PES Environmental, Inc.
Engineering & Environmental Services

February 15, 1996

502.0101.001

Alameda County Health Care Services
Department of Environmental Health
1131 Harbor Bay Parkway
Oakland, California 94502

Attention: Mr. Barney Chan

H 875
• daycare center
• vehicle area of tenant A inclusive

SCREENING-LEVEL EVALUATION OF VOC VOLATILIZATION FROM SOILS FOOTHILL SHOPPING CENTER 10700 MacARTHUR BOULEVARD OAKLAND, CALIFORNIA

Dear Barney:

This letter report presents a screening-level risk evaluation of estimated ambient air concentrations of chlorinated volatile organic compounds (VOCs) within tenant spaces at the Foothill Shopping Center in Oakland, California (see Plate 1). VOC concentrations in air that may result from volatilization of VOC residuals in soil beneath the spaces were modeled. This evaluation has been performed by PES Environmental, Inc. (PES) on behalf of Jay-Phares Corporation, which is the property management company and agent for Drake Builders (the property owner). The evaluation focused on tenant spaces that overlie recent excavations to remove VOC contaminated soil. The intent of the evaluation is to demonstrate that residual VOC concentrations at the bottom and sidewalls of the excavation do not present a significant risk requiring further excavation. Other on-site environmental issues, such as investigation and management of VOC-affected groundwater, will be addressed under separate cover.

After summarizing site background information and previous remedial activities, this letter documents the methodology used in the evaluation. In summary, a comparison is made between estimated indoor VOC concentrations and EPA Region IX preliminary remedial goals (PRGs) for ambient air. The results of this comparison are provided, and conclusions concerning the results and their indication of the need for further soil removal within the study area are presented below.

BACKGROUND INFORMATION

Site Location and Description

The Foothill Shopping Center is located at the northeastern corner of MacArthur Boulevard and 108th Avenue in Oakland, California. As shown on Plate 2, the shopping center consists

of four principal structures currently used by various commercial, retail, and governmental human services organizations. The area of focus for this evaluation is approximately 15,000 square feet (sf) of retail and commercial space located in the center of the complex (see Plates 2 and 3). This space is currently being redeveloped into six individual tenant spaces, as follows:

Tenant Space Designation	Proposed Use/Tenant Name	Footprint Area
A	Parent/Child Center	8,520 sf
B	General Retail	1,200 sf
C	Storage	1,200 sf
D	Na Mele Hula Ohana	1,860 sf
E	Counseling/Job Training	1,700 sf
F	Shoe Repair	1,045 sf

Tenant space B was formerly occupied by a dry cleaning operation.

Soil Remediation Activities

As a result of a previous environmental investigation at the site conducted by other environmental consultants, tetrachloroethylene (PCE) has been identified in near-surface soils beneath the former dry cleaning operation at the site. Based on these findings, Augeas Corporation (Augeas) concluded that chemical-affected soils were not widespread and recommended removing the soils with PCE concentrations in excess of 1 milligram per kilogram [mg/kg or parts per million (ppm)]. According to a soil excavation work plan prepared by Augeas, it was estimated that approximately 1,000 cubic yards of affected soil below the former dry cleaner, and below adjacent pedestrian corridors to the south, would require removal.

In late 1995, Drake Builders contracted with All Environmental, Inc. (AEI) to complete the recommended soil removal activities. During that removal action, the lateral and vertical extent of affected soil was found to be more widespread than initially estimated. In addition, breakdown products of PCE and chloroform[1] were detected in soil samples. Due to the

[1] The detection, using GC methods, of chloroform by Priority Environmental Laboratory (PEL) (AEI's analytical laboratory) during the soil excavation project is considered suspect. Chloroform was not detected in samples collected during previous environmental investigations in the remedation area. Due to this concern, additional quality control tests were performed by AEI. A sample with high reported concentrations of chloroform (by GC methods) was reanalyzed by PEL using GC/MS methods to confirm its presence. Chloroform was detected but at an order of magnitude lower concentration, and may be attributed to laboratory contamination. A second QC sample was collected by AEI and split for second laboratory confirmation. In this case, chloroform was again identified by PEL but was not detected by the second laboratory, American Environmental Network Laboratories. Based on this information, AEI concluded that the presence of chloroform is questionable. PES concurs with this conclusion.

presence of VOCs other than PCE, PES understands the clean-up goal was then revised to include removal of soils having total VOC concentrations above 1 ppm. The resultant excavation extended into adjacent tenant spaces to the west and required removal of approximately 2,500 cubic yards of soil. The limits of the excavation are shown on Plate 3.

While the removal action has been successful in removing the highest concentrations of chemical-affected soils from beneath the former dry cleaner, soils with residual total VOC concentrations above the 1 ppm goal are still present at localized areas at the excavation periphery. The confirmation testing results showing the VOC concentrations at the bottom and sidewalls of the excavation are shown on Plate 3 and summarized in Table 1.

FOCUSED RISK EVALUATION

PES has completed a focused risk evaluation to evaluate whether further soil excavation is required within the study area prior to reconstruction of the tenant spaces. Initially, an assessment of the potential exposure pathways for occupants of the tenant spaces was made. Because of the location of the VOC-affected soils beneath the concrete slab floor and clean backfill material placed in excavations, ingestion and dermal contact exposure pathways are incomplete, and therefore do not require further evaluation. The inhalation pathway, via vapor-phase transport of VOCs into the tenant spaces, is considered a complete exposure pathway. Accordingly, the risk evaluation was focused on assessing the potential ambient air concentrations of VOCs within the retail spaces overlying the remaining residually affected soils. The methodology, assumptions, and results of that evaluation follow.

Methodology Summary and Assumptions

VOC concentrations within each of the tenant spaces were estimated by modeling VOC volatilization from residually affected soils. The corresponding chemical vapor flux at the ground surface via upward diffusion through the soil column was estimated using the results of the volatilization model. Once the chemical vapor flux at the ground surface was determined, an estimate of chemical concentrations within each tenant space was made using a simplified air-mixing model. A generalized conceptual model of the estimation process is provided on Plate 4. Details of the VOC estimation process and a list of supporting references are provided in Appendices A and B, respectively. This method has been used by PES at other Bay Area facilities with similar environmental issues and accepted by the Regional Water Quality Control Board (RWQCB) and other local environmental health agencies.

For the volatilization model, site-specific assumptions were made based on field measurements and/or typical default criteria. As summarized on Table 2, the following assumptions were used in the model:

- Chemical concentrations in soil at the surface are assumed to be not detectable or below laboratory reporting limits;

- Chemical constituents used in the model include those found in soil during the investigative and remedial phases. The constituents include PCE and its breakdown products: trichloroethylene (TCE), 1,2-dichloroethylene (1,2-DCE) and 1,1-dichloroethylene (1,1-DCE). Vinyl Chloride has not been detected.

- Vapor transport is limited to upward diffusion [general model assumption, (see Appendix A)]

- The following criteria were assumed in modeling chemical concentrations in tenant spaces:

  - In portions of those tenant spaces where soil excavation was performed, the highest detected concentration of each VOC in post-removal confirmation samples was used; and

  - In portions of each tenant space where soil excavation was not performed, the highest detected concentration of each VOC located in the post-removal confirmation sidewall samples closest to the unremediated area in the tenant space was used.

- The thickness of soil cover over areas that were remediated correspond to average depths of excavation in each tenant space. The thickness of the soil cover over soil containing residual VOCs in unremediated areas was estimated to be 3.5 feet. origin ? concrete slab

- Soil properties are considered constant over space and time. The total porosity of the soil cover was estimated to be 0.30 cm^3/cm^3, which corresponds to a clayey silty sand. The air-filled porosity was assumed to be 0.08 cm^3/cm^3, which corresponds to a moist, compacted clayey silty sand.

- The area of emission flux is estimated to include the entire tenant space footprint (which assumes that the residual soil contamination beneath the tenant space is uniform), unless supporting data were available to limit the size of the flux area. These data were only available for Tenant Space A, where soil sampling and chemical analysis during infrastructure installation limited the area of emission flux to a portion of that tenant space.

