APPENDIX H

Dermal Exposure Model

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A. Introduction

The exposure model for dermal contact with ground water includes the term DA_{event}, which represents the absorbed dose per unit surface area of exposed skin during a single contact event. The methodology used to calculate the DA_{event} term is presented in USEPA 2001 and is based on previous work presented in USEPA's Dermal Exposure Assessment (USEPA 1992). All chemical-specific and default inputs used in the calculation of DA_{event} and all associated references are presented in Table H-1. For a more detailed description of the theory and analysis used to develop the following equations, the reader is referred to Appendix A of USEPA 2001.

B. Estimating DA_{event} for Inorganic Compounds

For inorganic compounds, the DA_{event} term is calculated as follows:

$$DA_{event} = K_p^w \cdot C_w \cdot t_{event}$$

where,

K_p^w = chemical-specific permeability coefficient from water (cm/hr);
C_w = concentration of compound in water (mg/cm^3); and
t_{event} = duration of contact event (hr).

The input values used for each chemical evaluated are presented in Table H-1. For the K_p^w term, a default value of 0.001 cm/hr was used for inorganic chemicals for which no chemical-specific value is provided in USEPA 2001 (Exhibit B-4).

C. Estimating DA_{event} for Organic Compounds

For organic compounds, the DA_{event} for each chemical of potential concern is calculated according to the following series of equations:

$$\log K_p^w = -2.80 + 0.66 \cdot \log K_{o/w} - 0.0056 \cdot MW$$

$$B = K_p^w \frac{\sqrt{MW}}{2.6}$$

where,

K_p^w = chemical-specific permeability coefficient from water (cm/hr);

$K_{o/w}$ = octanol-water partition coefficient (unitless);
MW = molecular weight (g/mol); and
B = chemical-specific parameter (unitless).

The stratum corneum diffusion coefficient (D_{sc}) is calculated by the following:

$$\log \frac{D_{sc}}{l_{sc}} = -2.80 - 0.0056 \cdot MW$$

where,

l_{sc} = stratum corneum length, 10^{-3} cm.

The remaining model inputs, τ and t^* (both in units of hours), are determined according to the following:

$$\tau = \frac{l_{sc}^2}{6 \cdot D_{sc}} = 0.105 \times 10^{0.0056 \cdot MW}$$

and

If $B \leq 0.6$ then

$$t^* = 2.4 \cdot \tau$$

Otherwise,

$$t^* = 6 \cdot \left(b - \sqrt{b^2 - c^2}\right) \cdot \tau$$

where,

$$b = \frac{2}{\pi} \cdot (1 + B)^2 - c; \text{ and}$$

$$c = \frac{1 + 3 \cdot B + 3 \cdot B^2}{3 \cdot (1 + B)}$$

where,

D_{sc} = effective diffusion coefficient for chemical transfer through the stratum corneum (cm^2/hr);

τ	=	lag time per event (hr/event);
t*	=	time to reach steady-state (hr); and
b,c	=	correlation coefficients that have been fitted to experimental data.

Finally, DA_{event} is calculated according to the following:

If $t_{event} < t^*$ then

$$DA_{event} = 2 \cdot FA \cdot K_p^w \cdot C_w \cdot \sqrt{\frac{6 \cdot \tau \cdot t_{event}}{\pi}}$$

If $t_{event} > t^*$ then

$$DA_{event} = FA \cdot K_p^w \cdot C_w \cdot \left[\frac{t_{event}}{1+B} + 2 \cdot \tau \cdot \left(\frac{1+3 \cdot B+3 \cdot B^2}{(1+B)^2} \right) \right]$$

where,

FA	=	chemical-specific fraction adsorbed (unitless).

The chemical concentrations in water, chemical-specific inputs, and the results of the DA_{event} calculation for each applicable COPC in both the NEA and SEA are presented in Table H-1.

D. References

Mackay, D., Shiu, W., and Ma, K. 1995. *Illustrated Handbook of Physical-Chemical Properties and Environmental Fate of Organic Chemicals*. Vol. 4, *Oxygen, Nitrogen, and Sulfur Containing Compounds*. Boca Raton, New York, London, Tokyo: CRC Press, Inc.

U.S. Environmental Protection Agency (USEPA). 1992. *Dermal Exposure Assessment Principles and Applications*. Office of Health and Environmental Assessment. EPA/600/8-91/011B. January.

U.S. Environmental Protection Agency (USEPA). 2001. *Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Interim*. Office of Emergency and Remedial Response, Washington, D.C. EPA/540/R/99/005. September.

