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APPENDIX B

ESTIMATING MEDIA CONCENTRATION EQUATIONS AND VARIABLE VALUES

Screening Level Ecological Risk Assessment Protocol

August 1999

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LIST OF VARIABLES AND PARAMETERS

γ = Empirical constant (unitless)
λ_z = Dimensionless viscous sublayer thickness (unitless)
μ_a = Viscosity of air (g/cm-s)
μ_w = Viscosity of water corresponding to water temperature (g/cm-s)
ρ_a = Density of air (g/cm^3 or g/m^3)
ρ_w = Density of water corresponding to water temperature (g/cm^3)
θ = Temperature correction factor (unitless)
θ_{bs} = Bed sediment porosity (L volume/L sediment)—unitless
θ_{sw} = Soil volumetric water content (mL water/cm^3 soil)

a = Empirical intercept coefficient (unitless)
A = Surface area of contaminated area (m^2)
A_I = Impervious watershed area receiving COPC deposition (m^2)
A_L = Total watershed area receiving COPC deposition (m^2)
A_W = Water body surface area (m^2)

b = Empirical slope coefficient (unitless)
BD = Soil bulk density (g soil/cm^3 soil)
$BCFr$ = Plant-soil biotransfer factor (mg COPC/kg DW plant)/(mg COPC/kg soil)—unitless
BS = Benthic solids concentration (g sediment/cm^3 sediment)
Bs = Soil bioavailability factor (unitless)
Bv = Air-to-plant biotransfer factor (mg COPC/kg DW plant)/(mg COPC/kg air)—unitless

c = Junge constant = 1.7×10^{-4} (atm-cm)
C = USLE cover management factor (unitless)
C_d = Drag coefficient (unitless)
C_{dw} = Dissolved phase water concentration (mg COPC/L water)
C_{hp} = Unitized hourly air concentration from vapor phase (μg-s/g-m^3)
C_{hv} = Unitized hourly air concentration from particle phase (μg-s/g-m^3)
Cs = COPC concentration in soil (mg COPC/kg soil)
C_{sed} = COPC concentration in bed sediment (mg COPC/kg sediment)
C_{wctot} = Total COPC concentration in water column (mg COPC/L water column)
C_{wtot} = Total water body COPC concentration including water column and bed sediment (g COPC/m^3 water body) or (mg/L)
Cyp = Unitized yearly average air concentration from particle phase (μg-s/g-m^3)
Cyv = Unitized yearly average air concentration from vapor phase (μg-s/g-m^3)
$Cywv$ = Unitized yearly average air concentration from vapor phase (over water body or watershed) (μg-s/g-m^3)

D_a = Diffusivity of COPC in air (cm^2/s)
d_{bs} = Depth of upper benthic sediment layer (m)

Ds = Deposition term (mg COPC/kg soil-yr)
d_{wc} = Depth of water column (m)
D_w = Diffusivity of COPC in water (cm^2/s)
$Dydp$ = Unitized yearly average dry deposition from particle phase (s/m^2-yr)
$Dytwp$ = Unitized yearly average total (wet and dry) deposition from particle phase (over water body or watershed) (s/m^2-yr)
$Dywp$ = Unitized yearly average wet deposition from particle phase (s/m^2-yr)
$Dywv$ = Unitized yearly average wet deposition from vapor phase (s/m^2-yr)
$Dywwv$ = Unitized yearly average wet deposition from vapor phase (over water body or watershed) (s/m^2-yr)
d_z = Total water body depth (m)

ER = Soil enrichment ratio (unitless)
E_v = Average annual evapotranspiration (cm/yr)

f_{bs} = Fraction of total water body COPC concentration in benthic sediment (unitless)
Fd = Fraction of diet that is soil (unitless)
Fw = Fraction of COPC wet deposition that adheres to plant surfaces (unitless)
f_{wc} = Fraction of total water body COPC concentration in the water column (unitless)
F_v = Fraction of COPC air concentration in vapor phase (unitless)

H = Henry’s Law constant (atm-m^3/mol)

I = Average annual irrigation (cm/yr)

k = Von Karman’s constant (unitless)
K = USLE erodibility factor (ton/acre)
k_b = Benthic burial rate constant (yr^{-1})
Kd_{bs} = Bed sediment/sediment pore water partition coefficient (cm^3 water/g bottom sediment or L water/kg bottom sediment)
Kd_s = Soil-water partition coefficient (cm^3 water/g soil)
Kd_{sw} = Suspended sediment-surface water partition coefficient (L water/kg suspended sediment)
K_G = Gas phase transfer coefficient (m/yr)
K_L = Liquid phase transfer coefficient (m/yr)
K_{oc} = Soil organic carbon-water partition coefficient (mL water/g soil)
K_{ow} = Octanol-water partition coefficient (mg COPC/L octanol)/(mg COPC/L octanol)—unitless
kp = Plant surface loss coefficient (yr^{-1})
ks = COPC soil loss constant due to all processes (yr^{-1})
kse = COPC loss constant due to soil erosion (yr^{-1})
ksg = COPC loss constant due to biotic and abiotic degradation (yr^{-1})
ksl = COPC loss constant due to leaching (yr^{-1})
ksr = COPC loss constant due to surface runoff (yr^{-1})
ksv = COPC loss constant due to volatilization (yr^{-1})
k_v = Water column volatilization rate constant (yr^{-1})
K_v = Overall COPC transfer rate coefficient (m/yr)
k_{wt} = Overall total water body dissipation rate constant (yr^{-1})

L_{DEP} = Total (wet and dry) particle phase and wet vapor phase COPC direct deposition load to water body (g/yr)
L_{Dif} = Vapor phase COPC diffusion (dry deposition) load to water body (g/yr)
L_E = Soil erosion load (g/yr)
L_R = Runoff load from pervious surfaces (g/yr)
L_{RI} = Runoff load from impervious surfaces (g/yr)
L_T = Total COPC load to the water body (including deposition, runoff, and erosion) (g/yr)
LS = USLE length-slope factor (unitless)

OC_{sed} = Fraction of organic carbon in bottom sediment (unitless)

p°_L = Liquid phase vapor pressure of chemical (atm)
p°_S = Solid phase vapor pressure of chemical (atm)
P = Average annual precipitation (cm/yr)
PF = USLE supporting practice factor (unitless)
Pd = Plant concentration due to direct deposition (mg COPC/kg DW)
Pr = Plant concentration due to root uptake (mg COPC/kg DW)
Pv = Plant concentration due to air-to-plant transfer (μg COPC/g DW plant tissue or mg COPC/kg DW plant tissue)

Q = COPC-specific emission rate (g/s)

r = Interception fraction—the fraction of material in rain intercepted by vegetation and initially retained (unitless)
R = Universal gas constant (atm-m^3/mol-K)
RO = Average annual surface runoff from pervious areas (cm/yr)
RF = USLE rainfall (or erosivity) factor (yr^{-1})
Rp = Interception fraction of the edible portion of plant (unitless)

SD = Sediment delivery ratio (unitless)
ΔSf = Entropy of fusion [$\Delta S_f/R$ = 6.79 (unitless)]
SF = Slope factor (mg/kg-day)$^{-1}$
S_T = Whitby's average surface area of particulates (aerosols)
= 3.5×10^{-6} cm^2/cm^3 air for background plus local sources
= 1.1×10^{-5} cm^2/cm^3 air for urban sources

T_a = Ambient air temperature (K)
T_1 = Time period at the beginning of combustion (yr)
T_2 = Length of exposure duration (yr)
tD = Time period over which deposition occurs (or time period of combustion) (yr)
T_m = Melting point of chemical (K)
Tp = Length of plant exposure to deposition per harvest of edible portion of plant (yr)
TSS = Total suspended solids concentration (mg/L)
T_{wk} = Water body temperature (K)
$t_{1/2}$ = Half-time of COPC (days)

u = Current velocity (m/s)

Vdv = Dry deposition velocity (cm/s)
Vf_x = Average volumetric flow rate through water body (m^3/yr)

W = Average annual wind speed (m/s)

X_e = Unit soil loss (kg/m^2-yr)

Yh = Dry harvest yield = 1.22×10^{11} kg DW, calculated from the 1993 U.S. average wet weight Yh of 1.35×10^{11} kg (USDA 1994b) and a conversion factor of 0.9 (Fries 1994)
Yh_i = Harvest yield of ith crop (kg DW)
Yp = Yield or standing crop biomass of the edible portion of the plant (productivity) (kg DW/m^2)

Z_s = Soil mixing zone depth (cm)

0.01 = Units conversion factor (kg cm^2/mg-m^2)
10^{-6} = Units conversion factor (g/µg)
10^{-6} = Units conversion factor (kg/mg)
0.31536 = Units conversion factor (m-g-s/cm-µg-yr)
365 = Units conversion factor (days/yr)
907.18 = Units conversion factor (kg/ton)
0.1 = Units conversion factor (g-kg/cm^2-m^2)
0.001 = Units conversion factor (kg-cm^2/mg-m^2)
100 = Units conversion factor (mg-cm^2/kg-cm^2)
1000 = Units conversion factor (mg/g)
4047 = Units conversion factor (m^2/acre)
1×10^3 = Units conversion factor (g/kg)
3.1536×10^7 = Units conversion factor (s/yr)

TABLE B-1-1

SOIL CONCENTRATION DUE TO DEPOSITION (SOIL EQUATIONS)

(Page 1 of 9)

Description
The equation in this table is used to calculate the highest annual average COPC concentration in soil resulting from wet and dry deposition of particles and vapors to soil. COPCs are assumed to be incorporated only to a finite depth (the soil mixing depth, Z_s). The highest annual average COPC concentration in soil is assumed to occur at the end of the time period of combustion. The following uncertainty is associated with this variable: (1) The time period for deposition of COPCs resulting from hazardous waste combustion is assumed to be a conservative, long-term value. (2) Deposition to hard surfaces may result in dust residues that have negligible dilution (as a result of potential mixing with in-situ materials), in comparison to that of other residues. This uncertainty may underestimate *Cs*.

TABLE B-1-1

SOIL CONCENTRATION DUE TO DEPOSITION
(SOIL EQUATIONS)

(Page 2 of 9)

Equation

Highest Annual Average Soil Concentration

$$Cs = \frac{Ds \cdot [1 - \exp(-ks \cdot tD)]}{ks}$$

where:

$$Ds = \frac{100 \cdot Q}{Z_s \cdot BD} \cdot [F_v \ (0.31536 \cdot Vdv \cdot Cyv + Dywv) + (Dydp + Dywp) \cdot (1 - F_v)]$$

For mercury modeling:

$$Ds_{Mercury} = \frac{100 \cdot (0.48 Q_{TotalMercury})}{Z_s \cdot BD} \cdot [F_{v_{Hg^{2+}}} \ (0.31536 \cdot Vdv \cdot Cyv + Dywv) + (Dydp + Dywp) \cdot (1 - F_{v_{Hg^{2+}}})]$$

In calculating *Cs* for mercury comounds, *Ds(Mercury)* is calculated as shown above using the total mercury emission rate (*Q*) measured at the stack and F_v for mercuric chloride (F_v = 0.85). As presented below, the calculated *Ds(Mercury)* value is apportioned into the divalent mercury (Hg^{2+}) and methyl mercury (MHg) forms based on a 98% Hg^{2+} and 2% MHg speciation split in dry land soils, and a 85% Hg^{2+} and 15% MHg speciation split in wetland soils (see Chapter 2).

<u>For Calculating *Cs* in Dry Land Soils</u>

Ds (Hg^{2+}) = 0.98 *Ds(Mercury)*
Ds (MHg) = 0.02 *Ds(Mercury)*
Ds (Hg^0) = 0.0

<u>For Calculating *Cs* in Wetland Soils</u>

Ds (Hg^{2+}) = 0.85 *Ds(Mercury)*
Ds (MHg) = 0.15 *Ds(Mercury)*
Ds (Hg^0) = 0.0

Calculate *Cs* for divalent and methyl mercury using the corresponding (1) fate and transport parameters for mercuric chloride (divalent mercury) and methyl mercury (provided in Appendix A-2), and (2) *Ds* (Hg^{2+}) and *Ds* (MHg) as calculated above. After calculating species specific *Cs* values, divalent and methyl mercury should continue to be modeled throughout Appendix B equations as individual COPCs.

Variable	Description	Units	Value
Cs	COPC concentration in soil	mg COPC/kg soil	

TABLE B-1-1

SOIL CONCENTRATION DUE TO DEPOSITION (SOIL EQUATIONS)

(Page 3 of 9)

Variable	Description	Units	Value
Ds	Deposition term	mg COPC/kg soil/yr	**Varies (calculated - Table B-1-1)** Consistent with U.S. EPA (1994a; 1998), U.S. EPA OSW recommends incorporating the use of a deposition term into the *Cs* equation. Uncertainties associated with this variable include the following: (1) Five of the variables in the equation for *Ds (Q, Cyv, Dywv, Dywp* and *Dydp*) are COPC- and site-specific measured or modeled variables. The direction and magnitude of any uncertainties should not be generalized. Uncertainties associated with these variables will probably be different at each facility. (2) Based on the narrow recommended ranges, uncertainties associated with *Vdv*, F_v, and *BD* are expected to be small. (3) Values for Z_s vary by about one order of magnitude. Uncertainty is greatly reduced if it is known whether soils are tilled or untilled.
tD	Time period over which deposition occurs (time period of combustion)	yr	**100** U.S. EPA (1990a) specified that this period of time can be represented by 30, 60 , or 100 years. U.S. EPA OSW recommends that facilities use the conservative value of 100 years unless site-specific information is available indicating that this assumption is unreasonable.
ks	COPC soil loss constant due to all processes	yr^{-1}	**Varies (calculated - Table B-1-2)** This variable is COPC- and site-specific, and is calculated by using the equation in Table B-1-2. Soil loss constant is the sum of all COPC removal processes. Uncertainties associated with this variable are discussed in Table B-1-2.
100	Units conversion factor	m^2-mg/cm^2-kg	

TABLE B-1-1

SOIL CONCENTRATION DUE TO DEPOSITION (SOIL EQUATIONS)

(Page 4 of 9)

Variable	Description	Units	Value
Q	COPC-specific emission rate	g/s	**Varies (site-specific)** This variable is COPC- and site-specific (see Chapters 2 and 3). Uncertainties associated with this variable are site-specific.
Z_s	Soil mixing zone depth	cm	**1 or 20** Z_s should be computed for two depth intervals. U.S. EPA OSW recommends the following values for this variable: <u>Soil</u> — <u>Depth (cm)</u> Untilled — 1 Tilled — 20 The following uncertainty is associated with this variable: (1) For soluble COPCs, leaching might lead to movement to below soil depths and justify a greater mixing depth. This uncertainty may overestimate *Cs*. (2) Deposition to hard surfaces may result in dust residues that have negligible dilution, in comparison to that of other residues. This uncertainty may underestimate *Cs*.
BD	Soil bulk density	g/cm^3	**1.5** This variable is affected by the soil structure, such as looseness or compaction of the soil, depending on the water and clay content of the soil (Hillel 1980), as summarized in U.S. EPA (1990a). A proposed range of 0.83 to 1.84 was originally cited in Hoffman and Baes (1979). U.S. EPA (1994c) recommends a default *BD* value of 1.5 g/cm^3, based on a mean value for loam soil that was obtained from Carsel, Parrish, Jones, Hansen, and Lamb (1988). The value of 1.5 g/cm^3 also represents the midpoint of the "relatively narrow range" for *BD* of 1.2 to 1.7 g/cm^3 (U.S. EPA 1993a). The following uncertainty is associated with this variable: (1) The recommended range of *BD* values may not accurately represent site-specific soil conditions.

TABLE B-1-1

SOIL CONCENTRATION DUE TO DEPOSITION (SOIL EQUATIONS)

(Page 5 of 9)

Variable	Description	Units	Value
F_v	Fraction of COPC air concentration in vapor phase	unitless	**0 to 1 (see Appendix A-2)** This variable is COPC-specific and should be determined from the COPC tables in Appendix A-2. Values are also presented in U.S. EPA (1993), RTI (1992), and NC DEHNR (1997) based on the work of Bidleman (1988), as cited in U.S. EPA (1994c). The following uncertainty is associated with this variable: (1) It is based on the assumption of a default S_T value for background plus local sources, rather than an S_T value for urban sources. If a specific site is located in an urban area, the use of the latter S_T value may be more appropriate. Specifically, the S_T value for urban sources is about one order of magnitude greater than that for background plus local sources, and it would result in a lower calculated F_v value; however, the F_v value is likely to be only a few percent lower. (2) According to Bidleman (1988), the equation used to calculate F_v assumes that the variable c (Junge constant) is constant for all chemicals. However, the value of c depends on the chemical (sorbate) molecular weight, the surface concentration for monolayer coverage, and the difference between the heat of desorption from the particle surface and the heat of vaporization of the liquid-phase sorbate. To the extent that site- or COPC-specific conditions may cause the value of c to vary, uncertainty is introduced if a constant value of c is used to calculate F_v.
0.31536	Units conversion factor	m-g-s/cm-µg-yr	
Vdv	Dry deposition velocity	cm/s	**3** U.S. EPA (1994c) recommended the use of 3 cm/s for the dry deposition velocity, based on median dry deposition velocity for HNO_3 from an unspecified U.S. EPA database of dry deposition velocities for HNO_3, ozone, and SO_2. HNO_3 was considered the most similar to the COPCs recommended for consideration. The value should be applicable to any organic COPC with a low Henry's Law Constant. The following uncertainty is associated with this variable: (1) HNO_3 may not adequately represent specific COPCs with high Henry's Law Constant values. Therefore, the use of a single value may under- or overestimate estimated soil concentration.

TABLE B-1-1

SOIL CONCENTRATION DUE TO DEPOSITION (SOIL EQUATIONS)

(Page 6 of 9)

Variable	Description	Units	Value
Cyv	Unitized yearly average air concentration from vapor phase	$\mu g\text{-}s/g\text{-}m^3$	**Varies (modeled)** This variable is COPC- and site-specific, and is determined by air dispersion modeling (see Chapter 3). Uncertainties associated with this variable are site-specific.
Dywv	Unitized yearly average wet deposition from vapor phase	$s/m^2\text{-}yr$	**Varies (modeled)** This variable is COPC- and site-specific, and is determined by air dispersion modeling (see Chapter 3). Uncertainties associated with this variable are site-specific.
Dydp	Unitized yearly average dry deposition from particle phase	$s/m^2\text{-}yr$	**Varies (modeled)** This variable is COPC- and site-specific, and is determined by air dispersion modeling (see Chapter 3). Uncertainties associated with this variable are site-specific.
Dywp	Unitized yearly average wet deposition from particle phase	$s/m^2\text{-}yr$	**Varies (modeled)** This variable is COPC- and site-specific, and is determined by air dispersion modeling (see Chapter 3). Uncertainties associated with this variable are site-specific.

TABLE B-1-1

SOIL CONCENTRATION DUE TO DEPOSITION
(SOIL EQUATIONS)

(Page 7 of 9)

REFERENCES AND DISCUSSION

Bidleman, T.F. 1988. "Atmospheric Processes." *Environmental Science and Technology*. Volume 22. Number 4. Pages 361-367.

This reference is for the statement that the equation used to calculate the fraction of air concentration in vapor phase (F_v) assumes that the variable c (the Junge constant) is constant for all chemicals. However, this document notes that the value of c depends on the chemical (sorbate) molecular weight, the surface concentration for monolayer coverage, and the difference between the heat of desorption from the particle surface and the heat of vaporization of the liquid-phase sorbate. The following equation, presented in this document, is cited by U.S. EPA (1994c) and NC DEHNR (1997) for calculating the variable F_v:

$$F_v = 1 - \frac{c \cdot S_T}{P^\circ_L + c \cdot S_T}$$

where:

F_v = Fraction of chemical air concentration in vapor phase (unitless)
c = Junge constant = 1.7 E-04 (atm-cm)
S_T = Whitby's average surface area of particulates = 3.5 E-06 cm^2/cm^3 air (corresponds to background plus local sources)
P°_L = Liquid-phase vapor pressure of chemical (atm) (see Appendix A-2)

If the chemical is a solid at ambient temperatures, the solid-phase vapor pressure is converted to a liquid-phase vapor pressure as follows:

$$\ln \frac{P^\circ_L}{P^\circ_S} = \frac{\Delta S_f}{R} \cdot \frac{(T_m - T_a)}{T_a}$$

where:

P°_S = Solid-phase vapor pressure of chemical (atm) (see Appendix A-2)
$\frac{\Delta S_f}{R}$ = Entropy of fusion over the universal gas constant = 6.79 (unitless)
T_m = Melting point of chemical (K) (see Appendix C)
T_a = Ambient air temperature = 298 K (25°C)

TABLE B-1-1

SOIL CONCENTRATION DUE TO DEPOSITION (SOIL EQUATIONS)

(Page 8 of 9)

Carsel, R.F., R.S. Parrish, R.L. Jones, J.L. Hansen, and R.L. Lamb. 1988. "Characterizing the Uncertainty of Pesticide Leaching in Agricultural Soils." *Journal of Contaminant Hydrology*. Vol. 2. Pages 11-24.

This reference is cited by U.S. EPA (1994b) as the source for a mean soil bulk density value of 1.5 g/cm^3 for loam soil.

Hillel, D. 1980. *Fundamentals of Soil Physics*. Academic Press, Inc. New York.

This document is cited by U.S. EPA (1990a) for the statement that dry soil bulk density, *BD*, is affected by the soil structure, such as looseness or compaction of the soil, depending on the water and clay content of the soil.

Hoffman, F.O., and C.F. Baes, 1979. *A Statistical Analysis of Selected Parameters for Predicting Food Chain Transport and Internal Dose of Radionuclides*. ORNL/NOREG/TM-882.

This document presents a soil bulk density range, *BD*, of 0.83 to 1.84.

NC DEHNR. 1997. *NC DEHNR Protocol for Performing Indirect Exposure Risk Assessments for Hazardous Waste Combustion Units*. January.

This is one of the source documents for for the equation in Table B-1-1. This document also recommends the use of (1) a deposition term, *Ds*, and (2) COPC-specific F_v (fraction of COPC air concentration in vapor phase) values.

Research Triangle Institute (RTI). 1992. *Preliminary Soil Action Level for Superfund Sites.* Draft Interim Report. Prepared for U.S. EPA Hazardous Site Control Division, Remedial Operations Guidance Branch. Arlington, Virginia. EPA Contract 68-W1-0021. Work Assignment No. B-03, Work Assignment Manager Loren Henning. December.

This document is a reference source for COPC-specific F_v (fraction of COPC air concentration in vapor phase) values.

U.S. EPA. 1990a. *Interim Final Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions.* Environmental Criteria and Assessment Office. Office of Research and Development. EPA 600-90-003. January.

This document is a reference source for the equation in Table B-1-1, and it recommends that (1) the time period over which deposition occurs (time period for combustion), *tD*, be represented by periods of 30, 60, and 100 years, and (2) undocumented values for soil mixing zone depth, Z_s, for tilled and untilled soil.

U.S. EPA. 1993. *Addendum to the Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions*. Working Group Recommendations. Office of Solid Waste. Office of Research and Development. Washington, D.C. September 24.

This document is a reference for the equation in Table B-1-1. It recommends using a deposition term, *Ds*, and COPC-specific F_v values (fraction of COPC air concentration in vapor phase) in the *Cs* equation.

U.S. EPA 1994a. *Revised Draft Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes. Attachment C, Draft Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities.* Office of Emergency and Remedial Response. Office of Solid Waste. April 15.

TABLE B-1-1

SOIL CONCENTRATION DUE TO DEPOSITION
(SOIL EQUATIONS)

This document is a reference for the equation in Table B-1-1; it recommends that the following be used in the *Cs* equation: (1) a deposition term, *Ds*, and (2) a default soil dry bulk density value of 1.5 g/cm^3, based on a mean value for loam soil from Carsel, Parrish, Jones, Hansen, and Lamb (1988).

U.S. EPA. 1994b. *Estimating Exposure to Dioxin-Like Compounds*. *Volume III: Site-Specific Assessment Procedures.* Review Draft. Office of Research and Development. Washington, D.C. June. EPA/600/6-88/005Cc.

U.S. EPA. 1994c. *Draft Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*. Office of Emergency and Remedial Response. Office of Solid Waste. December 14.

The value for dry deposition velocity is based on median dry deposition velocity for HNO_3 from a U.S. EPA database of dry deposition velocities for HNO3 ozone, and SO_2. HNO_3 was considered the most similar to the constituents covered and the value should be applicable to any organic compound having a low Henry's Law Constant. The reference document for this recommendation was not cited. This document recommends the following:

- F_v values (fraction of COPC air concentration in vapor phase) that range from 0.27 to 1 for organic COPCs
- *Vdv* value (dry deposition velocity) of 3 cm/s (however, no reference is provided for this recommendation)
- Default soil dry bulk density value of 1.5 g/cm^3, based on a mean for loam soil from Carsel, Parrish, Jones, Hansen, and Lamb (1988)
- *Vdv* value of 3 cm/s, based on median dry deposition velocity for HNO_3 from an unspecified U.S. EPA database of dry deposition velocities for HNO_3, ozone, and SO_2. HNO_3 was considered the most similar to the COPCs recommended for consideration.

U.S. EPA. 1998. "Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilitites." External Peer Review Draft. U.S. EPA Region 6 and U.S. EPA OSW. Volumes 1-3. EPA530-D-98-001A. July.

TABLE B-1-2

COPC SOIL LOSS CONSTANT DUE TO ALL PROCESSES (SOIL EQUATIONS)

(Page 1 of 4)

Description

This equation calculates the soil loss constant (*ks*), which accounts for the loss of COPCs from soil by several mechanisms.

Uncertainties associated with this equation include the following:

(1) COPC-specific values for *ksg* are empirically determined from field studies. No information is available regarding the application of these values to the site-specific conditions associated with affected facilities.

Equation

$$ks = ksg + kse + ksr + ksl + ksv$$

Variable	Description	Units	Value
ks	COPC soil loss constant due to all processes	yr^{-1}	
ksg	COPC loss constant due to biotic and abiotic degradation	yr^{-1}	**Varies (see Appendix A-2)** This variable is COPC-specific and should be determined from the COPC tables in Appendix A-2. "Degradation rate" values are also presented in NC DEHNR (1997). However, no reference or source is provided for the values. U.S. EPA (1994a and 1994b) state that *ksg* values are COPC-specific; however, all *ksg* values are presented as zero (U.S. EPA 1994a) or as "NA" (U.S. EPA 1994b). The basis of these assumptions is not addressed. The following uncertainty is associated with this variable: (1) COPC-specific values for *ksg* are empirically determined from field studies. No information is available regarding the application of these values to the site-specific conditions associated with affected facilities.

TABLE B-1-2

COPC SOIL LOSS CONSTANT DUE TO ALL PROCESSES
(SOIL EQUATIONS)

(Page 2 of 4)

Variable	Description	Units	Value
kse	COPC loss constant due to soil erosion	yr^{-1}	**0** This variable is COPC- and site-specific, and is further discussed in Table B-1-3. Consistent with U.S. EPA (1994a; 1994b; 1998) and NC DEHNR (1997), U.S. EPA OSW recommends that the default value assumed for *kse* is zero because of contaminated soil eroding onto the site and away from the site. Uncertainties associated with this variable include the following: (1) The source of the equation in Table B-1-3 has not been identified. (2) Deposition to hard surfaces may result in dust residues that have negligible dilution (as a result of potential mixing with in-situ materials), in comparison to that of other residues. This uncertainty may underestimate *kse*.
ksr	COPC loss constant due to surface runoff	yr^{-1}	**Varies (calculated - Table B-1-4)** This variable is COPC- and site-specific, and is calculated by using the equation in Table B-1-4. No reference document is cited for this equation. The use of this equation is consistent with U.S. EPA (1994b; 1998) and NC DEHNR (1997). U.S. EPA (1994a) states that all *ksr* values are zero but does not explain the basis of this assumption. Uncertainties associated with this variable include the following: (1) The source of the equation in Table B-1-4 has not been identified. (2) Deposition to hard surfaces may result in dust residues that have negligible dilution (as a result of potential mixing with in-situ materials), in comparison to that of other residues. This uncertainty may underestimate *ksr*.
ksl	COPC loss constant due to leaching	yr^{-1}	**Varies (calculated - Table B-1-5)** This variable is COPC- and site-specific, and is calculated by using the equation in Table B-1-5. No reference document is cited for this equation. The use of this equation is consistent with U.S. EPA (1993; 1994b; 1998), and NC DEHNR (1997). U.S. EPA (1994a) states that all *ksl* values are zero but does not explain the basis of this assumption. Uncertainties associated with this variable include the following: (1) The source of the equation in Table B-1-5 has not been identified. (2) Deposition to hard surfaces may result in dust residues that have negligible dilution (as a result of potential mixing with in-situ materials), in comparison to that of other residues. This uncertainty may underestimate *ksl*.

