

**To: CSAP Soil Vapour Advice and Practice Guidelines Review Committee**

**From: CSAP Soil Vapour Advice and Practice Guidelines Development Panel**

**Re: Soil Vapour Advice and Practice Guidelines Development - Stage 1**

On behalf of the Contaminated Sites Approved Professionals (CSAP) Society of British Columbia, the CSAP Soil Vapour Advice and Practice Guidelines Development Panel (the Panel) is pleased to provide the following document summarizing the results of completion of the Stage 1 Scope of Work as outlined in the revised document provided by CSAP on 2009-08-17. The Stage 1 Scope of Work included the following:

- A review of Ministry soil vapour documents.
- A review of questions/issues raised by Approved Professionals and other contaminated sites practitioners regarding soil vapour.
- An evaluation of practical solutions to soil vapour questions/issues.
- Provision of practical solutions to the soil vapour questions/issues.

### **1. Identification of Soil Vapour Questions/Issues**

Following the Panel's review of Ministry soil vapour documents and questions/issues encountered by the Panel and raised at both the GeoEnviroLogic Risk Assessment Symposium (June 6, 2008) and the Science Advisory Board for Contaminated Sites Soil Vapour Forum (July 8, 2008), the following issues were selected for further evaluation.

- a. Parameters to be analyzed when the following were present at a site: gasoline, diesel, waste oil and drycleaners.
- b. Measurement of shallow soil vapours at vacant sites (i.e. no buildings are present) and/or where exterior surfaces are not sealed (i.e. bare ground).
- c. Application of attenuation factors under the following circumstances:
  - i. presence of contamination within 1 m of grade or within 1 m of an existing building foundation;

- ii. presence of contamination within 1 m of a potential future building foundation (but greater than 1 m from current grade);
  - iii. presence of contamination within 5 m of an unlined crawlspace, earthen basement or wooden basement; and
  - iv. presence of potential preferential pathways.
- d. Frequency of leak testing during soil vapour sampling.

Practical solutions to these issues are outlined in subsequent sections of this document.

Other soil vapour issues that were recognized as needing additional guidance, but would not be the focus of the Panel's efforts, included the following:

- a. location of sampling points (i.e. pre- and post-remediation; biocells);
- b. number of times to sample (i.e. to account for varying barometric pressures, rainfall, groundwater fluctuation);
- c. background issues (eg. methylene chloride and chloroform in soil vapour); and
- d. methods of mitigation (i.e. vapour barriers, active protection systems).

## **2. Selection of Potential Contaminants of Concern for Analyses**

Vapour investigations at contaminated sites involve the assessment of vapour potential contaminants of concern (PCOCs) at identified areas of potential environmental concern (APECs). According to the Ministry of Environment (MoE, 2009), vapour PCOCs "include all substances that are both a) associated with the activities listed in Schedule 2 of the Regulation carried out on or near the site and b) listed in Schedule 11." The MoE allows for further refinement of vapour PCOCs to "include only those substances which are a) detectable ... in soil, sediment, or water on the site or b) detectable or likely to be detectable in soil, sediment, or water near the site" (MoE, 2009).

The panel recognizes that, prior to refining the vapour PCOCs, there should be a common understanding among CSAP members of the probable vapour PCOCs associated with typical APECs. The objective of this section is to identify vapour PCOCs associated with common commercial and industrial APECs, specifically drycleaning activities, waste oil storage/handling, diesel storage/handling and gasoline storage/handling.

Please note that it is the MoE's position (Q&As, Land Remediation Section website) that if soil, sediment (if applicable), and water data for a particular vapour PCOC is not

available, then the vapour PCOC refinement step cannot be completed. Approved Professionals will have to retain the chemical as a vapour PCOC and collect vapour data to investigate potential vapour contamination as modeling cannot be completed based on the absence of soil, sediment and water data.

*References:*

Ministry of Environment, 2009. Technical Guidance on Contaminated Sites 4, Vapour Investigation and Remediation (DRAFT). July 2009.

Ministry of Environment, 2009. Contaminated Sites Regulation, Schedule 11 Generic Numerical Vapour Standards. January 1, 2009.