- The attenuation factor of the existing concrete slab floors within each tenant space was assumed to be 0.005, unless they were scheduled for replacement as part of soil removal activities, in which case an attenuation factor of 0.001 was used (Johnson and Ettinger, 1991). The lower attenuation factor was used in the remediated areas because

these portions of the slab floor will be placed on top of a flexible membrane vapor barrier.

- The volume of air space within each tenant space was calculated using proposed development floor plans and measurements of the existing building shell. The height used in the model for each tenant space, with the exception of Space A, was 17 feet, which assumes that false ceilings do not appreciably inhibit air circulation. The Space A height used for the volatilization model was 20 feet, which corresponds to the interconnected bi-level construction of the tenant space.

- The air exchange rate for each tenant space equipped with HVAC systems was assumed to be 0.5 per hour. In spaces without the HVAC systems, installation of ventilation systems were assumed to achieve an exchange rate of 0.5 volume per hour.

Results of Evaluation

Using the methodology and assumptions outlined in the previous section, estimates of the indoor concentration for each space were determined. The results of the VOC estimation are summarized below:

VOC Constituent	Range of Estimated Indoor Concentrations (C_{in})	Ambient Air PRG (EPA, 1995)	Tenant Space With Highest C_{in}
Tetrachloroethylene	1.49×10^{-4} to 1.59×10^{-3}	3.3 ug/m3	Tenant Space C
Trichloroethylene	9.28×10^{-6} to 7.87×10^{-3}	1.1	Tenant Space C
1,2-Dichloroethylene	5.87×10^{-6} to 8.15×10^{-3}	3.3×10^{1}	Tenant Space D
1,1-Dichloroethylene	8.64×10^{-4} to 7.58×10^{-3}	3.80×10^{-2}	Tenant Space F

The estimated VOC concentrations within each tenant space is provided on Table 3, and the calculations used for estimating the indoor VOC concentration in each tenant space have been provided in Appendix C.

The results of the volatilization modeling indicate that the estimated concentrations of VOCs within the interior tenant spaces are well below the applicable PRGs. The range of estimated interior concentrations varied widely, depending primarily on the VOC constituent of concern, its concentration in underlying soil, the percentage of the tenant space remediated, and the air circulation rate within the tenant space.

It should be noted that the methodology used to calculate ambient air VOC concentrations likely overestimates the actual tenant space concentrations for several reasons: (1) the method conservatively estimates emission flux and indoor air concentrations; (2) site-specific input parameter values were conservatively chosen; (3) it was assumed that contaminant concentrations are uniform and ubiquitous in the emission flux area; (4) it was assumed that no adsorption of upward diffusing soil vapor occurs; and (5) it was assumed that no reduction in contaminant concentrations from biological or chemical degradation is occurring over time. A more detailed evaluation of these factors would likely result in significantly lower estimated ambient air concentrations.

CONCLUSIONS AND RECOMMENDATIONS

Based on the focused risk evaluation, the residual VOCs in soils below the subject tenant spaces do not present a significant health threat to users of the site. Therefore, further soil removal for the protection of human health is not warranted.

It is recommended, however, that ventilation systems be provided in Storage Space C and Tenant Space F to further lower potential VOC concentrations in ambient air. The ventilation systems could consist of exhaust fans which are operated in conjunction with lighting of each space so that when the space is entered, the ventilation system starts automatically to exchange the air within the space.

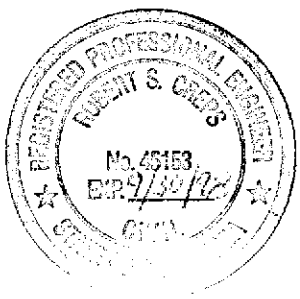
PES trusts that this letter provides you with the information you need at this time. Upon your review and concurrence with the findings of this focused evaluation, on behalf of Jay-Phares and Drake Builders, PES requests a letter from your office stating that no further soil removal is required. Upon receipt of this letter, the affected tenant spaces will be promptly repaired and returned to normal operation. If you have any questions, please feel free to contact either of the undersigned.

Very truly yours,

PES ENVIRONMENTAL, INC.

James P. Dunn, R.G.
Associate Geologist

Robert S. Creps, P.E.
Principal Engineer



Attachments:	Table 1	Confirmation Sampling Results from Soil Excavation
	Table 2	Tenant Space-Specific Modeling Parameters and Assumptions
	Table 3	Summary of Estimates Soil Vapor, Emission Flux and Building Interior
	Plate 1	Site Location Map
	Plate 2	Site Plan
	Plate 3	Confirmation Sample Locations and Limits of Excavation
	Plate 4	Volatilization of Chemical Vapors from Residual VOC's in Soil
	Appendix A	Evaluation Methodology
	Appendix B	Reference List
	Appendix C	Evaluation Calculations

Table 1
Confirmation Sampling Results from Soil Excavation Activities
Foothill Shopping Center Soil Remediation Risk Evaluation
10700 MacArthur Boulevard, Oakland, California

Sample Number	Sample Location			Sample Location Description	Analytical Results (micrograms per kilogram (ug/kg))						
	North	West	Depth		PCE	TCE	1,1-DCE	1,2-DCE	Chloroform	Total VOCs	Total VOCs except Chloroform
1	75	-1	9	Eastern Extent	120	56	0	0	23	199	176
2	40	1	7	Eastern Extent	110	460	0	43	180	793	613
4	0	1	8	Eastern Extent	14	58	0	0	21	93	72
7	60	2	4	Eastern Extent	0	0	0	30	0	30	30
6	80	2	8	Eastern Extent	770	570	12	0	260	1612	1352
5	5	2	8	Eastern Extent	17	100	0	0	40	157	117
10	13	5	12	Bottom	740	120	0	0	36	896	860
9	5	5	12	Bottom	420	40	0	0	31	491	460
11	80	5	15	Bottom	71	0	14	0	0	85	85
13	50	8	12	Bottom	200	91	0	29	19	339	320
14	40	10	12	Bottom	400	440	0	160	300	1300	1000
18	20	18	12	Bottom	640	190	0	0	82	912	830
19	54	19	10	Bottom	250	47	0	110	0	407	407
22	85	20	11	Bottom	490	390	18	93	0	991	991
20	25	20	18	Bottom	110	74	74	13	300	571	271
23	71	21	12	Bottom	150	59	0	0	250	459	209
66	71	23	12	Bottom	60	46	27	0	170	303	133
28	28	25	14	Bottom	140	140	0	10	89	379	290
79	35	25	12	Bottom	200	80	0	14	0	294	294
78	55	26	12	Bottom	80	32	0	0	0	112	112
29	18	27	11	Bottom	330	140	0	0	37	507	470
30	55	27	11	Bottom	160	17	0	0	20	197	177
32	27	28	18	Bottom	340	140	0	20	120	620	500
55	55	38	12	Bottom	210	72	0	0	100	382	282
70	23	42	15	Bottom	15	53	40	0	120	228	108
61	60	46	12	Bottom	430	120	50	0	78	678	600
74	71	55	12	Bottom	19	0	0	0	0	19	19
82	42	56	11	Bottom	25	0	0	0	0	25	25
72	22	57	12	Bottom	0	0	0	0	0	0	0
34	85	37	5	Northern Extent	18	0	25	280	0	323	323
27	90	24	5	Northern Extent	0	0	0	64	0	64	64
8	96	5	4	Northern Extent	230	350	0	80	1190	1850	660
16	96	15	4	Northern Extent	95	0	0	0	0	95	95
12	96	8	8	Northern Extent	430	950	24	250	320	1974	1654
73	74	57	5	Northern Extent	0	0	0	0	0	0	0
75	71	59	9	Northern Extent	0	0	0	0	0	0	0
4	0	1	8	Southern Extent	14	58	0	0	21	93	72
40	1	38	5	Southern Extent	0	0	0	0	0	0	0
5	5	2	8	Southern Extent	17	100	0	0	40	157	117
71	18	56	8	Southern Extent	0	0	0	0	0	0	0
34	85	37	5	Western Extent	18	0	25	280	0	323	323
38	15	37	7	Western Extent	45	0	0	10	90	145	55
40	1	38	5	Western Extent	0	0	0	0	0	0	0
64	78	45	5	Western Extent	0	0	0	31	32	63	31
80	52	54	5	Western Extent	38	0	0	0	0	38	38
76	55	57	9	Western Extent	59	12	0	0	0	71	71
73	74	57	12	Western Extent	0	0	0	0	0	0	0
77	42	59	8	Western Extent	110	38	0	0	0	148	148
75	71	59	9	Western Extent	0	0	0	0	0	0	0
65	60	61	5	Western Extent	16	0	18	0	32	66	34
63	33	61	5	Western Extent	0	0	51	0	44	95	51
50	45	66	5	Western Extent	570	1500	19	700	0	2789	2789
81	56	72	5	Western Extent	8	0	0	0	0	8	8