TABLE B-1-2

COPC SOIL LOSS CONSTANT DUE TO ALL PROCESSES
(SOIL EQUATIONS)

(Page 3 of 4)

Variable	Description	Units	Value
ksv	COPC loss constant due to volatilization	yr^{-1}	**Varies (calculated - Table B-1-6)** This variable is COPC- and site-specific, and is calculated using the equation in Table B-1-6. Uncertainties associated with this variable include the following: (1) Deposition to hard surfaces may result in dust residues that have negligible dilution, (as a result of potential mixing with in-situ materials), in comparison to that of other residues. This uncertainty may underestimate *ksv*.

TABLE B-1-2

COPC SOIL LOSS CONSTANT DUE TO ALL PROCESSES (SOIL EQUATIONS)

(Page 4 of 4)

REFERENCES AND DISCUSSION

NC DEHNR. 1997. *NC DEHNR Protocol for Performing Indirect Exposure Risk Assessments for Hazardous Waste Combustion Units.* January.

This document is one of the reference documents for the equations in Tables B-1-4, B-1-5, and B-1-6. No source for these equations has been identified. This document is also cited as (1) the source for a range of COPC-specific degradation rates (*ksg*), and (2) one of the sources that recommend using the assumption that the loss resulting from erosion (*kse*) is zero because of contaminated soil eroding onto the site and away from the site.

U.S. EPA. 1993. *Review Draft Addendum to the Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions.* Office of Health and Environmental Assessment. Office of Research and Development. EPA-600-AP-93-003. November 10.

This document is one of the reference documents for the equations in Tables B-1-4 and B-1-5.

U.S. EPA. 1994a. *Draft Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes. Attachment C, Draft Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities.* April 15.

This document is cited as a source for the assumptions regarding losses resulting from erosion (*kse*), surface runoff (*ksr*), degradation (*ksg*), and leaching (*ksl*), and volatilization (*ksv*).

U.S. EPA. 1994b. *Revised Draft Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes. Attachment C, Draft Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities.* Office of Emergency and Remedial Response. Office of Solid Waste. December 14.

This document is one of the reference documents for the equations in Tables B-1-4 and B-1-5. This document is also cited as one of the sources that recommend using the assumption that the loss resulting from erosion (*kse*) is zero and the loss resulting from degradation (*ksg*) is "NA" or zero for all compounds.

U.S. EPA. 1998. "Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilitites." External Peer Review Draft. U.S. EPA Region 6 and U.S. EPA OSW. Volumes 1-3. EPA530-D-98-001A. July.

TABLE B-1-3

COPC LOSS CONSTANT DUE TO SOIL EROSION (SOIL EQUATIONS)

(Page 1 of 6)

Description

This equation calculates the constant for COPC loss resulting from erosion of soil. Consistent with U.S. EPA (1994), U.S. EPA (1994b), NC DEHNR (1997), and U.S. EPA (1998), U.S. EPA OSW recommends that the default value assumed for *kse* is zero because of contaminated soil eroding onto the site and away from the site. In site-specific cases where the permitting authority considers it appropriate to calculate a *kse*, the following equation presented in this table should be considered along with associated uncertainties. Additional discussion on the determination of *kse* can be obtained from review of the methodologies described in U.S. EPA NCEA document, *Methodology for Assessing Health Risks Associated with Multiple Exposure Pathways to Combustor Emissions* (In Press).

Uncertainties associated with this equation include:

(1) For soluble COPCs, leaching might lead to movement below 1 cm in soils and justify a greater mixing depth. This uncertainty may overestimate *kse*.

(2) Deposition to hard surfaces may result in dust residues that have negligible dilution (as a result of potential mixing with in-situ materials) in comparison to that of other residues. This uncertainty may underestimate *kse*.

Equation

$$kse = \frac{0.1 \cdot X_e \cdot SD \cdot ER}{BD \cdot Z_s} \cdot \left(\frac{Kd_s \cdot BD}{\theta_{sw} + \left(Kd_s \cdot BD\right)} \right)$$

Variable	Description	Units	Value
kse	COPC loss constant due to soil erosion	yr^{-1}	**0** Consistent with U.S. EPA (1994), U.S. EPA (1994b), U.S. EPA (1998), and NC DEHNR (1997), U.S. EPA OSW recommends that the default value assumed for *kse* is zero because of contaminated soil eroding onto the site and away from the site.
0.1	Units conversion factor	g-kg/cm^2-m^2	

TABLE B-1-3

COPC LOSS CONSTANT DUE TO SOIL EROSION (SOIL EQUATIONS)

(Page 2 of 6)

Variable	Description	Units	Value
X_e	Unit soil loss	kg/m^2-yr	**Varies (calculated - Table B-2-7)** This variable is site-specific and is calculated by using the equation in Table B-2-7. The following uncertainty is associated with this variable: (1) All of the equation variables are site-specific. Use of default values rather than site-specific values for any or all of these variables will result in unit soil loss (X_e) estimates that are under- or overestimated to some degree. Based on default values, X_e estimates can vary over a range of less than two orders of magnitude.
SD	Sediment delivery ratio	unitless	**Varies (calculated - Table B-2-8)** This value is site-specific and is calculated by using the equation in Table B-2-8. Uncertainties associated with this variable include the following: (1) The recommended default values for the empirical intercept coefficient, *a*, are average values that are based on studies of sediment yields from various watersheds. Therefore, those default values may not accurately represent site-specific watershed conditions. As a result, use of these default values may under- or overestimate *SD*. (2) The recommended default value for the empirical slope coefficient, *b*, is based on a review of sediment yields from various watersheds. This single default value may not accurately represent site-specific watershed conditions. As a result, use of this default value may under- or overestimate *SD*.
ER	Soil enrichment ratio	unitless	**Inorganics: 1** **Organics: 3** COPC enrichment occurs because (1) lighter soil particles erode more than heavier soil particles, and (2) concentration of organic COPCs—which is a function of organic carbon content of sorbing media—is expected to be higher in eroded material than in in-situ soil (U.S. EPA 1993). In the absence of site-specific data, U.S. EPA OSW recommends a default value of 3 for organic COPCs and 1 for inorganic COPCs. This is consistent with other U.S. EPA guidance (1993), which recommends a range of 1 to 5 and a value of 3 as a "reasonable first estimate." This range has been used for organic matter, phosphorus, and other soil-bound COPCs (U.S. EPA 1993); however, no sources or references were provided for this range. *ER* is generally higher in sandy soils than in silty or loamy soils (U.S. EPA 1993). The following uncertainty is associated with this variable: (1) The default ER value may not accurately reflect site-specific conditions; therefore, *kse* may be over- or underestimated to an unknown extent.

TABLE B-1-3

COPC LOSS CONSTANT DUE TO SOIL EROSION (SOIL EQUATIONS)

(Page 3 of 6)

Variable	Description	Units	Value
BD	Soil bulk density	g/cm^3	**1.5** This variable is affected by the soil structure, such as looseness or compaction of the soil, depending on the water and clay content of the soil (Hillel 1980), as summarized in U.S. EPA (1990). A range of 0.83 to 1.84 was originally cited in Hoffman and Baes (1979). U.S. EPA (1994) recommends a default BD value of 1.5 g/cm^3, based on a mean value for loam soil that was taken from Carsel, Parrish, Jones, Hansen, and Lamb (1988). The value of 1.5 g/cm^3 also represents the midpoint of the "relatively narrow range" for BD of 1.2 to 1.7 g/cm^3 (U.S. EPA 1993). The following uncertainty is associated with this variable: (1) The recommended range of soil dry bulk density values may not accurately represent site-specific soil conditions.
Z_s	Soil mixing zone depth	cm	**1 or 20** U.S. EPA OSW recommends the following values for this variable: Soil — Depth (cm) Untilled — 1 Tilled — 20 The following uncertainty is associated with this variable: (1) For soluble COPCs, leaching might lead to movement to below 1 cm in soils and justify a greater mixing depth. This uncertainty may overestimate *kse*. (2) Deposition to hard surfaces may result in dust residues that have negligible dilution (as a result of potential mixing with in-situ materials), in comparison to that of other residues. This uncertainty may underestimate *kse*.
Kd_s	Soil-water partition coefficient	cm^3/g	**Varies (see Appendix A-2)** This variable is COPC-specific and should be determined from the COPC tables in Appendix A-2. The following uncertainty is associated with this variable: (1) Uncertainties associated with this parameter will be limited if Kd_s values are determined as described in Appendix A-2.

TABLE B-1-3

COPC LOSS CONSTANT DUE TO SOIL EROSION (SOIL EQUATIONS)

Variable	Description	Units	Value
θ_{sw}	Soil volumetric water content	mL/cm^3	**0.2** This variable depends on the available water and on soil structure. θ_{sw} can be estimated as the midpoint between a soil's field capacity and wilting point, if a representative watershed soil can be identified. However, U.S. EPA OSW recommends the use of 0.2 mL/cm^3 as a default value. This value is the midpoint of the range 0.1 (very sandy soils) to 0.3 (heavy loam/clay soils) recommended by U.S. EPA (1993) (no source or reference is provided for this range) and is consistent with U.S. EPA (1994). The following uncertainty is associated with this variable: (1) The default θ_{sw} values may not accurately reflect site-specific or local conditions; therefore, *kse* may be under- or overestimated to a small extent, based on the limited range of values.

TABLE B-1-3

COPC LOSS CONSTANT DUE TO SOIL EROSION (SOIL EQUATIONS)

(Page 5 of 6)

REFERENCES AND DISCUSSION

Carsel, R.F., R.S. Parish, R.L. Jones, J.L. Hansen, and R.L. Lamb. 1988. "Characterizing the Uncertainty of Pesticide Leaching in Agricultural Soils." *Journal of Contaminant Hydrology*. Vol. 2. Pages 11-24.

This document is cited by U.S. EPA (1994) as the source for a mean soil bulk density, *BD*, value of 1.5 g/cm^3 for loam soil.

Hillel, D. 1980. *Fundamentals of Soil Physics.* Academic Press, Inc. New York.

This document is cited by U.S. EPA (1990) for the statement that dry soil bulk density, *BD*, is affected by the soil structure, such as looseness or compaction of the soil, depending on the water and clay content of the soil.

Hoffman, F.O., and C.F. Baes. 1979. *A Statistical Analysis of Selected Parameters for Predicting Food Chain Transport and Internal Dose of Radionuclides*. ORNL/NUREG/TM-882.

This document presents a soil bulk density, *BD*, range of 0.83 to 1.84.

NC DEHNR. 1997. *Draft NC DEHNR Protocol for Performing Indirect Exposure Risk Assessments for Hazardous Waste Combustion Units*. January.

U.S. EPA. 1990. *Interim Final Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions.* Environmental Criteria and Assessment Office. Office of Research and Development. EPA 600-90-003. January.

This document presents a range of values for soil mixing zone depth, Z_s, for tilled and untilled soil. The basis or source of these values is not identified.

U.S. EPA. 1993. *Addendum to the Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions.* External Review Draft. Office of Research and Development. Washington, D.C. November 1993.

This document is the source of a range of COPC enrichment ratio, *ER*, values. The recommended range, 1 to 5, has been used for organic matter, phosphorous, and other soil-bound COPCs. This document recommends a value of 3 as a "reasonable first estimate," and states that COPC enrichment occurs because lighter soil particles erode more than heavier soil particles. Lighter soil particles have higher ratios of surface area to volume and are higher in organic matter content. Therefore, concentration of organic COPCs, which is a function of the organic carbon content of sorbing media, is expected to be higher in eroded material than in in-situ soil.

This document is also a source of the following:

- A "relatively narrow range" for soil dry bulk density, *BD*, of 1.2 to 1.7 g/cm^3
- COPC-specific (inorganic COPCs only) Kd_s values used to develop a proposed range (2 to 280,000 mL/g) of Kd_s values
- A range of soil volumetric water content (θ_{sw}) values of 0.1 mL/cm^3 (very sandy soils) to 0.3 mL/cm^3 (heavy loam/clay soils) (however, no source or reference is provided for this range)

TABLE B-1-3

COPC LOSS CONSTANT DUE TO SOIL EROSION (SOIL EQUATIONS)

(Page 6 of 6)

U.S. EPA. 1994. *Draft Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes. Attachment C, Draft Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities.* April 15.

U.S. EPA. 1994a. *Estimating Exposure to Dioxin-Like Compounds. Volume III: Site-specific Assessment Procedures.* External Review Draft. Office of Research and Development. Washington, D.C. EPA/600/6-88/005Cc. June.

This document is the source of values for soil mixing zone depth, Z_s, for tilled and untilled soil, as cited in U.S. EPA (1993).

U.S. EPA. 1994b. *Revised Draft Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes. Attachment C, Draft Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities.* Office of Emergency and Remedial Response. Office of Solid Waste. December 14.

This document recommends (1) a default soil bulk density value of 1.5 g soil/cm^3 soil, based on a mean value for loam soil that is taken from Carsel, Parrish, Jones, Hansen, and Lamb (1988), and (2) a default soil volumetric water content, θ_{sw}, value of 0.2 mL water/cm^3 soil, based on U.S. EPA (1993).

U.S. EPA. 1998. "Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilitites." External Peer Review Draft. U.S. EPA Region 6 and U.S. EPA OSW. Volumes 1-3. EPA530-D-98-001A. July.

TABLE B-1-4

COPC LOSS CONSTANT DUE TO RUNOFF
(SOIL EQUATIONS)

(Page 1 of 5)

Description

This equation calculates the constant for COPC loss resulting from runoff of soil. Uncertainties associated with this equation include the following:

(1) For soluble COPCs, leaching might lead to movement to below 1 cm in soils and resulting in a greater mixing depth. This uncertainty may overestimate *ksr*.
(2) Deposition to hard surfaces may result in dust residues that have negligible dilution, in comparison to that of other residues. This uncertainty may underestimate *ksr*.

Equation

$$ksr = \frac{RO}{\theta_{sw} \cdot Z_s} \cdot \left(\frac{1}{1 + \left(Kd_s \cdot BD / \theta_{sw} \right)} \right)$$

Variable	Description	Units	Value
ksr	COPC loss constant due to surface runoff	yr^{-1}	
RO	Average annual surface runoff	cm/yr	**Varies (site-specific)** This variable is site-specific. According to U.S. EPA (1993; 1994b) and NC DEHNR (1997), average annual surface runoff can be estimated by using the *Water Atlas of the United States* (Geraghty, Miller, Van der Leeden, and Troise 1973). According to NC DEHNR, (1997), estimates can also be made by using more detailed, site-specific procedures for estimating the amount of surface runoff, such as those based on the U.S. Soil Conservation Service curve number equation (CNE). U.S. EPA (1985) is cited as an example of such a procedure. The following uncertainty is associated with this variable: (1) To the extent that site-specific or local average annual surface runoff information is not available, default or estimated values may not accurately represent site-specific or local conditions. As a result, *ksl* may be under- or overestimated to an unknown degree.

TABLE B-1-4

COPC LOSS CONSTANT DUE TO RUNOFF (SOIL EQUATIONS)

(Page 2 of 5)

Variable	Description	Units	Value
θ_{sw}	Soil volumetric water content	mL/cm^3	**0.2** This variable depends on the available water and on soil structure; if a representative watershed soil can be identified, θ_{sw} can be estimated as the midpoint between a soil's field capacity and wilting point. However, U.S. EPA OSW recommends the use of 0.2 mL/cm^3 as a default value. This value is the midpoint of the range 0.1 (very sandy soils) to 0.3 (heavy loam/clay soils), which is recommended by U.S. EPA (1993) (no source or reference is provided for this range) and is consistent with U.S. EPA (1994b). The following uncertainty is associated with this variable: (1) The default θ_{sw} values may not accurately reflect site-specific or local conditions; therefore, *kse* may be under- or overestimated to a small extent, based on the limited range of values.
Z_s	Soil mixing zone depth	cm	**1 or 20** U.S. EPA OSW recommends the following values for this variable: Soil — Depth (cm) Untilled — 1 Tilled — 20 The following uncertainty is associated with this variable: (1) For soluble COPCs, leaching might lead to movement to below 1 cm in soils and justify a greater mixing depth. This uncertainty may overestimate *ksr*. (2) Deposition to hard surfaces may result in dust residues that have negligible dilution (as a result of potential mixing with in-situ materials), in comparison to that of other residues. This uncertainty may underestimate *ksr*.
Kd_s	Soil-water partition coefficient	cm^3/g	**Varies (see Appendix A-2)** This variable is COPC-specific and should be determined from the COPC tables in Appendix A-2. The following uncertainty is associated with this variable: (1) Uncertainties associated with this parameter will be limited if Kd_s values are calculated as described in Appendix A-2.

TABLE B-1-4

COPC LOSS CONSTANT DUE TO RUNOFF (SOIL EQUATIONS)

(Page 3 of 5)

Variable	Description	Units	Value
BD	Soil bulk density	g/cm^3	**1.5** This variable is affected by the soil structure, such as looseness or compaction of the soil, depending on the water and clay content of the soil (Hillel 1980), as summarized by U.S. EPA 1990. A range of 0.83 to 1.84 was originally cited in Hoffman and Baes (1979). U.S. EPA (1994) recommended a default soil bulk density value of 1.5 g/cm^3, based on a mean value for loam soil that is taken from Carsel, Parrish, Jones, Hansen, and Lamb (1988). The value of 1.5 g/cm^3 also represents the midpoint of the "relatively narrow range" for *BD* of 1.2 to 1.7 g/cm^3 (U.S. EPA 1993). The following uncertainty is associated with this variable: (1) The recommended range of soil dry bulk density values may not accurately represent site-specific soil conditions.

TABLE B-1-4

COPC LOSS CONSTANT DUE TO RUNOFF (SOIL EQUATIONS)

(Page 4 of 5)

REFERENCES AND DISCUSSION

Carsel, R.F., R.S. Parrish, R.L. Jones, J.L. Hansen, and R.L. Lamb. 1988. "Characterizing the Uncertainty of Pesticide Leaching in Agricultural Soils." *Journal of Contaminant Hydrology*. Vol. 2. Pages 11-24.

This document is cited by U.S. EPA (1994) as the source of a mean soil bulk density, *BD*, value of 1.5 g/cm^3 for loam soil.

Geraghty, J.J., D.W. Miller, F. Van der Leeden, and F.L. Troise. 1973. *Water Atlas of the United States*. Water Information Center, Port Washington, New York.

This document is cited by U.S. EPA (1993), U.S. EPA (1994c), and NC DEHNR (1997) as a reference to calculate average annual runoff, *R*. This reference provides maps with isolines of annual average surface water runoff, which is defined as all flow contributions to surface water bodies, including direct runoff, shallow interflow, and ground water recharge. Because these values are total contributions, and not only surface runoff, U.S. EPA (1994c) recommends that they be reduced by 50 percent to estimate surface runoff.

Hillel, D. 1980. Fundamentals of Soil Physics. Academic Press, Inc. New York.

This document is cited by U.S. EPA (1990) for the statement that dry soil bulk density, *BD*, is affected by the soil structure, such as looseness or compaction of the soil, depending on the water and clay content of the soil.

Hoffman, F.O., and C.F. Baes. 1979. *A Statistical Analysis of Selected Parameters for Predicting Food Chain Transport and Internal Dose of Radionuclides*. ORNL/NUREG/TM-882.

This document presents a soil bulk density, *BD*, range of 0.83 to 1.84.

NC DEHNR. 1997. *NC DEHNR Protocol for Performing Indirect Exposure Risk Assessments for Hazardous Waste Combustion Units*. January.

This document is one of the source documents that cites the use of the equation in Table B-1-4; however, this document is not the original source of this equation (this source is unknown). This document also recommends the following:

- Estimation of annual current runoff, *RO* (cm/yr), by using the *Water Atlas of the United States* (Geraghty, Miller, Van der Leeden, and Troise 1973) or site-specific procedures, such as using the U.S. Soil Conservation Service curve number equation (CNE) (U.S. EPA [1985]) is cited as an example of the use of the CNE
- Default value of 0.2 mL/cm^3 for soil volumetric water content (θ_{sw})
- Range (2 to 280,000 mL/g) of Kd_s values for inorganic COPCs (the original source of the values is not identified)

U.S. EPA. 1985. *Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants in Surface and Ground Water—Part I (Revised. 1985).* Environmental Research Laboratory. Athens, Georgia. EPA/600/6-85/002a. September.

This document is cited by NC DEHNR (1997) as an example of the use of the U.S. Soil Conservation Service CNE to estimate site-specific surface runoff.

U.S. EPA. 1990. *Interim Final Methodology for Assessing Health Risks Assocated with Indirect Exposure to Combustor Emissions*. Environmental Criteria and Assessment Office. Office of Research and Development. EPA 600-90-003. January.

TABLE B-1-4

COPC LOSS CONSTANT DUE TO RUNOFF
(SOIL EQUATIONS)

(Page 5 of 5)

This document presents the statement that dry soil bulk density, *BD*, is affected by the soil structure, such as looseness or compaction of the soil, depending on the water and clay content of the soil.

U.S. EPA. 1993. *Addendum to the Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions.* External Review Draft. Office of Research and Development. Washington, D.C. November.

This document recommends the following:

- A "relatively narrow range" for soil dry bulk density, *BD*, of 1.2 to 1.7 g./cm^3
- A range of soil volumetric water content, θ_{sw}, values of 0.1 (very sandy soils) to 0.3 (heavy loam/clay soils) (the original source of, or reference for, these values is not identified)
- A range (2 to 280,000 mL/g) of Kd_s values for inorganic COPCs
- Use of the *Water Atlas of the United States* (Geraghty, Miller, Van der Leeden, and Troise 1973) to calculate average annual runoff

U.S. EPA. 1994a. *Estimating Exposure to Dioxin-Like Compounds. Volume III: Site-specific Assessment Procedures.* External Review Draft. Office of Research and Development. Washington, D.C. EPA/600/6-88/005Cc. June.

This document presents a range of values for soil mixing zone depth, Z_s, for tilled and untilled soil as cited in U.S. EPA (1993).

U.S. EPA. 1994b. *Revised Draft Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*. Attachment C, Draft Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities. Offices of Emergency and Remedial Response. Office of Solid Waste. December 14.

This document recommends the following:

- Estimation of average annual runoff, *RO*, by using the *Water Atlas of the United States* (Geraghty, Miller, Van der Leeden, and Troise 1973)
- Default soil dry bulk density, *BD*, value of 1.5 g/cm^3, based on the mean for loam soil that is taken from Carsel, Parrish, Jones, Hansen, and Lamb (1988)
- Default soil volumetric water content, θ_{sw}, value of 0.2 mL/cm^3, based on U.S. EPA (1993)

TABLE B-1-5

COPC LOSS CONSTANT DUE TO LEACHING (SOIL EQUATIONS)

(Page 1 of 6)

Description

This equation calculates the constant for COPC loss resulting from leaching of soil. Uncertainties associated with this equation include the following:

(1) For soluble COPCs, leaching might lead to movement to below 1 or 20 cm in soils; resulting in a greater mixing depth. This uncertainty may overestimate *ksl*.
(2) Deposition to hard surfaces may result in dust residues that have negligible dilution (as a result of potential mixing with in-situ materials), in comparison to that of other residues. This uncertainty may underestimate *ksl*.
(3) The original source of this equation has not been identified. U.S. EPA (1993) presents the equation as shown here. U.S. EPA (1994) and NC DEHNR (1997) replaced the numerator as shown with "*q*", defined as average annual recharge (cm/yr).

Equation

$$ksl = \frac{P + I - RO - E_v}{\theta_{sw} \cdot Z_s \cdot \left[1.0 + \left(BD \cdot Kd_s / \theta_{sw}\right)\right]}$$

Variable	**Description**	**Units**	**Value**
ksl	COPC loss constant due to leaching	yr^{-1}	
P	Average annual precipitation	cm/yr	**18.06 to 164.19 (site-specific)** This variable is site-specific. This range is based on information, presented in U.S. EPA (1990), representing data for 69 selected cities (U.S. Bureau of Census 1987; Baes, Sharp, Sjoreen and Shor 1984). The 69 selected cities are not identified. However, they appear to be located throughout the continental United States. U.S. EPA OSW recommends that site-specific data be used. The following uncertainty is associated with this variable: (1) To the extent that a site is not located near an established meteorological data station, and site-specific data are not available, default average annual precipitation data may not accurately reflect site-specific conditions. As a result, *ksl* may be under- or overestimated. However, average annual precipitation data are reasonably available; therefore, uncertainty introduced by this variable is expected to be minimal.

TABLE B-1-5

COPC LOSS CONSTANT DUE TO LEACHING (SOIL EQUATIONS)

(Page 2 of 6)

Variable	Description	Units	Value
I	Average annual irrigation	cm/yr	**0 to 100 (site-specific)** This variable is site-specific. This range is based on information, presented in U.S. EPA (1990), representing data for 69 selected cities (Baes, Sharp, Sjoreen, and Shor 1984). The 69 selected cities are not identified; however, they appear to be located throughout the continental United States. The following uncertainty is associated with this variable: (1) To the extent that site-specific or local average annual irrigation information is not available, default values (generally based on the closest comparable location) may not accurately reflect site-specific conditions. As a result, *ksl* may be under- or overestimated to an unknown degree.
RO	Average annual surface runoff	cm/yr	**Varies (site-specific)** This variable is site-specific. According to U.S. EPA (1993; 1994) and NC DEHNR (1997), average annual surface runoff can be estimated by using the Water Atlas of the United States (Geraghty, Miller, Van der Leeden, and Troise 1973). Also according to NC DEHNR (1997), this estimate can also be made by using more detailed, site-specific procedures, such as those based on the U.S. Soil Conservation Service CNE. U.S. EPA (1985) is cited as an example of such a procedure. The following uncertainty is associated with this variable: (1) To the extent that site-specific or local average annual surface runoff information is not available, default or estimated values may not accurately represent site-specific or local conditions. As a result, *ksl* may be under- or overestimated to an unknown degree.
E_v	Average annual evapotranspiration	cm/yr	**35 to 100 (site-specific)** This variable is site-specific. This range is based on information, presented in U. S. EPA (1990), representing data from 69 selected cities. The 69 selected cities are not identified; however, they appear to be located throughout the continental United States. The following uncertainty is associated with this variable: (1) To the extent that site-specific or local average annual evapotranspiration information is not available, default values may not accurately reflect site-specific conditions. As a result, *ksl* may be under- or overestimated to an unknown degree.

TABLE B-1-5

COPC LOSS CONSTANT DUE TO LEACHING (SOIL EQUATIONS)

(Page 3 of 6)

Variable	Description	Units	Value
θ_{sw}	Soil volumetric water content	mL/cm^3	**0.2** This variable depends on the available water and on soil structure. θ_{sw} can be estimated as the midpoint between a soil's field capacity and wilting point, if a representative watershed soil can be identified. However, U.S. EPA OSW recommends the use of 0.2 mL/cm^3 as a default value. This value is the midpoint of the range of 0.1 (very sandy soils) to 0.3 (heavy loam/clay soils) recommended by U.S. EPA (1993) (no source or reference is provided for this range) and is consistent with U.S. EPA (1994). The following uncertainty is associated with this variable: (1) The default θ_{sw} values may not accurately reflect site-specific or local conditions; therefore, *ksl* may be under- or overestimated to a small extent, based on the limited range of values.
Z_s	Soil mixing zone depth	cm	**1 or 20** U.S. EPA OSW recommends the following values for this variable: Soil — Depth (cm) Untilled — 1 Tilled — 20 Uncertainties associated with this variable include the following: (1) For soluble COPCs, leaching might lead to movement to below 1 or 20 cm in soils; resulting in a greater mixing depth. This uncertainty may overestimate *ksl*. (2) Deposition to hard surfaces may result in dust residues that have negligible dilution, in comparison to that of other residues. This uncertainty may underestimate *ksl*.

TABLE B-1-5

COPC LOSS CONSTANT DUE TO LEACHING (SOIL EQUATIONS)

(Page 4 of 6)

Variable	Description	Units	Value
BD	Soil bulk density	g/cm^3	**1.5** This variable is affected by the soil structure, such as looseness or compaction of the soil, depending on the water and clay content of the soil (Hillel 1980), as summarized in U.S. EPA (1990). A range of 0.83 to 1.84 was originally cited in Hoffman and Baes (1979). U.S. EPA (1994) recommended a default soil bulk density value of 1.5 g/cm^3, based on a mean value for loam soil from Carsel, Parrish, Jones, Hansen, and Lamb (1988). The value of 1.5 g/cm^3 also represents the midpoint of the “relatively narrow range” for *BD* of 1.2 to 1.7 g/cm^3 (U.S. EPA 1993). The following uncertainties is associated with this variable: (1) The recommended range of soil dry bulk density values may not accurately represent site-specific soil conditions.
Kd_s	Soil-water partition coefficient	cm^3/g	**Varies (see Appendix A-2)** This variable is COPC-specific and should be determined from the COPC tables in Appendix A-2. The following uncertainty is associated with this variable: (1) Uncertainties associated with this parameter will be limited if Kd_s values are calculated as described in Appendix A-2.

