

**APPENDIX C**

**VAPOR INTRUSION MODEL AND  
SOIL VAPOR RBCS**

ENTER	ENTER	Soil gas conc., C <sub>g</sub> (μg/m <sup>3</sup> )	OR	Soil gas conc., C <sub>g</sub> (ppmv)	ENTER
71432		1			
108883		1			
100414		1			
95476		1			
108383		1			
106423		1			
95636		1			
108678		1			

no dashes)	( $\mu\text{g}/\text{m}^3$ )	(ppmv)	Chemical
71432	1		Benzene
108863	1		Toluene
100414	1		Ethylbenzene
95476	1		o-Xylene
108383	1		m-Xylene
106423	1		p-Xylene
95636	1		1,2,4-Trimethylbenzene
108678	1		1,3,5-Trimethylbenzene

ENTER	ENTER	ENTER
Depth below grade	Sol gas sampling depth	Average soil temperature,
L <sub>F</sub> (cm)	L <sub>s</sub> (cm)	T <sub>s</sub> (°C)
15	152	13
Totals must add up to value of L <sub>s</sub> (cell F24)		
ENTER	ENTER	ENTER
Thickness of soil stratum A, h <sub>A</sub> (cm)	Thickness of soil stratum B, (Enter value or 0) h <sub>B</sub> (cm)	Thickness of soil stratum C, (Enter value or 0) h <sub>C</sub> (cm)
152		
Soil stratum A SCS soil type (used to estimate sol vapor permeability)		Soil stratum A SCS soil type (used to estimate sol vapor permeability)
OR		
User-defined stratum A sol vapor permeability, k <sub>p</sub> (cm <sup>2</sup> )		
		S

[illegible]

ENTER	ENTER	ENTER	ENTER	ENTER	ENTER	ENTER	ENTER	ENTER
Enclosed space floor thickness, $L_{\text{crack}}$ (cm)	Soil-bldg. pressure differential, $\Delta P$ (g/cm-s <sup>2</sup> )	Enclosed space floor length, $L_B$ (cm)	Enclosed space floor width, $W_B$ (cm)	Enclosed space height, $H_B$ (cm)	Floor-wall seam crack width, $w$ (cm)	Indoor air exchange rate, ER (1/h)	Average vapor flow rate into bldg. OR Leave blank to calculate $Q_{\text{soil}}$ (L/m)	ENTER
15	40	3048	1615	320	0.1	2	24.6	

15	40	3048	1615
<b>ENTER</b>	<b>ENTER</b>	<b>ENTER</b>	<b>ENTER</b>
Averaging time for carcinogens, ATC (yrs)	Averaging time for noncarcinogens, ATNC (yrs)	Exposure duration, ED (yrs)	Exposure frequency, EF (days/yr)
70	25	25	250

Derivation of Soil Gas RBCs  
Future Onsite Residential Scenario  
Soil Gas to Indoor Air

