PARSONS 2-1-97

Calculation Sheet

Rev	By	Date	Ck	Date	Title "Back Check" of Equilibrium Equation Using Pre-SVE Soil Gas/Soil Analytical Data
∅	LAB	2/97	CBJ	2/97	
					Author L. Benson Sheet 1 Of 4

Purpose: To verify what simple equilibrium equation, proposed to estimate residual average soil concentration in soil beneath RCRA cap at Person Station from measured soil gas data, reasonably approximates conditions observed at site prior to SVE treatment.

Goal: To demonstrate that relationship can be used to conservatively approximate residual soil concentrations from measured soil gas data.

Relationship:

$$C_v = \frac{H C_s \rho_s}{[\theta_w + K_s \rho_s + H \theta_v]}$$

Reference: Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites, E 1739-95, American Society for Testing and Materials (ASTM)

where:

H = Henry's Law Constant $[(g/g\text{-soil})/(g/cm^3\text{-}H_2O)]$

C_s = soil concentration $(g/g\text{-soil})$

ρ_s = soil bulk density $[(g\text{-soil})/(cm^3\text{-soil})]$

θ_w = volumetric content of soil pore water $[cm^3\text{-}H_2O/cm^3\text{-soil}]$

K_s = sorption coefficient $[(g/g\text{-soil})/(g/cm^3\text{-}H_2O)]$ ($K_{oc} \times f_{oc}$)

θ_v = volumetric content of soil vapor $[cm^3\text{-vapor}/cm^3\text{-soil}]$

C_v = equilibrium soil vapor concentration $[g/cm^3\text{-vapor}]$

f_{oc} = fraction organic carbon content $(g/g\text{-soil})$

Since the objective is to test whether measured soil gas data can be used to reasonably approximate measured soil data, analytical data for both environmental media collected Prior to cap installation/SVE operation will be used (i.e., baseline conditions).

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(b) Parsons ES, 1994, Soil Vapor Concentrations prior to SVE start-up (deep + total) ppbv

	1,1,1-TCA	1,1-DCE	PCE
Max.	120,000	66,000	1,400,000

(c) METRIC/Parsons ES, 1994, soil analytical data – SVE installation

	1,1,1-TCA	1,1-DCE	PCE
Max.			

(d) Geoscience Consultants, Ltd., 1984, Soil analytical data prior to closure cap installation

mg/kg

	1,1,1-TCA	1,1-DCE	PCE	
Max - all	462.2	—	2127.0	
Avg. – all	36.9	—	51.9	
95% UCL*	147.15	—	55.86	(0 to 10' bgs)

* Note: Derivation of 95% UCLs for these data is explained in detail in the 1994b Final Focused Risk Assessment for the Person Generating Station, PNM

Assumed/Measured Site/Chemical Characteristics:

	1,1,1-TCA	1,1-DCE	PCE	Source
H	0.705	1.07	0.754	USEPA, 1996
ρ_s	1.6	1.6	1.6	Geoscience, 1984
θ_w	0.074	0.074	0.074	Geoscience, 1984
K_s	135	65	245	USEPA, 1996
θ_v	0.23	0.23	0.23	Parsons ES, 1994a
f_{oc}	0.0027	0.0027	0.0027	Parsons ES, 1994a

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1994 Soil Gas Data → Predicted Soil Concentrations