TABLE B-1-5

COPC LOSS CONSTANT DUE TO LEACHING (SOIL EQUATIONS)

(Page 5 of 6)

REFERENCES AND DISCUSSION

Baes, C.F., R.D. Sharp, A.L. Sjoreen and R.W. Shor. 1984. "A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture." Prepared for the U.S. Department of Energy under Contract No. DEAC05-840R21400.

For the continental United States, as cited in U.S. EPA (1990), this document is the source of a series of maps showing: (1) average annual precipitation (*P*); (2) average annual irrigation (*I*); and (3) average annual evapotranspiration isolines.

Carsel, R.F., R.S. Parrish, R.L. Jones, J.L. Hansen, and R.L. Lamb. 1988. "Characterizing the Uncertainty of Pesticide Leaching in Agricultural Soils." *Journal of Contaminant Hydrology*. Vol. 2. Pages 11-24.

This document is cited by U.S. EPA (1994b) as the source for a mean soil bulk density value of 1.5 g/cm^3 for loam soil.

Geraghty, J.J., D.W. Miller, F. Van der Leeden, and F.L. Troise. 1973. *Water Atlas of the United States*. Water Information Center, Port Washington, New York.

This document is cited by U.S. EPA (1993), U.S. EPA (1994), and NC DEHNR (1997) as a reference for calculating average annual runoff, *RO*. This document provides maps with isolines of annual average surface runoff, which is defined as all flow contributions to surface water bodies, including direct runoff, shallow interflow, and ground water recharge. Because these volumes are total contributions—and not only surface runoff—U.S. EPA (1994) notes that they need to be reduced by 50 percent to estimate average annual surface runoff.

This document presents a soil bulk density, *BD*, range of 0.83 to 1.84. U.S. EPA has not completed its review of this document.

Hillel, D. 1980. *Fundamentals of Soil Physics*. Academic Press, Inc. New York, New York.

This document is cited by U.S. EPA (1990) for the statement that dry soil bulk density, *BD*, is affected by the soil structure, such as looseness or compaction of the soil, depending on the water and clay content of the soil.

Hoffman, F.O., and C.F. Baes. 1979. *A Statistical Analysis of Selected Parameters for Predicting Food Chain Transport and Internal Dose of Radionuclides*. ORNL/NUREG/TM-882.

This document presents a soil bulk density, *BD*, range of 0.83 to 1.84.

NC DEHNR. 1997. *NC DEHNR Protocol for Performing Indirect Exposure Risk Assessments for Hazardous Waste Combustion Units*. January.

This document is one of the source documents that cites the use of the equation in Table B-1-5; however, the document is not the original source of this equation. This document also recommends the following:

- Estimation of average annual surface runoff, *RO* (cm/yr), by using the *Water Atlas of the United States* (Geraghty, Miller, Van der Leeden, and Troise 1973) or site-specific procedures, such as using the U.S. Soil Conservation Service CNE; U.S. EPA 1985 is cited as an example of the use of the CNE.

TABLE B-1-5

COPC LOSS CONSTANT DUE TO LEACHING (SOIL EQUATIONS)

- A default value of 0.2 mL/cm^3 for soil volumetric water content, θ_{sw}.
- A range (2 to 280,000 mL/g) of Kd_s values for inorganic COPCs; the original source of these values is not identified.

U.S. Bureau of the Census. 1987. *Statistical Abstract of the United States:* 1987. 107th edition. Washington, D.C.

This document is a source of average annual precipitation (*P*) information for 69 selected cites, as cited in U.S. EPA (1990); these 69 cities are not identified.

U.S. EPA. 1985. *Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants in Surface and Groundwater*. Part I (Revised 1985). Environmental Research Laboratory. Athens, Georgia. EPA/600/6-85/002a. September.

This document is cited by NC DEHNR (1997) as an example of the use of the U.S. Soil Conservation Service CNE to estimate site-specific average annual surface runoff.

U.S. EPA. 1990. *Interim Final Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions*. Environmental Criteria and Assessment Office. Office of Research and Development. EPA 600-90-003. January.

This document presents ranges of (1) average annual precipitation, (2) average annual irrigation, and (3) average annual evapotranspiration. This document identifies Baes, Sharp, Sjoreen, and Shor (1984) and U.S. Bureau of the Census (1987) as the original sources of this information.

U.S. EPA. 1993. *Addendum to the Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions*. External Review Draft. Office of Research and Development. Washington, D.C. November.

This document is one of the reference sources for the equation in Table B-1-5; this document also recommends the following:

- A range of soil volumetric water content, θ_{sw}, values of 0.1 (very sandy soils) to 0.3 (heavy loam/clay soils); the original source or reference for these values is not identified.
- A range (2 to 280,000 mL/g) of Kd_s values for inorganic COPCs
- A "relatively narrow range" for soil dry bulk density, *BD*, of 1.2 to 1.7 g/cm^3

This document is one of the reference source documents for equation in Table B-1-5. The original source of this equation is not identified.

U.S. EPA. 1994. *Review Draft Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes. Attachment C, Draft Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities*. Office of Emergency and Remedial Response. Office of Solid Waste. December 14.

This document recommends (1) a default soil volumetric water content, θ_{sw}, value of 0.2 mL/cm^3, based on U.S. EPA (1993), and (2) a default soil bulk density, *BD*, value of 1.5 g/cm^3, based on a mean value for loam soil from Carsel, Parrish, Jones, Hansen, and Lamb (1988).

TABLE B-1-6

COPC LOSS CONSTANT DUE TO VOLATILIZATION (SOIL EQUATIONS)

(Page 1 of 6)

Description

This equation calculates the COPC loss constant from soil due to volatilization, and was obtained from *Methodology for Assessing Health Risks Associated with Multiple Exposure Pathways to Combustor Emissions* (U.S. EPA In Press). The soil loss constant due to volatilization (*ksv*) is based on gas equilibrium coefficients and gas phase mass transfer. The first order decay constant, *ksv*, is obtained by adapting the Hwang and Falco equation for soil vapor phase diffusion (Hwang and Falco 1986).

Uncertainties associated with this equation include the following:

(1) For soluble COPCs, leaching might lead to movement to below 1 centimeter in untilled soils, resulting in a greater mixing depth. This uncertainty may overestimate *ksv*.
(2) Deposition to hard surfaces may result in dust residues that have negligible dilution (as a result of potential mixing with *in situ* materials) in comparison to that of other residues. This uncertainty may underestimate *ksv*.

Equation

$$ksv = \left[\frac{3.1536 \times 10^{7} \cdot H}{Z_s \cdot Kd_s \cdot R \cdot T_a \cdot BD}\right] \cdot \left(\frac{D_a}{Z_s}\right) \cdot \left[1 - \left(\frac{BD}{\rho_s}\right) - \theta_{sw}\right]$$

Variable	Definition	Units	Value
ksv	COPC loss constant due to volatilization	yr^{-1}	
3.1536 x 10^{7}	Units conversion factor	s/yr	
H	Henry's Law constant	atm-m^3/mol	**Varies (see Appendix A-2)** This variable is COPC-specific and should be determined from the COPC tables in Appendix A-2. The following uncertainty is associated with this variable: (1) Values for this variable, estimated by using the parameters and algorithms in Appendix A-2, may under- or overestimate the actual COPC-specific values. As a result, *ksv* may be under- or overestimated.

TABLE B-1-6

COPC LOSS CONSTANT DUE TO VOLATILIZATION (SOIL EQUATIONS)

(Page 2 of 6)

Variable	Definition	Units	Value
Z_s	Soil mixing zone depth	cm	**1 or 20** U.S. EPA OSW recommends the following values for this variable: <u>Soil</u> <u>Depth (cm)</u> Untilled 1 Tilled 20 The following uncertainty is associated with this variable: (1) For soluble COPCs, leaching might lead to movement to below 1 or 20 cm in soils and justify a greater mixing depth. This uncertainty may overestimate *ksv*. (2) Deposition to hard surfaces may result in dust residues that have negligible dilution, in comparison to that of other residues. This uncertainty may underestimate *ksv*.
Kd_s	Soil-water partition coefficient	cm^3/g	**Varies (see Appendix A-2)** This variable is COPC-specific and should be determined from the COPC tables in Appendix A-2. The following uncertainty is associated with this variable: (1) Uncertainties associated with this parameter will be limited if Kd_s values are calculated as described in Appendix A-2.
R	Universal gas constant	atm-m^3/mol-K	**8.205×10^{-5}** There are no uncertainties associated with this parameter.
T_a	Ambient air temperature	K	**298** This variable is site-specific. U.S. EPA (1990) recommended an ambient air temperature of 298 K. The following uncertainty is associated with this variable: (1) To the extent that site-specific or local values for the variable are not available, default values may not accurately represent site-specific conditions. The uncertainty associated with the selection of a single value from within the temperature range at a single location is expected to be more significant than the uncertainty associated with choosing a single ambient temperature to represent all localities.

TABLE B-1-6

COPC LOSS CONSTANT DUE TO VOLATILIZATION (SOIL EQUATIONS)

(Page 3 of 6)

Variable	Definition	Units	Value
BD	Soil bulk density	g/cm^3	**1.5** This variable is affected by the soil structure, such as looseness or compaction of the soil, depending on the water and clay content of the soil (Hillel 1980; Miller and Gardiner 1998), as summarized in U.S. EPA (1990). A range of 0.83 to 1.84 was originally cited in Hoffman and Baes (1979). U.S. EPA (1994) recommended a default soil bulk density value of 1.5 g/cm^3, based on a mean value for loam soil from Carsel, Parrish, Jones, Hansen, and Lamb (1988). The value of 1.5 g/cm^3 also represents the midpoint of the "relatively narrow range" for *BD* of 1.2 to 1.7 g/cm^3 (U.S. EPA 1993). The following uncertainty is associated with this variable: (1) The recommended range of soil bulk density values may not accurately represent site-specific soil conditions.
ρ_s	Solids particle density	g/cm^3	**2.7** U.S. EPA OSW recommends the use of this value, based on Blake and Hartage (1996) and Hillel (1980). The solids particle density will vary with location and soil type.
D_a	Diffusivity of COPC in air	cm^2/s	**Varies (see Appendix A-2)** This value is COPC-specific and should be determined from the COPC tables presented in Appendix A-2. The following uncertainty is associated with this variable: (1) The default D_a values may not accurately represent the behavior of COPCs under site-specific conditions. However, the degree of uncertainty is expected to be minimal.

TABLE B-1-6

COPC LOSS CONSTANT DUE TO VOLATILIZATION
(SOIL EQUATIONS)

(Page 4 of 6)

Variable	Definition	Units	Value
θ_{sw}	Soil volumetric water content	mL/cm^3	**0.2** This variable depends on the available water and on soil structure. θ_{sw} can be estimated as the midpoint between a soil's field capacity and wilting point, if a representative watershed soil can be identified. However, U.S. EPA OSW recommends the use of 0.2 mL/cm^3 as a default value. This value is the midpoint of the range of 0.1 (very sandy soils) to 0.3 (heavy loam/clay soils) recommended by U.S. EPA (1993) (no source or reference is provided for this range) and is consistent with U.S. EPA (1994). The following uncertainty is associated with this variable: (1) The default θ_{sw} values may not accurately reflect site-specific or local conditions; therefore, *ksl* may be under- or overestimated to a small extent, based on the limited range of values.

TABLE B-1-6

COPC LOSS CONSTANT DUE TO VOLATILIZATION (SOIL EQUATIONS)

(Page 5 of 6)

REFERENCES AND DISCUSSION

Blake, G.R. and K.H. Hartge. 1996. *Particle Density. Methods of Soil Analysis, Part 1: Physical and Mineralogical Methods*. Second Edition. Arnold Klute, Ed. American Society of Agronomy, Inc. Madison, WI., p. 381.

Carsel, R.F., R.S, Parrish, R.L. Jones, J.L. Hansen, and R.L. Lamb. 1988. "Characterizing the Uncertainty of Pesticide Leaching in Agricultural Soils." *Journal of Contaminant Hydrology*. Vol. 2. Pages 11-24.

This document is cited by U.S. EPA (1994) as the source of a mean soil bulk density value, *BD*, of 1.5 g/cm^3 for loam soil.

Hillel, D. 1980. *Fundamentals of Soil Physics.* Academic Press, Inc. New, New York.

Hoffman, F.O., and C.F. Baes. 1979. *A Statistical Analysis of Selected Parameters for Predicting Food Chain Transport and Internal Dose of Radionuclides.* ORNL/NUREG/TM-882.

This document presents a soil bulk density, *BD*, range of 0.83 to 1.84.

Hwang S. T. and Falco, J. W. 1986. "Estimation of multimedia exposures related to hazardous waste facilities", In: *Pollutants in a Multimedia Environment*. Yoram Cohen, Ed. Plenum Publishing Corp. New York.

Miller, R.W. and D.T. Gardiner. 1998. In: *Soils in Our Environment*. J.U. Miller, Ed. Prentice Hall. Upper Saddle River, NJ. pp. 80-123.

NC DEHNR. 1997. *NC DEHNR Protocol for Performing Indirect Exposure Risk Assessments for Hazardous Waste Combustion Units.* January.

This document is one of the source documents that cites the use of the equation in Table B-1-6; however, the original source of this equation is not identified. This document also recommends the following:

- A range of COPC-specific Henry's Law Constant (atm-m^3/mol) values
- A range (2 to 280,000 mL/g) of Kd_s values for inorganic COPCs; however, the sources of these values are not identified.
- A range (9.2 E-06 to 2.8 E-01 cm^2/sec) of values for diffusivity of COPCs in air; however, the sources of these values are not identified.

U. S. EPA. 1990. *Interim Final Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions.* Environmental Criteria and Assessment Office. Office of Research and Development. EPA 600-90-003. January.

This document recommends the following:

- A default ambient air temperature of 298 K

TABLE B-1-6

COPC LOSS CONSTANT DUE TO VOLATILIZATION
(SOIL EQUATIONS)

- An average annual wind speed of 3.9 m/s; however, no source or reference for this value is identified.

U.S. EPA. 1993. *Addendum to the Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions.* External Review Draft. Office of Research and Development. Washington, D.C. November.

This document is one of the reference source documents for the equation in Table B-1-6; however, the original reference for this equation is not identified.

This document also presents the following:

- COPC-specific Kd_s values that were used to establish a range (2 to 280,000 mL/g) of Kd_s values for inorganic COPCs
- a "relatively narrow range" for soil dry bulk density, *BD*, of 1.2 to 1.7 g/cm^3

U.S. EPA. 1994. *Revised Draft Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Waste. Attachment C, Draft Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities*. Office of Emergency and Remedial Response. Office of Solid Waste. December 14.

This document recommends a default soil density, *BD*, value of 1.5 g/cm^3, based on a mean value for loam soil that is taken from Carsel, Parrish, Jones, Hansen, and Lamb (1988).

U.S. EPA. 1994b. *Draft Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes. Attachment C, Draft Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities.* April 15.

U.S. EPA. 1998. "Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilitites." External Peer Review Draft. U.S. EPA Region 6 and U.S. EPA OSW. Volumes 1-3. EPA530-D-98-001A. July.

U.S. EPA. In Press. "*Methodology for Assessing Health Risks Associated with Multiple Exposure Pathways to Combustor Emissions*." Internal Review Draft. Environmental Criteria and Assessment Office. ORD. Cincinnati, Ohio.

TABLE B-2-1

TOTAL COPC LOAD TO WATER BODY (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 1 of 4)

Description

This equation calculates the total average water body load from wet and dry vapor and particle deposition, runoff, and erosion loads.

The limitations and uncertainties incorporated by using this equation include the following:

(1) The greatest uncertainties are associated with the site-specific variables in Tables B-2-2, B-2-3, B-2-4, B-2-5, and B-2-6 (used to estimate values for the variables in the below equation for L_T). These variables include Q, $Dywwv$, $Dytwp$, A_w, $Cywv$, A_I, A_L, Cs, and X_e. Values for many of these variables are estimated through the use of mathematical models and the uncertainties associated with values for these variables may be significant in some cases.

(2) Uncertainties associated with the remaining variables in Tables B-2-2, B-2-3, B-2-4, B-2-5, and B-2-6 are expected to be less significant, primarily because of the narrow ranges of probable values for these variables or because values for these variables (such as Kd_s) were estimated by using well-established estimation methods.

Equation

$$L_T = L_{DEP} + L_{Dif} + L_{RI} + L_R + L_E$$

Variable	Description	Units	Value
L_T	Total COPC load to the water body	g/yr	
L_{DEP}	Total (wet and dry) particle phase and wet vapor phase direct deposition load to water body	g/yr	**Varies (calculated - Table B-2-2)** This variable is COPC- and site-specific, and is calculated by using the equation in Table B-2-2. Uncertainties associated with this variable include the following: (1) Most of the uncertainties associated with the variables in Table B-2-2, specifically those associated with Q, $Dywwv$, $Dytwp$, and A_w, are site-specific and may be significant in some cases.

TABLE B-2-1

TOTAL COPC LOAD TO WATER BODY (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 2 of 4)

Variable	Description	Units	Value
L_{Dif}	Vapor phase COPC diffusion (dry deposition) load to water body	g/yr	**Varies (calculated - Table B-2-3)** This variable is calculated by using the equation in Table B-2-3. Uncertainties associated with this variable include the following: (1) Most of the uncertainties associated with the variables in the equation in Table B-2-3, specifically those associated with Q, $Cywv$, and A_W, are site-specific and may be significant in some cases.
L_{RI}	Runoff load from impervious surfaces	g/yr	**Varies (calculated - Table B-2-4)** This variable is calculated by using the equation in Table B-2-4. Uncertainties associated with this variable include the following: (1) Most of the uncertainties associated with the variables in this equation, specifically those associated with Q, $Dywwv$, $Dytwp$, and A_I, are site-specific.
L_R	Runoff load from pervious surfaces	g/yr	**Varies (calculated - Table B-2-5)** This variable is calculated by using the equation in Table B-2-5. Uncertainties associated with this variable include the following: (1) Most of the uncertainties associated with the variables in the equation in Table B-2-5, specifically those for A_L, A_I, and Cs, are site-specific and may be significant in some cases. (2) Uncertainties associated with the remaining variable in the equation in Table B-2-5 are not expected to be significant, primarily because of the narrow ranges of probable values for these variables or the use of well-established estimation procedures (Kd_s).

TABLE B-2-1

TOTAL COPC LOAD TO WATER BODY
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 3 of 4)

Variable	Description	Units	Value
L_E	Soil erosion load	g/yr	**Varies (calculated - Table B-2-6)** This variable is calculated by using the equation in Table B-2-6. Uncertainties associated with this variable include the following: (1) Most of the uncertainties associated with the variables in the equation in Table B-2-6, specifically those for X_e, A_L, A_I, and *Cs*, are site-specific and may be significant in some cases. (2) Uncertainties associated with the remaining variables in the equation in Table B-2-6 are not expected to be significant, primarily because of the narrow range of probable values for these variables or the use of well-established estimation procedures (Kd_s).

TABLE B-2-1

TOTAL COPC LOAD TO WATER BODY (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 4 of 4)

REFERENCES AND DISCUSSION

Bidleman, T.F. 1988. "Atmospheric Processes." *Environmental Science and Technology*. Volume 22. Number 4. Pages 361-367.

For discussion, see References and Discussion in Table B-1-1.

TABLE B-2-2

DEPOSITION TO WATER BODY
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 1 of 3)

Description

This equation calculates the average load to the water body from direct deposition of wet and dry particles and wet vapors onto the surface of the water body.

Uncertainties associated with this equation include the following:

(1) Most of the uncertainties associated with the variables in this equation, specifically those associated with Q, $Dywwv$, $Dytwp$, and A_W.
(2) It is calculated on the basis of the assumption of a default S_T value for background plus local sources, rather than an S_T value for urban sources. If a specific site is located in an urban area, the use of the latter S_T value may be more appropriate. Specifically, the S_T value for urban sources is about one order of magnitude greater than that for background plus local sources and would result in a lower calculated F_v value; however, the F_v value is likely to be only a few percent lower.

Equation

$$L_{DEP} = Q \bullet [F_v \bullet Dywwv + (1 - F_v) \bullet Dytwp] \bullet A_W$$

For mercury modeling:

$$L_{DEP_{Mercury}} = 0.48 Q_{TotalMercury} \cdot [F_{v_{Hg^{2+}}} \cdot Dywwv + (1 - F_{v_{Hg^{2+}}}) \cdot Dytwp] \cdot A_w$$

In calculating L_{DEP} for mercury comounds, $L_{DEP}(Mercury)$ is calculated as shown above using the total mercury emission rate (Q) measured at the stack and F_v for mercuric chloride (F_v = 0.85). As presented below, the calculated $L_{DEP}(Mercury)$ value is apportioned into the divalent mercury (Hg^{2+}) and methyl mercury (MHg) forms based on a 85% Hg^{2+} and 15% MHg speciation split in the water body (see Chapter 2).

$L_{DEP}(Hg^{2+})$ = $0.85\ L_{DEP}\ Mercury$
$L_{DEP}(MHg)$ = $0.15\ L_{DEP}\ Mercury$

After calculating species specific L_{DEP} values, divalent and methyl mercury should continue to be modeled throughout Appendix B equations as individual COPCs.

Variable	Description	Units	Value
L_{DEP}	Total (wet and dry) particle-phase and wet vapor phase direct deposition load to water body	g/yr	

TABLE B-2-2

DEPOSITION TO WATER BODY (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 2 of 3)

Variable	Description	Units	Value
Q	COPC-specific emission rate	g/s	**Varies (site-specific)** This variable is COPC- and site-specific (see Chapters 2 and 3). Uncertainties associated with this variable are site-specific.
F_v	Fraction of COPC air concentration in vapor phase	unitless	**0 to 1 (see Appendix A-2)** This variable is COPC-specific and should be determined from the COPC tables in Appendix A-2. Uncertainties associated with this variable include the following: (1) It is based on the assumption of a default S_T value for background plus local sources, rather than an S_T value for urban sources. If a specific site is located in an urban area, the use of the latter S_T value may be more appropriate. Specifically, the S_T value for urban sources is about one order of magnitude greater than that for background plus local sources and would result in a lower calculated F_v value; however, the F_v value is likely to be only a few percent lower. (2) According to Bidleman (1988), the equation used to calculate F_v assumes that the variable c (Junge constant) is constant for all chemicals; however, the value of c depends on the chemical (sorbate) molecular weight, the surface concentration for monolayer coverage, and the difference between the heat of desorption from the particle surface and the heat of vaporization of the liquid-phase sorbate. To the extent that site- or COPC-specific conditions may cause the value of c to vary, uncertainty is introduced if a constant value of c is used to calculate F_v.
$Dywwv$	Unitized yearly average wet deposition from vapor phase (over water body)	s/m^2-yr	**Varies (modeled)** This variable is COPC- and site-specific, and is determined by air dispersion modeling (see Chapter 3). Uncertainties associated with this variable are site-specific.
$Dytwp$	Unitized yearly average total (wet and dry) deposition from particle phase (over water body)	s/m^2-yr	**Varies (modeled)** This variable is COPC- and site-specific, and is determined by air dispersion modeling (see Chapter 3). Uncertainties associated with this variable are site-specific.
A_W	Water body surface area	m^2	**Varies (modeled)** This variable is COPC- and site-specific (see Chapter 4). Uncertainties associated with this variable are site-specific.

TABLE B-2-2

DEPOSITION TO WATER BODY (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 3 of 3)

REFERENCES AND DISCUSSION

Bidleman, T.F. 1988. "Atmospheric Processes." *Environmental Science and Technology.* Volume 22. Number 4. Pages 361-367.

Junge, C.E. 1977. *Fate of Pollutants in Air and Water Environments, Part I*. Suffet, I.H., Ed. Wiley. New York. Pages 7-26.

NC DEHNR. 1997. *NC DEHNR Protocol for Performing Indirect Exposure Risk Assessments for Hazardous Waste Combustion Units.* January.

> This document is a reference source for the equation in B-2-2. This document also recommends by using the equations in Bidleman (1988) to calculate F_v values for all organics other than dioxins (PCDD/PCDFs). However, the document does not present a recommendation for dioxins. Finally, this document states that metals are generally entirely in the particulate phase ($F_v = 0$) except for mercury, which is assumed to be entirely in the vapor phase. The document does not state whether F_v for mercury should be calculated by using the equations in Bidleman (1988).

U.S. EPA. 1994. *Revised Draft Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes. Attachment C, Draft Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities.* Office of Emergency and Remedial Response. Office of Solid Waste. December 14.

> This document is a reference source for the equation in Table B-2-2. This document also presents values for organic COPCs that range from 0.27 to 1. F_v values for organics other than PCDD/PCDFs are calculated by using the equations presented in Bidleman (1988). The F_v value for PCDD/PCDFs is assumed to be 0.27, based on U.S. EPA (no date). Finally, this document presents F_v values for inorganic COPCs equal to 0, based on the assumption that these COPCs are nonvolatile and assumed to be 100 percent in the particulate phase and 0 percent in the vapor phase.

TABLE B-2-3

DIFFUSION LOAD TO WATER BODY
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 1 of 4)

Description

This equation calculates the load to the water body due to dry vapor diffusion. Uncertainties associated with this equation include the following:

(1) Most of the uncertainties associated with the variables in this equation, specifically those associated with K_v, Q, Cyv, and A_w, are site-specific.
(2) This equation assumes a default S_T value for background plus local sources, rather than an S_T value for urban sources. If a specific site is located in an urban area, the use of the latter S_T value may be more appropriate. Specifically, the S_T value for urban sources is about one order of magnitude greater than that for background plus local sources and would result in a lower calculated F_v value; however, the F_v value is likely to be only a few percent lower.

Equation

$$L_{Dif} = \frac{K_v \cdot Q \cdot F_v \cdot Cywv \cdot A_W \cdot 1.0\times10^{-6}}{\dfrac{H}{R \cdot T_{wk}}}$$

For mercury modeling:

$$L_{Dif_{Mercury}} = \frac{K_{v_{Hg^{2+}}} \cdot 0.48Q_{TotalMercury} \cdot F_{v_{Hg^{2+}}} \cdot Cywv \cdot A_w \cdot 1.0\times10^{-06}}{\dfrac{H_{Hg^{2+}}}{R \cdot T_{wk}}}$$

In calculating L_{Dif} for mercury comounds, L_{Dif}*(Mercury)* is calculated as shown above using the total mercury emission rate (Q) measured at the stack and F_v for mercuric chloride ($F_v = 0.85$). As presented below, the calculated L_{Dif}*(Mercury)* value is apportioned into the divalent mercury (Hg^{2+}) and methyl mercury (MHg) forms based on a 85% Hg^{2+} and 15% MHg speciation split in the water body (see Chapter 2).

$L_{Dif}(Hg^{2+})$ = 0.85 L_{Dif} *Mercury*
$L_{Dif}(MHg)$ = 0.15 L_{Dif} *Mercury*

After calculating species specific L_{Dif} values, divalent and methyl mercury should continue to be modeled throughout Appendix B equations as individual COPCs.

TABLE B-2-3

DIFFUSION LOAD TO WATER BODY
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 2 of 4)

Variable	Description	Units	Value
L_{Dif}	Dry vapor phase diffusion load to water body	g/yr	
K_v	Overall transfer rate coefficient	m/yr	**Varies (calculated - Table 2-13)** This variable is COPC- and site-specific, and is calculated by using the equation in Table B-2-13.
Q	COPC-specific emission rate	g/s	**Varies (site-specific)** This variable is COPC- and site-specific (see Chapters 2 and 3). Uncertainties associated with this variable are site--specific.
F_v	Fraction of COPC air concentration in vapor phase	unitless	**0 to 1 (see Appendix A-2)** This variable is COPC-specific and should be determined from the COPC tables in Appendix A-2. Uncertainties associated with this variable include the following: (1) This equation assumes a default S_T value for background plus local sources, rather than an S_T value for urban sources. If a specific site is located in an urban area, the use of the latter S_T value may be more appropriate. Specifically, the S_T value for urban sources is about one order of magnitude greater than that for background plus local sources and would result in a lower calculated F_v value; however, the F_v value is likely to be only a few percent lower. (2) According to Bidleman (1988), the equation used to calculate F_v assumes that the variable c is constant for all chemicals; however, the value of c depends on the chemical (sorbate) molecular weight, the surface concentration for monolayer coverage, and the difference between the heat of desorption from the particle surface and the heat of vaporization of the liquid-phase sorbate. To the extent that site- or COPC-specific conditions may cause the value of c to vary, uncertainty is introduced if a constant value of c issued to calculate F_v.
$Cywv$	Unitized yearly average air concentration from vapor phase (over water body)	μg-s/g-m^3	**Varies (modeled)** This variable is COPC- and site-specific, and is determined for each water body by air dispersion modeling (see Chapter 3). Uncertainties associated with this variable are site-specific.

