ATTACHMENT A ADDENDUM

Soil Vapor Results for the Winter and Summer 2004 Sampling for Buildings K-1007, K-1225, K-1330, and K-1580 at the East Tennessee Technology Park, Oak Ridge, Tennessee

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Soil Vapor Results for the Winter and Summer 2004 Sampling for Buildings K-1007, K-1225, K-1330, and K-1580 at the East Tennessee Technology Park, Oak Ridge, Tennessee

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ACRONYMS

DOE	U. S. Department of Energy
EBS	Environmental Baseline Survey
EPA	U. S. Environmental Protection Agency
ETTP	East Tennessee Technology Park
ORO	Oak Ridge Operations Office
RL	acceptable total risk
TCE	trichloroethene
VOC	volatile organic compound

1. INTRODUCTION

1.1 BACKGROUND

Due to the occurrence of volatile organic compounds (VOCs) in shallow groundwater at the East Tennessee Technology Park (ETTP), the U. S. Environmental Protection Agency (EPA) Region 4 recommended investigation of the vapor intrusion pathway for ETTP facilities that are targeted for transfer to the Community Reuse Organization of East Tennessee or other qualified parties. EPA's recommendation is based upon their *Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils*, EPA-530-F-052, November 2002 (EPA 2002).

In accordance with the *Draft Vapor Intrusion Guidance*, and through consultation with representatives from EPA Region 4, the U. S. Department of Energy-Oak Ridge Operations Office (DOE-ORO) has developed a process to evaluate the potential for vapor intrusion at existing ETTP facilities to be transferred to the private sector under a Comprehensive Environmental Response, Compensation, and Liability Act of 1980 Sect. 120(h) Covenant Deferral Request. The process is described in Sect. 4.4 of the Environmental Baseline Survey (EBS) documents that were prepared for each of the four office buildings proposed for transfer (DOE 2004a, DOE 2004c, DOE 2004e, DOE 2004g). The EBS documents may be obtained from the DOE Information Center at 475 Oak Ridge Turnpike, Oak Ridge, Tennessee 37830 (865-241-4780), or from the DOE Public Information web site at http://www.oakridge.doe.gov/info_cntr.

The soil vapor data evaluation contained in this report serves to supplement the results of previous investigations documented in *Soil Vapor Results for the Winter Sampling for Building K-1007 at the East Tennessee Technology Park, Oak Ridge, Tennessee* (BJC 2004a); *Soil Vapor Results for the Winter Sampling for Building K-1225 at the East Tennessee Technology Park, Oak Ridge, Tennessee* (BJC 2004b); *Soil Vapor Results for the Winter Sampling for Building K-1330 at the East Tennessee Technology Park, Oak Ridge, Tennessee* (BJC 2004c); *and Soil Vapor Results for the Winter Sampling for Building K-1580 at the East Tennessee Technology Park, Oak Ridge, Tennessee* (BJC 2004d), for four office buildings, designated as K-1007, K-1225, K-1330, and K-1580, proposed for transfer. One of these buildings (i.e., K-1225) is located within 100 ft of a VOC-contaminated groundwater plume, while the other three (K-1007, K-1330, and K-1580) are not in close proximity (more than 100 ft away) and generally are down- or side-gradient from a plume. Soil vapor data were collected, compared to health-protective concentrations, evaluated for seasonal trends, and finally a re-sampling frequency was developed that is protective of human health.

1.2 DATA EVALUATION

As described in the EBS reports (DOE 2004a, DOE 2004c, DOE 2004e, DOE 2004g), evaluation of the potential for vapor intrusion was based on evaluation of two sampling events. To account for seasonal variability, soil vapor samples were obtained during both winter and summer months. The evaluation of winter data, augmented with additional summer sampling, provides confirmation that the vapor intrusion pathway is not complete beneath the buildings, and thus there is a low likelihood of adverse impacts to human health (DOE 2004b, DOE 2004d, DOE 2004f, DOE 2004h).

The following sections outline the process used in the data evaluation for each building, and the results of the analysis for each building are presented in Chaps. 2 through 5.

1.2.1 Comparison to Trigger Levels

Sub-slab soil vapor was collected in the winter of 2004, and again from the same locations in the summer of 2004, to determine if a potential source for VOCs exists under each building. The results were validated and the average concentration for each VOC was calculated and compared to its respective soil vapor trigger level, where the trigger level is a concentration calculated to be health protective. In addition, to ensure that the VOCs did not cumulatively exceed trigger levels, the average concentration for each VOC was divided by its respective trigger level to determine what fraction the concentration represented. The resulting fractions were then added for all VOCs that had at least one detection. If, collectively, the VOC concentrations had exceeded the trigger levels, the resulting value would be above 1.0 (i.e., the fractions would add up to over 1.0).

None of the VOCs detected in either the winter or summer sampling exceeded trigger levels for any building, and for all buildings and sampling events, the sum of trigger level fractions was below 1. Therefore, the vapor intrusion pathway is not considered complete beneath the buildings, and there is a low likelihood of adverse impacts to human health. Tables of the comparison of arithmetic mean concentrations to trigger levels are presented in Chaps. 2 through 5.

1.2.2 Evaluation of Seasonal Results

In addition to the comparison to trigger levels, the dataset was evaluated for seasonal variation in soil vapor concentrations between the winter and summer sampling. A confirmatory summer sampling event was conducted because of the potential for temperatures and/or depth to groundwater to influence soil vapor concentrations.

Numerous constituents had lower concentrations in summer versus winter, but an equal number of constituents had upward trends in detected soil vapor concentrations in summer versus winter. Chapters 2 through 5 present a description of results for each of the buildings evaluated.

1.2.3 Calculation of Re-Sampling Frequency

Soil vapor concentrations may vary due to groundwater movement; therefore, additional sampling may be required to ensure protection of human health in the future. The approach agreed to by EPA Region 4 and DOE-ORO for determining how often sampling will be needed in order to ensure protectiveness to the workers inside the transferred buildings is presented in the following section.

The process begins with an evaluation of the dataset to determine the maximum detected soil vapor concentration of each constituent for a particular building. Next, the equations used to calculate risk and hazard are rearranged to solve for the allowable days of exposure that, at the maximum detected soil concentration, would result in an intake of all detected contaminants that does not exceed health-based limits. For this analysis the acceptable risk level was 1E-6 and the acceptable hazard level was 1.

The general risk equation for a receptor exposed via inhalation to *n* carcinogenic constituents is:

$$Risk = \frac{IR \text{ x } EF \text{ x } ED}{ATc \text{ x } BW} \text{ x } \sum_{n}^{i=1} \left(Ca_1 \text{ x } SF_1 + ... Ca_n \text{ x } SF_n \right),$$

where

Risk	=	carcinogenic risk	(unitless)
IR	=	inhalation rate	(m^3/day)
EF	=	exposure frequency	(days/year)
ED	=	exposure duration	(years)
ATc	=	averaging time for carcinogens	(70 years × 365 days/year)
BW	=	body weight	(kg)
Ca	=	concentration in indoor air	(mg/m^3)
SF	=	carcinogenic slope factor	(risk/(mg/(kg-d))
i	=	index for constituent	
n	=	total number of constituents	

Re-arranged to solve for ED at a given risk level (RL), the equation is:

$$ED(\text{years}) = \frac{RL \text{ x } ATc \text{ x } BW}{IR \text{ x } EF} \text{ x } \frac{1}{\sum_{n}^{i=1} \left(Ca_1 \text{ x } SF_1 + \ldots Ca_n \text{ x } SF_n\right)}$$

The result of the risk-based calculation is the number of years that a receptor can be exposed to *n* constituents, at the assumed exposure rates, and not the acceptable total risk (RL) over a 70-year lifetime. The calculation of re-sampling frequency assumed an acceptable risk level of 1E-6 for the inhalation pathway.

