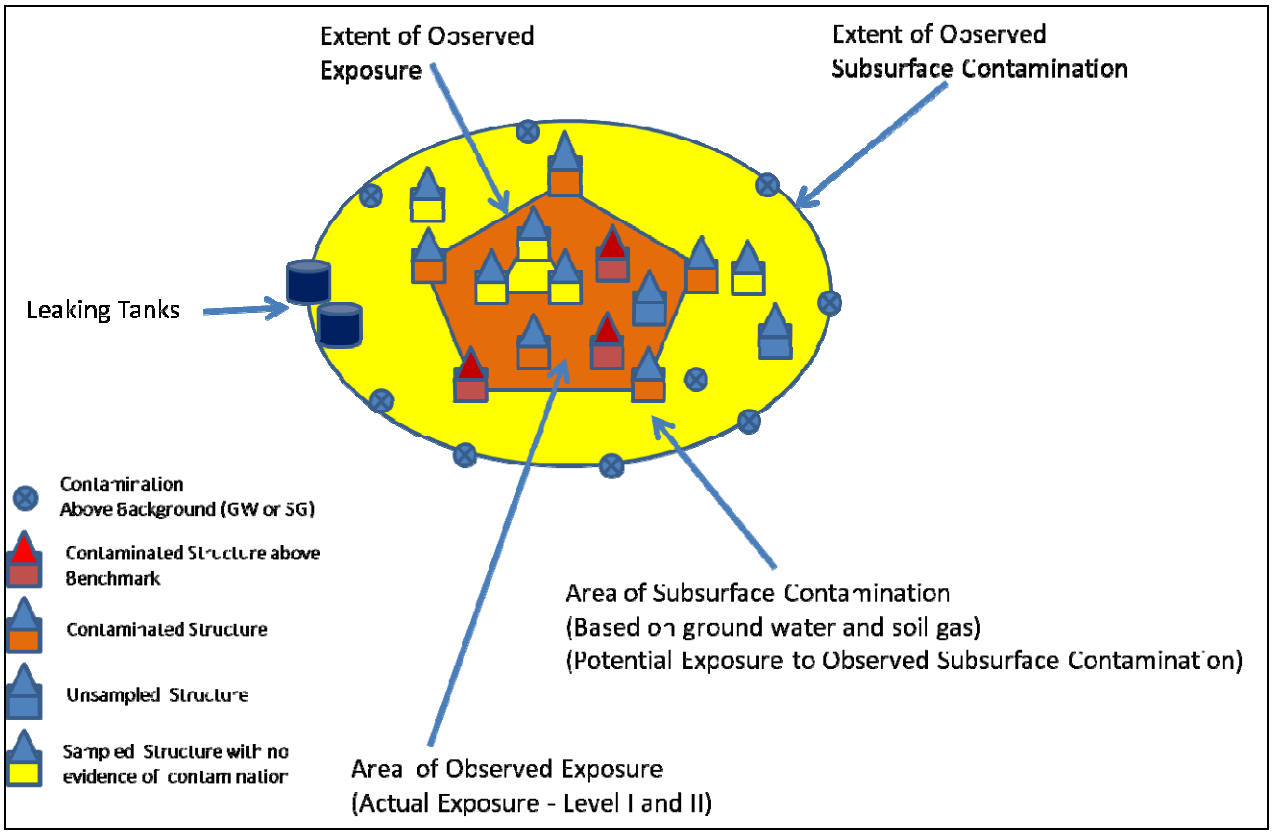

Figure 2

Charge Question #3: Is it appropriate to consider individuals/populations located within the area of subsurface contamination (ASC) to be at a higher relative risk in situations when sub-slab contaminant concentrations are at least ten times greater than a health-based benchmark? If no, please explain.

4. Multi-story and multi-tenant structures

Background: In the current HRS, multi-story and multi-tenant buildings are evaluated based on population associated with an actually or potentially impacted target. In the ground water pathway, all residents who are served by a well are considered subject to the actual or potential contamination of the well. In the air pathway, all residents who have an opportunity to breathe ambient air are considered subject to the actual or potential contamination of the ambient environment within a distance category. All receptors within a contaminated surface water stretch are subject to the level of contamination associated with that surface water stretch. In the soil exposure pathway, receptors must be able to come in contact with areas of contamination. In determining the likelihood a person will come in contact with areas of contamination, the HRS uses a 200 foot rule (see section 5.1.3 of the current HRS) because it is reasonable to assume that that a person will walk/use areas within a 200 foot areal extent of their residence/property. The 200 foot rule is used regardless of whether a building is multi-tenant or multi-story (the assumption being that is reasonable for people to use the outside of their properties).

Proposed Approach: EPA is proposing to evaluate multi-story/multi-tenant buildings utilizing a similar approach as soil exposure, limiting the receptors to those individuals that reasonably can be exposed to subsurface intrusion within an occupied multi-tenant/multi-story building. EPA is proposing to consider all receptors exposed to actual contamination as the population inhabiting the floor of the intruded space and the population inhabiting the floor above and the floor below the intruded space when calculating waste quantity and population. EPA considers that this approach will more accurately reflect risk to both actual and potential receptors, while also minimizing the potential for over counting (Figure 3).

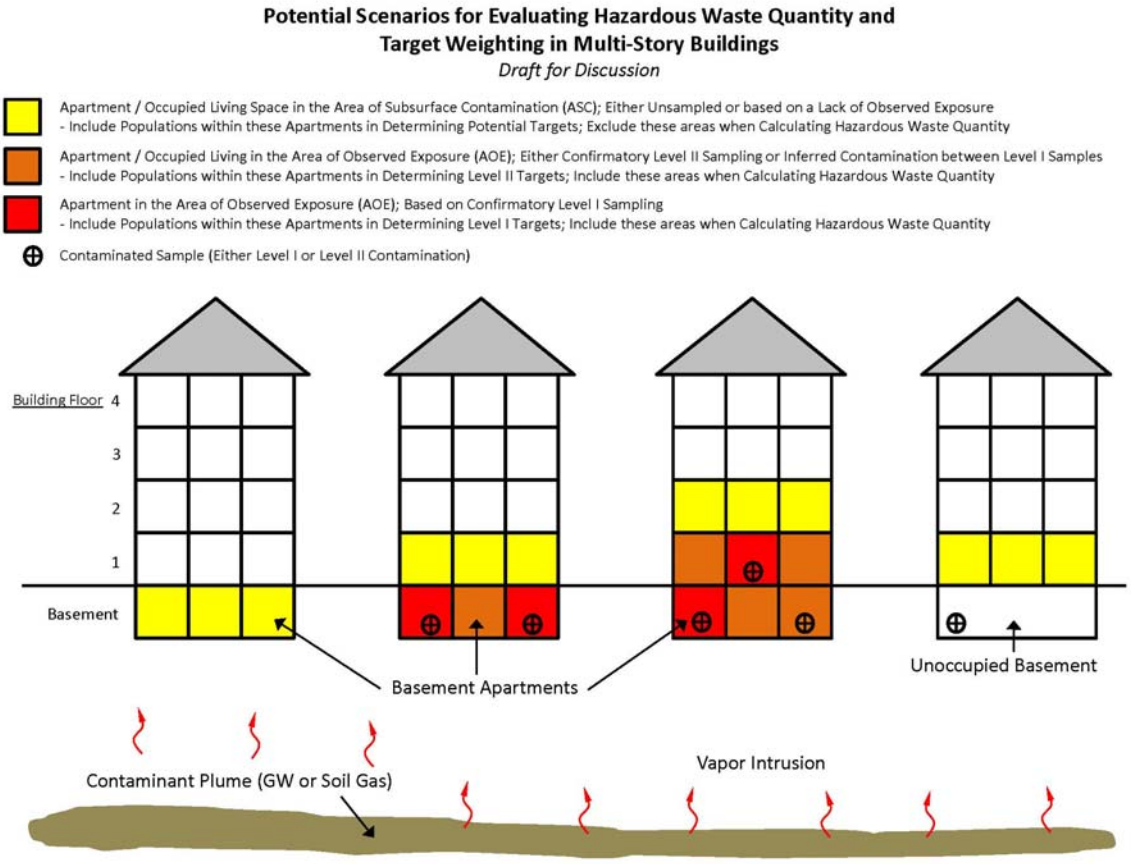

Figure 3

Charge Question #4: When calculating waste quantity and population, is it scientifically reasonable for populations in multi-story or multi-tenant structures to be evaluated based on using only the population inhabiting the intruded space and the population on the floor above and below the intruded space (For example, if contamination is found on the first floor, population from the basement and second floor would be used in the calculation. If contamination is found on the fifth floor, population from the fourth floor and sixth floor would be used in the calculation – for further explanation, see detailed discussion in above paragraph "Proposed Approach")? If no, what alternative approach would you recommend?

5. Factor Value for Workers

Background: In the current HRS, for the resident population threat of the soil exposure pathway, a factor value for workers is assigned based on the total number of workers present within the area of observed contamination. These factor values range from 0 to15, depending on the number of workers exposed to outdoor contamination (see section 5.1.3.3 of the current HRS).

Proposed Approach: EPA is proposing to mirror the procedures for the resident population threat in the soil exposure component when assigning a worker factor value in the subsurface intrusion component (see Table 5-4 in section 5.1.3.3 of the current HRS). However, since it is anticipated that workers spend a larger percentage of their time indoors and therefore may be more exposed to contamination resulting from subsurface intrusion than to outdoor soil (or other surface) contamination, EPA is proposing to assign workers exposed to subsurface intrusion a higher weighting (i.e., factor values ranging from 0 to 45).

Charge Question #5: Because of longer exposure times indoors, is it reasonable to assume that the relative risk is three times greater for workers exposed to subsurface intrusion within the workplace than it is for workers exposed to outdoor surface contamination at the workplace? If no, please explain.

Summary Matrix of Peer Review Comments on *Preamble*

Commenter	Guidance Section	Line Number		Comment	EPA Resolution
Burk	VI.B.2.b.	824	Parenthetical	Comment: Reference Section 5.2.1.3.2.3 for weighting	
Burk	VI.B.3.	842		Consider replacing “this” with “observed exposure (section 5.2.1.1.1.)”	
Burk	VI.B.3.a.ii	887-888		Comment: Consider using reference values as a first line of comparison, instead of nearby sampling data. If indoor air background occurs outside the area of release, what would the source(s) be? Many are totally dependent on individual occupants' lifestyles and choices and likely vary from one house to the next: use of household products (hobbies, cleaning, home/auto/garden maintenance), use of heating oil, cooking habits, home businesses, attached garages, and worker take-home exposures. Background sources that may come from regional sources could include volatilization from household water use from a similar water source, outdoor air, or subsurface sources from non-site related hazardous waste generators. However, most of these regional sources could be accounted for independently. Literature data is more likely to capture statistically significant sources from individual occupant sources than select samples in the region of the site under investigation. Also not discussed in this Preamble or the HRS Rule documents are whether background implies the average concentration, UCL or maximum levels. Reference to guidance on selecting background values could be provided (http://www.epa.gov/oswer/vaporintrusion/documents/oswer-vapor-intrusion-background-Report-062411.pdf), if explicit discussion is not. This reference includes data from thousands of indoor samples with statistical review to represent the wide range of behaviors and contributors to background indoor air contamination.	
Burk	VI.B.3.a.ii	894		Consider adding: “Furthermore, the background of some contaminants is expected to be negligible.”	
Burk	VI.B.3.a.ii	898		Consider adding “(or the similarity)” […that the difference **or the similarity** is not simply…]	
Burk	VI.B.3.a.ii	898-900		Extreme temporal and spatial variability is also a hallmark of the vapor migration pathway due to barometric pumping and other more subtle yet complex factors, such as HVAC operation, opening a window, varying soil moisture content, snow/ice cap of the surrounding surface, and seasonal effects, to name only a few examples. Note should be made within the document that such untraditional factors can play a significant role in SsI on an hourly, daily and monthly basis and should be noted in site assessment for NPL listing. Perhaps this can be reflected in the technical document.	
Burk	VI.B.3.a.ii	906		Consider inserting “a pre-determined” after "below" [...background level is below **a pre-determined** detection, any level…]	
Burk	VI.B.3.a.ii	906		Consider inserting “limit” after "detection" [...detection **limit**, any level…]	
Burk	VI.B.3.a.ii	929-931		This situation can get complex and may warrant further discussion in the technical document. While it is sufficient to indicate if an environment is significantly higher than background, should the background be elevated with regard to health or quality parameters, any elevation above those levels should be deemed “elevated.” Also, let’s not forget about false negatives. If a GW plume has VOCs and indoor air at several residences has a cadre of those VOCs , and the indoor air is above a benchmark, then we should consider the exposure from the CERCLA source is significant, unless household sources are removed and levels found to be below levels of concern.	
Burk	VI.B.3.b.v.	1033		Delete second "to be" [...projected to be ~~to be~~ the most...]	
Burk	VI.B.4.b.	1089		Remove "s" from "pathways"	
Burk	VI.B.4.b.	1100		Change "potions" to "portions"	
Burk	VI.B.4.b.	1108		Change "adequate" to "adequately"	
Burk	VI.B.4.b.	1121		Consider changing "occur" to “be detected” [subsurface intrusion would **be detected** if sampling…]	
Burk	VI.B.4.b.	1126		Consider changing "actual" to “indoor air” [...sampling would document **indoor air** contamination.]	
Burk	VI.B.5.c.ii	1280-1281		What is the basis for using 0.75? Consider using 0.80 instead of 0.75. It is more conservative and it is the actual value referenced here. If site-specific data is available, such as for a nearby AOE, perhaps consider that percentage.	
Burk	VI.B.5.c.ii	1284		Will additive effects for generic types of contaminant VOCs and sVOCs be taken into account?	
Hartman	I.B	170-171		[Response to statement: "The EPA does not expect that this proposed change will result in additional site assessments being conducted."] Oh yes it will	
Hartman	I.B	174-175		[Response to statement: "For these reasons, the EPA considers that this proposed rule is not expected to result in the listing of more sites on the NPL during any particular time period."] It definitely will	
Hartman	I.B	183-184		The proposed rule is not compliant with the current & updated EPA-OSWER & EPA-OUST vapor intrusion guidances. Hence all this is going to do is create more confusion.	
Hartman	III.A	241-243		This is deceptive. Because vapor intrusion screening levels are so low, the benchmarks the rule proposes to use, sites that are really not a huge risk will possibly score high in the HRS.	
Hartman	III.A	243-245		Only true for sites with only vapor releases, but not sites with soil & groundwater contamination. Your current system will catch these just fine.	

Commenter	Guidance Section	Line Number		Comment	EPA Resolution
Hartman	III.A	251-252		[In response to statement: "Over 40 written comments were received during the public comment period."] This is a tiny number of comments from a country with millions of people that could be affected by this new rule.	
Hartman	III.A	252-253		Your first line says "because of the substantial public support." But here you admit that of 40 comments, some were from government agencies. This is not the public. Just how many comments were actually from non-government agencies? This means that less than 40 comments were received. Seems to me that the public doesn't really care about this proposed new rule.	
Hartman	III.A	255-256		5 out of 50 states says to me that the 90% of the States are not interested in this new rule	
Hartman	III.A	256-258		ASTSWMO is NOT supportive of this rule for petroleum hydrocarbons. Your rule makes no distinction for petroleum vs. non-petroleum VOCs.	
Hartman	III.A	261-263		But didn't you say previously on lines #171 & #174 that this new rule would not result in additional site investigations? You're saying an additional 850 sites won't result in more investigations?	
Hartman	III.A	283-284		Lines #171 & #174 say that the new rule won't lead to additional site assessments, but here you admit there will be more.	
Hartman	III.A	286-289		[Regarding public support]: This is debatable as commented on above.	
Hartman	III.A	288		[Regarding national program consistency]: Don't the State Environmental regulatory agencies oversee this?	
Hartman	III.C	390-391		I disagree with this statement.	
Hartman	III.C	404-405		But your new rule is inconsistent with the EPA vapor intrusion guidance in some areas. This will create more confusion, not less.	
Hartman	III.C	415-416		[Regarding imposing costs on private entities]: But is likely the inevitable end-result.	
Hartman	IV.B.2	488-489		This is where the rule is really lacking. Petroleum hydrocarbon VOCs behave very differently than halogenated VOCs, but there is no distinction in the proposed rule.	
Hartman	V.A.2	569-572		This ITRC survey is out of date. Between 35 to 40 States now have their own vapor intrusion guidance	
Hartman	V.A.2	574-575		[Regarding ASTSWMO support]: Not for petroleum hydrocarbon sites.	
Hartman	V.A.3	605-607		Tiny number of comments from a nation this large. I consider this to not indicate a large public connern over this pathway.	
Hartman	V.A.4	628-629		[Regarding "placeholder for topics identified as needing peer review"]: Would be nice to know what these topic are.	
Hartman	VI.B.3.b.v.	1029-1030		This is where the rule is lacking. For hydrocarbon VOCs, bioattenuation will greatly reduce the migration potential, but your rule makes no allowance for that.	
Hartman	VI.B.4.b.	1120-1122		But again, this needs to be broken down into hydrocarbon VOCs and halogenated VOCs? This 80% should not apply to both compound groups.	
Hartman	VI.B.5.b.i	1203		[Regarding "• Screening concentration for cancer"]: The problem here is your are proposing to use a benchmark at 1 in 1 million risk level. This is far too low and will be easily exceeded. Some States regulate this pathway at 1 in 100,000 and some at 1 in 10,000. It is advised that you use a benchmark at the 1 in 10,000 risk level to avoid listing too many sites with a low potential for VI problems.	
Hartman	VI.B.5.b.i	1204		[Regarding "• Screening concentration for noncancer toxicological responses"] With new toxilogical data recently released, even the noncancer values (HI=1) are very low. Again, you will be listing too many sites if you use this as a benchmark. It is advised that you set non-cancer levels at a HI=10.	
Hartman	VI.B.5.b.ii	1220-1221		[Regarding value of 20]: This value seems completely subjective to me. What is the basis? You have no evidence that this individual is exposed.	
Hartman	VI.B.5.c.ii	1280-1282		No, this is the 95th percentile, in the EPA report not the average. The 10x criterion is too low and will result in overranking. It should be at least 50x. In addition, this rule should not apply to hydrocarbon VOCs since the EPA report was based upon halogenated VOCs.	
Hartman	VI.B.5.d	1303-1304		But the benchmark should also be set to published screening values for commercial/industrial receptors, not for residential receptors.	
Johnson		9	General Comment	I understand the need to generalize and provide flexibility to deal with any intrusion to buildings (gases or liquids), but 99% of the preamble discussion is specific to vapor intrusion and is not relevant to intrusion of liquids. This should probably be mentioned and the emphasis on vapor intrusion in the discussions of specifics should be stated up front.	
Johnson	Summary	25-26		To be consistent with other USEPA documents, should this state "The NPL is a list of national priorities among the known releases or threatened releases"?	
Johnson	Summary	30		I can understand this addition to the HRS not affecting the current placement of sites on the NPL, but couldn't it make a difference as to whether or not a "proposed" site is selected for the NPL?	
Johnson	I.B	163		"contaminant" is redundant, given the definition of "subsurface intrusion"given above.	
Johnson	I.B	170-171		[Regarding "The EPA does not expect that this proposed change will result in additional site assessments being conducted."]: Is this true? It seems that many sites do not have the appropriate data to assess the pathway. For example, I work close to a site that has been on the NPL list for more than a decade and that has in the last year conducted a new off-site site assessment specific to this pathway. See also lines 238 - 245 and 265-275 below.	

Commenter	Guidance Section	Line Number		Comment	EPA Resolution
Johnson	III.A	224-225		[Regarding "The most common form of subsurface intrusion is vapor intrusion."]: What other forms are anticipated?	
Johnson	III.A	230		Is “relative” necessary or appropriate here? If so, should you add “compared to other sites” as is done below to clarify what the risk is relative to?	
Johnson	III.A	233		[Regarding "exposure"]: Should you say “contact or ingestion” here to be consistent with the sentence structure and later discussions?	
Johnson	III.A	261		[Regarding "the subsurface"]: Should you insert “scope of”, “breadth of” or “scale of” here?	
Johnson	III.A	265-275	Bulleted Text	Are any of these sites ones where it is something other than vapor intrusion? It would be useful to clarify that.	
Johnson	III.A	280		[Regarding "...nor does the EPA have any specific subsurface intrusion sites for the NPL identified at this time…"]: Is this true? What about Motorola 52nd Street site? They are devoting a lot of effort now to look at this pathway.	
Johnson	III.A	280-283		This seems to conflict with earlier statements about how addition of this pathway is unlikely to change the number of sites on the NPL.	
Johnson	III.C	350		[Regarding "gas, vapor"]: Are “gas” and “vapor” different things to the authors? They mean the same to me.	
Johnson	III.C	383		[Regarding "is operated strictly by the public sector"]: Is this a true statement? There are DoD (non-public sector) sites in the program and many site assessments are reviewed and commented on by EPA and its contractors.	
Johnson	III.C	389-391		The reasoning here is a little strange – basically it’s saying that the number of sites on the NPL is constrained by resources and is not dictated by the risks posed by the sites. It is not clear why this concept is needed in this preamble or why it is repeated often? Isn’t the more important issue whether or not evaluation of this pathway will lead to more cleanup or the identification of more sites requiring further study (rather than does the number of sites on the NPL grow)? The GAO reported seemed to anticipate the potential growth in the number of sites resulting from consideration of the pathway.	
Johnson	III.C	392-394		What evidence do you have to back this up? There are a few well-known sites with exemplary programs (e.g., Hill AFB), but probably many others that have not yet even looked at the pathway.	
Johnson	III.C	400		[Regarding "most states"]: Is “most” a true statement at this point in time? I can think of “a few” or “some” that have made it a high priority. See lines 569 – 577 below as contradictory statements.	
Johnson	V.A.2	565		[Regarding "non-federal"]: Is it assumed here that there is a comprehensive program for evaluation SsI at federal sites? If so, what is that program?	
Johnson	VI.B.2.b.	820		Lines 817-819 indicate that that the ASC is based on known subsurface contamination, so why include the line “but either sampling has not documented that subsurface contamination has occurred..”?	
Johnson	VI.B.3.a.ii	887-894		How will you deal with the situation where health levels of concern are at or below background levels for some settings?	
Johnson	VI.B.3.a.ii	904-905		[Regarding "three times the background level"]: Why 3X? If I measure background at about 0.2 ug/m3 and I get 0.4 ug/m3 results and health levels are 0.2 ug/m3 , is this the right conclusion? These issues will be important for this pathway (more so than for other pathways) because many measured values, background levels, and levels of concern are likely to fall in the 1X – 10X real detection/reporting levels.	
Johnson	VI.B.3.a.ii	906-907		Even if 10% above detection levels?	
Johnson	VI.B.3.a.ii	919-923		Note that our research has shown that indoor air sources can themselves cause subsurface contamination through building “breathing” with the soil. So simply looking for the presence indoors and in the subsurface does not conclusively prove that indoor concentrations are resulting from SsI.	
Johnson	VI.B.3.a.ii	929-931		This section’s discussion is predicated on the assumption that not seeing a chemical in typical indoor air sampling results is evidence that SsI is not occurring. Our detailed field study data from Utah has shown that to not be true. Probably need to mention that this issue is being addressed below in lines 934 – 937.	
Johnson	VI.B.3.b	940		This “sampling” seems to assume that all sampling is of the point-in-time and point-in-space type (e.g. Summa cannisters). There are other methods that may prove to be more reliable in the next few years. The language should allow for the development of new methods and maybe needs to be specific to say that it is considering conventional sampling approaches as the current norm.	
Johnson	VI.B.3.b	944-945		Good point and this paragraph is pretty well written and important.	
Johnson	VI.B.3.b	949		Note that this figure [5] only shows vapor intrusion and not any other anticipated “subsurface intrusion” routes.	
Johnson	VI.B.3.b.ii	991-992		[Regarding "depth to contamination"]: This one should probably be replaced with chemical type. Whether or not a chemical is aerobically biodegradable is a much more significant factor than depth (see comment below) and modeling and empirical data show this to be the case.	
Johnson	VI.B.3.b.iii	996-1003		I have concerns about this factor. In theory, for non-biodegradable chemicals, depth can at most affect the flux rate linearly (e.g., the flux rate for a source 200 ft deep would only be 10X less than one from 20 ft deep, and there would be even less difference if the soil profile were not the controlling diffusion resistance (i.e., if the capillary fringe or the building structure were instead the controlling factors). The EPA empirical database also does not show a strong dependence on depth, if I remember correctly.	

Commenter	Guidance Section	Line Number		Comment	EPA Resolution
Johnson	VI.B.3.b.iv	1019-1022		I would like to see the back-up for this. As shown in EPA guidance document modeling and other work that we have published in the past, soil type does not have a significant effect on effective diffusion coefficients. 10000X differences in permeability might only correspond to 10X (at most) differences in diffusion coefficients. The one thing (perhaps the only thing) that will make a significant difference is the presence of perched water between the vapor source and building or the presence of a highly water saturated soil layer. The EPA empirical database also does not show a very significant effect of soil type.	
Johnson	VI.B.3.b.v	1034-1037		This should focus more on some combination of vapor pressure, Henry's Law constant, site concentrations, and threshold breathing levels as it is not always the most volatile chemical that poses the greatest health threat.	
Johnson	VI.B.4.b	1119		[Regarding "waste quantity"]: Wouldn't it make more sense to have this factor related to either groundwater or soil gas concentration?	
Johnson	VI.B.4.b	1123-1124		See comment above concerning the connection between indoor air sources and subsurface vapor clouds. The former has been shown to be capable of causing the latter.	
Johnson	VI.B.5.a	1167-1169		This makes sense.	
Johnson	VI.B.5.b.i	1189		[Regarding "outdoor"]: Do you mean "outdoor" or "exterior" sampling. The former implies above-ground sampling, while the latter is the EPA guidance terminology for sub-slab, subsurface, and groundwater sampling around and beneath a building.	
Johnson	VI.B.5.c.i	1251-1253		This seems reasonable for this pathway, although I'd expect some people to object.	
Johnson	VI.B.5.c.ii	1279-1282		Note comments above concerning indoor air sources and subslab vapor concentrations – this high correlation is expected in cases of indoor sources as well as for subsurface sources, so the relationship is not unique nor proof that subslab detections are proof of a complete subsurface to indoor air pathway.	
Lofstrum/Klein		13	General Comment	It should be made clear from the outset that the 'hazardous substances' referred to in the proposed subsurface intrusion component are those substances that can volatilize and migrate through the subsurface to inhabited structures. This is not made clear at all in this preamble.	
Lofstrum/Klein	III.A	225		There are several places where the term 'EPA' is used instead of 'the EPA'. It should be 'the EPA'	
Lofstrum/Klein	III.A	235-236		How would contaminants from surface water bodies enter indoor air spaces?	
Lofstrum/Klein	III.A	247		Replace with 'Second, the" and delete 'is' before 'because' to be consistent with the first paragraph on this page. [Sentence should read: "**Second, the** EPA is offering today's proposal **because** of the substantial…"]	
Lofstrum/Klein	III.A	260		Replace with 'Third,". [Sentence should read: "**Third,** the EPA has…"]	
Lofstrum/Klein	III.A	260		Replace with 'evaluated' [Sentence should read "…the EPA has **evaluated**…"]	
Lofstrum/Klein	III.A	261		Replace with 'by identifying the magnitude of". [Sentence should read "…to the current HRS **by identifying the magnitude of** the subsurface…"]	
Lofstrum/Klein	III.C	349		I think it would be clarifying to add 'volatile' before 'hazardous substances'. Or say 'hazardous substances that can volatilize'.	
Lofstrum/Klein	III.C	350		What is the difference between a gas and a vapor?	
Lofstrum/Klein	IV.B	474	Figure 2	Define the abbreviations/symbols across the bottom of this figure.	
Lofstrum/Klein	V.A.1	524		Replace with 'the EPA'.	
Lofstrum/Klein	V.A.1	526		Replace with 'the EPA'.	
Lofstrum/Klein	V.A.1	532		Add 'the' before 'Resource'.	
Lofstrum/Klein	V.A.1	547		Replace with 'are'. ['…intrusion issues **are** evaluated…"]	
Lofstrum/Klein	V.A.2	575		Define. [ASTSWMO]	
Lofstrum/Klein	V.A.2	579		Delete. ['In addition']	
Lofstrum/Klein	V.A.2	581		Define. [ATSDR]	
Lofstrum/Klein	V.A.2	584		Add 'the' before 'ATSDR'.	
Lofstrum/Klein	V.A.2	586		Make this a period. Start a new sentence. [Sentences should read: "...uniformly and consistently**. It** is highly resource intensive…"]	
Lofstrum/Klein	V.A.4	628		Replace [agency] with 'EPA'.	
Lofstrum/Klein	V.A.4	629		Replace [agency] with 'EPA'.	
Lofstrum/Klein	V.A.5.5	645		This sentence should be changed to match the style of the other points. Like 'Assemble and rely upon existing data to test the model.'.	
Lofstrum/Klein	VI.A	723		This paragraph should include a discussion of ground water and how the proposal will not overlook ground water as a source of hazardous substances with the capability of intruding into indoor air spaces.	
Lofstrum/Klein	VI.A	724		Replace ['are consideration of'] with 'consider'.	
Lofstrum/Klein	VI.B.2.b.	814		The approach for evaluating the area of subsurface contamination should be revised to include the ability to evaluate sites with subsurface contamination but without current structures.	
Lofstrum/Klein	VI.B.3	836		Delete the comma. [After 'HRS']	

Commenter	Guidance Section	Line Number		Comment	EPA Resolution
Lofstrum/Klein	VI.B.3.a	850		The terms contaminant and hazardous substance are used interchangeably throughout this preamble. When possible, 'contaminant' should be replaced with' hazardous substance', because this term is what is used in the proposed regulations, and it cannot be confused with other similar words like 'containment' to the tired reader.	
Lofstrum/Klein	VI.B.3.a.i	862		Why call out solid and liquid when only gas is addressed in the proposed revision to the HRS regulations?	
Lofstrum/Klein	VI.B.3.a.i	865		Same comment as previous [Why call out solid and liquid when only gas is addressed in the proposed revision to the HRS regulations?]. If not deleted, it should be clarified that the solid or liquid would contain a volatile hazardous substance(s).	
Lofstrum/Klein	VI.B.3.a.ii	904		Replace ['considered'] with 'assumed'.	
Lofstrum/Klein	VI.B.3.a.ii	919		Delete this phrase ['It is suggested that'] and add 'should' before 'include'. ["The evidence to support this determination **should** include…"]	
Lofstrum/Klein	VI.B.3.a.ii	923		Delete. ['In addition,']	
Lofstrum/Klein	VI.B.3.b	955	Figure 5	It would be clarifying to add the term 'Chemical-specific' to 'Vertical Migration Factor'.	
Lofstrum/Klein	VI.B.3.b.i	969		Change ['of'] to 'to'. […'minimize exposure **to** hazardous substances…"]	
Lofstrum/Klein	VI.B.4.b.	1096		Delete. ['ever']	
Lofstrum/Klein	VI.B.4.b.	1108		Replace ['insignificant'] with 'insufficient'.	
Lofstrum/Klein	VI.B.4.b.	1108		Replace ['adequate'] with 'adequately'.	
Lofstrum/Klein	VI.B.5.a	1164-1165		This ["Given that the subsurface…intrusion pathway."] is not a complete sentence.	
Lofstrum/Klein	VI.B.5.c.ii	1261		The approach to weighting targets should be revised to include evaluating areas of subsurface contamination without structures currently present.	
Lofstrum/Klein	VI.B.6	1351-1352		[Regarding: "...incorporation of the pathway score into a site score."]: Does this mean to say 'how the intrusion pathway score is incorporated into the site score'? If so, this sentence should be rewritten for clarity.	
Lofstrum/Klein	VI.B.6.a	1361		Change ['reflect'] to another word to avoid redundancy in the same sentence. Change to 'expresses'.	
Lofstrum/Klein	VI.B.6.a	1362		Change ["each of the"] to 'of each of the'. ["...the magnitude of each of the factor…"]	
Lofstrum/Klein	VI.B.6.a	1363		Change ['probably'] to 'probability'.	
Lofstrum/Klein	VI.B.6.a	1365		Change ['probably'] to 'probable'.	
Lofstrum/Klein	VI.B.6.b	1374		Delete. ["proposed to be"]	
Lofstrum/Klein	VI.B.6.b	1381		Move this phrase ["using this approach to assigning the pathway score"] to the end of the sentence for clarity and delete 'to assigning the pathway score'.	
Lofstrum/Klein	VII	1396		In Section 2.4.1.1 Toxicity Factor, carcinogenicity is divided into weight of evidence categories: A, B, and C (see Table 2-4). The EPA is no longer using these categories, so consideration should be given to updating that section as well.	

Summary Matrix of Peer Review Comments on Charge Questions and *Proposed Rule*

Commenter	Charge Question	Guidance Section	Page Number	Line Number		Comment	EPA Resolution
Burk	1.a					No mention of the potential for intrusion from wet basements or factors affecting indoor air pressure and exchange rate, such as HVAC systems or structural integrity ("leakiness") of building, was identified. Section 5.2.1.1.2.1 Structure Containment of the HRS Rule document may be an appropriate place to add consideration of these topics.	
Burk	1.b					Agreed, reasonable.	
Burk	1.c					Consideration of the possibility for hydraulic pumping in areas prone to rapid rise of the groundwater table may warrant a higher ranking. For example, vapor intrusion events in Hartford, IL have been correlated with rise in the Mississippi River and, to a lesser extent, rainfall (http://www.atsdr.cdc.gov/HAC/pha/HartfordResidentialCommunity/HartfordResidentialCommunityLHC02-24-2010.pdf).	
Burk	2					Agreed, appropriate.	
Burk	3					Agreed, however, the last bullet in section 5.2.1.2.2 of the HRS Rule document includes enclosed crawl spaces in this criteria. Since EPA's default attenuation factor for crawl space intrusion to indoor air is 1, the crawl space criteria may be better stated as considering populations when crawl space concentrations are greater than a benchmark (instead of 10 times a benchmark).	
Burk	4					The charge question seems to be worded differently than the description in the HRS Rule document on this topic. The charge question considers only the contaminated floor and one floor below and above the contaminated floor. Sections 5.2.1.3.2.1 and 5.2.1.3.2.2 say to consider those populations living within the story with Level I/II concentrations and those stories below that story. Section 5.2.1.3.3 says to count those workers in the highest story with observed exposure, one story above and all stories below. I agree with either approach with a caveat: preferential pathways, such as elevators and ventilation systems, may serve to transport hazardous vapors to distant floors. It may be prudent to consider the possibility of discontinuous contamination from floor to floor and not rule out floors that have not been sampled in such cases. Also, if a preferential pathway has not been identified to contamination in an isolated upper floor, all floors below seem at risk.	
Burk	5					Agreed reasonable.	
Burk		1.1	7	1		Phrases with the term "observed" are used frequently throughout the document but not explicitly defined. Could a more precise definition be included somewhere, such as adding Oserved Contamination: The presence of contamination determined by visual or olfactory recognition or chemical analysis and differentiated from background by comparison with background concentrations.	
Burk		2.4.2.2	23	36-37		Consider changing criteria for crawl space to: greater than its appropriate benchmark, since default EPA attenuation factor for crawl spaces is 1 (no attenuation).	
Burk		5.2.1.1.1	45	20		[Regarding background concentration]: More explanation of appropriate use of background or reference to a more detailed explanation might help here. A more detailed discussion is provided in the preamble. Consider inserting a reference to the comments in the preamble or the technical document for a more detailed section on this topic.	
Burk		5.2.1.1.2.1	45	37		[Regarding structure containment]: Perhaps add a paragraph to this section explaining the potential significance of wet basements, HVAC systems and structural integrity (leaky buildings) on structure containment. These topics are discussed in the ITRC vapor intrusion guidance: http://www.itrcweb.org/Documents/VI-1.pdf	
Burk		5.2.1.2.2	50	18-19		[Regarding enclosed crawl space]: Consider changing criteria for crawl space to: greater than its appropriate benchmark, since default EPA attenuation factor for crawl spaces is 1 (no attenuation).	
Burk		5.2.1.3	50	51		[Following "...with observed exporure."]: Consider adding: ", unless a preferential pathway exists to higher floors. If a preferential pathway to higher floors exists, such as an elevator shaft, count those targets in affected stories, unless information, such as indoor air sampling on those floors, indicates otherwise.	
Burk		5.2.1.3.1	51	11		Consider moving the word "only" to follow the word "observation" [...if there is an ~~only~~ observed exposure by direct observation **only**…]	
Burk		5.2.1.3.2.3	52	4-5		Consider the possibility of preferential pathways, such as by elevator shaft, to different floors.	
Burk		5.2.1.3.2.3	52	6-7		Consider changing criteria for crawl space to: greater than its appropriate benchmark, since default EPA attenuation factor for crawl spaces is 1 (no attenuation).	
Burk		5.2.1.3.2.3	52	11		Consider changing criteria for crawl space to: greater than its appropriate benchmark, since default EPA attenuation factor for crawl spaces is 1 (no attenuation).	
Burk		5.2.1.3.3	52	22-23		Consider the possibility of preferential pathways, such as by elevator shaft, to different floors.	
Hartman	1					No, it is not scientifically reasonable using these 3 factors alone.	
Hartman	1.c					This is a better approach than the one written above. However, this approach is also flawed if bioattenuation is not included into the vertical migration factor/potential. As now written, Section 5.2.1.1.2.3 & 4 & 5 have no allowance for bioattenuation, so the approach is fundamentally flawed for any VOCs that can bioattenuate such as vinyl chloride and petroleum VOCs.	
Hartman	2					This approach is appropriate, but what is not appropriate is defining the level I & II benchmarks at a 1 in 1 million risk level. Much too low. You should set benchmarks at a 1 in 10,000 risk level.	

Commenter	Charge Question	Guidance Section	Page Number	Line Number		Comment	EPA Resolution
Hartman	3					EPA OSWER has released a paper evaluating attenuation factors, including sub-slab to indoor air attenuation factors. The factor of 10 you refer to in the above paragraph is not an average. It is a 95th percentile. If you are going to use an average as you indicate, than the factor of 10 should be significantly higher. A paper released in 2011 says that a more reasonable subslab to indoor air attenuation factor is 50x. So, while it is appropriate to consider individuals/populations located within the area of subsurface contamination (ASC) to be at a higher relative risk in situations when sub-slab contaminant concentrations are high, the weighting factor of 0.75 should not apply until sub-slab values are at least 50 times higher than indoor air values rather than 10x higher.	
Hartman	4					This protocol is okay so long as there are no elevators in the building or pipe/electrical chases that act as vapor conduits between lower & upper floors.	
Hartman	5					There's no explanation as to where the factor of 3 came from. Hence, while it is reasonable to assume the risk is greater, I feel the basis for the factor of 3 should be explained.	
Hartman					General Comment	There needs to be a distinction in this rule between petroleum hydrocarbon VOCs which readily bioattenuate and recalcitrant VOCs (typically those containing halogens) that do not bioattenuate. I do not see any allowance for this under vapor migration potential factors.	
Hartman					General Comment	One idea to distinguish between VOCs that bioattenuate versus those that don't would be to come up with a bioattenuation factor. These factors would be 0.1, 0.01, 0.001, and 0.0 using exclusion criteria that EPA-OUST is now considering.	
Hartman					General Comment	Setting benchmarks for cancer effects at 1e-6 risk level and for non-cancer at a HI=1 is going to suck in almost every site as the screening levels for many compounds are below ambient levels. Since your goal is to rank the highest priority sites, you should set the benchmarks for cancer at 1e-4 risk and non-cancer at HI=10. This will accomplish the HRS goal of ranking the highest priority sites but not bog down your ranking with a large number of sites to rank that are unlikely to have a vapor intrusion concern.	
Hartman		Table 5-13	46	13	General Comment	In some places (such as table 5-13 and section 5.2.1.3.2.3), the rule is inconsistent with current & forthcoming EPA vapor intrusion guidances. This rule needs to be compliant with the two guidances coming out in March by EPA-OSWER & EPA-OUST.	
Hartman		5.2.1.3.2.3	52	3-16	General Comment	In some places (such as table 5-13 and section 5.2.1.3.2.3), the rule is inconsistent with current & forthcoming EPA vapor intrusion guidances. This rule needs to be compliant with the two guidances coming out in March by EPA-OSWER & EPA-OUST.	
Hartman		5.2.1.1.1	45	21-23		If you set benchmark at 1 in 10,000 risk level for cancer and HI=10 for non-cnacer, the background problem will go away.	
Hartman		5.2.1.1.2	45	32-36		You need to separate hydrocarbon VOCs from halogenated VOCs. Hydrocarbon VOCs bioattenuate which has a huge effect on vapor migration potential.	
Hartman		5.2.1.1.2	46	13	Table 5-13, Row 6	EPA vapor intrusion guidance only goes out to 100 feet, so to be consistent, this value needs to be 0, not 2	
Hartman		5.2.1.1.2.3	46	22		This should not be applied to hydrocarbon VOCs to be consistent with EPA vapor intrusion guidance	
Hartman		5.2.1.1.2.4	47	17		This approach is not valid for petroleum hydrocarbons as it does not account for bioattenuation. This approach should only be used for VOCs that do not bioattenuate.	
Hartman		5.2.1.3.2	51	29	Table 5-20	10-6 risk is far too low a benchmark. A more appropriate one for the HRS would be 10-4.	
Hartman		5.2.1.3.2	51	29	Table 5-20	A HI of 1 is too low a benchmark. A HI of 10 would be more appropriate as a benchmark for the HRS	
Hartman		5.2.1.3.2.3	52	6-9		10 times is too low for subslab samples for this ranking. 50x is more appropriate. For crawlspaces, EPA OSWER says there should be no multiplier (1x). This rule is inconsistent with EPA VI guidance.	
Hartman		5.2.1.3.2.3	52	13		Thisfactor should be zero, not 0.1.	
Johnson	1					Overall, the structure of this section seems to be based more on conventional wisdom (and common pathway misconceptions) than on the latest understanding gained from theory/modeling and critically-reviewed empirical observations. For example, field data and modeling show that the single-most significant influence on vapor intrusion impacts is whether or not a chemical is aerobically biodegradable, and that is not considered here. In addition, for chemicals that do not significantly biodegrade during vapor transport (i.e., chlorinated solvents), the potential significance of vapor intrusion impacts is primarily related to the quantity $\{(C\ D^{eff}/L\ A_B)/(Q_B\ C^{target})\}$, where C is the source concentration, D^{eff} is the overall effective vapor diffusion coefficient, L is the depth to the concentration C, A_B and E_B are the building footprint and exchange rate, and C^{target} is the target concentration for adverse impacts. Of these quantities, the ones that might vary most from site to site and have the greatest influence on the potential for adverse impacts are the ratios (C/C_{target}) and (D^{eff}/L). The first is a measure of how strong the source is, while the second is a measure of the overall resistance to transport through the soil. The relative interplay between these quantities, the strength of the source, and the realistic sensitivity of (D^{eff}/L) to depth and soil type are not reflected in the proposed approach. The proposed approach could be replaced by a simpler one based on only two primary factors: one derived from (C/C_{target}) ratios and one from a soil type vs. depth table. There could also be a modifying factor for chemical degradability that would be based on (total of all biodegradable concentrations/oxygen content in air and depth).	