TABLE B-2-3

DIFFUSION LOAD TO WATER BODY
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 3 of 4)

Variable	Description	Units	Value
A_W	Water body surface area	m^2	**Varies (site-specific)** This variable is site-specific (see Chapter 4). Uncertainties associated with this variable are site-specific. However, it is expected that the uncertainty associated with this variable will be limited, because maps, aerial photographs, and other resources from which water body surface areas can be measured, are readily available.
H	Henry's Law constant	atm-m^3/mol	**Varies (see Appendix A-2)** This variable is COPC-specific, and should be determined from the COPC tables in Appendix A-2. The following uncertainty is associated with this variable: (1) Values for this variable, estimated by using the parameters and algorithms in Appendix A-2, may under- or overestimate the actual COPC-specific values. As a result, L_{Dif} may be under- or overestimated to a limited degree.
R	Universal gas constant	atm-m^3/mol-K	**8.205 x 10^{-5}**
T_{wk}	Water body temperature	K	**298** This variable is site-specific. U.S. EPA OSW recommends the use of this default value in the absence of site-specific information, consistent with U.S. EPA (1993 and 1994). The following uncertainty is associated with this variable: (1) To the extent that the default water body temperature value does not accurately represent site-specific or local conditions, L_{Dif} will be under- or overestimated.

TABLE B-2-3

DIFFUSION LOAD TO WATER BODY
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 4 of 4)

REFERENCES AND DISCUSSION

Bidleman, T.F. 1988. *"Atmospheric Processes." Environmental Science and Technology.* Volume 22. Number 4. Pages 361-367.

NC DEHNR. 1997. NC DEHNR Protocol for Performing Indirect Exposure Risk Assessments for Hazardous Waste Combustion Units. January.

This document is a reference source for the equation in Table B-2-3. This document also recommends using the equations in Bidleman (1988) to calculate F_v values for all organics other than dioxins (PCDD/PCDFs).

U.S. EPA. 1993. *Addendum to Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions.* External Review Draft. Office of Solid Waste and Office Research and Development. Washington, D.C. November 10.

This document recommends a range (10°C to 30°C, 283 K to 303 K) for water body temperature, T_{wk}. No source was identified for this range.

U.S. EPA 1994. *Revised Draft Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes. Attachment C, Draft Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities.* Office of Emergency and Remedial Response. Office of Solid Waste. December 14.

This document is cited as the reference source for T_{wk}, water body temperature (298 K); however, no references or sources are identified for this value. This document is a reference source for the equation in Table B-2-2.

TABLE B-2-4

IMPERVIOUS RUNOFF LOAD TO WATER BODY (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 1 of 3)

Description

This equation calculates the average runoff load to the water body from impervious surfaces in the watershed from which runoff is conveyed directly to the water body.

Uncertainties associated with this equation include the following:

(1) Most of the uncertainties associated with the variables in this equation, specifically those associated with Q, $Dywwv$, $Dytwp$, and A_I, are site-specific.

(2) The equation assumes a default S_T value for background plus local sources, rather than an S_T value for urban sources. If a specific site is located in an urban area, the use of the latter S_T value may be more appropriate. Specifically, the S_T value for urban sources is about one order of magnitude greater than that for background plus local sources and would result in a lower calculated F_v value; however, the F_v value is likely to be only a few percent lower.

Equation

$$L_{RI} = Q \cdot \left[F_v \cdot Dywwv + (1 - F_v) \cdot Dytwp \right] \cdot A_I$$

For mercury modeling:

$$L_{RI_{Mercury}} = 0.48 Q_{TotalMercury} \cdot \left[F_{v_{Hg^{2+}}} \cdot Dywwv + (1.0 - F_{v_{Hg^{2+}}}) \cdot Dytwp \right] \cdot A_I$$

In calculating L_{RIP} for mercury comounds, $L_{RI}(Mercury)$ is calculated as shown above using the total mercury emission rate (Q) measured at the stack and F_v for mercuric chloride ($F_v = 0.85$). As presented below, the calculated $L_{RI}(Mercury)$ value is apportioned into the divalent mercury (Hg^{2+}) and methyl mercury (MHg) forms based on a 85% Hg^{2+} and 15% MHg speciation split in the water body (see Chapter 2).

$L_{RI}(Hg^{2+})$ = 0.85 L_{RI} *Mercury*
$L_{RI}(MHg)$ = 0.15 L_{RI} *Mercury*

After calculating species specific L_{RI} values, divalent and methyl mercury should continue to be modeled throughout Appendix B equations as individual COPCs.

TABLE B-2-4

IMPERVIOUS RUNOFF LOAD TO WATER BODY (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 2 of 3)

Variable	Description	Units	Value
L_{RI}	Runoff load from impervious surfaces	g/yr	
Q	COPC-specific emission rate	g/s	**Varies (site-specific)** This variable is COPC- and site-specific, and is determined by air dispersion modeling (see Chapters 2 and 3). Uncertainties associated with this variable are site-specific.
F_v	Fraction of COPC air concentration in vapor phase	unitless	**0 to 1 (see Appendix A-2)** This variable is COPC-specific and should be determined from the COPC tables in Appendix A-2. Uncertainties associated with this variable include the following: (1) The equation assumes a default S_T value for background plus local sources, rather than an S_T value for urban sources. If a specific site is located in an urban area, the use of the latter S_T value may be more appropriate. Specifically, the S_T value for urban sources is about one order of magnitude greater than that for background plus local sources and would result in a lower calculated F_v value; however, the F_v value is likely to be only a few percent lower. (2) According to Bidleman (1988), the equation used to calculate F_v assumes that the variable c is constant for all chemicals; however, the value of c depends on the chemical (sorbate) molecular weight, the surface concentration for monolayer coverage, and the difference between the heat of desorption from the particle surface and the heat of vaporization of the liquid-phase sorbate. To the extent that site- or COPC-specific conditions may cause the value of c to vary, uncertainty is introduced if a constant value of c is used to calculate F_v.
Dywwv	Unitized yearly average wet deposition from vapor phase (over watershed)	s/m^2-yr	**Varies (modeled)** This variable is COPC- and site-specific, and is determined by air dispersion modeling (see Chapter 3). Uncertainties associated with this variable are site-specific.
Dytwp	Unitized yearly average total (wet and dry) deposition from particle phase (over watershed)	s/m^2-yr	**Varies (modeled)** This variable is COPC- and site-specific, and is determined by air dispersion modeling (see Chapter 3). Uncertainties associated with this variable are site-specific.
A_I	Impervious watershed area receiving COPC deposition	m^2	**Varies (site-specific)** This variable is COPC- and site-specific. Uncertainties associated with this variable are site-specific.

TABLE B-2-4

IMPERVIOUS RUNOFF LOAD TO WATER BODY (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 3 of 3)

REFERENCES AND DISCUSSION

Bidleman, T.F. 1988. "Atmospheric Processes." *Environmental Science and Technology.* Volume 22. Number 4. Pages 361-367.

NC DEHNR. 1997. *NC DEHNR Protocol for Performing Indirect Exposure Risk Assessments for Hazardous Waste Combustion Units.* January.

This document is a reference source for the equation in Table B-2-4. This document also recommends using the equations in Bidleman (1988) to calculate F_v values for all organics other than dioxins (PCDD/PCDFs). However, the document does not present a recommendation for dioxins. Finally, this document states that metals are generally entirely in the particulate phase ($F_v = 0$) except for mercury, which is assumed to be entirely in the vapor phase. The document does not state whether F_v for mercury should be calculated by using the equations in Bidleman (1988).

U.S. EPA. 1994. *Revised Draft Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes. Attachment C, Draft Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities*. Office of Emergency and Remedial Response. Office of Solid Waste. December 14.

This document is a reference source for the equation in Table B-2-4.

TABLE B-2-5

PERVIOUS RUNOFF LOAD TO WATER BODY (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 1 of 5)

Description

This equation calculates the average runoff load to the water body from pervious soil surfaces in the watershed.

Uncertainties associated with this equation include the following:

(1) To the extent that site-specific or local average annual surface runoff information is not available, default or estimated values may not accurately represent site-specific or local conditions. As a result, L_R may be under- or overestimated to an unknown degree.
(2) The recommended range of soil bulk density values may not accurately represent site-specific soil conditions; specifically, this range may under- or overestimate site-specific soil conditions to an unknown degree.
(3) The default θ_{sw} values may not accurately reflect site-specific or local conditions; therefore, L_R may be under- or overestimated to a small extent, based on the limited range of values.
(4) Various uncertainties are associated with Cs; see the equation in Table B-1-1.

Equation

$$L_R = RO \cdot (A_L - A_I) \cdot \frac{Cs \cdot BD}{\theta_{sw} + Kd_s \cdot BD} \cdot 0.01$$

For mercury modeling:

For mercury modeling, $L_{R\,(Initial)}$ values are calculated for divalent mercury (Hg^{2+}) and methyl mercury (MHg) using their respective Cs and Kd_s values; then as indicated below, these values are apportioned based on a 85% Hg^{2+} and 15% MHg speciation split in the water body (see Chapter 2).

$$L_{R_{Hg^{2+}}} = L_{R_{Hg^{2+}\,(Initial)}} \cdot 0.85$$

$$L_{R_{MHg}} = L_{R_{MHg\,(Initial)}} + (L_{R_{Hg^{2+}\,(Initial)}} \cdot 0.15)$$

After calculating species specific L_R values, divalent and methyl mercury should continue to be modeled throughout Appendix B equations as individual COPCs.

TABLE B-2-5

PERVIOUS RUNOFF LOAD TO WATER BODY
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 2 of 5)

Variable	Description	Units	Value
L_R	Runoff load from pervious surfaces	g/yr	
RO	Average annual surface runoff	cm/yr	**Varies (site-specific)** This variable is site-specific. According to U.S. EPA (1993), U.S. EPA (1994), and NC DEHNR (1997), average annual surface runoff can be estimated by using the *Water Atlas of the United States* (Geraghty, Miller, Van der Leeden, and Troise 1973). According to NC DEHNR, (1997), more detailed, site-specific procedures for estimating the amount of surface runoff, such as those based on the U.S. Soil Conservation Service CNE may also be used. U.S. EPA (1985) is cited as an example of such a procedure. The following uncertainty is associated with this variable: (1) To the extent that site-specific or local average annual surface runoff information is not available, default or estimated values may not accurately represent site-specific or local conditions. As a result, K_R may be under- or overestimated to an unknown degree.
A_L	Total watershed area receiving COPC deposition	m^2	**Varies (site-specific)** This variable is site-specific (see Chapter 4). Uncertainties associated with this variable are site-specific.
A_I	Impervious watershed area receiving COPC deposition	m^2	**Varies (site-specific)** This variable is site-specific (see Chapter 4). Uncertainties associated with this variable are site-specific.
Cs	COPC concentration in soil	mg/kg	**Varies (calculated - Table B-1-1)** This value is COPC-and site-specific and should be calculated using the equation in Table B-1-1. For calculation of *Cs* in watersheds, the maximum or average of air parameter values at receptor grid nodes located within the watershed may be used (see Chapter 4). Uncertainties associated with this variable are site-specific.

TABLE B-2-5

PERVIOUS RUNOFF LOAD TO WATER BODY (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 3 of 5)

Variable	Description	Units	Value
BD	Soil bulk density	g/cm^3	**1.5** This variable is affected by the soil structure, such as looseness or compaction of the soil, depending on the water and clay content of the soil (Hillel 1980), as summarized in U.S. EPA (1990). A range of 0.83 to 1.84 was originally cited in Hoffman and Baes (1979). U.S. EPA (1994) recommended a default soil bulk density value of 1.5 g/cm^3, based on a mean value for loam soil from Carsel, Parrish, Jones, Hansen, and Lamb (1988). The value of 1.5 g/cm^3 also represents the midpoint of the "relatively narrow range" for BD of 1.2 to 1.7 g/cm^3. The following uncertainty is associated with this variable: (1) The recommended range of soil dry bulk density values may not accurately represent site-specific soil conditions.
θ_{sw}	Soil volumetric water content	mL/cm^3	**0.2** This variable depends on the available water and on soil structure. θ_{sw} can be estimated as the midpoint between a soil's field capacity and wilting point, if a representative watershed soil can be identified. However, U.S. EPA OSW recommends the use of 0.2 mL/cm^3 as a default value. This value is the midpoint of the range 0.1 (very sandy soils) to 0.3 (heavy loam/clay soils) recommended by U.S. EPA (1993) (no source or reference is provided for this range) and is consistent with U.S. EPA (1994). The following uncertainty is associated with this variable: (1) The default θ_{sw} values may not accurately reflect site-specific or local conditions; therefore, L_R may be under- or overestimated to a small extent, based on the limited range of values.
Kd_s	Soil-water partition coefficient	cm^3/g	**Varies (see Appendix A-2)** This variable is COPC-specific and should be determined from the COPC tables in Appendix A-2. The following uncertainty is associated with this variable: (1) Uncertainties associated with this parameter will be limited if Kd_s values are calculated as described in Appendix A-2.
0.01	Units conversion factor	$kg\text{-}cm^2/mg\text{-}m^2$	

TABLE B-2-5

PERVIOUS RUNOFF LOAD TO WATER BODY (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 4 of 5)

REFERENCES AND DISCUSSION

Carsel, R.F., R.S. Parrish, R.L. Jones, J.L. Hansen, and R.L. Lamb. 1988. "Characterizing the Uncertainty of Pesticide Leaching in Agricultural Soils." *Journal of Contaminant Hydrology*. Volume 2: pages 11-24.

Geraghty, J.J., D.W Miller, F. Van der Leeden, and F.L. Troise. 1973. *Water Atlas of the United States*. Water Information Center. Port Washington, New York.

This document is cited by U.S. EPA (1993), U.S. EPA (1994), and NC DEHNR (1997) as a reference for calculating average annual runoff, *RO*. Specifically, this reference provides maps with isolines of annual average surface water runoff, which is defined as all flow contributions to surface water bodies, including direct runoff, shallow interflow, and ground water recharge. Because these volumes are total contributions and not only surface runoff, U.S. EPA (1994) notes that they need to be reduced to estimate surface runoff. U.S. EPA (1994) recommends a reduction of 50 percent.

Hillel, D. 1980. *Fundamentals of Soil Physics*. Academic Pres, Inc. New York.

This document is cited by U.S. EPA (1990) for the statement that dry soil bulk density, *BD*, is affected by soil structure, such as looseness or compaction of the soil, depending on the water and clay content of the soil.

Hoffman, F.O., and C.F. Baes. 1979. *A Statistical Analysis of Selected Parameters for Predicting Food Chain Transport and Internal Dose of Radionuclides*. ORNL/NUREG/TM-882.

This document presents a soil bulk density, *BD*, range of 0.83 to 1.84 g/cm^3.

NC DEHNR. 1997. *NC DEHNR Protocol for Performing Indirect Exposure Assessments for Hazardous Waste Combustion Units*. January.

This document is one of the source documented that cites the use of the equation in Table B-2-5. However, the document is not the original source of this equation. This document also recommends the following:

- Estimation of average annual runoff, *RO* (cm/yr), by using the *Water Atlas of the United States* (Geraghty, Miller, Van der Leeden, and Troise 1973) or site-specific procedures, such as the U.S. Soil Conservation Service CNE; U.S. EPA (1985) is cited as an example of the use of the CNE
- A default value of 0.2 cm^3/cm^3 for soil volumetric content (θ_{sw})

U.S. EPA. 1985. *Water Quality Assessment: A Screening Procedures for Toxic and Conventional Pollutants in Surface and Ground Water - Part I (Revised - 1985)*. Environmental Research Laboratory. Athens, Georgia. EPA/600/6-85/002a. September.

TABLE B-2-5

PERVIOUS RUNOFF LOAD TO WATER BODY (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 5 of 5)

U.S. EPA. 1990. *Interim Final Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions.* Environmental Criteria and Assessment Office. Office of Research and Development. EPA 600-90-003. January.

This document cites Hillel (1980) for the statement that only soil bulk density, *BD*, is affected by the soil structure, such as loosened or compaction of the soil, depending on the water and clay content of the soil.

U.S. EPA. 1993. *Addendum: Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions.* Working Group Recommendations. Office of Solid Waste and Office of Research and Development. Washington, D.C. September 24.

This document is a source of COPC-specific (inorganics only) Kd_s values used to develop a range (2 to 280,000 mL/g) of Kd_s values. This document also recommends a range of soil volumetric water content (θ_{sw}) of 0.1 cm^3/cm^3 (very sandy soils) to 0.3 cm^3/cm^3 (heavy loam/clay soils); however, no source or reference is provided for this range.

U.S. EPA. 1994. *Revised Draft Guidance of Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*. Attachment C, Draft Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities. Office of Emergency and Remedial Response. Office of Solid Waste. December 14.

This document recommends (1) a default soil bulk density value of 1.5 g/cm^3, based on a mean value for loam soil from Carsel, Parrish, Jones, Hansen, and Lamb (1988), and (2) a default soil volumetric water content, θ_{sw}, value of 0.2 cm^3/cm^3, based on U.S. EPA (1993).

TABLE B-2-6

EROSION LOAD TO WATER BODY
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 1 of 6)

Description

This equation calculates the load to the water body from soil erosion.

Uncertainties associated with this equation include the following:

(1) Most of the uncertainties associated with the variables, specifically those for X_e, A_L, A_I, and Cs, are site-specific.
(2) Uncertainties associated with the remaining variables are not expected to be significant, primarily because of the narrow ranges of probable values for these variables or the use of well-established estimation procedures (Kd_s).

Equation

$$L_E = X_e \cdot (A_L - A_I) \cdot SD \cdot ER \cdot \frac{Cs \cdot Kd_s \cdot BD}{\theta_{sw} + Kd_s \cdot BD} \cdot 0.001$$

For mercury modeling:

For mercury modeling, $L_{E\,(Initial)}$ values are calculated for divalent mercury (Hg^{2+}) and methyl mercury (MHg) using their respective Cs and Kd_s values; then as indicated below, these values are apportioned based on a 85% Hg^{2+} and 15% MHg speciation split in the water body (see Chapter 2).

$$L_{E_{Hg^{2+}}} = L_{E_{Hg^{2+}\,(Initial)}} \cdot 0.85$$

$$L_{E_{MHg}} = L_{E_{MHg\,(Initial)}} + (L_{E_{Hg^{2+}\,(Initial)}} \cdot 0.15)$$

After calculating species specific L_E values, divalent and methyl mercury should continue to be modeled throughout Appendix B equations as individual COPCs.

TABLE B-2-6

EROSION LOAD TO WATER BODY
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 2 of 6)

Variable	Description	Units	Value
L_E	Soil erosion load	g/yr	
X_e	Unit soil loss	kg/m^2-yr	**Varies (calculated - Table B-2-7)** This variable is site-specific, and is calculated by using the equation in Table B-2-7. The following uncertainty is associated with this variable: (1) All of the equation variables (see Table B-2-7) are site-specific. Use of default values rather than site-specific values, for any or all or these variables, will result in estimates of unit soil loss, X_e, that are under- or overestimated to some degree. The range of X_e calculated on the basis of default values spans slightly more than one order of magnitude (0.6 to 36.3 kg/m^2-yr).
A_L	Total watershed area receiving COPC deposition	m^2	**Varies (site-specific)** This variable is site-specific (see Chapter 4). Uncertainties associated with this variable are site-specific.
A_I	Impervious watershed area receiving COPC deposition	m^2	**Varies (site-specific)** This variable is site-specific (see Chapter 4). Uncertainties associated with this variable are site-specific.
SD	Sediment delivery ratio	unitless	**Varies (calculated - Table B-2-8)** This value is site-specific and is calculated by using the equation in Table B-2-8. The following uncertainty is associated with this variable: (1) The recommended default values for the variables a and b (empirical intercept coefficient and empirical slope coefficient, respectively) are average values, based on a review of sediment yields from various watersheds. These default values may not accurately represent site-specific watershed conditions and, therefore, may contribute to the under- or over estimation of L_E.

TABLE B-2-6

EROSION LOAD TO WATER BODY
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 3 of 6)

Variable	Description	Units	Value
ER	Soil enrichment ratio	unitless	**1 to 3** **Inorganic COPCs: 1** **Organic COPCs: 3** COPC enrichment occurs because lighter soil particles erode more than heavier soil particles and concentrations of organic COPCs which is a function of organic carbon content of sorbing media, are expected to be higher in eroded material than in-situ soil (U.S. EPA 1993). In the absence of site-specific data, U.S. EPA OSW recommends a default value of 3 for organic COPCs and 1 for inorganic COPCs. This is consistent with other U.S. EPA guidance (1993), which recommends a range of 1 to 5 and a value of 3 as a "reasonable first estimate". This range has been used for organic matter, phosphorus, and other soil-bound COPCs (U.S. EPA 1993); however, no sources or references were provided for this range. ER is generally higher in sandy soils than in silty or loamy soils (U.S. EPA 1993). The following uncertainty is associated with this variable: (1) The default ER value may not accurately reflect site-specific conditions; therefore, L_E may be over- or underestimated to an unknown, but relatively small, extent.
Cs	COPC concentration in soil	mg/kg	**Varies (calculated - Table B-1-1)** This value is COPC-and site-specific and should be calculated using the equation in Table B-1-1. For calculation of Cs in watersheds, the maximum or average of air parameter values at receptor grid nodes located within the watershed may be used (see Chapter 4). Uncertainties associated with this variable are site-specific.
Kd_s	Soil-water partition coefficient	cm^3/g	**Varies (see Appendix A-2)** This variable is COPC-specific and should be determined from the COPC tables in Appendix A-2. The following uncertainty is associated with this variable: (1) Uncertainties associated with this parameter will be limited if Kd_s values are calculated as described in Appendix A-2.

TABLE B-2-6

EROSION LOAD TO WATER BODY
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 4 of 6)

Variable	Description	Units	Value
BD	Soil bulk density	g/cm^3	**1.5** This variable is affected by the soil structure, such as looseness or compaction of the soil, depending on the water and clay content of the soil (Hillel 1980), as summarized in U.S. EPA (1990). A range of 0.83 to 1.84 was originally cited in Hoffman and Baes (1979). U.S. EPA (1994a) recommended a default soil bulk density value of 1.5 g/cm^3, based on a mean value for loam soil from Carsel, Parrish, Jones, Hansen, and Lamb (1988). The value of 1.5 g/cm^3 also represents the midpoint of the "relatively narrow range" for *BD* of 1.2 to 1.7 g/cm^3. The following uncertainty is associated with this variable: (1) The recommended range of soil dry bulk density values may not accurately represent site-specific soil conditions.
θ_{sw}	Soil volumetric water content	mL/cm^3	**0.2** This variable depends on the available water and on soil structure. θ_{sw} can be estimated as the midpoint between a soil's field capacity and wilting point, if a representative watershed soil can be identified. However, U.S. EPA OSW recommends the use of 0.2 cm^3 as a default value. This value is the midpoint of the range of 0.1 (very sandy soils), to 0.3 (heavy loam/clay soils), recommended by U.S. EPA (1993) (no source or reference is provided for this range) and is consistent with U.S. EPA (1994). The following uncertainty is associated with this variable: (1) The default θ_{sw} values may not accurately reflect site-specific or local conditions; therefore, L_E may be under- or overestimated to a small extent, based on the limited range of values.
0.001	Units conversion factor	g/mg	

TABLE B-2-6

EROSION LOAD TO WATER BODY
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 5 of 6)

REFERENCES AND DISCUSSION

Carsel, R.F., R.S. Parrish, R.L. Jones, J.L. Hansen, and R.L. Lamb. 1988. "Characterizing the Uncertainty of Pesticide Leaching in Agricultural Soils." *Journal of Contaminant Hydrology*. Volume 2. Pages 11-24.

This document is the source for a mean soil bulk density of 1.5 cm^3 for loam soil.

Hillel, D. 1980. *Fundamentals of Soil Physics*. Academic Press, Inc. New York.

This document is cited by U.S. EPA (1990) for the statement that dry soil bulk density, *BD*, is affected by the soil structure, such as looseness or compaction of the soil, depending on the water and clay content of the soil.

Hoffman, F.O., and C.F. Baes. 1979. *A Statistical Analysis of Selected Parameters for Predicting Food Chain Transport and Internal Dose of Radionuclides*. ORNL/NUREG/TM-882.

This document presents a soil bulk density, *BD*, range of 0.83 to 1.84 g/cm^3.

NC DEHNR. 1997. *NC DEHNR Protocol for Performing Indirect Exposure Risk Assessments for Hazardous Waste Combustion Units*. January.

This document is cited as one of the sources for the range of *BD* and Kd_s values, and the default value for the volumetric soil water content.

U.S. EPA. 1990. *Interim Final Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions.* Environmental Criteria and Assessment Office. Office of Research and Development. EPA 600-90-003. January.

This document cites Hillel (1980) for the statement that dry soil bulk density, *BD*, is affected by the soil structure, such as looseness or compaction of the soil, depending on the water and clay content of the soil.

U.S. EPA. 1993. *Addendum to the Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions.* External Review Draft. Office of Research and Development. Washington, D.C. November 1993.

This document is the source of the recommended range of COPC enrichment ratio, *ER*, values. This range, 1 to 5, has been used for organic matter, phosphorous, and other soil-based COPCs. This document recommends a value of 3 as a "reasonable first estimate," and states that COPC enrichment occurs because lighter soil particles erode more than heavier soil particles. Lighter soil particles have higher surface-area-to-volume ratios and are higher in organic matter content. Therefore, concentrations of organic COPCs, which are a function of the organic carbon content of sorbing media, are expected to be higher in eroded material than in in-situ soil.

This document is also the source of the following:

- COPC-specific (inorganics only) Kd_s values used to develop a proposed range (0 to 280,000 mL/g) of Kd_s values

TABLE B-2-6

EROSION LOAD TO WATER BODY
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 6 of 6)

- A range of soil volumetric water content (θ_{sw}) values of 0.1 mL/cm^3 (very gravelly soils) to 0.3 mL/cm^3 (heavy loam/clay soils); however, no source or reference is provided for this range.

U.S. EPA. 1994. *Revised Draft Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes.* Attachment C, *Draft Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities*. Office of Emergency and Remedial Response. Office of Solid Waste. December 14.

This document recommends (1) a default soil bulk density value of 1.5 g/cm^3, based on a mean value for loam soil from Carsel, Parrish, Jones, Hansen, and Lamb (1988), and (2) a default soil volumetric water content, θ_{sw}, value of 0.2 cm^3, based on U.S. EPA (1993).

TABLE B-2-7

UNIVERSAL SOIL LOSS EQUATION (USLE)
(SOIL EQUATIONS)

(Page 1 of 5)

Description

This equation calculates the soil loss rate from the watershed by using the Universal Soil Loss Equation (USLE); the result is used in the soil erosion load equation in Table B-2-6. Estimates of unit soil loss, X_e, should be determined specific to each watershed evaluated. Information on determining site- and watershed-specific values for variables used in calculating X_e is provided in U.S. Department of Agriculture (U.S. Department of Agriculture 1997) and U.S. EPA guidance (U.S. EPA 1985). Uncertainties associated with this equation include the following:

(1) All of the equation variables are site-specific. Use of site-specific values will result in estimates of unit soil loss, X_e, that are under- or overestimated to some unknown degree.

Equation

$$X_e = RF \cdot K \cdot LS \cdot C \cdot PF \cdot \frac{907.18}{4047}$$

Variable	Description	Units	Value
X_e	Unit soil loss	kg/m^2-yr	
RF	USLE rainfall (or erosivity) factor	yr^{-1}	**50 to 300 (site-specific)** This value is site-specific and is derived on a storm-by-storm basis. As cited in U.S. EPA (1993b), average annual values have been compiled regionally by Wischmeier and Smith (1978). The recommended range reflects these compiled values. The following uncertainty is associated with this variable: (1) The range of average annual rainfall factors (50 to 300) from Wischmeier and Smith (1978) may not accurately reflect site-specific conditions. Therefore, unit soil loss, X_e, may be under- or overestimated.