Ministry of Environment, 2009. Questions and Answers (Q&As), Draft Guidance for Vapour Investigation and Remediation. Available online at <http://www.env.gov.bc.ca/epd/remediation/q-a/index.htm#5>.

**Drycleaning Sites**

**PCOC List:** tetrachloroethylene, trichloroethylene, cis-1,2-dichloroethylene, trans-1,2-dichloroethylene, vinyl chloride, chloroform, chloroethane, 1,1,1-trichloroethane, 1,1-dichloroethane, 1,2-dichloroethane, 1,1-dichloroethylene, carbon tetrachloride and methylene chloride.

**Rationale:** Although chemicals such as 1,1,1-trichloroethane, methylene chloride, carbon tetrachloride, chlorofluorocarbons (CFCs) and petroleum-based hydrocarbons have been used historically as drycleaning solvents (EPA, 1995; Dryclean Coalition, 2002), various sources indicate that tetrachloroethylene has been the primary solvent used in the drycleaning industry (EPA, 1994; Government of Canada, 1993). Health Canada is updating their guidance on human health preliminary quantitative risk assessments (currently in draft). One of the appendices to this document includes a list of contaminants commonly associated with various industrial and commercial operations. Contaminants potentially associated with dry cleaning facilities are listed as tetrachloroethylene and its degradation products. On this basis, where appropriate, the above PCOC list could be limited to tetrachloroethylene and its degradation products; it is recommended that the use of tetrachloroethylene as a primary solvent be confirmed/evaluated by Approved Professionals during the preliminary site investigation stage.

Transformation and degradation of tetrachloroethylene in soil and groundwater is limited (ATSDR, 1997). Microbial degradation occurs mainly under anaerobic conditions which results primarily in the production of trichloroethylene (ATSDR, 1997). Further reductive dehalogenation of trichloroethylene produces cis- and trans-1,2-dichloroethylene and ultimately, vinyl chloride.

Drycleaning grade tetrachloroethylene is reported to have a high (>99%) purity (Dryclean Coalition, 2002). Recycled tetrachloroethylene may contain small amounts of impurities, largely other chlorinated solvents used as spotting agents in the cleaning process. As a number of chlorinated solvents have been used in the drycleaning industry as spotting agents (eg. methylene chloride, 1,1,1-trichloroethane, trichloroethylene), these compounds have also been included in the panel's PCOC list above. It is noted however, that these compounds are typically stored/used in much lower volumes than tetrachloroethylene, and thus would be less likely released to the environment in large volumes.

The inclusion of cis-1,2-dichloroethylene in the panel's PCOC list provides Approved Professionals with a marker chemical for vapour intrusion studies since cis-1,2-dichloroethylene is not generally found in consumer products, building materials or outdoor air (ITRC, 2007).

*References:*

ATSDR, 1997. Agency for Toxic Substances and Disease Registry. Toxicological Profile for Tetrachloroethylene.

Dry Clean Coalition, 2002. State Coalition for Remediation of Drycleaners. Chemicals Used in Drycleaning Operations.

EPA, 1994. US Environmental Protection Agency. OPPT Chemical Fact Sheet, Chemicals in the Environment: Perchloroethylene (CAS No. 127-18-4).

EPA, 1995. US Environmental Protection Agency. EPA Office of Compliance Sector Notebook Project, Profile of the Dry Cleaning Industry.

Government of Canada, Environment Canada and Health Canada, 1993. Canadian Environmental Protection Act, Priority Substances List Assessment Report, Tetrachloroethylene.

Health Canada, in draft. Federal Contaminated Site Risk Assessment in Canada, Part 1: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA), Version 2.0.

ITRC, 2007. Interstate Technology Regulatory Council. Technical and Regulatory Guidance, Vapor Intrusion Pathway: A Practical Guideline.

***Waste Oil Sites***

**PCOC List:** Dependent on site-specific chemical handling procedures.

**Rationale:** Although waste oil is comprised of heavier end (C16+) hydrocarbons that are not considered to be volatile (and are not listed in Schedule 11), the greater concern with waste oil facilities from a soil vapour perspective is the potential presence of site-related volatile chemicals (gasoline, diesel, solvents) that may have been intentionally or erroneously included in the waste oil stream. Consequently, it is recommended that site-specific information be reviewed to determine whether volatile substances may have been included in the waste oil stream.