The first expression in the equation (RL × ATc × BW / IR × EF) is generated from the receptor-specific exposure parameters and is independent of the chemical. The summation component of the equation $\{\sum(Ca_1 \text{ x } SF_1 + \ldots Ca_n \text{ x } SF_n)\}$ is generated from the chemical-specific parameters that are independent of the receptor evaluated. The equations for carcinogens and non-carcinogens differ due to the fact that the carcinogenic exposure equation considers the number of years a receptor is exposed, while the non-carcinogenic equation does not. Therefore, only the carcinogenic-based calculation is used as the basis for determining the re-sampling frequency.

Maximum detected soil concentrations from the combined winter and summer datasets were converted into maximum indoor air concentrations. An attenuation factor of 1E-3 was used, and is based on modeling completed using the Johnson and Ettinger vapor intrusion model based on the assumed building configuration and surrounding soil characteristics. The resulting indoor air concentrations were used as the basis for calculating the allowed days of exposure.

The maximum detected concentration of each VOC from soil vapor sampling events conducted in winter and summer was included in the assessment of re-sampling frequency. A summary of the calculated re-sampling frequencies for each building is presented in Table 1.1 below as well as the primary constituents, maximum detected concentrations, and season in which the maximum occurred. Details of the calculations for each building are presented in Chaps. 2 through 5.

Table 1.1. Summary of re-sampling frequencies for Buildings K-1007, K-1225, K-1330, and K-1580 based on all data

Building	Re-sampling frequency (years)	Significant analytes	Maximum detected concentration (mg/m^3)
		All sampling data	
K-1007	17	Carbon tetrachloride (S)	0.15
		Chloroform (S)	0.12
K-1225	12	Carbon tetrachloride (W)	0.377
		Chloroform (W)	0.067
K-1330	367	1,1,2,2-Tetrachloroethane (W)	0.0006
		Benzene (W)	0.018
K-1580	20	Benzene (W)	0.33
		Chloroform (W)	0.032

Source: DOE 2004a–h.
(S) indicates data collected during the summer sampling event.
(W) indicates data collected during the winter sampling event.

K-1007

2. SOIL VAPOR RESULTS FOR THE WINTER AND SUMMER 2004 SAMPLING AT BUILDING K-1007

2.1 COMPARISON TO TRIGGER LEVELS

As shown in Tables 2.1 and 2.2, the sum of trigger level fractions was well below 1.0 for Bldg. K-1007 winter (0.01) and summer (0.08) sampling events, respectively. Therefore, the vapor intrusion pathway is not considered complete beneath the building, and there is a low likelihood of adverse impacts to human health.

2.2 EVALUATION OF SEASONAL RESULTS

A comparison of the soil vapor results from the winter and summer 2004 sampling results was performed and indicated soil vapor concentrations at Bldg. K-1007 are inconsistent with regard to seasonal changes. Constituents such as 1,1,1-trichloroethane, benzene, methylene chloride, toluene, and xylenes had generally higher concentrations in winter than in summer. In contrast, carbon disulfide, carbon tetrachloride, and trichloroethene (TCE) had higher vapor concentrations in summer than in winter.

2.3 CALCULATION OF RE-SAMPLING FREQUENCY

Once the sampling frequency has been established, re-sampling will be conducted either inside the buildings or immediately outside the buildings, depending on the potential impact to future owners and the calculated frequency. If sampling indoors is considered too intrusive to the future owners, sampling outside will be performed. The following text describes the outdoor sampling approach.

Soil piezometers, if not already present, would be installed in locations outside the building. In order to monitor sub-slab soil vapor from these piezometers, a correlation between the piezometer soil vapor measurements and the sub-slab soil vapor measurements taken outside the buildings must be established. The proposed sampling strategy is to pair interior sub-slab soil sampling locations with an exterior piezometer, with the number and locations of samples based on the size and configuration of the building. The paired interior and exterior sample results would be used to calculate a linear regression to relate the outside soil vapor concentration to the sub-slab soil vapor concentration. The number of samples that would be needed in order to establish a correlation between the indoor and outdoor soil vapor data will be determined using the Monte Carlo simulation approach.

Once the data from the outside piezometers are analyzed, the correlated concentrations for the sub-slab soil vapor can be determined and screened against the trigger levels to determine if concentrations are acceptable or unacceptable. If they are unacceptable, indoor ambient air sampling will need to be considered. All data collected to evaluate soil vapor will be used in re-calculating the re-sampling frequency.

The re-sampling frequency for Bldg. K-1007 is 17 years based on the equation presented in Chap. 1. The result indicates that should maximum soil vapor concentrations remain constant, an individual working in the building would be exposed to a risk of 1E-6 and a hazard of 1 over the 17-year period due to all constituents combined. Primary constituents contributing to the magnitude of the re-sampling frequency were carbon tetrachloride (maximum detected concentration of 0.15 mg/m^3) and chloroform (0.12 mg/m^3).

Table 2.1. Winter 2004 sub-slab soil vapor results for Building K-1007

Analyte	Frequency of detection	Minimum detected concentration	Maximum detected concentration	Arithmetic mean concentration	Trigger level[a]	Trigger level exceeded?	Arithmetic mean fraction of trigger level
			Volatile organic compounds (μg/m³)				
1,1,1-Trichloroethane	6/7	2.00E-01	1.00E-00	4.43E-01	3.01E+05	No	1.47E-06
1,1,2,2-Tetrachloroethane	6/7	2.00E-01	6.00E-01	2.74E-01	6.67E+02	No	4.10E-04
1,1,2-Trichloro-1,2,2-trifluoroethane	6/7	9.00E-01	7.10E+02	1.03E+02	4.04E+06	No	2.54E-05
1,1,2-Trichloroethane	1/7	2.00E-00	2.00E-00	5.43E-01	1.91E+03	No	2.84E-04
1,1-Dichloroethane	0/7	ND[b]	ND	ND	6.88E+04	NA[c]	NA
1,1-Dichloroethene	0/7	ND	ND	ND	7.55E+02	NA	NA
1,2-Dichloroethane	6/7	1.00E-01	7.00E-01	2.14E-01	1.43E+03	No	1.50E-04
1,2-Dichloroethene	0/7	ND	ND	ND	3.95E+03	NA	NA
1,2-Dichloropropane	6/7	6.00E-02	3.00E-01	1.41E-01	5.45E+02	No	2.59E-04
2-Butanone	5/7	1.00E-00	9.20E+02	1.34E+02	6.84E+05	No	1.96E-04
2-Hexanone	2/7	1.00E-00	2.00E-00	3.29E-00	2.51E+04	No	1.31E-04
4-Methyl-2-pentanone	0/7	ND	ND	ND	4.06E+05	NA	NA
Acetone	4/7	8.00E-00	7.50E+02	1.23E+02	4.13E+05	No	2.98E-04
Benzene	7/7	1.00E-00	2.50E+01	7.86E-00	4.05E+03	No	1.94E-03
Bromodichloromethane	2/7	2.00E-01	1.20E+01	1.99E-00	2.62E+03	No	7.61E-04
Bromoform	1/7	1.00E-01	1.00E-01	4.43E-01	1.39E+04	No	3.20E-05
Bromomethane	0/7	ND	ND	ND	6.89E+02	NA	NA
Carbon disulfide	2/7	2.00E-01	7.00E-01	2.36E-01	9.31E+04	No	2.53E-06
Carbon tetrachloride	6/7	5.00E-01	1.00E-00	7.00E-01	3.35E+02	No	2.09E-03
Chlorobenzene	1/7	4.00E-01	4.00E-01	2.71E-01	2.75E+03	No	9.86E-05
Chloroethane	1/7	2.00E-01	2.00E-01	1.57E-01	1.38E+06	No	1.14E-07
Chloroform	3/7	1.00E-01	8.00E-01	3.00E-01	1.62E+03	No	1.85E-04
Chloromethane	3/7	1.00E-01	1.00E-00	3.43E-01	1.24E+04	No	2.77E-05
Dibromochloromethane	1/7	6.00E-01	6.00E-01	4.71E-01	1.26E+04	No	3.74E-05
Ethylbenzene	7/7	2.00E-01	5.00E-00	1.59E-00	3.49E+04	No	4.54E-05
Methylene chloride	6/7	7.00E-01	4.80E+01	1.01E+01	7.92E+04	No	1.28E-04
Styrene	3/7	4.00E-01	4.50E+01	6.66E-00	1.38E+05	No	4.81E-05
Tetrachloroethene	5/7	4.00E-01	1.70E+01	3.41E-00	6.66E+04	No	5.13E-05
Toluene	7/7	2.00E-00	3.50E+01	1.70E+01	5.39E+04	No	3.15E-04
Total Xylene	7/7	2.00E-00	6.80E+01	2.27E+01	1.38E+04	No	1.64E-03
Trichloroethene	6/7	2.00E-01	2.00E-00	7.07E-01	5.45E+03	No	1.30E-04
Vinyl chloride	1/7	2.00E-01	2.00E-01	1.57E-01	4.23E+03	No	3.72E-05