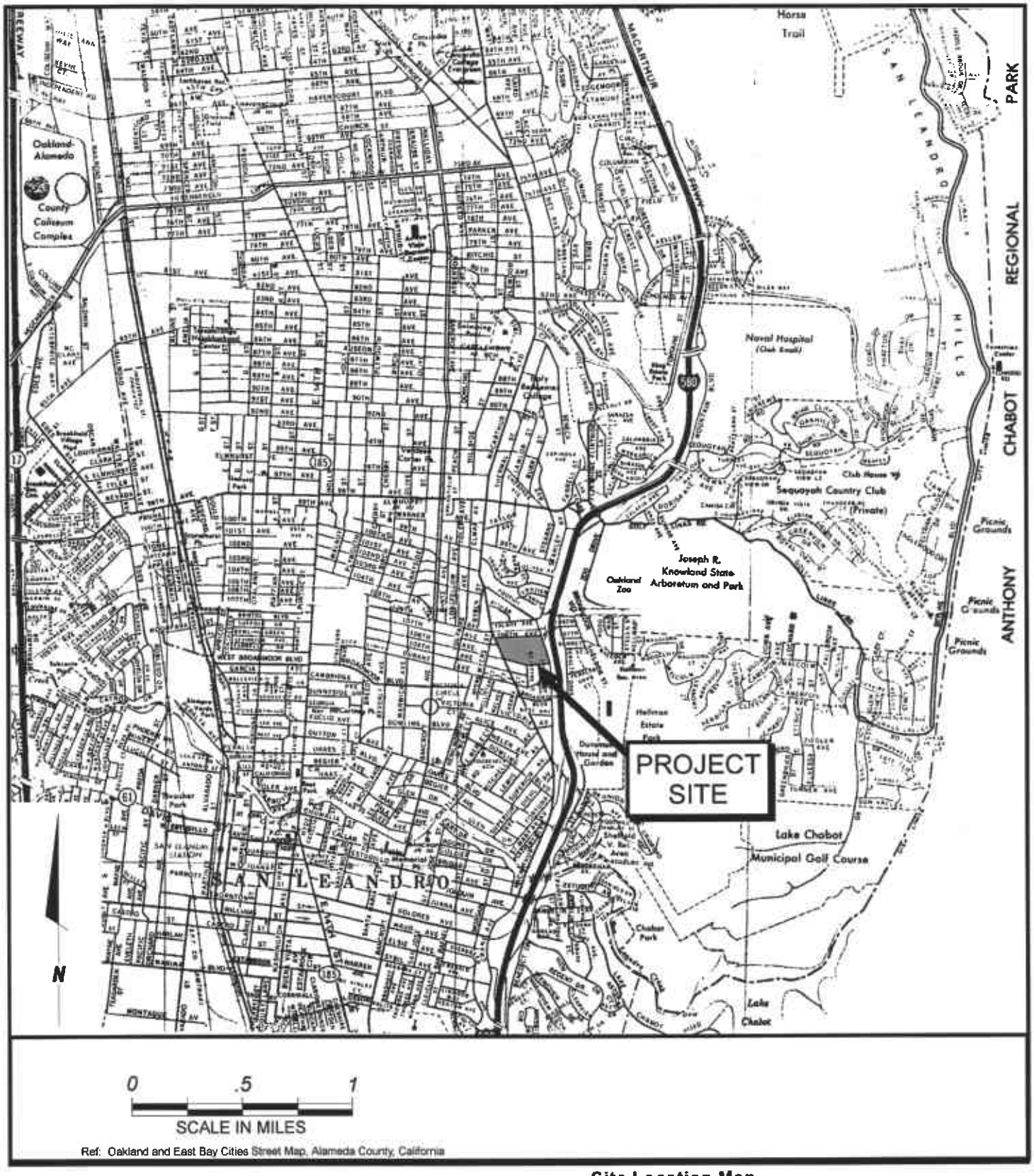
Notes: Data provided by Alt Environmental, Inc.

Table 2
Tenant Space Site-Specific Modeling Parameters and Assumptions
Foothill Shopping Center Soil Remediation Risk Evaluation
10700 MacArthur Boulevard, Oakland, California

Parameter	Tentant Space					
	A	B	C	D	E	F
Footprint Area (sf)	8520	1200	1200	1856	1700	1045
Height of Building (ft)	20	17	17	17	17	17
Air Exchange Rate (hr)	0.5	0.5	1	0.5	0.5	1
Total Porosity (cm^3/cm^3)	0.3	0.3	0.3	0.3	0.3	0.3
Air-Filled Porosity (cm^3/cm^3)	0.08	0.08	0.08	0.08	0.08	0.08
Organic Carbon Fraction	0.02	0.02	0.02	0.02	0.02	0.02
Remediated Portions						
Depth of Affected Soil	n/a	12	12	n/a	12	12
Area of Emission Flux	n/a	1200	160	n/a	1150	805
Attenuation Factor	n/a	0.001	0.001	n/a	0.001	0.001
Unremediated Portions						
Depth of Affected Soil (ft)	3.5	n/a	3.5	3.5	3.5	3.5
Area of Emission Flux (ft^2)	1200	n/a	1040	1856	550	240
Attenuation Factor	0.005	n/a	0.005	0.005	0.005	0.005

Table 3
Summary of Estimated Soil Vapor, Emission Flux, and Building Interior Air Concentrations
Foothill Shopping Center Soil Remdiation Risk Evaluation
10700 MacArthur Boulevard, Oakland, California