***Diesel Sites***

**PCOC List:** benzene, ethylbenzene, toluene, xylenes, 1,3,5-trimethylbenzene, 1,2,4-trimethylbenzene, n-decane, naphthalene and VPHv.

**Rationale:** The PCOCs were based on the parameters listed in CSR Schedule 11 and data showing the composition of diesel provided in the Total Petroleum Hydrocarbon (TPH) Working Group document Volume 2: Composition of Petroleum Mixtures (Potter, 1998). Please note that 1,2,4-trimethylbenzene is not listed in the TPH Working Group document; however, the substance has been considered as a diesel-related parameter in other regulatory jurisdictions (Pennsylvania Department of Environmental Protection, 2008).

***References:***

Potter, T.L. and K.E. Simmons, 1998. Total Petroleum Hydrocarbon Criteria Working Group Series. Volume 2, Composition of Petroleum Mixtures.

Pennsylvania Department of Environmental Protection, 2008. Table IV-9, Short List of Petroleum Products.

***Gasoline Sites***

**PCOC List:** benzene, ethylbenzene, toluene, xylenes, 1,3,5-trimethylbenzene, 1,2,4-trimethylbenzene, n-hexane, n-decane, naphthalene, 1,3-butadiene, methylcyclohexane, isopropylbenzene (cumene), VPHv, 1,2-dibromoethane, 1,2-dichloroethane and MTBE

**Rationale:** The list of PCOCs was based on the parameters listed in CSR Schedule 11 and on data regarding the composition of gasoline provided in the TPH Working Group document Volume 2: Composition of Petroleum Mixtures (Potter, 1998); 1,2-dibromoethane, 1,2-dichloroethane and MTBE were included in the full list due to their historical use as gasoline additives. Please note that the inclusion of 1,2-dibromoethane, 1,2-dichloroethane and MTBE as PCOCs should be evaluated by Approved Professionals

at the Stage 1 Preliminary Site Investigation stage (i.e. based on historical file review and known dates of product storage/handling) and only included as PCOCs where necessary.

*References:*

Potter, T.L. and K.E. Simmons, 1998. Total Petroleum Hydrocarbon Criteria Working Group Series. Volume 2, Composition of Petroleum Mixtures.

### **3. Measurement of Shallow Soil Vapours**

Recent revisions to the MoE draft soil vapour technical guidance (MoE, 2009) provides specific provisions for the assessment of shallow vapour sources, including:

- a) use of partitioning equations and conservative default indoor and outdoor air attenuation factors to estimate indoor and outdoor air concentrations from measured soil and groundwater data;
- b) collection of multiple indoor and outdoor air samples;
- c) collection of multiple sub-building (i.e. subslab) vapour samples and use of a conservative attenuation factor to estimate indoor air concentrations;
- d) collection of multiple outdoor subslab (i.e. sub-pavement, sub-roadway, sub-temporary slab, etc.) and use of a conservative attenuation factor to estimate outdoor air concentrations; and
- e) collection of vapour data using an alternative, defensible approach. However, the use of attenuation factors is not allowed and thus, soil vapour concentrations must be compared directly to the Schedule 11 standards. The Approved Professional must thoroughly document and defend the use of the alternative approach.

The Panel has focused its efforts on providing an alternative, defensible approach for Approved Professionals to use at sites with shallow vapour sources (i.e. option e) above) and in particular, at sites which are vacant (i.e. no buildings are present) and/or have unsealed exterior surfaces (i.e. bare ground). The application of attenuation factors to data collected using the approach is discussed further in Section 4.