Table 2.1. Winter 2004 sub-slab soil vapor results for Building K-1007 (continued)

Analyte	Frequency of detection	Minimum detected concentration	Maximum detected concentration	Arithmetic mean concentration	Trigger level[a]	Trigger level exceeded?	Arithmetic mean fraction of trigger level
cis-1,2-Dichloroethene	0/7	ND	ND	ND	4.81E+03	NA	NA
cis-1,3-Dichloropropene	1/7	2.00E-01	2.00E-01	2.43E-01	2.80E+03	No	8.66E-05
trans-1,2-Dichloroethene	0/7	ND	ND	ND	9.67E+04	NA	NA
trans-1,3-Dichloropropene	0/7	ND	ND	ND	4.91E+03	NA	NA
						Sum of fractions	**9.41E-03**

[a]Trigger level was developed with the Johnson-Ettinger (JE) model, assuming an indoor air preliminary remediation goal based on risk level of 1E-5 and hazard index of 0.1 for industrial exposure (250 d/year, 25 years).

[b]ND = non-detection.

[c]NA = not applicable; no detected concentrations.

Table 2.2. Summer 2004 sub-slab soil vapor results for Building K-1007

Analyte	Frequency of detection	Minimum detected concentration	Maximum detected concentration	Arithmetic mean concentration	Trigger level[a]	Trigger level exceeded?	Arithmetic mean fraction of TL
			Volatile organic compounds (μg/m³)				
1,1,1-Trichloroethane	7/7	7.50E-01	4.60E+00	1.47E+00	3.00E+05	No	4.90E-06
1,1,2,2-Tetrachloroethane	0/7	ND[b]	ND	ND	6.69E+02	NA[c]	NA
1,1,2-Trichloro-1,2,2-trifluoroethane	7/7	6.40E-01	4.60E+00	1.37E+00	3.98E+06	No	3.44E-07
1,1,2-Trichloroethane	0/7	ND	ND	ND	1.91E+03	NA	NA
1,1-Dichloroethane	0/7	ND	ND	ND	6.89E+04	NA	NA
1,1-Dichloroethene	1/7	5.80E-01	5.80E-01	1.25E-01	7.42E+02	No	1.68E-04
1,2-Dichloroethane	1/7	2.10E-01	2.10E-01	7.29E-02	1.38E+03	No	5.27E-05
1,2-Dichloroethene	0/7	ND	ND	1.13E+00	2.52E+03	No	4.46E-04
1,2-Dichloropropane	0/7	ND	ND	ND	5.44E+02	NA	NA
2-Butanone	7/7	2.00E+00	5.80E+00	3.89E+00	6.82E+05	No	5.70E-06
2-Hexanone	7/7	4.90E-01	6.10E+00	2.60E+00	7.95E+02	No	3.27E-03
4-Methyl-2-pentanone	7/7	3.40E-01	9.00E-01	6.04E-01	4.02E+05	No	1.50E-06
Acetone	7/7	1.30E+01	2.60E+01	1.80E+01	3.85E+05	No	4.67E-05
Benzene	7/7	1.70E-01	8.10E-01	3.93E-01	3.99E+03	No	9.84E-05
Bromodichloromethane	0/7	ND	ND	ND	2.73E+03	NA	NA
Bromoform	1/7	3.30E-01	3.30E-01	1.66E-01	1.49E+04	No	1.11E-05
Bromomethane	2/7	1.20E-01	1.90E-01	7.36E-02	6.91E+02	No	1.06E-04
Carbon disulfide	7/7	2.20E-01	4.20E+00	2.07E+00	8.99E+04	No	2.30E-05
Carbon tetrachloride	7/7	4.00E-01	1.50E+02	2.19E+01	3.34E+02	No	6.57E-02
Chlorobenzene	0/7	4.00E-01	4.00E-01	1.40E+00	2.76E+03	No	5.06E-04
Chloroethane	5/7	8.00E-02	4.60E-01	1.64E-01	1.38E+06	No	1.18E-07
Chloroform	7/7	2.00E-01	1.20E+02	1.76E+01	1.56E+03	No	1.13E-02
Chloromethane	3/7	9.00E-01	8.90E+00	1.97E+00	1.24E+04	No	1.59E-04
Dibromochloromethane	0/7	ND	ND	ND	1.34E+04	NA	NA
Ethylbenzene	4/7	1.60E-01	3.80E-01	1.54E-01	3.50E+04	No	4.39E-06
Methylene chloride	1/7	3.40E+00	3.40E+00	6.54E-01	7.68E+04	No	8.52E-06
Styrene	4/7	1.10E-01	2.30E-01	1.24E-01	1.39E+05	No	8.90E-07
Tetrachloroethene	7/7	3.00E-01	1.90E+01	4.01E+00	6.68E+04	No	6.00E-05
Toluene	7/7	5.20E-01	3.30E+00	1.01E+00	5.32E+04	No	1.89E-05
Total Xylene	7/7	1.00E+00	1.20E+01	3.29E+00	1.39E+04	No	2.36E-04
Trichloroethene	7/7	2.50E-01	5.10E+01	9.03E+00	5.43E+03	No	1.66E-03
Vinyl chloride	1/7	1.30E-01	1.30E-01	4.79E-02	4.07E+03	No	1.18E-05

Table 2.2. Summer 2004 sub-slab soil vapor results for Building K-1007 (continued)

Analyte	Frequency of detection	Minimum detected concentration	Maximum detected concentration	Arithmetic mean concentration	Trigger level[a]	Trigger level exceeded?[b]	Arithmetic mean fraction of TL
cis-1,2-Dichloroethene	0/7	ND	ND	ND	4.82E+03	NA	NA
cis-1,3-Dichloropropene	0/7	ND	ND	ND	2.84E+03	NA	NA
trans-1,2-Dichloroethene	0/7	ND	ND	ND	9.72E+04	NA	NA
trans-1,3-Dichloropropene	0/7	ND	ND	ND	4.97E+03	NA	NA
						Sum of fractions	**8.39E-02**

[a]Trigger level (TL) was developed with the Johnson-Ettinger (JE) model assuming an indoor air preliminary remediation goal based on risk level of 1E-5 and hazard index of 0.1 for industrial exposure (250 d/year, 25 years).

[b]ND = non-detection.