Commenter	Charge Question	Guidance Section	Page Number	Line Number		Comment	EPA Resolution
Johnson	1.a					With respect to Table 5-12 (structure containment), I am not aware of definitive studies or significant anecdotal experiences that support the inclusion of Items 4, 5, or 7. USEPA's empirical database does not show a clear dependence on foundation construction (Item 4) and I am not aware of any definitive validation studies of the performance of passive systems (Items 5 and 7). It is also not clear that Item 3 is needed either, especially given its value and the reality that it is not feasible to identify all intrusion points to buildings. Item 1 should include evidence of intrusion of hazardous contaminants (not just non-hazardous contaminants). This table could probably be reduced to three items (current Item 1 combined with Item 2, a combined Item 6 and Item 8, Item 9)	
Johnson	1.b					There are ambiguities and potential issues with application of Table 5-13 (depth to contamination) and its associated discussion. In particular, it is not clear if the authors intended for contaminant concentrations to be below background or detection levels for all distances less than this depth, or if it is simply the depth to the closest detection above background or detection levels? These are two very different concepts and have different implications for use in a scoring system like this. For example, if the authors intended contaminant concentrations to be below background or detection levels for all distances between the foundation and this depth, then Table 5-13 is likely overly conservative. On the other hand, if the depth to be used is the depth to the closest detection above background or detection levels (independent as to whether or not there are non-detect/background-level samples until that point is encountered), then the table might not be sufficiently protective. For many sites, there may only be groundwater data available, and so people will be using depth to groundwater with Table 5-13. The vapor intrusion impact dependence on depth to groundwater has not been shown through field data or modeling to be as significant as suggested by this table (e.g., modeling would show that at most intrusion rates would be 10X less for a 200 ft depth than for a 20 ft depth for comparable groundwater concentrations and soils, and empirical data show little dependence on depth for the range of depths represented in the empirical data set). The following revisions are suggested: 1) Clarify the meaning of "depth to contamination". 2) If contaminant concentrations are supposed to be below background or detection levels for all distances less than this depth (unlikely to be verified with typical data used for ranking), then only two or three depth categories are justified and the value should be 0 for all depths greater than about 10 or 20 ft. 3) If it is the depth to the closest detection above background or detection levels, then Depth to Contamination Assigned Values should not decline as significantly with depth as happens in Table 5-13. It is justified to have a high value for cases with liquid intrusion or very shallow depths to groundwater, but depths to about 100 ft (most sites) should probably all have about the same value and depths greater than 100 ft (few sites) should probably have values that are within 50% of the <100 ft values. This is in part because there is a second important dimension not considered here in the factors – contaminant concentration. For example, a groundwater plume with a 20 ug/L concentration at 10 ft depth poses the same risk as a groundwater plume with a 200 ug/L concentration at a 100 ft depth and a groundwater plume with a 400 ug/L concentration at a 200 ft depth (all other factors being equal, and a non-biodegradable chemical).	
Johnson	1.c					The vertical migration factor should be presented as being related to "soil type" and not effective porosity/permeability as these quantities are irrelevant to the vapor intrusion pathway and only soil descriptions are used in Table 5-14 anyway. Categories 2 and 3 in Table 5-14 should be adjusted so that "silty loams; loesses; silty clays; sediments that are predominantly silts; moderately permeable till (fine-grained, unconsolidated till, or compact till with some fractures)" should be included in Table 2. EPA's own modeling in its pathway assessment guidance document (as well as other publications) and empirical data show little difference in behavior across this range of soil types. Depth creeps in as an overly-sensitive modifying factor in Table 5-15, compounding its use already in Table 5-13.	
Johnson	2					It is suggested that this be eliminated as a factor in assessing the relative risk of vapor intrusion, as hazardous waste quantity has little relevance to vapor intrusion impacts, except to the extent that it might impact the longevity of the contaminant vapor source. The proposed approach makes little sense and is not technically defensible. The mass of contaminant in the residence is irrelevant for this pathway; instead it is the duration of time that the vapor source will produce vapor concentrations of significance that is the relevant quantity. That in turn is related to source zone longevity (under natural or remediation conditions) and groundwater migration rates for dissolved plume sources. That is likely to be a very long time – probably decades for most sites evaluated by this process, unless source removal and or control are going to reduce the time frame to less than a decade. Source concentrations should be included somewhere in the analysis as discussed above.	

Commenter	Charge Question	Guidance Section	Page Number	Line Number		Comment	EPA Resolution
Johnson	3					It should be recognized that this approach is predicated on two assumptions, both of which have weaknesses: 1) It is assumed that areas of subsurface contamination have a 10X lower relative potential for impact than areas of observed contamination, and 2) Sub-slab soil gas samples are reliable indicators of vapor intrusion. With respect to (1), the preamble document contains the paragraph: "When an observed exposure has not been established, the EPA is proposing to evaluate the potential for exposure within structures located in the ASC within the subsurface intrusion component. Given that contamination within an ASC is documented as present below these structures, there is a potential that intrusion and exposure to the intrusion has occurred but that sampling has not been performed at the time the exposure was taking place. As explained in section XXXX of the Proposal TSD, the factors affecting when intrusion will occur and the rate of subsurface intrusion are extremely time-, site- and climatic-specific. Sampling may not have been performed in these structures, or, even if performed during the limited time period of a site inspection, the sampling may have been during conditions that the intrusion was not occurring or occurring at levels not detectable or differentiable from background sources of the contaminant. Site inspections are conducted over a limited period (usually 1 to 3 days). Therefore it is important that the potential for exposure be included as a consideration when evaluating subsurface intrusion threats." This paragraph reasonably captures the current state of the practice – namely that conventional point in time and point in space sampling (e.g., Summa canisters) has been shown to be inadequate for confidently assessing the presence or absence of vapor intrusion. In addition, empirical data have shown unacceptable and highly variable indoor air impacts at chlorinated solvent sites with groundwater concentrations as low as 10 ug/L, with no clear dependence on groundwater concentration, soil type, or depth. Thus, the reality is that we are unable to confidently identify a priori whether homes are expected to be impacted, and which homes are likely to be the most impacted above a dissolved groundwater plume. This proposed approach seems to ignore this. There is no basis for assigning lower risks to areas of subsurface contamination having similar subsurface conditions as nearby areas of observed impacts simply because impacts have not been observed. It is arguably more appropriate to assume that the potential for exposure is the same in all areas having similar conditions, unless there has been extensive data collection to prove otherwise. The other factors discussed above already reflect differences in potential for impacts based on soil type and depth.	
Johnson	3 (con't)					USEPA's database (raw data – not the alpha factor analysis) should be reviewed carefully in dealing with the issue of relative risk of observed areas of exposure vs. areas of subsurface contamination. For example, the figure below is from this database, and to it has been added lines and text by P.C. Johnson (2011, presentations) to point out that indoor air concentrations of concern have been observed across the full concentration range of interest for chlorinated solvent sites: [*See graph included in pdf version of response to charge questions*] With respect to (2), the approach ignores the debate and recent technical advances regarding the utility of sub-slab soil gas samples for pathway assessment. It has been shown at a field study site in Utah that indoor air sources can cause sub-slab contaminant vapor plumes; thus, the nearly 1:1 correlation between indoor air and sub-slab soil gas detections is not validation that sub-slab samples are good indicators of vapor intrusion as stated above (as 1:1 correlation would occur with indoor sources as well). There are also field study results showing temporal and spatial variability in sub-slab soil gas samples and experience that sub-slab sampling may not even have been done for pathway assessment by the time that HRS calculations are being done.	
Johnson	4					It is not clear why possible exposures in the lowest floors (closest to the vapor source) would ever be discounted? Otherwise, I have no comments on this approach as I have little experience with impacts in multi-story buildings to draw from at this point in time. It is difficult to imagine many scenarios where this issue will be a determining factor in HRS calculations.	
Johnson	5					This seems to be a comparison of apples and oranges (indoor vapor inhalation vs. outdoor soil exposure), so assuming some fixed correlation between the two would be inappropriate. It might be reasonable to assume that worker inhalation risks would be less than those of residents in homes in similar conditions because of differences in exposure durations. The type of work might affect both the building ventilation and worker breathing rates, so indoor concentration rates might be lower and inhalation higher in more industrial settings vs. office and residential settings.	

Commenter	Charge Question	Guidance Section	Page Number	Line Number		Comment	EPA Resolution
Johnson		1.1	4	37		Need to add a manmade example to the list – perhaps “utility conduit”?	
Johnson		1.1	4	37-38		How is this different from “preferential subsurface intrusion pathways” given below?	
Johnson		2.1	10	8		[Referring to "Soil Exposure and Subsurface Intrusion"]: Might be better to make this the fourth bullet item so that the three “migration” pathways are listed sequentially.	
Johnson		2.1	10	17		It’s not clear that this is true if you define the subsurface intrusion pathway to include both vapor and liquid intrusion as the threat from the former is vapor inhalation while the threat from the latter might include direct contact as well as inhalation. Subsurface intrusion threats might also include explosions.	
Johnson		2.1.3	10	40		[Referring to "...or observed exposure..."]: Should be either “and any verified areas of exposure” or “and areas of observed exposure”. “or” seems not appropriate here as you will always have areas of observed contamination. Areas of observed contamination are defined in §2.3, the terminology in §5.2 is “area of subsurface contamination”	
Johnson		2.1.3	12	16		As “migration pathways” is used as terminology throughout the document, it is suggested that the term be included in the Definitions section.	
Johnson		2.2	12	32		[Referring to "...areas of **observed** contamination or observed exposure…"]: Should be “subsurface” to be consistent with terminology for the subsurface intrusion pathway?	
Johnson		2.2	12	32		[Referring to "...areas of observed contamination **or** observed exposure…"]: Should be “and areas of observed exposure”?	
Johnson		2.2	12	33		[Referring to "...areas of **observed** contamination or observed exposure…"]: Should be “subsurface” to be consistent with terminology for the subsurface intrusion pathway?	
Johnson		2.2	12	33		“areas of observed contamination” not a term defined in Definitions – “areas of subsurface contamination” is defined.	
Johnson		2.2	12	33		[Referring to "...areas of observed contamination **or** observed exposure…"]:Should be “and areas of observed exposure”?	
Johnson		2.2.1	12	39		I suspect that people will get confused by “migration pathway” terminology – so you might consider being more explicit on the forms like Table 2-2 and include additional headings that clearly group air, groundwater, and surface water together as migration pathways separate from the subsurface intrusion pathway.	
Johnson		2.2.1	12	41		[Referring to "...areas of **observed** contamination or observed exposure…"]: Should be “areas of subsurface contamination” to be consistent with terminology for the subsurface intrusion pathway?	
Johnson		2.2.1	12	45	Table 2-2	Should this also include area of observed exposure? Also, it’s not clear what should be entered in the boxes in table 2-2?	
Johnson		2.2.2	13	12		[Regarding "area of observed contamination"]: Needs to be defined in Definitions.	
Johnson		2.2.2	13	18		[Regarding "observed contamination"]: See comment above concerning “observed contamination”	
Johnson		2.2.3	14	31		[Regarding "observed contamination"]: This terminology is not used in §5.2	
Johnson		2.3	15	1	Table 2-3	Should be “Observed Release and Observed Contamination Criteria”? to be consistent with lines 37-38?	
Johnson		2.3	15	1	Table 2-3 [bulleted text]	I’m not sure if these criteria are useful for the vapor intrusion pathway. First, it is not clear what kinds of samples this applies to (indoor air, soil gas, groundwater?) and second it does not include consideration of indoor air sources. Finally, for vapor intrusion indoor air data sets, the SQL, background level, target acceptable breathing concentrations, and indoor air concentrations are often with about 10X of each other. You might consider limiting the analysis to only groundwater and soil gas data (and not indoor air data) for this part of the evaluation. That will eliminate some of my concerns. What do you do when you have conflicting lines of evidence (e.g., indications of groundwater impacts but no soil gas detections?)	
Johnson		2.4.1.1	15	30		[Referring to "**a** inhalation risk"]: [Should "a" be changed to]: “an”?	
Johnson		2.4.1.2	18	34		[Referring to the word "or"]: “and” more appropriate here?	
Johnson		2.4.1.2	18	34		[Referring to "underlying"]: “from substances underlying”?	
Johnson		2.4.2	18	38		[Referring to "...area of observed contamination or observed exposure…"]: Should be “area of observed contamination, subsurface contamination, or observed exposure”?	
Johnson		2.4.2	18	51		[Referring to "observed contamination"]: Should be “subsurface contamination” here?	
Johnson		2.4.2	18	51		[Referring to "...observed contamination or observed exposure…"]: Should be “area of observed contamination, subsurface contamination, or observed exposure”?	
Johnson		2.4.2	18	52		Do we have a criterion for “observed exposure”?	

Commenter	Charge Question	Guidance Section	Page Number	Line Number		Comment	EPA Resolution
Johnson		2.4.2	18-19	50-53, 1		This sentence makes my head hurt real bad [smiley face] Might be best to break it up into bulleted items to improve clarity… Also, make sure that the terminology is being used correctly. As they are introduced originally in the text, “Observed contamination” seems to refer to a determination as to whether or not chemicals are present at levels of significance, while areas of subsurface contamination and exposure are delineated areas. Thus, use of the term “area of observed contamination” confuses me…	
Johnson		2.4.2.1	19	13-14		What do you do in the situation where many homes overlie a single large dissolved chlorinated plume?	
Johnson		2.4.2.1.1	20	3-4		Why only the area of observed exposure, given the caveats concerning the difficulty in identifying actual exposures for this pathway?	
Johnson		2.4.2.1.1	20	6		[Regarding "or area of observed contamination or observed exposure"]: Should be “area of observed contamination, subsurface contamination, or observed exposure”?	
Johnson		2.4.2.1.1	20	8		[Regarding "area of observed contamination or observed exposure"]: Should be “area of observed contamination, subsurface contamination, or observed exposure”?	
Johnson		2.4.2.1.1	20	10		[Regarding "area of observed contamination or observed exposure"]: Should be “area of observed contamination, subsurface contamination, or observed exposure”?	
Johnson		2.4.2.1.2	21	1-2		[Regarding "area of observed contamination or observed exposure"]: Should be “area of observed contamination, subsurface contamination, or observed exposure”?	
Johnson		2.4.2.1.2	21	4		[Regarding "area of observed contamination or observed exposure"]: Should be “area of observed contamination, subsurface contamination, or observed exposure”?	
Johnson		2.4.2.1.2	21	15-16		Why only the area of observed exposure, given the caveats concerning the difficulty in identifying actual exposures for this pathway?	
Johnson		2.4.2.1.3	21	33		[Regarding "area of observed contamination or observed exposure"]: Should be “area of observed contamination, subsurface contamination, or observed exposure”?	
Johnson		2.4.2.1.3	21	43		Why only the area of observed exposure, given the caveats concerning the difficulty in identifying actual exposures for this pathway?	
Johnson		2.4.2.1.3	21	45		[Regarding "area of observed contamination or observed exposure"]: Should be “area of observed contamination, subsurface contamination, or observed exposure”?	
Johnson		2.4.2.1.3	21	48		[Regarding "area of observed contamination or observed exposure"]: Should be “area of observed contamination, subsurface contamination, or observed exposure”?	
Johnson		2.4.2.1.4	22	1-2		[Regarding "area of observed contamination or observed exposure"]: Should be “area of observed contamination, subsurface contamination, or observed exposure”?	
Johnson		2.4.2.1.4	22	11		Why only the area of observed exposure, given the caveats concerning the difficulty in identifying actual exposures for this pathway?	
Johnson		2.4.2.1.5	22	15		[Regarding "area of observed contamination or observed exposure"]: Should be “area of observed contamination, subsurface contamination, or observed exposure”?	
Johnson		2.4.2.2	23	12		[Regarding "observed contamination"]: “observed” or “subsurface” contamination?	
Johnson		2.4.2.2	23	14		[Regarding "observed contamination"]: “observed” or “subsurface” contamination?	
Johnson		2.4.2.2	23	18		Why only the area of observed exposure, given the caveats concerning the difficulty in identifying actual exposures for this pathway?	
Johnson		2.4.2.2	23	20		Why only the area of observed exposure, given the caveats concerning the difficulty in identifying actual exposures for this pathway?	
Johnson		2.4.2.2	23	36-38		This assumes that sub-slab samples are reliable indicators of vapor intrusion potential, and there is debate concerning that given their potential to be influenced by indoor air sources and the potential for significant spatial heterogeneity.	
Johnson		5.2.0	44	31-37		What do you do if you have conflicting lines of evidence (e.g., groundwater impact but no soil gas impact)? Conflicting lines of evidence is a common condition for vapor intrusion assessments.	
Johnson		5.2.0	44	39-40		You should probably also mention that unacceptable indoor air impacts have been observed at sites with fine-grained soils and dissolved concentrations in the 10’s of ug/L range to help put this issue in perspective.	
Johnson		5.2.1.1	45	1		Empirical and modeling data for indoor concentrations at chlorinated solvent sites do not show significant or clear dependences on structure type, depth, soil type, or groundwater concentration, etc.. (the factors considered here). They most significant factor seems to be contaminant type. This is contradictory to the implicit underlying assumptions that this section is based on.	
Johnson		5.2.1.1.1	45	21-23		Not clear why this is a bullet item under a statement specific to indoor air samples?	
Johnson		5.2.1.1.2	45	32-33		Need some statement here explaining that the vapor intrusion pathway is difficult to observe using conventional measurements, and therefore the potential must be looked at closely and weighted higher than for a pathway where it is easier to confidently document non-exposure. There is some good text in the Preamble on this topic.	

Commenter	Charge Question	Guidance Section	Page Number	Line Number		Comment	EPA Resolution
Johnson		5.2.1.1.2.1	45	37-39		I'm not familiar with any studies showing the effectiveness of passive systems, and am therefore uncomfortable with the assumption that they reduce the potential for exposure (Item 5) Also EPA's empirical database does not show any significant impact of foundation type on indoor impacts, so there is little basis for Item 4.	
Johnson		5.2.1.1.2.2	46	2-3		What if you only have groundwater data and no soil gas data? This would lead to deeper depths.	
Johnson		5.2.1.1.2.2	46	13	Table 5-13	This table assumes a significant reduction in exposure potential in moving to >20 ft BGS. For many sites, there may only be groundwater data available, and so people will be using depth to groundwater with Table 5-13. The vapor intrusion impact dependence on depth to groundwater has not been shown to be as significant as suggested by this table in either empirical data or modeling. Depth probably should probably not even be a significant modifying factor for this pathway, unless it is required that both groundwater and soil gas data be collected. Suggest changing to the following: - structures with intrusion of contaminated liquids probably should be prioritized above others that do not. - Depths to at least about 50 ft should probably all be assigned the same value	
Johnson		5.2.1.1.2.3	46	26		[Regarding "effective porosity/permeability"]: Suggest removing this terminology and just refer to "soil type" in this section. There is no need to mention effective porosity or permeability when discussing vapor intrusion, as these are irrelevant quantities.	
Johnson		5.2.1.1.2.3	47	4	Table 5-14	See comment above [[Regarding "effective porosity/permeability"]: Suggest removing this terminology and just refer to "soil type" in this section. There is no need to mention effective porosity or permeability when discussing vapor intrusion, as these are irrelevant quantities.]	
Johnson		5.2.1.1.2.3	47	4	Table 5-14	[Regarding "Assigned Porosity/Permeability Value"]: See comment above. Just call this "soil type factor" or something simple like that.	
Johnson		5.2.1.1.2.3	47	4	Table 5-14	[Regarding "...silty loams; loesses; silty clays; sediments that are predominantly silts; moderately permeable till (fine-grained, unconsolidated till, or compact till with some fractures)…"]: These materials should be in the second category – the empirical data and modeling do not support any significant difference in vapor intrusion impacts for these materials in comparison with sandy silts, etc.	
Johnson		5.2.1.1.2.3	47	6	Table 5-15	[Regarding "Lowest Porosity"]: Need to change…	
Johnson		5.2.1.1.2.4	48	9	Table 5-16	This approach assumes that there are no combinations of low volatility and high toxicity of concern. Has that been verified (e.g., pesticides, PNA's, etc.)?	
Johnson		5.2.1.1.2.4	48	14	Table 5-18	[Regarding "Average of Vapor Migration Potential Values for Three Hazardous Substances"]: ?? Why do this?	
Johnson		5.2.1.1.2.5	48	18-19		[Regarding "factor value for containment"]: What is this? Is it the structure containment value?	
Johnson		5.2.1.2.2	49	10		[Regarding "Hazardous waste quantity"]: It is not clear that this quantity has any relevance to assessing the significance or relative risk of this pathway? Why is it even considered?	
Johnson		5.2.1.2.2	49	37		Why only areas of observed exposure?	
Johnson		5.2.1.2.2	50	18-20		See comments above concerning the use of sub-slab samples.	
Johnson		5.2.1.3.2.3	52	6-7		See comments above concerning sub-slab and crawlspace samples.	
Johnson		5.2.1.3.2.3	52	10-13		This assumes a higher confidence in sub-slab samples than in groundwater samples.	
Larsen	1.a					**Potential for Exposure Equation** I agree generally with the mathematical set up of the equation (2a*(2b+2c+2d) and the decision to make the potential for exposure a product (in the mathematical sense) of a building's characteristics and the subsurface conditions that lay beneath it. It mimics the two compartment model that many professionals and researchers conceptualize the vapor intrusion pathway to be. Furthermore, I believe it accurately replicates the "breaking" of the pathway by assigning a value of 0 to structures that employ demonstrated effective vapor control measures. Overall, the term for the structure (a) ranges from 0-10 while the subsurface term (the sum of b+c+d) ranges from 1-50. Ideally the subsurface term should range as low as zero to reflect the absence of vapor intrusion risks associated with high molecular weight semi-volatile compounds like cPAHs, PCBs, and most pesticides. Thus, either term could have a zero value and the exposure pathway would then be considered broken or incomplete under two conditions: 1) in cases where a demonstrated effective vapor control technology is used, and 2) when a contaminant has sufficiently low volatility. Mathematically, this could be accomplished by multiplying the Depth to Contamination (b) and Vertical Migration (c) terms by the Vapor Migration Potential (d) term. Thus a zero Vapor Migration Potential value would yield a zero for the entire Potential for Exposure factor. If the equation is changed in this way, the range in values for the Depth to Contamination and Vertical Migration terms would likely have to be adjusted so that Potential for Exposure results fall into the intended range of values (0-500).	

Commenter	Charge Question	Guidance Section	Page Number	Line Number		Comment	EPA Resolution
Larsen	1.a				Table 5-12	**Table 5-12 Structure Containment** I suggest revisions to Table 5-12 with respect to the number of building types distinguished, their description, and their value assignments. • There does not appear to be a category that describes maybe the commonly encountered type of residence: a slab-on-grade constructed home with no apparent open preferential pathways or vapor migration barrier system. This is a significant omission that I believe will lead to confusion in categorizing structures. On the scale of 1-10 that is used for this factor I would assign this category of building a value of 9. It is vulnerable to vapor intrusion, but it is not the most vulnerable of residential structures. • Homes that are underlain by a combination of basement and crawl space, and which do not have any form of vapor mitigation system, should be described as such and placed in Category 2. This is a common type of residential construction and it would be an omission to leave it out of Table 5-12. With this type of building there usually is a 4-5 ft high stem wall that separates the crawl space from the basement and generally there is no seal or a very poor seal between the crawl space and basement areas. This allows vapors to freely migrate into the basement and living spaces making these homes some of the most sensitive and vulnerable with respect to vapor intrusion. This type of structure should be assigned a value of 10 in Table 5-12. • In my experience, residences that are completely underlain by vented crawl spaces generally have fairly small attenuation factors and their vulnerability to vapor intrusion is considerably less than other building types. This was observed at a chlorinated solvent release at the Eugene Rail Yards site in Eugene, Oregon. At this site, crawl space concentration showed a broad range of attenuation factors and a poor correlation to soil gas values. It appeared crawl space concentrations were most influenced by background and insignificantly by soil gas that spanned a range of PCE concentrations. Based on my experience I would assign a value of 6 rather than 8 to this type of construction. However, I acknowledge that nationally there may be regional/climatic differences that affect the degree of communication between the crawl space and the overlying building and justify the value of 8. • Evidence of biogas, inert gases. Is this referring to methane and radon? Typically this type of information is not available for relatively short inspections.	
Larsen	1.b					At the depths beyond the 0-10 ft range presented in Table 5-13 chemical diffusion is generally considered to be the dominant transport mechanism. Diffusion and diffusive flux is typically described using Fick's Law J= -D(dc/dz). Using Fick's Law and assuming 100 ug/m3 at the source and zero in indoor air, concentration gradients as a function of depth are plotted below. *[See Graph in PDF of Henning's Response to Charge Questions]* Using this approach and assuming a Depth to Contamination value of 10 for a source 10 ft below the occupied base of a structure, 20 ft would then have a value of 5, 50 feet would have a value of 2, 100 ft a value of 1 and 150 ft of 0.66. Since this term is evaluating the strength of diffusive flux in the subsurface and not attempting to consider geologic heterogeneity, the values should be based on Fick's Law of diffusion which has been empirically demonstrated to be accurate in numerous column tests of porous media; this is unless there is sufficient empirical field data that supports the numerical assignments in Table 5-13. **Considering Depth to Groundwater Contamination and Depth to Soil Vapor Contamination Equivalently** An important concern in the assignment of Depth to Contamination values under section 5.2.11.2.2 is the approach treats groundwater and soil gas as equivalent media and at any given site there depths are presumably comparable. However, it isn't an either or situation, if there is a groundwater plume of contamination at the water table, there will be corresponding soil gas contamination above it and by definition the soil gas will always be shallower than the groundwater contamination. Depending on where the soil gas measurement is taken it could be 20, 30, 50 ft or more shallower than the depth the groundwater contamination is measured at. Thus, the depth to contamination that is entered into this table may in large part be a consequence of which media was sampled and not the actual site conditions. I ran one of our bigger vapor intrusion sites (Tarr Oil, Portland, OR) through the Potential for Exposure calculation and it scored a 380 based on the initial groundwater data, and a 500 based on soil gas data. The location of the measurement also affects assignment of the Vapor Migration Potential value. The depth of measurement and choice of media to sample potentially introduces a bias that should ideally be eliminated from the calculations.	

Commenter	Charge Question	Guidance Section	Page Number	Line Number		Comment	EPA Resolution
Larsen	1.c					**Assignment of Vertical Migration Factor Values** Vertical migration values for soils assigned a porosity/permeability value of 4 (clays, low permeability till, unfractured igneous rocks etc.) appear to be excessively high when compared to the values of other soils and thicknesses in Table 5-15 and relative to values assigned to the Depth to Contamination factor. True clays and unfractured igneous rocks have extremely low effective porosities and if they have any appreciable thickness should act as a virtually complete barrier to vapor transport. The only exception would be if the clays were or had been desiccated leaving fractures for preferential flow. It is difficult to say the 0-5 ft thickness value of 15 for soils assigned a porosity/permeability value of 4 is disproportionately high given the thickness ranges down to zero. However, I suggest revising the value for the 5-10 ft thickness to 8 rather 12, and the 10-20 ft thickness range 6 rather than 9 and the 20-50 ft range to 3 rather than 6 and the 50-100 ft and 100-150 ft ranges both should be 1. I cannot think of a more restrictive barrier to vapor transport than 50-100 ft of true clay. The values in Table 5-15 applied to soils assigned a permeability/porosity value of 1-3 appear appropriate. Although not discussed, effective porosity for gas transport (diffusion rates through water-filled pore spaces are generally 100,000x or more lower than through air-filled) is highly sensitive to moisture content in the soil and I assume this consideration is embedded in the values of Table 5-15. Finer-grained soils typically retain a higher moisture content that further reduces effective porosity. This degree to which soils are saturated is largely a consequence of annual precipitation rates and their seasonal distribution. Therefore, for identical soils it's anticipated that there would be regional differences in the vertical migration factor. Ideally the moisture content factor would be considered in the scoring, however, there may be insufficient information to confidently develop values.	
Larsen	2					I disagree with the proposed approach to calculating hazardous waste quantities for the subsurface intrusion component. Compared to soil and water, air is a much less dense medium and as a consequence, for equivalent risk levels between various media, it typically contains much less contaminant mass. Essentially airborne contaminants can generate equivalent human health risks to those resulting from contact with other media, although with far less mass. For example, the State of Oregon assumes benzo(k)anthene has an oral slope factor of 0.073 and has calculated a residential soil screening level of 6.2 mg/kg (equating to 1x10-6 risk). Assuming a 5000 ft2 property that is 70% land 30% impervious surface, a 1 foot thick layer of soil contaminated up to the screening level would contain approximately 1,190 grams of benzo(k)fluoranthene. In comparison, a 1300 ft2 residence with vinyl chloride (inhalation slope factor of 0.031) contamination at a concentration 0.14 ug/m3 (equivalent to 1x10-6 risk) has 0.000047 grams in the indoor air at any one time. Assuming an air exchange rate of 6 exchanges/day, approximately 3.1 grams would have moved through the home over a 30 year period of time. Assuming an identical toxicity and slope factor to that of benzo(k)fluoranthene, the mass of vinyl chloride in the air over the 30 year period is 6.3 grams for the equivalent risk. Humans contact and take up air contaminants much more efficiently than contaminants in water or soil, therefore, it requires far less mass for equivalent risk. Using Table 2-6 (pg. 22) and the methods outlined in 5.2.1.2.2 to assign a Hazardous Waste Quantity Factor value, it is likely most vapor intrusion sites would get a quantity of 1 unless an exposure is documented then it defaults to 100. It appears very unlikely any VI site would have hazardous quantity factor larger than 100. This results in relatively low Waste Characteristic Factor values compared to what can calculated for other media and pathways. In this respect it appears to underestimate the risk of the subsurface intrusion pathway relative to others. **Suggested Alternative Proposed HRS Method of Estimating Hazardous Waste Quantity** Quantify and include contaminant sources in the subsurface in addition to the contamination found within the buildings. These sources constantly feed the contamination within the buildings and so could be legitimately included in the inventory of waste quantities. For this particular factor, the change would make the magnitude/mass of sources of vapor intrusion more comparable to those contaminating other media.	

Commenter	Charge Question	Guidance Section	Page Number	Line Number		Comment	EPA Resolution
Larsen	3					An obvious answer to the Charge Question #3 is: yes, in general occupants of buildings where sub-slab concentrations exceed 10x a health-based benchmark are at higher risk relative to occupants of buildings with sub-slab concentrations that are less than this value. However, the scheme for weighting individual targets/receptors is crude in the ASC, does not appear consistent with the results of EPA's compilation of paired sub-slab and indoor data, and potentially underestimates population risks. As described in sections xxxx of the draft HRS rule revisions, for targets/receptors occupying buildings over an ASC and where subslab contaminant concentrations exceed 10x the benchmark screening level should assigned a weighting of 0.75. The explanation given is that the review of the compiled paired data indicate 80% of the time a subslab concentration exceeds 10x its respective health based benchmark, the contaminant is detected in indoor air. • Why wasn't a value of 0.8 used instead 0.75 since the correlation described above was observed 80% of the time? • 0.75 is used in all where a subslab VOC concentration greater than 10x its corresponding health-based benchmark has been observed within the ASC. However, subslab VOC concentrations at many sites are routinely observed at levels from 100-100,000 times their corresponding benchmarks. Yet in the proposed HRS scheme for weighting targets, irrespective of the concentration observed, any time it exceeds 10x the benchmark a value of 0.75 is used. Using a single value (such as 0.75) may be reasonable for weighting receptors when subslab levels are just 1-2 orders of magnitude above benchmark values, and indoor concentrations are likely detectable but below benchmark values. However, as subslab contaminant levels increase, eventually a concentration threshold is crossed where the results of EPA data compilation indicate the probability of exceeding a benchmark value in indoor air is very high. For these cases assigning a weighting factor that is closer to10 is more appropriate.	
Larsen	3 (con't)					The proposed target weighting approach may introduce a low bias to population risks, particularly at sites where the primary medium sampled is subslab and not indoor air. soil gas and not • It is not clear from the rule revision whether the appropriate weighting for targets within the ASC is based on the maximum observed subslab concentration or whether some form of average value is considered (i.e. arithmetic mean, UCL, etc.) My recommendation, since this is a screening process, would be to use the maximum subslab concentration observed, and that this expectation should be specified in the rule if it isn't already. • The EPA database on paired subslab and indoor air data has been reviewed by many states and individual practitioners. Statistics have been performed on both filtered and unfiltered data. The filtering was done in an effort to eliminate the influence of ambient background concentration on calculated attenuation factors. EPA has recognized the need to perform the data filtering to remove outlier attenuation rates. A strategy that Oregon DEQ used in an attempt to separate out background influences was to only consider data from sites with strong sources, for examples sites with subslab concentrations greater than 1000 ug/m3. The results of the data analysis indicate unfiltered paired subslab-indoor air data had an average attenuation factor of 0.003 and median value of approximately 0.002. An analysis of highly filtered similar to data by ODEQ produced an average attenuation factor of 0.0007 and a median value of 0.0002. Thus the statement that approximately half of the vapor intrusion sites had an average attenuation factor of 0.1 is not supported by EPA previous analysis of VI data. [*See pdf of charge questions response for three graphs*]	
Larsen	3 (con't)					**Recommendation** Based on: statistical analyses of the EPA Database, and the recognition that it does not necessarily populated by the most sensitive structure types, I recommend that within defined ASCs assign a target weight factor of: • 0.1 to occupants of buildings with subslab contaminant concentrations less than 50x the health-based benchmark value. • 1 to occupants of buildings with subslab contaminant concentrations between 50x-500x the health-based benchmark value. • 10 to occupants of buildings with subslab contaminant concentrations greater than 500x the health-based benchmark value	
Larsen	4				Figue 3	[Referring to graphic of second building from left]: In this contaminant distribution, I would assume all basement residences are Level I due to error and uncertainty from temporal variability of indoor air quality	
Larsen	4				Figure 3	[Referring to graphic of third building from left]: In the above scenario, if level I and level II exposures are observed on the first floor I would assign level I values to the basement dwellings also. They are overwhelming the most sensitive locations and having a reverse gradient scenario as depicted, where higher concentrations overlie lower concentrations would be very unusual for a VI site. A more likely explanation for this type of observed distribution would be simply being temporal variability in indoor air levels.	

Commenter	Charge Question	Guidance Section	Page Number	Line Number		Comment	EPA Resolution
Larsen	4				Figure 3	[Referring to graphic of far right building]: I would weight the occupants of the first floor based on the concentration observed in the basement. These residences and their occupants may be under weighted just because of the absence of direct observations – to remedy this use the EPA database to make educated inferences of exposure levels	
Larsen	4					**Regarding the Calculation of Waste Quantity** See comments and responses to Charge Question #2 **Regarding Assumptions and Weighting of Occupants/Targets in Multi-Family Residences** Some comments are made directly on the Figure 3 – see boxed text. Aside from those suggested modifications, the general scheme looks appropriate. **Regarding the Weighting of Population Targets in AOE** In my opinion the weighting is disproportionately influenced by data type – specifically the difference in weighting directly observed impacts as compared to inferred impacts based on subslab sampling. Whereas an individual or population directly observed (through indoor air sampling) to be exposed to levels above the health-based benchmark is indoor exposure directly observed to be over a benchmark is assigned The weighting of targets/receptors exposed to Level 1 contamination 10x higher than those exposed to Level II concentrations by a factor of 10, coupled with the recognized temporal variability in indoor air concentrations (See Paul Johnson's recent work at Hill Air Force Base, Arizona) could produce significant swings in the population score that are more artifacts of when the sampling occurred than true differences in the magnitude of the average VOC exposure. The concern regarding accurately characterizing indoor exposure levels is particularly relevant if site inspections are conducted and indoor air concentrations measured, within a short 2-3 day period. **Potential Ways to Mitigate Errors and Uncertainties** Two ways to mitigate this uncertainty and potential error is to characterize exposure levels using ambient air sampling methods that accommodate long sampling periods, or alternatively increase the number of (shorter period) air samples that target meteorological conditions particularly conducive to vapor intrusion. In short, use sampling technologies are approaches that provide better representations of long term exposure levels. A different approach would be to apply a scheme that has more than two designations for confirmed exposure levels. Perhaps the value 1 for detected/observed exposures that are <0.5x the benchmark health value, a value of 3 for values 0.5 -1.0 x the benchmark value, and 10 for those occupying buildings with exposures greater than the benchmark value.	

Commenter	Charge Question	Guidance Section	Page Number	Line Number		Comment	EPA Resolution
Larsen	4 (con't)					**Weighting of Population Targets in ASC** In the proposed approach for weighting target populations within the ASC it appears there is a disproportionate undervaluing of susbslab data relative to indoor data. Under the proposed scheme, subslab concentrations greater than 10x the health-based benchmark value would weighted with a factor of 0.75 (weighted slightly less than a level II exposure) irrespective of the specific concentration measured. EPA compiled a large database that provides opportunities for robust statistical analyses including the derivation of attenuation rate percentiles and confidence intervals. This information should be used to help appropriately weight targets where only subslab data is available. For example, using unfiltered statistics the 50th percentile attenuation factor is 0.03, thus it can be concluded that if subslab levels exceed benchmarks by a factor of 33 or greater then there is 50% chance occupants are being exposed to levels above the corresponding health-based criteria and that the appropriate weighting is 10 rather than 0.75. In section 5.2.1.3.2.3, the proposed rule indicates subslab data and crawlspace data will be similarly evaluated and weighted. The implies the data types are equivalent, however, EPA and others have generally assumed the attenuation factor between the crawl space and the residence interior should be assumed 1and thus is a reasonable surrogate for actual indoor air data. So, this would suggest detection of COCs below benchmark values in the crawl space should be weighted under the proposed scheme at a value of 1 and that if concentration exceeds benchmark values in the crawl space the appropriate weighting would be 10. In general there appears to be a undervaluing of susbslab data, even when that is the only type of data available. However, susbslab data may be the primary type of data available at a site and the population component of the scoring may be biased low as consequence. Thus, at any given site, the scored risk may be substantially lower if the primary data source is subslab measurements than compared to the same site if the primary source of data was indoor measurements. **Recommendation** Use EPAs database of paired subslab and indoor air data to perform more refined weighting of targets in an ASC. Ideally, the weighting would relate to the probability a Level I or Level II exposure is occurring based on subslab data. **Additional Comment** The example scenario described in the Charge Question #4 is highly unusual contamination found on 5th floor consider tenants on 4th and 6th floors. Under this scenario I would expect all floors beneath the 4th floor to be considered and actually most of them contaminated. Overall, it's an unrealistic scenario and the actual proposed rule indicates all floors beneath the observed exposure would be considered in the calculations, as they should be.	
Larsen	5					I agree with the proposed weighting for workers. Generally, workers do spend more time indoors and that this pathway is more likely to be complete.	
Larsen		1.1	7	2		It seems, the question of non-occupancy should consider how long a residence has been vacant. To indicate the probability it will be occupied again.	
Larsen		1.1	8	21		Might consider discussing effective air-filled porosity since this is the actual porosity that counts.	
		1.1	8	31		I would add a definition of crawl space type construction and crawl space sample.	
Larsen		2.1.1	10	27	Equation	I agree with the form of the equation and how vapor intrusion pathway was incorporated. It allows the soil exposure or VI component to drive risk. They typically will be different substances driving the two pathway components.	
Larsen		2.4.1.1	16	18	Table 2-4	[Referring to "0.0001 ≤ RfC < 0.006"]: Factor of 60 difference	
Larsen		2.4.1.1	16	18	Table 2-4	[Referring to "0.006 ≤ RfC < 0.2"]: Factor of 33 difference	
Larsen		2.4.1.1	16	18	Table 2-4	[Referring to "0.2 ≤ RfC < 2.0"]: Factor of 10 difference	
Larsen		2.4.1.1	16	18	Table 2-4	[Referring to "0"]: Changes in RFC are directly proportional to benchmark values and calculated risk. Yet the RFC does not increase consistently (order of magnitude) the way the assigned values do. I do not see the justification for abandoning the order of magnitude approach as was previously used.	
Larsen		2.4.1.2	18	35		Within large chlorinated solvent plumes, risk drivers can change depending on location. Thus to capture true risk you may not focus on only one substance. This should be accounted for in the general approach.	
Larsen		2.4.2.2	23	21		As indicated in my responses to the charge questions, these calculations should consider the quantity of contaminant in the subsurface as well as in buildings. This would make better comparisons to hazardous waste quantities in other media and also account for the uniqueness of the indoor air pathway with respect to waste quantity.	
Larsen		5.2.1.1.2.1	45	40	Table 5-12	[Referring to "Evidence of intrusion by biogas, inert gases or other non-hazardous substances, pollutants or contaminants"]: Does not represent a circumstance I typically come across or information that is not typically gathered.	

Commenter	Charge Question	Guidance Section	Page Number	Line Number		Comment	EPA Resolution
Larsen		5.2.1.1.2.1	45	40	Table 5-12	[Referring to "Existence of maintained vapor migration barrier system but not addressing all preferential pathways"]: Typical home struction often falls somewhere between No. 2 and No.3 – there should be one or more categories added to represent fuller range of structures encountered.	
Larsen		5.2.1.1.2.2	46	11		Treating subslab and water media as equivalent make work for overall predictions of VI. But depending on what media has been sampled, the same site may score differently based on whether soil gas or only groundwater data was collected. I scored the same site using both sets of data and the scoring based on soil gas came out at 500, the same site scored 380 based on groundwater data.	
Larsen		5.2.1.1.2.2	46	13	Table 5-13 Last Row	[Referring to ">150ft 0"]: These values should mirror predicted changes in diffusive flux as predicted by Ficks Law – one-dimensional application.	
Larsen		5.2.1.1.2.3	46	20		Use the most sensitive structure.	
Larsen		5.2.1.1.2.3	47	4	Table 5-14	There is no consideration of moisture content and its affects on diffusive/advective flux. This would likely be better captured in regional differences related to climate. However, it is an important factor that does not appear in the scheme at all.	
Larsen		5.2.1.1.2.3	47	4	Table 5-14	True clays are unusual and are very effective barriers. They seem overvalued in Table 5-15.	
Larsen		5.2.1.1.2.4	48	14	Table 5-18	I don't understand why we average the transport potential of three substances then use only toxicity data from 1.	
Lofstrom/Klein	1					There is no provision for significant volatile organic chemical (VOC) concentrations detected in soil and/or surficial groundwater but without structures. Alternative: Provide default structure properties. The vertical migration factor ranking considers certain geologic factors and identifies karst, lava tubes, open fractures (5.2.1.1.2.2) as features that would allow channelized flow. Manmade preferential pathways such as utility corridors and sewer lines should be included in the HRS assessment, if identified in the site inspection. Alternative: Expand the definition of channelized flow to include most commonly encountered features and/or include that expanded list in the regulatory language (Perhaps as part of Table 5-15 Vertical Migration Factor Values).	
Lofstrom/Klein	2					The hazardous waste quantity ranking is based on the assumption that a structure or structures currently exist on the site being evaluated. If this is the case at the site being evaluated, the approach seems appropriate. But it is difficult to imagine that the sampling necessary to carry this approach out can be accomplished within a 1 -2 day site inspection. Soil gas/groundwater sampling should be done prior to indoor air sampling in order to identify those substances to be analyzed for in indoor air (substances associated with subsurface contamination). However, the approach does not allow for the determination of the hazardous waste quantity in the absence of structures but where significant hazardous substance (VOC) contamination exists in soil/groundwater where structures could or will be constructed. Alternative: Provide a simple approach for estimating indoor air concentrations from measured environmental media concentrations (soil gas, groundwater) using default attenuation factors and parameters for a default structure. Provide default volume values (a default area value is provided (Table 5-19)). I could not find in the proposed regulations explicit direction on "where no home is subject to actual contamination".	
Lofstrom/Klein	3					This approach is consistent with the California Department of Toxic Substances Control (DTSC) vapor intrusion guidance.	
Lofstrom/Klein	4					This is a reasonably conservative approach. However, there is much uncertainty surrounding the stated assumptions. Therefore, there should be an in-depth discussion of this approach in the proposal Technical Support Document with references to support it.	
Lofstrom/Klein	5					Assuming a relative risk of three times greater for indoor workers vs. outdoor workers for volatile organic chemicals (VOCs) may be an underestimate, since indoor workers would be exposed to contaminated air in a limited volume over much of their work day; whereas, contamination in outdoor air is not constrained in a limited space but is immediately diluted by atmospheric air. Other direct exposure pathways (incidental soil ingestion; dermal contact) contribute very little to uptake/intake because of the volatile nature of the chemicals under discussion in the subsurface intrusion component. The proposal Technical Support Document should discuss and provide support for any factor chosen to reflect the greater relative risk for indoor workers.	
Lofstrom/Klein		1.1	6	16	Definitions	[The word 'agent']: Should be changed to 'hazardous substance' to be consistent with the language in the proposed regulations.	
Lofstrom/Klein		1.1	7	1	Definitions	[The word 'was']: should be 'were'.	
Lofstrom/Klein		1.1	7	34	Definitions	[The word 'toxicant']: Should be changed to 'substance' or 'hazardous substance'.	
Lofstrom/Klein		1.1	8	42	Definitions	[The word 'agent']: Change to 'hazardous substance'.	
Lofstrom/Klein		1.1	9	7	Definitions	[Regarding weight of evidence classification system] This classification scheme is no longer being used by the EPA	
Lofstrom/Klein		5.2.1	44	41		There should be a bullet addressing area of subsurface contamination not containing a structure(s).	
Lofstrom/Klein		5.2.1.1.1	45	14		[Regarding word 'by']: Replace with 'from'.	
Lofstrom/Klein		5.2.1.2.2	49	28	Table 5-19	The superscripts for C and D are incorrect.	