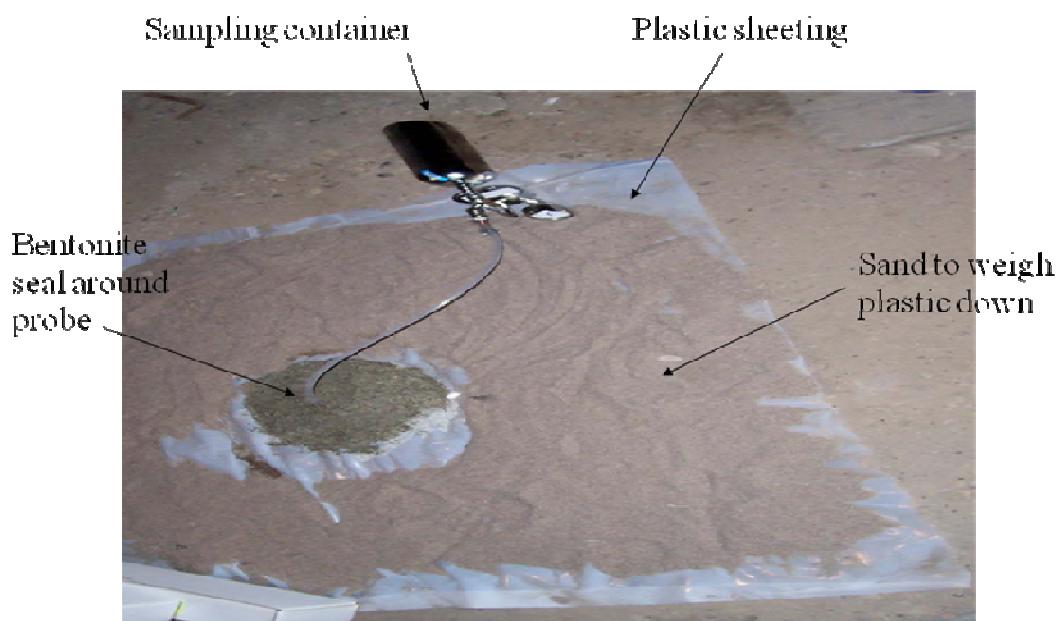
The Panel's recommended approach varies depending on whether indoor or outdoor air concentrations require assessment. For estimation of outdoor air concentrations, a surface seal should be installed at least 24 hours prior to sampling. Surface seals should be at least 1.5 m by 1.5 m in size and made of a non-porous material (e.g. liner). The proposed size of the surface seal is considered appropriate for soil vapour sample volumes up to approximately 10 L; if the sampling volume is larger than this, the size of the surface seal should be increased accordingly. Other important considerations regarding the surface seal include the following:

- the surface seal should be sufficiently robust to ensure that perforations or openings in the surface seal are not created during assessment activities;

- the surface seal should be held in place in such a way that no ambient air can enter under the seal (i.e., the seal should be weighted down); and
- the surface seal should be composed of a material that will not introduce vapours that affect the sample results.

A photograph showing an example of a surface seal used to facilitate shallow soil vapour sampling is provided below in Figure 1.

## Soil Vapour Sampling - Surface Seal



D. Gray Modified from New York State Training in Soil Vapor Testing

**Figure 1. Temporary Surface Seal**

It is important to note that the above surface seal is NOT meant to simulate a building slab or a large covered area (e.g., concrete, asphalt, etc). For estimation of indoor air concentrations in a future building, a larger surface seal would be required. The size of the surface seal would depend on the size of the future building to be constructed on the site (i.e. professional judgment is required). Also, the seal should be left in place for approximately 6-8 months prior to sampling to help mimic the soil vapour transport and fate conditions that will exist when a building is placed on the site, including soil moisture conditions beneath permanently sealed surfaces and subsurface oxygen concentrations (for biodegradable vapour PCOCs).

To help ensure that the data collected using the above approach is defensible, the Approved Professional should consider the following.

- a) Adequate leak testing should be conducted to ensure that only subsurface vapour is extracted during the sampling event. This may involve leak testing during the entire sampling period (using liquid/gas tracers that can be identified by the project laboratory) or pre-sampling leak testing over a volume similar to the proposed sampling volume (i.e. if the proposed sampling volume is 6 litres, then the leak test should evaluate concentrations following a 6 litre purge volume). The use of leak testing shrouds with larger surface areas is also recommended.
- b) Purging and sampling volumes should be minimized.
- c) If simulating a future building, the collection of subsurface oxygen, carbon dioxide and methane data over time is encouraged to evaluate whether the seal is operating effectively and mimicking future subsurface conditions.
- d) One reference (Missouri, 2005) indicates that under no circumstances should vapour samples be collected from depths shallower than 0.45 m below grade. If the collection of vapour samples from shallower depths is required, the Approved Professional should provide additional justification regarding the representativeness of the data.