[c]NA = not applicable based on sampling or toxicological data.

K-1225

3. SOIL VAPOR RESULTS FOR THE WINTER AND SUMMER 2004 SAMPLING AT BUILDING K-1225

3.1 COMPARISON TO TRIGGER LEVELS

As shown in Tables 3.1 and 3.2, the sum of trigger level fractions was well below 1.0 for Bldg. K-1225 winter (0.25) and summer (0.01) sampling events, respectively. Therefore, the vapor intrusion pathway is not considered complete beneath the buildings, and there is a low likelihood of adverse impacts to human health.

3.2 EVALUATION OF SEASONAL RESULTS

A comparison of the soil vapor results from the winter and summer 2004 sampling results was performed and indicated soil vapor concentrations at Bldg. K-1225 were generally higher in winter than in summer. Specifically, constituents such as benzene, toluene, xylenes, and TCE showed lower detected concentrations in the summer sampling versus winter.

3.3 CALCULATION OF RE-SAMPLING FREQUENCY

Once the sampling frequency has been established, re-sampling will be conducted either inside the buildings or immediately outside the buildings, depending on the potential impact to future owners and the calculated frequency. If sampling indoors is considered too intrusive to the future owners, sampling outside will be performed. The following text describes the outdoor sampling approach.

Soil piezometers, if not already present, would be installed in locations outside the building. In order to monitor sub-slab soil vapor from these piezometers, a correlation between the piezometer soil vapor measurements and the sub-slab soil vapor measurements taken outside the buildings must be established. The proposed sampling strategy is to pair interior sub-slab soil sampling locations with an exterior piezometer, with the number and locations of samples based on the size and configuration of the building. The paired interior and exterior sample results would be used to calculate a linear regression to relate the outside soil vapor concentration to the sub-slab soil vapor concentration. The number of samples that would be needed in order to establish a correlation between the indoor and outdoor soil vapor data will be determined using the Monte Carlo simulation approach.

Once the data from the outside piezometers are analyzed, the correlated concentrations for the sub-slab soil vapor can be determined and screened against the trigger levels to determine if concentrations are acceptable or unacceptable. If they are unacceptable, indoor ambient air sampling will need to be considered. All data collected to evaluate soil vapor will be used in re-calculating the re-sampling frequency.

The re-sampling frequency for Bldg. K-1225 is 12 years based on the equation presented in Chap. 1. The result indicates that should maximum soil vapor concentrations remain constant, an individual working in the building would be exposed to a risk of 1E-6 and a hazard of 1 over the 12-year period due to all constituents combined. Primary constituents contributing to the magnitude of the re-sampling frequency were carbon tetrachloride (maximum detected concentration of 0.377 mg/m^3) and chloroform (0.067 mg/m^3).

Table 3.1. Winter 2004 sub-slab soil vapor results for Building K-1225

Analyte	Frequency of detection	Minimum detected concentration	Maximum detected concentration	Arithmetic mean concentration	Trigger level[a]	Trigger level exceeded?	Arithmetic mean fraction of trigger level
			Volatile organic compounds ($\mu g/m^3$)				
1,1,1-Trichloroethane	4/5	2.00E-01	8.10E+01	1.66E+01	3.01E+05	No	5.51E-05
1,1,2,2-Tetrachloroethane	3/5	5.00E-02	2.00E+00	6.30E-01	6.67E+02	No	9.45E-04
1,1,2-Trichloro-1,2,2-trifluoroethane	3/5	5.00E-01	9.00E-01	5.60E-01	4.04E+06	No	1.39E-07
1,1,2-Trichloroethane	2/5	1.00E+00	3.00E+00	9.80E-01	1.91E+03	No	5.12E-04
1,1-Dichloroethane	0/5	ND[b]	ND	ND	6.88E+04	NA[c]	NA
1,1-Dichloroethene	1/5	8.00E-01	8.00E-01	3.20E-01	7.55E+02	No	4.24E-04
1,2-Dichloroethane	3/5	3.00E-01	5.00E+00	1.34E+00	1.43E+03	No	9.35E-04
1,2-Dichloroethene	1/5	1.00E+00	1.00E+00	3.60E-01	3.95E+03	No	9.10E-05
1,2-Dichloropropane	3/5	3.00E-01	7.00E-01	4.00E-01	5.45E+02	No	7.34E-04
2-Butanone	3/5	1.00E+00	5.00E+00	2.80E+00	6.84E+05	No	4.09E-06
2-Hexanone	1/5	9.00E-01	9.00E-01	3.38E+00	2.51E+04	No	1.34E-04
4-Methyl-2-pentanone	0/5	ND	ND	ND	4.06E+05	NA	NA
Acetone	4/5	4.00E+00	3.90E+01	1.52E+01	4.13E+05	No	3.68E-05
Benzene	5/5	1.00E+00	8.50E+01	2.58E+01	4.05E+03	No	6.37E-03
Bromodichloromethane	0/5	ND	ND	ND	2.62E+03	NA	NA
Bromoform	0/5	ND	ND	ND	1.39E+04	NA	NA
Bromomethane	0/5	ND	ND	ND	6.89E+02	NA	NA
Carbon disulfide	1/5	3.00E-01	3.00E-01	1.80E-01	9.31E+04	No	1.93E-06
Carbon tetrachloride	4/5	6.00E-01	3.77E+02	7.62E+01	3.35E+02	No	2.27E-01
Chlorobenzene	2/5	8.00E-02	7.00E-01	3.06E-01	2.75E+03	No	1.11E-04
Chloroethane	0/5	ND	ND	ND	1.38E+06	NA	NA
Chloroform	1/5	6.70E+01	6.70E+01	1.36E+01	1.62E+03	No	8.40E-03
Chloromethane	4/5	8.00E-01	3.00E+00	1.38E+00	1.24E+04	No	1.11E-04
Dibromochloromethane	1/5	2.00E-01	2.00E-01	4.00E-01	1.26E+04	No	3.17E-05
Ethylbenzene	4/5	6.00E-02	3.00E+00	9.12E-01	3.49E+04	No	2.61E-05
Methylene chloride	5/5	9.00E-01	1.20E+02	2.66E+01	7.92E+04	No	3.36E-04
Styrene	2/5	3.00E-01	2.00E+00	5.80E-01	1.38E+05	No	4.19E-06
Tetrachloroethene	4/5	3.00E-01	6.70E+01	1.38E+01	6.66E+04	No	2.07E-04
Toluene	5/5	2.00E-01	4.00E+01	1.38E+01	5.39E+04	No	2.57E-04
Total Xylene	3/5	1.00E+00	3.30E+01	1.01E+01	1.38E+04	No	7.28E-04
Trichloroethene	2/5	3.00E+00	7.80E+01	1.64E+01	5.45E+03	No	3.00E-03

Table 3.1. Winter 2004 sub-slab soil vapor results for Building K-1225 (continued)

Analyte	Frequency of detection	Minimum detected concentration	Maximum detected concentration	Arithmetic mean concentration	Trigger level[a]	Trigger level exceeded?	Arithmetic mean fraction of trigger level
Vinyl chloride	0/5	ND	ND	ND	4.23E+03	NA	NA
cis-1,2-Dichloroethene	1/5	9.00E-01	9.00E-01	3.40E-01	4.81E+03	No	7.06E-05
cis-1,3-Dichloropropene	0/5	ND	ND	ND	2.80E+03	NA	NA
trans-1,2-Dichloroethene	1/5	4.00E-01	4.00E-01	2.40E-01	9.67E+04	No	2.48E-06
trans-1,3-Dichloropropene	0/5	ND	ND	ND	4.91E+03	NA	NA
						Sum of fractions	**2.51E-01**

[a]Trigger level was developed with the Johnson-Ettinger (JE) model, assuming an indoor air preliminary remediation goal based on risk level of 1E-5 and hazard index of 0.1 for industrial exposure (250 d/year, 25 years).