Commenter	Charge Question	Guidance Section	Page Number	Line Number		Comment	EPA Resolution
Lofstrom/Klein		5.2.1.3.2.3	52	3		There should be an approach for evaluating a potential population over an area of subsurface contamination that is not based on the presence of a current structure.	

Peer Reviews

Tonia Burk (ATSDR)

- Charge Question Comments
- CV
- COI Certification

Peer Review Charge for:
U.S. Environmental Protection Agency (EPA). *Proposed Rule: Addition of a Subsurface Intrusion Component to the Hazard Ranking System*; 40 CFR Part 300; EPA-HQ-SFUND-2010-1086; FRL_XXXX-X (review draft).

Background
The U.S. Environmental Protection Agency (EPA) is proposing to include a subsurface intrusion (SsI) component to the Hazard Ranking System (HRS). Subsurface intrusion is the migration of hazardous substances from the unsaturated zone and/or the surficial ground water into overlying structures. The HRS is the principal mechanism the EPA uses to evaluate sites for placement on the National Priorities List (NPL). The subsurface intrusion component addition (this addition) would primarily expand the number of available options for EPA and state and tribal organizations performing work on behalf of EPA to evaluate potential threats to public health and the environment from releases of hazardous substances.

This addition will allow the HRS evaluation to directly consider human exposure to hazardous substances that enter building structures through subsurface intrusion, and thus enable sites with subsurface intrusion contamination to be evaluated for placement on the NPL. This addition will make the HRS more accurate in assessing a site's relative potential risk. The Agency is not considering changes to the remainder of the HRS except for minor updates reflecting changes in terminology related to revised toxicological parameters. This proposed regulatory change does not affect the status of sites currently on or proposed to the NPL.

Expertise Required
The peer review panel for U.S. EPA's *Proposed Rule: Addition of a Subsurface Intrusion Component to the Hazard Ranking System* should include expertise in:

***Federal Agency Panelist**:* Panelist must have a strong working knowledge of policy and technical issues related to topic of vapor intrusion. Knowledge of recent developments in vapor intrusion technologies and research is required, in addition to working knowledge of federal vapor intrusion response programs. Expertise in hydrogeology, chemistry, knowledge of public health risks associated with indoor air threats, and the subsurface migration of volatile hazardous substances is necessary. Field experience conducting vapor intrusion investigations, while not required, is highly desirable. Experience conducting field investigations for the purpose of listing sites on the NPL and/or experience working with the HRS to evaluate sites for inclusion on the NPL is highly recommended, but not necessary.

Peer Review Charge Questions

1. Potential for subsurface exposure (intrusion) into occupied structures

Background: The current HRS evaluates the likelihood of a release of a hazardous substance when an actual release has occurred through either chemical analysis or direct observation. The current HRS also evaluates the potential for a release to occur within the ground water, surface water and air pathways (see section 2.3 of the current HRS). The potential for a release is determined by the consideration of pathway specific factors that aid the site evaluator in predicting whether a release to the pathway is likely to occur. These factors are based on containment features of the source of contamination (whether or not hazardous substance can get out), route characteristics specific to each pathway (how far hazardous substances could migrate based on knowledge of site conditions) and include physical/chemical properties of the hazardous substances being evaluated (how the hazardous substances act in the environment).

Proposed Approach: EPA is proposing a parallel approach for evaluating potential and actual exposure of intruded hazardous substances for the subsurface intrusion addition to the HRS. In determining which route characteristics are appropriate for evaluating potential exposure to subsurface contaminants, EPA examined present modeling methods such as the Johnson-Ettinger model and also considered multiple lines of evidence approaches which estimate the levels of contaminant exposure based on numerous route characteristics. In addition, EPA examined the relationship between these factors to determine which have the greatest influence on the likelihood that an exposure would occur, and then incorporated these factors within its proposed approach. EPA also gave careful consideration to ensure that the data necessary to obtain route characteristic factors could be measured or calculated on a site-specific basis and in a manner consistent with current HRS evaluations. Based on the Agency's analysis, the following three factors for which sufficient site-specific information could be collected during a site inspection represented the greatest impact on the potential for exposure: (1) depth to contamination; (2) vertical migration; and (3) vapor migration potential (see Figure 1).

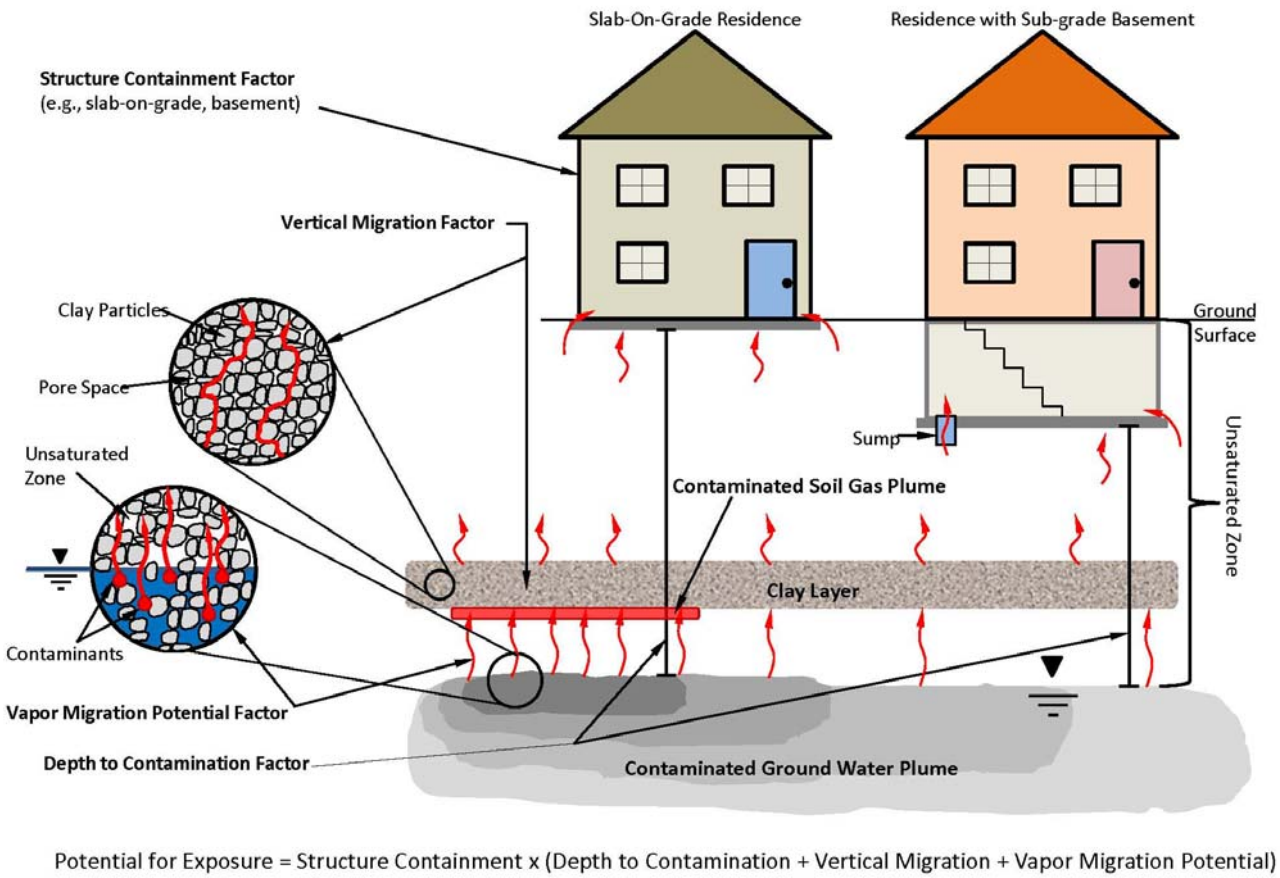

Figure 1

Charge Question #1 : Is EPA's proposed approach scientifically reasonable for evaluating and assigning proportional weightings for the following when evaluating potential for exposure? If no, what alternative approach would you recommend?

a. Consideration of the construction/structure type for which sufficient site-specific information could be collected during a site inspection for the occupied structure;
b. Distance between occupied structure and depth of contamination; and
c. Evaluation of the vertical migration factor based on the thickness and porosity/permeability of geologic materials in the interval between the lowest point of an occupied structure and the highest known point of hazardous substances in the subsurface.

Response 1.a. No mention of the potential for intrusion from wet basements or factors affecting indoor air pressure and exchange rate, such as HVAC systems or structural integrity ("leakiness") of building, was identified. Section 5.2.1.1.2.1 *Structure Containment* of the HRS Rule document may be an appropriate place to add consideration of these topics.
Response 1.b. Agreed, reasonable.
Response 1.c. Consideration of the possibility for hydraulic pumping in areas prone to rapid rise of the groundwater table may warrant a higher ranking. For example, vapor intrusion events in Hartford, IL have been correlated with rise in the Mississippi River and, to a lesser extent, rainfall

(http://www.atsdr.cdc.gov/HAC/pha/HartfordResidentialCommunity/HartfordResidentialCommunityLHC02-24-2010.pdf).

2. Hazardous Waste Quantity

Background: In the current HRS, the hazardous waste quantity factor reflects the risk consideration related to the magnitude and duration of either the release for ground water, surface water, and air pathways, or the exposure for the soil exposure pathway (see section 2.4.2 of the current HRS). Hazardous waste quantity is evaluated for all four pathways. At each site evaluated, EPA uses a four-tiered hierarchy for calculating the hazardous waste quantity that is based on (1) constituent quantity; (2) waste stream; (3) volume; and (4) area of the sources of hazardous waste at the site. EPA uses minimum waste quantity factors when there is insufficient information to estimate hazardous waste quantity. In the ground water, surface water, and air pathways, the HRS evaluates the total quantity of hazardous substances available to migrate from the original sources (how much has migrated and how much can be released in the future). In the soil exposure pathway, the hazardous waste quantity does not include the total amount of hazardous substances in all site sources, but rather is based on the amount of hazardous substances to which a receptor can be exposed where actual contamination has been documented. In other words, for the soil exposure pathway, the risk posed by a release of hazardous substances is directly related to the amount of hazardous substances that receptors are exposed to, as opposed to how much of the hazardous substances from the original sources may migrate to the receptors.

Proposed Approach: EPA is proposing a parallel approach to the soil exposure pathway to calculate hazardous waste quantity for the subsurface intrusion addition to the HRS. Since the subsurface intrusion component also focuses on exposure, the waste quantity factor value for this component should also reflect only the amount of hazardous substances that people actually are exposed to (the amount present in occupied structures). EPA is proposing to use a similar four-tiered hierarchical approach to calculate hazardous waste quantity within occupied structures with contamination. In cases where no home is subject to actual contamination, EPA is proposing to use minimum waste quantity factors. In situations where there is an observed release within a structure above benchmarks (Level I), a default value of 100 is proposed for the hazardous waste quantity factor value. This value is not used in the current soil exposure pathway, but is consistent with the ground water, surface water, and air pathways and reflects the increased exposure risk of a release within an occupied structure.

Charge Question #2: Is EPA's approach of basing the hazardous waste quantity on the amount of contaminants that could be found in the intruded structures appropriate? If no, what alternative approach would you recommend?

Response 2. Agreed, appropriate.

3. Population score

Background: Within the current HRS, receptors are evaluated in two main categories: whether they are exposed to 1) actual contamination; or 2) potential contamination (see section 2.5 of the current HRS). If receptors are exposed to contaminant levels meeting observed release criteria, they are identified as actually contaminated; however, if the receptors are not exposed to contaminants that meet the observed release criteria but are within the target area being evaluated, they are considered potentially contaminated. Actual contamination is further divided into two sub-categories based on whether the hazardous substance is present at or above a health-based benchmark. If the concentration of the hazardous substance released at the receptor is greater than a health-based benchmark, the receptors are identified as Level I receptors and are weighted (multiplied by a factor of 10) in scoring. If the release concentrations are less than a health-based benchmark, the receptors are identified as Level II receptors and are not weighted (multiplied by a factor of 1). Potential receptors are distance/dilution weighted; in other words, the farther away a receptor is located from a source, the less the population contributes to the site score.

Proposed Approach: EPA is proposing to generally use the same receptor weighting structure in the subsurface intrusion component as the one used in the current HRS. Those receptors in the area(s) of observed exposure (AOE) are considered actually contaminated, and those in the area(s) of subsurface contamination (ASC) are considered potentially contaminated (See Figure 2). The receptors in an AOE are further differentiated based on whether the contaminant concentrations are at levels above identified benchmarks (Level I) or are at levels establishing a release but below identified benchmarks (Level II). The benchmarks that EPA is proposing to use for the subsurface intrusion component are:

- Screening concentration for cancer effects; and
- Screening concentration for non-cancer effects (systemic toxicants).

Consistent with the weighting of populations throughout the HRS, the proposed subsurface intrusion component will weight targets within the AOE subject to Level I contaminant concentrations by a factor of 10 and weight targets subject to Level II contaminant concentrations by a factor of 1.

EPA is proposing to evaluate the weighting of targets within the ASC based on sub-slab, soil gas, and/or ground water samples. Potential receptors within the ASC receive less weight (population multiplied by a factor of 0.1), except in cases where a sub-slab sample indicates contaminant levels are at least 10 times higher than a health-based benchmark (population is multiplied by a factor 0.75). The value of 0.75 was determined based on an evaluation of paired data when both a sub-slab and indoor air sample were collected. The 0.75 weighting reflects the observation that for approximately 80 percent of the sampling events where contamination was detected in the sub-slab, contamination was also detected in the indoor air sample. The order of magnitude adjustment applied to the health-based benchmark reflects EPA's finding that, in such paired sampling events, the indoor air sample concentration is, on average, 10 times lower than the sub-slab sample concentration.

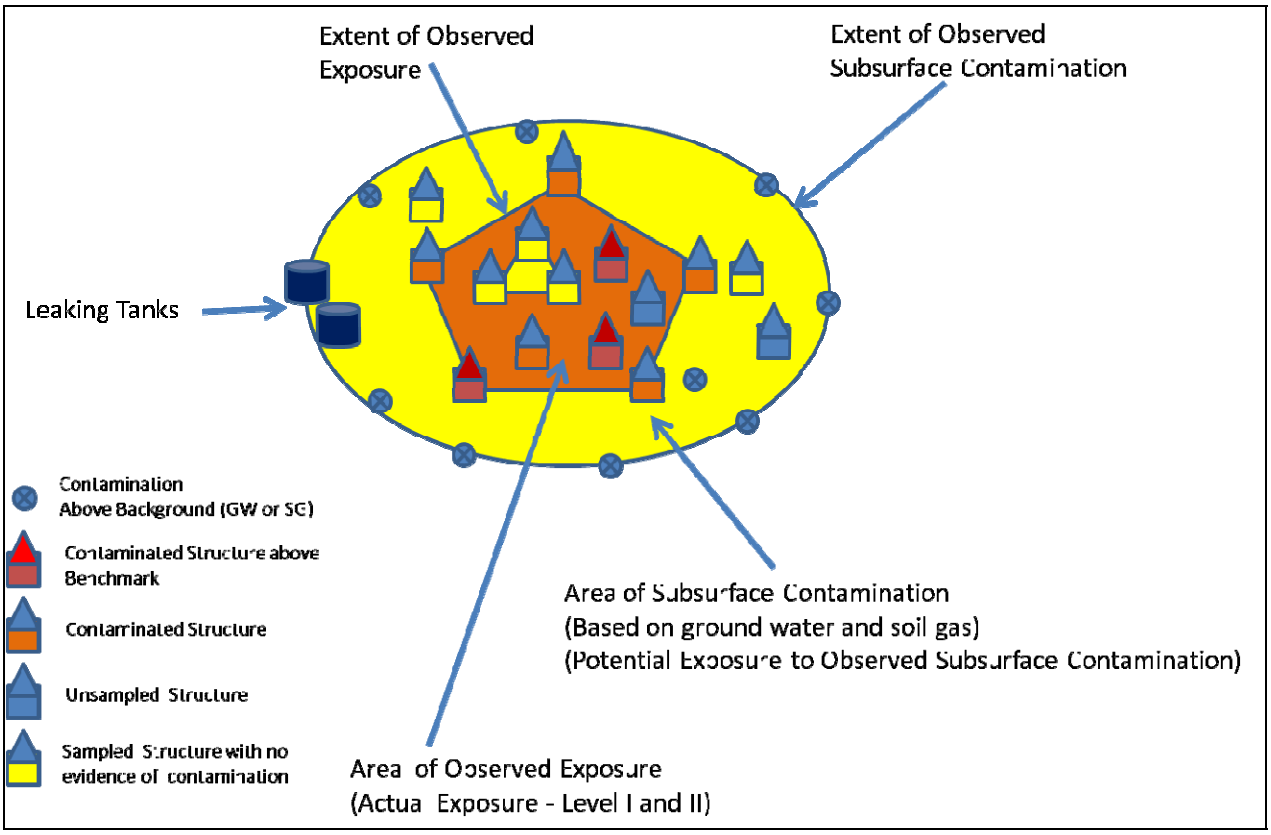

Figure 2

Charge Question #3: Is it appropriate to consider individuals/populations located within the area of subsurface contamination (ASC) to be at a higher relative risk in situations when sub-slab contaminant concentrations are at least ten times greater than a health-based benchmark? If no, please explain.

Response 3. Agreed, however, the last bullet in section 5.2.1.2.2 of the HRS Rule document includes enclosed crawl spaces in this criteria. Since EPA's default attenuation factor for crawl space intrusion to indoor air is 1, the crawl space criteria may be better stated as considering populations when crawl space concentrations are greater than a benchmark (instead of 10 times a benchmark).

4. Multi-story and multi-tenant structures

Background: In the current HRS, multi-story and multi-tenant buildings are evaluated based on population associated with an actually or potentially impacted target. In the ground water pathway, all residents who are served by a well are considered subject to the actual or potential contamination of the well. In the air pathway, all residents who have an opportunity to breathe ambient air are considered subject to the actual or potential contamination of the ambient environment within a distance category. All receptors within a contaminated surface water stretch are subject to the level of contamination associated with that surface water stretch. In the soil exposure pathway, receptors must be able to come in contact with areas of contamination. In determining the likelihood a person will come in contact with areas of contamination, the HRS uses a 200 foot rule (see section 5.1.3 of the current HRS) because it is reasonable to assume that that a person will walk/use areas within a 200 foot areal extent of their residence/property. The 200 foot rule is used regardless of whether a building is multi-tenant or multi-story (the assumption being that is reasonable for people to use the outside of their properties).

Proposed Approach: EPA is proposing to evaluate multi-story/multi-tenant buildings utilizing a similar approach as soil exposure, limiting the receptors to those individuals that reasonably can be exposed to subsurface intrusion within an occupied multi-tenant/multi-story building. EPA is proposing to consider all receptors exposed to actual contamination as the population inhabiting the floor of the intruded space and the population inhabiting the floor above and the floor below the intruded space when calculating waste quantity and population. EPA considers that this approach will more accurately reflect risk to both actual and potential receptors, while also minimizing the potential for over counting (Figure 3).

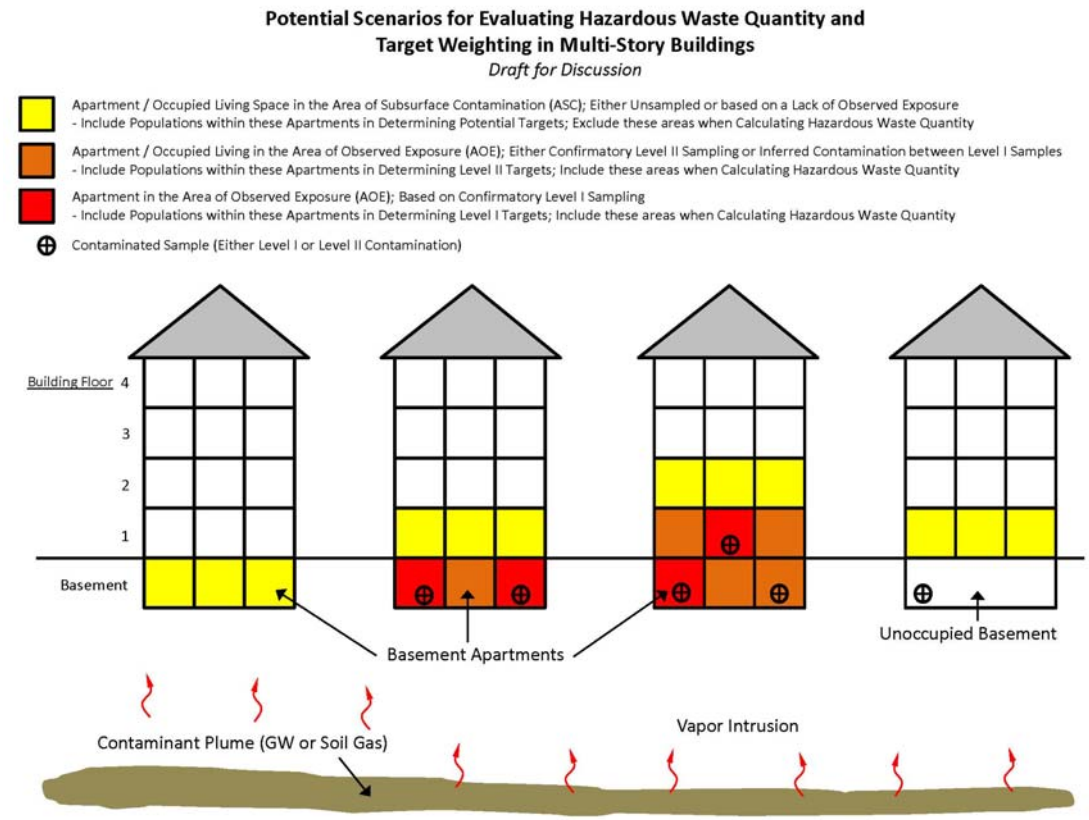

Figure 3

Charge Question #4: When calculating waste quantity and population, is it scientifically reasonable for populations in multi-story or multi-tenant structures to be evaluated based on using **only** the population inhabiting **the intruded space and the population on the floor above and below the intruded space** (For example, if contamination is found on the first floor, population from the basement and second floor would be used in the calculation. If contamination is found on the fifth floor, population from the fourth floor and sixth floor would be used in the calculation – for further explanation, see detailed discussion in above paragraph "Proposed Approach")? If no, what alternative approach would you recommend?

Response 4. The charge question seems to be worded differently than the description in the HRS Rule document on this topic. The charge question considers only the contaminated floor and one floor below and above the contaminated floor. Sections 5.2.1.3.2.1 and 5.2.1.3.2.2 say to consider those populations living **within** the story with Level I/II concentrations **and those stories below** that story. Section 5.2.1.3.3 says to count those **workers** in the **highest story with** observed exposure, **one story above and all stories below**. I agree with either approach with a caveat: preferential pathways, such as elevators and ventilation systems, may serve to transport hazardous vapors to distant floors. It may be prudent to consider the possibility of discontinuous contamination from floor to floor and not rule out floors that have not been sampled in such cases. Also, if a preferential pathway has not been identified to contamination in an isolated upper floor, all floors below seem at risk.

5. Factor Value for Workers

Background: In the current HRS, for the resident population threat of the soil exposure pathway, a factor value for workers is assigned based on the total number of workers present within the area of observed contamination. These factor values range from 0 to15, depending on the number of workers exposed to outdoor contamination (see section 5.1.3.3 of the current HRS).

Proposed Approach: EPA is proposing to mirror the procedures for the resident population threat in the soil exposure component when assigning a worker factor value in the subsurface intrusion component (see Table 5-4 in section 5.1.3.3 of the current HRS). However, since it is anticipated that workers spend a larger percentage of their time indoors and therefore may be more exposed to contamination resulting from subsurface intrusion than to outdoor soil (or other surface) contamination, EPA is proposing to assign workers exposed to subsurface intrusion a higher weighting (i.e., factor values ranging from 0 to 45).

Charge Question #5: Because of longer exposure times indoors, is it reasonable to assume that the relative risk is three times greater for workers exposed to subsurface intrusion within the workplace than it is for workers exposed to outdoor surface contamination at the workplace? If no, please explain.

Responst 5. Agreed reasonable.

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WORK EXPERIENCE

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Dates Employed: 11/2006 - present
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Responsibilities: Review information on environmental contamination and make recommendations to protect public health using the recent scientific body of knowledge, writing skills and interpersonal communication skills. Serve as agency expert on vapor intrusion.

Position: **Human Health Risk Assessment Analyst**
Dates Employed: 5/2002 - 11/2006
Employer: State of Georgia, Department of Natural Resources, Environmental Protection Division, Hazardous Waste Management Branch, Corrective Action Program
Address: Suite 1154, East Floyd Tower, 2 MLK Jr Dr, Atlanta, GA 30334
Responsibilities: Review and critique risk assessment reports, policies and regulations. Assist field teams with environmental sampling. Provide technical assistance regarding environmental contaminants for internal and external inquiries. Speak to concerned citizens.

EDUCATION

Ph.D. **Chemical Engineering, May 2001**
Minor: Biochemistry/Genetics
Dissertation: Surface Characterization and Interactions in a Dry Powder Inhalant Drug Delivery System
Auburn University, AL US

Dual Degree Undergraduate
B.S., Chemical Engineering, Auburn University, AL, Aug 1994
B.A., Math, Huntingdon College, Montgomery, AL Jun 1995

CERTIFICATIONS

OSHA, 29 CFR 1910.120 (HAZWOPER)
Heartsaver First Aid, American Heart Association

SUBJECT MATTER EXPERT EXPERIENCE

Teaching

ATSDR Vapor Intrusion Workshop, course coordinator, Aug 2007, Agency for Toxic Substances and Disease Registry, Atlanta, GA

Public Health Assessment of Vapor Intrusion, ATSDR Basic Health Assessor Course, presenter, Jun 2008-9, Agency for Toxic Substances and Disease Registry, Atlanta, GA

Presentation

ATSDR Health Assessment of Vapor Intrusion at Military Facilities (Abstract #10073), Environment Energy & Sustainability Symposium & Exhibition: Soil and Groundwater Contamination Session, Denver, CO, June 16 2010.

Current {Vapor Intrusion} Evaluations at ATSDR Associated with DoD, Multi-services DoD Panel, Crystal City, VA Aug 2009

ATSDR Health Assessment of TCE Exposure by Vapor intrusion at Military Facilities, Environment Energy & Sustainability Symposium & Exhibition in Denver CO, May 4 2009.

Public Health Assessment of Vapor Intrusion, Board of Scientific Counselors Meeting, November 2008, Atlanta, GA.

Public Health Effects from Vapor Intrusion, Morehouse School of Medicine Grand Rounds, October 2008, Atlanta, GA.

Vapor Intrusion at Military Sites: An ATSDR Overview, Joint Services Environmental Management Training Conference & Exposition: Environment and Energy Management in a Transforming DoD, May 5, 2008, Denver, CO.

Public Health Assessment of Vapor Intrusion, Region 6 ATSDR Partnership meeting in Dallas, TX, February 2008.

An Approach to Protecting the Public from Vapor Intrusion at a Well Defined Site: A Screening Procedure for Kelly AFB, San Antonio, TX, Regions 2 ATSDR/EPA Meeting, Bear Mountain, NY, October 2007

An Overview of ATSDR's Perspective on Vapor Intrusion, Region 8 & 9 ATSDR/EPA Meeting, Las Vegas, NV, September 2007

An Overview of the ITRC Guidance on Vapor Intrusion Guidance, ATSDR Vapor Intrusion Workshop, August 2007

Risk Assessment of Air Toxics in Georgia, in the US EPA Regional Risk Assessors Conference, San Francisco, CA, 2006.

Peer Reviewer Conflict of Interest Certification

Peer Review: *Proposed Rule: Addition of a Subsurface Intrusion Component to the Hazard Ranking System*; 40 CFR Part 300; EPA-HQ-SFUND-2010-1086; FRL_XXXX-X (review draft).

A conflict of interest or lack of impartiality exists when the proposed peer reviewer personally (or the peer reviewer's immediate family), or his or her employer, has financial interests that may be affected by the results of the peer review; or may provide an unfair competitive advantage to the peer reviewer (or employer); or if the peer reviewer's objectivity in performing the peer review may be impaired due to other factors. When the Peer Reviewer knows that a reasonable person with knowledge of the facts may question the peer reviewer's impartiality or financial involvement, an apparent lack of impartiality or conflict of interest exists.

The following questions, if answered affirmatively, represent potential or apparent lack of impartiality (*any affirmative answers should be explained on the back of this form or in an attachment*):

- Did you contribute to the development of the document under peer review, or were you consulted during its development, or did you offer comments or suggestions to any drafts or versions of the document during its development? ☒ No ☐ Yes
- Do you know of any reason that you might be unable to provide impartial advice on the matter under consideration in this peer review, or any reason that your impartiality in the matter might be questioned? ☒ No ☐ Yes
- Have you had any previous involvement with the review document(s) under consideration? ☒ No ☐ Yes
- Have you served on previous advisory panels, committees, or subcommittees that have addressed the topic under consideration? ☒ No ☐ Yes
- Have you made any public statements (written or oral) on the issue? ☐ No ☒ Yes
- Have you made any public statements that would indicate to an observer that you have taken a position on the issue under consideration? ☒ No ☐ Yes
- Do you, your family, or your employer have any financial interest(s) in the matter or topic under peer review, or could someone with access to relevant facts reasonably conclude that you (or your family or employer) stand to benefit from a particular outcome of this peer review? ☒ No ☐ Yes

With regard to real or apparent conflicts of interest or questions of impartiality, the following provisions shall apply for the duration of this peer review:

(a) Peer Reviewer warrants, to the best of his/her knowledge and belief, that there are no relevant facts or circumstances that could give rise to an actual, apparent, or potential organizational or personal conflict of interest, or that Peer Reviewer has disclosed all such relevant information to EMS or to EPA.
(b) Peer Reviewer agrees that if an actual, apparent, or potential personal or organizational conflict of interest is identified during performance of this peer review, he/she immediately will make a full disclosure in writing to EMS. This disclosure shall include a description of actions that Peer Reviewer (or his/her employer) has taken or proposes to take after consultation with EMS to avoid, mitigate, or neutralize the actual, apparent, or potential organizational conflict of interest. Peer Reviewer shall continue performance until notified by EMS of any contrary action to be taken.

Tonia Burk 1/26/2012 ☒ Check here if any explanation is attached

Signature Date

Tonia Burk

Printed Name

U.S. Department of Health and Human Services

Affiliation/Organization

The comments provided in this peer review are those of the author and do not represent the views of the Centers for Disease Control and Prevention or the U.S. Department of Health and Human Services. This document has not been revised or edited to conform to agency

Regarding the question: Have you served on previous advisory panels, committees, or subcommittees that have addressed the topic under consideration? NO

I have served on numerous workgroups, provided training and serve as agency subject matter expert, but none of these have advised the HRS process.

Regarding the question: Have you made any public statements (written or oral) on the issue? YES

I routinely author public health assessments and health consultations on sites that are subject to vapor intrusion. I have also given presentations on the topic of vapor intrusion at interagency and professional conferences. However, none of these statements have regarded the HRS.

Regarding the question: Do you, your family or your employer have any financial interest(s) in the matter or topic under peer review, or could someone with access to relevant facts reasonably conclude that you (or your family or employer) stand to benefit from a particular outcome of this peer review? NO

It is possible that I could receive a routine performance cash or time-off award for performing my daily duties on future sites ranked by the HRS. However, any work I perform is eligible for such an award and being selected for such an award should be unbiased by the site work I am assigned.

Peer Reviews

Blayne Hartman
(Hartman Environmental Geoscience)

- Charge Question Comments
- CV
- COI Certification

Comments on Proposed HRS Rule
Addition of a Subsurface Intrusion Component
to the Hazard Ranking System

Dr. Blayne Hartman
858-204-6170
blayne@hartmaneg.com

February 10, 2012

Key Comments on this Document

- There needs to be a distinction in this rule between petroleum hydrocarbon VOCs which readily bioattenuate and recalcitrant VOCs (typically those containing halogens) that do not bioattenuate. I do not see any allowance for this under vapor migration potential factors.

- One idea to distinguish between VOCs that bioattenuate versus those that don't would be to come up with a bioattenuation factor. These factors would be 0.1, 0.01, 0.001, and 0.0 using exclusion criteria that EPA-OUST is now considering.

- Setting benchmarks for cancer effects at 1e-6 risk level and for non-cancer at a HI=1is going to suck in almost every site as the screening levels for many compounds are below ambient levels. Since your goal is to rank the highest priority sites, you should set the benchmarks for cancer at 1e-4 risk and non-cancer at HI=10. This will accomplish the HRS goal of ranking the highest priority sites but not bog down your ranking with a large number of sites to rank that are unlikely to have a vapor intrusion concern.

- In some places (such as table 5-13 and section 5.2.1.3.2.3), the rule is inconsistent with current & forthcoming EPA vapor intrusion guidances. This rule needs to be compliant with the two guidances coming out in March by EPA-OSWER & EPA-OUST.

Feel free to contact me with any questions on these comments.

Blayne Hartman

Peer Review Charge for:
U.S. Environmental Protection Agency (EPA). *Proposed Rule: Addition of a Subsurface Intrusion Component to the Hazard Ranking System*; 40 CFR Part 300; EPA-HQ-SFUND-2010-1086; FRL_XXXX-X (review draft).

Background
The U.S. Environmental Protection Agency (EPA) is proposing to include a subsurface intrusion (SsI) component to the Hazard Ranking System (HRS). Subsurface intrusion is the migration of hazardous substances from the unsaturated zone and/or the surficial ground water into overlying structures. The HRS is the principal mechanism the EPA uses to evaluate sites for placement on the National Priorities List (NPL). The subsurface intrusion component addition (this addition) would primarily expand the number of available options for EPA and state and tribal organizations performing work on behalf of EPA to evaluate potential threats to public health and the environment from releases of hazardous substances.

This addition will allow the HRS evaluation to directly consider human exposure to hazardous substances that enter building structures through subsurface intrusion, and thus enable sites with subsurface intrusion contamination to be evaluated for placement on the NPL. This addition will make the HRS more accurate in assessing a site's relative potential risk. The Agency is not considering changes to the remainder of the HRS except for minor updates reflecting changes in terminology related to revised toxicological parameters. This proposed regulatory change does not affect the status of sites currently on or proposed to the NPL.

Expertise Required
The peer review panel for U.S. EPA's *Proposed Rule: Addition of a Subsurface Intrusion Component to the Hazard Ranking System* should include expertise in:

Panelist from non-specified sector: Panelist must have a strong working knowledge of policy and technical issues related to the topic of vapor intrusion. Knowledge of recent developments in vapor intrusion technologies and research is required, in addition to working knowledge of federal vapor intrusion response programs. Expertise in hydrogeology, chemistry, knowledge of public health risks associated with indoor air threats, and the subsurface migration of volatile hazardous substances is necessary. Field experience conducting vapor intrusion investigations, while not required, is highly desirable. Experience conducting field investigations for the purpose of listing sites on the NPL and/or experience working with the HRS to evaluate sites for inclusion on the NPL is highly recommended, but not necessary.

Peer Review Charge Questions

1. Potential for subsurface exposure (intrusion) into occupied structures
Background: The current HRS evaluates the likelihood of a release of a hazardous substance when an actual release has occurred through either chemical analysis or direct observation. The current HRS also evaluates the potential for a release to occur within the ground water, surface water and air pathways (see section 2.3 of the current HRS). The potential for a release is determined by the consideration of pathway specific factors that aid the site evaluator in predicting whether a release to the pathway is likely to occur. These factors are based on containment features of the source of contamination (whether or not hazardous substance can get out), route characteristics specific to each pathway (how far hazardous substances could migrate based on knowledge of site conditions) and include physical/chemical properties of the hazardous substances being evaluated (how the hazardous substances act in the environment).

Proposed Approach: EPA is proposing a parallel approach for evaluating potential and actual exposure of intruded hazardous substances for the subsurface intrusion addition to the HRS. In determining which route characteristics are appropriate for evaluating potential exposure to subsurface contaminants, EPA examined present modeling methods such as the Johnson-Ettinger model and also considered multiple lines of evidence approaches which estimate the levels of contaminant exposure based on numerous route characteristics. In addition, EPA examined the relationship between these factors to determine which have the greatest influence on the likelihood that an exposure would occur, and then incorporated these factors within its proposed approach. EPA also gave careful consideration to ensure that the data necessary to obtain route characteristic factors could be measured or calculated on a site-specific basis and in a manner consistent with current HRS evaluations. Based on the Agency's analysis, the following three factors for which sufficient site-specific information could be collected during a site inspection represented the greatest impact on the potential for exposure: (1) depth to contamination; (2) vertical migration; and (3) vapor migration potential (see Figure 1).

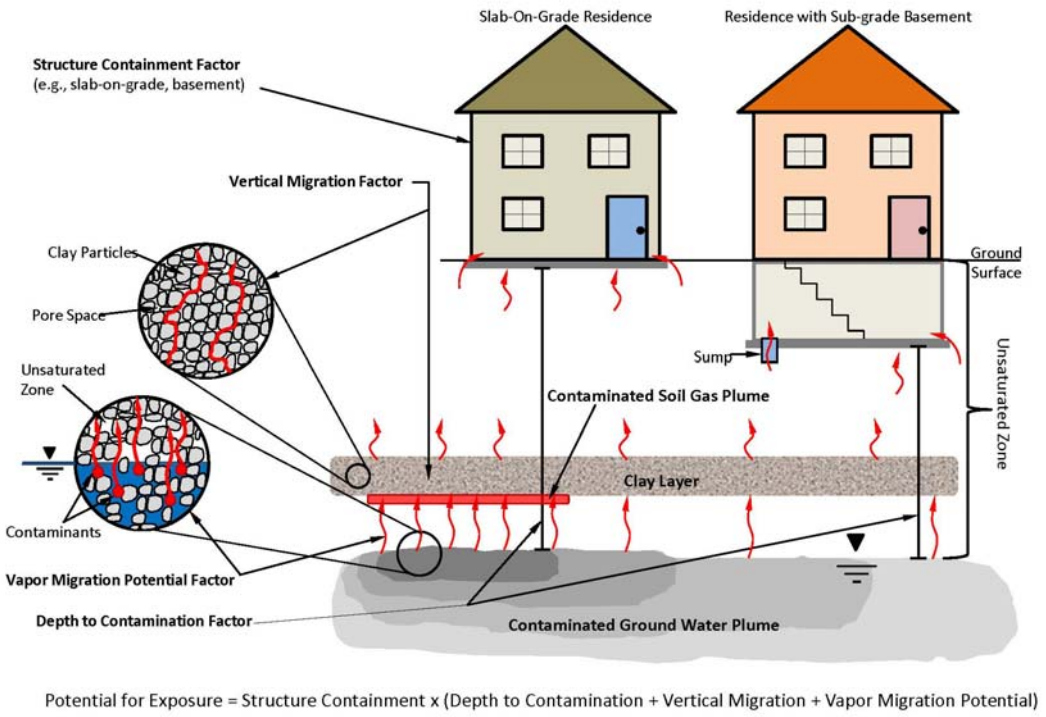

Figure 1

Charge Question #1: Is EPA's proposed approach scientifically reasonable for evaluating and assigning proportional weightings for the following when evaluating potential for exposure? If no, what alternative approach would you recommend?

Comment [B1]: No, it is not scientifically reasonable using these 3 factors alone.

a. Consideration of the construction/structure type for which sufficient site-specific information could be collected during a site inspection for the occupied structure;
b. Distance between occupied structure and depth of contamination; and
c. Evaluation of the vertical migration factor based on the thickness and porosity/permeability of geologic materials in the interval between the lowest point of an occupied structure and the highest known point of hazardous substances in the subsurface.

Comment [B2]: This is a better approach than the one written above. However, this approach is also flawed if bioattenuation is not included into the vertical migration factor/potential. As now written, Section 5.2.1.1.2.3 & 4 & 5 have no allowance for bioattenuation, so the approach is fundamentally flawed for any VOCs that can bioattenuate such as vinyl chloride and petroleum VOCs.

2. Hazardous Waste Quantity

Background: In the current HRS, the hazardous waste quantity factor reflects the risk consideration related to the magnitude and duration of either the release for ground water, surface water, and air pathways, or the exposure for the soil exposure pathway (see section 2.4.2 of the current HRS). Hazardous waste quantity is evaluated for all four pathways. At each site evaluated, EPA uses a four-tiered hierarchy for calculating the hazardous waste quantity that is based on (1) constituent quantity; (2) waste stream; (3) volume; and (4) area of the sources of hazardous waste at the site. EPA uses minimum waste quantity factors when there is insufficient information to estimate hazardous waste quantity. In the ground water, surface water, and air pathways, the HRS evaluates the total quantity of hazardous substances available to migrate from the original sources (how much has migrated and how much can be released in the future). In the soil exposure pathway, the hazardous waste quantity does not include the total amount of hazardous substances in all site sources, but rather is based on the amount of hazardous substances to which a receptor can be exposed where actual contamination has been documented. In other words, for the soil exposure pathway, the risk posed by a release of hazardous substances is directly related to the amount of hazardous substances that receptors are exposed to, as opposed to how much of the hazardous substances from the original sources may migrate to the receptors.