*References:*

Ministry of Environment, 2009. Technical Guidance on Contaminated Sites 4, Vapour Investigation and Remediation (DRAFT). July 2009.

Missouri Department of Natural Resources, 2005. Missouri Risk-Based Corrective Action (MRBCA) for Petroleum Storage Tanks - Soil Gas Sampling Protocol.

New York State Department of Health, 2006. Guidance for Evaluating Soil Vapor Intrusion in the State of New York.

#### **4. Attenuation Factors**

The current Ministry guidance precludes the use of the attenuation factors listed in Table 1 of Technical Guidance 4, Vapour Investigation and Remediation, when the following conditions exist.

- a) The water table or detectable PCOC concentrations in soil are within 1 metre of a building foundation or ground surface. The use of conservative, alternative attenuation factors may be allowed under specific conditions (see below).
- b) The water table or detectable PCOC concentrations in soil are within 5 metres of an unlined crawl space, earthen basement, or wooden basement.
- c) The building or site surface is located above a very high gas permeability media.

- d) There is a preferential pathway (e.g. utility corridor backfill) connecting the vapour source to the breathing zone of the receptor of concern.
- e) Subsurface or subslab vapour is under pressure.
- f) Groundwater contamination is present in fractured bedrock.
- g) There is active pumping or drawdown of groundwater at the site.

Revisions to Technical Guidance 4 made by the Ministry in July 2009 allow for the application of a 0.1 indoor air attenuation factor for delineation of shallow (i.e. < 1m between contaminant source and receptor breathing zone) vapour sources in the following circumstances only:

- a) where indoor air concentrations are estimated from measured soil and groundwater concentrations using partitioning equations; or
- b) where indoor air concentrations are estimated from measured subslab (i.e. sub-building) vapour concentrations.

Based on informal discussions with the Ministry, it is the Panel's understanding that the Ministry has adopted the aforementioned 0.1 attenuation factor based on empirical databases, specifically the USEPA's Vapour Intrusion Database (USEPA, 2008a), which suggest that subslab to indoor air attenuation may occur at factors of 0.1 or higher. Furthermore, it is this reported empirical evidence of attenuation factors of 0.1 or higher that has resulted in the Ministry being reluctant to adopt attenuation factors for other precluding conditions.

Although the USEPA Vapour Intrusion Database is an incredibly useful tool, caution is warranted in the interpretation of the empirical data. With respect to the USEPA's database, the most significant confounding factor in the interpretation of the empirical data is contributions from background contaminants. Consequently, the efforts of the USEPA have focused heavily on assessing background indoor air contaminant concentrations and evaluating the database contents using a variety of filters.

In their draft 2008 report (USEPA, 2008b), the USEPA indicated that two filtering steps were taken to evaluate the compiled data. The first filtering step was a data consistency screening which removed suspect data where field notes indicated the presence of background sources of contamination, where indoor air concentrations exceeded subsurface concentrations, where calculated attenuation factors for a particular chemical were not consistent with other chemicals assessed in a particular study and where concentrations were less than the laboratory reporting limits. The second filtering step involved the removal of data where indoor air concentrations were consistent with background concentrations (as determined from the 95th percentile of compiled indoor air statistics and/or the reporting limit for the particular chemical).

The USEPA's 2008 draft report indicated that the 95th percentile subslab alpha value from the first filtering step (Dataset 1) was 0.48 and was 0.15 from the second filtering step (Dataset 2). The corresponding median alpha values were 0.0055 and 0.005.