TABLE H-1
Summary of Dermal Exposure Model Parameters

Chemical	C_w (µg/L)	log $K_{o/w}$ [a,b]	MW [a,b] (g/mol)	K_p [w(c,d)] (cm/hr)	B [c]	D_{sc} [c] (cm^2/hr)	Tau [c] (hr)	b [c]	c [c]	t* [c] (hr)	FA [e]	t_{event} [f] (hr)	DA_{event} [c] (mg/cm^2-event)
Northern Exposure Area													
Acetone	3	-0.24	58.08	5.20E-04	1.53E-03	7.49E-07	2.22E-01	3.04E-01	3.34E-01	5.34E-01	1	1	2.25E-09
Carbon tetrachloride	1.6	2.83	153.82	1.61E-02	7.67E-02	2.18E-07	7.64E-01	3.52E-01	3.86E-01	1.83E+00	1	1	6.22E-08
Chloroform	150	1.97	119.38	6.79E-03	2.85E-02	3.40E-07	4.90E-01	3.21E-01	3.53E-01	1.18E+00	1	1	1.97E-06
Tetrachloroethene	1	3.4	165.8	3.28E-02	1.62E-01	1.87E-07	8.92E-01	4.11E-01	4.49E-01	2.14E+00	1	1	8.55E-08
Toluene	0.27	2.73	92.14	3.06E-02	1.13E-01	4.83E-07	3.45E-01	3.76E-01	4.12E-01	8.28E-01	1	1	1.38E-08
Aluminum	82600			1.00E-03								1	8.26E-05
Arsenic	142			1.00E-03								1	1.42E-07
Barium	1150			1.00E-03								1	1.15E-06
Beryllium	5.1			1.00E-03								1	5.10E-09
Cadmium	3.5			1.00E-03								1	3.50E-09
Chromium (hexavalent)	97.3			1.00E-03								1	9.73E-08
Chromium (total)	85			1.00E-03								1	8.50E-08
Cobalt	0.37			1.00E-03								1	3.70E-10
Copper	71.9			1.00E-03								1	7.19E-08
Iron	68500			1.00E-03								1	6.85E-05
Lead	37			1.00E-03								1	3.70E-08
Magnesium	570000			1.00E-03								1	5.70E-04
Manganese	1130			1.00E-03								1	1.13E-06
Molybdenum	824			1.00E-03								1	8.24E-07
Nickel	63.6			1.00E-03								1	6.36E-08
Selenium	128			1.00E-03								1	1.28E-07
Silver	1.1			1.00E-03								1	1.10E-09
Thorium	24.1			1.00E-03								1	2.41E-08
Titanium	1830			1.00E-03								1	1.83E-06
Vanadium	158			1.00E-03								1	1.58E-07
Zinc	262			1.00E-03								1	2.62E-07
Total Cyanide	2.9			1.00E-03								1	2.90E-09

TABLE H-1
Summary of Dermal Exposure Model Parameters

Chemical	C_w (µg/L)	log $K_{o/w}$ [a,b]	MW [a,b] (g/mol)	K_p [w(c,d)] (cm/hr)	B [c]	D_{sc} [c] (cm^2/hr)	Tau [c] (hr)	b [c]	c [c]	t* [c] (hr)	FA [e]	t_{event} [f] (hr)	DA_{event} [c] (mg/cm^2-event)
Southern Exposure Area													
Acetone	2.8	-0.24	58.08	5.20E-04	1.53E-03	7.49E-07	2.22E-01	3.04E-01	3.34E-01	5.34E-01	1	1	2.10E-09
Carbon tetrachloride	0.325	2.83	153.82	1.61E-02	7.67E-02	2.18E-07	7.64E-01	3.52E-01	3.86E-01	1.83E+00	1	1	1.26E-08
Chloroform	93	1.97	119.38	6.79E-03	2.85E-02	3.40E-07	4.90E-01	3.21E-01	3.53E-01	1.18E+00	1	1	1.22E-06
Tetrachloroethene	3.3	3.4	165.8	3.28E-02	1.62E-01	1.87E-07	8.92E-01	4.11E-01	4.49E-01	2.14E+00	1	1	2.82E-07
Toluene	0.72	2.73	92.14	3.06E-02	1.13E-01	4.83E-07	3.45E-01	3.76E-01	4.12E-01	8.28E-01	1	1	3.67E-08
Aluminum	844			1.00E-03								1	8.44E-07
Arsenic	86.3			1.00E-03								1	8.63E-08
Barium	12.1			1.00E-03								1	1.21E-08
Beryllium	0.05			1.00E-03								1	5.00E-11
Cadmium	1.1			1.00E-03								1	1.10E-09
Chromium (hexavalent)	82.3			1.00E-03								1	8.23E-08
Chromium (total)	60.2			1.00E-03								1	6.02E-08
Cobalt	0.03			1.00E-03								1	3.00E-11
Copper	9.75			1.00E-03								1	9.75E-09
Iron	769			1.00E-03								1	7.69E-07
Lead	0.215			1.00E-03								1	2.15E-10
Magnesium	310000			1.00E-03								1	3.10E-04
Manganese	6.1			1.00E-03								1	6.10E-09
Molybdenum	292			1.00E-03								1	2.92E-07
Nickel	24.3			1.00E-03								1	2.43E-08
Selenium	47.3			1.00E-03								1	4.73E-08
Silver	0.065			1.00E-03								1	6.50E-11
Thorium	0.48			1.00E-03								1	4.80E-10
Titanium	7.4			1.00E-03								1	7.40E-09
Vanadium	29.7			1.00E-03								1	2.97E-08
Zinc	5.6			1.00E-03								1	5.60E-09
Total Cyanide	1.25			1.00E-03								1	1.25E-09

References:
a - Value for acetone from Mackay et al (1995)
b - Exhibit B-2, USEPA 2001
c - Calculated according to equations presented in USEPA 2001
d - For inorganics, Exhibit B-4, USEPA 2001 (default value = 0.001)
e - Exhibit B-3, USEPA 2001 (default value = 1)
f - ENVIRON assumption