Proposed Approach: EPA is proposing a parallel approach to the soil exposure pathway to calculate hazardous waste quantity for the subsurface intrusion addition to the HRS. Since the subsurface intrusion component also focuses on exposure, the waste quantity factor value for this component should also reflect only the amount of hazardous substances that people actually are exposed to (the amount present in occupied structures). EPA is proposing to use a similar four-tiered hierarchical approach to calculate hazardous waste quantity within occupied structures with contamination. In cases where no home is subject to actual contamination, EPA is proposing to use minimum waste quantity factors. In situations where there is an observed release within a structure above benchmarks (Level I), a default value of 100 is proposed for the hazardous waste quantity factor value. This value is not used in the current soil exposure pathway, but is consistent with the ground water, surface water, and air pathways and reflects the increased exposure risk of a release within an occupied structure.

Charge Question #2: Is EPA's approach of basing the hazardous waste quantity on the amount of contaminants that could be found in the intruded structures appropriate? If no, what alternative approach would you recommend?

Comment [B3]: This approach is appropriate, but what is not appropriate is defining the level I & II benchmarks at a 1 in 1 million risk level. Much too low. You should set benchmarks at a 1 in 10,000 risk level.

3. Population score

Background: Within the current HRS, receptors are evaluated in two main categories: whether they are exposed to 1) actual contamination; or 2) potential contamination (see section 2.5 of the current HRS). If receptors are exposed to contaminant levels meeting observed release criteria, they are identified as actually contaminated; however, if the receptors are not exposed to contaminants that meet the observed release criteria but are within the target area being evaluated, they are considered potentially contaminated. Actual contamination is further divided into two sub-categories based on whether the hazardous substance is present at or above a health-based benchmark. If the concentration of the hazardous substance released at the receptor is greater than a health-based benchmark, the receptors are identified as Level I receptors and are weighted (multiplied by a factor of 10) in scoring. If the release concentrations are less than a health-based benchmark, the receptors are identified as Level II receptors and are not weighted (multiplied by a factor of 1). Potential receptors are distance/dilution weighted; in other words, the farther away a receptor is located from a source, the less the population contributes to the site score.

Proposed Approach: EPA is proposing to generally use the same receptor weighting structure in the subsurface intrusion component as the one used in the current HRS. Those receptors in the area(s) of observed exposure (AOE) are considered actually contaminated, and those in the area(s) of subsurface contamination (ASC) are considered potentially contaminated (See Figure 2). The receptors in an AOE are further differentiated based on whether the contaminant concentrations are at levels above identified benchmarks (Level I) or are at levels establishing a release but below identified benchmarks (Level II). The benchmarks that EPA is proposing to use for the subsurface intrusion component are:

- Screening concentration for cancer effects; and
- Screening concentration for non-cancer effects (systemic toxicants).

Consistent with the weighting of populations throughout the HRS, the proposed subsurface intrusion component will weight targets within the AOE subject to Level I contaminant concentrations by a factor of 10 and weight targets subject to Level II contaminant concentrations by a factor of 1.

EPA is proposing to evaluate the weighting of targets within the ASC based on sub-slab, soil gas, and/or ground water samples. Potential receptors within the ASC receive less weight (population multiplied by a factor of 0.1), except in cases where a sub-slab sample indicates contaminant levels are at least 10 times higher than a health-based benchmark (population is multiplied by a factor 0.75). The value of 0.75 was determined based on an evaluation of paired data when both a sub-slab and indoor air sample were collected. The 0.75 weighting reflects the observation that for approximately 80 percent of the sampling events where contamination was detected in the sub-slab, contamination was also detected in the indoor air sample. The order of magnitude adjustment applied to the health-based benchmark reflects EPA's finding that, in such paired sampling events, the indoor air sample concentration is, on average, 10 times lower than the sub-slab sample concentration.

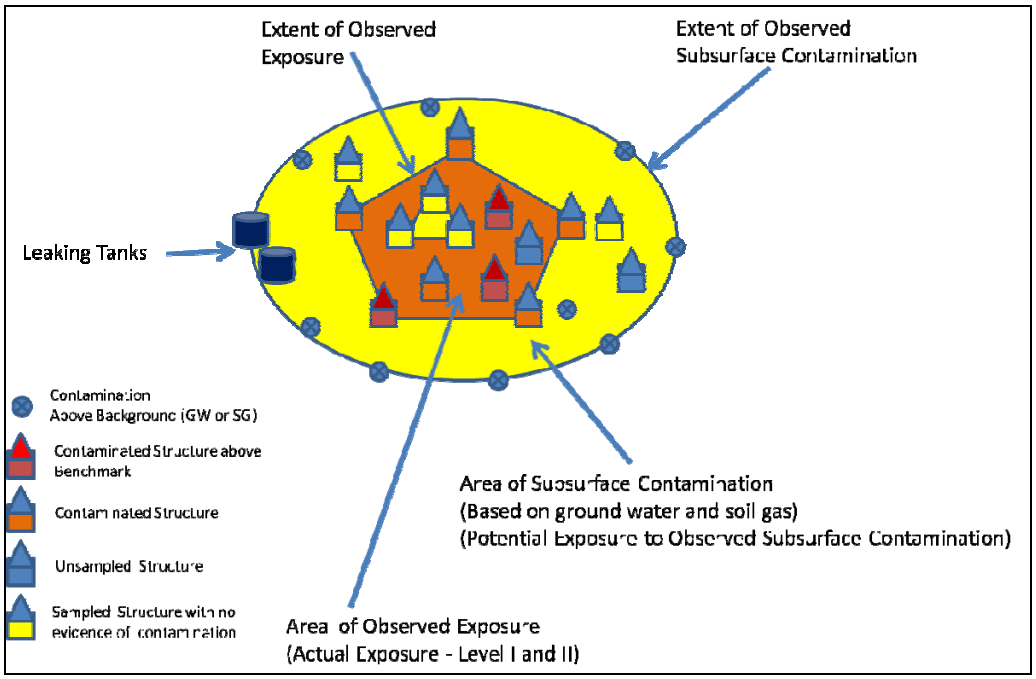

Figure 2

Charge Question #3: Is it appropriate to consider individuals/populations located within the area of subsurface contamination (ASC) to be at a higher relative risk in situations when sub-slab contaminant concentrations are at least ten times greater than a health-based benchmark? If no, please explain.

Comment [B4]: EPA OSWER has released a paper evaluating attenuation factors, including sub-slab to indoor air attenuation factors. The factor of 10 you refer to in the above paragraph is not an average. It is a 95th percentile. If you are going to use an average as you indicate, than the factor of 10 should be significantly higher. A paper released in 2011 says that a more reasonable subslab to indoor air attenuation factor is 50x. So, while it is appropriate to consider individuals/populations located within the area of subsurface contamination (ASC) to be at a higher relative risk in situations when sub-slab contaminant concentrations are high, the weighting factor of 0.75 should not apply until sub-slab values are at least 50 times higher than indoor air values rather than 10x higher.

4. Multi-story and multi-tenant structures

Background: In the current HRS, multi-story and multi-tenant buildings are evaluated based on population associated with an actually or potentially impacted target. In the ground water pathway, all residents who are served by a well are considered subject to the actual or potential contamination of the well. In the air pathway, all residents who have an opportunity to breathe ambient air are considered subject to the actual or potential contamination of the ambient environment within a distance category. All receptors within a contaminated surface water stretch are subject to the level of contamination associated with that surface water stretch. In the soil exposure pathway, receptors must be able to come in contact with areas of contamination. In determining the likelihood a person will come in contact with areas of contamination, the HRS uses a 200 foot rule (see section 5.1.3 of the current HRS) because it is reasonable to assume that that a person will walk/use areas within a 200 foot areal extent of their residence/property. The 200 foot rule is used regardless of whether a building is multi-tenant or multi-story (the assumption being that is reasonable for people to use the outside of their properties).

Proposed Approach: EPA is proposing to evaluate multi-story/multi-tenant buildings utilizing a similar approach as soil exposure, limiting the receptors to those individuals that reasonably can be exposed to subsurface intrusion within an occupied multi-tenant/multi-story building. EPA is proposing to consider all receptors exposed to actual contamination as the population inhabiting the floor of the intruded space and the population inhabiting the floor above and the floor below the intruded space when calculating waste quantity and population. EPA considers that this approach will more accurately reflect risk to both actual and potential receptors, while also minimizing the potential for over counting (Figure 3).

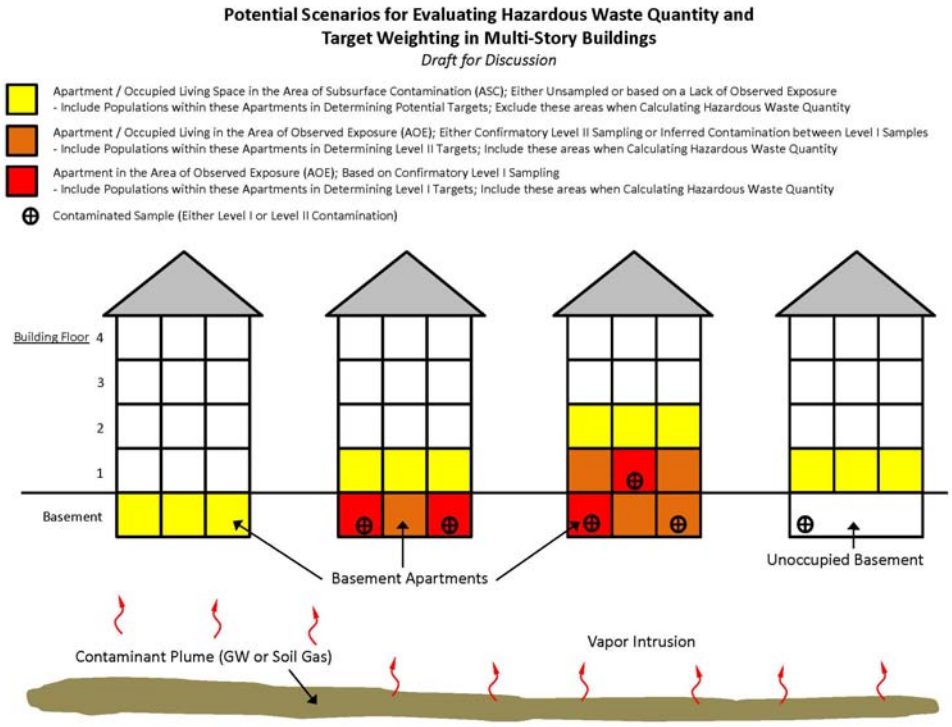

Figure 3

Charge Question #4: When calculating waste quantity and population, is it scientifically reasonable for populations in multi-story or multi-tenant structures to be evaluated based on using only the population inhabiting the intruded space and the population on the floor above and below the intruded space (For example, if contamination is found on the first floor, population from the basement and second floor would be used in the calculation. If contamination is found on the fifth floor, population from the fourth floor and sixth floor would be used in the calculation – for further explanation, see detailed discussion in above paragraph "Proposed Approach")? If no, what alternative approach would you recommend?

Comment [B5]: This protocol is okay so long as there are no elevators in the building or pipe/electrical chases that act as vapor conduits between lower & upper floors.

5. Factor Value for Workers

Background: In the current HRS, for the resident population threat of the soil exposure pathway, a factor value for workers is assigned based on the total number of workers present within the area of observed contamination. These factor values range from 0 to15, depending on the number of workers exposed to outdoor contamination (see section 5.1.3.3 of the current HRS).

Proposed Approach: EPA is proposing to mirror the procedures for the resident population threat in the soil exposure component when assigning a worker factor value in the subsurface intrusion component (see Table 5-4 in section 5.1.3.3 of the current HRS). However, since it is anticipated that workers spend a larger percentage of their time indoors and therefore may be more exposed to contamination resulting from subsurface intrusion than to outdoor soil (or other surface) contamination, EPA is proposing to assign workers exposed to subsurface intrusion a higher weighting (i.e., factor values ranging from 0 to 45).

Charge Question #5: Because of longer exposure times indoors, is it reasonable to assume that the relative risk is three times greater for workers exposed to subsurface intrusion within the workplace than it is for workers exposed to outdoor surface contamination at the workplace? If no, please explain.

Comment [B6]: There's no explanation as to where the factor of 3 came from. Hence, while it is reasonable to assume the risk is greater, I feel the basis for the factor of 3 should be explained.

HARTMAN
ENVIRONMENTAL GEOSCIENCE

Vapor Intrusion Support Services

Hartman Environmental specializes in vapor intrusion support services. Blayne Hartman has been performing vapor intrusion assessments since the mid 90s and has performed soil gas sampling since the mid 80s. Hartman's vast connections throughout the vapor intrusion community enable him to call in additional expertise as needed for a specific project. Hartman typically works with the local consultant to provide the necessary expertise for assessing the vapor intrusion pathway. These services include:

- Assessment program design (type of samples, where to sample)
- Determination of site-specific screening levels
- Indoor air and soil gas field sampling and/or sampling supervision
- On-site analysis of indoor air and/or soil gas samples by 8021, 8260, TO-15, TO-17
- Data review and interpretation.
- Risk calculations using J-E models.
- Preparation of workplans and interpretive reports.
- Review of workplans prepared by others.
- Review of interpretive reports prepared by others.
- Interaction with regulatory agencies.
- Training on the vapor intrusion pathway and sampling methods.
- Mitigation system design & installation
- Expert witness and litigation support

HARTMAN
ENVIRONMENTAL GEOSCIENCE

Biosketch - Dr. Blayne Hartman

Blayne Hartman received his Ph.D. in geochemistry from the University of Southern California. He co- founded & operated H&P Mobile GeoChemistry, a business partnership offering on-site laboratory analysis, direct push environmental sampling, soil vapor surveys, and vapor intrusion services for twenty years. He sold H&P in 2008 and is currently an independent consultant offering vapor intrusion and soil gas support.

Dr. Hartman is a nationally recognized expert on soil vapor sampling, soil vapor analysis, and vapor intrusion. He has provided training on soil gas methods and vapor intrusion to County and State regulatory agencies in over 30 states, many of the EPA regions, the DOD, and numerous stakeholder groups and consultants. He has written numerous articles on the collection, analysis, and interpretation of soil vapor data, including chapters in four textbooks. He has participated in technical workgroups on soil vapor methods for EPA, CA-EPA, CA Regional Water Boards, County of San Diego, ITRC & ASTM and has reviewed/edited instructional manuals for the EPA OUST and Superfund groups. Over the past four years, Dr. Hartman has been a contributing author/editor to vapor intrusion and soil gas guidance documents to federal EPA, CA-EPA, San Diego County, ITRC, DOD, API, and more than 25 individual State documents. He is currently a trainer in the EPA-OUST, ITRC, and API vapor intrusion courses and was formerly a co-trainer of the ASTM vapor intrusion course.

Complete Resume – Blayne Hartman, Ph.D.

EDUCATION

Ph.D., Geological Sciences - 1983; University of Southern California, Los Angeles, CA

M.S., Geological Sciences - 1978; University of Southern California, Los Angeles, CA

B.S., Chemical Engineering- 1975; Clarkson University, Potsdam, New York

EMPLOYMENT HISTORY

Present: Hartman Environmental Geoscience, Vapor Intrusion Assessments of methane and volatile organic compounds (VOCs), Soil Gas Support

1998 to 2008: *H&P Mobile Geochemistry,* Carlsbad, CA, 92010
Founder, partner, principal geochemist.
1988 to 1998: *Transglobal Exploration and Geoscience (TEG), Inc.*, Solana Beach, CA
President , founder, principal geochemist.
1986 to 1988: *InterOcean Systems, Inc.*, San Diego, California,
Chief Geochemist
1982 to 1986: *Unocal Science and Technology Division*, Brea, California
Research Geochemist

SUMMARY OF PROFESSIONAL EXPERIENCE

Dr. Hartman is a nationally recognized expert on soil vapor sampling, soil vapor analysis, and vapor intrusion of volatile compounds and methane. He has provided training on soil gas methods and vapor intrusion to County and State regulatory agencies in over 30 states, many of the EPA regions, the DOD, and numerous stakeholder groups and consultants. He has written numerous articles on the collection, analysis, and interpretation of soil vapor data, including chapters in four textbooks. He has participated in technical workgroups on soil vapor methods for EPA, CA-EPA, ITRC, ASTM, CA Regional Water Boards, County of San Diego, has reviewed/edited instructional manuals for the EPA OUST and Superfund groups, and lectured on soil gas methods in the EPA-OSWER vapor intrusion seminars. He has been involved with five research studies with EPA-ORD on soil gas methods, soil gas temporal variations and indoor air variations in 2011, 2010, 2009, 2008, & 2007.

At H&P Geochemistry, Dr. Hartman was primarily responsible for geochemical data interpretation, corporate and business development, and method development. As Founder and President of TEG, Dr. Hartman was personally responsible for geochemical technical development, equipment design and maintenance, laboratory director, applications development, and implementation of exploration programs, analyses, and reporting. Prior to co-founding TEG, Dr. Hartman was chief marine geochemist with InterOcean Systems, where his responsibilities included direction of marine sediment and bottom-water geochemical exploration programs. As a research chemist with Unocal Research, Dr. Hartman was responsible for development of geochemical prospecting techniques in onshore and offshore applications including fingerprinting of methane and light hydrocarbons using isotopes.

PRESENTATIONS & TRAINING ON SOIL GAS METHODS & VAPOR INTRUSION

Too numerous to list. Go to www.handpmg.com, Presentations & Training for a partial list.

RECENT PUBLICATIONS ON SOIL GAS METHODS & VAPOR INTRUSION

Hartman, B. (2010). *Vapor Intrusion Pathway: Regulatory Updates and Issues Specifically for Petroleum Hydrocarbons,* LustLine, November 2010.

McHugh, Thomas E., Hammond, Douglas E., Nickels, Tim & Hartman, Blayne (2008) 'Use of Radon Measurements for Evaluation of Volatile *Organic Compound (VOC) Vapor Intrusion*', Environmental Forensics, 9:1, 107 - 114

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Hartman, B. and J. Jacobs (2000a). *Soil vapor principles*, in Standard Handbook of Environmental Science, Health, and Technology, Lehr, J. and J. Lehr, eds., Mc Graw Hill, ISBN#0-07-038309-X.

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REGULATORY GUIDANCE DOCUMENTS CONTRIBUTED TO

- CA Leaking Underground Fuel Tanks (LUFT) Manual, 2011
- EPA-OUST Vapor Intrusion Guidance, 2011
- San Diego County Dept. Env. Health Soil Gas Collection Guidance, 2011
- San Diego County Dept. Env. Health Soil Gas Analytical Guidance, August 2011
- CA-EPA (DTSC) Soil Gas Collection Guidance, March 2010
- CA-EPA (DTSC) Soil Gas Collection Guidance, 2011 & 2003
- ASTM Vapor Intrusion Standard, March 2008
- ITRC Vapor Intrusion Guidance, February 2007
- States of CA, MO, MI, TN, AZ, NY, NJ, KS, IN, WA, NH, WI, AK, OH, HI
- San Diego County Building Dept. Methane Testing Ordinance, 2001
- EPA OUST Site Assessment Manual, 1997
- LA-RWQCB Soil Gas Analytical Guidance, 1997-1992

REFERENCES

- Jeff Kuhn, MT-DEP, jkuhn@mt.gov, 406-841-5055
- John Boyer, NJ-DEP, john.boyer@dep.state.nj.us, (609) 984-9751
- Kevin Graves, CA-SWQCB, kgraves@waterboards.ca.gov, 916-341-5782
- Robin Davis, UT-DEP, rvdavis@utah.gov, 801-512-4767
- Brian Schumacher, EPA-ORD, schumacher.brian@epa.gov, 702-513-2661
- Lorraine LaFreniere, Argonne Nat'l Lab, lafreniere@anl.gov, 630-252-7969
- Todd Ririe, BP-Arco, TODD.RIRIE@BP.COM, 714-670-3062
- Robin Mongeon, NH-DEH, rmongeon@des.state.nh.us
- Richard Spiese, VT-DEP, Richard.Spiese@state.vt.us
- John Menatti, UT-DEP, jmenatti@utah.gov, 801-536-4159

CURRENT & RECENT PROJECT DESCRIPTIONS

Site: Clocktowers Site, Lancaster PA
Date Conducted: March 2011 to Present (project in progress)
Client: General Dynamics OTS
Oversite Agency: PA-DEP & EPA Region 3
Project Description: Vapor intrusion assessment of TCE to existing school and residential units located on a former watch manufacturing facility property. Hartman providing work scope, conducted soil gas, sub-slab soil gas, and indoor air sampling programs, on-site analysis by Method TO-14, and data interpretation.

Site: Research House, Indianapolis, IN
Date Conducted: August 2011 to Persent (project in progress)
Client: Dr. Brian Schumacher, EPA-ORD, Las Vegas
Oversite Agency: EPA-ORD
Project Description: Research program by EPA studing temporal variation of soil gas and indoor concentrations. Hartman proving real-time, continuous (24 hour) monitoring of chloroform, TCE, and PCE by method TO-14 for a period of 4 months.

Site: Residential neighborhood, Phoenix AZ
Date Conducted: June 2011 to Present (project in progress)
Client: Motorola/Freescale Semiconductor
Oversite Agency: EPA Region 9
Project Description: Vapor intrusion assessment of over 100 residential units located over a TCE groundwater plume. Hartman providing work scope, conducted soil gas, sub-slab soil gas, and indoor air sampling programs, and data interpretation.

Site: Residential neighborhood**,** Miles City, MT
Date Conducted: May 2011 to present (project in progress)
Client: Trinity Industries, Dallas TX
Oversite Agency: Montana DEQ
Project Description: Vapor intrusion assessment of houses neighboring a rail yard located over diesel contamination. Hartman providing work scope, conducted soil gas, sub-slab soil gas, and indoor air sampling programs, and data interpretation.

Site: 20 townships in rural Kansas
Date Conducted: 2008 through 2011
Client: USDA & Argonne National Laboratory
Oversite Agency: Kansas DHE
Project Description: Hartman consucted a preliminary vapor intrusion screening assessment of approximately 20 townships in rural Kansas with former or current grain storage silos using carbon tetrachloride. In Hanover KS, Hartman provided a detailed vapor intrusion assessment of carbon tetrachloride in ~ 20 residences located near a former US grain storage site. Hartman provided work scope, conducted soil gas, sub-slab soil gas, and indoor air sampling programs, and data interpretation.

Site: Residential neighborhood**,** Seal Beach, CA
Date Conducted: 2009 - 2010
Client: Arco
Oversite Agency: CA-EPA
Project Description: Vapor intrusion assessment of ~ 50 houses neighboring a operating Arco service station. Hartman providing work scope, conducted soil gas, sub-slab soil gas, and indoor air sampling programs, and data interpretation.

Peer Reviewer Conflict of Interest Certification

Peer Review: *Proposed Rule: Addition of a Subsurface Intrusion Component to the Hazard Ranking System*; 40 CFR Part 300; EPA-HQ-SFUND-2010-1086; FRL_XXXX-X (review draft).

A conflict of interest or lack of impartiality exists when the proposed peer reviewer personally (or the peer reviewer's immediate family), or his or her employer, has financial interests that may be affected by the results of the peer review; or may provide an unfair competitive advantage to the peer reviewer (or employer); or if the peer reviewer's objectivity in performing the peer review may be impaired due to other factors. When the Peer Reviewer knows that a reasonable person with knowledge of the facts may question the peer reviewer's impartiality or financial involvement, an apparent lack of impartiality or conflict of interest exists.

The following questions, if answered affirmatively, represent potential or apparent lack of impartiality (*any affirmative answers should be explained on the back of this form or in an attachment*):

- Did you contribute to the development of the document under peer review, or were you consulted during its development, or did you offer comments or suggestions to any drafts or versions of the document during its development? ☒ No ☐ Yes
- Do you know of any reason that you might be unable to provide impartial advice on the matter under consideration in this peer review, or any reason that your impartiality in the matter might be questioned? ☒ No ☐ Yes
- Have you had any previous involvement with the review document(s) under consideration? ☒ No ☐ Yes
- Have you served on previous advisory panels, committees, or subcommittees that have addressed the topic under consideration? ☒ No ☐ Yes
- Have you made any public statements (written or oral) on the issue? ☒ No ☐ Yes
- Have you made any public statements that would indicate to an observer that you have taken a position on the issue under consideration? ☒ No ☐ Yes
- Do you, your family, or your employer have any financial interest(s) in the matter or topic under peer review, or could someone with access to relevant facts reasonably conclude that you (or your family or employer) stand to benefit from a particular outcome of this peer review? ☒ No ☐ Yes

With regard to real or apparent conflicts of interest or questions of impartiality, the following provisions shall apply for the duration of this peer review:

(a) Peer Reviewer warrants, to the best of his/her knowledge and belief, that there are no relevant facts or circumstances that could give rise to an actual, apparent, or potential organizational or personal conflict of interest, or that Peer Reviewer has disclosed all such relevant information to EMS or to EPA.
(b) Peer Reviewer agrees that if an actual, apparent, or potential personal or organizational conflict of interest is identified during performance of this peer review, he/she immediately will make a full disclosure in writing to EMS. This disclosure shall include a description of actions that Peer Reviewer (or his/her employer) has taken or proposes to take after consultation with EMS to avoid, mitigate, or neutralize the actual, apparent, or potential organizational conflict of interest. Peer Reviewer shall continue performance until notified by EMS of any contrary action to be taken.

Blayne Hartman 12-7-2011 ☐ Check here if any explanation is attached

Signature Date

BLAYNE HARTMAN

Printed Name

HARTMAN ENVIRONMENTAL GEOSCIENCE

Affiliation/Organization

Peer Reviews

Paul Johnson
(Arizona State University)

- **Charge Question Comments**
- **CV**
- **COI Certification**

Peer Review Charge for:
U.S. Environmental Protection Agency (EPA). *Proposed Rule: Addition of a Subsurface Intrusion Component to the Hazard Ranking System*; 40 CFR Part 300; EPA-HQ-SFUND-2010-1086; FRL_XXXX-X (review draft).

Background
The U.S. Environmental Protection Agency (EPA) is proposing to include a subsurface intrusion (SsI) component to the Hazard Ranking System (HRS). Subsurface intrusion is the migration of hazardous substances from the unsaturated zone and/or the surficial ground water into overlying structures. The HRS is the principal mechanism the EPA uses to evaluate sites for placement on the National Priorities List (NPL). The subsurface intrusion component addition (this addition) would primarily expand the number of available options for EPA and state and tribal organizations performing work on behalf of EPA to evaluate potential threats to public health and the environment from releases of hazardous substances.

This addition will allow the HRS evaluation to directly consider human exposure to hazardous substances that enter building structures through subsurface intrusion, and thus enable sites with subsurface intrusion contamination to be evaluated for placement on the NPL. This addition will make the HRS more accurate in assessing a site's relative potential risk. The Agency is not considering changes to the remainder of the HRS except for minor updates reflecting changes in terminology related to revised toxicological parameters. This proposed regulatory change does not affect the status of sites currently on or proposed to the NPL.

Expertise Required
The peer review panel for U.S. EPA's *Proposed Rule: Addition of a Subsurface Intrusion Component to the Hazard Ranking System* should include expertise in:

Academia: Panelist must have experience working, researching, and developing opinions on the topic of vapor intrusion. Expertise in the history and recent developments of vapor intrusion research and development, remediation, and mitigation technologies is required. Expertise in hydrogeology, chemistry, knowledge of public health risks associated with indoor air threats, and the subsurface migration of volatile hazardous substances is necessary. Experience working on Superfund issues is highly recommended, but not necessary.

Peer Review Charge Questions

1. Potential for subsurface exposure (intrusion) into occupied structures
Background: The current HRS evaluates the likelihood of a release of a hazardous substance when an actual release has occurred through either chemical analysis or direct observation. The current HRS also evaluates the potential for a release to occur within the ground water, surface water and air pathways (see section 2.3 of the current HRS). The potential for a release is determined by the consideration of pathway specific factors that aid the site evaluator in predicting whether a release to the pathway is likely to occur. These factors are based on containment features of the source of contamination (whether or not hazardous substance can get out), route characteristics specific to each pathway (how far hazardous substances could migrate based on knowledge of site conditions) and include

physical/chemical properties of the hazardous substances being evaluated (how the hazardous substances act in the environment).

Proposed Approach: EPA is proposing a parallel approach for evaluating potential and actual exposure of intruded hazardous substances for the subsurface intrusion addition to the HRS. In determining which route characteristics are appropriate for evaluating potential exposure to subsurface contaminants, EPA examined present modeling methods such as the Johnson-Ettinger model and also considered multiple lines of evidence approaches which estimate the levels of contaminant exposure based on numerous route characteristics. In addition, EPA examined the relationship between these factors to determine which have the greatest influence on the likelihood that an exposure would occur, and then incorporated these factors within its proposed approach. EPA also gave careful consideration to ensure that the data necessary to obtain route characteristic factors could be measured or calculated on a site-specific basis and in a manner consistent with current HRS evaluations. Based on the Agency's analysis, the following three factors for which sufficient site-specific information could be collected during a site inspection represented the greatest impact on the potential for exposure: (1) depth to contamination; (2) vertical migration; and (3) vapor migration potential (see Figure 1).

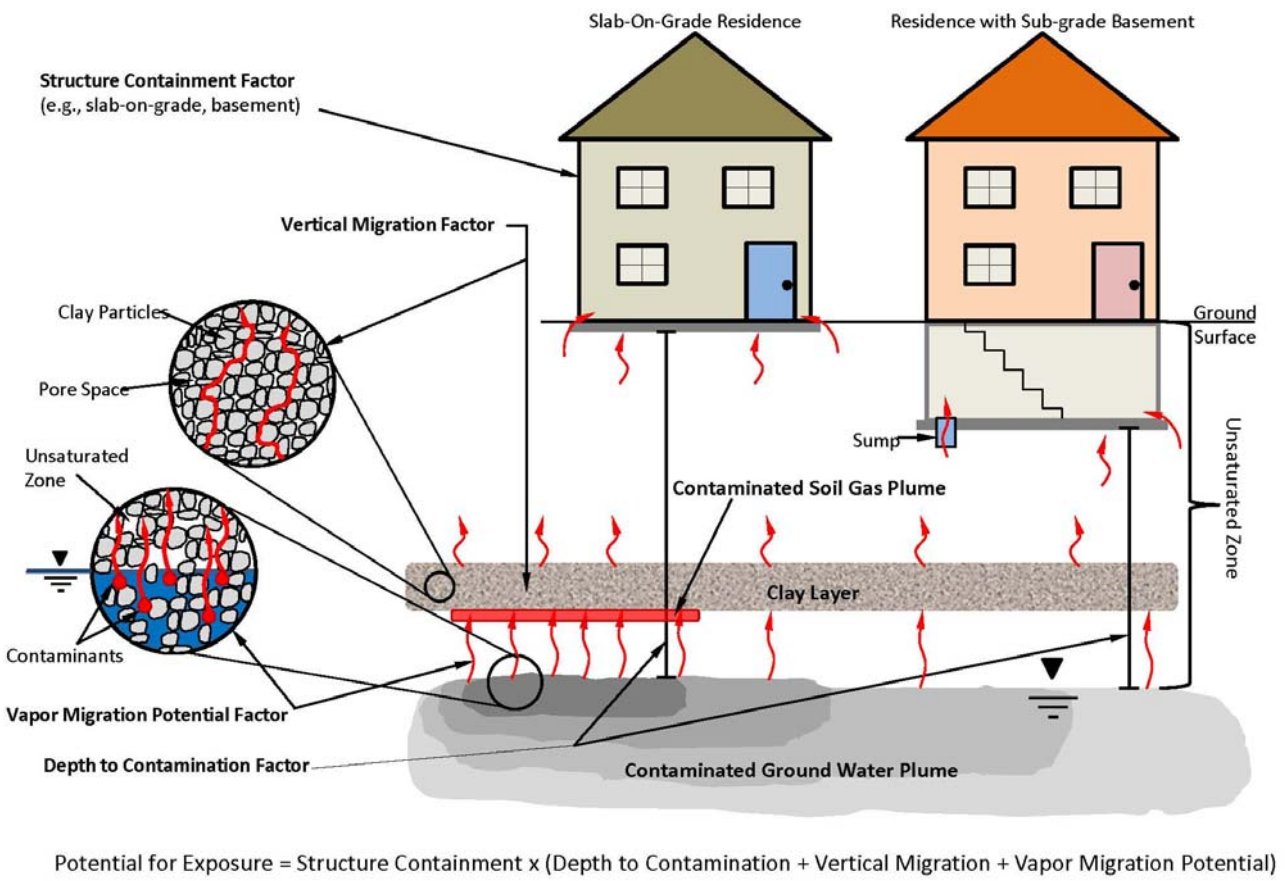


Figure 1

Charge Question #1: Is EPA's proposed approach scientifically reasonable for evaluating and assigning proportional weightings for the following when evaluating potential for exposure? If no, what alternative approach would you recommend?

Overall, the structure of this section seems to be based more on conventional wisdom (and common pathway misconceptions) than on the latest understanding gained from theory/modeling and critically-reviewed empirical observations.

For example, field data and modeling show that the single-most significant influence on vapor intrusion impacts is whether or not a chemical is aerobically biodegradable, and that is not considered here.

In addition, for chemicals that do not significantly biodegrade during vapor transport (i.e., chlorinated solvents), the potential significance of vapor intrusion impacts is primarily related to the quantity {(C D^{eff}/L A_B)/(Q_B C^{target})}, where C is the source concentration, D^{eff} is the overall effective vapor diffusion coefficient, L is the depth to the concentration C, A_B and E_B are the building footprint and exchange rate, and C^{target} is the target concentration for adverse impacts. Of these quantities, the ones that might vary most from site to site and have the greatest influence on the potential for adverse impacts are the ratios (C/C_{target}) and (D^{eff}/L). The first is a measure of how strong the source is, while the second is a measure of the overall resistance to transport through the soil. The relative interplay between these quantities, the strength of the source, and the realistic sensitivity of (D^{eff}/L) to depth and soil type are not reflected in the proposed approach.

The proposed approach could be replaced by a simpler one based on only two primary factors: one derived from (C/C_{target}) ratios and one from a soil type vs. depth table. There could also be a modifying factor for chemical degradability that would be based on (total of all biodegradable concentrations/oxygen content in air and depth).

a. Consideration of the construction/structure type for which sufficient site-specific information could be collected during a site inspection for the occupied structure;

With respect to Table 5-12 (structure containment), I am not aware of definitive studies or significant anecdotal experiences that support the inclusion of Items 4, 5, or 7. USEPA's empirical database does not show a clear dependence on foundation construction (Item 4) and I am not aware of any definitive validation studies of the performance of passive systems (Items 5 and 7). It is also not clear that Item 3 is needed either, especially given its value and the reality that it is not feasible to identify all intrusion points to buildings. Item 1 should include evidence of intrusion of hazardous contaminants (not just non-hazardous contaminants). This table could probably be reduced to three items (current Item 1 combined with Item 2, a combined Item 6 and Item 8, Item 9)

b. Distance between occupied structure and depth of contamination; and

There are ambiguities and potential issues with application of Table 5-13 (depth to contamination) and its associated discussion. In particular, it is not clear if the authors intended for contaminant concentrations to be below background or detection levels for all distances less than this depth, or if it is simply the depth to the closest detection above background or detection levels? These are two very different concepts and have different implications for use in a scoring system like this.

For example, if the authors intended contaminant concentrations to be below background or detection levels for all distances between the foundation and this depth, then Table 5-13 is likely overly conservative.

On the other hand, if the depth to be used is the depth to the closest detection above background or detection levels (independent as to whether or not there are non-detect/background-level samples until that point is encountered), then the table might not be sufficiently protective. For many sites, there may only be groundwater data available, and so people will be using depth to groundwater with Table 5-13. The vapor intrusion impact dependence on depth to groundwater has not been shown through field data or modeling to be as significant as suggested by this table (e.g., modeling would show that at most intrusion rates would be 10X less for a 200 ft depth than for a 20 ft depth for comparable groundwater concentrations and soils, and empirical data show little dependence on depth for the range of depths represented in the empirical data set).

The following revisions are suggested:

1) *Clarify the meaning of "depth to contamination".*
2) *If contaminant concentrations are supposed to be below background or detection levels for all distances less than this depth (unlikely to be verified with typical data used for ranking), then only two or three depth categories are justified and the value should be 0 for all depths greater than about 10 or 20 ft.*
3) *If it is the depth to the closest detection above background or detection levels, then Depth to Contamination Assigned Values should not decline as significantly with depth as happens in Table 5-13. It is justified to have a high value for cases with liquid intrusion or very shallow depths to groundwater, but depths to about 100 ft (most sites) should probably all have about the same value and depths greater than 100 ft (few sites) should probably have values that are within 50% of the <100 ft values. This is in part because there is a second important dimension not considered here in the factors – contaminant concentration. For example, a groundwater plume with a 20 ug/L concentration at 10 ft depth poses the same risk as a groundwater plume with a 200 ug/L concentration at a 100 ft depth and a groundwater plume with a 400 ug/L concentration at a 200 ft depth (all other factors being equal, and a non-biodegradable chemical).*

c. Evaluation of the vertical migration factor based on the thickness and porosity/permeability of geologic materials in the interval between the lowest point of an occupied structure and the highest known point of hazardous substances in the subsurface.

The vertical migration factor should be presented as being related to "soil type" and not effective porosity/permeability as these quantities are irrelevant to the vapor intrusion pathway and only soil descriptions are used in Table 5-14 anyway.

Categories 2 and 3 in Table 5-14 should be adjusted so that "silty loams; loesses; silty clays; sediments that are predominantly silts; moderately permeable till (fine-grained, unconsolidated till, or compact till with some fractures)" should be included in Table 2. EPA's own modeling in its pathway assessment guidance document (as well as other publications) and empirical data show little difference in behavior across this range of soil types.

Depth creeps in as an overly-sensitive modifying factor in Table 5-15, compounding its use already in Table 5-13.

2. Hazardous Waste Quantity

Background: In the current HRS, the hazardous waste quantity factor reflects the risk consideration related to the magnitude and duration of either the release for ground water, surface water, and air pathways, or the exposure for the soil exposure pathway (see section 2.4.2 of the current HRS). Hazardous waste quantity is evaluated for all four pathways. At each site evaluated, EPA uses a four-tiered hierarchy for calculating the hazardous waste quantity that is based on (1) constituent quantity; (2) waste stream; (3) volume; and (4) area of the sources of hazardous waste at the site. EPA uses minimum waste quantity factors when there is insufficient information to estimate hazardous waste quantity. In the ground water, surface water, and air pathways, the HRS evaluates the total quantity of hazardous substances available to migrate from the original sources (how much has migrated and how much can be released in the future). In the soil exposure pathway, the hazardous waste quantity does not include the total amount of hazardous substances in all site sources, but rather is based on the amount of hazardous substances to which a receptor can be exposed where actual contamination has been documented. In other words, for the soil exposure pathway, the risk posed by a release of hazardous substances is directly related to the amount of hazardous substances that receptors are exposed to, as opposed to how much of the hazardous substances from the original sources may migrate to the receptors.

Proposed Approach: EPA is proposing a parallel approach to the soil exposure pathway to calculate hazardous waste quantity for the subsurface intrusion addition to the HRS. Since the subsurface intrusion component also focuses on exposure, the waste quantity factor value for this component should also reflect only the amount of hazardous substances that people actually are exposed to (the amount present in occupied structures). EPA is proposing to use a similar four-tiered hierarchical approach to calculate hazardous waste quantity within occupied structures with contamination. In cases where no home is subject to actual contamination, EPA is proposing to use minimum waste quantity factors. In situations where there is an observed release within a structure above benchmarks (Level I), a default value of 100 is proposed for the hazardous waste quantity factor value. This value is not used in the current soil exposure pathway, but is consistent with the ground water, surface water, and air pathways and reflects the increased exposure risk of a release within an occupied structure.

Charge Question #2: Is EPA's approach of basing the hazardous waste quantity on the amount of contaminants that could be found in the intruded structures appropriate? If no, what alternative approach would you recommend?

It is suggested that this be eliminated as a factor in assessing the relative risk of vapor intrusion, as hazardous waste quantity has little relevance to vapor intrusion impacts, except to the extent that it might impact the longevity of the contaminant vapor source.

The proposed approach makes little sense and is not technically defensible. The mass of contaminant in the residence is irrelevant for this pathway; instead it is the duration of time that the vapor source will produce vapor concentrations of significance that is the relevant quantity. That in turn is related to source zone longevity (under natural or remediation conditions) and groundwater migration rates for dissolved plume sources. That is likely to be a very long time – probably decades for most sites evaluated by this process, unless source removal and or control are going to reduce the time frame to less than a decade.

Source concentrations should be included somewhere in the analysis as discussed above.

3. Population score

Background: Within the current HRS, receptors are evaluated in two main categories: whether they are exposed to 1) actual contamination; or 2) potential contamination (see section 2.5 of the current HRS). If receptors are exposed to contaminant levels meeting observed release criteria, they are identified as actually contaminated; however, if the receptors are not exposed to contaminants that meet the observed release criteria but are within the target area being evaluated, they are considered potentially contaminated. Actual contamination is further divided into two sub-categories based on whether the hazardous substance is present at or above a health-based benchmark. If the concentration of the hazardous substance released at the receptor is greater than a health-based benchmark, the receptors are identified as Level I receptors and are weighted (multiplied by a factor of 10) in scoring. If the release concentrations are less than a health-based benchmark, the receptors are identified as Level II receptors and are not weighted (multiplied by a factor of 1). Potential receptors are distance/dilution weighted; in other words, the farther away a receptor is located from a source, the less the population contributes to the site score.

Proposed Approach: EPA is proposing to generally use the same receptor weighting structure in the subsurface intrusion component as the one used in the current HRS. Those receptors in the area(s) of observed exposure (AOE) are considered actually contaminated, and those in the area(s) of subsurface contamination (ASC) are considered potentially contaminated (See Figure 2). The receptors in an AOE are further differentiated based on whether the contaminant concentrations are at levels above identified benchmarks (Level I) or are at levels establishing a release but below identified benchmarks (Level II). The benchmarks that EPA is proposing to use for the subsurface intrusion component are:

- Screening concentration for cancer effects; and

- Screening concentration for non-cancer effects (systemic toxicants).

Consistent with the weighting of populations throughout the HRS, the proposed subsurface intrusion component will weight targets within the AOE subject to Level I contaminant concentrations by a factor of 10 and weight targets subject to Level II contaminant concentrations by a factor of 1.

EPA is proposing to evaluate the weighting of targets within the ASC based on sub-slab, soil gas, and/or ground water samples. Potential receptors within the ASC receive less weight (population multiplied by a factor of 0.1), except in cases where a sub-slab sample indicates contaminant levels are at least 10 times higher than a health-based benchmark (population is multiplied by a factor 0.75). The value of 0.75 was determined based on an evaluation of paired data when both a sub-slab and indoor air sample were collected. The 0.75 weighting reflects the observation that for approximately 80 percent of the sampling events where contamination was detected in the sub-slab, contamination was also detected in the indoor air sample. The order of magnitude adjustment applied to the health-based benchmark reflects EPA's finding that, in such paired sampling events, the indoor air sample concentration is, on average, 10 times lower than the sub-slab sample concentration.