		Unremediated Area			Remediated Area				
Building Lease Space	Chemical Compound	Concentration in Soil C_{S1} (mg/kg)	Vapor-Phase Concentration from Soil C_{VS1} (mg/cm^3)	Calculated Emission Flux From Soil E_{i1} (mg/m^2 s)	Concentration in Soil C_{S2} (mg/kg)	Vapor-Phase Concentration from Soil C_{VS2} (mg/cm^3)	Calculated Emission Flux From Soil E_{i2} (mg/m^2 s)	Estimated Indoor Air Concentration C_{in} (µg/m^3)	EPA Region IX Ambient Air PRG (µg/m^3)
A	PCE	0.77	5.48E-05	9.15E-07	--	--	--	7.61E-04	3.30E+00
	TCE	0.57	8.11E-05	1.52E-06	--	--	--	1.27E-03	1.10E+00
	1,1-DCE	0.012	5.68E-05	1.04E-06	--	--	--	8.64E-04	3.80E-02
	1,2-DCE (mixture)	0.043	9.84E-06	1.80E-07	--	--	--	1.50E-04	3.30E+01
B	PCE	--	--	--	0.77	5.48E-05	9.15E-07	1.27E-03	3.30E+00
	TCE	--	--	--	0.57	8.11E-05	1.52E-06	2.12E-03	1.10E+00
	1,1-DCE	--	--	--	0.018	8.52E-05	1.56E-06	2.17E-03	3.80E-02
	1,2-DCE (mixture)	--	--	--	0.16	3.66E-05	6.70E-07	9.31E-04	3.30E+01
C	PCE	0.43	3.06E-05	5.11E-07	0.43	3.06E-05	5.11E-07	1.59E-03	3.30E+00
	TCE	0.95	1.35E-04	2.54E-06	0.95	1.35E-04	2.54E-06	7.87E-03	1.10E+00
	1,1-DCE	0.024	1.14E-04	2.08E-06	0.024	1.14E-04	2.08E-06	6.45E-03	3.80E-02
	1,2-DCE (mixture)	0.25	5.72E-05	1.05E-06	0.25	5.72E-05	1.05E-06	3.25E-03	3.30E+01
D	PCE	0.018	1.28E-06	2.14E-08	--	--	--	1.49E-04	3.30E+00
	TCE	0.0005	7.12E-08	1.34E-09	--	--	--	9.28E-06	1.10E+00
	1,1-DCE	0.025	1.18E-04	2.17E-06	--	--	--	1.50E-02	3.80E-02
	1,2-DCE (mixture)	0.28	6.41E-05	1.17E-06	--	--	--	8.15E-03	3.30E+01
E	PCE	0.018	1.28E-06	2.14E-08	0.21	1.50E-05	2.49E-07	2.83E-04	3.30E+00
	TCE	0.0005	7.12E-08	1.34E-09	0.14	1.99E-05	3.74E-07	3.55E-04	1.10E+00
	1,1-DCE	0.025	1.18E-04	2.17E-06	0.027	1.28E-04	2.34E-06	7.06E-03	3.80E-02
	1,2-DCE (mixture)	0.28	6.41E-05	1.17E-06	0.28	6.41E-05	1.17E-06	3.74E-03	3.30E+01
F	PCE	0.0005	3.56E-08	1.25E-09	0.43	3.06E-05	1.07E-06	5.76E-04	3.30E+00
	TCE	0.0005	7.12E-08	2.81E-09	0.12	1.71E-05	6.74E-07	3.63E-04	1.10E+00
	1,1-DCE	0.018	8.52E-05	3.28E-06	0.051	2.41E-04	9.29E-06	7.58E-03	3.80E-02
	1,2-DCE (mixture)	0.0005	1.14E-07	4.40E-09	0.0005	1.14E-07	4.40E-09	5.87E-06	3.30E+01



Ref: Oakland and East Bay Cities Street Map, Alameda County, California

PES Environmental, Inc.
Engineering & Environmental Services

Site Location Map
Soil Remediation Risk Evaluation
Foothill Shopping Center
10700 MacArthur Boulevard
Oakland, California

PLATE
1

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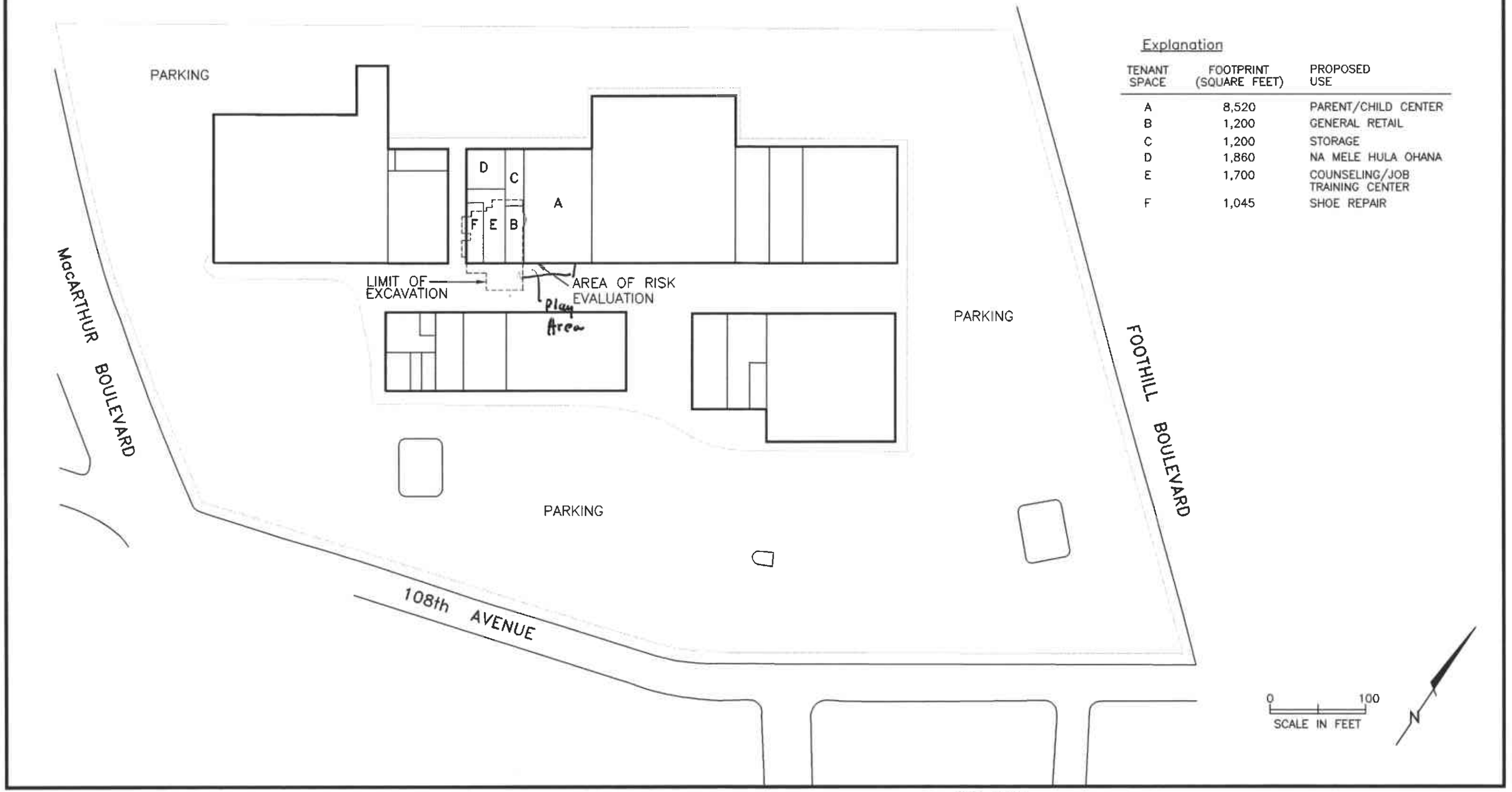
JOB NUMBER	DRAWING NUMBER	REVIEWED BY	DATE



Explanation

TENANT SPACE	FOOTPRINT (SQUARE FEET)	PROPOSED USE
A	8,520	PARENT/CHILD CENTER
B	1,200	GENERAL RETAIL
C	1,200	STORAGE
D	1,860	NA MELE HULA OHANA
E	1,700	COUNSELING/JOB TRAINING CENTER
F	1,045	SHOE REPAIR

PES Environmental, Inc.
Engineering & Environmental Services

Site Plan
Soil Remediation Risk Evaluation
Foothill Shopping Center
10700 MacArthur Boulevard
Oakland, California

PLATE
2

502.0101.001	010010Z-		2/96
JOB NUMBER	DRAWING NUMBER	REVIEWED BY	DATE

TENANT SPACE D

SPACE C

• if you extend roof can cover into tenant space A still no rent Day Care

TENANT SPACE A

TENANT SPACE E

TENANT SPACE F

TENANT SPACE B

(95) 16 (1974) 12 (1850) 8

(64) 27

(323) 34 (991) 22

(85) 11 (1612) 6

(53) 64

(199) 1

(0) 73

(0) 75 (19) 74

(303) 66 (459) 23

(66) 65

(678) 61

(30) 7

(8) 81

71 76

(382) 55

(197) 30 (112) 78 (407) 19

sewer spl

(8) 3

(339) 13

(2789) 50

(148) 77 (25) 82

(1300) 14 (793) 2

(294) 79

95 63

(379) 28 (620) 32 (571) 20

(228) 70

(0) 72

(912) 18

(0) 71

(507) 29

(145) 38

(896) 10

LIMIT OF SOIL EXCAVATION

(491) 9 (157) 5

(0) 40

(93) 4

(4) Location with sample designation and TVOC Concentration (µg/kg)

Sample Location (depth 1–6 ft.)