Helen Dawson, one of the key USEPA personnel involved in the development of the empirical database, presented additional filtered data from the USEPA's Vapour Intrusion Database at an Association for Environmental Health and Sciences workshop in 2008 (Dawson, 2008). Specifically, Dr. Dawson presented subslab alpha values with different levels of filtering against background indoor air concentrations. When indoor air concentrations were consistent with background air concentrations, the 95th percentile subslab alpha was 0.15 (i.e. Dataset 2). When indoor air concentrations were at least ten times higher than background concentrations, the 95th percentile subslab alpha dropped to 0.04. When indoor air concentrations were at least fifty times higher than background concentrations, the 95th percentile subslab alpha was reduced to approximately 0.02. With additional filtering (i.e. 100 times and 500 times background concentrations), the 95th percentile alpha values did not decrease significantly from the 95th percentile alpha value at a 50 times filtering strength. Based on the filtering exercises conducted by Dr. Dawson, it would appear that an alpha value of 0.02 is likely the true 95th percentile of the data when the confounding influence of background contaminant sources is removed and can be considered a worst-case alpha value. An explanation of the theoretical basis for considering an alpha value of 0.02 to be "worst-case" is provided in subsequent sections of this document.

Based on the above, and considering that the Ministry guidance currently does not allow for the application of attenuation factors under several commonly encountered conditions, the Panel has focused its efforts on providing guidance on the defensible application of attenuation factors where:

- a) contamination is present within 1 m of grade or within 1 m of an existing building foundation;
- b) contamination is present within 1 m of a potential future building foundation (but greater than 1 m from current grade);
- c) contamination is present within 5 m of an unlined crawlspace, earthen basement or wooden basement; and
- d) potential preferential pathways between the contaminant source and receptor breathing zone exist.

Evaluations were conducted to assess whether or not the location of the contaminant source or the presence of preferential pathways would affect the predicted attenuation that would occur as measured vapours migrate into a building. One of the objectives was to determine whether or not there was a maximum attenuation factor (i.e. minimum dilution factor) that could be applied, regardless of the location of the contaminant source and/or preferential pathways, that would be protective of indoor receptors.

***Contaminant Source Within 1 m of Grade or 1 m of an Existing Building Foundation***

Provided representative soil vapour is collected in a defensible manner (such as outlined in Section 3), the Panel recommends the application of a 0.02 attenuation factor to the data to estimate indoor air concentrations. The rationale for the use of the 0.02 attenuation factor is provided below.

The rate at which contaminant vapours enter a building is limited by the soil gas flow rate, and the rate at which they leave is based on the air exchange rate. The worst-case attenuation factor (or alpha value) is therefore  $Q_{soil}/Q_b$  where:

- $Q_{soil}$  is the volumetric flow rate of soil gas into a building; and
- $Q_b$  is the building ventilation rate.

Health Canada (2008 draft) assumes an air exchange rate of 0.35/h for a residential building. Based on a building height of 2.4 m and a soil gas flow rate ( $Q_{soil}$ ) of 10 L/min (generally considered to be a worst-case value), the  $Q_{soil}/Q_b$  value would be 0.00475. Johnson (2002) indicated that the reasonable range for  $Q_{soil}/Q_b$  is 0.0001 to 0.05, based on radon studies and vapour intrusion case studies.

The attenuation factor of 0.02 applied by the MoE to subslab vapours is based on empirical data (for subslab vapours), and is, as discussed previously, a worst-case value (i.e. considered to be the true 95<sup>th</sup> percentile attenuation factor based on the USEPA empirical database). The  $Q_{soil}/Q_b$  limit on the alpha value should not be affected by whether the source is within 1 m of the building or not, and therefore in our opinion, the worst-case alpha of 0.02 should still be applicable. However, there are a couple of caveats to this approach. Firstly, the vapour data should be collected in a defensible manner (as outlined in Section 3) and thoroughly documented. Secondly, this approach would not apply in the event that contaminated groundwater was in contact with the building (i.e. the potential for seepage into the basement) due to direct contact concerns.

It is noted that the MoE currently prohibits the use of attenuation factors to shallow vapour data collected using alternative methods in the issuance of numerical standards-based instruments. However, as the MoE guidance remains in draft form, the Panel encourages the MoE to adopt the Panel's recommendations.