TABLE B-2-7

UNIVERSAL SOIL LOSS EQUATION (USLE)
(SOIL EQUATIONS)

(Page 2 of 5)

Variable	Description	Units	Value
K	USLE erodibility factor	ton/acre	**Varies** This value is site-specific. U.S. EPA OSW recommends the use of current guidance (U.S. Department of Agriculture 1997; U.S. EPA 1985) in determining watershed-specific values for this variable based on site-specific information. A default value of 0.36, as cited in U.S. EPA (1994), was based on a soil organic matter content of 1 percent (Droppo, Strenge, Buck, Hoopes, Brockhaus, Walter, and Whelan 1989), and chosen to be representative of a whole watershed. The following uncertainty is associated with this variable: (1) The determination and use of site-specific values for the USLE soil erodibility factor, K, may not accurately represent site-specific conditions. Therefore, use of this value may cause unit soil loss, X_e, to be under- or overestimated.
LS	USLE length-slope factor	unitless	**Varies** This value is site-specific. U.S. EPA OSW recommends the use of current guidance (U.S. Department of Agriculture 1997; U.S. EPA 1985) in determining watershed-specific values for this variable based on site-specific information. A value of 1.5, as cited in U.S. EPA (1994), reflects a variety of possible distance and slope conditions (U.S. EPA 1988), and was chosen to be representative of a whole watershed. The following uncertainty is associated with this variable: (1) The determination and use of site-specific values for the USLE length-slope factor, LS, may not accurately represent site-specific conditions. Therefore, use of this value may cause unit soil loss, X_e, to be under- or overestimated.

TABLE B-2-7

UNIVERSAL SOIL LOSS EQUATION (USLE)
(SOIL EQUATIONS)

(Page 3 of 5)

Variable	Description	Units	Value
C	USLE cover management factor	unitless	**Varies** This value is site-specific. U.S. EPA OSW recommends the use of current guidance (U.S. Department of Agriculture 1997; U.S. EPA 1985) in determining watershed-specific values for this variable based on site-specific information. The range of values up to 0.1 reflect dense vegetative cover, such as pasture grass; values from 0.1 to 0.7 reflect agricultural row crops; and a value of 1.0 reflects bare soil (U.S. EPA 1993b). U.S. EPA (1993a) recommended a value of 0.1 for both grass and agricultural crops. This range of values was also cited in NC DEHNR (1997). However, U.S. EPA (1994) and NC DEHNR (1997) both recommend a default value of 0.1 to be representative of a whole watershed. The following uncertainty is associated with this variable: (1) The determination and use of site-specific values for USLE cover management factor, C, may not accurately represent site-specific conditions. Therefore, use of default value for C may result in the under- or overestimation of unit soil loss, X_e.
PF	USLE supporting practice factor	unitless	**Varies** This value is site-specific. U.S. EPA OSW recommends the use of current guidance (U.S. Department of Agriculture 1997; U.S. EPA 1985) in determining watershed-specific values for this variable based on site-specific information. A default value of 1.0, which conservatively represents the absence of any erosion or runoff control measures, was cited in U.S. EPA (1993a; 1994) and NC DEHNR (1997). The following uncertainty is associated with this variable: (1) The determination and use of site-specific values for the USLE supporting practice factor, PF, may not accurately represent site-specific conditions. Therefore, resulting in the under- or overestimation of unit soil loss, X_e.
907.18	Conversion factor	kg/ton	
4047	Conversion factor	m^2/acre	

TABLE B-2-7

UNIVERSAL SOIL LOSS EQUATION (USLE)
(SOIL EQUATIONS)

(Page 4 of 5)

REFERENCES AND DISCUSSION

Droppo, J.G. Jr., D.L. Strenge, J.W. Buck, B.L. Hoopes, R.D. Brockhaus, M.B. Walter, and G. Whelan. 1989. *Multimedia Environmental Pollutant Assessment System (MEPAS) Application Guidance: Volume 2-Guidelines for Evaluating MEPAS Input Parameters*. Pacific Northwest Laboratory. Richland, Washington. December.

This document is cited by U.S. EPA 1994 and NC DEHNR 1997 as the reference source for the default USLE erodibility factor value of 0.36, based on a soil organic matter content of 1 percent.

NC DEHNR. 1997. *NC DEHNR Protocol for Performing Indirect Exposure Risk Assessments for Hazardous Waste Combustion Units*. January.

This document recommends the following:

- A USLE erodibility factor, *K*, value of 0.36 ton/acre
- A USLE length-slope factor, *LS*, value of 1.5 (unitless)
- A range of USLE cover management factor, *C*, values of 0.1 to 1; it also recommends a default value of 0.1 to be representative of a whole watershed, not just an agricultural field.
- A USLE supporting practice factor, *P*, value of 1

U.S. Department of Agriculture. 1997. *Predicting Soil Erosion by Water: A Guide to Conservation Planning With the Revised Universal Soil Loss Equation (RUSLE).* Agricultural Research Service, Agriculture Handbook Number 703. January.

U.S. EPA. 1985. *Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants in Surface and Ground Water—Part I (Revised).* ORD. Athens, Georgia. EPA/600/6-85/002a.

U.S. EPA. 1988. *Superfund Exposure Assessment Manual*. Office of Solid Waste. Washington, D.C. April.

This document is cited by U.S. EPA 1994 and NC DEHNR 1997 as the reference source for the USLE length-slope factor value of 1.5. This value reflects a variety of possible distance and slope conditions and was chosen to be representative of a whole watershed, not just an agricultural field.

U.S. EPA. 1993a. *Addendum: Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions. Working Group Recommendations.* Office of Solid Waste and Office of Research and Development. Washington, D.C. September 24.

This document cites Wischmeier and Smith (1978) as the source of average annual USLE rainfall factors, *RF*, and states that annual values range from less than 50 for the arid western United States to greater than 300 for the southeast.

This document also recommends the following:

- A USLE cover management factor, *C*, of 0.1 for both grass and agricultural crops
- A USLE supporting practice factor, *P*, of 1, based on the assumed absence of any erosion or runoff control measures

TABLE B-2-7

UNIVERSAL SOIL LOSS EQUATION (USLE)
(SOIL EQUATIONS)

(Page 5 of 5)

U.S. EPA. 1993b. *Review Draft Addendum to the Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustion Emissions.* Office of Health and Environmental Assessment. Office of Research and Development. EPA-600-AP-93-003. November 10.

This document discusses the USLE cover management factor. This factor, *C*, primarily reflects how erosion is influenced by vegetative cover and cropping practices, such as planting across slope rather than up and down slope. This document discusses a range of *C* values for 0.1 to 1; values greater than 0.1 but less than 0.2 are appropriate for agricultural row crops, and a value of 1 is appropriate for sites mostly devoid of vegetation.

U.S. EPA. 1994. *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes.* Office of Emergency and Remedial Response. Office of Solid Waste. December 14.

This document recommends the following:

- A USLE erodibility factor, *K*, value of 0.36 ton/acre
- A USLE length-slope factor, *LS*, value of 1.5 (unitless)
- A range of USLE cover management factor, *C*, values of 0.1 to 1; it recommends a default value of 0.1 to be representative of a whole watershed, not just an agricultural field.
- A USLE supporting practice factor, *P*, value of 1

Wischmeire, W.H., and D.D. Smith. 1978. *Predicting Rainfall Erosion Losses—A Guide to Conservation Planning.* Agricultural Handbook No. 537. U.S. Department of Agriculture Washington, D.C.

This document is cited by U.S. EPA (1993) as the source of average annual USLE rainfall factors, *RF*, compiled regionally. According to U.S. EPA (1993), annual values range from less than 50 for the arid western United States to greater than 300 for the southeast.

TABLE B-2-8

SEDIMENT DELIVERY RATIO
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 1 of 4)

Description

This equation calculates the sediment delivery ratio for the watershed. The result is used in the soil erosion load equation.

Uncertainties associated with this equation include the following:

(1) The recommended default empirical intercept coefficient, *a*, values are average values based on various studies of sediment yields from various watersheds. Therefore, these default values may not accurately represent site-specific watershed conditions. As a result, use of these default values may under- or overestimate the watershed sediment delivery ratio, *SD*.
(2) The recommended default empirical slope coefficient, *b*, value is based on a review of sediment yields from various watersheds. This single default value may not accurately represent site-specific watershed conditions. As a result, use of this default value may under- or overestimate the watershed sediment delivery ratio, *SD*.

Equation

$$SD = a \cdot (A_L)^{-b}$$

Variable	Description	Units	Value
SD	Watershed sediment delivery ratio	unitless	

TABLE B-2-8

SEDIMENT DELIVERY RATIO
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 2 of 4)

<table>
<tr><th>Variable</th><th>Description</th><th>Units</th><th>Value</th></tr>
<tr><td>a</td><td>Empirical intercept coefficient</td><td>unitless</td><td>

0.6 to 2.1 (depends on watershed area)

This variable is site-specific and is determined on the basis of the watershed area (Vanoni 1975), as cited in U.S. EPA (1993):

<table>
<tr><th>Watershed Area (sq. miles)</th><th>"a" Coefficient (unitless)</th></tr>
<tr><td>≤ 0.1</td><td>2.1</td></tr>
<tr><td>>0.1 but ≤ 1</td><td>1.9</td></tr>
<tr><td>>1 but ≤ 10</td><td>1.4</td></tr>
<tr><td>>10 but ≤ 100</td><td>1.2</td></tr>
<tr><td>>100</td><td>0.6</td></tr>
</table>

Note: 1 sq. mile = 2.59×10^6 m^2

The use of these values is consistent with U.S. EPA (1994a and 1994b) and NC DEHNR (1997).

The following uncertainty is associated with this variable:

(1) The recommended default empirical intercept coefficient, a, values are average values based on various studies of sediment yields from various watersheds. Therefore, these default values may not accurately represent site-specific watershed conditions. As a result, use of these default values may under- or overestimate the watershed sediment delivery ratio, *SD*.

</td></tr>
<tr><td>A_L</td><td>Watershed area receiving COPC deposition</td><td>m^2</td><td>

Varies (site-specific)

This variable is site-specific (see Chapter 4). Uncertainties associated with this variable are site-specific.

</td></tr>
</table>

TABLE B-2-8

SEDIMENT DELIVERY RATIO
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 3 of 4)

Variable	Description	Units	Value
b	Empirical slope coefficient	unitless	**0.125** As cited in U.S. EPA (1993), this variable is an empirical constant based on the research of Vanoni (1975), which concludes that sediment delivery ratios vary approximately with the -(1/8) power of the drainage area. The use of this value is consistent with U.S. EPA (1994a and 1994b) and NC DEHNR (1997). U.S. EPA has not completed its review of Vanoni (1975). The following uncertainty is associated with this variable: (1) The recommended default empirical slope coefficient, *b*, value is based on a review of sediment yields from various watersheds. This single default value may not accurately represent site-specific watershed conditions. As a result, use of this default value may under- or overestimate the watershed sediment delivery ratio, *SD*.

TABLE B-2-8

SEDIMENT DELIVERY RATIO (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 4 of 4)

REFERENCES AND DISCUSSION

NC DEHNR. 1997. *NC DEHNR Protocol for Performing Indirect Exposure Risk Assessments for Hazardous Waste Combustion Units*. January.

This document is cited as one of the reference source documents for the empirical intercept coefficient, *a*, and empirical slope coefficient, *b*, values. This document cites U.S. EPA (1993) as the source of its information.

U.S. EPA. 1993. *Addendum to the Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions.* External Review Draft. Office of Research and Development. Washington, D.C. November.

This document is cited as one of the reference source documents for the empirical intercept coefficient, *a*, and empirical slope coefficient, *b*, values. This document cites Vanoni (1975) as its source of information.

U.S. EPA. 1994a. *Draft Guidance for Performing Screening Level Risk Analyses at Combustor Facilities Burning Hazardous Wastes. Attachment C, Draft Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities*. April 15.

This document is cited as one of the reference source documents for the empirical intercept coefficient, *a*, and empirical slope coefficient, *b*, values. This document does not identify Vanoni (1975) as the source of its information.

U.S. EPA. 1994b. *Revised Draft Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes. Attachment C, Draft Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities*. Office of Emergency and Remedial Response. Office of Solid Waste. December 14.

This document is cited as one of the reference source documents for the empirical intercept coefficient, *a*, and the empirical slope coefficient, *b*, values. This document cites U.S. EPA (1993) as the source of its information.

Vanoni, V.A. 1975. *Sedimentation Engineering*. American Society of Civil Engineers. New York, New York. Pages 460-463.

This document is cited by U.S. EPA (1993) as the source of the equation in Table B-2-8 and the empirical intercept coefficient, *a*, and empirical slope coefficient, *b*, values. Based on various studies of sediment yields from watersheds, this document concludes that the sediment delivery ratios vary approximately with the -(1/8) power of the drainage ratio.

TABLE B-2-9

TOTAL WATER BODY CONCENTRATION
(SURFACE WATER AND SEDIMENT EQUATIONS)

Description

This equation calculates the total water body concentration; including the water column and the bed sediment.

Uncertainties associated with this equation include the following:

(1) The default variable values recommended for use in the equation in Table B-2-9 may not accurately represent site-specific water body conditions. The degree of uncertainty associated with the variables Vf_x, A_W, d_{wc}, *and* d_{bs} is expected to be limited either because the probable ranges for these variables are narrow or information allowing accurate estimates is generally available.

(2) Uncertainty associated with f_{wc} is largely the result of uncertainty associated with default organic carbon (*OC*) content values and may be significant in specific instances. Uncertainties associated with the total core load into water body (L_T) and overall total water body core dissipation rate constant (k_{wt}) may also be significant in some instances because of the summation of many variable-specific uncertainties.

Equation

$$C_{wtot} = \frac{L_T}{Vf_x \cdot f_{wc} + k_{wt} \cdot A_W \cdot \left(d_{wc} + d_{bs}\right)}$$

For mercury modeling:

Total water body concentration is calculated for divalent mercury (Hg^{2+}) and methyl mercury (MHg) using their respective L_T values, f_{wc} values, and k_{wt} values.

Variable	Description	Units	Value
C_{wtot}	Total water body COPC concentration (including water column and bed sediment)	g/m^3 (equivalent to mg/L)	
L_T	Total COPC load to the water body (including deposition, runoff, and erosion)	g/yr	**Varies (calculated - Table B-2-1)** This variable is COPC- and site-specific, and is calculated by using the equation in Table B-2-1. Uncertainties associated with L_{DEP}, L_{Dif}, L_{RI}, L_R, *and* L_E, as presented in Table B-2-1, are also associated with L_T.

TABLE B-2-9

TOTAL WATER BODY CONCENTRATION
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 2 of 4)

Variable	Description	Units	Value
Vf_x	Average volumetric flow rate through water body	m^3/yr	**Varies (site-specific)** This variable is site-specific and should be an annual average. The following uncertainty is associated with this variable: (1) Use of default average volumetric flow rate (Vf_x) information may not accurately represent site-specific conditions, especially for those water bodies for which flow rate information is not readily available. Therefore, use of default Vf_x values may contribute to the under- or overestimation of total water body COPC concentration, C_{wtot}.
f_{wc}	Fraction of total water body COPC concentration that occurs in the water column	unitless	**0 to 1 (calculated - Table B-2-10)** This variable is COPC- and site-specific, and is calculated by using the equation in Table B-2-10. The following uncertainty is associated with this variable: (1) The default values for the variables in the equation in Table B-2-10 may not accurately represent site- and water body - specific conditions. However, the range of several variables—including d_{bs}, C_{BS}, *and* θ_{bs}—is relatively narrow. Other variables, such as d_{wc} and d_z, can be reasonably estimated on the basis of generally available information. The largest degree of uncertainty may be introduced by the default medium-specific organic carbon (*OC*) content values. Because *OC* content values may vary widely in different locations in the same medium, by using default values may result in insignificant uncertainty in specific cases.
k_{wt}	Overall total water body COPC dissipation rate constant	yr^{-1}	**Varies (calculated - Table B-2-11)** This variable is COPC- and site-specific, and is calculated by using the equation in Table B-2-11. The following uncertainty is associated with this variable: (1) All of the variables in the equation in Table B-2-11 are site-specific; therefore, the use of default values for any or all of these variables will contribute to the under- or overestimation of C_{wtot}. The degree of uncertainty associated with the variable k_b is expected to be under one order of magnitude and is associated largely with the estimation of the unit soil loss, X_e, values for the variables f_{wc}, k_v, and f_{bs} are dependent on medium-specific estimates of *OC* content. Because *OC* content can vary widely for different locations in the same medium, uncertainty associated with these three may be significant in specific instances.

TABLE B-2-9

TOTAL WATER BODY CONCENTRATION (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 3 of 4)

Variable	Description	Units	Value
A_W	Water body surface area	m^2 (average value for the entire year)	**Varies (site-specific)** This variable is site-specific (see Chapter 4). The value selected is assumed to represent an average value for the entire year. Uncertainties associated with this variable are site-specific and expected to be limited, because maps, aerial photographs, and other resources from which water body surface areas can be measured, are readily available.
d_{wc}	Depth of water column	m (average value for the entire year)	**Varies (site-specific)** This variable is site-specific and should be an average annual value. The following uncertainty is associated with this variable: (1) Use of default depth of water column, d_{wc}, values may not accurately reflect site-specific conditions, especially for those water bodies for which depth of water column information is unavailable or outdated. Therefore, use of default d_{wc} values may contribute to the under-or overestimation of total water body COPC concentration, C_{wtot}.
d_{bs}	Depth of upper benthic sediment layer	m	**0.03** This variable is site-specific. The value selected is assumed to represent an average value for the entire year. U.S. EPA OSW recommends a default upper benthic sediment depth of 0.03 meter, which is consistent with U.S. EPA (1994) and NC DEHNR (1997) guidance. This range was cited by U.S. EPA (1993); however, no reference was cited for this range. The following uncertainty is associated with this variable: (1) Use of default depth of upper benthic layer, d_{bs}, values may not accurately represent site-specific water body conditions. However, based on the narrow recommended range, any uncertainty introduced is expected to be limited.

TABLE B-2-9

TOTAL WATER BODY CONCENTRATION
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 4 of 4)

REFERENCES AND DISCUSSION

NC DEHNR. 1997. *NC DEHNR Protocol for Performing Indirect Exposure Risk Assessments for Hazardous Waste Combustion Units*. January.

This document is also cited as one of the reference source documents for the default depth of upper benthic layer value. The default value is the midpoint of an acceptable range. This document cites U.S. EPA (1993) as its source of information for the range of values for the depth of the upper benthic layer.

U.S. EPA. 1993. *Addendum: Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions.* Working Group Recommendations. Office of Solid Waste and Office of Research and Development. Washington, D.C. September 24.

This document is cited by NC DEHNR (1997) and U.S. EPA (1994) as the source of the range and default value for the depth of the upper benthic layer (d_{bs}).

U.S. EPA. 1994. *Draft Guidance for Performing Screening Level Risk Analyses at Combustor Facilities Burning Hazardous Wastes. Attachment C, Draft Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities*. April 15.

This document is cited as one of the reference source documents for the default depth of the upper benthic layer value. The default value is the midpoint of an acceptable range. This document cites U.S. EPA (1993) as its source of information for the range of values for the depth of the upper benthic layer.

TABLE B-2-10

FRACTION IN WATER COLUMN AND BENTHIC SEDIMENT
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 1 of 5)

Description

This equation calculates the fraction of total water body concentration occurring in the water column and the bed sediments.

Uncertainties associated with this equation include the following:

(1) The default variable values may not accurately represent site-specific water body conditions. However, the range of several variables —including d_{bs}, BS, and θ_{bs}—is relatively narrow. Other variables, such as d_{wc} and d_z, can be reasonably estimated on the basis of generally available information. The largest degree of uncertainty may be introduced by the default medium-specific *OC* content values. *OC* content values can vary widely for different locations in the same medium. Therefore, the use of default values may introduce significant uncertainty in some cases.

Equations

$$f_{wc} = \frac{(1 + Kd_{sw} \cdot TSS \cdot 10^{-6}) \cdot d_{wc} / d_z}{(1 + Kd_{sw} \cdot TSS \cdot 1x10^{-6}) \cdot d_{wc} / d_z + (\theta_{bs} + Kd_{bs} \cdot BS) \cdot d_{bs} / d_z}$$

$$f_{bs} = 1 - f_{wc}$$

For mercury modeling:

The fraction in water column (f_{wc}) is calculated for divalent mercury (Hg^{2+}) and methyl mercury (MHg) using their respective Kd_{sw} values and Kd_{bs} values.
The fraction in benthic sediment (f_{bs}) is calculated for divalent mercury (Hg^{2+}) and methyl mercury (MHg) using their respective f_{wc} values.

Variable	Description	Units	Value
f_{wc}	Fraction of total water body COPC concentration in the water column	unitless	
f_{bs}	Fraction of total water body COPC concentration in the benthic sediment	unitless	

TABLE B-2-10

FRACTION IN WATER COLUMN AND BENTHIC SEDIMENT (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 2 of 5)

Variable	Description	Units	Value
Kd_{sw}	Suspended sediments/surface water partition coefficient	L/kg	**Varies (see Appendix A-2)** This variable is COPC-specific and should be determined from the COPC tables in Appendix A-2. The following uncertainty is associated with this variable: (1) The Kd_{sw} values in Appendix A-2 are based on default OC contents for surface water and soil. Kd_{sw} values based on default values may not accurately reflect site- and water body-specific conditions and may under- or overestimate actual Kd_{sw} values. Uncertainty associated with this variable will be reduced if site-specific and medium-specific OC estimates are used to calculate Kd_{sw}.
TSS	Total suspended solids concentration	mg/L	**2 to 300** This variable is site-specific. U.S. EPA OSW recommends the use of site- and waterbody specific measured values, representative of long-term average annual values for the water body of concern (see Chapter 3). A value of 10 mg/L was cited by NC DEHNR (1997), U.S. EPA (1993a), and U.S. EPA (1993b) in the absense of site-specific measured data. The following uncertainty is associated with this variable: Limitation on measured data used for determining a water body specific total suspended solids (TSS) value may not accurately reflect site- and water body-specific conditions long term. Therefore, the TSS value may contribute to the under-or overestimation of f_{wc}.
10^{-6}	Units conversion factor	kg/mg	
d_{wc}	Depth of water column	m	**Varies (site-specific)** This variable is site-specific and should be an average annual value. The following uncertainty is associated with this variable: (1) Use of default depth of water column, d_{wc}, values may not accurately reflect site-specific conditions, especially for those water bodies for which depth of water column information is unavailable or outdated. Therefore, use of default d_{wc} values may contribute to the under- or overestimation of total water body COPC concentration, C_{wtot}.

TABLE B-2-10

FRACTION IN WATER COLUMN AND BENTHIC SEDIMENT (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 3 of 5)

Variable	Description	Units	Value
d_{bs}	Depth of upper benthic sediment layer	m	**0.03** This variable is site-specific. U.S. EPA OSW recommends a default upper benthic sediment depth of 0.03 meter, which is consistent with U.S. EPA (1994) and NC DEHNR (1997) guidance. This range was cited by U.S. EPA (1993b); however, no reference was cited for this range. The following uncertainty is associated with this variable: (1) Use of default depth of upper benthic layer, d_{bs}, values may not accurately represent site-specific water body conditions. However, any uncertainly introduced is expected to be limited on the basis of the narrow recommended range.
d_z	Total water body depth	m	**Varies (calculated)** This variable is site-specific. U.S. EPA OSW recommends that the following equation be used to calculate total water body depth, consistent with NC DEHNR (1997): $d_z = d_{wc} + d_{bs}$ The following uncertainty is associated with this variable: (1) Calculation of this variable combines the concentrations associated with the two variables (d_{wc} and d_{bs}) being summed. Because most of the total water body depth (d_z) is made up of the depth of the water column (d_{wc}), and the uncertainties associated with d_{wc} are not expected to be significant, the total uncertainties associated with this variable, d_z, are also not expected to be significant.
BS	Benthic solids concentration	g/cm^3 (equivalent to kg/L)	**1.0** This variable is site-specific. U.S. EPA OSW recommends a default value of 1.0, consistent with U.S. EPA (1993a), which states that this value should be reasonable for most applications. The recommended default value is also consistent with other U.S. EPA (1993b and 1994) and NC DEHNR (1997) guidance. The following uncertainty is associated with this variable: (1) The recommended default value may not accurately represent site- and water body-specific conditions. Therefore, the variable f_{wc} may be under- or overestimated; the assumption that the under- or overestimation will be limited is based on the narrow recommended range.

TABLE B-2-10

FRACTION IN WATER COLUMN AND BENTHIC SEDIMENT (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 4 of 5)

Variable	Description	Units	Value
θ_{bs}	Bed sediment porosity	$L_{water}/L_{sediment}$	**0.6** This variable is site-specific. U.S. EPA OSW recommends a default bed sediment porosity of 0.6 (by using a *BS* value of 1 g/cm^3 and a solid density (ρ_s) value of 2.65 kg/L, calculated by using the following equation (U.S. EPA 1993a): $\theta_{bs} = 1 - BS/\rho_s$ This is consistent with other U.S. EPA (1993b and 1994) guidance. The following uncertainty is associated with this variable: (1) Calculation of this variable combines the uncertainties associated with the two variables (*BS* and ρ_s) used in the calculation. To the extent that the recommended default values of *BS* and ρ_s do not accurately represent site- and water body-specific conditions, θ_{bs} will be under- or overestimated.
Kd_{bs}	Bed sediment/sediment pore water partition coefficient	L/kg	**Varies (see Appendix A-2)** This variable is COPC-specific, and should be determined from the COPC tables in Appendix A-2. The following uncertainty is associated with this variable: (1) The Kd_{bs} values in Appendix A-2 are based on default *OC* contents for sediment and soil. Kd_{bs} values based on default *OC* values may not accurately represent site- and water body-specific conditions and may under- or overestimate actual Kd_{bs} values. Uncertainty associated with this variable will be reduced if site- and water body-specific *OC* estimates are used to calculate Kd_{bs}.

TABLE B-2-10

FRACTION IN WATER COLUMN AND BENTHIC SEDIMENT (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 5 of 5)

REFERENCES AND DISCUSSION

NC DEHNR. 1997. *NC DEHNR Protocol for Performing Indirect Exposure Risk Assessments for Hazardous Waste Combustion Units*. January.

This document is cited as one of the sources of the range of Kd_s values and assumed *OC* values of 0.075 and 0.04 for surface water and sediment, respectively. This document is also cited as one of the sources of TSS. This document cites U.S. EPA (1993b) as its source of information. This document is also cited as the source of the equation for calculating total water body depth. No source of this equation was identified. This document is also cited as one of the reference source documents for the default value for bed sediment porosity. This document cites U.S. EPA (1993b) as its source of information. This document is also cited as one of the reference source documents for the default value for depth of the upper benthic layer. The default value is the midpoint of an acceptable range. This document cites U.S. EPA (1993b) as its source of information for the range of values for the depth of the upper benthic layer. This document is also cited as one of the reference source documents for the default bed sediment concentration.

U.S. EPA. 1993a. *Addendum to the Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions.* External Review Draft. Office of Research and Development. Washington, D.C. November 1993.

This document is cited as one of the sources of the range of Kd_s values and assumed *OC* values of 0.075 and 0.04 for surface water and sediment, respectively. The generic equation for calculating partition coefficients (soil, surface water, and bed sediments) is as follows: $Kd_{ij} = Koc * OC_i$. *Koc* is a chemical-specific value; however, *OC* is medium-specific. The range of Kd_s values was based on an assumed *OC* value of 0.01 for soil. Kd_{sw} and Kd_{bs} values were estimated by multiplying the Kd_s values by 7.5 and 4, because the *OC* values for surface water and sediment are 7.5 and 4 times greater than the *OC* value for soil. This document also presents the equation for calculating bed sediment porosity (θ_{bs}); no source of this equation was identified. This document was also cited as the source for the range of the benthic solids concentration (BS); no original source of this range was identified. Finally, this document recommends that, in the absence of site-specific information, a *TSS* value of 1 to 10 be specified for parks and lakes, and a *TSS* value of 10 to 20 be specified in streams and rivers.

U.S. EPA. 1993b. *Addendum: Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions.* Working Group Recommendations. Office of Solid Waste and Office of Research and Development. Washington, D.C. September 24.

This document is cited by NC DEHNR (1997) as the source of the *TTS* value. This document is also cited by NC DEHNR (1997) and U.S. EPA (1994) as the source of the default bed sediment porosity value and the equation used to calculate the variable, the default bed sediment concentration value, and the range for the depth of the upper benthic layer values.

U.S. EPA. 1994. *Draft Guidance for Performing Screening Level Risk Analyses at Combustor Facilities Burning Hazardous Wastes. Attachment C, Draft Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities*. April 15.

This document is cited as one of the reference source documents for the default value for bed sediment porosity. This document cites U.S. EPA (1993b) as its source of information. This document is also cited as one of the reference source documents for the default value for depth of the upper benthic layer. The default value is the midpoint of an acceptable range. This document cites U.S. EPA (1993b) as its source of information for the range of values for the depth of the upper benthic layer. This document is also cited as one of the reference source documents for the default benthic solids concentration.

