

APPENDIX D

SAMPLE SCREENING CALCULATIONS

D.1 SAMPLE CANCER SCREENING CALCULATION FOR DERMAL CONTAMINANTS IN WATER

The equations used in calculating the risk from dermal exposure for contaminants in water are summarized in Exhibit D-1. This example illustrates the steps used to calculate the clean-up level from dermal exposure to compounds in water given an acceptable risk of 10^{-6} . The default scenarios used in the calculations are (1) the adult 30 year exposure, and (2) an age-adjusted 30 year exposure incorporating a child bathing for 1 hour/event (RME value), once a day, 350 days/year for 6 years and an adult showering at 35 min/event (RME value), once a day, 350 days/year for 24 years. The general equations are presented for any compound, and the example gives the calculation for one compound in water with a cancer risk of 10^{-6} .

EXHIBIT D-1
SUMMARY OF DERMAL RISK ASSESSMENT PROCESS

| Risk Assessment Process | | Cancer Risk | | Hazard Index | |
|-------------------------|---|--|----------------------------------|---|----------------------------------|
| Hazard ID | | Section 2 | | Section 2 | |
| Exposure Assessment | Child or Adult | Water Dose | Soil Dose | Water Dose | Soil Dose |
| | | Section 3.1, Equations 3.1-3.4 Appendix A | Section 3.2, Equations 3.11/3.12 | Section 3.1, Equations 3.1-3.4 | Section 3.2, Equations 3.11/3.12 |
| | Age-adjusted Child/Adult SFS _{ADJ} | See Note | Section 3.2.2.5 Equation 3.21 | See Note | Section 3.2.2.5, Equation 3.21 |
| Toxicity Assessment | | Section 4, SF _{ABS} , Equation 4.2 | | Section 4, RfD _{ABS} , Equation 4.3 | |
| Risk Characterization | | Section 5.1, Equation 5.1 DAD x SF _{ABS} | | Section 5.1, Equation 5.2 DAD/RfD _{ABS} | |
| | | Uncertainty Analysis Section 5.2 | | | |

Note: The calculations used in developing the screening tables in Appendix B (Exhibits B-3 and B-4) for the water pathway determined that the adult receptor experiences the highest dermal dose. Therefore, the adult exposure scenario is recommended for screening purposes. However, if an age-adjusted exposure scenario for the dermal route is selected to be consistent with methods for determining the risk of other routes of exposure (e.g., oral), sample calculations are provided as guidance.

Procedures: Given a cancer risk level at 10^{-6}

1) For cancer risk, from Equation 5.1:

$$DAD = \frac{\text{Dermal cancer risk}}{SF_{ABS}} = \frac{(\text{Dermal cancer risk}) \times (ABS_{GI})}{SF_o} \quad (D.1)$$

2) For hazard quotient, from Equation 5.2:

$$\begin{aligned} DAD &= \text{Dermal hazard quotient} \times RfD_{ABS} \\ &= \text{Dermal hazard quotient} \times RfD_o \times ABS_{GI} \end{aligned} \quad (D.2)$$

3) Evaluate DA_{event} from Equation 3.1

$$DA_{event} = \frac{DAD \times BW \times AT}{EV \times ED \times EF \times SA} \quad (D.3)$$

4) Evaluate permissible water concentration C_w :

For organics, from Equations 3.2 and 3.3:

$$\text{If } t_{event} \leq t^*, \text{ then: } C_w = \frac{DA_{event}}{2 \times FA \times K_p \sqrt{\frac{6 \tau_{event} \times t_{event}}{\pi}}} \quad (D.4)$$

$$\text{If } t_{event} > t^*, \text{ then: } C_w = \frac{DA_{event}}{FA \times K_p \left[\frac{t_{event}}{1+B} + 2 \tau_{event} \left(\frac{1+3B+3B^2}{(1+B)^2} \right) \right]} \quad (D.5)$$

For inorganics, from Equation 3.4:

$$C_w = \frac{DA_{event}}{K_p \times t_{event}} \quad (D.6)$$

| Parameter | Definition | Default - Child | Default - Adult |
|------------------------|--|------------------------|------------------------|
| TRL | Target Risk Level (unitless) | 10^{-6} | 10^{-6} |
| BW | Body Weight (kg) | 15 | 70 |
| AT | Averaging Time (yr) | 70 | 70 |
| SF _{ABS} | Absorbed Cancer Slope Factor (mg/kg-day) ⁻¹ | chemical-specific | chemical-specific |
| ED | Exposure Duration (yr) | 6 | 30 |
| EV | Event Frequency (events/day) | 1 | 1 |
| EF | Exposure Frequency (days/yr) | 350 | 350 |
| FA | Fraction Absorbed (unitless) | chemical-specific | chemical-specific |
| t _{event-RME} | Event Duration (hr) | 1 (bathing) | 0.58 (showering) |
| SA | Surface Area (cm ²) | 6,600 | 18,000 |
| K _p | Permeability coefficient (cm/hr) | chemical-specific | chemical-specific |
| ABS _{GI} | Absorption Fraction (unitless) | chemical-specific | chemical-specific |
| τ _{event} | Lag time per event (hr) | chemical-specific | chemical-specific |
| SF _o | Oral Cancer Slope Factor (mg/kg-day) | chemical-specific | chemical-specific |
| t* | Time to Reach Steady-State (hr) | chemical-specific | chemical-specific |
| DAD | Dermal Absorbed Dose (mg/kg-day) | site-specific | site-specific |
| DAD _{event} | Absorbed Dose per Event (mg/cm ² -event) | site-specific | site-specific |