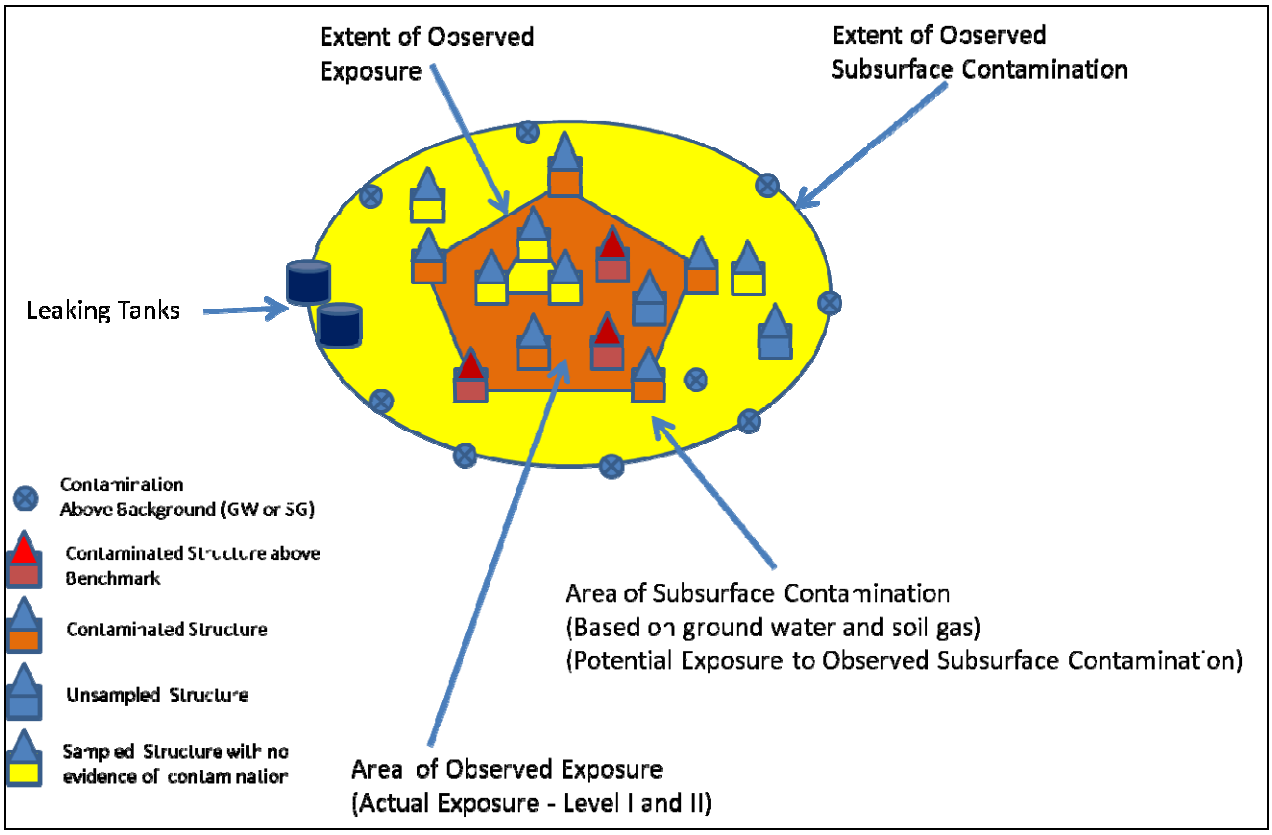


Figure 2

Charge Question #3: Is it appropriate to consider individuals/populations located within the area of subsurface contamination (ASC) to be at a higher relative risk in situations when sub-slab contaminant concentrations are at least ten times greater than a health-based benchmark? If no, please explain.

It should be recognized that this approach is predicated on two assumptions, both of which have weaknesses:

1) *It is assumed that areas of subsurface contamination have a 10X lower relative potential for impact than areas of observed contamination, and*

2) *Sub-slab soil gas samples are reliable indicators of vapor intrusion.*

With respect to (1), the preamble document contains the paragraph:

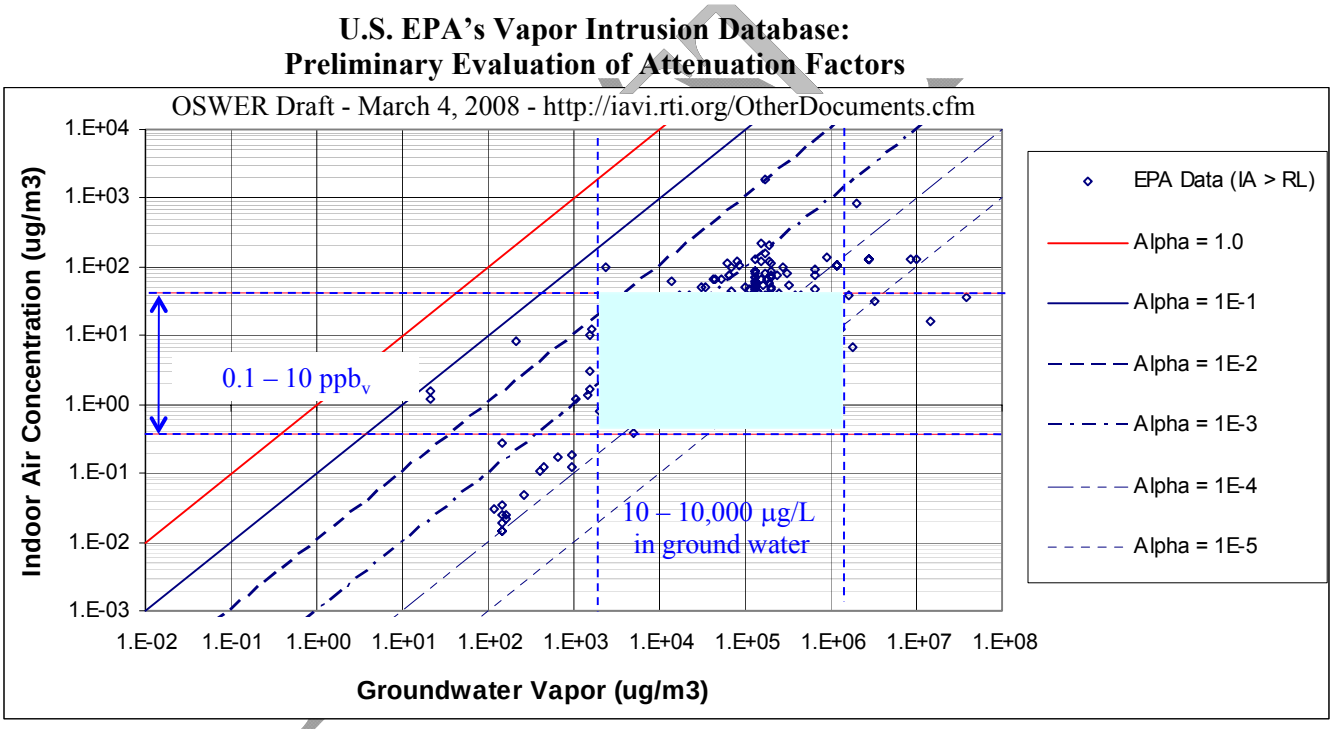
"When an observed exposure has not been established, the EPA is proposing to evaluate the potential for exposure within structures located in the ASC within the subsurface intrusion component. Given that contamination within an ASC is documented as present below these structures, there is a potential that intrusion and exposure to the intrusion has occurred but that sampling has not been performed at the time the exposure was taking place. As explained in section XXXX of the Proposal TSD, the factors affecting when intrusion will occur and the rate of subsurface intrusion are extremely time-, site- and climatic-specific. Sampling may not have been performed in these structures, or, even if performed during the limited time period of a site inspection, the sampling may have been during conditions that the intrusion was not occurring or occurring at levels not detectable or differentiable from background sources of the contaminant. Site inspections are conducted over a limited period (usually 1 to 3 days). Therefore it is important that the potential for exposure be included as a consideration when evaluating subsurface intrusion threats."

This paragraph reasonably captures the current state of the practice – namely that conventional point in time and point in space sampling (e.g., Summa canisters) has been shown to be inadequate for confidently assessing the presence or absence of vapor intrusion. In addition, empirical data have shown unacceptable and highly variable indoor air impacts at chlorinated solvent sites with groundwater concentrations as low as 10 ug/L, with no clear dependence on groundwater concentration, soil type, or depth. Thus, the reality is that we are unable to confidently identify a priori whether homes are expected to be impacted, and which homes are likely to be the most impacted above a dissolved groundwater plume.

This proposed approach seems to ignore this. There is no basis for assigning lower risks to areas of subsurface contamination having similar subsurface conditions as nearby areas of observed impacts simply because impacts have not been observed. It is arguably more appropriate to assume that the potential for exposure is the same in all areas having similar conditions, unless there has been extensive data collection to prove otherwise. The other factors discussed above already reflect differences in potential for impacts based on soil type and depth.

USEPA's database (raw data – not the alpha factor analysis) should be reviewed carefully in dealing with the issue of relative risk of observed areas of exposure vs. areas of subsurface contamination. For example, the figure below is from this database, and to it has been added lines and text by P.C. Johnson

(2011, presentations) to point out that indoor air concentrations of concern have been observed across the full concentration range of interest for chlorinated solvent sites:



With respect to (2), the approach ignores the debate and recent technical advances regarding the utility of sub-slab soil gas samples for pathway assessment. It has been shown at a field study site in Utah that indoor air sources can cause sub-slab contaminant vapor plumes; thus, the nearly 1:1 correlation between indoor air and sub-slab soil gas detections is not validation that sub-slab samples are good indicators of vapor intrusion as stated above (as 1:1 correlation would occur with indoor sources as well).

There are also field study results showing temporal and spatial variability in sub-slab soil gas samples and experience that sub-slab sampling may not even have been done for pathway assessment by the time that HRS calculations are being done.

4. Multi-story and multi-tenant structures

Background: In the current HRS, multi-story and multi-tenant buildings are evaluated based on population associated with an actually or potentially impacted target. In the ground water pathway, all residents who are served by a well are considered subject to the actual or potential contamination of the well. In the air pathway, all residents who have an opportunity to breathe ambient air are considered subject to the actual or potential contamination of the ambient environment within a distance category. All receptors within a contaminated surface water stretch are subject to the level of contamination associated with that surface water stretch. In the soil exposure pathway, receptors must be able to come in contact with areas of contamination. In determining the likelihood a person will come in contact with areas of contamination, the HRS uses a 200 foot rule (see section 5.1.3 of the current HRS) because it is reasonable to assume that that a person will walk/use areas within a 200 foot areal extent of their residence/property. The 200 foot rule is used regardless of whether a building is multi-tenant or multi-story (the assumption being that is reasonable for people to use the outside of their properties).

Proposed Approach: EPA is proposing to evaluate multi-story/multi-tenant buildings utilizing a similar approach as soil exposure, limiting the receptors to those individuals that reasonably can be exposed to subsurface intrusion within an occupied multi-tenant/multi-story building. EPA is proposing to consider all receptors exposed to actual contamination as the population inhabiting the floor of the intruded space and the population inhabiting the floor above and the floor below the intruded space when calculating waste quantity and population. EPA considers that this approach will more accurately reflect risk to both actual and potential receptors, while also minimizing the potential for over counting (Figure 3).

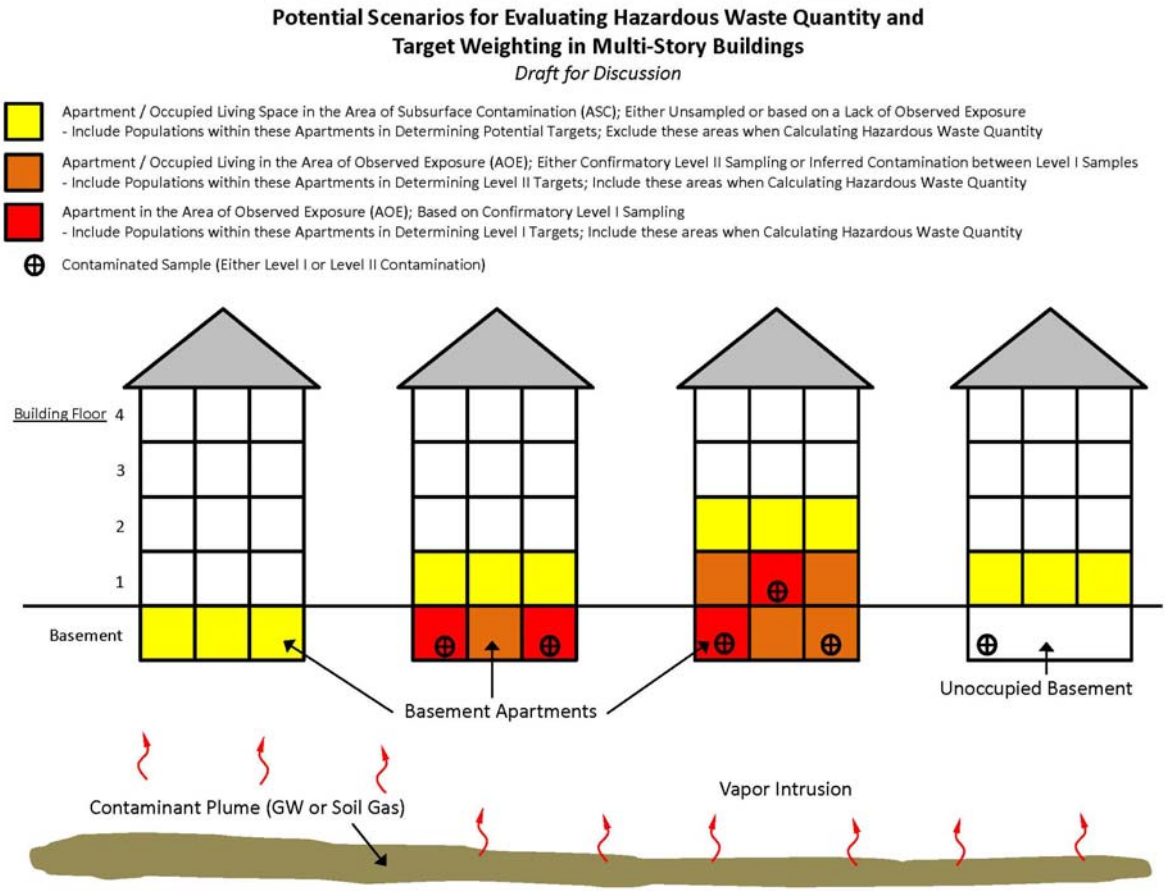


Figure 3

Charge Question #4: When calculating waste quantity and population, is it scientifically reasonable for populations in multi-story or multi-tenant structures to be evaluated based on using only the population inhabiting the intruded space and the population on the floor above and below the intruded space (For example, if contamination is found on the first floor, population from the basement and second floor would be used in the calculation. If contamination is found on the fifth floor, population from the fourth floor and sixth floor would be used in the calculation – for further explanation, see detailed discussion in above paragraph "Proposed Approach")? If no, what alternative approach would you recommend?

It is not clear why possible exposures in the lowest floors (closest to the vapor source) would ever be discounted? Otherwise, I have no comments on this approach as I have little experience with impacts in multi-story buildings to draw from at this point in time. It is difficult to imagine many scenarios where this issue will be a determining factor in HRS calculations.

5. Factor Value for Workers

Background: In the current HRS, for the resident population threat of the soil exposure pathway, a factor value for workers is assigned based on the total number of workers present within the area of observed contamination. These factor values range from 0 to15, depending on the number of workers exposed to outdoor contamination (see section 5.1.3.3 of the current HRS).

Proposed Approach: EPA is proposing to mirror the procedures for the resident population threat in the soil exposure component when assigning a worker factor value in the subsurface intrusion component (see Table 5-4 in section 5.1.3.3 of the current HRS). However, since it is anticipated that workers spend a larger percentage of their time indoors and therefore may be more exposed to contamination resulting from subsurface intrusion than to outdoor soil (or other surface) contamination, EPA is proposing to assign workers exposed to subsurface intrusion a higher weighting (i.e., factor values ranging from 0 to 45).

Charge Question #5: Because of longer exposure times indoors, is it reasonable to assume that the relative risk is three times greater for workers exposed to subsurface intrusion within the workplace than it is for workers exposed to outdoor surface contamination at the workplace? If no, please explain.

This seems to be a comparison of apples and oranges (indoor vapor inhalation vs. outdoor soil exposure), so assuming some fixed correlation between the two would be inappropriate.

It might be reasonable to assume that worker inhalation risks would be less than those of residents in homes in similar conditions because of differences in exposure durations. The type of work might affect both the building ventilation and worker breathing rates, so indoor concentration rates might be lower and inhalation higher in more industrial settings vs. office and residential settings.

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Education:

1987	Ph.D. - Princeton University - Chemical Engineering
1984	M.A. - Princeton University - Chemical Engineering
1983	B.S. - University of California, Davis - Chemical Engineering

Academic and Administrative Experience:

2011 – present	Ira A. Fulton Schools of Engineering, Dean
2006 – 2011	Ira A. Fulton Schools of Engineering, Executive Dean
2006 – 2007	Ira A. Fulton School of Engineering, Executive and Interim Dean
2004 – 2006	ASU Associate Vice President – Research
2003 – 2004	Ira A. Fulton School of Engineering, Associate Dean – Research
2002 – 2003	College of Engineering and Applied Science Interim Associate Dean - Research
2000 – present	Assistant Chair – Graduate Programs Dept. of Civil and Environmental Engineering
2003 – present	Professor, Arizona State University
1997 - 2003	Associate Professor, Arizona State University (tenured)
1994 - 1997	Associate Professor, Arizona State University (untenured)

Industrial Experience:

1994 – present	Consultant to industry and federal and state agencies
1993 - 1994	Senior Research Engineer, Shell Development, Houston
1990 - 1993	Research Engineer, Shell Development, Houston
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Other:

2003 – 2011	Editor-In-Chief, National Ground Water Association Journal – *Ground Water Monitoring and Remediation*
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Awards & Honor Societies:

National Ground Water Association Keith E. Anderson Award	2011
Strategic Environmental Research and Development Program (SERDP) Project of the Year	2011
Outstanding Educator (AZ Society of Professional Engineers)	2011
2006 AEHS Academic Career Recognition Award	2006
ASCE/CERF Charles Pankow Award for Innovation Finalist	2005
White House Closing the Circle Award Winner	2003
National Pollution Prevention Roundtable Most Valuable Pollution Prevention Project Award	2003
ASCE/CERF Charles Pankow Award for Innovation Finalist	2003
Environmental Security Technology Certification Program (ESTCP) Project of the Year	2002
ASU College of Engineering Teaching Excellence Award	2002
CEAS Alumni SOAR Outstanding Faculty Advisor Award	2002
National Ground Water Association (NGWA) 2001 Outstanding Ground Water Remediation Project Award	2001
ASCE Journal of Environmental Engineering Editor's Award	2001
AWPCA Quentin Mees Research Award (w/C. Bruce)	2000
ASU Parents Association Teacher of the Year Finalist	2000
ASU College of Engineering Teaching Excellence Award	1998
ASCE Student Chapter Best Teacher Award	1996
AWPCA Quentin Mees Research Award	1995
NGWA/API National Conference Best Paper	1994
Shell Oil Company Recognition Award	1990, 1991, 1993, 1994
Princeton University Wallace Memorial Fellowship in Engineering	1986-1987
University of California Stauffer Chemical Scholarship	1983
University of California ARCO Scholarship	1982
American Military Engineers Scholarship	1982
Associate Western Universities DOE Research Fellowship	1981
Phi Kappa Phi - National Honor Society	
Tau Beta Pi - National Engineering Honor Society	
Pi Mu Epsilon - National Mathematics Honor Society	

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Other Peer-Reviewed Reviewed Publications:

1. Johnson P.C., R.L. Johnson, C.L. Bruce CL. 2010. *In Situ* Air Sparging for the Treatment of Dissolved Hydrocarbon Groundwater Plumes. In Stroo HF, Ward CH, eds, *In Situ* Remediation of Chlorinated Solvent Plumes, Vol 2, SERDP/ESTCP Remediation Technology Monograph Series. Springer Science+Business Media, LLC, New York, NY, USA, In Press.

2. Johnson R.L. and P.C. Johnson. 2010. *In Situ*Sparging for the Delivery of Gases in the Subsurface. In Kitanidis, P.K. and P.L. McCarty eds, *Delivery and Mixing in the Subsurface: Processes and Principles for In Situ Remediation.* SERDP/ESTCP Remediation Technology Monograph Series. Springer Science+Business Media, LLC, New York, NY, USA, In Press.

3. McAlary, T., R.A. Ettinger, P.C. Johnson, B. Eklund, H. Hayes, D.B. Chadwick, I. Rivera-Duarte. 2009. Review of Best Practices, Knowledge and Data Gaps, and Research Opportunties for the U.S. Department of Navy Vapor Intrusion Focus Areas. Technical Report 1982. May. SPAWAR Systems Center Pacific.

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5. Dablow, J.F., J.A. Pearce, P.C. Johnson. 1998. Steam and Electro-Heating Remediation of Tight Soils. Ann Arbor Press.

6. Johnson, P. C. and R. A. Ettinger. 1997. Some Considerations for the Design of In Situ Vapor Extraction Systems: Radius of Influence -vs- Radius of Remediation. Subsurface Restoration (C.H. Ward, J.A. Cherry, M.R. Scalf, editors). Ann Arbor Press. 209 - 216.

7. Hinchee, R.L., R.N. Miller, and P.C. Johnson. 1995. In Situ Aeration: Air Sparging, Bioventing, and Related Remediation Processes. Battelle Press. ISBN 1-57477-003-9.

8. Johnson, P.C., G.E. Hoag, R.H. Hinchee, R.A. Brown, and A.L. Baehr. 1994. Innovative Site Remediation Technology: Vapor Extraction-Based Technologies (Soil Vapor Extraction, Bioventing, Air Sparging, and Thermally-Enhanced Soil Vapor Extraction). USEPA/AAEE WASTECH Monograph. ISBN 1-883767-08-3.

9. Johnson, P.C. and A.J. Stabenau. 1991. HyperVentilate - A Software Guidance System Created for Vapor Extraction Applications - Users Manual. USEPA 600/R-93/028.

10. Johnson, P.C., R.L. Johnson, C. Neaville, E.E. Hansen, S.M. Stearns, and I.J. Dortch. 1995. Do Conventional Practices Indicate In Situ Air Sparging Performance?. In Situ Aeration: Air Sparging, Bioventing, and Related Remediation Processes (Hinchee, Miller, Johnson, eds.). Battelle Press. 1 - 20.

11. Bedient P.B. and P.C. Johnson. 1992. Soil Vapor Extraction Systems. Groundwater Remediation. Charbeneau, R.J., P.B. Bedient, and R.C. Loehr Eds.. Technomic Publishing Inc.. 143-160.

12. Johnson, P.C., C.C. Stanley, D.L. Byers, D.A. Benson, and M.A. Acton. 1991. Soil Venting at a California Site: Field Data Reconciled with Theory. Hydrocarbon Contaminated Soils and Groundwater: Analysis, Fate, Environmental and Public Health Effects, Remediation, Vol I." P.T. Kostecki and E.J. Calabrese (eds.). Lewis Publishers. 253 - 282.

13. Rixey, W.G., P.C. Johnson, G.M. Deeley, D.L. Byers, and I.J. Dortch. 1991. Mechanisms for the Removal of Residual Hydrocarbons for Soils by Water, Solvent, and Surfactant Flushing. In Petroleum Contaminated Soils Volume 4 (P.T. Kostecki and E.J. Calabrese Eds.). Lewis Publishers.

14. Johnson, P.C., Hertz, M.B. and D.L. Byers. 1990. Estimates for Hydrocarbon Vapor Emissions Resulting from Service Station Remediations and Buried Gasoline-Contaminated Soils. In Petroleum Contaminated Soils Volume 3 (P.T. Kostecki and E.J. Calabrese Eds.). Lewis Publishers. 295-326.

15. Johnson, P.C.. 1987. Frictional-Collisional Relationships for Particulate Flows and Their Application to Plane Shear Flows. Ph.D. Thesis. Department of Chemical Engineering. Princeton University

Invited Presentations/Papers:

1. Johnson, P.C., P. Dahlen, H. Luo, C. Holton, K. Gorder, E. Dettenmaier. 2011. Temporal Changes in VI Behavior:Considerations for Pathway Assessment. U. Washington/USEPA Superfund Research Center. June 15. Seattle, WA.

2. Johnson, P.C., P. Dahlen, H. Luo, C. Holton, K. Gorder, E. Dettenmaier. 2011. Temporal Changes in VI Behavior:Considerations for Pathway Assessment. 21at Annual Training Program – National Association of Remedial Program Managers. May 16-20. Kansas City, MO.

3. Johnson, P.C. and E. Nichols. 2011. Session Keynote: Measurement and Control of Subsurface Contaminant Discharge and Its Use in Decision-Making. RemTEC Summit. May 16-19. Chicago, IL.

4. Kavanaugh, M., K. Pennell, Johnson, P.C., and Anna Willett. 2011. Panel Discussion -Future of Subsurface Remediation Efforts in the United States: Barriers to Success. RemTEC Summit. May 16-19. Chicago, IL.

5. Johnson, P.C. 2011. Soil and Groundwater Remediation: Issues, Advances, and Challenges. Engineers Club of the West Valley. April. Sun City, AZ.

6. Johnson, P.C., P. Dahlen, H. Luo, C. Holton. 2011. Temporal Changes in VI Behavior:Considerations for Pathway Assessment. USEPA Workshop on Addressing Regulatory Challenges in Vapor Intrusion: A State of the Science Update Focusing on Chlorinated VOCs. AEHS 21st Annual Meeting and West Coast Conference on Soils, Sediments, Water. San Diego, CA.

7. Johnson, P.C. 2010.Session Keynote: Vapor Intrusion Pathway Assessment: State of the Practice and Opportuntites for v3.0. SERDP/ESTCP Partners Conference. December, 2010.

8. Johnson, P.C., P. Dahlen, H. Luo, C. Holton, K. Gorder, E. Dettenmaier. 2011. Integrated Field-scale, Lab-scale, and Modeling Studies for Improving Our Ability to Assess the Groundwater to Indoor Air Pathway. SERDP Technical Exchange Meeting on Vapor Intrusion. August 16 - 17. Salt Lake City, UT.

9. Johnson, P.C. 2010.Vapor Intrusion Pathway Assessment: Challenges, Developments, and Ongoing Research. Air Force Restoration and Technology Transfer Workshop. April 6 – 8, 2010.

10. Johnson, P.C. 2009. Subsurface Vapor to Indoor Air Pathway: Consideration of Multiple Lines of Evidence in Pathway Assessment. . CA Department of Toxic Substances Control (DTSC), Asilomar, CA. November.

11. Johnson, P.C. 2008. Aeration-Based Remediation Technologies. Remediation Technology Symposium. CA Department of Toxic Substances Control (DTSC). Sacramento. May 14 – 16.

12. Johnson, P.C., J. Triplett-Kingston, P. Dahlen, E. Foote, S. and Williams. 2008. Critical Evaluation of In Situ Thermal Treatment Technologies for DNAPL Source Zone Treatment. 2008 AFCEE Technology Transfer Workshop. March 25-28, 2008.

13. Johnson, P.C. 2008. The Path to More Confident and Cost-Effective Vapor Intrusion Pathway Assessment. 18th Annual AEHS Meeting and International Conference on Soils, Sediments & Water. San Diego. March 10 - 13.

14. Johnson, P.C. and R.A. Ettinger. 2008. An Empirical Analysis of Data From the Colorado DoT Materials Laboratory Testing Site, Denver CO. 18th Annual AEHS Meeting and International Conference on Soils, Sediments & Water. San Diego. March 10 - 13.

15. Johnson, P.C., 2007. Vapor Intrusion – Conceptualizing and Dealing with Spatial and Temporal Variability. Air and Waste Management Association: Vapor Intrusion – A Rapidly Developing Environmental Challenge. November 13 – 15, 2007.

16. Dahlen, P. and P.C. Johnson. 2007. Field Comparison of Oxygen Delivery Technologies. University Consortium for Field-Focused Groundwater Contamination Research. April 17 – 19. Ontario, Canada.

17. Triplett-Kingston, J.. and P.C. Johnson. 2007. Empirical Assessment of Thermal Technology Performance. April 17 – 19. Ontario, Canada.

18. Johnson, P.C.. 2007. Vapor Intrusion Field Studies and Modeling. April 17 – 19. Ontario, Canada.

19. Johnson, P.C.. 2007. Subsurface Vapor to Indoor Air Pathway Assessment: Lessons-Learned and Challenges for the Future. Keynote Presentation at the 6th State of Washington Hydrology Symposium. May 1 – 3.

20. Johnson, P.C.. 2006. Field Studies of Oxygen and Hydrocarbon Vapor Transport Beneath and Around Buildings Located Over NAPL Sources. 16th Annual AEHS Meeting and International Conference on Soils, Sediments & Water. San Diego. March.

21. Johnson, P.C. 2005. Vapor Intrusion – Lessons Learned Through Numerical Simulation. 15th Annual AEHS Meeting and International Conference on Soils, Sediments & Water. San Diego. March.

22. Johnson, P.C. and L. D. V. Abreu. 2004. Advances in the Modeling of Vapor Migration to Buildings. Annual International Conference on Soils, Sediments & Water. University of Massachusetts. October.

23. Johnson, P.C. and L. D. V. Abreu. 2004. Advances in the Modeling of Vapor Migration to Buildings. Annual International Conference on Soils, Sediments & Water. University of Massachusetts. October.

24. Johnson, P.C.. 2002. Confusion and Delusion in the World of Vapor Intrusion. Keynote Speech – First Annual Midwestern States Risk Assessment Symposium. July 16 – 17. Indianapolis, Indiana.

25. Johnson, P.C.. 2002. Arizona Groundwater Study – Preliminary Results. Fourth Annual Underground Storage Tank Program Conference, Arizona Department of Environmental Quality. June 5. Phoenix, AZ.

26. Johnson, P.C.. 2001. Assessing Risks From Vapor Migration To Enclosed Spaces. Pennsylvania Department of Environmental Protection Annual Conference. June 7. Harrisburg, PA.

27. Johnson P. C.. 2000. Advances in Vapour Intrusion Modelling for Risk-Based Decision Making. 2000 Contaminated Site Remediation Conference. December 4 – 8. Melbourne Australia

28. Johnson, P.C.. 2000. A Retrospective Look to the Future of LUST Issues. Third Annual Underground Storage Tank Program Conference, Arizona Department of Environmental Quality. September 29. Phoenix, AZ.

29. Johnson, P.C. and R.A. Ettinger. 2000. Progress Towards Gaining a Better Understanding of Subsurface Vapor Migration. RCRA: Visions for the Future Conference. USEPA. August 15 –18. Washington, D.C..

30. Johnson, P.C. and R.A. Ettinger. 2000. An Empirical Analysis of Data From the Colorado DoT Materials Laboratory Testing Site, Denver CO. RCRA: Visions for the Future Conference. USEPA. August 15 –18. Washington, D.C..

31. Johnson, P.C., C. Bruce, J. P. Salanitro, G. E. Spinnler. 2000. MTBE Biobarrier Studies at Port Hueneme, CA. 2000 National LUST Conference – U.S. Environmental Protection Agency. March. Portland, OR.

32. Johnson, P.C. and J.P. Salanitro. 1999. MTBE Bioremediation. New Jersey Department of Environmental Protection. August 17, 1999. Trenton, NJ.

33. Ward, C.H., P.C. Johnson, and J.B. Hughes. 1999. Plenary Lecture: Enhanced BioAttenuation for Subsurface Remediation. In Situ and On Site Bioremediation – Fifth International Symposium. April 19-22, 1999. San Diego, CA.

34. Johnson, P.C. 1998. An Introduction to Natural Attenuation. First National Stakeholders Forum on Monitored Natural Attenuation. San Francisco. August 31 – September 1. (voted best presentation by attendees)

35. Johnson, P.C.. 1997. Keynote Lecture: Vadose Zone Natural Attenuation - Issues, Modeling Challenges, and Critical Measurements. NGWA Petroleum Hydrocarbons and Organic Chemicals in Groundwater: Prevention, Detection, and Restoration. November 12 - 14. Houston. (voted best presentation by attendees)

36. Johnson, P.C. and R.L. Johnson. 1997. Plenary Lecture: It Looks Good on Paper and You've Paid a Bunch, But is Your Remediation System out to Lunch? The Fourth International Symposium - In Situ and On-Site Bioremediation. April 28 - May 1, 1997. New Orleans, LA.

37. Johnson, P.C.. 1997. Keynote Lecture: US Field and Research Experiences with In Situ Air Sparging. ATV Danish National Groundwater Conference. March 11 - 12. Billund, Denmark.

38. Johnson, P.C.. 1997. Conventional and Innovative In Situ Air Sparging Pilot Test Procedures. ATV Danish National Groundwater Conference. March 11 - 12. Billund, Denmark.

39. Johnson, P.C.. 1996. Risk-Based Corrective Action. Santa Fe Pacific Pipeline Partnership. Los Angeles. August 23.

40. Johnson, P.C.. 1996. Risk-Based Corrective Action Training. USEPA/OUST/ADEQ. Phoenix Arizona. August 15 - 16.

41. Johnson, P.C.. 1996. An Engineer's Introduction to Bioremediation. First Arizona Soil Remediation Conference. Phoenix. May 3.

42. Johnson, P.C.. 1996. Soil Vapor Extraction - Mass Transfer Effects. First Arizona Soil Remediation Conference. Phoenix. May 3.

43. Johnson, P.C.. 1996. Risk-Based Corrective Action for Tribal Lands. USEPA/OUST. Denver Colorado. March 25 - 29.

44. Johnson, P.C.. 1996. Risk-Based Corrective Action. USEPA/OUST and State of Colorado. Denver Colorado. March 19 - 22.

45. Johnson, P.C.. 1995. Risk-Based Corrective Action Demonstration Project. USEPA/OUST and West Virginia Department of Environmental Quality. September 28 - 29.

46. Johnson, P.C.. 1995. Hydrocarbon Removal - How Much is Enough? USEPA OUST Strategic Research Planning Meeting. Las Vegas. September 20 - 21.

47. Johnson, P.C.. 1995. Risk-Based Corrective Action for UST Sites. Arizona Department of Environmental Quality. Phoenix. September 18.

48. Johnson, P.C.. 1995. Research Needs for the Remediation of DNAPL Sites. USAF Research Planning Meeting. Tallahasee. August.

49. Johnson, P.C.. 1995. Modeling Biodegradation in Groundwater - Analytical Models. API Biodegradation Modelling Workshop. Dallas. May 8 - 9.

50. Johnson, P.C.. 1995. In Situ Remediation Technologies. Arizona Water Pollution Control Association. Phoenix. March 17.

51. Johnson, P.C.. 1995. Risk-Based Corrective Action. South Dakota Dept. of Environmental Quality. March 8.

52. Johnson, P.C.. 1995. Aeration-based Remediation Technologies. ARCO Research. Los Angeles. February 7.

53. Johnson, P.C.. 1994. Considerations for the Design and Optimization of Soil Vapor Extraction Systems. Invited presentation at the 1994 API/NGWA Conference: Petroleum Hydrocarbons and Organic Chemicals in Groundwater. Houston.

54. Johnson, P.C., R.L. Johnson, C. Neaville, and E.E. Hansen. 1994. Performance Monitoring and Pilot Testing of In Situ Air Sparging Systems. Invited Presentation at the AGWSE National Education Program. October 9-12. Las Vegas, Nevada.

55. Johnson, P.C.. 1994. Pilot Testing of In Situ Air Sparging Systems. Invited Presentation at the Annual Air Force Center for Environmental Excellence (AFCEE) Conference. San Antonio.

56. Johnson, P.C. and D. Mohr. 1994. Soil Vapor Extraction, Bioventing, and Air Sparging. Invited presentation at the 1st USEPA Strategic Technology Evaluation Workshop. February.

57. Johnson, P.C.. 1993. Risk-Based Corrective Action: Developments and Opportunities. Presented at the 14th Annual Society of Toxicology and Chemistry Meeting. November 14-18. Houston, TX.

National Conference Proceedings Reviewed Papers, Abstracts, and Presentations:

1. Luo, H., C. Holton, P. Dahlen, and P.C. Johnson. 2011. Field and Modeling Studies of Temporal Variability of Sub-Slab Soil Gas and Indoor Air Concentrations at a House Overlying a Chlorinated Compound-Impacted Groundwater Plume. Bioremediation and Sustainable Environmental Technologies. Reno, NV. June 27-30, 2011.

2. Escobar, E., P. Dahlen, and P.C. Johnson. 2011. Biodegradation of Petroleum Hydrocarbon Vapor Components in the Subsurface: A Laboratory Soil Column Study. Bioremediation and Sustainable Environmental Technologies. Reno, NV. June 27-30, 2011.

3. Escobar, E., P. Dahlen, P. C. Johnson. 2011. Transport and Biodegradation of Petroleum Hydrocarbon Vapor Components in the Subsurface – A Soil Column Study. USEPA Workshop on Addressing Regulatory Challenges in Vapor Intrusion: A State of the Science Update Focusing on Chlorinated VOCs. AEHS 21st Annual Meeting and West Coast Conference on Soils, Sediments, Water. San Diego, CA.

4. H. Luo and P. C. Johnson. 2011. Incorporating Barometric Pressure and Wind Effects into Vapor Intrusion Simulations. USEPA Workshop on Addressing Regulatory Challenges in Vapor Intrusion: A State of the Science Update Focusing on Chlorinated VOCs. AEHS 21st Annual Meeting and West Coast Conference on Soils, Sediments, Water. San Diego, CA.

5. Luo. H., P. Dahlen, T. Peargin, P.C. Johnson. 2010. Proof-of-Concept Study of an Engineering Bio-Attenuation Barrier Beneath a Building at a Petroleum Hydrocarbon-Impacted Site. Remediation of Chlorinated Solvents and Recalcitrant Compounds. May 24- 27. Monterey, CA.

6. P.Lundegard, P., P. Johnson, and P. Dahlen. 2008. Oxygen Transport from the Atmosphere to Soil Gas Beneath a Slab-on-Grade Foundation Overlying Petroleum-Impacted Soil. 18th Annual AEHS Meeting and International Conference on Soils, Sediments & Water. San Diego. March 10 - 13.

7. Spinnler, G.E., P.C. Johnson, L. Lesser, C.L. Bruce, R. Aravena, J.P. Salanitro, R.L. Johnson. 2003, MTBE and TBA Biodegradation Assessment Under Natural and Engineered Conditions Using Compound-Specific Carbon Isotope Analysis at Port Hueneme, CA. NGWA/API Petroleum Hydrocarbons and Organic Chemicals in Groundwater. August 20- 22. Costa Mesa, CA.

8. Johnson, P.C. and L. Abreu. 2003. Learning Through the Simulation of Vapor Intrusion Scenarios. NGWA/API Petroleum Hyrocarbons and Other Organic Chemicals in Groundwater. August 20 – 22. Costa Mesa, CA.

9. Johnson, P.C., P. Dahlen, E. Henry, and M. Matsumura. 2003. It's Not About Plume Lengths – The Arizona Groundwater Study. NGWA/API Petroleum Hyrocarbons and Other Organic Chemicals in Groundwater. August 20 – 22. Costa Mesa, CA.

10. P.C. Johnson, and K. Miller. 2002. Large-Scale Mixed MTBE-BTEX Plume Containment at Port Hueneme, CA, Using A Combination of Biostimulation and Bioaugmentation. Third International Conference on Remediation of Chlorinated and Recalcitrant Compounds. Monterey, CA. May 20 – 23.

11. Bruce, C.L. and P.C. Johnson. 2001. Effect of Chemical Properties on IAS Treatment: An Evaluation of Field and Lab Data Comparing MTBE vs. BTEX Removal. API/NGWA Conference: Petroleum Hydrocarbons and Organic Chemicals in Groundwater. Houston, TX. November 14 – 16.

12. Johnson, P. C.. 2001. Gaining a Better Understanding of the Johnson and Ettinger Model Through Sensisivity Analysis. API/NGWA Conference: Petroleum Hydrocarbons and Organic Chemicals in Groundwater. Houston, TX. November 14 – 16.

13. Spinnler, G.E., J.P. Salanitro, and P.C. Johnson. 2001. MTBE Remediation at Retail Gas Stations by Bioaugmentation. API/NGWA Conference: Petroleum Hydrocarbons and Organic Chemicals in Groundwater. Houston, TX. November 14 – 16.

14. Salanitro, J.P., P.C. Johnson, C.L. Bruce, Spinnler, G.E., P.M. Maner, D.L. Tharpe, H.L. Wisniewski. 2001. In Situ Bioremediation of MTBE Using Biobarriers of Single or Mixed Cultures. In Situ and On-Site Bioremediation – The Sixth International Symposium. San Diego. June 4 - 7.

15. Spinnler, G.E., P.M. Maner, J.P. Salanitro and P.C. Johnson. 2001. Demonstration of the BioRemedy Process for MTBE Remediation at Retail Gasoline Stations. In Situ and On-Site Bioremediation – The Sixth International Symposium. San Diego. June 4 - 7.

16. Johnson, P.C. and R.A. Ettinger. 2000. Progress Towards Gaining a Better Understanding of Subsurface Vapor Migration. RCRA: Visions for the Future Conference. USEPA. August 15 –18. Washington, D.C..

17. Johnson, P.C. and R.A. Ettinger. 2000. An Empirical Analysis of Data From the Colorado DoT Materials Laboratory Testing Site, Denver CO. RCRA: Visions for the Future Conference. USEPA. August 15 –18. Washington, D.C..

18. Kemblowski, M.W. and P.C. Johnson. 2000. Environmental Monitoring, Modeling, and Management and Bayesian Belief Networks. Envirosoft. June. Bilbao, Spain.

19. Arulantham, R., P. C. Johnson, and M. W. Kemblowski. 2000. Identifying Low-Risk MTBE-Impacted Sites. Pacific Focus Ground Water Conference. February 17 – 18. San Francisco, CA.

20. Salanitro, J.P., P.C. Johnson, G.E. Spinnler, C.C. Neaville, P.M. Maner, S.M. Stearns, C.L. Bruce. 1999. Demonstration of the Enhanced MTBE Bioremediation (EMB) IN Situ Process. In Situ and On Site Bioremediation – Fifth International Symposium. April 19-22, 1999. San Diego, CA.

21. Bruce, C.L., I.L. Amerson, P.C. Johnson, R.L. Johnson. 1999. Diagnostic Tools for Quantifying Oxygen Mass Transfer Rates. In Situ and On Site Bioremediation – Fifth International Symposium. April 19-22, 1999. San Diego, CA.

22. Bruce, C.L., P.C. Johnson, and R.L. Johnson 1998. Methyl Tert-Butyl Ether Removal by In Situ Air Sparging in Physical Model Studies. The First International Conference on Remediation of Chlorinated and Recalcitrant Compounds. May 18-21. Monterey, CA.

23. Johnson, P.C., A. Das, R.L. Johnson, C. Bruce, A. Leeson, D. McWhorter, and R.E. Hinchee. 1997. Removal of Immiscible-Phase Hydrocarbons - Effects of Process Control Changes, Chemical Properties, and Distribution. In Situ and On-Site Bioremediation: The Fourth International Symposium. April 28 - May 1, 1997. New Orleans.

24. Johnson, R.L., P.C. Johnson, A. Leeson, C.M. Vogel. 1997. Air Distribution During In Situ Air Sparging: Tracer and Geophysical Measurements. In Situ and On-Site Bioremediation: The Fourth International Symposium. April 28 - May 1, 1997. New Orleans.

25. Rutherford, K.W., D. Bass, W. McPhee, and P.C. Johnson. 1997. Estimation of Oxygen Mass Transfer Coefficients During In Situ Air Sparging. In Situ and On-Site Bioremediation: The Fourth International Symposium. April 28 - May 1, 1997. New Orleans.

26. Johnson, R.L., P.C. Johnson, A. Leeson, C.M. Vogel. 1997. Air Distribution During In Situ Air Sparging: Tracer and Geophysical Measurements. The Fourth International Symposium - In Situ and On-Site Bioremediation. April 28 - May 1, 1997. New Orleans, LA.