Area of enclosed space below grade, $A_B$	Crack-to-total area ratio, $\eta$ (unitless)	Crack depth below grade, $Z_{crack}$ (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, $H_{TS}$ (atm-m <sup>3</sup> /mol)	Henry's law constant at ave. soil temperature, $H_{TS}$ (unitless)	Vapor viscosity at ave. soil temperature, $\mu_{TS}$ (g/cm-s)	Stratum A		Stratum B		Stratum C		Total overall effective diffusion coefficient, $D_{eff,T}$ (cm <sup>2</sup> /s)	Diffusion path length, $L_d$ (cm)	
							effective diffusion coefficient, $D_{eff,A}$ (cm <sup>2</sup> /s)	effective diffusion coefficient, $D_{eff,B}$ (cm <sup>2</sup> /s)	effective diffusion coefficient, $D_{eff,C}$ (cm <sup>2</sup> /s)	effective diffusion coefficient, $D_{eff,C}$ (cm <sup>2</sup> /s)					
4.92E+06	1.00E-03	15	8.091	3.12E-03	1.33E-01	1.76E-04	6.87E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.87E-03	137	Benzene	
4.92E+06	1.00E-03	15	9.122	3.47E-03	1.48E-01	1.76E-04	6.79E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.79E-03	137	Toluene	
4.92E+06	1.00E-03	15	10.121	3.84E-03	1.64E-01	1.76E-04	5.85E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.85E-03	137	Ethylbenzene	
4.92E+06	1.00E-03	15	10.370	2.48E-03	1.06E-01	1.76E-04	6.79E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.79E-03	137	o-Xylene	
4.92E+06	1.00E-03	15	10.220	3.55E-03	1.51E-01	1.76E-04	5.46E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.46E-03	137	m-Xylene	
4.92E+06	1.00E-03	15	10.213	3.71E-03	1.58E-01	1.76E-04	6.00E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.00E-03	137	p-Xylene	
4.92E+06	1.00E-03	15	11.654	2.69E-03	1.15E-01	1.76E-04	4.73E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.73E-03	137	1,2,4-Trimethylbenzene	
4.92E+06	1.00E-03	15	11.640	2.57E-03	1.10E-01	1.76E-04	4.70E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.70E-03	137	1,3,5-Trimethylbenzene	
Convection path length, $L_p$ (cm)	Source vapor conc., $C_{source}$ (µg/m <sup>3</sup> )	Crack radius, $r_{crack}$ (cm)	Average vapor flow rate into bldg., $Q_{soil}$ (cm <sup>3</sup> /s)		Crack effective diffusion coefficient, $D_{crack}$ (cm <sup>2</sup> /s)	Area of crack, $A_{crack}$ (cm <sup>2</sup> )	Exponent of equivalent foundation		Infinite source indoor attenuation coefficient, $\alpha$ (unitless)		Infinite source bldg. conc., $C_{building}$ (µg/m <sup>3</sup> ) <sup>-1</sup>		Unit risk factor, URF	Reference conc., RfC (mg/m <sup>3</sup> )	
			flow rate	into bldg.,			Peclet number, exp(Pe)	foundation	attenuation coefficient, $\alpha$	$C_{building}$					
15	1.00E+00	0.53	4.10E+02	4.10E+02	6.87E-03	4.9E+03	1.02E+79	1.76E-04	1.76E-04	1.76E-04	2.9E-05	3.0E-02	Benzene		
15	1.00E+00	0.53	4.10E+02	4.10E+02	6.79E-03	4.9E+03	8.25E+79	1.75E-04	1.75E-04	1.75E-04	NA	3.0E-01	Toluene		
15	1.00E+00	0.53	4.10E+02	4.10E+02	5.85E-03	4.9E+03	5.05E+92	1.59E-04	1.59E-04	1.59E-04	NA	1.0E+00	Ethylbenzene		
15	1.00E+00	0.53	4.10E+02	4.10E+02	6.79E-03	4.9E+03	8.20E+79	1.75E-04	1.75E-04	1.75E-04	NA	1.0E-01	o-Xylene		
15	1.00E+00	0.53	4.10E+02	4.10E+02	5.46E-03	4.9E+03	2.11E+99	1.52E-04	1.52E-04	1.52E-04	NA	1.0E-01	m-Xylene		
15	1.00E+00	0.53	4.10E+02	4.10E+02	6.00E-03	4.9E+03	2.59E+90	1.61E-04	1.61E-04	1.61E-04	NA	1.0E-01	p-Xylene		
15	1.00E+00	0.53	4.10E+02	4.10E+02	4.73E-03	4.9E+03	5.34E+114	1.37E-04	1.37E-04	1.37E-04	NA	6.0E-03	1,2,4-Trimethylbenzene		
15	1.00E+00	0.53	4.10E+02	4.10E+02	4.70E-03	4.9E+03	3.08E+115	1.37E-04	1.37E-04	1.37E-04	NA	6.0E-03	1,3,5-Trimethylbenzene		

**Table C-1**  
**Soil Gas Risk-Based Concentrations**  
**Astoria Area-Wide Petroleum Site**  
**Astoria, Oregon**

Chemicals of Potential Concern	Molecular Weight g/mol	DEQ Air RBC µg/m <sup>3</sup>	Attenuation Coefficient unitless	Soil Gas RBC	
				µg/m <sup>3</sup>	ppbv
Benzene	78	1.5E+00	1.76E-04	8.5E+03	2.7E+03
Toluene	92	2.0E+04	1.75E-04	1.1E+08	3.0E+07
Ethylbenzene	106	4.2E+03	1.59E-04	2.6E+07	6.1E+06
o-Xylene	106	4.2E+02	1.75E-04	2.4E+06	5.5E+05
m,p-Xylene	106	4.2E+02	1.57E-04	2.7E+06	6.2E+05
1,2,4-Trimethylbenzene	120	2.5E+01	1.37E-04	1.8E+05	3.7E+04
1,3,5-Trimethylbenzene	120	2.5E+01	1.37E-04	1.8E+05	3.7E+04
Gasoline-range organics	103	2.6E+03	1.76E-04	1.5E+07	3.5E+06 <sup>a</sup>

NOTES:  
COPC = chemicals of potential concern.  
DEQ Air RBC = Oregon Department of Environmental Quality risk-based concentration for air for occupational workers (DEQ, 2003).  
µg/m<sup>3</sup> = micrograms per cubic meter.  
ppbv = parts per billion by volume. ppbv = µg/m<sup>3</sup>\*24.45/molecular weight @ 25°C  
<sup>a</sup>The gasoline-range organics RBC units were converted to ppbv using an average molecular weight of 103 grams per mole.