TABLE B-2-11

OVERALL TOTAL WATER BODY DISSIPATION RATE CONSTANT (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 1 of 2)

Description

This equation calculates the overall dissipation rate of COPCs in surface water, resulting from volatilization and benthic burial.

Uncertainties associated with this equation include the following:

(1) All of the variables in the equation in Table B-2-11 are site-specific. Therefore, the use of default values for any or all of these variables will contribute to the under- or overestimation of k_{wt}. The degree of uncertainty associated with the variable k_b is expected to be one order of magnitude at most and is associated with the estimation of the unit soil loss, X_e. Values for the variables f_{wc}, k_v, and f_{bs} are dependent on medium-specific estimates of medium-specific *OC* content. Because *OC* content can vary widely for different locations in the same medium, uncertainty associated with these three variables may be significant in specific instances.

Equation

$$k_{wt} = f_{wc} \cdot k_v + f_{bs} \cdot k_b$$

Variable	Description	Units	Value
k_{wt}	Overall total water body dissipation rate constant	yr^{-1}	
f_{wc}	Fraction of total water body COPC concentration in the water column	unitless	**Varies (calculated - Table B-2-10)** This variable is COPC- and site-specific, and is calculated by using the equation in Table B-2-10. Uncertainties associated with this variable include the following: (1) The default variable values recommended for use in the equation in Table B-2-10 may not accurately represent site-specific water body conditions. However, the range of several variables—including d_{bs}, *BS*, and θ_{sw}—is moderate (factors of 5, 3, and 2, respectively); therefore, the degree of uncertainty associated with these variables is expected to be moderate. Other variables, such as d_{wc} and d_z, can be reasonably estimated on the basis of generally available information; therefore, the degree of uncertainty associated with these variables is expected to be relatively small. (2) The largest degree of uncertainty may be introduced by the default medium-specific *OC* content values. *OC* content values are often not readily available and can vary widely for different locations in the same medium. Therefore, the degree of uncertainty may be significant in specific instances.

TABLE B-2-11

OVERALL TOTAL WATER BODY DISSIPATION RATE CONSTANT (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 2 of 2)

Variable	Description	Units	Value
k_v	Water column volatilization rate constant	yr^{-1}	**Varies (calculated - Table B-2-13)** This variable is COPC- and site-specific, and is calculated by using the equation in Table B-2-13. Uncertainties associated with this variable include the following: (1) All of the variables in Table B-2-13 are site-specific. Therefore, the use of default values for any or all of these variables could contribute to the under- or overestimation of k_v. (2) The degree of uncertainty associated with the variables d_z and TSS is expected to be minimal either because information necessary to estimate these variables is generally available or because the range of probable values is narrow. (3) Values for the variable k_v and Kd_{sw} are dependent on medium-specific estimates of OC content. Because OC content can vary widely for different locations in the same medium, uncertainty associated with these two variables may be significant in specific instances.
f_{bs}	Fraction of total water body COPC concentration in the benthic sediment	unitless	**Varies (calculated - Table B-2-10)** This variable is COPC- and site-specific, and is calculated by using the equation in Table B-2-10. Uncertainties associated with this variable include the following: (1) The default variable values recommended for use in the equation in Table B-2-10 may not accurately represent site-specific water body conditions. However, the range of several variables—including d_{bs}, BS, and θ_{sw}—is relatively narrow; therefore, the degree of uncertainty associated with these variables is expected to be relatively small. Other variables, such as d_{wc} and d_z, can be reasonably estimated on the basis of generally available information. (2) The largest degree of uncertainty may be introduced by the default medium-specific OC contact values. OC content values are often not readily available and can vary widely for different locations in the same medium. Therefore, the degree of uncertainty may be significant in specific instances.
k_b	Benthic burial rate constant	yr^{-1}	**Varies (calculated - Table B-2-16)** This variable is COPC- and site-specific, and is calculated by using the equation in Table B-2-16. Uncertainties associated with this variable include the following: (1) All of the variables in Table B-2-16 are site-specific. Therefore, the use of default values rather than site-specific values, for any or all of these variables, will contribute to the under- or overestimation of k_b. (2) The degree of uncertainty associated with each of these variables is as follows: (1) X_e—about one order of magnitude at most, (2) BS , d_{bs}, Vf_x, TSS, and A_w—limited because of the narrow recommended ranges for these variables or because resources to estimate variable values are generally available, and (3) A_L and SD—very site-specific and degree of uncertainty unknown.

TABLE B-2-12

WATER COLUMN VOLATILIZATION LOSS RATE CONSTANT (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 1 of 4)

Description

This equation calculates the water column of COPCs loss resulting from volatilization. Uncertainties associated with this equation include the following:

(1) All of the variables in Table B-2-12 are site-specific. Therefore, the use of default values for any or all of these variables will contribute to the under- or over estimation of k_v. The degree of uncertainty associated with the variables d_{wc}, d_{bs}, d_z, and TSS are expected to be minimal either because information necessary to estimate these variables is generally available or because the range of probable values is narrow. Values for the variables K_v and Kd_{sw} are dependent on medium-specific estimates of OC content. Because OC content can vary widely for different locations in the same medium, uncertainty associated with these two variables may be significant in specific instances.

Equation

$$k_v = \frac{K_v}{d_z \cdot (1 + Kd_{sw} \cdot TSS \cdot 10^{-6})}$$

For mercury modeling:

The water column volatilization loss rate constant is calculated for divalent mercury (Hg^{2+}) and methyl mercury (MHg) using their respective fate and transport parameters.

Variable	Description	Units	Value
k_v	Water column volatilization rate constant	yr^{-1}	

TABLE B-2-12

WATER COLUMN VOLATILIZATION LOSS RATE CONSTANT
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 2 of 4)

Variable	Description	Units	Value
K_v	Overall COPC transfer rate coefficient	m/yr	**Varies (calculated - Table B-2-13)** This variable is COPC- and site-specific, and is calculated by using the equation in Table B-2-13. Uncertainties associated with this variable include the following: (1) All of the variables in Table B-2-13—except R, the universal gas constant, which is well-established—are site-specific. Therefore, the use of default values, for any or all these variables, could contribute to the under- or overestimation of K_v. (2) The degree of uncertainty associated with the variables H and T_{wk} is expected to be minimal; values for H are well-established, and average water body temperature, T_{wk}, will likely vary less than 10 percent of the default value. (3) The uncertainty associated with the variables K_L and K_G is attributable largely to medium-specific estimates of *OC* content. Because *OC* content values can vary widely for different locations in the same medium, the use of default values may generate significant uncertainty in specific instances. Finally, the origin of the recommended θ value is unknown; therefore, the degree of associated uncertainty is also unknown.
d_{wc}	Depth of water column	m	**Varies (site-specific)** This variable is site-specific and should be an average annual value. The following uncertainty is associated with this variable: (1) Use of default values for depth of water column, d_{wc}, may not accurately reflect site-specific conditions, especially for those water bodies for which depth of water column information is unavailable or outdated. Therefore, use of default d_{wc} values may contribute to the under- or overestimation of total water body COPC concentration, C_{wtot}. However, the degree of under- or overestimation is not expected to be significant.
d_{bs}	Depth of upper benthic sediment layer	m	**0.03** This variable is site-specific. U.S. EPA OSW recommends a default upper-benthic sediment depth of 0.03 meter, which is based on the center of this range cited by U.S. EPA (1993b). This is consistent with U.S. EPA (1994) and NC DEHNR (1997). The following uncertainty is associated with this variable: (1) Use of default values for depth of upper benthic layer, d_{bs}, may not accurately represent site-specific water body conditions. However, any uncertainty introduced is expected to be limited, based on the narrow recommended range.

TABLE B-2-12

WATER COLUMN VOLATILIZATION LOSS RATE CONSTANT (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 3 of 4)

Variable	Description	Units	Value
d_z	Total water body depth	m	**Varies (calculated)** This variable is site-specific. U.S. EPA OSW recommends that the following equation be used to calculate total water body depth, consistent with NC DEHNR (1997): $d_z = d_{wc} + d_{bs}$ The following uncertainty is associated with this variable: (1) Calculation of this variable combines the concentrations associated with the two variables (d_{wc} and d_{bs}) being summed. Because most of the total water body depth (d_z) is made up of the depth of the water column (d_{wc}), and the uncertainties associated with d_{wc} are not expected to be significant, the total uncertainties associated with this variable, d_z, are also not expected to be significant.
Kd_{sw}	Suspended sediments/surface water partition coefficient	L/kg	**Varies (see Appendix A-2)** This variable is COPC-specific and should be determined from the COPC tables in Appendix A-3. The following uncertainty is associated with this variable: (1) The values contained in Appendix A-2 for Kd_{sw} are calculated on the basis of default *OC* contents for surface water and soil. Kd_{sw} values based on default values may not accurately reflect site-and water body-specific conditions and may under- or overestimate actual Kd_{sw} values. Uncertainty associated with this variable will be reduced if site-specific and medium-specific *OC* estimates are used to calculate Kd_{sw}.
TSS	Total suspended solids concentration	mg/L	**2 to 300** This variable is site-specific. U.S. EPA OSW recommends the use of site- and waterbody specific measured values, representative of long-term average annual values for the water body of concern (see Chapter 3). A value of 10 mg/L was cited by NC DEHNR (1997), U.S. EPA (1993a), and U.S. EPA (1993b) in the absense of site-specific measured data. The following uncertainty is associated with this variable: Limitation on measured data used for determining a water body specific total suspended solids (*TSS*) value may not accurately reflect site- and water body-specific conditions long term. Therefore, the *TSS* value may contribute to the under-or overestimation of f_{wc}.
10^{-6}	Units conversion factor	kg/mg	

TABLE B-2-12

WATER COLUMN VOLATILIZATION LOSS RATE CONSTANT
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 4 of 4)

REFERENCES AND DISCUSSION

NC DEHNR. 1997. *NC DEHNR Protocol for Performing Indirect Exposure Risk Assessments for Hazardous Waste Combustion Units*. January.

This document is cited as the source of the equation for calculating total water body depth. No source of this equation was identified. This document is also cited as one of the sources of the range of Kd_s values and an assumed *OC* value of 0.075 for surface water. This document is also cited as one of the sources of *TSS.* This document cites U.S. EPA (1993b) as its source of information.

U.S. EPA. 1993a. *Addendum to the Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions.* External Review Draft. Office of Research and Development. Washington, D.C. November 1993.

This document is cited as one of the sources of the range of Kd_s values and assumed *OC* content value of 0.075 for surface water. The generic equation for calculating partition coefficients (soil, surface water, and bed sediments) is as follows: $Kd_{ij} = K_{ocj}\ OC_i$. K_{oc} is a chemical-specific value; however, *OC* is medium-specific. The range of Kd_s values was based on an assumed *OC* value of 0.01 for soil. This document is one of the sources cited that assumes an *OC* value of 0.075 for surface water. Therefore, the Kd_{sw} value was estimated by multiplying the Kd_s values by 7.5, because the *OC* value for surface water is 7.5 times greater than the *OC* value for soil.

U.S. EPA. 1993b. *Addendum: Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions.* Working Group Recommendations. Office of Solid Waste and Office of Research and Development. Washington, D.C. September 24.

This document is cited by U.S. EPA (1994) and NC DEHNR (1997) as the source of the range and default value for the depth of the upper benthic layer (d_{bs}). This document is also cited by NC DEHNR (1997) as the source of the *TSS* value.

U.S. EPA. 1994. *Draft Guidance for Performing Screening Level Risk Analysis at Combustion Facility Burning Hazardous Wastes. Attachment C, Draft Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facility*. April 15.

This document is cited as one of the reference source documents for the default value of the depth of the upper benthic layer. The default value is the midpoint of an acceptable range. This document cites U.S. EPA (1993b) as its source of information.

TABLE B-2-13

OVERALL COPC TRANSFER RATE COEFFICIENT (SURFACE WATER AND SEDIMENT EQUATIONS)

Page (1 of 4)

Description

This equation calculates the overall transfer rate of contaminants from the liquid and gas phases in surface water.

Uncertainties associated with this equation include the following:

(1) All of the variables in Table B-2-13—except *R*, the universal gas constant, which is well-established—are site-specific. Therefore, the use of any or all of these variables will contribute to the under- or overestimation of K_v. The degree of uncertainty associated with the variables *H* and T_{wk} is expected to be minimal; values for *H* are well-established, and average water body temperature will likely vary less than 10 percent of the default value. The uncertainty associated with the variables K_v and K_G is attributable largely to medium-specific estimates of *OC* content. Because *OC* content values can vary widely for different locations in the same medium, the use of default values may generate significant uncertainty in specific instances.

Equation

$$K_v = \left[K_L^{-1} + \left(K_G \cdot \frac{H}{R \cdot T_{wk}} \right)^{-1} \right]^{-1} \cdot \theta^{(T_{wk} - 293)}$$

For mercury modeling:

The overall COPC transfer rate coefficient is calculated for divalent mercury (Hg^{2+}) and methyl mercury (MHg) using their respective fate and transport parameters.

Variable	Description	Units	Value
K_v	Overall COPC transfer rate coefficient	m/yr	

TABLE B-2-13

OVERALL COPC TRANSFER RATE COEFFICIENT (SURFACE WATER AND SEDIMENT EQUATIONS)

Page (2 of 4)

Variable	Description	Units	Value
K_L	Liquid-phase transfer coefficient	m/yr	**Varies (calculated - Table B-2-14)** This variable is COPC- and site-specific, and is calculated by using the equation in Table B-2-14. Uncertainties associated with this variable include the following: All of the variables in Table B-2-14 are site-specific. Therefore, the use of default values rather than site-specific values, for any or all of these variables, will contribute to the under- or overestimation of K_v. The degree of uncertainty associated with these variables is as follows: (1) Minimal or insignificant uncertainty is assumed to be associated with six variables —D_w, u, d_z, ρ_a, ρ_w, and μ_w—either because of narrow recommended ranges for these variables or because information to estimate variable values is generally available. (2) No original sources were identified for the equations used to derive recommended values or specific recommended values for variables Cd, k, and λ_z. Therefore, the degree and direction of any uncertainties associated with these variables are unknown. (3) Uncertainties associated with the variable W are site-specific.
K_G	Gas-phase transfer coefficient	m/yr	**Varies (calculated - Table B-2-15)** This variable is COPC- and site-specific, and is calculated by using the equation in Table B-2-15. Uncertainties associated with this variable include the following: All of the variables in Table B-2-15, with the exception of k, are site-specific. Therefore, the use of default values rather than site-specific values, for any or all of these variables, will contribute to the under- or overestimation of K_G. The degree of uncertainty associated with each of these variables is as follows: (1) Minimal or insignificant uncertainty is assumed to be associated with the variables D_a, μ_a, and ρ_a, because these variables have been extensively studied, and equation procedures are well-established. (2) No original sources were identified for equations used to derive recommended values or specific recommended values for variables C_d, k, and d_z. Therefore, the degree and direction of any uncertainties are unknown. (3) Uncertainties associated with the variable W are site-specific and cannot be readily estimated.

TABLE B-2-13

OVERALL COPC TRANSFER RATE COEFFICIENT (SURFACE WATER AND SEDIMENT EQUATIONS)

Page (3 of 4)

Variable	Description	Units	Value
H	Henry's Law constant	atm-m^3/mol	**Varies (see Appendix A-2)** This variable is COPC-specific and should be determined from the COPC tables in Appendix A-2. The following uncertainty is associated with this variable: (1) Values for this variable, estimated by using the parameters and algorithms in Appendix A-2, may under- or overestimate the actual COPC-specific values. As a result, K_v may be under- or overestimated to a limited degree.
R	Universal gas constant	atm-m^3/mol-K	**8.205×10^{-5}** There are no uncertainties associated with this parameter.
T_{wk}	Water body temperature	K	**298** This variable is site-specific. U.S. EPA OSW recommends the use of this default value when site-specific information is not available; this is consistent with U.S. EPA (1993a; 1993b; and 1994). The following uncertainty is associated with this variable: (1) To the extent that the default Water body temperature value does not accurately represent site- and water body-specific conditions, K_v, will be under- or overestimated to a limited degree.
θ	Temperature correction factor	unitless	**1.026** This variable is site-specific. U.S. EPA OSW recommends the use of this default value when site-specific information is not available; this is consistent with U.S. EPA (1993a; 1993b; and 1994). The following uncertainty is associated with this variable: (1) The purpose and sources of this variable and the recommended value are unknown.

TABLE B-2-13

OVERALL COPC TRANSFER RATE COEFFICIENT (SURFACE WATER AND SEDIMENT EQUATIONS)

Page (4 of 4)

REFERENCES AND DISCUSSION

U.S. EPA. 1993a. *Addendum: Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions*. Working Group Recommendations. Office of Solid Waste and Office of Research and Development. Washington, D.C. September 24.

This document is the reference source for the equation in Table B-2-12, including the use of the temperature correction fraction (θ).

This document is also cited by U.S. EPA (1994) as the source of the T_{wk} value of 298 K (298 K = 25°C) and the default θ value of 1.026.

U.S. EPA. 1993b *Addendum to Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions.* External Review Draft. Office of Solid Waste and Office Research and Development. Washington, D.C. November 10.

This document recommends the T_{wk} value of 298 K (298 K = 25 °C) and the value θ of 1.026. No source was identified for these values.

U.S. EPA 1994. *Revised Draft Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*. *Attachment C, Draft Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities*. Office of Emergency and Remedial Response. Office of Solid Waste. December 14.

This document is cited as the reference source for water body temperature (T_{wk}) and temperature correction factor (θ). This document apparently cites U.S. EPA (1993a) as its source of information.

TABLE B-2-14

LIQUID-PHASE TRANSFER COEFFICIENT (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 1 of 5)

Description

This equation calculates the rate of contaminant transfer from the liquid phase for a flowing or quiescent system.

Uncertainties associated with this equation include the following:

(1) Minimal or insignificant uncertainly is assumed to be associated with the following six variables: D_w, d_z, ρ_a, ρ_w, and μ_w.
(2) No original sources were identified for equations used to derive recommended values or specific recommended values for the following three variables: C_d, k, and d_z. Therefore, the degree and duration of any uncertainties associated with these variables is unknown.
(3) Uncertainties associated with the variable W are site-specific.

Equation

For flowing streams or rivers

$$K_L = \sqrt{\frac{10^{-4} \cdot D_w \cdot u}{d_z}} \cdot 3.1536 \times 10^7$$

For quiescent lakes or ponds

$$K_L = (C_d^{0.5} \cdot W) \cdot \left(\frac{\rho_a}{\rho_w}\right)^{0.5} \cdot \left(\frac{k^{0.33}}{\lambda_z}\right) \cdot \left(\frac{\mu_w}{\rho_w \cdot D_w}\right)^{-0.67} \cdot 3.1536 \times 10^7$$

For mercury modeling:

The liquid phase transfer coefficient is calculated for divalent mercury (Hg^{2+}) and methyl mercury (MHg) using their respective fate and transport parameters.

TABLE B-2-14

LIQUID-PHASE TRANSFER COEFFICIENT
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 2 of 5)

Variable	Description	Units	Value
K_L	Liquid-phase transfer coefficient	m/yr	
D_w	Diffusivity of COPC in water	cm^2/s	**Varies (see Appendix A-2)** This variable is COPC-specific and should be determined from the COPC physical and chemical parameter tables in Appendix A-2. The following uncertainty is associated with this variable: (1) The default D_w values may not accurately represent the behavior of COPCs under water body-specific conditions. However, the degree of uncertainty is expected to be minimal.
u	Current velocity	m/s	**Varies (site-specific)** This variable is site-specific. The following uncertainty is associated with this variable: (1) Sources of values for this variable are reasonably available for most large surface water bodies. Estimated values for this variable be necessary for smaller water bodies; uncertainty will be associated with these estimates. The degree of uncertainty associated with this variable is not expected to be significant.

TABLE B-2-14

LIQUID-PHASE TRANSFER COEFFICIENT
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 3 of 5)

Variable	Description	Units	Value
d_z	Total water body depth	m	**Varies (calculated)** This variable is site-specific. U.S. EPA OSW recommends that this value be calculated by using the following equation, consistent with U.S. EPA (1994): $d_z = d_{wc} + d_{bs}$ No reference was cited for this recommendation. The following uncertainty is associated with this variable: (1) Calculation of this variable combines the concentrations associated with the two variables (d_{wc} and d_{bs}) being summed. Because most of the total water body depth (d_z) is made up of the depth of the water column (d_{wc}), and the uncertainties associated with d_{wc} are not expected to be significant, the total uncertainties associated with this variable, d_z, are also not expected to be significant.
3.1536×10^7	Units conversion constant	s/yr	
C_d	Drag coefficient	unitless	**0.0011** This variable is site-specific. U.S. EPA OSW recommends a default value of 0.0011, consistent with U.S. EPA (1993a; 1993b; 1994) and NC DEHNR (1997). The following uncertainty is associated with this variable: (1) The original source of this variable value is unknown. Therefore, any uncertainties associated with its use are also unknown.
W	Average annual wind speed	m/s	**3.9** Consistent with U.S. EPA (1990), U.S. EPA OSW recommends a default value of 3.9 m/s. See Chapter 3 for guidance regarding the references and methods used to determine site-specific values for air dispersion modeling.

TABLE B-2-14

LIQUID-PHASE TRANSFER COEFFICIENT
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 4 of 5)

Variable	Description	Units	Value
ρ_a	Density of air corresponding to water temperature	g/cm^3	**0.0012** U.S. EPA OSW recommends this default value when site-specific information is not available, consistent with U.S. EPA (1994), both of which cite Weast (1979) as the source of this value. This value applies at standard conditions (298 K and 1 atm). There is no significant uncertainty associated with this variable.
ρ_w	Density of water corresponding to water temperature	g/cm^3	**1** U.S. EPA OSW recommends this default value, consistent with U.S. EPA (1994), both of which cite Weast (1979) as the source of this value. This value applies at standard conditions (298 K and 1 atm). There is no significant uncertainty associated with this variable.
k	von Karman's constant	unitless	**0.4** This value is a constant. U.S. EPA OSW recommends the use of this value, consistent with U.S. EPA (1994). The following uncertainty is associated with this variable: (1) The original source of this variable value is unknown. Therefore, any uncertainties associated with its use are also unknown.
λ_z	Dimensionless viscous sublayer thickness	unitless	**4** This value is site-specific. U.S. EPA OSW recommends the use of this default value when site-specific information is not available; consistent with U.S. EPA (1994).
μ_w	Viscosity of water corresponding to water temperature	g/cm-s	**0.0169** U.S. EPA OSW recommends this default value, consistent with U.S. EPA (1994), which both cite Weast (1979) as the source of this value. This value applies at standard conditions (298 K and 1 atm). There is no significant uncertainty associated with this variable.

TABLE B-2-14

LIQUID-PHASE TRANSFER COEFFICIENT (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 5 of 5)

REFERENCES AND DISCUSSION

NC DEHNR. 1997. *NC DEHNR Protocol for Performing Indirect Exposure Risk Assessments for Hazardous Waste Combustion Units*. January.

This document is cited as one of the sources of the range of D_w values and assumed C_d, ρ_a, ρ_w, k, λ_z, and μ_w values of 0.0011, 1.2×10^{-3}, 1, 0.4, 4, and 1.69×10^{-2}, respectively. This document cites (1) Weast (1979) as its source of information regarding ρ_a, ρ_w, and μ_w; and (2) U.S. EPA (1993a) as its source of information regarding C_d, k, and d_z.

U.S. EPA. 1993a. *Addendum: Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions*. Working Group Recommendations. Office of Solid Waste and Office of Research and Development. Washington, D.C. September 24.

This document is cited by U.S. EPA (1994) and NC DEHNR (1997) as the source of the recommended drag coefficient (C_d) value of 0.0011 and the recommended von Karman's constant (k) value of 0.4. The original sources of variable values are not identified.

U.S. EPA. 1993b. *Addendum to Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions*. External Review Draft. Office of Solid Waste and Office of Research and Development. Washington, D.C. November 10.

This document recommends a value of 0.0011 for the drag coefficient (C_d) variable or a value of 0.4 for von Karman's constant (k). No sources are cited for these values.

U.S. EPA. 1994. *Revised Draft Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes. Attachment C, Draft Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities*. Office of Emergency and Remedial Response. Office of Solid Waste. December 14.

This document is cited as one of the sources of the range of D_w values and assumed C_d, ρ_a, ρ_w, k, λ_z, and μ_w values of 0.0011, 1.2×10^{-3}, 1, 0.4, 4, and 1.69×10^{-2}, respectively. This document cites (1) Weast (1979) as its source of information regarding ρ_a, ρ_w, and μ_w; and (2) U.S. EPA (1993a) as its source of information regarding C_d, k, and d_z.

Weast, R. C. 1979. *CRC Handbook of Chemistry and Physics*. 60th ed. CRC Press, Inc. Cleveland, Ohio.

This document is cited as the source of ρ_a, ρ_w, and μ_w variables of 1.2×10^{-3}, 1, and 1.69×10^{-2}, respectively.

TABLE B-2-15

GAS-PHASE TRANSFER COEFFICIENT
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 1 of 4)

Description

This equation calculates the rate of contaminant transfer from the gas phase for a flowing or quiescent system. Uncertainties associated with this equation include the following:

(1) Minimal or insignificant uncertainty is assumed to be associated with the variables D_a, μ_a, and ρ_a.
(2) No original sources were identified for equations used to derive recommended values or specific recommended values for variables C_d, k, and λ_z. Therefore, the degree and direction of any uncertainties associated with these variables are unknown.
(3) Uncertainties associated with the remaining variables are site-specific.

Equation

Flowing streams or rivers

$$K_G = 36{,}500 \ m/yr$$

Quiescent lakes or ponds

$$K_G = (C_d^{0.5} \cdot W) \cdot \left(\frac{k^{0.33}}{\lambda_z}\right) \cdot \left(\frac{\mu_a}{\rho_a \cdot D_a}\right)^{-0.67} \cdot 3.1536 \times 10^7$$

For mercury modeling:

The gas phase transfer coefficient is calculated for divalent mercury (Hg^{2+}) and methyl mercury (MHg) using their respective fate and transport parameters .

Variable	Description	Units	Value
K_G	Gas-phase transfer coefficient	m/yr	

TABLE B-2-15

GAS-PHASE TRANSFER COEFFICIENT
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 2 of 4)

Variable	Description	Units	Value
C_d	Drag coefficient	unitless	**0.0011** This variable is site-specific. U.S. EPA OSW recommends the use of this default value when site-specific information is not available, consistent with U.S. EPA (1993a; 1993b; 1994) and NC DEHNR (1997). The following uncertainty is associated with this variable: (1) The original source of this variable is unknown.
W	Average annual wind speed	m/s	**3.9** Consistent with U.S. EPA (1990), U.S. EPA OSW recommends a default value of 3.9 m/s. See Chapter 3 for guidance regarding the references and methods used to determine a site-specific value that isconsistent with air dispersion modeling. The following uncertainty is associated with this variable: To the extent that site-specific or local values for this variable are not available, default values may not accurately represent site-specific conditions. The uncertainty associated with the selection of a single value from within the range of windspeeds at a single location may be more significant than the uncertainty associated with choosing a single windspeed to represent all locations.
k	von Karman's constant	unitless	**0.4** This value is a constant. U.S. EPA OSW recommends the use of this value, consistent with U.S. EPA (1994). The following uncertainty is associated with this variable: (1) The original source of this variable is unknown.
λ_z	Dimensionless viscous sublayer thickness	unitless	**4** This value is site-specific. U.S. EPA OSW recommends the use of this default value when site-specific information is not available, consistent with U.S. EPA (1994). The following uncertainty is associated with this variable: (1) The original source of this variable is unknown.

TABLE B-2-15

GAS-PHASE TRANSFER COEFFICIENT
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 3 of 4)

Variable	Description	Units	Value
μ_a	Viscosity of air	g/cm-s	**1.81×10^{-4}** U.S. EPA OSW recommends the use of this value, based on Weast (1980). This is consistent with NC DEHNR (1997). This value applies at standard conditions (20 °C or 298 K and 1 atm, or 760 mm Hg). The following uncertainty is associated with this variable: (1) The viscosity of air may vary with temperature.
ρ_a	Density of air	g/cm^3	**0.0012** U.S. EPA OSW recommends the use of this value, based on Weast (1980); this is consistent with NC DEHNR (1997). This value applies at standard conditions (20 °C or 298 K and 1 atm, or 760 mm Hg). The following uncertainty is associated with this variable: (1) The density of air will vary with temperature.
D_a	Diffusivity of COPC in air	cm^2/s	**Varies (see Appendix A-2)** This variable is COPC-specific and should be determined from the COPC physical and chemical parameter tables in Appendix A-2. The following uncertainty is associated with this variable: (1) The recommended D_a values may not accurately represent the behavior of COPCs under water body-specific conditions. However, the degree of uncertainty is expected to be minimal.
3.1536×10^7	Units conversion factor	s/yr	

TABLE B-2-15

GAS-PHASE TRANSFER COEFFICIENT (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 4 of 4)

REFERENCES AND DISCUSSION

NC DEHNR. 1997. *NC DEHNR Protocol for Performing Indirect Exposure Risk Assessments for Hazardous Waste Combustion Units*. January.