Sample Calculations for Exposure to a Carcinogen in Water
Tetrachloroethylene (PCE)

$$SF_o = 5.2 \times 10^{-2} \text{ (mg/kg-d)}^{-1}$$

$$K_p = 0.033 \text{ cm/hr}$$

$$ABS_{GI} = 1$$

$$t^* = 2.18 \text{ hr}$$

$$\tau_{event} = 0.91 \text{ hr}$$

$$t_{event} = 0.58 \text{ hr}$$

$$FA = 1$$

Residential exposure scenarios

Using Equations D.1, D.3 and D.4 and default values presented:

Adult:

$$DA_{event} = DAD \times AT \left[\frac{BW_{adult}}{EV_a \times ED_a \times EF_a \times SA_a} \right] \quad (D.3)$$

$$DA_{event} = (1.9 \times 10^{-5} \text{ mg/kg-day}) (25550 \text{ day}) \left[\frac{70 \text{ kg}}{1 \text{ event/day} \times 30 \text{ yr} \times 350 \text{ day/yr} \times 18,000 \text{ cm}^2} \right] = 1.8 \times 10^{-7} \text{ mg/cm}^2\text{-event}$$

$$C_w = \frac{DA_{event}}{2 \times FA \times K_p \sqrt{\frac{6 \tau_{event} \times t_{event}}{\pi}}} \quad (D.4)$$

$$C_w = \frac{1.8 \times 10^{-7} \text{ mg/cm}^2\text{-event}}{2 (1) (0.033 \text{ cm/hr}) \sqrt{\frac{6 \times 0.91 \text{ hr} \times 0.58 \text{ hr}}{\pi}}} = 2.7 \times 10^{-6} \text{ mg/cm}^3$$

$$C_w = 2.7 \times 10^{-6} \text{ mg/cm}^3 = 2.7 \text{ } \mu\text{g/L} = 2.7 \text{ ppb}$$

Age-Adjusted:

$$DA_{event} = DAD \times AT \left[\frac{BW_{child}}{EV_c \times ED_c \times EF_c \times SA_c} + \frac{BW_{adult}}{EV_a \times ED_a \times EF_a \times SA_a} \right]$$

Note: age-adjusted t_{event} for 6 years as child and 24 years as adult.

$$t_{event} = \frac{(6 \text{ year} \times 1 \text{ hr/event}) + (24 \text{ years} \times 0.58 \text{ hr/event})}{30 \text{ years}}$$

$$t_{event} = 0.66 \text{ hr/event}$$

$$DA_{event} = (1.9 \times 10^{-5} \text{ mg/kg-day}) (25550 \text{ day}) \left[\frac{15 \text{ kg}}{1 \text{ event/day} \times 6 \text{ yr} \times 350 \text{ day/yr} \times 6,600 \text{ cm}^2} + \frac{70 \text{ kg}}{1 \text{ event/day} \times 24 \text{ yr} \times 350 \text{ day/yr} \times 18,000 \text{ cm}^2} \right]$$

$$DA_{event} = 7.5 \times 10^{-7} \text{ mg/cm}^2\text{-event}$$

$$C_w = \frac{7.5 \times 10^{-7} \text{ mg/cm}^2\text{-event}}{2 (1) (0.033 \text{ cm/hr}) \sqrt{\frac{6 \times 0.91 \text{ hr} \times 0.66 \text{ hr}}{\pi}}} = 1.1 \times 10^{-5} \text{ mg/cm}^3$$

$$1.1 \times 10^{-5} \text{ mg/cm}^3 = 11 \text{ ug/L} = 11 \text{ ppb}$$

D.2 SAMPLE NON-CANCER SCREENING CALCULATION FOR CONTAMINANTS IN RESIDENTIAL SOIL

The equations to be used in the determination of a dermal hazard index for residential soil contamination are outlined in Exhibit 5-1. This example uses cadmium in soil and calculates a level of concern that is equal to a hazard index of 1. Following the four steps of the risk assessment process.

Hazard ID: cadmium has both an oral reference dose and ABS_d to allow for a quantitative evaluation.

Exposure Assessment: the scenario to be evaluated is residential soil. Equations 3.11 and 3.12 are combined and solved for the soil concentration C_{soil} resulting in the following.