27. Johnson, P.C.., A. Das, R.L. Johnson, A. Leeson, D. McWhorter, R. Hinchee, and C.M. Vogel. 1997. Effects of IAS Process Changes on the Removal of Immiscible-Phase Hydrocarbons. The Fourth International Symposium - In Situ and On-Site Bioremediation. April 28 - May 1, 1997. New Orleans, LA.

28. Rutherford, K.W., D. Bass, W. McPhee, and P. C. Johnson. 1997. Estimating Oxygen Mass Transfer Coefficients During Air Sparging. The Fourth International Symposium - In Situ and On-Site Bioremediation. April 28 - May 1, 1997. New Orleans, LA.

29. Westerhoff, P., L. Baker, P. Fox, P. Johnson, and S. Houston. 1997. A Low-Cost Strategy to Treating and Reuse Wastewater in Nogales, AZ. AWRA Long Beach '97. October 19-23.

30. Johnson, P.C., K. Balshaw-Biddle, T. Reeves, and C. Bruce. 1997. In Situ Air Sparging Studies Using the AATDF ECRS Large-Scale Physical Model. AATDF Conference. Rice University. February.

31. Johnson, P.C., R.L. Johnson, C. Neaville, and E.E. Hansen. 1995. Short-Term Pilot Tests - Reliable Indicators of Long-Term In Situ Air Sparging Performance? In Situ and On-Site Bioreclamation Conference - 3rd International Symposium. San Diego. April 24-27.

32. Johnson, R. L., N. R. Thomson, and P. C. Johnson. 1995. Does Sustained Groundwater Circulation Occur During In Situ Air Sparging. In Situ and On-Site Bioreclamation Conference - 3rd International Symposium. San Diego. April 24-27.

33. Rutherford, K. and P.C. Johnson. 1995. Interfacial Mass Transfer During In Situ Air Sparging - Effects of Process Changes and Lithology. API/NGWA Conference: Petroleum Hydrocarbons and Organic Chemicals in Groundwater. Houston, TX. November.

34. Johnson, P.C., R.L. Johnson, C. Neaville, and E.E. Hansen. 1995. Short-Term Pilot Tests - Reliable Indicators of Long-Term In Situ Air Sparging Performance? AWPCA Annual Conference - Quentin Mees Award. Phoenix. May.

35. Wheeless, W., S. Hicken, C. Beitler, J. Rowe, M.A. Robbins, R.E. Hinchee, P.C. Johnson, R.L. Johnson, and D.B. McWhorter. 1995. In Situ Air Sparging - Technology Demonstration for Remediating Groundwater Contaminated with Dissolved-Phase Constituents at Hill Air Force Base. API/NGWA Conference: Petroleum Hydrocarbons and Organic Chemicals in Groundwater. Houston, TX. November.

36. Johnson, P.C., Rounds, D., and C.C. Stanley. 1994. Risk-Based Corrective Action (RBCA) at Petroleum Release Sites. API/NGWA Conference: Petroleum Hydrocarbons and Organic Chemicals in Groundwater. Houston, TX. November.

37. Neaville, C., P.C. Johnson, and R.L. Johnson. 1994. Evaluation of Air Sparging Technology at a Gasoline UST Site. AEHS Petroleum Contaminated Soils Conference. Long Beach, CA.

38. Sabadell, G.P., J.B. Gustafson, P.C. Johnson, E.R. Cruz, L.W.R. Dicks and C.C. Wang. 1993. Evaluation of Soil Vapor Extraction System Design and Operation Utilizing Tracer Tests. Presented at the CSCE-ASCE National Conference on Environmental Engineering. July.

39. Johnson, P.C. and C.C. Stanley. 1993. An Integrated Exposure/Risk-Based Corrective Action Approach for Underground Storage Tank Sites. Presented at the 86th Annual Meeting and Exhibition of the Air & Waste Management Association. Denver, Colorado.

40. Stanley, C.C., P.C. Johnson, R.K. Wenzlau, J.L. Rous, J.F. Vargas, and J.L. Peterson. 1992. An Exposure/Risk-Based Corrective Action Approach for UST Sites. Proceedings of Petroleum Hydrocarbons and Organic Chemicals in Groundwater. Houston, TX. November.

41. Johnson, P.C., M.W. Kemblowski, and J.D. Colthart. 1988. Practical Screening Models for Soil Venting Applications. Proceedings; Petroleum Hydrocarbons and Organic Chemicals in Ground Water Conference, National Water Well Association, American Petroleum Institute; Houston, TX.

Sponsored Research - External Grants and Gifts:

1. Johnson P.C. and P. Dahlen. Improving Our Understanding of Dissolved Groundwater Plume Sources at Petroleum-Impacted Sites Through Physical Model, Mathematical Model, and Field-Site Studies. Chevron.$500,000. 9/1/2010 – 8/31/2012.

2. Johnson, P.C. and P. Dahlen. Integrated Field-Scale, Lab-Scale, and Modeling Studies for Improving Our Ability to Assess the Groundwater to Indoor Air Pathway at Chlorinated Solvent Impacted Sites. SERDP. $1,256,000. 10/1/2009 – 9/30/2012.

3. Johnson, P. C. and P. Dahlen. Chemical Oxidation Technologies. Johnson. Shell Global Solutions. $120,000. 12/1/08 – 6/31/11.

4. Johnson, B. Rittmann. Assessment of the Natural Attenuation of NAPL Source Zones and Post-Treatment NAPL Source Zone Residuals. ESTCP. $899,424. 4/1/07 – 3/30/10.

5. Johnson, P.C. Capillary Properties of Soils and Residual Fluid Levels. American Petroleum Institute. $50,000. 1/1/2010 – 12/31/2010.

6. Johnson. Field Study of Vapor Intrusion of Petroleum Hydrocarbon Vapors. Chevron. $40,000. 1/1/08 – 1/1/09

7. Johnson. Vapor Migration Studies. Chevron. $80,000. 1/1/06 – 12/31/07.

8. Johnson. Oxygen Delivery Technologies. Shell Global Solutions. $20,000. 1/1/07 – 12/31/07.

9. Johnson. Critical Evaluation of State-of-the-Art In Situ Thermal Treatment Technologies for DNAPL Source Zone Treatment. Battelle (from ESTCP). $325,000. 2/1/05 – 9/31/07.

10. Johnson. Computer Simulation Of Subsurface Hydrocarbon Vapor Migration In The Vicinity Of Homes And Buildings. Arco/Atlantic Richfield. $30,000. 9/1/05 – 8/31/06.

11. Razdan, Johnson. East Valley Water Forum Simulations. East Valley Water Forum. $117,500. 9/1/05 – 9/1/06.

12. Johnson. Bench-Scale Evaluation Of Long-Term Biosparging Effect On Ground Water Quality In Diluent Source Areas At The Guadalupe Restoration Project. Unocal. $57,860. 6/14/04 – 6/1/06.

13. Johnson. Field Evaluation of Oxygen Delivery Technologies. Shell Global Solutions. $50,000. 1/1/05 – 5/31/06.

14. Johnson. Modeling of Vapor Intrusion of Petroleum Hydrocarbon Vapors. Chevron. $30,000. 1/1/05 – 12/31/06.

15. Johnson. Numerical Modeling of Vapor Intrusion of Petroleum Hydrocarbon Vapors. British Petroleum. $20,000. 1/1/04 – 1/31/05.

16. Johnson. Mobil Foundation Gift. $10,000. 1/1/04 – 1/31/04.

17. Johnson. Innovative Technologies for Assessing and Treating Impacted Aquifers. U.S. Navy. $275,000. 10/1/02 – 9/30/04.

18. Anderson-Rowland and Johnson. Collaborative Interdisciplinary Research Community /Maricopa Engineering Transition Scholars (CIRC/METS). National Science Foundation. $400,000. 7/1/03 – 6/30/07.

19. Johnson. Predicting Groundwater Quality Downgradient of Permeable Reaction Barriers. U.S. Navy. $200,000. 10/1/03 – 5/30/06.

20. Johnson. Release of Regulated Substances to Arizona Ground Water – Supplemental Data Collection. Arizona Department of Environmental Quality. 7/1/2002 – 12/31/2002. $150,000. XCT9312.

21. Johnson. Release of Regulated Substances to Arizona Ground Water. Arizona Department of Environmental Quality. 2/1/2001 – 12/31/2002. $331,143. XCT9312.

22. Johnson. Remediation of MTBE-Impacted Aquifers. Gift – Shell Oil Foundation. $10,000. 1/1/02 – 12/31/02.

23. Johnson. Environmental Restoration and Risk Assessment. Mobil Research Foundation. $10,000. 1/1/02 – 12/31/02.

24. Johnson. Demonstration of the Enhanced MTBE Bioremediation Process at Port Hueneme, CA. Equilon Enterprises. $80,114. 9/15/99 – 12/31/02. ORCA00310.

25. Johnson. Innovative Technologies for Assessing and Treating MTBE-Impacted Aquifers – Phase 1, 2, and 3. US Navy. $374,198. 8/30/99 – 5/31/02. XCA6526.

26. Johnson. Assessing the Longevity of Hydrocarbon Source Zones. Rio Tinto. $51,528. 9/1/99 – 12/31/01.

27. Johnson. NEX MTBE Plume Characterization. US Navy. $5,000. 6/8/99 – 6/1/00. XCA6525.

28. Johnson. Gift – Remediation of MTBE-Impacted Aquifers. Equilon Enterprises. $20,000. 12/1/99 – 12/1/00

29. Johnson. Gift – Remediation of MTBE-Impacted Aquifers. Equilon Enterprises. $10,000. 10/19/99 – 10/18/00.

30. Baker and Johnson. Management of Nitrate Contaminated Aquifers. Salt River Project. $22,306. 6/1/99 – 5/16/01. XCT9292.

31. Johnson. Gift - Environmental Restoration and Risk Assessment. Mobil Research Foundation. $12,000. 12/1/98 – 12/1/99.

32. Johnson. Gift - Remediation of MTBE in Ground Water. Equilon Enterprises. $86,000. 6/29/98 – 6/1/02.

33. Westerhoff and P.C. Johnson (40%). A Zero-Valent Treatment Process for Removing Nitrate and Perchlorate from Groundwater. American Water Works Association. $64,812. XCT9283.

34. Johnson and R. Johnson (Oregon Graduate Institute). Vadose Zone Natural Attenuation. American Petroleum Institute. $95,058. XCT9272. 2/12/97 - 6/1/99.

35. Johnson (Oregon Graduate Institute) and P. Johnson (10%). Natutal Attenuation of Dissolved MTBE Plume. American Petroleum Institute. $90,000. 970060. 2/12/97 - 6/1/99.

36. Johnson (33%), R. Johnson (Oregon Graduate Institute), and M. Kemblowski (Utah State University). Diagnostic Tools for the Monitoring and Optimization of In Situ Air Sparging Systems. American Petroleum Institute. $133,117. XCT9255. 1/1/96 - 12/31/99.

37. Johnson and M. Kemblowski (Utah State University). Vadose Zone Natural Attenuation. American Petroleum Institute. $45,864. 970060. 2/12/97 - 12/31/97.

38. Johnson. In Situ Bioremediation of Contaminated Aquifer Soils. Battelle/SERDP/USAF. $223,152. XCJ 6230. 11/1/96 - 12/31/98.

39. Johnson. Chlorinated Hydrocarbon Remediation. Salt River Project. $22,000. 5/1/95 - 11/1/97. GFT4628.

40. Johnson. Gift - Environmental Restoration and Risk Assessment. Mobil Research Foundation. $20,000. 2/1/97 -. XC51001.

41. Johnson and R. Charbeneau (U. Texas). Graphical Tools for Determining Site-Specific Risk-Based Soil Screening Levels for the Soil to Groundwater Transport Pathway - A Practical Alternative to Generic Dilution Attenuation Factors. American Petroleum Institute. $105,000. 2/1/95 - 7/31/96. XCT 8786.

42. Johnson. Iron-Induced Hydrocarbon Degradation. Arizona Department of Water Resources. $24,470. 95-0483. 11/1/95-2/1/97.

43. Johnson. Regional Water Quality and Supply Management Strategies for the Phoenix Metropolitan Area. Arizona Department of Water Resources. $24,220. XCT1465. 11/1/95-2/1/97.

44. Fox, S. Houston, W. Houston, P.C. Johnson (25%). Direct Well Recharge of Tertiary Effluent. Arizona Department of Water Resources. $77,558. XCT9251. 11/1/95 - 2/28/97.

45. Westerhoff, L. Baker, P. Johnson (20%). Linking Nitrate Models to Existing Salt River Project Canal Hydraulic Models to Predict Water Quality Impacts of Well Pumping. Salt River Project. $25,358. GFT 4653. 6/1/96 - 5/31/97.

46. Johnson. An Evaluation of EPA-Recommended Stack Emissions Monitoring Using Tracer Gas Mass Balance Approach. Salt River Project. $14,327. GFT 4654. 6/1/96 - 5/31/97.

47. Johnson. Evaluation of the Use of Elemental Iron to Treat DBCP-Impacted Groundwater. Salt River Project. $9,327. GFT 4654. 6/1/96 - 5/31/97.

48. Baker, P. Westerhoff, P. Fox, S. Houston, P. Johnson (15%), C. Klopotek. US-Mexico Border Water Resource Management Technologies for Sustained Development - Low Cost Strategy for Treating and Reusing Wastewater. SCERP/USEPA. $135,000. 96287. 9/1/96 - 8/31/97.

49. Johnson. Environmental Restoration and Risk Assessment. Mobil Research Foundation. $20,000. 10/1/94 -. XC51001.

Sponsored Research - Equipment Loans:

1. Experimental Controlled Release System.DOE/DOD/ AAATDF/ Rice University. 1/1/97 - 12/31/98. 970936.

2. Geoprobe Unit. University of California at Santa Barbara. 6/1/98 – 11/1/05

Sponsored Research - Internal Grants:

1. Johnson, P. Westerhoff, S. Beaudoin. Assessing the Impact of New Products and Process Changes on Environmental Resources. $22,000. CEAS. 7/29/97 - 7/29/98.

2. Johnson. Chemistry Module for Undergraduate Civil Engineers. FEIGIA. $6000. 6/1/95 - 5/31/96. ST1001.

3. Johnson. Restoration of Aquifers Contaminated with Solvents. FGIA. $6000. XCRG0110. 4/1/95 - 3/31/96.

4. Johnson. Bioremediation of Contaminated Aquifer Soils. $8000. OVPR. 9/1/94 - 8/31/95. XCR230.

STUDENT THESES AND DISSERTATIONS SUPERVISED

Masters Degrees Awarded:

Student	Date	M.S. Thesis Title

Lisa Clifton	12/08	Effect of Dissolved Oxygen Manipulation on the Benzene Flux from a Low Permeability Soil Layer
Pamela Maass	12/05	Modeling Groundwater Quality Changes Down-gradient of Permeable Reactive Barriers
Roberta Lenski	12/04	Source Longevity Estimates for Ground Water Impacts at the Former Williams AFB Site
Maikel Mendez	5/03	Use of MFI Tests to Project Secondary Effluent Recharge Well Performance in Costa Rica
Makiko Matsumuro	12/02	Occurrence of Fuel Oxygenates in Groundwater at Arizona Leaking Underground Fuel Sites
Suzanne Braunschneider	12/00	Visualization Studies for Bioaugmentation
Jennifer Sigley [w/ S. Beaudoin – ChE]	12/99	Use of Nonionic Surfactants for Reducing Sulfuric Acid Mist Emissions During the Copper Electrowinning Process
JeskoSollner	6/99	Bioremediation of a MTBE-Contaminated Site – Factors Influencing the Transport of Bacteria Through Soil and Aquifer Sand *[Technical University Berlin]*
Victoria Hermes	12/98	Numerical Modeling of Vadose Zone Natural Attenuation
Sophie Roggemans	12/98	An Empirical Assessment of Natural Attenuation in the Vadose Zone
Patricia McSparren	12/98	Regional Scale Groundwater Flow Modeling and Assessment of the Impacts of Treated Effluent Discharge near the US-Mexico Border at Nogales
Illa Lyn Amerson	12/97	Diagnostic Tools for the Monitoring and Optimization of In Situ Air Sparging Systems
Angie Luckie	5/97	Long-Term Pump Test Performance of a Deep Horizontal Well in a Highly Heterogeneous Formation
Amar Das	12/96	Laboratory-Scale Study of Volatilization from Residual Source Zones During Air Sparging
David Abranovic	5/96	Graphical Tools for Determining Site-Specific Risk-Based Soil Screening Levels
Kyle Wayne Rutherford	12/95	Effects of Process Control Changes on Interfacial Mass Transfer Rates During In Situ Air Sparging
Jennifer Campbell	12/96	Iron-Induced Degradation of Chlorinated Solvents in Groundwater [MSE Project]
Cindy Barker	5/96	Learning Tools for Undergraduate Students - Chemistry Module for Civil Engineers [MSE Project]

Doctoral Degrees Awarded:

Student	Date	Ph.D. Project Title
Hong Luo	5/09	Field and Modeling studies of Soil Vapor Migration into Buildings at Petroleum Hydrocarbon Impacted Sites
Jennifer Triplett-Kingston	5/08	Critical Evaluation of Thermal-Based Remediation Technologies
Luis Lesser	5/08	Spatial and Temporal Variations in MTBE Degrading

		Activity
LilianDeize de Abreu	3/05	A Three-Dimensional Numerical Model for Subsurface Vapor Migration to Enclosed Spaces
Zhuang Liu	12/04	Accelerated Bench-Scale Weathering Tests for Petroleum Hydrocarbons
Paul Dahlen	12/04	Impact of Leaking Underground Storage Tanks on Arizona Groundwater Resources
Ying Xu	4/02	Empirical Analysis of Historical Trends and Prediction of Future behavior of Nitrate Concentrations in Groundwater in the SRP Service Area, AZ
Cristin Bruce.	6/01	Performance Expectations for In Situ Air Sparging Systems

STUDENT THESES AND DISSERTATIONS SUPERVISED

Current Graduate Projects in Progress:

Student	Degree	Project
Ryan Ekre	Ph.D.	Source Zone Natural Attenuation of DNAPL Sources
Elsy Escobar	Ph.D.	Vapor Co-Migration of Aerobically Biodegradable Components
Bridgette Cavanagh	Ph.D.	Assessing the Impact of Chemical Oxidation for Treatment of Petroleum-Impacted Sites
Chase Holton	Ph.D.	Vapor Migration of Chlorinated Solvents from Groundwater to Indoor Air

Post-Doctoral Students:

Paul Dahlen (2004 – 2007)
Hong Luo (2009 – present)
Eric Henry (2001) – currently at University of North Carolina , Wilmington
Cristin Bruce (2001 – 2003) – currently at Shell Global Solutions, Houston, TX.

Undergraduate Projects Supervised:

1. Shawn Whitmer - Iron-Induced Chlorinated Hydrocarbon Degradation Studies
2. Makiko Matsumuro – WISE Program. Vapor Transport Studies.

PROFESSIONAL AND SCIENTIFIC SERVICE

Local Professional Committees and Appointments:

1. Governor Appointment to the Arizona UST Technical Appeals Board (1998 - 2002)

2. Governor Appointment to the Arizona Water Quality Assurance Revolving Fund (WQARF) Advisory Panel (1997 - 2000)

3. ADEQ Ground Water Study Working Group (1999 - 2000)

4. Arizona Groundwater Clean-up Standards Task Force (1996 - 1997)

5. Arizona Department of Environmental Quality Director's Advisory Panel on Soil Clean-up Standards (1996)

Scientific and Professional Society Memberships:

1. American Society for Testing and Materials - Co-Chairman, Risk-Based Corrective Action for Superfund and Self-Directed Cleanups Task Group (1995 - 1997)

2. Groundwater Remediation Technologies Analysis Center - Guidance Committee Member (1995 - 1998).

3. Advanced Applied Technology Demonstration Facility (DoD - AATDF) Program - Advisory Committee Member (1994 - 1998)

4. National Ground Water Association

5. American Chemical Society

6. American Society of Civil Engineers

Conference Activities:

1. Session Chairman, Annual SERDP/ESTCP Partners in Innovation Conference. Vapor Intrusion. Washington, D.C.. (2010).

2. Session Chairman, International Conference on Chlorinated Solvents and Other Recalcitrant Compounds. Combining Thermal with Other Remediation Technologies. Monterey, CA (2010).

3. Session Chairman, Annual SERDP/ESTCP Partners in Innovation Conference. Vapor Intrusion.Washington, D.C.. (2009).

4. Session Chairman, International Conference on Chlorinated Solvents and Other Recalcitrant Compounds. Combining Thermal with Other Remediation Technologies. Monterey, CA (2008).

5. Session Chairman, Third International Conference on Chlorinated Solvents and Other Recalcitrant Compounds. Monterey, CA (2002).

6. Session Chairman, In Situ and On-Site Bioreclamation Conference - 6th International Symposium. June 4- 7. San Diego, CA (2001).

7. Session Chairman, Second International Conference on Chlorinated Solvents and Other Recalcitrant Compounds. Monterey, CA (2000).

8. Session Chairman, In Situ and On-Site Bioreclamation Conference - 5th International Symposium. San Diego, CA (1999).

9. Session Chairman, First International Conference on Chlorinated Solvents and Other Recalcitrant Compounds. Monterey, CA (1998).

10. Session Chairman, In Situ and On-Site Bioreclamation Conference - 4th International Symposium. New Orleans, LA (1997).

11. Session Chairman, Advanced Applied Technology Demonstration Conference. Rice University. Houston, TX (1996).

12. Session Chairman, In Situ and On-Site Bioreclamation Conference - 3rd International Symposium. San Diego, CA (1995).

13. Session Chairman, API/NGWA Conference: Petroleum Hydrocarbons and Organic Chemicals in Groundwater. Houston, TX (1993).

Journal Editor Service:

1. Ground Water Monitoring and Remediation – Editor-in-Chief (2003 -)

2. Journal of Bioremediation (1996 - 2003) - Associate Editor

3. International Journal of Soil Contamination (1996 - 2003) - Editorial Advisory Board

Journal Referee Service:

1. Bioremediation Journal (Associate Editor)

2. Ground Water

3. Ground Water Monitoring and Remediation

4. Environmental Science and Technology

5. Environmental Engineering Science

6. Water Resources Research

7. Separation Science and Technology

8. ASCE Journal of Environmental Engineering

9. Soils (Associate Editor)

10. Water Environment Research

11. Biotechnology and Bioengineering

12. International Journal of Bioremediation

Proposal Reviewer:

1. National Science Foundation - Directorate for Geosciences (1993)

2. USEPA OUST Program (1994 - 1995)

3. Department of Energy/Department of Defense - AATDF Program (1993 - 1997)

4. DOE SERDP Program (1995, 1999, 2003, 2004, 2005)

Other:

Mentor - USEPA EarthVision Program (high school students; 1996 - 1997)

UNIVERSITY COMMITTEE SERVICE AND OTHER SERVICE

University-Level Service

Associate Vice President – Research (2004 – 2006)

College of Engineering and Applied Sciences/Ira A. Fulton School of Engineering:

Ira A. Fulton School of Engineering: Dean (2011 –)

Ira A. Fulton School of Engineering: Executive Dean (2006 –2010)

College of Engineering and Applied Science Associate Dean – Research (2003 - 2004)

College of Engineering and Applied Science Interim Associate Dean – Research (2002 - 2003)

Dean's Personnel Advisory Committee – Chair (2000 – 2001, 2001 – 2002)

Dean's Personnel Advisory Committee (1999 - 2000)

College of Engineering and Applied Science Research Committee (1998 – 1999)

College of Engineering and Applied Science ECE-100 Curriculum Committee (2000 – 2001, 2001 – 2002)

Department of Civil and Environmental Engineering:

Associate Chair – Graduate Programs (2000 – 2001, 2001 – 2002)

ASCE Student Chapter Advisor (2001 – 2002)

CEE Personnel Committee - Chair (1997 – 1998, 1998 - 1999)

CEE Advisory Committee (1999 – 2000, 2001 – 2002)

CEE Self-Study Committee (2001 – 2002)

CEE Faculty Search Committee – Chair (1996 – 1997)

CEE Faculty Search Committee (1995 – 1996)

CEE Scholarship Committee (2001 – 2003)

EVALUATION OF INSTRUCTION – AWARDS

ASU College of Engineering Teaching Excellence Award	2002*
ASU Parents Association Teacher of the Year Finalist	2000
ASU College of Engineering Teaching Excellence Award	1998*
ASCE Student Chapter Best Teacher Award	1996

** - The College of Engineering and Applied Sciences (CEAS) presents this award only to two faculty each year.*

[max. score = 5.0]

Year and Term	Course #	Course Title	No. Students	Instructor Evaluation	Course Evaluation
2011	CEE564	Contaminant Fate and Transport	22	4.73	4.16
2010	ASU101	Introduction to ASU	18	4.94	4.57
2010	CEE560	Soil and Groundwater Remediation	23	4.44	4.12
2009	CEE564	Contaminant Fate and Transport	25	4.85	4.43
2009	CEE560	Soil and Groundwater Remediation	9	4.92	4.49
2009	ASU101	Introduction to ASU	19	NA	NA
2008	CEE564	Contaminant Fate and Transport	16	4.55	4.39
2007	CEE560	Soil and Groundwater Remediation	13	4.59	4.39
2007	ASU101	Introduction to ASU	14	NA	NA
2007	CEE598	Special Topics: Data Systems – Environmental	7	4.85	4.74
2006	CEE591	Seminar	25	NA	NA
2006	CEE564	Contaminant Fate and Transport	24	4.61	4.25
2006	CEE 598	Special Topics: Advanced Environmental Chemistry	9	4.40	4.41
2005	CEE 598	Special Topics: Data Systems – Environmental	10	4.86	4.71
2005	CEE 564	Contaminant Fate and Transport	29	4.55	4.04
2003	CEE 564	Contaminant Fate and	23	4.38	3.98

		Transport			
2002	CEE 560	Soil and Groundwater Remediation	25	4.77	4.40
2002 Spring	CEE 598	Contaminant Fate and Transport	18	4.79	4.43
2001 Fall	CEE 540	Groundwater Hydrology (new course)	23	4.73	4.42

EVALUATION OF INSTRUCTION – SUMMARY OF STUDENT EVALUATIONS [CONT.]
[max. score = 5.0]

Year and Term	Course #	Course Title	No. Students	Instructor Evaluation	Course Evaluation
2001 Spring	CEE 598	Contaminant Fate and Transport	18	4.84	4.45
2000 Fall	CEE 540	Groundwater Hydrology (new course)	23	4.73	4.42
1999 Fall	ECE 100 M	Introduction to Engineering: Modeling	45	4.47*	3.71
1999 Fall	CEE 598	Contaminant Fate and Transport	11	4.88	4.49
1998 Fall	ECE 100 M	Introduction to Engineering: Modeling	32	4.68**	3.46
1998 Fall	CEE 560	Soil and Groundwater Remediation	12	4.79	4.32
1998 Spring	CEE 598	Contaminant Fate and Transport	21	4.63	4.31
1998 Fall	CEE 560	Soil and Groundwater Remediation	12	4.79	4.32
1998 Spring	CEE 598	Contaminant Fate and Transport	21	4.63	4.31
1997 Fall	CEE 560	Soil and Groundwater Remediation	20	4.65	4.27
1997 Fall	ECE 300	Intermediate Engineering Design	39	4.50***	4.30
1996 Fall	CEE 361	Introduction to Environmental Engineering	26	4.81	4.18

* - highest rating of ECE100 M instructors that semester - and highest rating achieved by any ECE100 modeling instructors in the three-year period

** - highest rating of ECE100 M instructors that semester

*** - highest rating of ECE300 instructors that semester

For reference, the average ECE100 M instructor rating is approx. 3.9

For reference, the average ECE300 instructor rating is approx. 3.8

EVALUATION OF INSTRUCTION – NEW COURSES DEVELOPED
CEE560 – Soil and Ground Water Remediation
CEE598 – Contaminant Fate and Transport
ECE100 – Curriculum Development Committee (ECE100 revisions)
CEE598 – Environmental Data Systems and Analysis

WORKSHOPS/SHORT COURSES DEVELOPED

USEPA Vapor Intrusion Workshop
P. C. Johnson, T. McAlary, I. Hers, H. Dawson, R. Truesdale, H. Schuver and others
• March and October 2004, March 2005, March 2006

Vapor Intrusion Workshop
P. C. Johnson, R.A. Ettinger, T. McAlary, E. Nichols, and others
• September and October 2003

In Situ Air SpargingDoD Field Camp Course
P. C. Johnson, R.L Johnson, C. Bruce, P. Dahlen, J. Osgood
• May 2002, July 2002 (twice)

MTBE Remediation
[requested by USEPA and CA State Water Quality Control Board]
• April 1999, May 1999, June 1999, September 1999

Risk Assessment
J. Rocco, L. Hay-Wilson, J. Mercer, J. Till, Johnson, P.C.
Santa Fe, NM.
• April 1998, April 1999.

USEPA/ASTM ES-38 Risk-Based Corrective Action Workshop
ASTM ES-38 Task Group
• August 1996, March 1996, October 1995, September 1995, May 1995, December 1994

Air Sparging Workshop
International Network for Environmental Training
P.C. Johnson, R.E. Hinchee
• December 1994

Risk-Based Corrective Action Workshop
P.C. Johnson, C.C. Stanley, G.E. DeVaull, R.A. Ettinger, P.M. McAllister
• AWMA Conference March 1994, AEHS Conference March 1994

Aeration-Based Technologies (Soil Venting, Air Sparging, Bioventing) - Environmental Education Enterprises
P.C. Johnson, R.E. Brown and G.E. Hoag
• October 1995, January 1995, June 1994, March 1994, June 1993, December 1993

Groundwater Contamination from Petroleum Hydrocarbons

University of Texas - College of Engineering, Austin, TX.
Charbeneau, R., P. Bedient, C.Y. Chiang, D.Daniel, P.C. Johnson, R. Loehr, G.E. Speitel Jr., and J. Weaver.
• April 1994, April 1993, October 1992, April 1992, April 1991

USEPA Strategic Technology Evaluation Workshop
P.C. Johnson and D. Mohr
• February 1994

Soil Remediation Workshop - Petroleum Contaminated Soils Conferences
Johnson, P.C. J.P. Salanitro, L.W.R. Dicks, M.H. Huesemann, G.M. Deeley, A.R. Marsden, Jr., W.G. Rixey, and J.B. Gustafson.
• March 1993, September 1992, March 1992, September 1991, March 1991

USEPA Corrective Action Technology Transfer Workshop on NAPL Recovery and Residual Hydrocarbon Removal.
Johnson, P.C., J. Parker, T. Peargin
• January 1993

An Exposure/Risk-Based Corrective Action for UST Sites - Petroleum Contaminated Soils Conferences
Johnson P.C. and C.C. Stanley
• March 1993

HyperVentilate© - A Software Guidance System for Vapor Extraction - Applications.
P.C. Johnson
• USEPA Region VII - March 1994, USEPA Region VII - February 1994

Other Professional Information

Past or Current Consultant to:

US Environmental Protection Agency	IT Corporation
US Department of Defense	Battelle
US Department of Energy	Envirogen
Rice University	Siemens
Parsons-Engineering Science	Phillip Environmental
Baker Environmental	BP Oil
Mobil Oil Corporation	GeoMatrix
Lockheed	Chevron
Occidental Chemical	State Regulatory Agencies
Motorola	Lawrence Livermore National Laboratory
Unocal	Oxygenated Fuels Association
Allied Signal/Honeywell	Woodward-Clyde Consultants
Equilon Enterprises	California Water Quality Control Board
Groundwater Services, Inc.	Geosyntec
Shell Global Solutions	Haley and Aldrich

Peer Reviewer Conflict of Interest Certification

Peer Review: *Proposed Rule: Addition of a Subsurface Intrusion Component to the Hazard Ranking System*; 40 CFR Part 300; EPA-HQ-SFUND-2010-1086; FRL_XXXX-X (review draft).

A conflict of interest or lack of impartiality exists when the proposed peer reviewer personally (or the peer reviewer's immediate family), or his or her employer, has financial interests that may be affected by the results of the peer review; or may provide an unfair competitive advantage to the peer reviewer (or employer); or if the peer reviewer's objectivity in performing the peer review may be impaired due to other factors. When the Peer Reviewer knows that a reasonable person with knowledge of the facts may question the peer reviewer's impartiality or financial involvement, an apparent lack of impartiality or conflict of interest exists.

The following questions, if answered affirmatively, represent potential or apparent lack of impartiality (*any affirmative answers should be explained on the back of this form or in an attachment*):

- Did you contribute to the development of the document under peer review, or were you consulted during its development, or did you offer comments or suggestions to any drafts or versions of the document during its development? ☑ No ☐ Yes
- Do you know of any reason that you might be unable to provide impartial advice on the matter under consideration in this peer review, or any reason that your impartiality in the matter might be questioned? ☑ No ☐ Yes
- Have you had any previous involvement with the review document(s) under consideration? ☑ No ☐ Yes
- Have you served on previous advisory panels, committees, or subcommittees that have addressed the topic under consideration? ☑ No ☐ Yes
- Have you made any public statements (written or oral) on the issue? ☑ No ☐ Yes
- Have you made any public statements that would indicate to an observer that you have taken a position on the issue under consideration? ☑ No ☐ Yes
- Do you, your family, or your employer have any financial interest(s) in the matter or topic under peer review, or could someone with access to relevant facts reasonably conclude that you (or your family or employer) stand to benefit from a particular outcome of this peer review? ☑ No ☐ Yes

With regard to real or apparent conflicts of interest or questions of impartiality, the following provisions shall apply for the duration of this peer review:

(a) Peer Reviewer warrants, to the best of his/her knowledge and belief, that there are no relevant facts or circumstances that could give rise to an actual, apparent, or potential organizational or personal conflict of interest, or that Peer Reviewer has disclosed all such relevant information to EMS or to EPA.
(b) Peer Reviewer agrees that if an actual, apparent, or potential personal or organizational conflict of interest is identified during performance of this peer review, he/she immediately will make a full disclosure in writing to EMS. This disclosure shall include a description of actions that Peer Reviewer (or his/her employer) has taken or proposes to take after consultation with EMS to avoid, mitigate, or neutralize the actual, apparent, or potential organizational conflict of interest. Peer Reviewer shall continue performance until notified by EMS of any contrary action to be taken.

1-18-12

Signature Date

☐ Check here if any explanation is attached

Paul C Johnson

Printed Name

Arizona State University

Affiliation/Organization

Peer Reviews

Kimi Klein & Dot Lofstrom
(Joint Reviewers, California DTSC)

- Charge Questions Comments
- CVs
- COI Certifications

Peer Review Charge for:
U.S. Environmental Protection Agency (EPA). *Proposed Rule: Addition of a Subsurface Intrusion Component to the Hazard Ranking System*; 40 CFR Part 300; EPA-HQ-SFUND-2010-1086; FRL_XXXX-X (review draft).

Background
The U.S. Environmental Protection Agency (EPA) is proposing to include a subsurface intrusion (SsI) component to the Hazard Ranking System (HRS). Subsurface intrusion is the migration of hazardous substances from the unsaturated zone and/or the surficial ground water into overlying structures. The HRS is the principal mechanism the EPA uses to evaluate sites for placement on the National Priorities List (NPL). The subsurface intrusion component addition (this addition) would primarily expand the number of available options for EPA and state and tribal organizations performing work on behalf of EPA to evaluate potential threats to public health and the environment from releases of hazardous substances.

This addition will allow the HRS evaluation to directly consider human exposure to hazardous substances that enter building structures through subsurface intrusion, and thus enable sites with subsurface intrusion contamination to be evaluated for placement on the NPL. This addition will make the HRS more accurate in assessing a site's relative potential risk. The Agency is not considering changes to the remainder of the HRS except for minor updates reflecting changes in terminology related to revised toxicological parameters. This proposed regulatory change does not affect the status of sites currently on or proposed to the NPL.

Expertise Required
The peer review panel for U.S. EPA's *Proposed Rule: Addition of a Subsurface Intrusion Component to the Hazard Ranking System* should include expertise in:

Panelist from non-specified sector: Panelist must have a strong working knowledge of policy and technical issues related to the topic of vapor intrusion. Knowledge of recent developments in vapor intrusion technologies and research is required, in addition to working knowledge of federal vapor intrusion response programs. Expertise in hydrogeology, chemistry, knowledge of public health risks associated with indoor air threats, and the subsurface migration of volatile hazardous substances is necessary. Field experience conducting vapor intrusion investigations, while not required, is highly desirable. Experience conducting field investigations for the purpose of listing sites on the NPL and/or experience working with the HRS to evaluate sites for inclusion on the NPL is highly recommended, but not necessary.

Peer Review Charge Questions

1. Potential for subsurface exposure (intrusion) into occupied structures
Background: The current HRS evaluates the likelihood of a release of a hazardous substance when an actual release has occurred through either chemical analysis or direct observation. The current HRS also evaluates the potential for a release to occur within the ground water, surface water and air pathways (see section 2.3 of the current HRS). The potential for a release is determined by the consideration of pathway specific factors that aid the site evaluator in predicting whether a release to the pathway is likely to occur. These factors are based on containment features of the source of contamination (whether or not hazardous substance can get out), route characteristics specific to each pathway (how far hazardous substances could migrate based on knowledge of site conditions) and include physical/chemical properties of the hazardous substances being evaluated (how the hazardous substances act in the environment).

Proposed Approach: EPA is proposing a parallel approach for evaluating potential and actual exposure of intruded hazardous substances for the subsurface intrusion addition to the HRS. In determining which route characteristics are appropriate for evaluating potential exposure to subsurface contaminants, EPA examined present modeling methods such as the Johnson-Ettinger model and also considered multiple lines of evidence approaches which estimate the levels of contaminant exposure based on numerous route characteristics. In addition, EPA examined the relationship between these factors to determine which have the greatest influence on the likelihood that an exposure would occur, and then incorporated these factors within its proposed approach. EPA also gave careful consideration to ensure that the data necessary to obtain route characteristic factors could be measured or calculated on a site-specific basis and in a manner consistent with current HRS evaluations. Based on the Agency's analysis, the following three factors for which sufficient site-specific information could be collected during a site inspection represented the greatest impact on the potential for exposure: (1) depth to contamination; (2) vertical migration; and (3) vapor migration potential (see Figure 1).

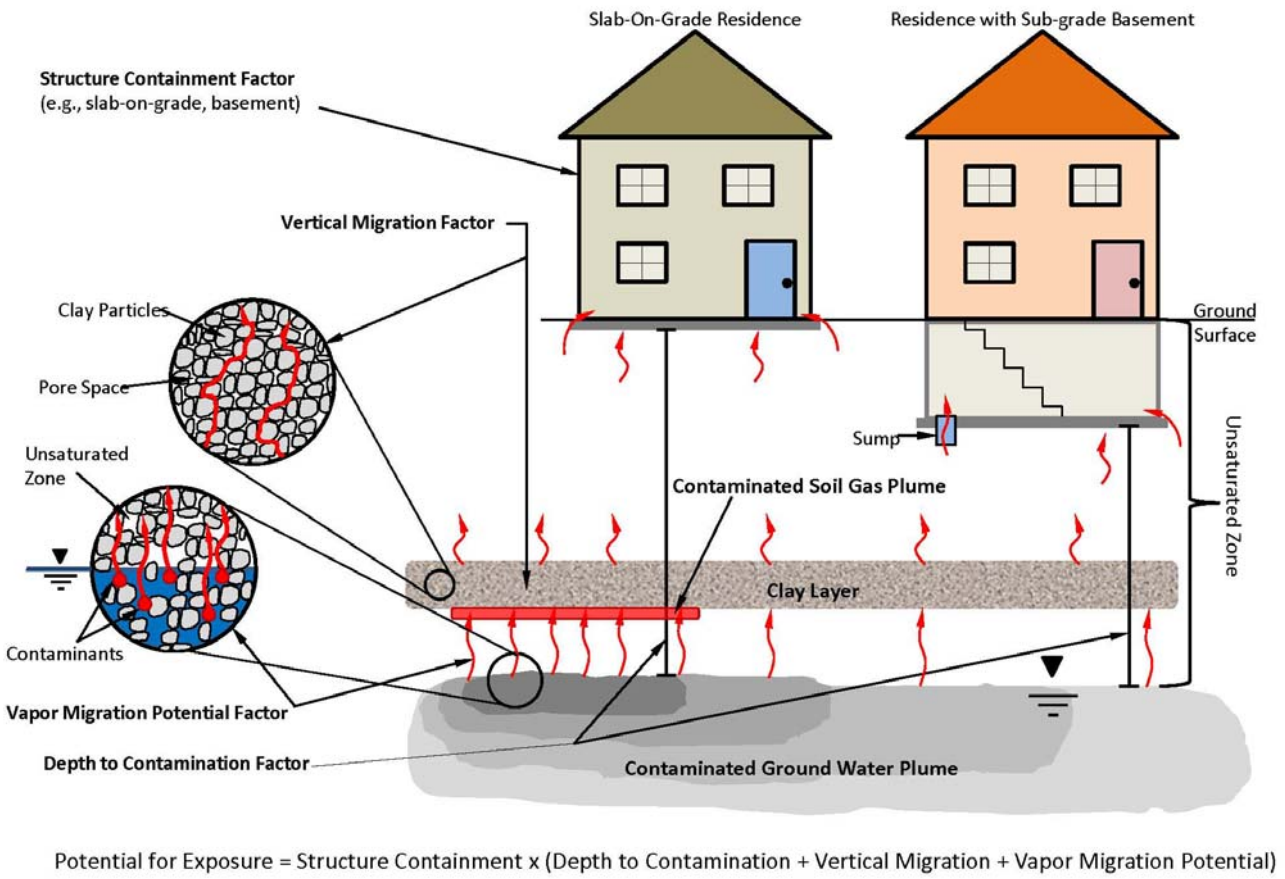

Figure 1

Charge Question #1 : Is EPA's proposed approach scientifically reasonable for evaluating and assigning proportional weightings for the following when evaluating potential for exposure? If no, what alternative approach would you recommend?

a. Consideration of the construction/structure type for which sufficient site-specific information could be collected during a site inspection for the occupied structure;
b. Distance between occupied structure and depth of contamination; and
c. Evaluation of the vertical migration factor based on the thickness and porosity/permeability of geologic materials in the interval between the lowest point of an occupied structure and the highest known point of hazardous substances in the subsurface.

1) There is no provision for significant volatile organic chemical (VOC) concentrations detected in soil and/or surficial groundwater but without structures. Alternative: Provide default structure properties.

2) The vertical migration factor ranking considers certain geologic factors and identifies karst, lava tubes, open fractures (5.2.1.1.2.2) as features that would allow channelized flow. Manmade preferential pathways such as utility corridors and sewer lines should be included in the HRS assessment, if identified in the site inspection. Alternative: Expand the definition of channelized flow to include most commonly encountered features and/or include that expanded list in the regulatory language (Perhaps as part of Table 5-15 Vertical Migration Factor Values).