[b]ND = non-detection.

[c]NA = not applicable; no detected concentrations.

Table 3.2. Summer 2004 sub-slab soil vapor results for Building K-1225

Analyte	Frequency of detection	Minimum detected concentration	Maximum detected concentration	Arithmetic mean concentration	Trigger level[a]	Trigger level exceeded?	Arithmetic mean fraction of TL
Volatile organic compounds (μg/m³)							
1,1,1-Trichloroethane	5/5	1.30E+00	3.00E+00	2.06E+00	3.00E+05	No	6.86E-06
1,1,2,2-Tetrachloroethane	0/5	ND[b]	ND	ND	6.69E+02	NA[c]	NA
1,1,2-Trichloro-1,2,2-trifluoroethane	5/5	6.80E-01	9.90E-01	8.08E-01	3.98E+06	No	2.03E-07
1,1,2-Trichloroethane	0/5	ND	ND	ND	1.91E+03	NA	NA
1,1-Dichloroethane	0/5	ND	ND	ND	6.89E+04	NA	NA
1,1-Dichloroethene	0/5	ND	ND	ND	7.42E+02	NA	NA
1,2-Dichloroethane	1/5	1.60E-01	1.60E-01	7.30E-02	1.38E+03	No	5.28E-05
1,2-Dichloroethene	0/5	ND	ND	ND	2.52E+03	NA	NA
1,2-Dichloropropane	0/5	ND	ND	ND	5.44E+02	NA	NA
2-Butanone	4/5	3.20E+00	7.80E+00	4.12E+00	6.82E+05	No	6.04E-06
2-Hexanone	5/5	7.80E-01	4.60E+00	1.88E+00	7.95E+02	No	2.37E-03
4-Methyl-2-pentanone	5/5	3.40E-01	1.50E+00	1.05E+00	4.02E+05	No	2.60E-06
Acetone	5/5	1.80E+01	7.20E+01	3.72E+01	3.85E+05	No	9.66E-05
Benzene	5/5	3.40E-01	1.20E+00	6.10E-01	3.99E+03	No	1.53E-04
Bromodichloromethane	0/5	ND	ND	ND	2.73E+03	NA	NA
Bromoform	1/5	2.90E-01	2.90E-01	1.68E-01	1.49E+04	No	1.12E-05
Bromomethane	5/5	9.30E-02	1.40E+00	3.97E-01	6.91E+02	No	5.74E-04
Carbon disulfide	1/5	3.40E+01	3.40E+01	6.95E+00	8.99E+04	No	7.73E-05
Carbon tetrachloride	5/5	6.10E-01	6.50E-01	6.36E-01	3.34E+02	No	1.90E-03
Chlorobenzene	0/5	ND	ND	ND	2.76E+03	NA	NA
Chloroethane	2/5	8.60E-02	1.90E-01	7.79E-02	1.38E+06	No	5.64E-08
Chloroform	5/5	3.60E-01	4.70E-01	3.98E-01	1.56E+03	No	2.55E-04
Chloromethane	4/5	9.60E-01	1.10E+01	2.86E+00	1.24E+04	No	2.30E-04
Dibromochloromethane	0/5	ND	ND	ND	1.34E+04	NA	NA
Ethylbenzene	5/5	1.40E-01	4.70E-01	2.64E-01	3.50E+04	No	7.55E-06
Methylene chloride	1/5	4.60E+00	4.60E+00	1.27E+00	7.68E+04	No	1.65E-05
Styrene	2/5	4.00E-01	4.20E-01	1.98E-01	1.39E+05	No	1.43E-06
Tetrachloroethene	4/5	2.70E-01	9.40E-01	3.82E-01	6.68E+04	No	5.72E-06
Toluene	5/5	5.00E-01	2.70E+00	1.34E+00	5.32E+04	No	2.52E-05
Total Xylene	5/5	1.00E+00	1.30E+01	3.94E+00	1.39E+04	No	2.83E-04
Trichloroethene	5/5	5.60E-01	1.20E+01	4.35E+00	5.43E+03	No	8.02E-04
Vinyl chloride	0/5	ND	ND	ND	4.07E+03	NA	NA

Table 3.2. Summer 2004 sub-slab soil vapor results for Building K-1225 (continued)

Analyte	Frequency of detection	Minimum detected concentration	Maximum detected concentration	Arithmetic mean concentration	Trigger level[a]	Trigger level exceeded?[b]	Arithmetic mean fraction of TL
cis-1,2-Dichloroethene	0/5	ND	ND	ND	4.82E+03	NA	NA
cis-1,3-Dichloropropene	0/5	ND	ND	ND	2.84E+03	NA	NA
trans-1,2-Dichloroethene	0/5	ND	ND	ND	9.72E+04	NA	NA
trans-1,3-Dichloropropene	0/5	ND	ND	ND	4.97E+03	NA	NA
						Sum of fractions	**6.88E-03**

[a]Trigger level (TL) was developed with the Johnson-Ettinger (JE) model assuming an indoor air preliminary remediation goal based on risk level of 1E-5 and hazard index of 0.1 for industrial exposure (250 d/year, 25 years).

[b]ND = no data available.

[c]NA = not applicable based on sampling or toxicological data.

K-1330

4. SOIL VAPOR RESULTS FOR THE WINTER AND SUMMER 2004 SAMPLING AT BUILDING K-1330

4.1 COMPARISON TO TRIGGER LEVELS

As shown in Tables 4.1 and 4.2, the sum of trigger level fractions was well below 1.0 for Bldg. K-1330 winter (0.01) and summer (0.01) sampling events, respectively. Therefore, the vapor intrusion pathway is not considered complete beneath the buildings, and there is a low likelihood of adverse impacts to human health.

4.2 EVALUATION OF SEASONAL RESULTS

A comparison of the soil vapor results from the winter and summer 2004 sampling results was performed and indicated soil vapor concentrations at Bldg. K-1330 were generally higher in winter than in summer. Specifically, constituents such as benzene, carbon tetrachloride, ethylbenzene, toluene, and xylenes had generally higher concentrations in winter than in summer.

4.3 CALCULATION OF RE-SAMPLING FREQUENCY

Once the sampling frequency has been established, re-sampling will be conducted either inside the buildings or immediately outside the buildings, depending on the potential impact to future owners and the calculated frequency. If sampling indoors is considered too intrusive to the future owners, sampling outside will be performed. The following text describes the outdoor sampling approach.

Soil piezometers, if not already present, would be installed in locations outside the building. In order to monitor sub-slab soil vapor from these piezometers, a correlation between the piezometer soil vapor measurements and the sub-slab soil vapor measurements taken outside the buildings must be established. The proposed sampling strategy is to pair interior sub-slab soil sampling locations with an exterior piezometer, with the number and locations of samples based on the size and configuration of the building. The paired interior and exterior sample results would be used to calculate a linear regression to relate the outside soil vapor concentration to the sub-slab soil vapor concentration. The number of samples that would be needed in order to establish a correlation between the indoor and outdoor soil vapor data will be determined using the Monte Carlo simulation approach.

Once the data from the outside piezometers are analyzed, the correlated concentrations for the sub-slab soil vapor can be determined and screened against the trigger levels to determine if concentrations are acceptable or unacceptable. If they are unacceptable, indoor ambient air sampling will need to be considered. All data collected to evaluate soil vapor will be used in re-calculating the re-sampling frequency.