Sample Location (depth 7–12 ft.)

Sample Location (depth 13–18 ft.)

Sample Location (depth 3.5 ft.) collected during sewer lateral construction

0 10
SCALE IN FEET

N

PES Environmental, Inc.
Engineering & Environmental Services

Confirmation Sample Locations and Limit of Excavation
Soil Remediation Risk Evaluation
Foothill Shopping Center
10700 MacArthur Boulevard
Oakland, California

PLATE 3

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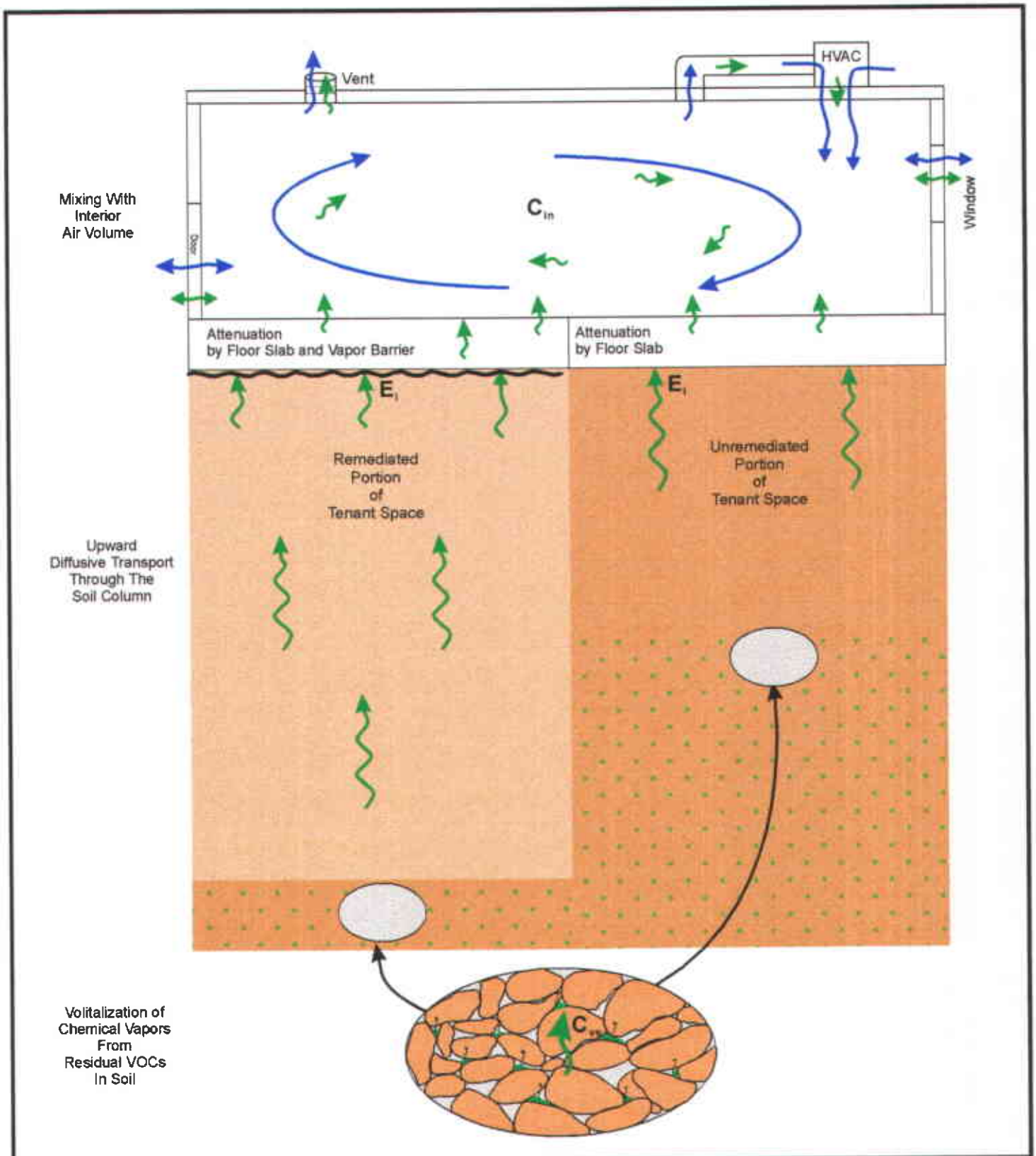
JOB NUMBER	DRAWING NUMBER	REVIEWED BY	DATE



PES Environmental, Inc.
Engineering & Environmental Services

Volatilization of Chemical Vapors from Residual VOCs in Soil
Soil Remediation Risk Evaluation
Foothill Shopping Center
10700 MacArthur Boulevard
Oakland, California

PLATE 4

502.0101.001	502011D1.CDR	jed	2/96
JOB NUMBER	DRAWING NUMBER	REVIEWED BY	DATE

APPENDIX A

EVALUATION METHODOLOGY FOR ASSESSMENT OF RESIDUAL VOC VOLATILIZATION TO BUILDING INTERIORS

The estimation of volatile organic compounds (VOC) concentrations in ambient air within the building interiors was accomplished by modeling volatilization of VOCs from residually contaminated soil beneath the building. In general, the model included three primary steps: (1) calculation of the chemical vapor concentrations of VOCs at the source soil, (2) calculation of the chemical vapor flux at the ground surface due to upward diffusion of the VOCs through the soil cover, and (3) estimation of the building interior ambient air chemical concentration using a simplified air-mixing model. A discussion of each of these steps is presented in the following sections. Each section also includes general model assumptions. Site-specific assumptions are presented in the main document and attachments, where appropriate.

Estimation of Chemical Vapor Concentrations

Chemical vapor in soil pores can arise from volatilization from residually-contaminated soil (i.e., adsorbed phase). The adsorbed-phase concentrations are in equilibrium in accordance with Jury's Behavior Assessment Model (Jury et al, 1983 and Jury et al, 1990) and the following:

Soil pore vapor conc

$$C_{vs} = C_s \frac{H}{K_d}\left(10^{-3}\right)$$

1 conversion factor

where:

C_{vs} = chemical concentration in the vapor phase arising from volatilization from soil, in mg/cm^3;
C_s = chemical i concentration in soil, in mg/kg;
H = Henry's Law coefficient for chemical i, (dimensionless); and
K_d = distribution coefficient for chemical, in cm^3/g.

and:

$$K_d = K_{oc} f_{oc}$$

where:

K_{oc} = organic carbon partition coefficient for chemical i, in ml/g; and
f_{oc} = organic carbon fraction in the soil by weight, in g/g.

for water to air no K_d $H(10^{-3})$

$C_{vs} = C_w$

Estimation of Chemical Vapor Flux

Steady-state vapor flux at the ground surface within each remediated and unremediated portion of a tenant space is estimated using the following equation (Farmer et. al., 1980), which is a modified form of Fick's law of diffusion:

$$E_i = D_{air} \frac{C_v}{L} \left(\frac{P_a^{3.33}}{P_t^2} \right) (10^4)$$

where:

E_i = emission flux of chemical i at the ground surface, in mg/m^2-s;
D_{air} = chemical air diffusion coefficient of chemical i, in cm^2/s;
C_v = chemical i concentration in the vapor phase in the remediated or unremediated portions of a tenant space at depth L, in mg/cm^3;
L = soil cover thickness in the remediated or unremediated portion of a tenant space, in cm;
P_t = total porosity of soil cover, (dimensionless); and
P_a = air-filled porosity of soil cover, (dimensionless).

In this model, the following assumptions are made:

- steady-state single direction (upward) movement of soil vapors occur;
- diffusive transport dominates over convective transport and no net upward dissolved-phase flux occurs (Johnson and Ettinger, 1991);
- soil properties are constant over space and time;
- the chemical concentration at the ground surface (C_o) is negligible relative to the chemical concentration at depth (C_v), therefore the concentration gradient (C_v - C_o) equals C_v; and
- soil porosity and tortuosity factors are assumed to follow the model of Millington and Quirk (1961).