This document is cited as one of the sources of the variables ρ_a, k, λ_z, and μ_a values of 1.2 x 10^{-3}, 0.4, 4, and 1.81 E-04, respectively. This document cites (1) Weast (1979) as its source of information for ρ_a and μ_a, and (2) U.S. EPA (1993a) as its source of information for k and λ_z.

U.S. EPA. 1993a. *Addendum: Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustion Emissions*. Working Group Recommendations. Office of Solid Waste, and Office of Research and Development. Washington, D.C. September 24.

This document is cited by U.S. EPA (1994) and NC DEHNR (1997) as the source of (1) the recommended drag coefficient (C_d) value of 0.0011, (2) the recommended von Karman's constant (k) value of 0.4, and (3) the recommended dimensionless viscous sublayer thickness (λ_z) value of 4. The original sources of these variable values are not identified.

U.S. EPA. 1993b. *Addendum to Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions*. External Review Draft. Office of Solid Waste, and Office of Research and Development. Washington, D.C. November 10.

This document recommends (1) a value of 0.0011 for the drag coefficient (C_d) variable, (2) a value of 0.4 for von Karman's constant (K), and (3) a value of 4 for the dimensionless viscous sublayer thickness (λ_z) variable. The original sources of the variable values are not identified.

U.S. EPA. 1994. *Revised Draft Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*. *Attachment C, Draft Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities*. Office of Emergency and Remedial Response. Office of Solid Waste. December 14.

This document is cited as one of the sources of the variables ρ_a, k, λ_z, and μ_a values of 1.2 x 10^{-3}, 0.4, 4, and 1.81 E-04, respectively. This document cites (1) Weast (1979) as its source of information for ρ_a and μ_a, and (2) U.S. EPA (1993a) as its source of information for k and λ_z.

Weast, R.C. 1979. *CRC Handbook of Chemistry and Physics.* 60th ed. CRC Pres, Inc. Cleveland, Ohio. This document is cited as the source of ρ_a, ρ_w, and μ_a variables of 1.2 x 10^{-3}, 1, and 1.69 x 10^{-2}, respectively.

TABLE B-2-16

BENTHIC BURIAL RATE CONSTANT
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 1 of 5)

Description

This equation calculates the constant for water column loss constant due to burial in benthic sediment.

Uncertainties associated with this equation include the following:

(1) All of the variables in Table B-2-16 are site-specific. Therefore, the use of default values rather than site-specific values, for any or all of these variables, will contribute to the under- or overestimation of K_b. The degree of uncertainty associated with each of these variables is as follows: (a) X_e—about one order of magnitude at the most, (b) BS, d_{bs}, Vf_x, TSS, and A_W—limited because of the narrow recommended ranges for these variables or because resources to estimate variable values are generally available, (c) A_L and SD—very site-specific, degree of uncertainty unknown.

Based on the possible ranges for the input variables to this equation, values of k_b can range over about one order of magnitude.

Equation

$$k_b = \left(\frac{X_e \cdot A_L \cdot SD \cdot 10^3 - Vf_x \cdot TSS}{A_W \cdot TSS} \right) \left(\frac{TSS \cdot 10^{-6}}{BS \cdot d_{bs}} \right)$$

Variable	Description	Units	Value
k_b	Benthic burial rate constant	yr^{-1}	
X_e	Unit soil loss	kg/m^2-yr	**Varies (calculated - Table B-2-7)** This variable is site-specific and is calculated by using the equation in Table B-2-7. The following uncertainty is associated with this variable: (1) All of the variables in the equation used to calculate unit soil loss, X_e, are site-specific. Use of default values rather than site-specific values, for any or all of the equation variables, will result in estimates of X_e that under- or overestimate the actual value. The degree or magnitude of any under- or overestimation is expected to be about one order of magnitude or less.

TABLE B-2-16

BENTHIC BURIAL RATE CONSTANT
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 2 of 5)

Variable	Description	Units	Value
A_L	Total watershed area receiving deposition	m^2	**Varies (site-specific)** This variable is site-specific (see Chapter 4). Uncertainties associated with this variable are site-specific.
SD	Sediment delivery ratio	unitless	**Varies (calculated - Table B-2-8)** This variable is site-specific and is calculated by using the equation in Table B-2-8. Uncertainties associated with this variable include the following: (1) The default values for empirical intercept coefficient, a, recommended for use in the equation in Table B-2-8, are average values based on various studies of sediment yields from various watersheds. Therefore, these default values may not accurately represent site-specific watershed conditions. As a result, use of these default values may contribute to under- or overestimation of the benthic burial rate constant, k_b. (2) The default value for empirical slope coefficient, b, recommended for use in in the equation in Table B-2-8 is based on a review of sediment yields from various watersheds. This single default value may not accurately represent site-specific water shed conditions. As a result, use of this default value may contribute to under-or overestimation of k_b.
10^3	Units conversion factor	g/kg	
Vf_x	Average volumetric flow rate through water body	m^3/yr	**Varies (site-specific)** This variable is site-specific and should be an annual average value. The following uncertainty is associated with this variable: (1) Use of default average volumetric flow rate, Vf_x, values may not accurately represent site-specific water body conditions. Therefore, the use of such default values may contribute to the under- or overestimation of k_b. However, it is expected that the uncertainty associated with this variable will be limited, because resources such as maps, aerial photographs, and gauging station measurements—from which average volumetric flow rate through water body, Vf_x, can be estimated—are generally available.

TABLE B-2-16

BENTHIC BURIAL RATE CONSTANT (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 3 of 5)

Variable	Description	Units	Value
TSS	Total suspended solids concentration	mg/L	**2 to 300** This variable is site-specific. U.S. EPA OSW recommends the use of site- and waterbody specific measured values, representative of long-term average annual values for the water body of concern (see Chapter 3). A value of 10 mg/L was cited by NC DEHNR (1997), U.S. EPA (1993a), and U.S. EPA (1993b) in the absense of site-specific measured data. The following uncertainty is associated with this variable: Limitation on measured data used for determining a water body specific total suspended solids (TSS) value may not accurately reflect site- and water body-specific conditions long term. Therefore, the TSS value may contribute to the under-or overestimation of f_{wc}.
A_W	Water body surface area	m^2 (average for the entire year)	**Varies (site-specific)** This variable is site-specific (see Chapter 4), and should be an average annual value. The units of this variable are presented as they are because the value selected is assumed to represent an average value for the entire year. Uncertainties associated with this variable are site-specific, and expected to be limited, because maps, aerial photographs —and other resources from which water body surface area, A_W, can be measured—are readily available.
1×10^{-6}	Units conversion factor	kg/mg	
BS	Benthic solids concentration	g/cm^3 (equivalent to kg/L)	**1.0** This variable is site-specific. U.S. EPA OSW recommends a default value of 1.0, consistent with U.S. EPA (1993b), which states that this value should be reasonable for most applications. The recommended default value is also consistent with other U.S. EPA (1993a; 1993b; 1994) guidance. The following uncertainty is associated with this variable: (1) The recommended default benthic solids concentration, BS, value may not accurately represent site-specific water body conditions. Therefore, use of this default value may contribute to the under- or overestimation of k_b.

TABLE B-2-16

BENTHIC BURIAL RATE CONSTANT (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 4 of 5)

Variable	Description	Units	Value
d_{bs}	Depth of upper benthic sediment layer	m	**0.03** This variable is site-specific. U.S. EPA OSW recommends a default upper-benthic sediment depth of 0.03 meter, which is based on the center of this range cited by U.S. EPA (1993a; 1993b). This range is consistent with U.S. EPA (1994). The following uncertainty is associated with this variable: (1) The recommended default value for depth of upper benthic layer, d_{bs}, may not accurately represent site-specific water body conditions. Therefore, use of this default value may contribute to the under- or overestimation of k_b. However, the degree of uncertainty associated with this variable is expected to be limited because of the narrow recommended range.

TABLE B-2-16

BENTHIC BURIAL RATE CONSTANT (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 5 of 5)

REFERENCES AND DISCUSSION

NC DEHNR 1997. *NC DEHNR Protocol for Performing Indirect Exposure Risk Assessments for Hazardous Waste Combustion Units.* January.

This document is cited as one of the sources of the range of all recommended specific *BS* and d_{bs} values, and the recommended *TSS* value. This document cites U.S. EPA (1993a) as its source.

U.S. EPA. 1993a. *Addendum: Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions.* Working Group Recommendations. Office of Solid Waste, and Office of Research and Development. Washington, D.C. September 24.

This document is cited by U.S. EPA (1994) and NC DEHNR (1997) as the source of (1) the *TSS* value, (2) the range and recommended *BS* value, and (3) the range and recommended depth of upper benthic layer (d_{bs}) value.

U.S. EPA 1993b. *Addendum to the Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions*. External Review Draft. Office of Research and Development. Washington, D.C. November.

This document states that the upper benthic sediment depth, d_{bs}, representing the portion of the bed in equilibrium with the water column, cannot be precisely specified. However, the document states that values from 0.01 to 0.05 meter would be appropriate. This document also recommends a *TSS* value of 10 mg/L and a specific benthic solids concentration (*BS*) value.

U.S. EPA 1994. *Draft Guidance for Performing Screening Level Risk Analyses at Combustor Facilities Burning Hazardous Waste*. *Attachment C, Draft Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities*. April 15.

This document is cited as one of the reference sources for the d_{bs} value. The recommended value is the midpoint of an acceptable range. This document is also cited as one of the reference source documents for the default *BS* value. This document cites U.S. EPA (1993a) as its source.

TABLE B-2-17

TOTAL WATER COLUMN CONCENTRATION (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 1 of 4)

Description

This equation calculates the total water column concentration of COPCs; this includes both dissolved COPCS and COPCs sorbed to suspended solids.

Uncertainties associated with this equation include the following:

(1) All of the variables in Table B-2-17 are COPC- and site-specific. Therefore, the use of default values rather than site-specific values, for any or all of these variables, will contribute to the under- or overestimation of C_{wctot}.

The degree of uncertainty associated with the variables d_{wc} and d_{bs} is expected to be minimal either because information for estimating a variable (d_{wc}) is generally available or because the probable range for a variable (d_{bs}) is narrow. The uncertainty associated with the variables f_{wc} and C_{wtot} is associated with estimates of *OC* content. Because *OC* content values can vary widely for different locations in the same medium, the uncertainty associated with using default *OC* values may be significant in specific cases.

Equation

$$C_{wctot} = f_{wc} \cdot C_{wtot} \cdot \frac{d_{wc} + d_{bs}}{d_{wc}}$$

For mercury modeling:

Total water column concentration is calculated for divalent mercury (Hg^{2+}) and methyl mercury (MHg) using their respective C_{wtot} values and f_{wc} values.

Variable	Description	Units	Value
C_{wctot}	Total COPC concentration in water column	mg/L	

TABLE B-2-17

TOTAL WATER COLUMN CONCENTRATION (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 2 of 4)

Variable	Description	Units	Value
f_{wc}	Fraction of total water body COPC concentration in the water column	unitless	**0 to 1 (calculated - Table B-2-10)** This variable is COPC- and site-specific, and is calculated by using the equation in Table B-2-10. The following uncertainty is associated with this variable: (1) The default variable values recommended for use in Table B-2-10 may not accurately represent site-specific water body conditions. However, the ranges of several variables—including d_{bs}, and θ_{bs} - is relatively narrow; therefore, the uncertainty is expected to be relatively small. Other variables, such as d_{wc} and d_z, can be reasonably estimated on the basis of generally available information. The largest degree of uncertainty may be introduced by the default medium specific *OC* content values. *OC* content values are often not readily available and can vary widely for different locations in the same medium. Therefore, default values may not adequately represent site-specific conditions.
C_{wtot}	Total water body COPC concentration, including water column and bed sediment	mg/L	**Varies (calculated - Table B-2-9)** This variable is COPC- and site-specific, and is calculated by using the equation in Table B-2-9. The following uncertainty is associated with this variable: (1) The default variable values recommended for use in the equation in Table B-2-9 may not accurately represent site--specific water body conditions. The degree of uncertainty associated with variables Vf_x, A_w, d_{wc}, and d_{bs} is expected to be limited either because the probable ranges for variables are narrow or information allowing accurate estimates is generally available. Uncertainty associated with f_{wc} is largely the result of water body associated with default *OC* content values, and may be significant in specific instances. Uncertainties associated with the total COPC load into water body (L_T) and overall total water body COPC dissipation rate constant (k_{wt}) may also be significant in some instances because of the summation of many variable-specific uncertainties.

TABLE B-2-17

TOTAL WATER COLUMN CONCENTRATION (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 3 of 4)

Variable	Description	Units	Value
d_{wc}	Depth of water column	m	**Varies (site-specific)** This variable is site-specific, and should be an average annual value. The following uncertainty is associated with this variable: (1) Use of default values for depth of water column, d_{wc}, may not accurately reflect site-specific water body conditions. Therefore, use of default values may contribute to the under- or overestimation of C_{wctot}. However, the degree of uncertainty associated with this variable is expected to be limited, because information regarding this variable is generally available.
d_{bs}	Depth of upper benthic sediment layer	m	**0.03** This variable is site-specific. U.S. EPA OSW recommends a default upper-benthic sediment depth of 0.03 meter, which is based on the center of this range cited by U.S. EPA (1993a; 1993b) This range is consistent with U.S. EPA (1994). The following uncertainty is associated with this variable: (1) The recommended default value for depth of upper benthic layer, d_{bs}, may not accurately represent site-specific water body conditions. Therefore, use of this default value may contribute to the under- or overestimation of C_{wctot}. However, the degree of uncertainty associated with this variable is expected to be limited because of the narrow recommended range.

TABLE B-2-17

TOTAL WATER COLUMN CONCENTRATION (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 4 of 4)

REFERENCES AND DISCUSSION

NC DEHNR. 1997. *NC DEHNR Protocol for Performing Indirect Exposure Risk Assessments for Hazardous Waste Combustion Units.* January.

This document is cited as one of the sources of the range of d_{bs} values. This document cites U.S. EPA (1993a) as its source.

U.S. EPA. 1993a. *Addendum: Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions.* Working Group Recommendations. Office of Solid Waste and Office of Research and Development. Washington, D.C. September 24.

This document is cited by U.S. EPA (1994) and NC DEHNR (1997) as one of the sources of the ranges of d_{bs} values. No original source of this range was identified.

U.S. EPA. 1993b. *Addendum to the Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions.* External Review Draft. Office of Research and Development. Washington, D.C. November.

This document states that the upper benthic sediment depth, d_{bs}, representing the portion of the bed in equilibrium with the water column, cannot be precisely specified. However, the document states that values from 0.01 to 0.05 meter would be appropriate.

U.S. EPA. 1994. *Draft Guidance for Performing Screening Level Risk Analyses at Combustor Facilities Burning Hazardous Waste. Attachment C, Draft Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facility*. April 15.

This document is cited as one of the reference sources for the default value for depth of upper benthic layer (d_{bs}). The recommended value is the midpoint of an acceptable range. This document cites U.S. EPA (1993a) as the source of its information. The degree of uncertainty associated with the variables d_{wc} and d_{bs} is expected to be minimal either because information for estimating these variables is generally available (d_{wc}) or the probable range for a variable (d_{bs}) is narrow. Uncertainty associated with the variables f_{wc} and C_{wtot} is largely associated with the use of default *OC* content values. Because *OC* content is known to vary widely in different locations in the same medium, use of default medium-specific values can result in significant uncertainty in some instances.

TABLE B-2-18

DISSOLVED PHASE WATER CONCENTRATION
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 1 of 3)

Description

This equation calculates the concentration of contaminant dissolved in the water column.

Uncertainties associated with this equation include the following:

(1) The variables in Table B-2-18 are site-specific. Therefore, the use of default values rather than site-specific values, for any or all of these variables, will contribute to the under- or overestimation of C_{dw}. The uncertainty associated with the variables C_{wCTOT} and Kd_{sw} is associated with estimates of *OC* content. Because *OC* content values can vary widely for different locations in the same medium, using default *OC* values may result in significant uncertainty in specific cases.

Equation

$$C_{dw} = \frac{C_{wctot}}{1 + Kd_{sw} \cdot TSS \cdot 10^{-6}}$$

For mercury modeling:

Dissolved phase water concentration is calculated for divalent mercury (Hg^{2+}) and methyl mercury (MHg) using their respective C_{wctot} values and Kd_{sw} values.

Variable	Description	Units	Value
C_{dw}	Dissolved phase water concentration	mg/L	
10^{-6}	Units conversion factor	kg/mg	

TABLE B-2-18

DISSOLVED PHASE WATER CONCENTRATION
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 2 of 3)

Variable	Description	Units	Value
C_{wctot}	Total COPC concentration in water column	mg/L	**Varies (calculated - Table B-2-17)** This variable is COPC- and site-specific, and is calculated by using the equation in Table B-2-17. The following uncertainty is associated with this variable: (1) All of the variables in Table B-2-17 are COPC- and site-specific. Therefore, the use of default values rather than site-specific values, for any or all of these variables, will contribute to the under- or overestimation of C_{wctot}. The degree of uncertainty associated with the variables d_{wc} and d_{bs} is expected to be minimal either because information for estimating a variable (d_{wc}) is generally available or because the probable range for a variable (d_{bs}) is narrow. The uncertainty associated with the variables f_{wc} and C_{wtot} is associated with estimates of *OC* content. Because *OC* content values can vary widely for different locations in the same medium, using default *OC* values may result in significant uncertainty in specific cases.
Kd_{sw}	Suspended sediments/surface water partition coefficient	L/kg	**Varies (see Appendix A-2)** This variable is COPC-specific and should be determined from the COPC tables in Appendix A-2. The following uncertainty is associated with this variable: (1) Values contained in Appendix A-2 for Kd_{sw} are based on default *OC* content values for surface water and soil. Because OC content can vary widely for different locations in the same medium, the uncertainty associated with estimated Kd_{sw} values based on default *OC* content values may be significant in specific cases.
TSS	Total suspended solids concentration	mg/L	**2 to 300** This variable is site-specific. U.S. EPA OSW recommends the use of site- and waterbody specific measured values, representative of long-term average annual values for the water body of concern (see Chapter 5). A value of 10 mg/L was cited by NC DEHNR (1997), U.S. EPA (1993a), and U.S. EPA (1993b) in the absense of site-specific measured data. The following uncertainty is associated with this variable: Limitation on measured data used for determining a water body specific total suspended solids (*TSS*) value may not accurately reflect site- and water body-specific conditions long term. Therefore, the *TSS* value may contribute to the under-or overestimation of f_{wc}.

TABLE B-2-18

DISSOLVED PHASE WATER CONCENTRATION (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 3 of 3)

REFERENCES AND DISCUSSION

NC DEHNR 1997. *NC DEHNR Protocol for Performing Indirect Exposure Risk Assessments for Hazardous Waste Combustion Units.* January.

This document is cited as one of the sources for Kd_s values and a default *TSS* value of 10. This document cites (1) U.S. EPA (1993a; 1993b) as its sources of information regarding *TSS*, and (2) RTI (1992) as its source regarding Kd_s.

U.S. EPA. 1993a. *Addendum to the Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions.* Working Group Recommendations. Office of Solid Waste and Office of Research and Development. Washington, D.C. September 24.

This document is cited by U.S. EPA (1994) and NC DEHNR (1997) as one of the sources of the range of Kd_s value and the assumed *OC* value of 0.075 for surface water. The generic equation for calculating partition coefficients (soil, surface water, and bed sediments) is as follows: $Kd_{ij} = K_{ocj} * OC_i$. K_{oc} is a chemical-specific value; however, *OC* is medium-specific. The range of Kd_s values was based on an assumed *OC* value of 0.01 for soil. Therefore, the Kd_{sw} values were estimated by multiplying the Kd_s values by 7.5, because the *OC* value for surface water is 7.5 times greater than the *OC* value for soil. This document is also cited by U.S. EPA (1994) and NC DEHNR (1997) as the source of the recommended *TSS* value.

U.S. EPA. 1993b. *Addendum: Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions.* External Review Draft. Office of Research and Development. November.

This document is cited by U.S. EPA (1994) and NC DEHNR (1997) as one of the sources of the range of Kd_s value and the assumed *OC* value of 0.075 for surface water. The generic equation for calculating partition coefficients is as follows: $Kd_{ij} = K_{ocj} * OC_i$. K_{oc} is a chemical-specific value; however, *OC* is medium-specific. The range of Kd_s values was based on an assumed *OC* value of 0.01 for soil. Therefore, the Kd_{sw} values were estimated by multiplying the Kd_s values by 7.5, because the *OC* value for surface water is 7.5 times greater than the *OC* value for soil. This document is also cited by U.S. EPA (1994) and NC DEHNR (1997) as the source of the recommended *TSS* value.

U.S. EPA. 1994. *Draft Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Waste. Attachment C, Draft Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities*. April 15.

This document is cited as one of the sources of the range of Kd_s values, citing RTI (1992) as its source of information.

TABLE B-2-19

COPC CONCENTRATION IN BED SEDIMENT
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 1 of 4)

Description

This equation calculates the COPC concentration in bed sediments.

Uncertainties associated with this equation include the following:

(1) The default variable values recommended for use in the equation in Table B-2-19 may not accurately represent site-specific water body conditions. The degree of uncertainty associated with variables θ_{bs}, BS, d_{wc}, and d_{bs} is expected to be limited either because the probable ranges for these variables are narrow or because information allowing reasonable estimates is generally available.

(2) Uncertainties associated with variables f_{bs}, C_{wtot} and Kd_{bs} are largely associated with the use of default OC content values in their calculation. The uncertainty may be significant in specific instances, because OC content is known to vary widely in different locations in the same medium.

Equation

$$C_{sed} = f_{bs} \cdot C_{wtot} \cdot \frac{Kd_{bs}}{\theta_{bs} + Kd_{bs} \cdot BS} \cdot \frac{d_{wc} + d_{bs}}{d_{bs}}$$

For mercury modeling’:

COPC concentration in bed sediment is calculated for divalent mercury (Hg^{2+}) and methyl mercury (MHg) using their respective C_{wtot} values; f_{bs} values; and Kd_{bs} values.

Variable	Description	Units	Value
C_{sed}	COPC concentration in bed sediment	mg/kg	
f_{bs}	Fraction of total water body COPC concentration in benthic sediment	unitless	**Varies (calculated - Table B-2-10)** This variable is COPC- and site-specific, and is calculated by using the equation in Table B-2-10. The following uncertainty is associated with this variable: (1) The default values for the variables in Table B-2-10 may not accurately represent site- and water body-specific conditions. However, the range of several variables—including d_{bs},BS, and θ_{bs}—is relatively narrow. Other variables, such as d_{wc} and d_z, can be reasonably estimated on the basis of generally available information. The largest degree of uncertainty may be introduced by the default medium-specific OC content values. Because OC content values may vary widely in different locations in the same medium, by using default values may result in significant uncertainty in specific cases.

TABLE B-2-19

COPC CONCENTRATION IN BED SEDIMENT
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 2 of 4)

Variable	Description	Units	Value
C_{wtot}	Total water body COPC concentration, including water column and bed sediment	mg/L	**Varies (calculated - Table B-2-9)** This variable is COPC- and site-specific, and is calculated by using the equation in Table B-2-9. The following uncertainty is associated with this variable: (1) The default variable values recommended for use in the equation in Table B-2-9 may not accurately represent site-specific water body conditions. The degree of uncertainty associated with variables Vf_x, A_W, d_{wc}, and d_{bs} is expected to be limited either because the probable ranges for these variables are narrow or information allowing reasonable estimates is generally available. (2) Uncertainty associated with f_{wc} is largely the result of uncertainty associated with default *OC* content values and may be significant in specific instances. Uncertainties associated with the variable L_T and k_{wt} may also be significant because of the summation of many variable-specific uncertainties.
Kd_{bs}	Bed sediment/sediment pore water partition coefficient	L/kg	**Varies (see Appendix A-2)** This variable is COPC-specific, and should be determined from the COPC tables in Appendix A-2. The following uncertainty is associated with this variable: (1) The default range (8 to 2,100,000 L/kg) of Kd_{bs} values are based on default *OC* content values for sediment and soil. Because medium-specific *OC* content may vary widely at different locations in the same medium, the uncertainty associated with Kd_{bs} values calculated by using default *OC* content values may be significant in specific instances.
θ_{bs}	Bed sediment porosity	$L_{water}/L_{sediment}$	**0.4 to 0.8** **Default: 0.6** This variable is site-specific. U.S. EPAOSW recommends a default bed sediment porosity of 0.6 (by using a *BS* value of 1 g/cm^3 and a solids density [ρ_s] value of 2.65 kg/L), calculated by using the following equation (U.S. EPA 1993a): $\theta_{bs} = 1 - BS / \rho_s$ This is consistent with other U.S. EPA (1993b and 1994) guidance. The following uncertainty is associated with this variable: (1) To the extent that the recommended default values of *BS* and ρ_s do not accurately represent site- and water body-specific conditions, θ_{bs} will be under- or overestimated to some degree. However, the degree of uncertainty is expected to be minimal, based on the narrow range of recommended values.

TABLE B-2-19

COPC CONCENTRATION IN BED SEDIMENT
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 3 of 4)

Variable	Description	Units	Value
BS	Benthic solids concentration	g/cm^3	**0.5 to 1.5** **Default: 1.0** This variable is site-specific. U.S. EPA OSW recommends a default value of 1.0, consistent with U.S. EPA (1993a), which states that this value should be reasonable for most applications. No reference is cited for this recommendation. This is also consistent with other U.S. EPA (1993b and 1994) guidance. The following uncertainty is associated with this variable: (1) The recommended default value for *BS* may not accurately represent site- and water body-specific conditions. Therefore, the variable *Csed* may be under- or overestimated to a limited degree, as indicated by the narrow range of recommended values.
d_{wc}	Depth of water column	m	**Varies (site-specific)** This variable is site-specific. The following uncertainty is associated with this variable: (1) Use of default d_{wc} values may not accurately reflect site-specific conditions. Therefore, use of these default values may contribute to the under- or overestimation of the variable C_{sed}. However, the degree of uncertainty is expected to be minimal, because resources allowing reasonable water body-specific estimates of d_{wc} are generally available.
d_{bs}	Depth of upper benthic sediment layer	m	**0.03** This variable is site-specific. U.S. EPA recommends a default upper-benthic sediment depth of 0.03 meter, which is based on the center of this range cited by U.S. EPA (1993b). This is consistent with U.S. EPA (1994) and NC DEHNR (1997). The following uncertainty is associated with this variable: (1) Use of default d_{bs} values may not accurately reflect site-specific conditions. Therefore, use of these values may contribute to the under- or overestimation of the variable C_{sed}. However, the degree of uncertainty is expected to be small, based on the narrow recommended range of default values.

TABLE B-2-19

COPC CONCENTRATION IN BED SEDIMENT
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 4 of 4)

REFERENCES AND DISCUSSION

NC DEHNR. 1997. *NC DEHNR Protocol for Performing Indirect Exposure Risk Assessments for Hazardous Waste Combustion Units.* January.

This document is cited as one of the reference source documents for the default value for bed sediment porosity (θ_{bs}). This document cites U.S. EPA (1993a; 1993b) as its source of information. This document is also cited as one of the reference source documents for the default value for depth of the upper benthic layer. The default value is the midpoint of an acceptable range. This document cites U.S. EPA (1993a; 1993b) as its source of information for the range of values for the depth of the upper benthic layer. This document is also cited as one of the reference source documents for the default benthic solids concentration (BS).

U.S. EPA. 1993a. *Addendum to the Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions.* External Review Draft. Office of Research and Development. Washington, D.C. November 1993.

This document is cited by U.S. EPA (1994) and NC DEHNR (1997) as one of the sources of the range of Kd_s values and an assumed OC value of 0.04 for sediment. The generic equation for calculating partition coefficients (soil, surface water, and bed sediments) is as follows: $Kd_{ij} = K_{oc} * OC_i$. K_{oc} is a chemical-specific value; however, OC is medium-specific. The range of Kd_s values was based on an assumed OC value of 0.01 for soil. Therefore, the Kd_{bs} value was estimated by multiplying the Kd_s values by 4, because the OC value for sediment is four times greater than the OC value for soil. This document is also cited as the source of the equation for calculating bed sediment porosity (θ_{bs}). No source of this equation was identified. This document was also cited as the source for the range of the benthic solids concentration (BS). No source of this range was identified.