Example Dermal Calculations Using Child, Adult, and Age-Adjusted Scenarios:

Screening Level Equation for Dermal Contact with Non-Carcinogenic Contaminants in Residential Soil

Equation for use with age-adjusted parameters:

$$C_{soil} = \frac{THQ \times RfD \times BW \times AT \times 365 \text{ days/yr} \times 10^6 \text{ mg/kg}}{ED \times EV \times EF \times SA \times AF \times ABS_d}$$

$$C_{soil} = \frac{THQ \times RfD \times AT \times 365 \text{ days/yr} \times 10^6 \text{ mg/kg}}{EV \times EF \times SFS_{adj} \times ABS_d}$$

| Parameter | Definition | Default - Child | Default - Adult | Default - Age-Adjusted |
|-----------|-----------------------------------|-----------------|-----------------|------------------------|
| THQ | Target Hazard Quotient (unitless) | 1 | 1 | 1 |
| BW | Body Weight (kg) | 15 | 70 | – |

| Parameter | Definition | Default - Child | Default - Adult | Default - Age-Adjusted |
|--------------------|---|------------------------|------------------------|-------------------------------|
| AT | Averaging Time (yr) | 6 | 30 | 30 |
| RfD | Reference Dose (mg/kg-day) | chemical-specific | chemical-specific | chemical-specific |
| ED | Exposure Duration (yr) | 6 | 30 | – |
| EV | Event Frequency (events/day) | 1 | 1 | 1 |
| EF | Exposure Frequency (days/yr) | 350 | 350 | 350 |
| SA | Surface Area (cm ²) | 2800 | 5700 | – |
| AF | Adherence Factor (mg/cm ² -event) | 0.2 | 0.07 | – |
| ABS | Absorption Fraction (unitless) | chemical-specific | chemical-specific | chemical-specific |
| SFS _{adj} | Age-Adjusted Dermal Factor (see equation below) | – | – | 360 |

The age-adjusted, body-part weighted dermal factor is as presented in Section 3.2.2.5.

$$SFS_{adj} = \frac{(SA_{1-6}) \times (AF_{1-6}) \times (ED_{1-6})}{(BW_{1-6})} + \frac{(SA_{7-31}) \times (AF_{7-31}) \times (ED_{7-31})}{(BW_{7-31})}$$

$$SFS_{adj} = \frac{(2800cm^2) \times (0.2mg/cm^2-event) \times (6yr)}{(15kg)} + \frac{(5700cm^2) \times (0.07mg/cm^2-event) \times (24yr)}{(70kg)}$$

$$SFS_{adj} = 360 \text{ mg-yrs/kg-event}$$

The dermal absorption fraction for cadmium comes from Exhibit 3-4 and is 0.001.

Toxicity Assessment: In order to determine the dermal reference dose, data from Exhibit 4-1 suggests that the gastrointestinal adjustment for cadmium is either 5% for water or, more applicable for this example, 2.5% from food. Therefore, the dermal reference dose is 3E-5 (mg/kg-day) using Equation 4.3, the oral reference dose of 1E-3 from food, and a GI absorption of 2.5%. Note: since the pharmacokinetic model used to derive the oral RfD is based on human data and the differential absorption data between different media is taken into account, the dermal reference dose would be the same via either media, food or water.

$$RfD_{ABS} = RfD_o \times ABS_{GI}$$

$$(1 \times 10^{-3} \text{ mg/kg-day}) \times (0.025) = 2.5 \times 10^{-5} \text{ mg/kg-day}$$

Risk Characterization: Incorporating all the previous data results in the following:

Sample Calculations for Exposure to a Non-Carcinogen
Cadmium

Child:

$$C_{soil} = \frac{(1) \times (0.000025 \text{ mg/kg-day}) \times (15 \text{ kg}) \times (6 \text{ yr}) \times (365 \text{ days/yr}) \times (10^6 \text{ mg/kg})}{(6 \text{ yr}) \times (1 \text{ event/day}) \times (350 \text{ days/yr}) \times (2800 \text{ cm}^2) \times (0.2 \text{ mg/cm}^2\text{-event}) \times (0.001)}$$

$$C_{soil} = 700 \text{ mg/kg} = 700 \text{ ppm}$$

Adult:

$$C_{soil} = \frac{(1) \times (0.000025 \text{ mg/kg-day}) \times (70 \text{ kg}) \times (30 \text{ yr}) \times (365 \text{ days/yr}) \times (10^6 \text{ mg/kg})}{(30 \text{ yr}) \times (1 \text{ event/day}) \times (350 \text{ days/yr}) \times (5700 \text{ cm}^2) \times (0.07 \text{ mg/cm}^2\text{-event}) \times (0.001)}$$

$$C_{soil} = 4,600 \text{ mg/kg} = 4,600 \text{ ppm}$$

Age-Adjusted:

$$C_{soil} = \frac{(1) \times (0.000025 \text{ mg/kg-day}) \times (30 \text{ yr}) \times (365 \text{ days/yr}) \times (10^6 \text{ mg/kg})}{(1 \text{ event/day}) \times (350 \text{ days/yr}) \times (360 \text{ mg-yr/kg-event}) \times (0.001)}$$

$$C_{soil} = 2,200 \text{ mg/kg} = 2,200 \text{ ppm}$$