Estimating Indoor Air Concentrations

Indoor air concentrations were estimated using the methodology of the Orange County Public Health Care Agency Vapor Diffusion Model (Orange County, 1994).

$$C_{in} = \frac{\left[\left(E_{i_r} b_r A_{f_r}\right) + \left(E_{i_u} b_u A_{f_u}\right)\right]}{V}\left(10^3\right)$$

where:

C_{in} = indoor air concentration of chemical i, in $\mu g/m^3$;
E_{ir} = emission flux in remediated portion, in $mg/m^2 \cdot s$;
b_r = attention factor remediated portion, based on surface cover type, (dimensionless);
A_{fr} = area of emission flux in remediated area; in m^2;
E_{iu} = emission flux in unremediated portion, in $mg/m^2 \cdot s$;
b_u = attenuation factor in unremediated portion, based on surface cover type, (dimensionless);
A_{fu} = area of emission flux in unremediated portion, in m^2; and
V = indoor ventilation rate, in m^3/s.

and:

$$V = A_{building} hR$$

where:

$A_{building}$ = indoor tenant space area where chemical vapors concentrate, in m^2;
h = indoor height of tenant space, in m; and
R = air exchange rate in, s^{-1}.

The following assumptions are made in applying this method:

- Vapor emissions are constant over time (i.e., steady-state);
- Vapors emissions are instantaneously and uniformly mixed within the tenant space;

APPENDIX B

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APPENDIX C

EVALUATION CALCULATIONS

Area A Site-Specific Modeling Paramters

Chemical Specific Data

Compound	D_{air} (cm^2/s)	H (unitless)	K_{oc} (ml/g)
PCE	0.072	0.94	660
TCE	0.081	0.37	130
1,1-DCE	0.079	6.15	65
1,2-DCE (mixture)	0.079	0.27	59

Site Specific and Default Data

chemical concentration at surface	C_i	0	cm		
soil cover over groundwater	L_w	366	cm	12	ft
soil cover over contaminated soil	L_s	107	cm	3.5	ft
air-filled porosity of soil cover	P_a	0.08	cm^3/cm^3		
total porosity of soil cover (silty clay)	P_t	0.3	cm^3/cm^3		
area of emission flux	A_f	111.5	m^2	1200	ft^2
attenuation factor	b	0.005			
area of building	$A_{building}$	791.5	m^2	8520	ft^2
inside height of building	h	6.1	m	20	ft
air exchange rate	R	1.39E-04	1/s	0.5	hr
organic carbon fraction in soil	f_{oc}	0.02	g/g		

Area A Calculations

Estimation of Chemical Vapor Concentrations

formula $C_{vs} = C_s \times (H/K_d) \times 10^{-3}$

chemical	C_s	H	K_d	C_{vs}
PCE	0.77	0.94	13.2	**5.48E-05**
TCE	0.57	0.37	2.6	**8.11E-05**
1,1-DCE	0.012	6.15	1.3	**5.68E-05**
1,2-DCE (mixture)	0.043	0.27	1.18	**9.84E-06**

Estimation of Chemical Flux

formula $E_i = D_{air} * C_{vs} * 1/L * (P_a \text{^} 3.33 / P_t \text{^} 2) * (10^4)$

L = 107 P_a = 0.08 P_t = 0.3

chemical	D_{air}	C_{vs}	E_i
PCE	0.072	5.48E-05	**9.15E-07**
TCE	0.081	8.11E-05	**1.52E-06**
1,1-DCE	0.079	5.68E-05	**1.04E-06**
1,2-DCE (mixture)	0.079	9.84E-06	**1.80E-07**

Estimating Indoor Air Concentrations

formula $C_{in} = (E_i b A_f)/V * 10^3$

$A_{building}$ = 791.508 h = 6.1 R = 1.39E-04

chemical	E_i	b	A_f	V	C_{in}	PRGs
PCE	9.15E-07	0.005	111.5	6.70E-01	**7.61E-04**	3.3
TCE	1.52E-06	0.005	111.5	6.70E-01	**1.27E-03**	1.1
1,1-DCE	1.04E-06	0.005	111.5	6.70E-01	**8.64E-04**	3.80E-02
1,2-DCE (mixture)	1.80E-07	0.005	111.5	6.70E-01	**1.50E-04**	33

Area B Site-Specific Modeling Parameters

Chemical Specific Data

Compound	D_{air} (cm^2/s)	H (unitless)	K_{oc} (ml/g)
PCE	0.072	0.94	660
TCE	0.081	0.37	130
1,1-DCE	0.079	6.15	65
1,2-DCE (mixture)	0.079	0.27	59

Site Specific and Default Data

chemical concentration at surface	C_i	0	cm		
soil cover over groundwater	L_w	366	cm	12	ft
soil cover over contaminated soil (unremediated)	L_{s1}	107	cm	3.5	ft
soil cover over contaminated soil (remediated)	L_{s2}	366	cm	12	ft
air-filled porosity of soil cover	P_a	0.08	cm^3/cm^3		
total porosity of soil cover (silty clay)	P_t	0.3	cm^3/cm^3		
area of emission flux (unremediated)	A_{f1}	0.0	m^2	0	ft^2
area of emission flux (remediated)	A_{f2}	111.5	m^2	1200	
attenuation factor (unremediated)	b_1	0.005			
attenuation factor (remediated)	b_2	0.001			
area of building	$A_{building}$	111.5	m^2	1200	ft^2
inside height of building	h	5.2	m	17	ft
air exchange rate	R	1.39E-04	1/s	0.5	hr
organic carbon fraction in soil	f_{oc}	0.02	g/g		

Area B Calculations

Estimation of Chemical Vapor Concentrations

formula $C_{vs} = C_s \times (H/K_d) \times 10^{-3}$

chemical	C_s	H	K_d	C_{vs}
(unremediated)				
PCE	0	0.94	13.2	**0.00E+00**
TCE	0	0.37	2.6	**0.00E+00**
1,1-DCE	0	6.15	1.3	**0.00E+00**
1,2-DCE (mixture)	0	0.27	1.18	**0.00E+00**
(remediated)				
PCE	0.77	0.94	13.2	**5.48E-05**
TCE	0.57	0.37	2.6	**8.11E-05**
1,1-DCE	0.018	6.15	1.3	**8.52E-05**
1,2-DCE (mixture)	0.16	0.27	1.18	**3.66E-05**

Estimation of Chemical Flux

formula $E_i = D_{air}*C_{vs}*1/L*(P_a\text{^}3.33/P_t\text{^}2)*(10^4)$

$L_{s1} = 107$ $P_a = 0$ $P_t = 0.3$

$L_{s2} = 366$

chemical	D_{air}	C_{vs}	E_i
(unremediated)			
PCE	0.072	0.00E+00	**0.00E+00**
TCE	0.081	0.00E+00	**0.00E+00**
1,1-DCE	0.079	0.00E+00	**0.00E+00**
1,2-DCE (mixture)	0.079	0.00E+00	**0.00E+00**
(remediated)			
PCE	0.072	5.48E-05	**9.15E-07**
TCE	0.081	8.11E-05	**1.52E-06**
1,1-DCE	0.079	8.52E-05	**1.56E-06**
1,2-DCE (mixture)	0.079	3.66E-05	**6.70E-07**

Estimating Indoor Air Concentrations

formula $C_{in} = ((E_i bA_{f1})+(E_{ib}Af2))/V*10^3$

$A_{building} =$ 111.48 h = 5.2 R = 1.39E-04

chemical	Ei1	Ei2	b1	b2	Af1	Af2	V	C_{in}	PRGs
PCE	0.00E+00	9.15E-07	0.005	0.001	0.0	111.5	0.080228	**1.27E-03**	3.3
TCE	0.00E+00	1.52E-06	0.005	0.001	0.0	111.5	0.080228	**2.12E-03**	1.1
1,1-DCE	0.00E+00	1.56E-06	0.005	0.001	0.0	111.5	0.080228	**2.17E-03**	3.80E-02
1,2-DCE (mixture)	0.00E+00	6.70E-07	0.005	0.001	0.0	111.5	0.080228	**9.31E-04**	33