Indicator Compound PCE (Total Mass %, "Risk Driver")

$$C_s = \frac{C_v[\theta_w + K_s \rho_s + H\theta_a]}{H\rho_s}$$

$$PCE\left(\frac{g}{g}\right) = \frac{(1.4E6\ ppb)\left(\frac{6.89}{1E12}\right)^{a/}\left[0.074 + (0.7155)(1.6) + (0.754)(0.23)\right]}{(0.754)(1.6)}$$

a/ Conversion for $ppbv_{PCE}$ to $\frac{g}{cm^3}_{PCE}$ ← chemical-specific (NIOSH, 1990)

$$(ppb)\left(\frac{1\ ppm}{1000\ ppb}\right)\left(\frac{6.89\ \frac{mg}{m^3}}{1\ ppm}\right)\left(\frac{g}{1000\ mg}\right)\left(\frac{m}{100\ cm}\right)^3 = \frac{6.89}{1E12}$$

$$PCE\left(\frac{g}{g}\right) = 1.11E\text{-}5 \quad \text{or} \quad PCE\left(\frac{mg}{kg}\right) = 11.13$$

$$\left(\frac{g}{g}\right)\left(\frac{1000\ mg}{g}\right)\left(\frac{1000\ g}{kg}\right) = \frac{mg}{kg}$$

Estimated	1994 Avg.	1994 Max	1984 Avg	1984 95% UCL	1984 Max.
11.13 mg/kg	152.2 mg/kg	880 mg/kg	51.9 mg/kg	55.9 mg/kg (shallow soils only)	2,127 mg/kg

∴ Estimated residual soil concentration for indicator compound PCE using Pre-SVE soil gas data corresponds well to the 1984 average (and 95% UCL) soil concentrations. The 1984 data were collected throughout the soil source area; the 1994 data were collected in the center during VEW/DW installation. The soil gas data reflects the contaminant mass removed from 110+ feet-long soil column, with a radius of influence greater than 55 feet.

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0	LAB	3/97			
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References:

Geoscience Consultants, Ltd. 1984. Final Soil Contamination Assessment and Preliminary Ground Water Contamination Assessment, PNM Person Generating Station

Parsons ES. 1994a. Test Plan for Evaluation of the Soil Vapor Extraction System at Person Generating Station, Public Service Company of New Mexico.

Parsons ES. 1994b. Final Focused Risk Assessment for the Person Generating Station, Public Service Company of New Mexico.

ASTM. 1995. Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites (E1739-95).

US Environmental Protection Agency. 1996. Soil Screening Guidance: Technical Background Document. EPA/540/R-95/128 (May).

NIOSH. 1990. Pocket Guide to Chemical Hazards. DHHS Publication No. 90-117.

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Calculation Sheet

Rev	By	Date	Ck	Date	Title
0	LAB	2/97	CBB	2/97	Estimated Soil Gas Levels Corresponding to Most Stringent Soil Cleanup Goals
					Author L. Benson Sheet 1 Of 2

Purpose: To estimate the soil gas concentrations corresponding to most stringent proposed soil cleanup levels (e.g., USEPA groundwater-protective soil screening levels [SSLs])

Goal: To confirm no measured soil gas concentrations exceed estimated target cleanup levels/indicators.

Relationship:

$$C_v = \frac{H C_s \rho_s}{[\theta_w + K_s \rho_s + H \theta_v]}$$

Reference: ASTM, 1995

Where:

H = Henry's Law Constant $[(g/g\text{-soil})/(g/cm^3\text{-}H_2O)]$

C_s = soil concentration $(g/g\text{-soil})$

ρ_s = soil bulk density $[(g\text{-soil})/(cm^3\text{-soil})]$

θ_w = volumetric content of soil pore water $(cm^3\text{-}H_2O/cm^3_{soil})$

K_s = Sorption Coefficient $[(g/g\text{-soil})/(g/cm^3\text{-}H_2O)]$ $(K_{oc} \times f_{oc})$

θ_v = volumetric content of soil vapor $[cm^3\text{-vapor}/cm^3\text{-soil}]$

C_v = equilibrium soil vapor concentration $(g/cm^3\text{-vapor})$

f_{oc} = fraction organic carbon content $(g/g\text{-soil})$

Target Soil Levels (USEPA, 1996)

1,1,1-TCA	(ug/kg)	= 2000
1,1-DCE	(ug/kg)	= 60
PCE	(ug/kg)	= 60

} Groundwater protective w/ DAF = 20 (depth to GW = 110' most contam. previously existed above 70' bgs)