The re-sampling frequency for Bldg. K-1330 is 367 years based on the equation presented in Chap. 1. The result indicates that should maximum soil vapor concentrations remain constant, a hypothetical individual working in the building would be exposed to a risk of 1E-6 and a hazard of 1 over the 367-year period due to all constituents combined. Primary constituents contributing to the magnitude of the re-sampling frequency were 1,1,2,2-tetrachloroethane (maximum detected concentration of 0.0006 mg/m^3) and benzene (0.018 mg/m^3).

Table 4.1. Winter 2004 sub-slab soil vapor results for Building K-1330

Analyte	Frequency of detection	Minimum detected concentration	Maximum detected concentration	Arithmetic mean concentration	Trigger level[a]	Trigger level exceeded?	Arithmetic mean fraction of trigger level
Volatile organic compounds (μg/m³)							
1,1,1-Trichloroethane	1/4	6.00E-01	6.00E-01	3.75E-01	3.01E+05	No	1.25E-06
1,1,2,2-Tetrachloroethane	4/4	3.00E-01	6.00E-01	4.25E-01	6.67E+02	No	6.38E-04
1,1,2-Trichloro-1,2,2-trifluoroethane	2/4	8.00E-01	8.00E-01	6.00E-01	4.04E+06	No	1.48E-07
1,1,2-Trichloroethane	1/4	1.00E-00	1.00E-00	4.75E-01	1.91E+03	No	2.48E-04
1,1-Dichloroethane	0/4	ND[b]	ND	ND	6.88E+04	NA[c]	NA
1,1-Dichloroethene	0/4	ND	ND	ND	7.55E+02	NA	NA
1,2-Dichloroethane	4/4	2.00E-01	4.00E-01	2.75E-01	1.43E+03	No	1.92E-04
1,2-Dichloroethene	1/4	1.00E-00	1.00E-00	4.00E-01	3.95E+03	No	1.01E-04
1,2-Dichloropropane	4/4	7.00E-02	3.00E-01	2.18E-01	5.45E+02	No	3.99E-04
2-Butanone	4/4	3.00E-00	5.00E-00	3.75E-00	6.84E+05	No	5.48E-06
2-Hexanone	1/4	7.00E-01	7.00E-01	3.18E-00	2.51E+04	No	1.26E-04
4-Methyl-2-pentanone	0/4	ND	ND	ND	4.06E+05	NA	NA
Acetone	3/4	4.00E-00	3.10E+01	1.55E+01	4.13E+05	No	3.76E-05
Benzene	4/4	5.00E-00	1.80E+01	1.25E+01	4.05E+03	No	3.09E-03
Bromodichloromethane	0/4	ND	ND	ND	2.62E+03	NA	NA
Bromoform	0/4	ND	ND	ND	1.39E+04	NA	NA
Bromomethane	0/4	ND	ND	ND	6.89E+02	NA	NA
Carbon disulfide	0/4	ND	ND	ND	9.31E+04	NA	NA
Carbon tetrachloride	4/4	1.00E-00	2.00E-00	1.75E-00	3.35E+02	No	5.23E-03
Chlorobenzene	1/4	1.00E-00	1.00E-00	4.38E-01	2.75E+03	No	1.59E-04
Chloroethane	0/4	ND	ND	ND	1.38E+06	NA	NA
Chloroform	0/4	ND	ND	ND	1.62E+03	NA	NA
Chloromethane	4/4	8.00E-01	3.00E-00	1.70E-00	1.24E+04	No	1.37E-04
Dibromochloromethane	0/4	ND	ND	ND	1.26E+04	NA	NA
Ethylbenzene	4/4	1.00E-00	8.00E-00	3.25E-00	3.49E+04	No	9.30E-05
Methylene chloride	4/4	1.00E-00	3.00E-00	1.50E-00	7.92E+04	No	1.89E-05
Styrene	4/4	1.00E-00	4.00E-00	2.00E-00	1.38E+05	No	1.45E-05
Tetrachloroethene	4/4	7.00E-01	1.00E-00	8.25E-01	6.66E+04	No	1.24E-05
Toluene	4/4	8.00E-00	3.10E+01	2.03E+01	5.39E+04	No	3.75E-04
Total Xylene	4/4	1.00E+01	4.10E+01	2.45E+01	1.38E+04	No	1.77E-03
Trichloroethene	2/4	7.00E-01	1.00E-00	5.50E-01	5.45E+03	No	1.01E-04

Table 4.1. Winter 2004 sub-slab soil vapor results for Building K-1330 (continued)

Analyte	Frequency of detection	Minimum detected concentration	Maximum detected concentration	Arithmetic mean concentration	Trigger level[a]	Trigger level exceeded?	Arithmetic mean fraction of trigger level
Vinyl chloride	0/4	ND	ND	ND	4.23E+03	NA	NA
cis-1,2-Dichloroethene	1/4	1.00E-00	1.00E-00	4.00E-01	4.81E+03	No	8.31E-05
cis-1,3-Dichloropropene	0/4	ND	ND	ND	2.80E+03	NA	NA
trans-1,2-Dichloroethene	0/4	ND	ND	ND	9.67E+04	NA	NA
trans-1,3-Dichloropropene	0/4	ND	ND	ND	4.91E+03	NA	NA
						Sum of fractions	**1.28E-02**

[a]Trigger level was developed with the Johnson-Ettinger (JE) model, assuming an indoor air preliminary remediation goal based on risk level of 1E-5 and hazard index of 0.1 for industrial exposure (250 d/year, 25 years).

[b]ND = non-detection.

[c]NA = not applicable; no detected concentrations.

Table 4.2. Summer 2004 sub-slab soil vapor results for Building K-1330

Analyte	Frequency of detection	Minimum detected concentration	Maximum detected concentration	Arithmetic mean concentration	Trigger level[a]	Trigger level exceeded?	Arithmetic mean fraction of TL
			Volatile organic compounds ($\mu g/m^3$)				
1,1,1-Trichloroethane	4/4	2.00E-01	2.60E-01	2.23E-01	3.00E+05	No	7.41E-07
1,1,2,2-Tetrachloroethane	0/4	ND[b]	ND	ND	6.69E+02	NA[c]	NA
1,1,2-Trichloro-1,2,2-trifluoroethane	4/4	5.80E-01	7.20E-01	6.15E-01	3.98E+06	No	1.55E-07
1,1,2-Trichloroethane	0/4	ND	ND	ND	1.91E+03	NA	NA
1,1-Dichloroethane	0/4	ND	ND	ND	6.89E+04	NA	NA
1,1-Dichloroethene	0/4	ND	ND	ND	7.42E+02	NA	NA
1,2-Dichloroethane	0/4	ND	ND	ND	1.38E+03	NA	NA
1,2-Dichloroethene	0/4	ND	ND	ND	2.52E+03	NA	NA
1,2-Dichloropropane	0/4	ND	ND	ND	5.44E+02	NA	NA
2-Butanone	4/4	2.00E+00	5.40E+00	2.93E+00	6.82E+05	No	4.29E-06
2-Hexanone	4/4	2.30E-01	1.70E+00	7.15E-01	7.95E+02	No	8.99E-04
4-Methyl-2-pentanone	4/4	8.80E-01	2.00E+00	1.27E+00	4.02E+05	No	3.16E-06
Acetone	4/4	2.30E+01	6.00E+01	3.60E+01	3.85E+05	No	9.35E-05
Benzene	4/4	3.40E-01	6.50E-01	4.98E-01	3.99E+03	No	1.25E-04
Bromodichloromethane	0/4	ND	ND	ND	2.73E+03	NA	NA
Bromoform	0/4	ND	ND	ND	1.49E+04	NA	NA
Bromomethane	1/4	4.70E-01	4.70E-01	1.48E-01	6.91E+02	No	2.14E-04
Carbon disulfide	2/4	7.00E+00	1.40E+01	5.41E+00	8.99E+04	No	6.02E-05
Carbon tetrachloride	4/4	6.00E-01	7.60E-01	6.63E-01	3.34E+02	No	1.98E-03
Chlorobenzene	0/4	ND	ND	ND	2.76E+03	NA	NA
Chloroethane	1/4	1.40E-01	1.40E-01	6.33E-02	1.38E+06	No	4.58E-08
Chloroform	4/4	2.70E-01	3.30E-01	3.10E-01	1.56E+03	No	1.98E-04
Chloromethane	4/4	1.00E+00	4.80E+00	2.30E+00	1.24E+04	No	1.85E-04
Dibromochloromethane	0/4	ND	ND	ND	1.34E+04	NA	NA
Ethylbenzene	4/4	1.80E-01	6.30E-01	3.43E-01	3.50E+04	No	9.80E-06
Methylene chloride	0/4	ND	ND	ND	7.68E+04	NA	NA
Styrene	3/4	1.10E-01	1.80E-01	1.24E-01	1.39E+05	No	8.91E-07
Tetrachloroethene	4/4	2.20E-01	8.40E-01	4.13E-01	6.68E+04	No	6.17E-06
Toluene	4/4	7.00E-01	2.00E+00	1.43E+00	5.32E+04	No	2.68E-05
Total Xylene	4/4	5.60E-01	3.50E+00	1.55E+00	1.39E+04	No	1.11E-04
Trichloroethene	4/4	3.70E-01	2.40E+00	9.05E-01	5.43E+03	No	1.67E-04
Vinyl chloride	0/4	ND	ND	ND	4.07E+03	NA	NA