The Panel also encourages the MoE to revisit the indoor air attenuation factor currently prescribed for subslab vapour collected when the contaminant source is within 1 m of the building for reasons presented previously. Provided that Approved Professionals can document that contaminated groundwater is not in contact with the building foundation at any point in the year and that they collect sufficient subslab samples to

spatially and temporally characterize vapour beneath a building, the use of a 0.02 attenuation factor should still be protective.

***Contaminant Source Within 1 m of a Potential Future Building Foundation (but collected more than 1 m below current grade)***

This property condition is a frequent obstacle for many Approved Professionals. Although a contaminant source may be located more than 1 m below grade, it may not be located more than 1 m from a future building foundation (particularly if property owners want to ensure that the Ministry instrument for the site is as flexible as possible to facilitate future site development). It is not clear from the current MoE guidance what attenuation factors, if any, are allowed in such circumstances. Based on discussions with MoE personnel, it is the Panel's understanding that only a 0.1 alpha value may be applied.

Based on the rationale provided in the previous section, an attenuation factor of 0.02 is considered protective of such circumstances and should be applied to representative soil vapour data. As discussed in the previous section, Approved Professionals should ensure that soil vapour is collected in a documented and defensible manner and should not apply the proposed attenuation factor if contaminated groundwater may be in contact with the future building foundation (i.e. if the water table is located at or above the potential depth of the future building) due to direct contact concerns.

***Contaminant Source Within 5 m of an Unlined Crawlspace, Earthen Basement or Wooden Basement***

Current MoE guidance precludes the use of an attenuation factor to soil vapour data collected within 5 m of an unlined crawlspace, earthen basement or wooden basement. It is noted that Health Canada's vapour intrusion guidance (2008, draft) also precludes the application of screening attenuation factors under such conditions. The rationale provided by Health Canada is that the conditions fall outside the conceptual site model described by Johnson and Ettinger (1991).

However, based on information provided by Robert Ettinger (AWMA, 2007), soil vapour intrusion models, such as the Johnson and Ettinger (J&E) model, can in fact be used to evaluate buildings with unlined crawl spaces. This is accomplished by setting the crack factor in the vapour intrusion model at 1 (or unity), which in essence, treats the crawl space as a building with a bare dirt floor. Using this approach, the attenuation factors for unlined crawl spaces are found to be slightly higher than those for slab-on-grade buildings. As an example, the Canadian Council of the Ministers of Environment (CCME) implementation of the J&E model, as incorporated into Health Canada's spreadsheet model for detailed quantitative risk assessment (DQRA) (Health Canada, unpublished), was used to model a generic unlined crawl space. The model was initially run for sand using Health Canada default assumptions and a soil vapour permeability of  $3 \times 10^{-6} \text{ cm}^2$  in order to reproduce the MoE default attenuation factors. (The Health Canada method

itself was not used as it does not allow adjustment of the crack factor). The crack area was then adjusted to 1,500,625 cm<sup>2</sup> to reflect the absence of a slab, yielding an attenuation factor at 1 m of 2.9x10<sup>-3</sup>. Using an alternate combination of vapour permeability (1.35x10<sup>-7</sup> cm<sup>2</sup>) and air exchange rate (0.25/h) that also matches the MoE default values, an attenuation factor at 1 m of 5.4x10<sup>-3</sup> was determined. These values are well below an attenuation factor of 0.1.

Additionally, based on empirical data presented in the EPA Vapor Intrusion Database (as accessed through <http://iavi.rti.org/login.cfm>), the use of an attenuation factor of 0.1 appears to be conservative. The EPA database includes approximately 34 entries of coupled soil gas and indoor air data from sites with buildings with crawlspaces. All of the data was for chlorinated solvents, which are considered to migrate conservatively (i.e. migrate without losses due to biodegradation). The mean alpha value of the 34 observations is approximately 0.06, with a 90th percentile value of 0.1.

Based on the above, it is the Panel's recommendation that an attenuation factor of 0.1 can be conservatively applied to soil vapour data collected in a documented and defensible manner within 5 m of an unlined crawlspace, earthen basement or wooden basement. It should be noted that the soil vapour data should be collected from depths more than 1 m below an earthen basement (i.e. more than 1 m below the exposed soil surface) or more than 0.45 m below a surface seal installed on the exposed soil surface.