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Calculation Sheet

Rev	By	Date	Ck	Date	Title: Estimated Soil Gas Levels Corresponding to Most Stringent Soil Cleanup Goals
0	LAB	7/97			
					Author: L. Benson — Sheet 2 Of 2

Assumed / Measured Site/Chemical Characteristics:

	1,1,1-TCA	1,1-DCE	PCE	Source
H	0.705	1.07	0.754	USEPA, 1996
ρ_s	1.6	1.6	1.6	Geoscience, 1984
θ_w	0.074	0.074	0.074	Geoscience, 1984
K_s	135	65	265	USEPA, 1996
θ_v	0.23	0.23	0.23	Parsons, 1994
foc	0.0027	0.0027	0.0027	Parsons, 1994

Example Calculation:

$$PCE\left(\frac{g}{cm^3}\right) = \frac{(0.754)(60\ \frac{ug}{Kg})\left(\frac{1}{1E9}\right)^{a/}(1.6)}{[0.074 + (0.7155)(1.6) + (0.754)(0.23)]}$$

a/ $\frac{ug}{Kg} \Rightarrow \frac{g}{g}$ $\therefore \left(\frac{ug}{Kg}\right)\left(\frac{mg}{1000ug}\right)\left(\frac{g}{1000mg}\right)\left(\frac{1\ Kg}{1000\ g}\right) = \frac{1}{1E9}$

↑ units of C_s

$PCE\left(\frac{g}{cm^3}\right) = 5.2E-8$ or $PCE(ppbv) = 7,546$

↑ $\left(\frac{g}{cm^3}\right)\left(\frac{100cm}{m}\right)^3\left(\frac{1000\ mg}{g}\right)\left(\frac{1\ ppm}{6.89\ mg/m^3}\right)\left(\frac{1000\ ppb}{1\ ppm}\right) = ppbv$

∴ Would need to measure at least 16.1 ppbv PCE in soil gas to suggest residual soil PCE concentrations exceed most stringent USEPA SSLs appropriate for site.

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Calculation Sheet

Rev	By	Date	Ck	Date	Title
0	LAB	2/97	CLB	2/97	Calculation Residual Soil Concentrations Using Sept 1996 Soil Gas Data
					Author L. Benson Sheet 1 Of 1

Purpose: To estimate the residual soil concentrations from most recent soil gas analytical data.

Relationship:

$$C_v = \frac{H C_s \rho_s}{[\theta_w + K_s \rho_s + H \theta_v]}$$

where all elements are as described and defined previously.

Sept 96 $\Rightarrow$ PCE = 3.3 $\frac{mg}{m^3}$ = 3.3E-9 g/cm^3 TCA = 0.42 $\frac{mg}{m^3}$ = 4.2E-10 g/cm^3 DCE = 1.3 $\frac{mg}{m^3}$ = 1.3E-9 g/cm^3

PCE $\Rightarrow$ $\frac{(3.3E\text{-}9)[0.074 + (0.7155)(1.6) + (0.754)(0.23)]}{(0.754)(1.6)}$

$\Rightarrow$ 3.81E-9 $\frac{g}{g}$ or 3.81E-3 $\frac{mg}{kg}$

TCA $\Rightarrow$ $\frac{(4.2E\text{-}10)[0.074 + (0.364)(1.6) + (0.705)(0.23)]}{(0.705)(1.6)}$

$\Rightarrow$ 3.05-10 $\frac{g}{g}$ or 3.05E-4 $\frac{mg}{kg}$

DCE $\Rightarrow$ $\frac{(1.3E\text{-}9)[0.074 + (0.1755)(1.6) + (1.07)(0.23)]}{(1.07)(1.6)}$

$\Rightarrow$ 4.56E-10 $\frac{g}{g}$ or 4.56E-4 $\frac{mg}{kg}$