2. Hazardous Waste Quantity

Background: In the current HRS, the hazardous waste quantity factor reflects the risk consideration related to the magnitude and duration of either the release for ground water, surface water, and air pathways, or the exposure for the soil exposure pathway (see section 2.4.2 of the current HRS). Hazardous waste quantity is evaluated for all four pathways. At each site evaluated, EPA uses a four-tiered hierarchy for calculating the hazardous waste quantity that is based on (1) constituent quantity; (2) waste stream; (3) volume; and (4) area of the sources of hazardous waste at the site. EPA uses minimum waste quantity factors when there is insufficient information to estimate hazardous waste quantity. In the ground water, surface water, and air pathways, the HRS evaluates the total quantity of hazardous substances available to migrate from the original sources (how much has migrated and how much can be released in the future). In the soil exposure pathway, the hazardous waste quantity does not include the total amount of hazardous substances in all site sources, but rather is based on the amount of hazardous substances to which a receptor can be exposed where actual contamination has been documented. In other words, for the soil exposure pathway, the risk posed by a release of hazardous substances is directly related to the amount of hazardous substances that receptors are exposed to, as opposed to how much of the hazardous substances from the original sources may migrate to the receptors.

Proposed Approach: EPA is proposing a parallel approach to the soil exposure pathway to calculate hazardous waste quantity for the subsurface intrusion addition to the HRS. Since the subsurface intrusion component also focuses on exposure, the waste quantity factor value for this component should also reflect only the amount of hazardous substances that people actually are exposed to (the amount present in occupied structures). EPA is proposing to use a similar four-tiered hierarchical approach to calculate hazardous waste quantity within occupied structures with contamination. In cases where no home is subject to actual contamination, EPA is proposing to use minimum waste quantity factors. In situations where there is an observed release within a structure above benchmarks (Level I), a default value of 100 is proposed for the hazardous waste quantity factor value. This value is not used in the current soil exposure pathway, but is consistent with the ground water, surface water, and air pathways and reflects the increased exposure risk of a release within an occupied structure.

Charge Question #2: Is EPA's approach of basing the hazardous waste quantity on the amount of contaminants that could be found in the intruded structures appropriate? If no, what alternative approach would you recommend?

Response from K. Klein

1) The hazardous waste quantity ranking is based on the assumption that a structure or structures currently exist on the site being evaluated. If this is the case at the site being evaluated, the approach seems appropriate. But it is difficult to imagine that the sampling necessary to carry this approach out can be accomplished within a 1 -2 day site inspection. Soil gas/groundwater sampling should be done prior to indoor air sampling in order to identify those substances to be analyzed for in indoor air (substances associated with subsurface contamination).

2) However, the approach does not allow for the determination of the hazardous waste quantity in the absence of structures but where significant hazardous substance (VOC) contamination exists in soil/groundwater where structures could or will be constructed. Alternative: Provide a simple approach for estimating indoor air concentrations from measured environmental media concentrations (soil gas, groundwater) using default attenuation factors and parameters for a default structure. Provide default volume values (a default area value is provided (Table 5-19)). I could not find in the proposed regulations explicit direction on "where no home is subject to actual contamination".

3. Population score

Background: Within the current HRS, receptors are evaluated in two main categories: whether they are exposed to 1) actual contamination; or 2) potential contamination (see section 2.5 of the current HRS). If receptors are exposed to contaminant levels meeting observed release criteria, they are identified as actually contaminated; however, if the receptors are not exposed to contaminants that meet the observed release criteria but are within the target area being evaluated, they are considered potentially contaminated. Actual contamination is further divided into two sub-categories based on whether the hazardous substance is present at or above a health-based benchmark. If the concentration of the hazardous substance released at the receptor is greater than a health-based benchmark, the receptors are identified as Level I receptors and are weighted (multiplied by a factor of 10) in scoring. If the release concentrations are less than a health-based benchmark, the receptors are identified as Level II receptors and are not weighted (multiplied by a factor of 1). Potential receptors are distance/dilution weighted; in other words, the farther away a receptor is located from a source, the less the population contributes to the site score.

Proposed Approach: EPA is proposing to generally use the same receptor weighting structure in the subsurface intrusion component as the one used in the current HRS. Those receptors in the area(s) of observed exposure (AOE) are considered actually contaminated, and those in the area(s) of subsurface contamination (ASC) are considered potentially contaminated (See Figure 2). The receptors in an AOE are further differentiated based on whether the contaminant concentrations are at levels above identified benchmarks (Level I) or are at levels establishing a release but below identified benchmarks (Level II). The benchmarks that EPA is proposing to use for the subsurface intrusion component are:

- Screening concentration for cancer effects; and
- Screening concentration for non-cancer effects (systemic toxicants).

Consistent with the weighting of populations throughout the HRS, the proposed subsurface intrusion component will weight targets within the AOE subject to Level I contaminant concentrations by a factor of 10 and weight targets subject to Level II contaminant concentrations by a factor of 1.

EPA is proposing to evaluate the weighting of targets within the ASC based on sub-slab, soil gas, and/or ground water samples. Potential receptors within the ASC receive less weight (population multiplied by a factor of 0.1), except in cases where a sub-slab sample indicates contaminant levels are at least 10 times higher than a health-based benchmark (population is multiplied by a factor 0.75). The value of 0.75 was determined based on an evaluation of paired data when both a sub-slab and indoor air sample were collected. The 0.75 weighting reflects the observation that for approximately 80 percent of the sampling events where contamination was detected in the sub-slab, contamination was also detected in the indoor air sample. The order of magnitude adjustment applied to the health-based benchmark reflects EPA's finding that, in such paired sampling events, the indoor air sample concentration is, on average, 10 times lower than the sub-slab sample concentration.

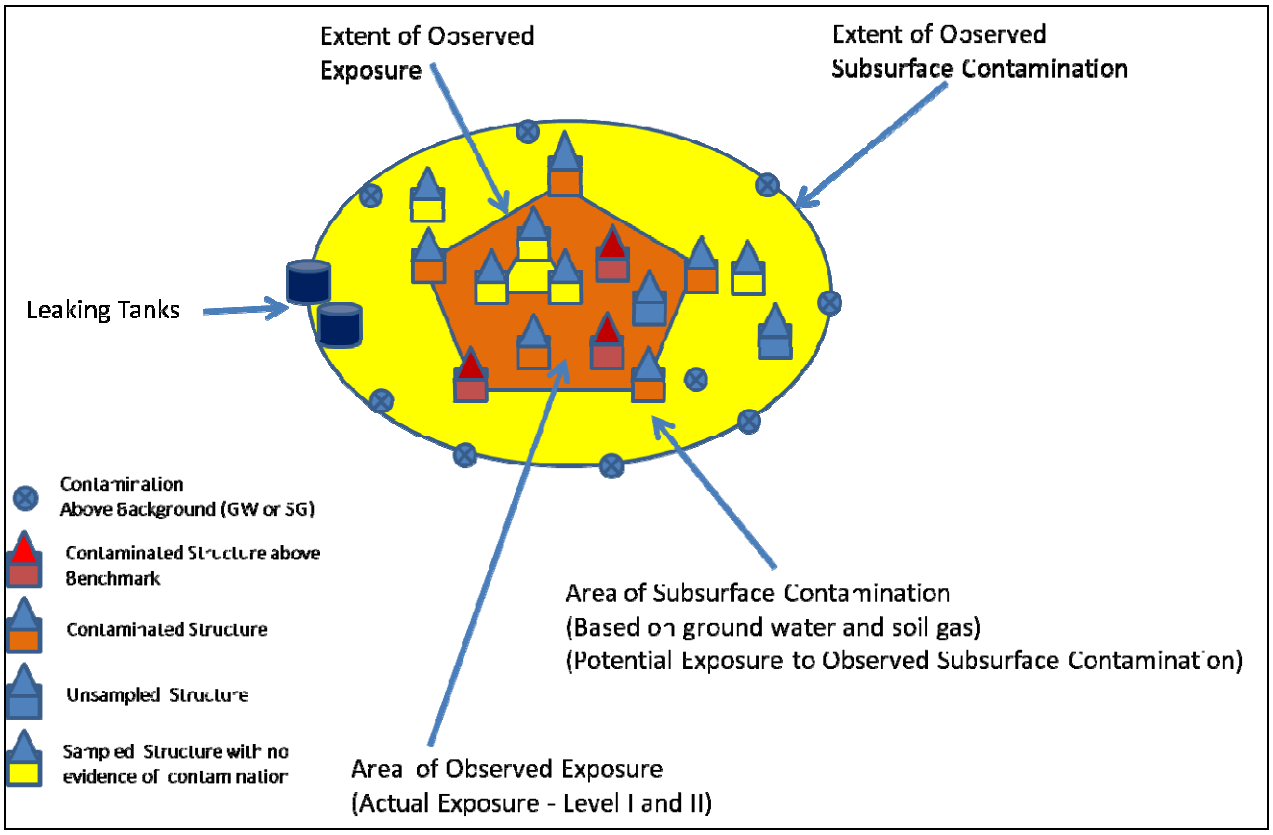

Figure 2

Charge Question #3: Is it appropriate to consider individuals/populations located within the area of subsurface contamination (ASC) to be at a higher relative risk in situations when sub-slab contaminant concentrations are at least ten times greater than a health-based benchmark? If no, please explain.

Response from K. Klein

This approach is consistent with the California Department of Toxic Substances Control (DTSC) vapor intrusion guidance.

4. Multi-story and multi-tenant structures

Background: In the current HRS, multi-story and multi-tenant buildings are evaluated based on population associated with an actually or potentially impacted target. In the ground water pathway, all residents who are served by a well are considered subject to the actual or potential contamination of the well. In the air pathway, all residents who have an opportunity to breathe ambient air are considered subject to the actual or potential contamination of the ambient environment within a distance category. All receptors within a contaminated surface water stretch are subject to the level of contamination associated with that surface water stretch. In the soil exposure pathway, receptors must be able to come in contact with areas of contamination. In determining the likelihood a person will come in contact with areas of contamination, the HRS uses a 200 foot rule (see section 5.1.3 of the current HRS) because it is reasonable to assume that that a person will walk/use areas within a 200 foot areal extent of their residence/property. The 200 foot rule is used regardless of whether a building is multi-tenant or multi-story (the assumption being that is reasonable for people to use the outside of their properties).

Proposed Approach: EPA is proposing to evaluate multi-story/multi-tenant buildings utilizing a similar approach as soil exposure, limiting the receptors to those individuals that reasonably can be exposed to subsurface intrusion within an occupied multi-tenant/multi-story building. EPA is proposing to consider all receptors exposed to actual contamination as the population inhabiting the floor of the intruded space and the population inhabiting the floor above and the floor below the intruded space when calculating waste quantity and population. EPA considers that this approach will more accurately reflect risk to both actual and potential receptors, while also minimizing the potential for over counting (Figure 3).

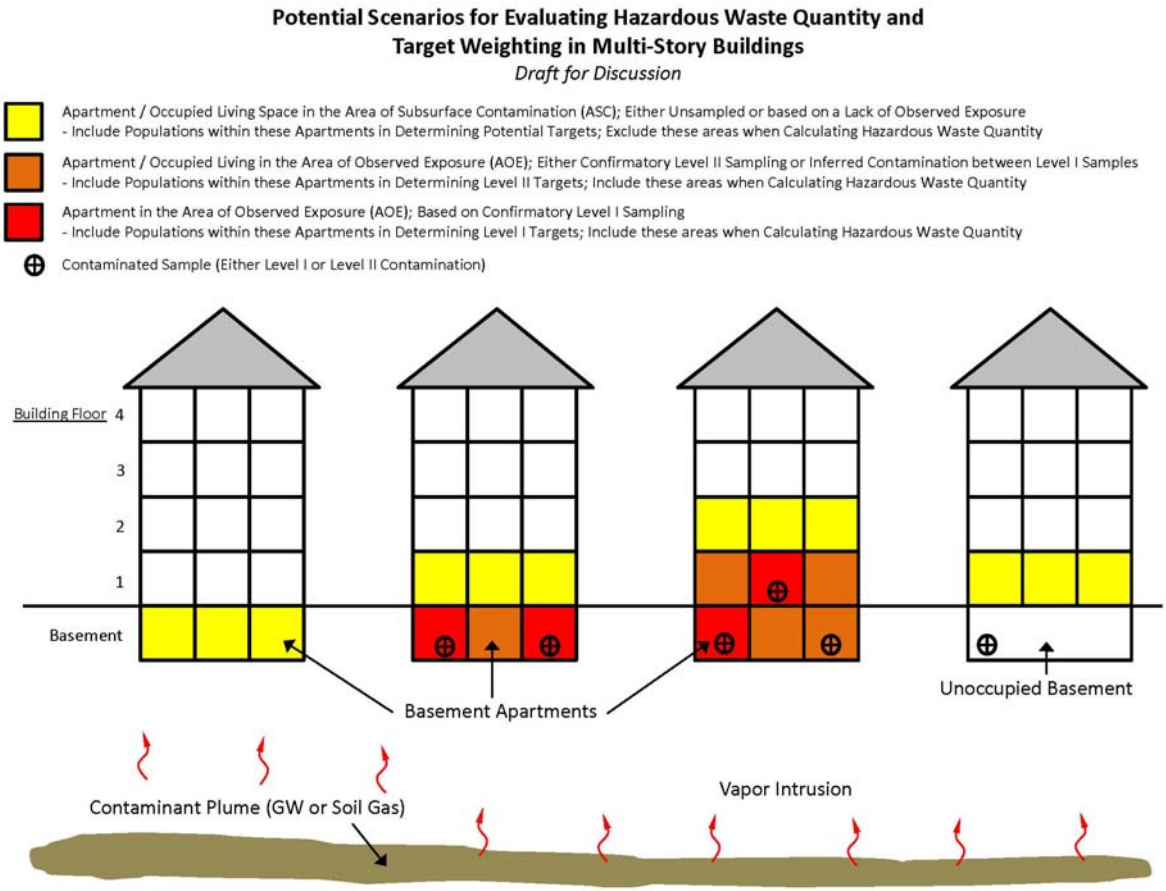

Figure 3

Charge Question #4: When calculating waste quantity and population, is it scientifically reasonable for populations in multi-story or multi-tenant structures to be evaluated based on using only the population inhabiting the intruded space and the population on the floor above and below the intruded space (For example, if contamination is found on the first floor, population from the basement and second floor would be used in the calculation. If contamination is found on the fifth floor, population from the fourth floor and sixth floor would be used in the calculation – for further explanation, see detailed discussion in above paragraph "Proposed Approach")? If no, what alternative approach would you recommend?

Response from K. Klein

This is a reasonably conservative approach. However, there is much uncertainty surrounding the stated assumptions. Therefore, there should be an in-depth discussion of this approach in the proposal Technical Support Document with references to support it.

5. Factor Value for Workers

Background: In the current HRS, for the resident population threat of the soil exposure pathway, a factor value for workers is assigned based on the total number of workers present within the area of observed contamination. These factor values range from 0 to15, depending on the number of workers exposed to outdoor contamination (see section 5.1.3.3 of the current HRS).

Proposed Approach: EPA is proposing to mirror the procedures for the resident population threat in the soil exposure component when assigning a worker factor value in the subsurface intrusion component (see Table 5-4 in section 5.1.3.3 of the current HRS). However, since it is anticipated that workers spend a larger percentage of their time indoors and therefore may be more exposed to contamination resulting from subsurface intrusion than to outdoor soil (or other surface) contamination, EPA is proposing to assign workers exposed to subsurface intrusion a higher weighting (i.e., factor values ranging from 0 to 45).

Charge Question #5: Because of longer exposure times indoors, is it reasonable to assume that the relative risk is three times greater for workers exposed to subsurface intrusion within the workplace than it is for workers exposed to outdoor surface contamination at the workplace? If no, please explain.

Response from K. Klein

Assuming a relative risk of three times greater for indoor workers vs. outdoor workers for volatile organic chemicals (VOCs) may be an underestimate, since indoor workers would be exposed to contaminated air in a limited volume over much of their work day; whereas, contamination in outdoor air is not constrained in a limited space but is immediately diluted by atmospheric air. Other direct exposure pathways (incidental soil ingestion; dermal contact) contribute very little to uptake/intake because of the volatile nature of the chemicals under discussion in the subsurface intrusion component. The proposal Technical Support Document should discuss and provide support for any factor chosen to reflect the greater relative risk for indoor workers.

CURRICULUM VITAE

August 2010

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EDUCATION

1986 Ph.D., Comparative Pathology, University of California, Davis

1962 Medical Technology Internship, U.S. Public Health Service Hospital, Staten Island, New York

1961 B.S. with honors, Public Health Laboratory Technology, University of California, Berkeley

HONORS

2006 Superior Accomplishment Silver Team Award, Department of Toxic Substances Control

1998 Sustained Superior Accomplishment, Department of Toxic Substances Control

1982 Special Performance Award, University of California, Davis

1980 Citation for Excellence in Supervision, University of California, Davis

1979 Outstanding Service to the Laboratory, Radiobiology Laboratory, University of California, Davis

POSITIONS HELD

3/10 – Present Staff Toxicologist Emerita, California Department of Toxic Substances Control, Berkeley

6/90 – 11/09 Staff Toxicologist, California Department of Toxic Substances Control, Sacramento

10/87 - 6/90 Staff Toxicologist; Environmental Hazards Scientist, California Department of Food and Agriculture, Sacramento

1974 - 1987 Staff Research Associate IV, Laboratory for Energy-Related Health Research, University of California, Davis

1965 - 1970 Laboratory Technician III, Radiobiology Laboratory, University of California, Davis

1962 - 1965 Laboratory Technician II, University of California, San Francisco

ACTIVITIES

1992 Membership Officer, Genetic and Environmental Toxicology Association of Northern California.

2000 Secretary, Genetic and Environmental Toxicology Association of Northern California

1979-1982 Member, FDA Advisory Committee, Hematology Section of the Clinical Chemistry and Hematology Devices Panel, Washington, DC. Consumer representative to the panel.

1976-1977 Member, Task Force on Long-Term Care, Golden Empire Health Systems Agency, Sacramento

DISSERTATION

Canine Lymphohematopoiesis - June 1986

PUBLISHED PAPERS

– 17 published papers from 1967 through 1995 on hematopoiesis and toxicology
  The following are papers in toxicology:

  1987 Klein, A. K., M. L. Nasr and M. Goldman. The effects of in vitro exposure to the neurotoxins Sarin (GB) and Soman (GD) on unscheduled DNA synthesis by rat hepatocytes. Toxicology Letters 38:239-249.

  1988 Nasr, M. L., M. Goldman, A. K. Klein, and J. C. Dacre. SCE induction in Chinese Hamster Ovary cells (CHO) exposed to G agents. Mutation Research 204:649-654.

  1995 Klein, A. K., J. P. Christopher. Evaluation of crystalline silica as a threshold carcinogen. Scandinavian Journal of Work, Environment & Health 21 suppl2:95-98.

– 3 chapters on toxicology and risk assessment in books from 1993 through 2002

The following are the chapter citations:

1993 Wade, M. J., B. K. Davis, J. S. Carlisle, A. K. Klein, L. M. Valoppi. Environmental Transformation of Toxic Metals. In: De Novo Toxicants: Combustion Toxicology, Mixing Incompatibilities, and Environmental Activation of Toxic Agents. State of the Art Reviews, Occupational Medicine. Eds. D. J. Shusterman, J. E. Peterson. Volume 8/Number 3. Hanley & Belfus, Inc. Philadelphia.

1995 Davis, B. K., A. K. Klein. Medium-specific and multimedium risk assessment. In: Toxicology and Risk Assessment, Principles, Methods, and Applications. Eds. A. M. Fan, L. W. Chang. Marcel Dekker, Inc., New York.

2002 Klein, Kimiko, Marilyn Underwood. Remediation. In: Encyclopedia of Agrochemicals. Eds. Jack R. Plimmer, D. W. Gammon, N. N. Ragsdale. John Wiley & Sons, Inc. 2003.

PUBLICATIONS OF THE CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE

1988 Oudiz, D. and A. K. Klein. Evaluation of Ethyl Parathion as a Toxic Air Contaminant. 179 pp. CDFA EH-88-5. NTIS PB90-134909.

PUBLICATIONS OF THE CALIFORNIA DEPARTMENT OF TOXIC SUBSTANCES CONTROL (DTSC)

2009 Klein, K. and D. L. Berry. Remedial Goals for Dioxins and Dioxin-like Compounds for Consideration at California Hazardous Waste Sites. Human Health Risk Assessment (HHRA) Note 2. DTSC. May 2009.

COURSES TAUGHT

1. 1990 - 1993. Risk and Decision Making Workshop. Three-day course sponsored by the US EPA Region IX and the Department of Toxic Substances Control for governmental regulatory agency personnel. Team instructor. .

2. 1993 - 1994. Critical Issues in Risk Assessment: Risk Assessment Guidance for Superfund and DTSC Supplemental Guidance. One-day course for staff of the Department of Toxic Substances Control. Team instructor with Dr. Brian Davis.

3. 1994. Risk and Decision Making at Petroleum Impacted Sites. Three-day course sponsored by the San Francisco Bay Regional Water Quality Control Board for governmental regulatory agency personnel. Team instructor with Dr. Brian Davis for the sections on risk assessment.

4. 1996 -1997, 2001. Environmental Toxicology 146. Spring quarter course given at the University of California at Davis for upper division students. Team instructor for sections on topics related to regulatory risk assessment.

5. 1996, 1997. Risk Assessment Modeling: The CalTOX Model. Three-day extension course sponsored by the University of California at Davis for interested parties. Team instructor.

6. 1996. Risk-based Cleanup: What's Acceptable? One-day extension course sponsored by the University of California at Davis for interested parties. Team instructor responsible for the topic of calculating human health-based safe soil levels.

7. 1997. Health Risk Assessment at Hazardous Waste Sites. Two-day short course on human and ecological risk assessment principles at Chulalongkorn University, Bangkok, Thailand.

8. 1997, 1998. Integrated Multimedia Exposure Modeling with Sensitivity and Uncertainty Analysis. One-day course sponsored by the International Society of Exposure Analysis. Team instructor with Dr. Ned Butler.

9. 1998. Modeling Environmental Risk – Demonstration of California Toxic Risk Models. One-day course sponsored by the Harvard School of Public Health. Team instructor with Dr. Ned Butler.

10. 2000. Advanced Health Risk Assessment. Three-day short course at Chiang Mai University, Chiang Mai Thailand. Given also for Pollution Control Department staff, Ministry of Science Technology and Environment, at Chulalongkorn University, Bangkok, Thailand. Team instructor with Dr. Brian Davis.

11. 2009. Vapor Intrusion Guidance. Two-day short course on evaluating vapor intrusion into indoor air spaces from sub-surface sources. Team instructor responsible for the topic of proper application of California Human Health Screening Levels (CHHSLs) in estimating the risk from this exposure pathway.

PRESENTATIONS

Davis, B.K., Klein, A.K., Wade, M.J., Valoppi, L.M., and Carlisle, J.S., 1994. Environmental transformation of metals and risk assessment. The Toxicologist 14:39.

Davis, B.K., Christopher, J., Wade, M.J., and Klein, A.K., 1995. Risk assessment for multiple source exposures. The Toxicologist 15:36.

Christopher, J.P., Butler, E.G., Klein, A.K., Davis, B.K., and Wade, M.J., 1996. CalTOX Stochastic Risk Assessment Compared to Standard CERCLA Methods. The Toxicologist, (Fundamental and Applied Toxicology) 30:113.

Butler, E.G., Klein, A.K., Davis, B.K., Christopher, J.P., Wade, M.J., Wong, J.J., and McKone, T.P., 1996. Use of CalTOX to Guide Site Characterization and Risk Management Decisions for Contaminated Soil. Fundamental and Applied Toxicology, (The Toxicologist) 30:113-4.

Davis B.K., Klein, A.K., and Wade, M.J., 1998. Approaches to Screening Level Risk Assessment at California Hazardous Waste Sites. Toxicological Sciences 42:231.

Christopher, J.P., Carlisle, J.C., Davis, B.K., Klein, A.K., Renzi, B.E., and Wade, M.J., 2000. Comparison of Updated Leadspread to Integrated Uptake, Exposure and Biokinetic Model (IEUBK) for predicting blood lead in children. The Toxicologist, Supplement to Toxicological Sciences 54:72.

Carlisle, J.C., Christopher, J.P., Davis, B.K., Klein, A.K., Renzi, B.E., and Wade, M.J., 2000. Updated version of Cal/EPA's Leadspread model for predicting blood lead in children and adults. The Toxicologist, Supplement to Toxicological Sciences 54:72.

Renzi, B., Wade, M.J., Davis, B.K., Klein, A.K., and Christopher, J.P., 2001. Lead-Based Paint in Soil: When Worlds Collide – CERCLA Meets HUD. The Toxicologist, Supplement to Toxicological Sciences 60:422.

Davis, B.K., J.F. Beach, M.J. Wade, A.K. Klein, and K. Hoch, 2002. Risk Assessment of Polychlorinated Biphenyls (PCBs) in Indoor Air. The Toxicologist, Supplement to Toxicological Sciences 66:106. Abstract number 516.

DiBiasio, K., K. Klein, 2003. Human Health Risk Evaluation of Structural Surfaces Contaminated with Metals, presented at the Society of Toxicology Annual Meeting.

DTSC WORK GROUPS/TEAMS – I was a member of the following work groups/teams involved in developing guidance or resolving issues associated with risk assessment:

2005 HERD Work Group on Environmentally Acceptable Endpoints for Lampblack and Lampblack-Impacted Soils – Polycyclic Aromatic Hydrocarbons available for dermal and ingestion absorption

2006 Cal/EPA Work Group on Use of California Human Health Screening Levels (CHHSLs) in Evaluation of Contaminated Properties

2005; 2010 DTSC Work Group on Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air

2005 HERD Work Group on Default Exposure Parameters for Non-Residential Receptors at Abandoned Mining Sites

2006 DTSC Voluntary Cleanup Program Team charged to review voluntary cleanup operations and recommend changes to make the process go more quickly, more effectively and better.

2010 Co-author revising the DTSC Preliminary Endangerment Assessment Guidance Manual

RESEARCH INTERESTS AND SKILL SET

Toxicologists in the Human and Ecological Risk Office of the Department of Toxic Substances Control perform and review human and ecological health risk assessments. Our primary focus is assessment of exposure by humans and non-human receptors to chemicals that have been released to the environment and have the potential to cause adverse health effects. My principal scientific interest is alternative approaches to exposure assessment that address site-specific characteristics of locations affected by past manufacturing activities. Technical writing and risk communication are particular skills I possess. These skills are important in the clear transmittal of critiques and reviews of documents submitted to the Department and in the teaching of risk assessment to students and individuals in the community.

The following is a summary of my experience in and knowledge of environmental fate and transport.

1. 1987-88. As an environmental hazards scientist in the environmental monitoring program of the California Department of Food and Agriculture, I was responsible for reviewing the protocol, performance, and results of field experiments designed to measure residual pesticide concentrations in environmental media after legal application. I was a co-author of a report on the evaluation of ethyl parathion as a toxic air contaminant with responsibility for the sections on the environmental fate of this pesticide.

2. 1993-98. As a member of the team overseeing the development and use of a spreadsheet model, called CalTOX, that relates the concentration of an organic chemical in soil to the risk of an adverse health effect for a person living or working on or near the contaminated soil. I was responsible for writing the technical reports describing the model for the California Department of Toxic Substances Control (DTSC). CalTOX was developed by the University of California and has been extensively peer-reviewed. The spreadsheet model consists of two parts. The first part uses equations based on conservation of mass and chemical equilibrium to predict the time-dependent concentrations of a chemical in the eight environmental compartments of air, surface water, groundwater, three soil layers, sediment, and plants at a site. The second part relates those calculated chemical concentrations in environmental media over time to concentrations in personal air, tap water, food, household dusts, etc., thereby combining environmental fate and transport of the chemical to potential exposure to the chemical by human receptors.

3. 1996-98. I was part of a DTSC team teaching courses that emphasized multi-media exposure modeling as a screening tool in human health risk assessment. Environmental fate processes were discussed in depth in these courses.

4. 2005- present. I was part of a DTSC team writing guidance on evaluating the intrusion of subsurface vapors intruding into indoor air. This evaluation is based on a spreadsheet model that considers diffusion and advective forces in the transport of volatile chemicals in sub-surface soil and/or groundwater to indoor air spaces. This model is called the Johnson and Ettinger Model and has been extensively peer-reviewed and modified by the DTSC for use in human health risk assessment.

Dot Lofstrom
Section Chief, Geological Services Unit
California Environmental Protection Agency – Department of Toxic Substances Control (DTSC)
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Sacramento, California 95826

- Lead Author of Vapor Intrusion Mitigation Advisory (DTSC 2011)
- Co-Author of Advisory- Active Soil Gas Investigations (Cal/EPA –expected publication date February 2012)
- Technical Editor for the Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air (Vapor Intrusion Guidance) (DTSC 2011).

M.S. – Geology, University of Missouri, 1988

B.S. – Geology, Missouri State University, 1981

Professional Geologist #7022

Summary of Work Experience: 24 years with primary emphasis on soil and groundwater investigations under RCRA and CERCLA. Background includes State government, consulting, federal government (Department of the interior) and academics (Arizona Western College).

Summary of Vapor Intrusion Experience: Actively working on vapor intrusion guidances at DTSC since 2008; presented papers on DTSC guidance at Air and Waste Management Association (San Diego 2009), National Brownfield Association (Sacramento 2009), and the Batelle conference in Monterey (2010).

2009 to present

DTSC, Sacramento CA- Supervisor for Cal Center Geological Services Unit. As a supervisor, provide technical and professional leadership to nine registered geologists working on investigation and remediation of soil, soil gas, and groundwater within the State of California, under the RCRA and CERCLA processes. Serve as Vapor Intrusion/Soil Gas Collection Specialist within DTSC.

2005 to 2009

DTSC, Sacramento CA -Senior Engineering Geologist.Remedial Project Manager for the NPL site Naval Air Station-Alameda, California.Worked closely with EPA RPM Anna-Marie Cook, San Francisco Region 9, following the CERCLA process from remedial investigation through the Record of Decision and Remedial Design.Reviewed and commented on technical documents and represented DTSC in public meetings.

2001 to 2005

DTSC, Sacramento CA- Engineering Geologist. Provided geologic support the RCRA sites, primarily focused on post-closure permits or corrective action for treatment, storage and disposal facilities.

2000 – 2001

San Joaquin County, Stockton CA – Registered Geologist.Provided technical guidance and leadership for six registered environmental health specialists, ensuring proper investigation and remediation of leaking underground storage tanks.

1998 – 2000

Tetra Tech, EMI, Sacramento CA – Senior Environmental Geologist.Remedial Project Manager for Naval Computer and Telecommunication Station- Stockton. Lead investigator for ten landfill sites, collecting relevant soil and groundwater data, and managing writing/production of remedial investigation reports for U.S. Navy.

1993 - 1998

Arizona Western College, Yuma AZ – Professor of Environmental Technology. Lead faculty instructor and creator of Department of Environmental Technology, a program designed to give students a practical background to prepare them for work as environmental technicians. Taught courses in Environmental Regulations, Sampling and Analysis, Hazardous Waste Management, and Physical Geology.

1991-1993

Department of Defense (USBR and BLM), Yuma AZ

- USBR - Hydrogeologist. Responsible for installation and development of large-diamater irrigation and drinking water wells.
- BLM –District Geologist. Responsible for administering the Minerals program in the Yuma District, reviewing mining and reclamation plans.

1988 – 1993

IT Corporation, Irvine CA – Assistant Project Scientist. Responsible for investigation of leaking underground storage tanks and pesticide contaminated sites. Conducted site investigations, analyzed soil and groundwater data, and wrote subsequent reports.

Peer Reviewer Conflict of Interest Certification

Peer Review: *Proposed Rule: Addition of a Subsurface Intrusion Component to the Hazard Ranking System*; 40 CFR Part 300; EPA-HQ-SFUND-2010-1086; FRL_XXXX-X (review draft).

A conflict of interest or lack of impartiality exists when the proposed peer reviewer personally (or the peer reviewer's immediate family), or his or her employer, has financial interests that may be affected by the results of the peer review; or may provide an unfair competitive advantage to the peer reviewer (or employer); or if the peer reviewer's objectivity in performing the peer review may be impaired due to other factors. When the Peer Reviewer knows that a reasonable person with knowledge of the facts may question the peer reviewer's impartiality or financial involvement, an apparent lack of impartiality or conflict of interest exists.

The following questions, if answered affirmatively, represent potential or apparent lack of impartiality (*any affirmative answers should be explained on the back of this form or in an attachment*):

- Did you contribute to the development of the document under peer review, or were you consulted during its development, or did you offer comments or suggestions to any drafts or versions of the document during its development? ☑ No ☐ Yes
- Do you know of any reason that you might be unable to provide impartial advice on the matter under consideration in this peer review, or any reason that your impartiality in the matter might be questioned? ☑ No ☐ Yes
- Have you had any previous involvement with the review document(s) under consideration? ☑ No ☐ Yes
- Have you served on previous advisory panels, committees, or subcommittees that have addressed the topic under consideration? ☐ No ☑ Yes
- Have you made any public statements (written or oral) on the issue? ☑ No ☐ Yes
- Have you made any public statements that would indicate to an observer that you have taken a position on the issue under consideration? ☑ No ☐ Yes
- Do you, your family, or your employer have any financial interest(s) in the matter or topic under peer review, or could someone with access to relevant facts reasonably conclude that you (or your family or employer) stand to benefit from a particular outcome of this peer review? ☑ No ☐ Yes

With regard to real or apparent conflicts of interest or questions of impartiality, the following provisions shall apply for the duration of this peer review:

(a) Peer Reviewer warrants, to the best of his/her knowledge and belief, that there are no relevant facts or circumstances that could give rise to an actual, apparent, or potential organizational or personal conflict of interest, or that Peer Reviewer has disclosed all such relevant information to EMS or to EPA.
(b) Peer Reviewer agrees that if an actual, apparent, or potential personal or organizational conflict of interest is identified during performance of this peer review, he/she immediately will make a full disclosure in writing to EMS. This disclosure shall include a description of actions that Peer Reviewer (or his/her employer) has taken or proposes to take after consultation with EMS to avoid, mitigate, or neutralize the actual, apparent, or potential organizational conflict of interest. Peer Reviewer shall continue performance until notified by EMS of any contrary action to be taken.

Kimiko Klein 12/22/2011

Signature Date

☑ Check here if any explanation is attached

KIMIKO KLEIN

Printed Name

DTSC HUMAN & ECOLOGICAL RISK OFFICE

Affiliation/Organization

December 22, 2011

Question: Have you served on previous advisory panels, committees, or subcommittees that have addressed the topic under consideration?

I was on the team that produced the California Department of Toxic Substances Control (DTSC) Vapor Intrusion Guidance and its recent revision. My main tasks were to provide technical editorial assistance and to address human health risk assessment issues associated with vapor intrusion within that guidance.

Kimiko Klein

Kimiko Klein, Ph.D.
Staff Toxicologist Emerita

Peer Reviewer Conflict of Interest Certification

Peer Review: *Proposed Rule: Addition of a Subsurface Intrusion Component to the Hazard Ranking System*; 40 CFR Part 300; EPA-HQ-SFUND-2010-1086; FRL_XXXX-X (review draft).

A conflict of interest or lack of impartiality exists when the proposed peer reviewer personally (or the peer reviewer's immediate family), or his or her employer, has financial interests that may be affected by the results of the peer review; or may provide an unfair competitive advantage to the peer reviewer (or employer); or if the peer reviewer's objectivity in performing the peer review may be impaired due to other factors. When the Peer Reviewer knows that a reasonable person with knowledge of the facts may question the peer reviewer's impartiality or financial involvement, an apparent lack of impartiality or conflict of interest exists.

The following questions, if answered affirmatively, represent potential or apparent lack of impartiality (*any affirmative answers should be explained on the back of this form or in an attachment*):

- Did you contribute to the development of the document under peer review, or were you consulted during its development, or did you offer comments or suggestions to any drafts or versions of the document during its development? ☒ No ☐ Yes
- Do you know of any reason that you might be unable to provide impartial advice on the matter under consideration in this peer review, or any reason that your impartiality in the matter might be questioned? ☒ No ☐ Yes
- Have you had any previous involvement with the review document(s) under consideration? ☒ No ☐ Yes
- Have you served on previous advisory panels, committees, or subcommittees that have addressed the topic under consideration? ☒ No ☐ Yes
- Have you made any public statements (written or oral) on the issue? ☒ No ☐ Yes
- Have you made any public statements that would indicate to an observer that you have taken a position on the issue under consideration? ☒ No ☐ Yes
- Do you, your family, or your employer have any financial interest(s) in the matter or topic under peer review, or could someone with access to relevant facts reasonably conclude that you (or your family or employer) stand to benefit from a particular outcome of this peer review? ☐ No ☒ Yes

With regard to real or apparent conflicts of interest or questions of impartiality, the following provisions shall apply for the duration of this peer review:

(a) Peer Reviewer warrants, to the best of his/her knowledge and belief, that there are no relevant facts or circumstances that could give rise to an actual, apparent, or potential organizational or personal conflict of interest, or that Peer Reviewer has disclosed all such relevant information to EMS or to EPA.
(b) Peer Reviewer agrees that if an actual, apparent, or potential personal or organizational conflict of interest is identified during performance of this peer review, he/she immediately will make a full disclosure in writing to EMS. This disclosure shall include a description of actions that Peer Reviewer (or his/her employer) has taken or proposes to take after consultation with EMS to avoid, mitigate, or neutralize the actual, apparent, or potential organizational conflict of interest. Peer Reviewer shall continue performance until notified by EMS of any contrary action to be taken.

Dottie Lofstrom
Signature Date

☒ Check here if any explanation is attached

Dottie Lofstrom
Printed Name

Cal/EPA - DTSC
Affiliation/Organization

Peer Reviewer Conflict of Interest Certification

Peer Review: Proposed Rule: Addition of a Subsurface Intrsuion Component to the Hazard Ranking System; 40 CFR Part 300; EPA-HQ-SFUND-200-1086; FRL_XXXX-X (review draft).

Question: Do you, your family, or your employer have any financial interest(s) in the matter of topic under peer review, or could someone with access to relevant facts reasonably conclude that you (or your family or employer) stand to benefit forma particular outcome of this peer review?

Answer: Yes. I work for the California Environmental Protection Agency, Department of Toxic Substances Control. Much of our work is funded directly by the U.S. EPA. Thus, it is possible for someone to conclude that DTSC might be in favor of the proposed rule solely because it might generate additional work for the Department. While untrue, it is a conceivable charge that might be made.

Peer Reviews

Henning Larsen
(Oregon DEQ)

- **Charge Questions Comments**
- **CV**
- **COI Certification**

Peer Review Charge for:
U.S. Environmental Protection Agency (EPA). *Proposed Rule: Addition of a Subsurface Intrusion Component to the Hazard Ranking System*; 40 CFR Part 300; EPA-HQ-SFUND-2010-1086; FRL_XXXX-X (review draft).

Background
The U.S. Environmental Protection Agency (EPA) is proposing to include a subsurface intrusion (SsI) component to the Hazard Ranking System (HRS). Subsurface intrusion is the migration of hazardous substances from the unsaturated zone and/or the surficial ground water into overlying structures. The HRS is the principal mechanism the EPA uses to evaluate sites for placement on the National Priorities List (NPL). The subsurface intrusion component addition (this addition) would primarily expand the number of available options for EPA and state and tribal organizations performing work on behalf of EPA to evaluate potential threats to public health and the environment from releases of hazardous substances.

This addition will allow the HRS evaluation to directly consider human exposure to hazardous substances that enter building structures through subsurface intrusion, and thus enable sites with subsurface intrusion contamination to be evaluated for placement on the NPL. This addition will make the HRS more accurate in assessing a site's relative potential risk. The Agency is not considering changes to the remainder of the HRS except for minor updates reflecting changes in terminology related to revised toxicological parameters. This proposed regulatory change does not affect the status of sites currently on or proposed to the NPL.

Expertise Required
The peer review panel for U.S. EPA's *Proposed Rule: Addition of a Subsurface Intrusion Component to the Hazard Ranking System* should include expertise in:

State Environmental Program Panelist: Panelist must have strong technical experience and working knowledge of policy and technical issues (e.g., mitigation and remediation) related to the topic of vapor intrusion. Expertise in hydrogeology, chemistry, knowledge of public health risks associated with indoor air threats, and the subsurface migration of volatile hazardous substances is necessary. Knowledge of recent developments in vapor intrusion technologies and research is required, in addition to working knowledge of state vapor intrusion response programs. Field experience conducting vapor intrusion investigations, while not required, is highly desirable. Experience related to conducting field investigations for the purpose of listing sites on the NPL and/or experience working with the HRS to evaluate sites for inclusion on the NPL is highly recommended, but not necessary.

Peer Review Charge Questions

1. Potential for subsurface exposure (intrusion) into occupied structures
Background: The current HRS evaluates the likelihood of a release of a hazardous substance when an actual release has occurred through either chemical analysis or direct observation. The current HRS also evaluates the potential for a release to occur within the ground water, surface water and air pathways (see section 2.3 of the current HRS). The potential for a release is determined by the consideration of pathway specific factors that aid the site evaluator in predicting whether a release to the pathway is likely to occur. These factors are based on containment features of the source of contamination (whether or not hazardous substance can get out), route characteristics specific to each pathway (how far hazardous substances could migrate based on knowledge of site conditions) and include physical/chemical properties of the hazardous substances being evaluated (how the hazardous substances act in the environment).

Proposed Approach: EPA is proposing a parallel approach for evaluating potential and actual exposure of intruded hazardous substances for the subsurface intrusion addition to the HRS. In determining which route characteristics are appropriate for evaluating potential exposure to subsurface contaminants, EPA examined present modeling methods such as the Johnson-Ettinger model and also considered multiple lines of evidence approaches which estimate the levels of contaminant exposure based on numerous route characteristics. In addition, EPA examined the relationship between these factors to determine which have the greatest influence on the likelihood that an exposure would occur, and then incorporated these factors within its proposed approach. EPA also gave careful consideration to ensure that the data necessary to obtain route characteristic factors could be measured or calculated on a site-specific basis and in a manner consistent with current HRS evaluations. Based on the Agency's analysis, the following three factors for which sufficient site-specific information could be collected during a site inspection represented the greatest impact on the potential for exposure: (1) depth to contamination; (2) vertical migration; and (3) vapor migration potential (see Figure 1).