Area C Site-Specific Modeling Parameters

Chemical Specific Data

Compound	D_{air} (cm^2/s)	H (unitless)	K_{oc} (ml/g)
PCE	0.072	0.94	660
TCE	0.081	0.37	130
1,1-DCE	0.079	6.15	65
1,2-DCE (mixture)	0.079	0.27	59

Site Specific and Default Data

chemical concentration at surface	C_i	0	cm		
soil cover over groundwater	L_w	366	cm	12	ft
soil cover over contaminated soil (unremediated)	L_{s1}	107	cm	3.5	ft
soil cover over contaminated soil (remediated)	L_{s2}	366	cm	12	ft
air-filled porosity of soil cover	P_a	0.08	cm^3/cm^3		
total porosity of soil cover (silty clay)	P_t	0.3	cm^3/cm^3		
area of emission flux (unremediated)	A_{f1}	96.6	m^2	1040	ft^2
area of emission flux (remediated)	A_{f2}	14.9	m^2	160	
attenuation factor (unremediated)	b_1	0.005			
attenuation factor (remediated)	b_2	0.001			
area of building	$A_{building}$	111.5	m^2	1200	ft^2
inside height of building	h	5.2	m	17	ft
air exchange rate	R	2.78E-04	1/s	1	hr
organic carbon fraction in soil	f_{oc}	0.02	g/g		

Area C Calculations

Estimation of Chemical Vapor Concentrations

formula $C_{vs} = C_s \times (H/K_d) \times 10^{-3}$

chemical	C_s	H	K_d	C_{vs}
(unremediated)				
PCE	0.43	0.94	13.2	**3.06E-05**
TCE	0.95	0.37	2.6	**1.35E-04**
1,1-DCE	0.024	6.15	1.3	**1.14E-04**
1,2-DCE (mixture)	0.25	0.27	1.18	**5.72E-05**
(remediated)				
PCE	0.43	0.94	13.2	**3.06E-05**
TCE	0.95	0.37	2.6	**1.35E-04**
1,1-DCE	0.024	6.15	1.3	**1.14E-04**
1,2-DCE (mixture)	0.25	0.27	1.18	**5.72E-05**

Estimation of Chemical Flux

formula $E_i = D_{air}*C_{vs}*1/L*(P_a\text{^}3.33/P_t\text{^}2)*(10^4)$

$L_{s1} = 107$ $P_a = 0$ $P_t = 0.3$

$L_{s2} = 366$

chemical	D_{air}	C_{vs}	E_i
(unremediated)			
PCE	0.072	3.06E-05	**5.11E-07**
TCE	0.081	1.35E-04	**2.54E-06**
1,1-DCE	0.079	1.14E-04	**2.08E-06**
1,2-DCE (mixture)	0.079	5.72E-05	**1.05E-06**
(remediated)			
PCE	0.072	3.06E-05	**5.11E-07**
TCE	0.081	1.35E-04	**2.54E-06**
1,1-DCE	0.079	1.14E-04	**2.08E-06**
1,2-DCE (mixture)	0.079	5.72E-05	**1.05E-06**

Estimating Indoor Air Concentrations

formula $C_{in} = ((E_i bA_{f1})+(EibAf2))/V*10^3$

$A_{building} =$ 111.48 h = 5.2 R = 2.78E-04

chemical	Ei1	Ei2	b1	b2	Af1	Af2	V	C_{in}	PRGs
PCE	5.11E-07	5.11E-07	0.005	0.001	96.6	14.9	0.160457	**1.59E-03**	3.3
TCE	2.54E-06	2.54E-06	0.005	0.001	96.6	14.9	0.160457	**7.87E-03**	1.1
1,1-DCE	2.08E-06	2.08E-06	0.005	0.001	96.6	14.9	0.160457	**6.45E-03**	3.80E-02
1,2-DCE (mixture)	1.05E-06	1.05E-06	0.005	0.001	96.6	14.9	0.160457	**3.25E-03**	33

Area D Site-Specific Modeling Parameters

Chemical Specific Data

Compound	D_{air} (cm^2/s)	H (unitless)	K_{oc} (ml/g)
PCE	0.072	0.94	660
TCE	0.081	0.37	130
1,1-DCE	0.079	6.15	65
1,2-DCE (mixture)	0.079	0.27	59

Site Specific and Default Data

chemical concentration at surface	C_i	0	cm		
soil cover over groundwater	L_w	366	cm	12	ft
soil cover over contaminated soil (unremediated)	L_{s1}	107	cm	3.5	ft
soil cover over contaminated soil (remediated)	L_{s2}	244	cm	8	ft
air-filled porosity of soil cover	P_a	0.08	cm^3/cm^3		
total porosity of soil cover (silty clay)	P_t	0.3	cm^3/cm^3		
area of emission flux (unremediated)	A_{f1}	172.4	m^2	1856	ft^2
area of emission flux (remediated)	A_{f2}	0.0	m^2	0	
attenuation factor (unremediated)	b_1	0.005			
attenuation factor (remediated)	b_2	0.001			
area of building	$A_{building}$	172.4	m^2	1856	ft^2
inside height of building	h	5.2	m	17	ft
air exchange rate	R	1.39E-04	1/s	0.5	hr
organic carbon fraction in soil	f_{oc}	0.02	g/g		

Area D Calculations

Estimation of Chemical Vapor Concentrations

formula $C_{vs} = C_s \times (H/K_d) \times 10^{-3}$

chemical	C_s	H	K_d	C_{vs}
(unremediated)				
PCE	0.018	0.94	13.2	**1.28E-06**
TCE	0.0005	0.37	2.6	**7.12E-08**
1,1-DCE	0.025	6.15	1.3	**1.18E-04**
1,2-DCE (mixture)	0.28	0.27	1.18	**6.41E-05**
(remediated)				
PCE	0	0.94	13.2	**0.00E+00**
TCE	0	0.37	2.6	**0.00E+00**
1,1-DCE	0	6.15	1.3	**0.00E+00**
1,2-DCE (mixture)	0	0.27	1.18	**0.00E+00**

Estimation of Chemical Flux

formula $E_i = D_{air}*C_{vs}*1/L*(P_a\text{^}3.33/P_t\text{^}2)*(10^4)$

L_{s1} = 107 P_a = 0 P_t = 0.3

L_{s2} = 244

chemical	D_{air}	C_{vs}	E_i
(unremediated)			
PCE	0.072	1.28E-06	**2.14E-08**
TCE	0.081	7.12E-08	**1.34E-09**
1,1-DCE	0.079	1.18E-04	**2.17E-06**
1,2-DCE (mixture)	0.079	6.41E-05	**1.17E-06**
(remediated)			
PCE	0.072	0.00E+00	**0.00E+00**
TCE	0.081	0.00E+00	**0.00E+00**
1,1-DCE	0.079	0.00E+00	**0.00E+00**
1,2-DCE (mixture)	0.079	0.00E+00	**0.00E+00**

Estimating Indoor Air Concentrations

formula $C_{in} = ((E_i bA_{f1})+(E_i bA_{f2}))/V*10^3$

$A_{building}$ = 172.4224 h = 5.2 R = 1.39E-04

chemical	Ei1	Ei2	b1	b2	Af1	Af2	V	C_{in}	PRGs
PCE	2.14E-08	0.00E+00	0.005	0.001	172.4	0.0	0.124087	**1.49E-04**	3.3
TCE	1.34E-09	0.00E+00	0.005	0.001	172.4	0.0	0.124087	**9.28E-06**	1.1
1,1-DCE	2.17E-06	0.00E+00	0.005	0.001	172.4	0.0	0.124087	**1.50E-02**	3.80E-02
1,2-DCE (mixture)	1.17E-06	0.00E+00	0.005	0.001	172.4	0.0	0.124087	**8.15E-03**	33