Table 4.2. Summer 2004 sub-slab soil vapor results for Building K-1330 (continued)

Analyte	Frequency of detection	Minimum detected concentration	Maximum detected concentration	Arithmetic mean concentration	Trigger level[a]	Trigger level exceeded?[b]	Arithmetic mean fraction of TL
cis-1,2-Dichloroethene	0/4	ND	ND	ND	4.82E+03	NA	NA
cis-1,3-Dichloropropene	0/4	ND	ND	ND	2.84E+03	NA	NA
trans-1,2-Dichloroethene	0/4	ND	ND	ND	9.72E+04	NA	NA
trans-1,3-Dichloropropene	0/4	ND	ND	ND	4.97E+03	NA	NA
						Sum of fractions	**4.09E-03**

[a]Trigger level (TL) was developed with the Johnson-Ettinger (JE) model assuming an indoor air preliminary remediation goal based on risk level of 1E-5 and hazard index of 0.1 for industrial exposure (250 d/year, 25 years).

[b]ND = no data available.

[c]NA = not applicable based on sampling or toxicological data.

5. SOIL VAPOR RESULTS FOR THE WINTER AND SUMMER 2004 SAMPLING AT BUILDING K-1580

5.1 COMPARISON TO TRIGGER LEVELS

As shown in Tables 5.1 and 5.2, the sum of trigger level fractions was well below 1.0 for Bldg. K-1580 winter (0.08) and summer (0.02) sampling events, respectively. Therefore, the vapor intrusion pathway is not considered complete beneath the buildings, and there is a low likelihood of adverse impacts to human health.

5.2 EVALUATION OF SEASONAL RESULTS

A comparison of the soil vapor results from the winter and summer 2004 sampling results was performed and indicated soil vapor concentrations at Bldg. K-1580 are inconsistent with regard to seasonal changes. Soil vapor concentrations at K-1580 generally decreased between the winter and summer sampling events. The majority of constituents had maximum detected concentrations in the winter sampling event.

5.3 CALCULATION OF RE-SAMPLING FREQUENCY

Once the sampling frequency has been established, re-sampling will be conducted either inside the buildings or immediately outside the buildings, depending on the potential impact to future owners and the calculated frequency. If sampling indoors is considered too intrusive to the future owners, sampling outside will be performed. The following text describes the outdoor sampling approach.

Soil piezometers, if not already present, would be installed in locations outside the building. In order to monitor sub-slab soil vapor from these piezometers, a correlation between the piezometer soil vapor measurements and the sub-slab soil vapor measurements taken outside the buildings must be established. The proposed sampling strategy is to pair interior sub-slab soil sampling locations with an exterior piezometer, with the number and locations of samples based on the size and configuration of the building. The paired interior and exterior sample results would be used to calculate a linear regression to relate the outside soil vapor concentration to the sub-slab soil vapor concentration. The number of samples that would be needed in order to establish a correlation between the indoor and outdoor soil vapor data will be determined using the Monte Carlo simulation approach.

Once the data from the outside piezometers are analyzed, the correlated concentrations for the sub-slab soil vapor can be determined and screened against the trigger levels to determine if concentrations are acceptable or unacceptable. If they are unacceptable, indoor ambient air sampling will need to be considered. All data collected to evaluate soil vapor will be used in re-calculating the re-sampling frequency.

The re-sampling frequency for Bldg. K-1580 is 20 years based on the equation presented in Chap. 1. The result indicates that should maximum soil vapor concentrations remain constant, an individual working in the building would be exposed to a risk of 1E-6 and a hazard of 1 over the 20-year period due to all constituents combined. Primary constituents contributing to the magnitude of the re-sampling frequency were benzene (maximum detected concentration of 0.33 mg/m^3) and chloroform (0.032 mg/m^3).

Table 5.1. Winter 2004 sub-slab soil vapor results for Building K-1580

Analyte	Frequency of detection	Minimum detected concentration	Maximum detected concentration	Arithmetic mean concentration	Trigger level[a]	Trigger level exceeded?	Arithmetic mean fraction of trigger level
Volatile organic compounds (μg/m³)							
1,1,1-Trichloroethane	2/4	7.00E-01	4.00E+00	1.33E+00	3.01E+05	No	4.40E-06
1,1,2,2-Tetrachloroethane	4/4	2.00E-02	7.00E-01	3.05E-01	6.67E+02	No	4.58E-04
1,1,2-Trichloro-1,2,2-trifluoroethane	4/4	2.00E-01	1.00E+00	8.00E-01	4.04E+06	No	1.98E-07
1,1,2-Trichloroethane	3/4	3.00E-01	1.00E+00	5.00E-01	1.91E+03	No	2.61E-04
1,1-Dichloroethane	0/4	ND[b]	ND	ND	6.88E+04	NA[c]	NA
1,1-Dichloroethene	0/4	ND	ND	ND	7.55E+02	NA	NA
1,2-Dichloroethane	4/4	1.00E-01	3.00E-01	2.50E-01	1.43E+03	No	1.75E-04
1,2-Dichloroethene	0/4	ND	ND	ND	3.95E+03	NA	NA
1,2-Dichloropropane	4/4	1.00E-01	6.10E+01	1.54E+01	5.45E+02	No	2.82E-02
2-Butanone	2/4	2.00E+00	5.00E+00	3.25E+00			4.75E-06
2-Hexanone	2/4	8.00E-01	2.00E+00	2.70E+00	2.51E+04	No	1.08E-04
4-Methyl-2-pentanone	0/5	ND	ND	ND	4.06E+05	NA	NA
Acetone	5/5	5.00E-01	7.90E+01	3.52E+01	4.13E+05	No	8.52E-05
Benzene	4/4	2.00E+00	3.30E+02	8.65E+01	4.05E+03	No	2.14E-02
Bromodichloromethane	2/4	1.00E+00	4.00E+00	1.43E+00	2.62E+03	No	5.44E-04
Bromoform	0/4	ND	ND	ND	1.39E+04	NA	NA
Bromomethane	0/4	ND	ND	ND	6.89E+02	NA	NA
Carbon disulfide	2/4	2.00E-01	7.40E+02	1.85E+02	9.31E+04	No	1.99E-03
Carbon tetrachloride	4/4	2.00E-01	1.00E+00	8.00E-01	3.35E+02	No	2.39E-03
Chlorobenzene	2/4	1.00E-01	2.00E+00	6.50E-01	2.75E+03	No	2.36E-04
Chloroethane	0/4	ND	ND	ND	1.38E+06	NA	NA
Chloroform	2/4	2.40E+01	3.20E+01	1.41E+01	1.62E+03	No	8.72E-03
Chloromethane	2/4	3.00E-01	2.00E+00	6.25E-01	1.24E+04	No	5.04E-05
Dibromochloromethane	0/4	ND	ND	ND	1.26E+04	NA	NA
Ethylbenzene	4/4	1.00E+00	1.60E+01	5.25E+00	3.49E+04	No	1.50E-04
Methylene chloride	4/4	2.00E+00	1.70E+02	4.58E+01	7.92E+04	No	5.78E-04
Styrene	4/4	5.00E-01	1.90E+02	5.21E+01	1.38E+05	No	3.77E-04
Tetrachloroethene	4/4	4.00E-01	4.00+00	2.35E+00	6.66E+04	No	3.53E-05
Toluene	4/4	4.00E+00	2.90E+02	8.20E+01	5.39E+04	No	1.52E-03
Total Xylene	4/4	1.00E+00	2.10E+02	6.28E+01	1.38E+04	No	4.53E-03
Trichloroethene	3/4	6.00E-01	7.00E+00	2.21E+00	5.45E+03	No	4.06E-04
Vinyl chloride	1/4	2.00E+01	2.00E+01	5.11E+00	4.23E+03	No	1.21E-03