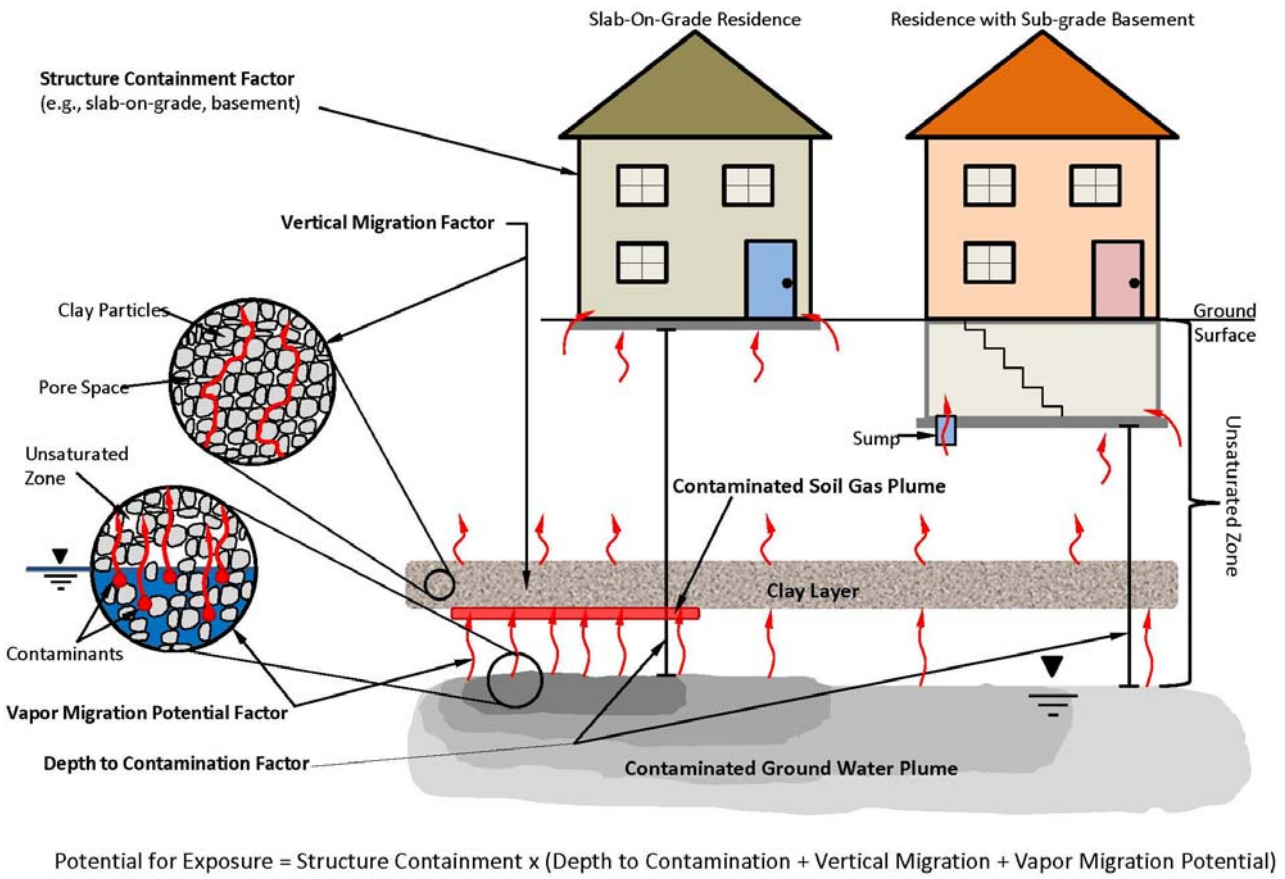


Figure 1

Charge Question #1*: *Is EPA's proposed approach scientifically reasonable for evaluating and assigning proportional weightings for the following when evaluating potential for exposure? If no, what alternative approach would you recommend?

> ***a. Consideration of the construction/structure type for which sufficient site-specific information could be collected during a site inspection for the occupied structure;***

Potential for Exposure Equation

I agree generally with the mathematical set up of the equation (2a*(2b+2c+2d) and the decision to make the *potential for exposure* a product (in the mathematical sense) of a building's characteristics and the subsurface conditions that lay beneath it. It mimics the two compartment model that many professionals and researchers conceptualize the vapor intrusion pathway to be. Furthermore, I believe it accurately replicates the "breaking" of the pathway by assigning a value of 0 to structures that employ demonstrated effective vapor control measures.

Overall, the term for the structure (a) ranges from 0-10 while the subsurface term (the sum of b+c+d) ranges from 1-50. Ideally the subsurface term should range as low as zero to reflect the absence of vapor intrusion risks associated with high molecular weight semi-volatile compounds like cPAHs, PCBs, and most pesticides. Thus, either term could have a zero value and the exposure pathway would then be considered broken or incomplete under two conditions: 1) in cases where a demonstrated effective vapor control technology is used, and 2) when a contaminant has sufficiently low volatility.

Mathematically, this could be accomplished by multiplying the *Depth to Contamination* (b) and *Vertical Migration* (c) terms by the *Vapor Migration Potential* (d) term. Thus a zero *Vapor Migration Potential* value would yield a zero for the entire *Potential for Exposure* factor. If the equation is changed in this way, the range in values for the *Depth to Contamination* and *Vertical Migration* terms would likely have to be adjusted so that Potential for Exposure results fall into the intended range of values (0-500).

Table 5-12 Structure Containment

I suggest revisions to Table 5-12 with respect to the number of building types distinguished, their description, and their value assignments.

- There does not appear to be a category that describes maybe the commonly encountered type of residence: a slab-on-grade constructed home with no apparent open preferential pathways or vapor migration barrier system. This is a significant omission that I believe will lead to confusion in categorizing structures. On the scale of 1-10 that is used for this factor I would assign this category of building a value of 9. It is vulnerable to vapor intrusion, but it is not the most vulnerable of residential structures.

- Homes that are underlain by a combination of basement and crawl space, and which do not have any form of vapor mitigation system, should be described as such and placed in Category 2. This is a common type of residential construction and it would be an omission to leave it out of Table 5-12.

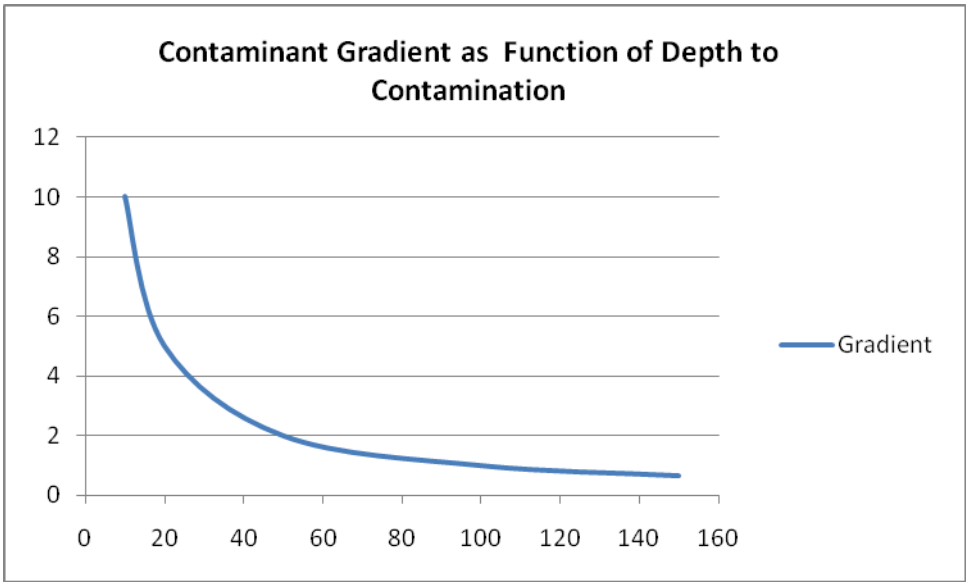
With this type of building there usually is a 4-5 ft high stem wall that separates the crawl space from the basement and generally there is no seal or a very poor seal between the crawl space and basement areas. This allows vapors to freely migrate into the basement and living spaces making these homes some of the most sensitive and vulnerable with respect to vapor intrusion. This type of structure should be assigned a value of 10 in Table 5-12.

- In my experience, residences that are completely underlain by vented crawl spaces generally have fairly small attenuation factors and their vulnerability to vapor intrusion is considerably less than other building types. This was observed at a chlorinated solvent release at the Eugene Rail Yards site in Eugene, Oregon. At this site, crawl space concentration showed a broad range of attenuation factors and a poor correlation to soil gas values. It appeared crawl space concentrations were most influenced by background and insignificantly by soil gas that spanned a range of PCE concentrations. Based on my experience I would assign a value of 6 rather than 8 to this type of construction. However, I acknowledge that nationally there may be regional/climatic differences that affect the degree of communication between the crawl space and the overlying building and justify the value of 8.

- Evidence of biogas, inert gases. Is this referring to methane and radon? Typically this type of information is not available for relatively short inspections.

b. Distance between occupied structure and depth of contamination; and

At the depths beyond the 0-10 ft range presented in Table 5-13 chemical diffusion is generally considered to be the dominant transport mechanism. Diffusion and diffusive flux is typically described using Fick's Law J= -D(dc/dz). Using Fick's Law and assuming 100 ug/m^3 at the source and zero in indoor air, concentration gradients as a function of depth are plotted below.



Using this approach and assuming a *Depth to Contamination* value of 10 for a source 10 ft below the occupied base of a structure, 20 ft would then have a value of 5, 50 feet would have a value of 2, 100 ft a value of 1 and 150 ft of 0.66. Since this term is evaluating the strength of diffusive flux in the subsurface and not attempting to consider geologic heterogeneity, the values should be based on Fick's Law of diffusion which has been empirically demonstrated to be accurate in numerous column tests of porous media; this is unless there is sufficient empirical field data that supports the numerical assignments in Table 5-13.

Considering Depth to Groundwater Contamination and Depth to Soil Vapor Contamination Equivalently

An important concern in the assignment of *Depth to Contamination* values under section 5.2.11.2.2 is the approach treats groundwater and soil gas as equivalent media and at any given site there depths are presumably comparable. However, it isn't an either or situation, if there is a groundwater plume of contamination at the water table, there will be corresponding soil gas contamination above it and by definition the soil gas will always be shallower than the groundwater contamination. Depending on where the soil gas measurement is taken it could be 20, 30, 50 ft or more shallower than the depth the groundwater contamination is measured at. Thus, the depth to contamination that is entered into this table may in large part be a consequence of which media was sampled and not the actual site conditions.

I ran one of our bigger vapor intrusion sites (Tarr Oil, Portland, OR) through the Potential for Exposure calculation and it scored a 380 based on the initial groundwater data, and a 500 based on soil gas data. The location of the measurement also affects assignment of the *Vapor Migration Potential* value. The depth of measurement and choice of media to sample potentially introduces a bias that should ideally be eliminated from the calculations.

c. Evaluation of the vertical migration factor based on the thickness and porosity/permeability of geologic materials in the interval between the lowest point of an occupied structure and the highest known point of hazardous substances in the subsurface.

Assignment of Vertical Migration Factor Values

Vertical migration values for soils assigned a porosity/permeability value of 4 (*clays, low permeability till, unfractured igneous rocks etc.)* appear to be excessively high when compared to the values of other soils and thicknesses in Table 5-15 and relative to values assigned to the *Depth to Contamination* factor. True clays and unfractured igneous rocks have extremely low effective porosities and if they have any appreciable thickness should act as a virtually complete barrier to vapor transport. The only exception would be if the clays were or had been desiccated leaving fractures for preferential flow.

It is difficult to say the 0-5 ft thickness value of 15 for soils assigned a porosity/permeability value of 4 is disproportionately high given the thickness ranges down to zero. However, I suggest revising the value for the *5-10 ft* thickness to **8** rather 12, and the 10-20 ft thickness range **6** rather than 9 and the 20-50 ft range to **3** rather than 6 and the 50-100 ft and 100-150 ft ranges both should be **1**. I cannot think of a more restrictive barrier to vapor transport than 50-100 ft of true clay.

The values in Table 5-15 applied to soils assigned a *permeability/porosity* value of 1-3 appear appropriate.

Although not discussed, effective porosity for gas transport (diffusion rates through water-filled pore spaces are generally 100,000x or more lower than through air-filled) is highly sensitive to moisture content in the soil and I assume this consideration is embedded in the values of Table 5-15. Finer-grained soils typically retain a higher moisture content that further reduces effective porosity. This degree to which soils are saturated is largely a consequence of annual precipitation rates and their seasonal distribution. Therefore, for identical soils it's anticipated that there would be regional differences in the vertical migration factor. Ideally the moisture content factor would be considered in the scoring, however, there may be insufficient information to confidently develop values.

2. Hazardous Waste Quantity

Background: In the current HRS, the hazardous waste quantity factor reflects the risk consideration related to the magnitude and duration of either the release for ground water, surface water, and air pathways, or the exposure for the soil exposure pathway (see section 2.4.2 of the current HRS). Hazardous waste quantity is evaluated for all four pathways. At each site evaluated, EPA uses a four-tiered hierarchy for calculating the hazardous waste quantity that is based on (1) constituent quantity; (2) waste stream; (3) volume; and (4) area of the sources of hazardous waste at the site. EPA uses minimum waste quantity factors when there is insufficient information to estimate hazardous waste quantity. In the ground water, surface water, and air pathways, the HRS evaluates the total quantity of hazardous substances available to migrate from the original sources (how much has migrated and how much can be released in the future). In the soil exposure pathway, the hazardous waste quantity does not include the total amount of hazardous substances in all site sources, but rather is based on the amount of hazardous substances to which a receptor can be exposed where actual contamination has been documented. In other words, for the soil exposure pathway, the risk posed by a release of hazardous substances is directly related to the amount of hazardous substances that receptors are exposed to, as opposed to how much of the hazardous substances from the original sources may migrate to the receptors.

Proposed Approach: EPA is proposing a parallel approach to the soil exposure pathway to calculate hazardous waste quantity for the subsurface intrusion addition to the HRS. Since the subsurface intrusion component also focuses on exposure, the waste quantity factor value for this component should also reflect only the amount of hazardous substances that people actually are exposed to (the amount present in occupied structures). EPA is proposing to use a similar four-tiered hierarchical approach to calculate hazardous waste quantity within occupied structures with contamination. In cases where no home is subject to actual contamination, EPA is proposing to use minimum waste quantity factors. In situations where there is an observed release within a structure above benchmarks (Level I), a default value of 100 is proposed for the hazardous waste quantity factor value. This value is not used in the current soil exposure pathway, but is consistent with the ground water, surface water, and air pathways and reflects the increased exposure risk of a release within an occupied structure.

Charge Question #2: Is EPA's approach of basing the hazardous waste quantity on the amount of contaminants that could be found in the intruded structures appropriate? If no, what alternative approach would you recommend?

I disagree with the proposed approach to calculating hazardous waste quantities for the subsurface intrusion component. Compared to soil and water, air is a much less dense medium and as a consequence, for equivalent risk levels between various media, it typically contains much less contaminant mass. Essentially airborne contaminants can generate equivalent human health risks to those resulting from contact with other media, although with far less mass. For example, the State of Oregon assumes benzo(k)anthene has an oral slope factor of 0.073 and has calculated a residential soil screening level of 6.2 mg/kg (equating to 1x10-6 risk). Assuming a 5000 ft^2 property that is 70% land 30% impervious surface, a 1 foot thick layer of soil contaminated up to the screening level would contain approximately 1,190 grams of benzo(k)fluoranthene. In comparison, a 1300 ft^2 residence with vinyl chloride (inhalation slope factor of 0.031) contamination at a concentration 0.14 ug/m^3 (equivalent to $1x10^{-6}$ risk) has 0.000047 grams in the indoor air at any one time.

Assuming an air exchange rate of 6 exchanges/day, approximately 3.1 grams would have moved through the home over a 30 year period of time. Assuming an identical toxicity and slope factor to that of benzo(k)fluoranthene, the mass of vinyl chloride in the air over the 30 year period is 6.3 grams for the equivalent risk. Humans contact and take up air contaminants much more efficiently than contaminants in water or soil, therefore, it requires far less mass for equivalent risk.

Using Table 2-6 (pg. 22) and the methods outlined in 5.2.1.2.2 to assign a Hazardous Waste Quantity Factor value, it is likely most vapor intrusion sites would get a quantity of 1 unless an exposure is documented then it defaults to 100. It appears very unlikely any VI site would have hazardous quantity factor larger than 100. This results in relatively low Waste Characteristic Factor values compared to what can calculated for other media and pathways. In this respect it appears to underestimate the risk of the subsurface intrusion pathway relative to others.

Suggested Alternative Proposed HRS Method of Estimating Hazardous Waste Quantity

Quantify and include contaminant sources in the subsurface in addition to the contamination found within the buildings. These sources constantly feed the contamination within the buildings and so could be legitimately included in the inventory of waste quantities. For this particular factor, the change would make the magnitude/mass of sources of vapor intrusion more comparable to those contaminating other media.

3. Population score

Background: Within the current HRS, receptors are evaluated in two main categories: whether they are exposed to 1) actual contamination; or 2) potential contamination (see section 2.5 of the current HRS). If receptors are exposed to contaminant levels meeting observed release criteria, they are identified as actually contaminated; however, if the receptors are not exposed to contaminants that meet the observed release criteria but are within the target area being evaluated, they are considered potentially contaminated. Actual contamination is further divided into two sub-categories based on whether the hazardous substance is present at or above a health-based benchmark. If the concentration of the hazardous substance released at the receptor is greater than a health-based benchmark, the receptors are identified as Level I receptors and are weighted (multiplied by a factor of 10) in scoring. If the release concentrations are less than a health-based benchmark, the receptors are identified as Level II receptors and are not weighted (multiplied by a factor of 1). Potential receptors are distance/dilution weighted; in other words, the farther away a receptor is located from a source, the less the population contributes to the site score.

Proposed Approach: EPA is proposing to generally use the same receptor weighting structure in the subsurface intrusion component as the one used in the current HRS. Those receptors in the area(s) of observed exposure (AOE) are considered actually contaminated, and those in the area(s) of subsurface contamination (ASC) are considered potentially contaminated (See Figure 2). The receptors in an AOE are further differentiated based on whether the contaminant concentrations are at levels above identified benchmarks (Level I) or are at levels establishing a release but below identified benchmarks (Level II). The benchmarks that EPA is proposing to use for the subsurface intrusion component are:

- Screening concentration for cancer effects; and
- Screening concentration for non-cancer effects (systemic toxicants).

Consistent with the weighting of populations throughout the HRS, the proposed subsurface intrusion component will weight targets within the AOE subject to Level I contaminant concentrations by a factor of 10 and weight targets subject to Level II contaminant concentrations by a factor of 1.

EPA is proposing to evaluate the weighting of targets within the ASC based on sub-slab, soil gas, and/or ground water samples. Potential receptors within the ASC receive less weight (population multiplied by a factor of 0.1), except in cases where a sub-slab sample indicates contaminant levels are at least 10 times higher than a health-based benchmark (population is multiplied by a factor 0.75). The value of 0.75 was determined based on an evaluation of paired data when both a sub-slab and indoor air sample were collected. The 0.75 weighting reflects the observation that for approximately 80 percent of the sampling events where contamination was detected in the sub-slab, contamination was also detected in the indoor air sample. The order of magnitude adjustment applied to the health-based benchmark reflects EPA's finding that, in such paired sampling events, the indoor air sample concentration is, on average, 10 times lower than the sub-slab sample concentration.

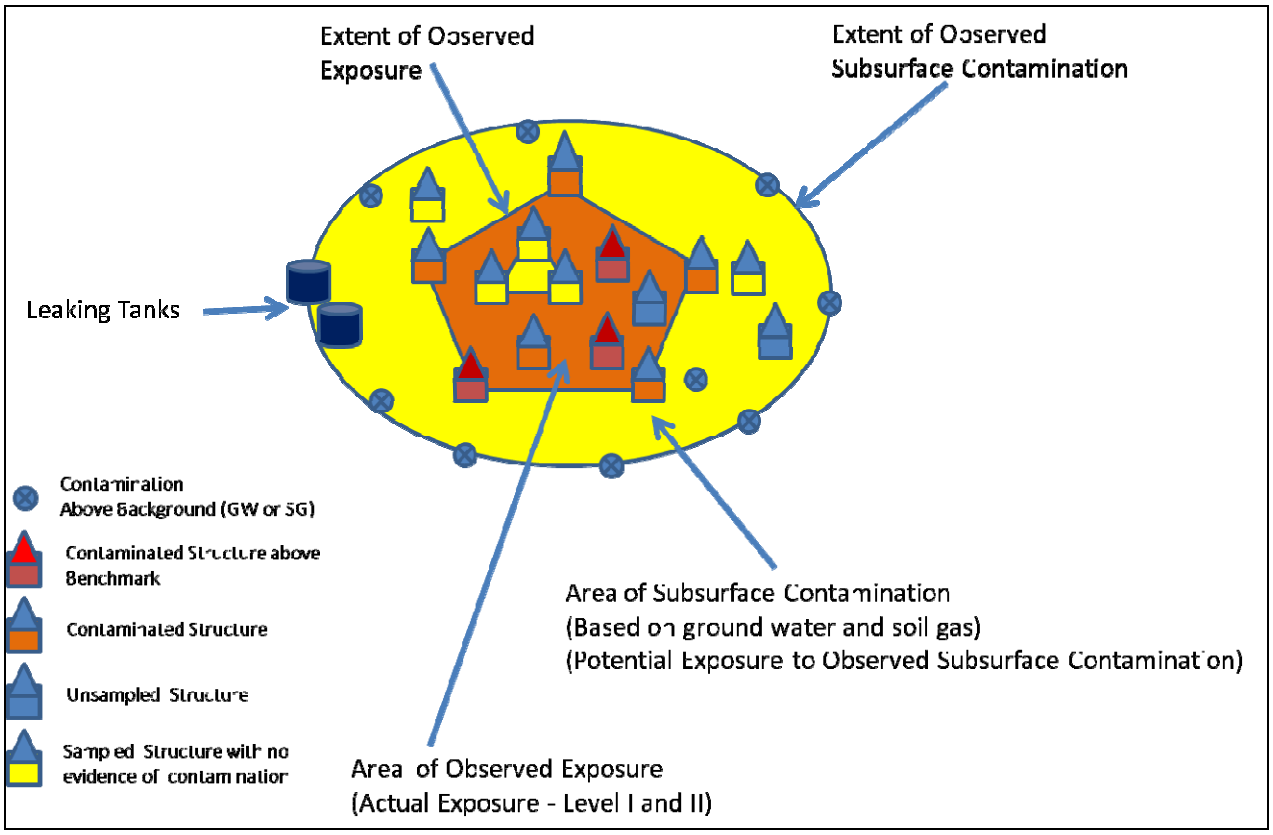


Figure 2

***Charge Question #3:* Is it appropriate to consider individuals/populations located within the area of subsurface contamination (ASC) to be at a higher relative risk in situations when sub-slab contaminant concentrations are at least ten times greater than a health-based benchmark? If no, please explain.**

An obvious answer to the Charge Question #3 is: yes, in general occupants of buildings where sub-slab concentrations exceed 10x a health-based benchmark are at higher risk relative to occupants of buildings with sub-slab concentrations that are less than this value. However, the scheme for weighting individual targets/receptors is crude in the ASC, does not appear consistent with the results of EPA's compilation of paired sub-slab and indoor data, and potentially underestimates population risks.

As described in sections xxxx of the draft HRS rule revisions, for targets/receptors occupying buildings over an ASC and where subslab contaminant concentrations exceed 10x the benchmark screening level should assigned a weighting of 0.75. The explanation given is that the review of the compiled paired data indicate 80% of the time a subslab concentration exceeds 10x its respective health based benchmark, the contaminant is detected in indoor air.

- Why wasn't a value of 0.8 used instead 0.75 since the correlation described above was observed 80% of the time?
- 0.75 is used in all where a subslab VOC concentration greater than 10x its corresponding health-based benchmark has been observed within the ASC. However, subslab VOC concentrations at many sites are routinely observed at levels from 100-100,000 times their corresponding benchmarks. Yet in the proposed HRS scheme for weighting targets, irrespective of the concentration observed,

any time it exceeds 10x the benchmark a value of 0.75 is used. Using a single value (such as 0.75) may be reasonable for weighting receptors when subslab levels are just 1-2 orders of magnitude above benchmark values, and indoor concentrations are likely detectable but below benchmark values. However, as subslab contaminant levels increase, eventually a concentration threshold is crossed where the results of EPA data compilation indicate the probability of exceeding a benchmark value in indoor air is very high. For these cases assigning a weighting factor that is closer to10 is more appropriate.

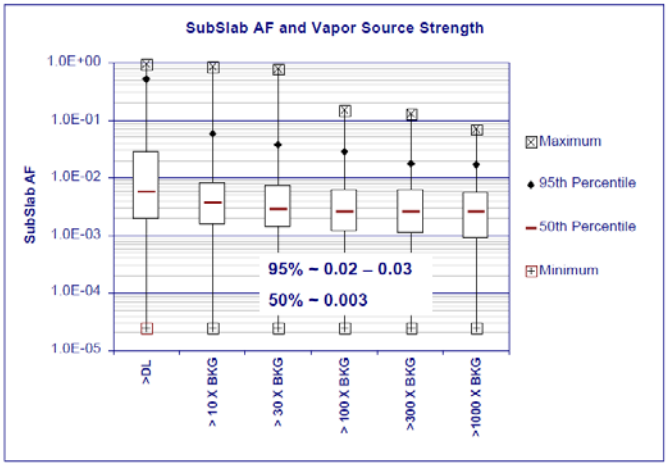
The proposed target weighting approach may introduce a low bias to population risks, particularly at sites where the primary medium sampled is subslab and not indoor air. soil gas and not

- It is not clear from the rule revision whether the appropriate weighting for targets within the ASC is based on the maximum observed subslab concentration or whether some form of average value is considered (i.e. arithmetic mean, UCL, etc.) My recommendation, since this is a screening process, would be to use the maximum subslab concentration observed, and that this expectation should be specified in the rule if it isn't already.

- The EPA database on paired subslab and indoor air data has been reviewed by many states and individual practitioners. Statistics have been performed on both filtered and unfiltered data. The filtering was done in an effort to eliminate the influence of ambient background concentration on calculated attenuation factors. EPA has recognized the need to perform the data filtering to remove outlier attenuation rates. A strategy that Oregon DEQ used in an attempt to separate out background influences was to only consider data from sites with strong sources, for examples sites with subslab concentrations greater than 1000 ug/m^3.

The results of the data analysis indicate unfiltered paired subslab-indoor air data had an average attenuation factor of 0.003 and median value of approximately 0.002. An analysis of highly filtered similar to data by ODEQ produced an average attenuation factor of 0.0007 and a median value of 0.0002. Thus the statement that approximately half of the vapor intrusion sites had an average attenuation factor of 0.1 is not supported by EPA previous analysis of VI data.

All Sites. Progressive Filtering



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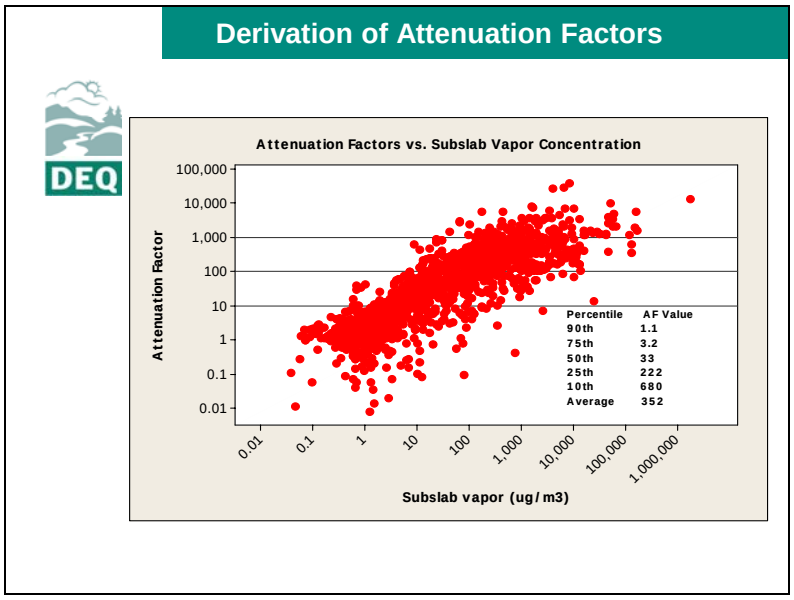
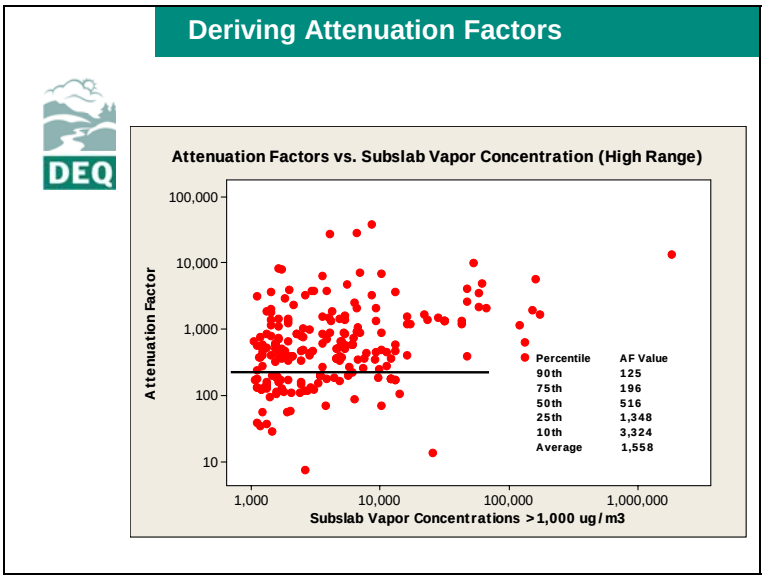




ODEQ, March 2010

Recommendation

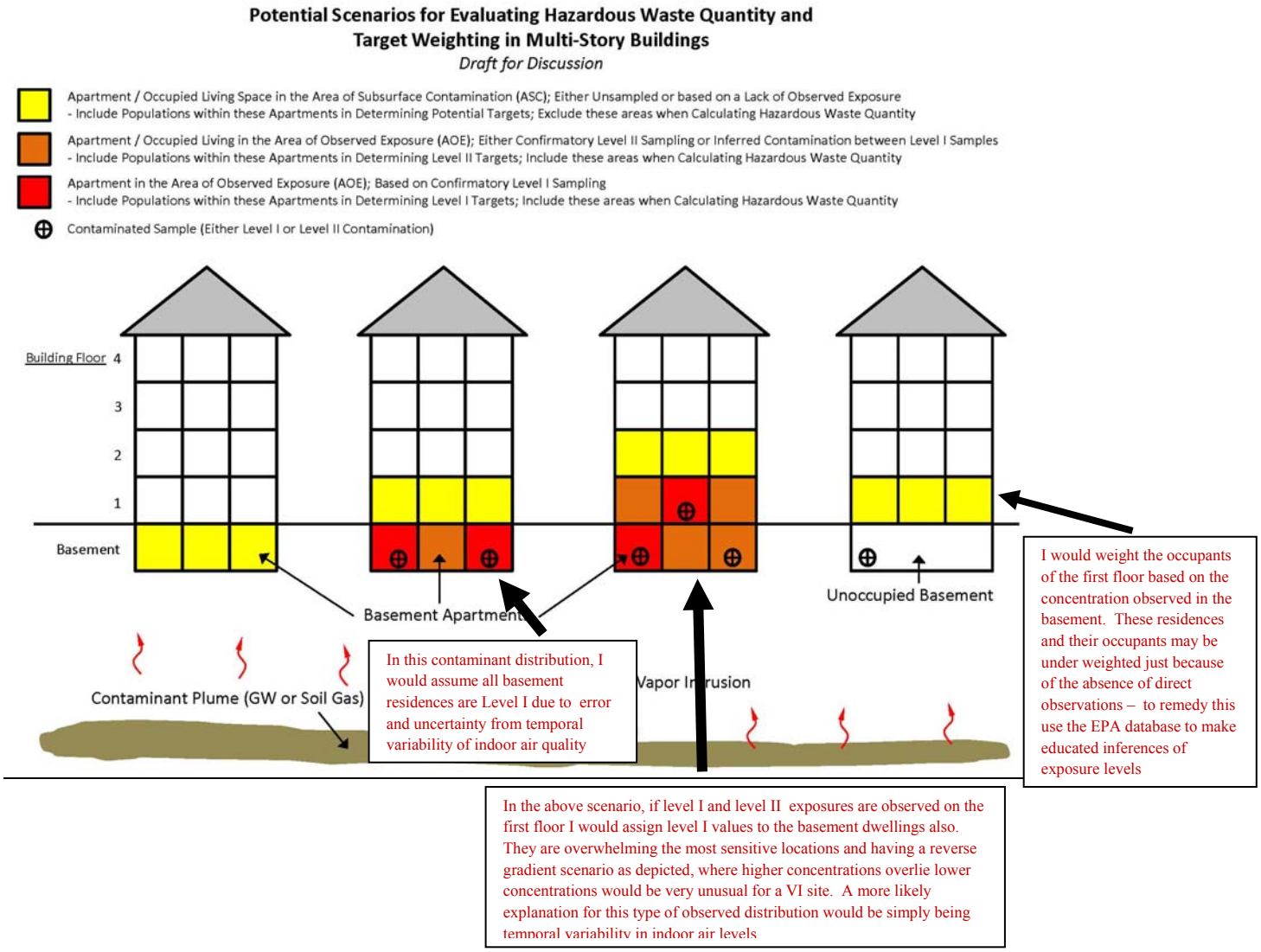
Based on: statistical analyses of the EPA Database, and the recognition that it does not necessarily populated by the most sensitive structure types, I recommend that within defined ASCs assign a target weight factor of:

- 0.1 to occupants of buildings with subslab contaminant concentrations less than 50x the health-based benchmark value.
- 1 to occupants of buildings with subslab contaminant concentrations between 50x-500x the health-based benchmark value.
- 10 to occupants of buildings with subslab contaminant concentrations greater than 500x the health-based benchmark value

4. Multi-story and multi-tenant structures

Background: In the current HRS, multi-story and multi-tenant buildings are evaluated based on population associated with an actually or potentially impacted target. In the ground water pathway, all residents who are served by a well are considered subject to the actual or potential contamination of the well. In the air pathway, all residents who have an opportunity to breathe ambient air are considered subject to the actual or potential contamination of the ambient environment within a distance category. All receptors within a contaminated surface water stretch are subject to the level of contamination associated with that surface water stretch. In the soil exposure pathway, receptors must be able to come in contact with areas of contamination. In determining the likelihood a person will come in contact with areas of contamination, the HRS uses a 200 foot rule (see section 5.1.3 of the current HRS) because it is reasonable to assume that that a person will walk/use areas within a 200 foot areal extent of their residence/property. The 200 foot rule is used regardless of whether a building is multi-tenant or multi-story (the assumption being that is reasonable for people to use the outside of their properties).

Proposed Approach: EPA is proposing to evaluate multi-story/multi-tenant buildings utilizing a similar approach as soil exposure, limiting the receptors to those individuals that reasonably can be exposed to subsurface intrusion within an occupied multi-tenant/multi-story building. EPA is proposing to consider all receptors exposed to actual contamination as the population inhabiting the floor of the intruded space and the population inhabiting the floor above and the floor below the intruded space when calculating waste quantity and population. EPA considers that this approach will more accurately reflect risk to both actual and potential receptors, while also minimizing the potential for over counting (Figure 3).



Charge Question #4: When calculating waste quantity and population, is it scientifically reasonable for populations in multi-story or multi-tenant structures to be evaluated based on using only the population inhabiting the intruded space and the population on the floor above and below the intruded space (For example, if contamination is found on the first floor, population from the basement and second floor would be used in the calculation. If contamination is found on the fifth floor, population from the fourth floor and sixth floor would be used in the calculation – for further explanation, see detailed discussion in above paragraph "Proposed Approach")? If no, what alternative approach would you recommend?

Regarding the Calculation of Waste Quantity

See comments and responses to Charge Question #2

Regarding Assumptions and Weighting of Occupants/Targets in Multi-Family Residences

Some comments are made directly on the Figure 3 – see boxed text. Aside from those suggested modifications, the general scheme looks appropriate.

Regarding the Weighting of Population Targets in AOE

In my opinion the weighting is disproportionately influenced by data type – specifically the difference in weighting directly observed impacts as compared to inferred impacts based on subslab sampling. Whereas an individual or population directly observed (through indoor air sampling) to be exposed to levels above the health-based benchmark is indoor exposure directly observed to be over a benchmark is assigned

The weighting of targets/receptors exposed to Level 1 contamination 10x higher than those exposed to Level II concentrations by a factor of 10, coupled with the recognized temporal variability in indoor air concentrations (See Paul Johnson's recent work at Hill Air Force Base, Arizona) could produce significant swings in the population score that are more artifacts of when the sampling occurred than true differences in the magnitude of the average VOC exposure. The concern regarding accurately characterizing indoor exposure levels is particularly relevant if site inspections are conducted and indoor air concentrations measured, within a short 2-3 day period.

Potential Ways to Mitigate Errors and Uncertainties

Two ways to mitigate this uncertainty and potential error is to characterize exposure levels using ambient air sampling methods that accommodate long sampling periods, or alternatively increase the number of (shorter period) air samples that target meteorological conditions particularly conducive to vapor intrusion. In short, use sampling technologies are approaches that provide better representations of long term exposure levels.

A different approach would be to apply a scheme that has more than two designations for confirmed exposure levels. Perhaps the value 1 for detected/observed exposures that are <0.5x the benchmark health value, a value of 3 for values 0.5 -1.0 x the benchmark value, and 10 for those occupying buildings with exposures greater than the benchmark value.

Weighting of Population Targets in ASC

In the proposed approach for weighting target populations within the ASC it appears there is a disproportionate undervaluing of susbslab data relative to indoor data. Under the proposed scheme, subslab concentrations greater than 10x the health-based benchmark value would weighted with a factor of 0.75 (weighted slightly less than a level II exposure) irrespective of the specific concentration measured. EPA compiled a large database that provides opportunities for robust statistical analyses including the derivation of attenuation rate percentiles and confidence intervals. This information should be used to help appropriately weight targets where only subslab data is available. For example, using unfiltered statistics the 50th percentile attenuation factor is 0.03, thus it can be concluded that if subslab levels exceed benchmarks by a factor of 33 or greater then there is 50% chance occupants are being exposed to levels above the corresponding health-based criteria and that the appropriate weighting is 10 rather than 0.75.

In section 5.2.1.3.2.3, the proposed rule indicates subslab data and crawlspace data will be similarly evaluated and weighted. The implies the data types are equivalent, however, EPA and others have generally assumed the attenuation factor between the crawl space and the residence interior should be assumed 1and thus is a reasonable surrogate for actual indoor air data. So, this would suggest detection of COCs below benchmark values in the crawl space should be weighted under the proposed scheme at a value of 1 and that if concentration exceeds benchmark values in the crawl space the appropriate weighting would be 10.

In general there appears to be a undervaluing of susbslab data, even when that is the only type of data available. However, susbslab data may be the primary type of data available at a site and the population component of the scoring may be biased low as consequence. Thus, at any given site, the scored risk may be substantially lower if the primary data source is subslab measurements than compared to the same site if the primary source of data was indoor measurements.

Recommendation

Use EPAs database of paired subslab and indoor air data to perform more refined weighting of targets in an ASC. Ideally, the weighting would relate to the probability a Level I or Level II exposure is occurring based on subslab data.

Additional Comment

The example scenario described in the Charge Question #4 is highly unusual contamination found on 5th floor consider tenants on 4th and 6th floors. Under this scenario I would expect all floors beneath the 4th floor to be considered and actually most of them contaminated. Overall, it's an unrealistic scenario and the actual proposed rule indicates all floors beneath the observed exposure would be considered in the calculations, as they should be.

5. Factor Value for Workers

Background: In the current HRS, for the resident population threat of the soil exposure pathway, a factor value for workers is assigned based on the total number of workers present within the area of observed contamination. These factor values range from 0 to15, depending on the number of workers exposed to outdoor contamination (see section 5.1.3.3 of the current HRS).

Proposed Approach: EPA is proposing to mirror the procedures for the resident population threat in the soil exposure component when assigning a worker factor value in the subsurface intrusion component (see Table 5-4 in section 5.1.3.3 of the current HRS). However, since it is anticipated that workers spend a larger percentage of their time indoors and therefore may be more exposed to contamination resulting from subsurface intrusion than to outdoor soil (or other surface) contamination, EPA is proposing to assign workers exposed to subsurface intrusion a higher weighting (i.e., factor values ranging from 0 to 45).

Charge Question #5: Because of longer exposure times indoors, is it reasonable to assume that the relative risk is three times greater for workers exposed to subsurface intrusion within the workplace than it is for workers exposed to outdoor surface contamination at the workplace? If no, please explain.

I agree with the proposed weighting for workers. Generally, workers do spend more time indoors and that this pathway is more likely to be complete.

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Work History: 1987-1989 – Geologist, Newmont Mining Corporation

1992 – Geologist, Oregon Health Division

1992-1994 - Hydrogeologist, Oregon Department of Environmental Quality

1994-1998 – Cleanup Project Manager, Oregon Department of Environmental Quality

1998-current - Senior Hydrogeologist, Oregon Department of Environmental Quality

Current Duties/Responsibilities: Develop and provide senior level review of hydrogeological investigations; develop statewide policy, guidance and rule recommendations for the State of Oregon Cleanup Program; Agency expert on contaminant fate and transport modeling; represents DEQ at hearing, public meetings, and conferences to explain the bases for soil, soil vapor, and groundwater-related cleanup requirements.

Professional Work Groups

Participant in EPA Groundwater Forum since 2007

Vapor Intrusion Related Guidance Work

1996 – co-author of State of Oregon *Risk-Based Corrective Action for Petroleum Cleanups* . Document used J&E models to assess indoor vapor intrusion and outdoor volatilization pathways.

1999 – co-author of State of Oregon *Risk-Based Decision Making at Petroleum Cleanup Sites.* Document used J&E level models to assess indoor vapor intrusion.

2006 –author of *Guidance for Managing Hazardous Substance Air Discharges From Remedial Systems*

2010 – co-author/primary author of State of Oregon *Guidance for Assessing and Remediating Vapor Intrusion in Buildings.*

Vapor Intrusion Training Given

February 2003 – Developed and presented Risk-Based Decision Making training including training on VI pathway, State of Oregon

November 2007 – Developed and presented 2-day course on vapor intrusion pathway for the Northwest Environmental Training Center (NWETC). I gave the 2-day course three separate times in Seattle, WA and Portland, OR.

April 2010 – Developed and led 1-day training course on use of State of Oregon Guidance on *Assessing and Remediating Vapor Intrusion in Buildings* .

Vapor Intrusion Presentations

1998 – National UST-LUST Conference, Albuquerque, NM – *Vapor Intrusion – The Oregon Experience*

2007 – Oregon Brownfields Conference, Salem OR, *Primer on Vapor Intrusion*

2009 – Northwest Environmental Conference, Portland, OR, *Vapor Intrusion Continues to Mature: Legal, Regulatory and Technical Updates*

2010 – EPA, Region 10 All States Meeting - *Assessing and Remediating Vapor Intrusion in Buildings*

2011 – Northwest Environmental Business Conference, Portland, OR, *Vapor Intrusion- Evaluating the Marginal Cases*

Peer Reviewer Conflict of Interest Certification

Peer Review: *Proposed Rule: Addition of a Subsurface Intrusion Component to the Hazard Ranking System*; 40 CFR Part 300; EPA-HQ-SFUND-2010-1086; FRL_XXXX-X (review draft).

A conflict of interest or lack of impartiality exists when the proposed peer reviewer personally (or the peer reviewer's immediate family), or his or her employer, has financial interests that may be affected by the results of the peer review; or may provide an unfair competitive advantage to the peer reviewer (or employer); or if the peer reviewer's objectivity in performing the peer review may be impaired due to other factors. When the Peer Reviewer knows that a reasonable person with knowledge of the facts may question the peer reviewer's impartiality or financial involvement, an apparent lack of impartiality or conflict of interest exists.

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(b) Peer Reviewer agrees that if an actual, apparent, or potential personal or organizational conflict of interest is identified during performance of this peer review, he/she immediately will make a full disclosure in writing to EMS. This disclosure shall include a description of actions that Peer Reviewer (or his/her employer) has taken or proposes to take after consultation with EMS to avoid, mitigate, or neutralize the actual, apparent, or potential organizational conflict of interest. Peer Reviewer shall continue performance until notified by EMS of any contrary action to be taken.

Henning Larsen 12/12/11

Signature Date

☐ Check here if any explanation is attached

Henning Larsen

Printed Name

Oregon Dept. of Environmental Quality

Affiliation/Organization