### ***Preferential Pathways to Buildings***

The MoE has also prohibited the use of attenuation factors in numeric instrument submissions when preferential pathways to the receptor's breathing zone exist. An argument could be made that the depth-specific attenuation factors provided in Table 1 of Technical Guidance 4 (MoE, 2009) may not be appropriate if there is a preferential migration pathway. However, as the final building concentrations would still be limited by Qsoil/Qb, there does not seem to be any reason why coarse fill in a utility corridor would result in a higher Qsoil than the coarse fill assumed to be present immediately beneath a building slab. Therefore, unless there is a preferential pathway through the foundation slab or other direct connection between the utility backfill and the indoor air (such as an unlined inspection or clean-out box), an alpha value of 0.02 should still be applicable (and likely conservative).

Where there is direct connection of subsurface vapour to indoor air, the recommended attenuation factor provided above for earthen crawlspaces (i.e. 0.1) should be applied based on the same rationale as that provided for the earthen crawlspace scenario.

### ***Recommendations***

Based on the above information and with the exception of the specified exclusions (eg. if impacted groundwater directly contacts the building slab), default attenuation factors are recommended as follows for numerical instrument submissions:

- a) presence of contamination, or groundwater, within 1 m of grade or within 1 m of an existing building foundation – use an attenuation factor of 0.02;
- b) presence of contamination within 1 m of a potential future building foundation (but greater than 1 m from current grade) – use an attenuation factor of 0.02;
- c) presence of contamination within 5 m of an unlined crawlspace, earthen basement or wooden basement – use an attenuation factor of 0.1; and
- d) presence of potential preferential pathways directly connecting the contaminant source to the breathing zone – use an attenuation factor of 0.1.

*References:*

Air and Waste Management Association, 2007. Vapor Intrusion Pathway Modeling: Development and Application. AIR-274, Providence, Rhode Island.

Dawson, H. 2008. EPA Vapor Intrusion Database, Preliminary Analysis of Attenuation Factors. Vapor Intrusion Workshop, Association for Environmental Health and Sciences, San Diego, California.

Health Canada, 2008 (draft). Federal Contaminated Site Risk Assessment in Canada: Part VIII: Guidance for Soil Vapour Intrusion Assessment at Contaminated Sites.

Health Canada (unpublished). Spreadsheet Tool for Human Health Detailed Quantitative Risk Assessment (DQRA) – Draft. Available on request to [cs-sc@hc-sc.gc.ca](mailto:cs-sc@hc-sc.gc.ca).

Johnson, P.C. and R. Ettinger 1991. "Heuristic Model for Predicting the Intrusion Rate of Contaminant Vapours into Buildings" Environmental Science and Technology, 25 #8, 1445-1452.

Johnson, P.C., 2002. Identification of Critical Parameters for the Johnson and Ettinger (1991) Vapour Intrusion Model, API Technical Bulletin #17.

Ministry of Environment, 2009. Technical Guidance on Contaminated Sites 4, Vapour Investigation and Remediation (DRAFT). July 2009.

United States Environmental Protection Agency, 2008a. U.S. EPA's Vapor Intrusion Database. As accessed through <http://iavi.rti.org/login.cfm>.

United States Environmental Protection Agency, 2008b. U.S. EPA's Vapor Intrusion Database: Preliminary Evaluation of Attenuation Factors (DRAFT, March 2008).

## **5. Frequency of Leak Testing During Soil Vapour Sampling**

It is recommended that leak testing be completed at least once for every soil vapour sampling installation (whether the installation is temporary or permanent). If additional sampling events are to be conducted at permanent installations that were previously tested, leak testing should be completed at approximately 10 % of the installations during each subsequent sampling event. Furthermore, as discussed in Section 3, more extensive leak testing may be required at shallow vapour probes to ensure that representative and defensible subsurface vapour is collected.

In addition, it is noted that at least one field duplicate should be collected per sampling event, or one per ten samples, whichever is greater. Field duplicates should be collected using a "T" splitter, as opposed to collecting the two samples sequentially.