Table 5.1. Winter 2004 sub-slab soil vapor results for Building K-1580 (continued)

Analyte	Frequency of detection	Minimum detected concentration	Maximum detected concentration	Arithmetic mean concentration	Trigger level[a]	Trigger level exceeded?	Arithmetic mean fraction of trigger level
cis-1,2-Dichloroethene	1/4	2.00E-01	2.00E-01	2.00E-01	4.81E+03	No	4.15E-05
cis-1,3-Dichloropropene	0/4	ND	ND	ND	2.80E+03	NA	NA
trans-1,2-Dichloroethene	0/4	ND	ND	ND	9.67E+04	NA	NA
trans-1,3-Dichloropropene	2/4	2.00E-01	3.00E+01	7.68E+00	4.91E+03	No	1.56E-03
						Sum of fractions	**7.52E-02**

[a]Trigger level was developed with the Johnson-Ettinger (JE) model, assuming an indoor air preliminary remediation goal based on risk level of 1E-5 and hazard index of 0.1 for industrial exposure (250 d/year, 25 years).

[b]ND = non-detection.

[c]NA = not applicable; no detected concentrations.

Table 5.2. Summer 2004 sub-slab soil vapor results for Building K-1580

Analyte	Frequency of detection	Minimum detected concentration	Maximum detected concentration	Arithmetic mean concentration	Trigger level[a]	Trigger level exceeded?	Arithmetic mean fraction of trigger level
			Volatile organic compounds (μg/m³)				
1,1,1-Trichloroethane	5/5	5.20E-01	7.30E+00	2.14E+00	3.00E+05	No	7.12E-06
1,1,2,2-Tetrachloroethane	0/5	ND[b]	ND	ND	6.69E+02	NA[c]	NA
1,1,2-Trichloro-1,2,2-trifluoroethane	5/5	5.80E-01	7.70E-01	6.46E-01	3.98E+06	No	1.62E-07
1,1,2-Trichloroethane	0/5	ND	ND	ND	1.91E+03	NA	NA
1,1-Dichloroethane	0/5	ND	ND	ND	6.89E+04	NA	NA
1,1-Dichloroethene	0/5	ND	ND	ND	7.42E+02	NA	NA
1,2-Dichloroethane	1/5	8.30E-01	8.30E-01	2.10E-01	1.38E+03	No	1.52E-04
1,2-Dichloroethene	0/5	ND	ND	ND	2.52E+03	NA	NA
1,2-Dichloropropane	0/5	ND	ND	ND	5.44E+02	NA	NA
2-Butanone	5/5	2.80E+00	1.20E+01	6.08E+00	6.82E+05	No	8.92E-06
2-Hexanone	4/5	5.80E-01	2.50E+00	1.33E+00	7.95E+02	No	1.67E-03
4-Methyl-2-pentanone	5/5	3.10E-01	5.10E+00	1.89E+00	4.02E+05	No	4.70E-06
Acetone	5/5	1.70E+01	5.40E+01	3.40E+01	3.85E+05	No	8.83E-05
Benzene	5/5	2.30E-01	2.50E+01	5.34E+00	3.99E+03	No	1.34E-03
Bromodichloromethane	0/5	ND	ND	ND	2.73E+03	NA	NA
Bromoform	0/5	ND	ND	ND	1.49E+04	NA	NA
Bromomethane	1/5	2.40E-01	2.40E-01	8.32E-02	6.91E+02	No	1.20E-04
Carbon disulfide	5/5	1.00E+00	5.30E+00	2.32E+00	8.99E+04	No	2.58E-05
Carbon tetrachloride	5/5	4.30E-01	5.60E+00	1.51E+00	3.34E+02	No	4.53E-03
Chlorobenzene	0/5	ND	ND	ND	2.76E+03	NA	NA
Chloroethane	1/5	2.30E-01	2.30E-01	7.88E-02	1.38E+06	No	5.70E-08
Chloroform	5/5	2.20E-01	2.10E+00	7.60E-01	1.56E+03	No	4.86E-04
Chloromethane	2/5	1.20E+00	2.70E+00	9.26E-01	1.24E+04	No	7.45E-05
Dibromochloromethane	0/5	ND	ND	ND	1.34E+04	NA	NA
Ethylbenzene	4/5	1.60E-01	7.20E+00	1.62E+00	3.50E+04	No	4.64E-05
Methylene chloride	0/5	ND	ND	ND	7.68E+04	NA	NA
Styrene	4/5	1.40E-01	4.30E-01	2.02E-01	1.39E+05	No	1.45E-06
Tetrachloroethene	5/5	2.50E-01	3.80E+00	2.21E+00	6.68E+04	No	3.31E-05
Toluene	5/5	4.00E-01	4.00E+01	8.99E+00	5.32E+04	No	1.69E-04
Total Xylene	4/5	2.10E+00	6.80E+01	1.57E+01	1.39E+04	No	1.13E-03
Trichloroethene	5/5	3.10E-01	2.30E+00	1.06E+00	5.43E+03	No	1.95E-04
Vinyl chloride	0/5	ND	ND	ND	4.07E+03	NA	NA

Table 5.2. Summer 2004 sub-slab soil vapor results for Building K-1580 (continued)

Analyte	Frequency of detection	Minimum detected concentration	Maximum detected concentration	Arithmetic mean concentration	Trigger level[a]	Trigger level exceeded?	Arithmetic mean fraction of trigger level
cis-1,2-Dichloroethene	0/5	ND	ND	ND	4.82E+03	NA	NA
cis-1,3-Dichloropropene	0/5	ND	ND	ND	2.84E+03	NA	NA
trans-1,2-Dichloroethene	0/5	ND	ND	ND	9.72E+04	NA	NA
trans-1,3-Dichloropropene	0/5	ND	ND	ND	4.97E+03	NA	NA
						Sum of fractions	**1.01E-02**

[a]Trigger level (TL) was developed with the Johnson-Ettinger (JE) model assuming an indoor air preliminary remediation goal based on risk level of 1E-5 and hazard index of 0.1 for industrial exposure (250 d/year, 25 years).

[b]ND = no data available.

[c]NA = not applicable based on sampling or toxicological data.

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