Area E Site-Specific Modeling Parameters

Chemical Specific Data

Compound	D_{air} (cm^2/s)	H (unitless)	K_{oc} (ml/g)
PCE	0.072	0.94	660
TCE	0.081	0.37	130
1,1-DCE	0.079	6.15	65
1,2-DCE (mixture)	0.079	0.27	59

Site Specific and Default Data

chemical concentration at surface	C_i	0	cm		
soil cover over groundwater	L_w	366	cm	12	ft
soil cover over contaminated soil (unremediated)	L_{s1}	107	cm	3.5	ft
soil cover over contaminated soil (remediated)	L_{s2}	366	cm	12	ft
air-filled porosity of soil cover	P_a	0.08	cm^3/cm^3		
total porosity of soil cover (silty clay)	P_t	0.3	cm^3/cm^3		
area of emission flux (unremediated)	A_{f1}	51.1	m^2	550	ft^2
area of emission flux (remediated)	A_{f2}	106.8	m^2	1150	
attenuation factor (unremediated)	b_1	0.005			
attenuation factor (remediated)	b_2	0.001			
area of building	$A_{building}$	157.9	m^2	1700	ft^2
inside height of building	h	5.2	m	17	ft
air exchange rate	R	1.39E-04	1/s	0.5	hr
organic carbon fraction in soil	f_{oc}	0.02	g/g		

Area E Calculations

Estimation of Chemical Vapor Concentrations

formula $C_{vs} = C_s \times (H/K_d) \times 10^{-3}$

chemical	C_s	H	K_d	C_{vs}
(unremediated samples used : 27, 34, 64, 75)				
PCE	0.018	0.94	13.2	**1.28E-06**
TCE	0.0005	0.37	2.6	**7.12E-08**
1,1-DCE	0.025	6.15	1.3	**1.18E-04**
1,2-DCE (mixture)	0.28	0.27	1.18	**6.41E-05**
(remediated samples used: 27,34,64,75,23,66,55,78,28)				
PCE	0.21	0.94	13.2	**1.50E-05**
TCE	0.14	0.37	2.6	**1.99E-05**
1,1-DCE	0.027	6.15	1.3	**1.28E-04**
1,2-DCE (mixture)	0.28	0.27	1.18	**6.41E-05**

Estimation of Chemical Flux

formula $E_i = D_{air} * C_{vs} * 1/L * (P_a \wedge 3.33/P_t \wedge 2) * (10^4)$

$L_{s1} = 107$ $P_a = 0$ $P_t = 0.3$

$L_{s2} = 366$

chemical	D_{air}	C_{vs}	E_i
(unremediated)			
PCE	0.072	1.28E-06	**2.14E-08**
TCE	0.081	7.12E-08	**1.34E-09**
1,1-DCE	0.079	1.18E-04	**2.17E-06**
1,2-DCE (mixture)	0.079	6.41E-05	**1.17E-06**
(remediated)			
PCE	0.072	1.50E-05	**2.49E-07**
TCE	0.081	1.99E-05	**3.74E-07**
1,1-DCE	0.079	1.28E-04	**2.34E-06**
1,2-DCE (mixture)	0.079	6.41E-05	**1.17E-06**

Estimating Indoor Air Concentrations

formula $C_{in} = ((E_i b A_{f1}) + (E_i b A_{f2}))/V * 10^3$

$A_{building} = 157.93$ $h = 5.2$ $R = 1.39E-04$

chemical	Ei1	Ei2	b1	b2	Af1	Af2	V	C_{in}	PRGs
PCE	2.14E-08	2.49E-07	0.005	0.001	51.1	106.8	0.113657	**2.83E-04**	3.3
TCE	1.34E-09	3.74E-07	0.005	0.001	51.1	106.8	0.113657	**3.55E-04**	1.1
1,1-DCE	2.17E-06	2.34E-06	0.005	0.001	51.1	106.8	0.113657	**7.06E-03**	3.80E-02
1,2-DCE (mixture)	1.17E-06	1.17E-06	0.005	0.001	51.1	106.8	0.113657	**3.74E-03**	33

Area F Site-Specific Modeling Parameters

Chemical Specific Data

Compound	D_{air} (cm^2/s)	H (unitless)	K_{oc} (ml/g)
PCE	0.072	0.94	660
TCE	0.081	0.37	130
1,1-DCE	0.079	6.15	65
1,2-DCE (mixture)	0.079	0.27	59

Site Specific and Default Data

chemical concentration at surface	C_i	0	cm		
soil cover over groundwater	L_w	366	cm	12	ft
soil cover over contaminated soil (unremediated)	L_{s1}	107	cm	3.5	ft
soil cover over contaminated soil (remediated)	L_{s2}	366	cm	12	ft
air-filled porosity of soil cover	P_a	0.1	cm^3/cm^3		
total porosity of soil cover (silty clay)	P_t	0.3	cm^3/cm^3		
area of emission flux (unremediated)	A_{f1}	22.3	m^2	240	ft^2
area of emission flux (remediated)	A_{f2}	74.8	m^2	805	
attenuation factor (unremediated)	b_1	0.005			
attenuation factor (remediated)	b_2	0.001			
area of building	$A_{building}$	97.1	m^2	1045	ft^2
inside height of building	h	5.2	m	17	ft
air exchange rate	R	2.78E-04	1/s	1	hr
organic carbon fraction in soil	f_{oc}	0.02	g/g		

Area F Calculations

Estimation of Chemical Vapor Concentrations

formula $C_{vs} = C_s \times (H/K_d) \times 10^{-3}$

chemical	C_s	H	K_d	C_{vs}
(unremediated)				
PCE	0.0005	0.94	13.2	**3.56E-08**
TCE	0.0005	0.37	2.6	**7.12E-08**
1,1-DCE	0.018	6.15	1.3	**8.52E-05**
1,2-DCE (mixture)	0.0005	0.27	1.18	**1.14E-07**
(remediated)				
PCE	0.43	0.94	13.2	**3.06E-05**
TCE	0.12	0.37	2.6	**1.71E-05**
1,1-DCE	0.051	6.15	1.3	**2.41E-04**
1,2-DCE (mixture)	0.0005	0.27	1.18	**1.14E-07**

Estimation of Chemical Flux

formula $E_i = D_{air}*C_{vs}*1/L*(P_a\text{^}3.33/P_t\text{^}2)*(10^4)$

$L_{s1} = 107$ $P_a = 0.1$ $P_t = 0.3$

$L_{s2} = 366$

chemical	D_{air}	C_{vs}	E_i
(unremediated)			
PCE	0.072	3.56E-08	**1.25E-09**
TCE	0.081	7.12E-08	**2.81E-09**
1,1-DCE	0.079	8.52E-05	**3.28E-06**
1,2-DCE (mixture)	0.079	1.14E-07	**4.40E-09**
(remediated)			
PCE	0.072	3.06E-05	**1.07E-06**
TCE	0.081	1.71E-05	**6.74E-07**
1,1-DCE	0.079	2.41E-04	**9.29E-06**
1,2-DCE (mixture)	0.079	1.14E-07	**4.40E-09**

Estimating Indoor Air Concentrations

formula $C_{in} = ((E_i bA_{f1})+(EibAf2))/V*10^3$

$A_{building} =$ 97.0805 h = 5.2 R = 2.78E-04

chemical	Ei1	Ei2	b1	b2	Af1	Af2	V	C_{in}	PRGs
PCE	1.25E-09	1.07E-06	0.005	0.001	22.3	74.8	0.139731	**5.76E-04**	3.3
TCE	2.81E-09	6.74E-07	0.005	0.001	22.3	74.8	0.139731	**3.63E-04**	1.1
1,1-DCE	3.28E-06	9.29E-06	0.005	0.001	22.3	74.8	0.139731	**7.58E-03**	3.80E-02
1,2-DCE (mixture)	4.40E-09	4.40E-09	0.005	0.001	22.3	74.8	0.139731	**5.87E-06**	33