U.S. EPA. 1993b. *Addendum: Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions.* Working Group Recommendations. Office of Solid Waste and Office of Research and Development. Washington, D.C. September 24.

This document is cited by NC DEHNR (1997) and U.S. EPA (1994) as the source of the default bed sediment porosity value (θ_{bs}), the default benthic solids concentration value (BS), and the range for depth of upper benthic layer (d_{bs}) values.

U.S. EPA. 1994. *Draft Guidance for Performing Screening Level Risk Analyses at Combustor Facilities Burning Hazardous Wastes. Attachment C, Draft Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities*. April 15.

This document is cited as one of the sources of the range of Kd_s values and an assumed OC value of 0.04 for sediment. This document cites RTI (1992) as its source of information regarding Kd_s values. This document is cited as one of the reference source documents for the default value for bed sediment porosity (θ_{bs}). This document cites U.S. EPA (1993a; 1993b) as its source. This document is also cited as one of the reference source documents for the default value for depth of upper benthic layer (d_{bs}). The default value is the midpoint of an acceptable range. This document cites U.S. EPA (1993a; 1993b) as its source of information for the range of values for the depth of the upper benthic layer. This document is also cited as one of the reference source documents for the default benthic solids concentration (BS).

TABLE B-3-1

PLANT CONCENTRATION DUE TO DIRECT DEPOSITION (TERRESTRIAL PLANT EQUATIONS)

(Page 1 of 10)

Description

This equation calculates the COPC concentration in plants, resulting from wet and dry deposition of particle phase COPCs onto the exposed plant surface.

The limitations and uncertainty associated with calculating this value include the following:

(1) Uncertainties associated with the variables *Q*, *Dydp*, and *Dywp* are site-specific.
(2) The calculation of *kp* values does not consider chemical degradation processes. Inclusion of chemical degradation process would decrease the amount of time that a compound remains on plant surfaces (half-time) and thereby increase *kp* values. *Pd* decreases with increased *kp* values. Reduction of half-time from the assumed 14 days to 2.8 days, for example, would decrease *Pd* about 5-fold.
(3) The calculation of other parameter values (for example, *Fw* and *Rp*) is based directly or indirectly on studies of specific types of vegetation (primarily grasses and forbes). To the extent that the calculated parameter values do not accurately represent all site-specific forage species, uncertainty is introduced.
(4) The uncertainties associated with the variables F_v, *Tp*, and *Yp* are not expected to be significant.

Equation

$$Pd = \frac{1000 \cdot Q \cdot (1 - F_v) \cdot [Dydp + (Fw \cdot Dywp)] \cdot Rp \cdot [1.0 - \exp(-kp \cdot Tp)] \cdot 0.12}{Yp \cdot kp}$$

For mercury modeling:

$$Pd_{Mercury} = \frac{1000 \cdot (0.48 Q_{TotalMercury}) \cdot (1 - F_{v_{Hg^{2+}}}) \cdot [Dydp + (Fw \cdot Dywp)] \cdot Rp \cdot [1.0 - \exp(-kp \cdot Tp)] \cdot 0.12}{Yp \cdot kp}$$

In calculating *Pd* for mercury comounds, *Pd(Mercury)* is calculated as shown above using the total mercury emission rate (*Q*) measured at the stack and F_v for mercuric chloride ($F_v = 0.85$). As presented below, the calculated *Pd(Mercury)* value is apportioned into the divalent mercury (Hg^{2+}) and methyl mercury (MHg) forms based on a 78% Hg^{2+} and 22% MHg speciation split in plants (see Chapter 2).

$Pd\ (Hg^{2+}) = 0.78\ Pd(Mercury)$
$Pd\ (MHg) = 0.22\ Pd(Mercury)$

After calculating species specific *Pd* values, divalent and methyl mercury should continue to be modeled throughout Appendix B equations as individual COPCs.

TABLE B-3-1

PLANT CONCENTRATION DUE TO DIRECT DEPOSITION (TERRESTRIAL PLANT EQUATIONS)

(Page 2 of 10)

Variable	Description	Units	Value
Pd	Plant concentration due to direct deposition	mg/kg WW	
1000	Units conversion factor	mg/g	
Q	COPC-specific emission rate	g/s	**Varies (site-specific)** This value is COPC- and site-specific (see Chapters 2 and 3). Uncertainties associated with this variable are also COPC- and site-specific.
F_v	Fraction of COPC air concentration in vapor phase	unitless	**0 to 1 (see Appendix A-2)** This variable is COPC-specific and should be determined from the COPC tables in Appendix A-2. Uncertainties associated with this variable include the following: (1) Calculation is based on an assumption of a default S_T value for background plus local sources, rather than an S_T value for urban sources. If a specific site is located in an urban area, the use of the latter S_T value may be more appropriate. Specifically, the S_T value for urban sources is about one order of magnitude greater than that for background plus local sources and would result in a lower calculated F_v value; however, the F_v value is likely to be only a few percent lower. (2) According to Bidleman (1988), the equation used to calculate F_v assumes that the variable *c* is constant for all chemicals; however, the value of *c* depends on the chemical (sorbate) molecular weight, the surface concentration for monolayer coverage, and the difference between the heat of desorption from the particle surface and the heat of vaporization of the liquid-phase sorbate. To the extent that site- or COPC-specific conditions may cause the value of *c* to vary, uncertainty is introduced if a constant value of *c* is used to calculate F_v.
Dydp	Unitized yearly average dry deposition from particle phase	s/m^2-yr	**Varies (modeled)** This variable is COPC- and site-specific, and is determined by air dispersion modeling (see Chapter 3). Uncertainties associated with this variable are site-specific.

TABLE B-3-1

PLANT CONCENTRATION DUE TO DIRECT DEPOSITION (TERRESTRIAL PLANT EQUATIONS)

(Page 3 of 10)

Variable	Description	Units	Value
Rp	Interception fraction of the edible portion of plant	unitless	**0.5** U.S. EPA OSW recommends the use of the *Rp* value of 0.5 , which is consistent with the value used by U.S. EPA (1994b; 1995) in development of values for the fraction of deposition that adheres to plant surfaces, *Fw*, for forage. As summarized in Baes, Sharp, Sjoreen, and Shor (1984), experimental studies of pasture grasses identified a correlation between initial *Rp* values and productivity (standing crop biomass [*Yp*]) (Chamberlain 1970): $Rp = 1 - e^{-\gamma \cdot Yp}$ where: Rp = Interception fraction of edible portion of plant (unitless) γ = Empirical constant; Chamberlain (1970) presents a range of 2.3 to 3.3; Baes, Sharp, Sjoreen, and Shor (1984) uses the midpoint, 2.88, for pasture grasses. Yp = Yield or standing crop biomass (productivity) (kg DW/m^2) Baes, Sharp, Sjoreen, and Shor (1984) proposed using the same empirical relationship developed by Chamberlain (1970) for other vegetation classes. Class-specific estimates of the empirical constant, γ, were developed by forcing an exponential regression equation through several points, including average and theoretical maximum estimates of *Rp* and *Yp* (Baes, Sharp, Sjoreen, and Shor 1984). Uncertainties associated with this variable include the following: (1) The empirical relationship developed by Chamberlain (1970) on the basis of a study of pasture grass may not accurately represent all forage varieties of plants. (2) The empirical constants developed by Baes, Sharp, Sjoreen, and Shor (1984) for use in the empirical relationship developed by Chamberlain (1970) may not accurately represent site-specific mixes of plants.

TABLE B-3-1

PLANT CONCENTRATION DUE TO DIRECT DEPOSITION (TERRESTRIAL PLANT EQUATIONS)

(Page 4 of 10)

Variable	Description	Units	Value
Fw	Fraction of COPC wet deposition that adheres to plant surfaces	unitless	**Anions: 0.20** **Cations and most Organics: 0.6** Consistent with U.S. EPA (194b; 1995) in evaluating aboveground forage, U.S. EPA OSW recommends using the value of 0.2 for anions and 0.6 for cations and most organics. These values are the best available information, based on a review of the current scientific literature, with the following exception: U.S. EPA OSW recommends using an *Fw* value of 0.2 for the three organic COPC that ionize to anionic forms. These include (1) 4-chloroaniline, (2) n-nitrosodiphenylamine, and (3) n-nitrosodi-n-proplyamine (see Appendix A-2). The values estimated by U.S. EPA (1994b; 1995) are based on information presented in Hoffman, Thiessen, Frank, and Blaylock (1992), which presented values for a parameter (*r*) termed the "interception fraction." These values were based on a study in which soluble radionuclides and insoluble particles labeled with radionuclides were deposited onto pasture grass (specifically a combination of fescues, clover, and old field vegitation) via simulated rain. The parameter (*r*) is defined as "the fraction of material in rain intercepted by vegetation and initially retained" or, essentially, the product of *Rp* and *Fw,* as defined for use in this guidance: $r = Rp \cdot Fw$ The *r* values developed by Hoffman, Thiessen, Frank, and Blaylock (1992) were divided by an *Rp* value of 0.5 for forage (U.S. EPA 1994b). The *Fw* values developed by U.S. EPA (1994b) are 0.2 for anions and 0.6 for cations and insoluble particles. U.S. EPA (1994b; 1995) recommended using the *Fw* value calculated by using the *r* value for insoluble particles to represent organic compounds; however, no rationale for this recommendation is provided. Uncertainties associated with this variable include the following: (1) Values of *r* developed experimentally for pasture grass (specifically a combination of fescues, clover, and old field vegitation) may not accurately represent all forage varieties specificto a site. (2) Values of *r* assumed for most organic compounds, based on the behavior of insoluble polystryene microspheres tagged with radionuclides, may not accurately represent the behavior of organic compounds under site-specific conditions.
Dywp	Unitized yearly average wet deposition from particle phase	s/m^2-yr	**Varies (modeled)** This variable is COPC- and site-specific, and is determined by air dispersion modeling (see Chapter 3). Uncertainties associated with this variable are site-specific.

TABLE B-3-1

PLANT CONCENTRATION DUE TO DIRECT DEPOSITION (TERRESTRIAL PLANT EQUATIONS)

(Page 5 of 10)

Variable	Description	Units	Value
kp	Plant surface loss coefficient	yr^{-1}	**18** U.S. EPA OSW recommends the *kp* value of 18 recommended by U.S. EPA (1993; 1994b). The *kp* value selected is the midpoint of a possible range of values. U.S. EPA (1990) identified several processes—including wind removal, water removal, and growth dilution—that reduce the amount of contaminant that has been deposited on a plant surface. The term *kp* is a measure of the amount of contaminant lost to these physical processes over time. U.S. EPA (1990) cited Miller and Hoffman (1983) for the following equation used to estimate *kp*: $$kp = (\ln 2/\ t_{1/2}) \cdot 365 \text{ days/yr}$$ where: $t_{1/2}$ = half-time (days) Miller and Hoffman (1983) report half-time values ranging from 2.8 to 34 days for a variety of contaminants on herbaceous vegetation. These half-time values result in *kp* values of 7.44 to 90.36 yr^{-1}. U.S. EPA (1993; 1994b) recommend a *kp* value of 18, based on a generic 14-day half-time, corresponding to physical processes only. The 14-day half-time is approximately the midpoint of the range (2.8 to 34 days) estimated by Miller and Hoffman (1983). Uncertainties associated with this variable include the following: (1) Calculation of *kp* does not consider chemical degradation processes. The addition of chemical degradation processes would decrease half-times and thereby increase *kp* values; plant concentration decreases as *kp* increases. Therefore, use of a *kp* value that does not consider chemical degradation processes is conservative. (2) The half-time values reported by Miller and Hoffman (1983) may not accurately represent the behavior of all COPCs on plants. (3) Based on this range (7.44 to 90.36), plant concentrations could range from about 1.8 times higher to about 5 times lower than the plant concentrations, based on a *kp* value of 18.

TABLE B-3-1

PLANT CONCENTRATION DUE TO DIRECT DEPOSITION (TERRESTRIAL PLANT EQUATIONS)

(Page 6 of 10)

Variable	Description	Units	Value
Tp	Length of plant exposure to deposition per harvest of edible portion of plant	yr	**0.12** This variable is site-specific. U.S. EPA OSW recommends the use of these default values in the absence of site-specific information. U.S. EPA (1990), U.S. EPA (1994b), and NC DEHNR (1997) recommended treating *Tp* as a constant, based on the average periods between successive hay harvests and successive grazing. For forage, the average of the average period between successive hay harvests (60 days) and the average period between successive grazing (30 days) is used (that is, 45 days). *Tp* is calculated as follows: $Tp = (60 \text{ days} + 30 \text{ days})/\ 2 \div 365 \text{ days/yr} = 0.12 \text{ yr}$ These average periods are from Belcher and Travis (1989), and are used when calculating the COPC concentration in cattle forage. The following uncertainty is associated with this variable: (1) Beyond the time frame of about 3 months for harvest cycles, if the *kp* value remains unchanged at 18, higher *Tp* values will have little effect on predicted COPC concentrations in plants.
0.12	Dry weight to wet weight conversion factor	unitless	**0.12** U.S. EPA OSW recommends using the value of 0.12. This default value is based on the average rounded value from the range of 80 to 95 percent water content in herbaceous plants and nonwoody plant parts (Taiz at al. 1991). The following uncertainty is associated with this variable: (1) The plant species considered in determining the default value may be different from plant varieties actually present at a site.

TABLE B-3-1

PLANT CONCENTRATION DUE TO DIRECT DEPOSITION (TERRESTRIAL PLANT EQUATIONS)

(Page 7 of 10)

Variable	Description	Units	Value
Yp	Yield or standing crop biomass of the edible portion of the plant (productivity)	kg DW/m^2	**0.24** U.S. EPA OSW recommends using the *Yp* value of 0.24. This default value is consistent with values presented in U.S. EPA (1994b) for forage (weighted average of pasture grass and hay *Yp* values determined in considering ingestion by an herbivorous mammal [cattle]), and with the resulting Rp value (see Table B-3-1) as determined by correlation with productivity (standing crop biomass [*Yp*]) (Chamberlain 1970). Based on a review of the currently available literature, this value appears to be based on the most complete and thorough information. The following uncertainty is associated with this variable: (1) The plant species considered in determining the default value for forage may be different from plant varieties actually present at a site. This may under- or overestimate *Yp*.

TABLE B-3-1

PLANT CONCENTRATION DUE TO DIRECT DEPOSITION
(TERRESTRIAL PLANT EQUATIONS)

(Page 8 of 10)

REFERENCES AND DISCUSSION

Baes, C.F., R.D. Sharp, A.L. Sjoreen, and R.W. Shor. 1984. *Review and Analysis of Parameters and Assessing Transport of Environmentally Released Radionuclides through Agriculture*. ORNL-5786. Oak Ridge National Laboratory. Oak Ridge, Tennessee. September.

This document proposed using the same empirical relationship developed by Chamberlain (1970) for other vegetation classes. Class-specific estimates of the empirical constant, γ, were developed by forcing an exponential regression equation through several points, including average and theoretical maximum estimates of *Rp* and *Yp*.

Belcher, G.D., and C.C. Travis. 1989. "Modeling Support for the RURA and Municipal Waste Combustion Projects: Final Report on Sensitivity and Uncertainty Analysis for the Terrestrial Food Chain Model." Interagency Agreement No. 1824-A020-A1, Office of Risk Analysis, Health and Safety Research Division, Oak Ridge National Laboratory. Oak Ridge, Tennessee. October.

This document recommends *Tp* values based on the average period between successive hay harvests and successive grazing.

Bidleman, T.F. 1988. "Atmospheric Processes." *Environmental Science and Technology*. Volume 22. Pages 361-367. November 4.

This document is cited by U.S. EPA (1994a) and NC DEHNR (1997) as the source of the equations for calculating F_v.

Chamberlain, A.C. 1970. "Interception and Retention of Radioactive Aerosols by Vegetation." *Atmospheric Environment*. 4:57 to 78.

Experimental studies of pasture grasses identified a correlation between initial *Rp* values and productivity (standing crop biomass [*Yp*]):

$Rp = 1 - e^{-\gamma \times Yp}$
γ = Empirical constant; range provided as 2.3 to 3.3
Yp = Standing crop biomass (productivity) (kg DW/m^2)

Hoffman, F.O., K.M. Thiessen, M.L. Frank, and B.G. Blaylock. 1992. "Quantification of the Interception and Initial Retention of Radioactive Contaminants Deposited on Pasture Grass by Simulated Rain." *Atmospheric Environment*. Vol. 26A. 18:3313 to 3321.

This document developed values for a parameter (*r*) that it termed "interception fraction," based on a study in which soluble gamma-emitting radionuclides and insoluble particles tagged with gamma-emitting radionuclides were deposited onto pasture grass (specifically, a combination of fescues, clover, and old field vegetation, including fescue) via simulated rain. The parameter, *r*, is defined as "the fraction of material in rain intercepted by vegetation and initially retained" or, essentially, the product of *Rp* and *Fw*, as defined by this guidance:

$$r = Rp \cdot Fw$$

Experimental *r* values obtained include the following:

- A range of 0.006 to 0.3 for anions (based on the soluble radionuclide iodide-131 [^{131}I]); when calculating *Rp* values for anions, U.S. EPA (1994a) used the highest geometric mean *r* value (0.08) observed in the study.

- A range of 0.1 to 0.6 for cations (based on the soluble radionuclide beryllium-7 [7Be]; when calculating *Rp* values for cations, U.S. EPA (1994a) used the highest geometric mean *r* value (0.28) observed in the study.

- A geometric range of values from 0.30 to 0.37 for insoluble polystyrene microspheres (IPM) ranging in diameter from 3 to 25 micrometers, labeled with cerium-141 [^{141}Ce], [^{95}N]b, and strontium-85 ^{85}Sr; when calculating *Rp* values for organics (other than three organics that ionize to anionic forms: 4-chloroaniline; n-nitrosodiphenylamine; and n-nitrosodi-n-propylamine, —see Appendix A-2), U.S. EPA (1994a) used the geometric mean *r* value for IPM with a diameter of 3 micrometers. However, no rationale for this selection was provided.

The authors concluded that, for the soluble ^{131}I anion, interception fraction *r* is an inverse function of rain amount, whereas for the soluble cation ^{7}Be and the IPMs, *r* depends more on biomass than on amount of rainfall. The authors also concluded that (1) the anionic ^{131}I is essentially removed with the water after the vegetation surface has become saturated, and (2) the cationic ^{7}Be and the IPMs are adsorbed to, or settle out on, the plant surface. This discrepancy between the behavior of the anionic and cationic species is consistent with a negative charge on the plant surface.

Miller, C.W. and F.O. Hoffman. 1983. "An Examination of the Environmental Half-Time for Radionuclides Deposited on Vegetation." *Health Physics*. 45 (3): 731 to 744.

This document is the source of the equation used to calculate kp:

kp = $(\ln 2 / t_{1/2}) \cdot 365$ days/year
$t_{1/2}$ = half-time (days)

The study reports half-time values ranging from 2.8 to 34 days for a variety of contaminants on herbaceous vegetation. These half-time values result in calculate *kp* values from 7.44 to 90.36 yr^{-1}.

NC DEHNR. 1997. *NC DEHNR Protocol for Performing Indirect Exposure Risk Assessments for Hazardous Waste Combustion Units*. January.

Shor, R.W., C.F. Baes, and R.D. Sharp. 1982. *Agricultural Production in the United States by County: A Compilation of Information from the 1974 Census of Agriculture for Use in Terrestrial Food-Chain Transport and Assessment Models.* Oak Ridge National Laboratory Publication. ORNL-5786.

This document is the source of the equation used to calculate *Yp*, as cited by U.S. EPA (1994b). Baes, Sharp, Sjoreen, and Shor (1984) also presents and discusses this equation.

Taiz, L., and E. Geiger. 1991. *Plant Physiology*. Benjamin/Cammius Publishing Co. Redwood City, California. 559 pp.

U.S. EPA. 1990. *Interim Final Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions.* Environmental Criteria and Assessment Office. Office of Research and Development. EPA 600/6-90/003. January.

This is one of the source documents for the equation, and also states that the best estimate of *Yp* (yield or standing crop biomass) is productivity, as defined under Shor, Baes, and Sharp (1982).

U.S. EPA. 1993. *Review Draft Addendum to the Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions.* Office of Health and Environmental Assessment. Office of Research and Development. EPA/600/AP-93/003. November.

TABLE B-3-1

PLANT CONCENTRATION DUE TO DIRECT DEPOSITION (TERRESTRIAL PLANT EQUATIONS)

(Page 10 of 10)

U.S. EPA. 1994a. *Estimating Exposure to Dioxin-Like Compounds. Volume III: Site-Specific Assessment Procedures. Review Draft.* Office of Research and Development. Washington, D.C. EPA/600/6-88/005Cc. June.

U.S. EPA. 1994b. *Revised Draft Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes. Attachment C, Draft Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities*. Office of Emergency and Remedial Response. Office of Solid Waste. December 14.

U.S. EPA. 1995. *Review Draft Development of Human Health-Based and Ecologically-Based Exit Criteria for the Hazardous Waste Identification Project*. Volumes I and II. Office of Solid Waste. March 3.

TABLE B-3-2

PLANT CONCENTRATION DUE TO AIR-TO-PLANT TRANSFER (TERRESTRIAL PLANT EQUATIONS)

(Page 1 of 5)

Description

This equation calculates the COPC concentration in plants, resulting from uptake of vapor phase COPCs by plants through their foliage.

The limitations and uncertainty associated with calculating this value include the following:

(1) The algorithm used to calculate values for the variable F_v assumes a default value for the parameter S_T (Whitby's average surface area of particulates [aerosols]) of background plus local sources, rather than an S_T value for urban sources. If a specific site is located in an urban area, the use of the latter S_T value may be more appropriate. The S_T value for urban sources is about one order of magnitude greater than that for background plus local sources and would result in a lower F_v value; however, the F_v value is likely to be only a few percent lower.

As highlighted by uncertainties described above, *Pv* is most significantly affected by the value calculated for *Bv*.

Equation

$$Pv = Q \cdot F_v \cdot 0.12 \cdot \frac{Cyv \cdot Bv}{\rho_a}$$

For mercury modeling

$$Pv_{Mercury} = (0.48 Q_{TotalMercury}) \cdot F_{v_{Hg^{2+}}} \cdot 0.12 \cdot \frac{Cyv \cdot Bv_{Hg^{2+}}}{\rho_a}$$

In calculating *Pv* for mercury comounds, *Pv(Mercury)* is calculated as shown above using the total mercury emission rate (Q) measured at the stack and F_v for mercuric chloride ($F_v = 0.85$). As presented below, the calculated *Pv(Mercury)* value is apportioned into the divalent mercury (Hg^{2+}) and methyl mercury (MHg) forms based on a 78% Hg^{2+} and 22% MHg speciation split in plants (see Chapter 2).

Pv (Hg^{2+}) = 0.78 *Pv(Mercury)*
Pv (MHg) = 0.22 *Pv(Mercury)*

After calculating species specific *Pv* values, divalent and methyl mercury should continue to be modeled throughout Appendix B equations as individual COPCs.

Variable	Description	Units	Value
Pv	Plant concentration due to air-to-plant transfer	mg/kg WW (equivalent to μg/g)	

TABLE B-3-2

PLANT CONCENTRATION DUE TO AIR-TO-PLANT TRANSFER (TERRESTRIAL PLANT EQUATIONS)

(Page 2 of 5)

Variable	Description	Units	Value
Q	COPC-specific emission rate	g/s	**Varies (site-specific)** This variable is COPC- and site-specific (see Chapters 2 and 3). Uncertainties associated with this variable are site-specific.
F_v	Fraction of COPC air concentration in vapor phase	unitless	**0 to 1 (see Appendix A-2)** This variable is COPC-specific and should be determined from the COPC tables in Appendix A-2. Uncertainties associated with this variable include the following: (1) Calculation is based on an assumption of a default S_T value for background plus local sources, rather than an S_T value for urban sources. If a specific site is located in an urban area, the use of the latter S_T value may be more appropriate. Specifically, the S_T value for urban sources is about one order of magnitude greater than that for background plus local sources and would result in a lower calculated F_v value; however, the F_v value is likely to be only a few percent lower. (2) According to Bidleman (1988), the equation used to calculate F_v assumes that the variable c is constant for all chemicals; however, the value of c depends on the chemical (sorbate) molecular weight, the surface concentration for monolayer coverage, and the difference between the heat of desorption from the particle surface and the heat of vaporization of the liquid-phase sorbate. To the extent that site- or COPC-specific conditions may cause the value of c to vary, uncertainty is introduced if a constant value of c is used to calculate F_v.
Cyv	Unitized yearly air concentration from vapor phase	μg-s/g-m^3	**Varies (modeled)** This variable is COPC- and site-specific, and is determined by air dispersion modeling (see Chapter 3). Uncertainties associated with this variable are site-specific.
Bv	Air-to-plant biotransfer factor	unitless (μg/g plant tissue DW) / (μg/g air)	**Varies (see Appendix C)** This variable is COPC-specific and should be determined from the tables in Appendix C. Uncertainties associated with this variable include the following: (1) The studies that formed the basis of the algorithm used to estimate Bv values were conducted on azalea leaves and grasses, and may not accurately represent Bv for all forage species of plants.

TABLE B-3-2

PLANT CONCENTRATION DUE TO AIR-TO-PLANT TRANSFER (TERRESTRIAL PLANT EQUATIONS)

(Page 3 of 5)

Variable	Description	Units	Value
0.12	Dry weight to wet weight conversion factor	unitless	**0.12** U.S. EPA OSW recommends using the value of 0.12. This default value is based on the average rounded value from the range of 80 to 95 percent water content in herbaceous plants and nonwoody plant parts (Taiz et al. 1991). The following uncertainty is associated with this variable: (1) The plant species considered in determining the default value may be different from plant varieties actually present at a site.
ρ_a	Density of air	g/m^3	**0.0012** U.S. EPA OSW recommends the use of this value based on Weast (1980). This reference indicates that air density varies with temperature. U.S. EPA (1990) recommended this same value but states that it was based on a temperature of 25°C; no reference was provided. U.S. EPA (1994b) and NC DEHNR (1997) recommend this same value but state that it was calculated at standard conditions of 20°C and 1 atm. Both documents cite Weast (1981). There is no significant uncertainty associated with this variable.

TABLE B-3-2

PLANT CONCENTRATION DUE TO AIR-TO-PLANT TRANSFER (TERRESTRIAL PLANT EQUATIONS)

(Page 4 of 5)

REFERENCES AND DISCUSSION

Bacci E., D. Calamari, C. Gaggi, and M. Vighi. 1990. "Bioconcentration of Organic Chemical Vapors in Plant Leaves: Experimental Measurements and Correlation." *Environmental Science and Technology*. Volume 24. Number 6. Pages 885-889.

This is the source of the equation to adjust B_{vol}, based on volume/volume basis, to Bv on a mass/mass basis—see Bacci, Cerejeira, Gaggi, Chemello, Calamari, and Vighi (1992) below.

Bacci E., M. Cerejeira, C. Gaggi, G. Chemello, D. Calamari, and M. Vighi. 1992. "Chlorinated Dioxins: Volatilization from Soils and Bioconcentration in Plant Leaves." *Bulletin of Environmental Contamination and Toxicology*. Volume 48. Pages 401-408.

This is the source of the algorithm based on a study of 14 organic compounds, including 1,2,3,4-TCDD, used to calculate the air-to-plant biotransfer factor (Bv):

$$\log B_{vol} = 1.065 \log K_{ow} - \log \left(\frac{H}{R.T_a}\right) - 1.654$$

where:

B_{vol} = Volumetric air-to-plant bio transfer factor ([μg/L wet leaf]/[μg/L air])
K_{ow} = Octanol-water partition coefficient (dimensionless)
H = Henry's Law Constant (atm-m^3/ mol)
R = Ideal gas constant, 8.2 x 10^{-5} atm-m^3/mol-deg K
T_a = Ambient air temperature, 298.1 K (25°C)

This volumetric transfer factor can be transformed to a mass-based transfer factor by using the following equation (Bacci, Calamari, Gaggi, and Vighi 1990):

$$Bv = \frac{\rho_a \cdot B_{vol}}{(1 - f_{wc}) \cdot \rho_{forage}}$$

where:

Bv = mass-based air-to-plant biotransfer factor ([μg/g DW plant]/[μg/g air])
B_{vol} = volumetric air-to-plant biotransfer factor ([μg/L wet leaf]/[μg/L air])
ρ_a = density of air, 1.19 g/L (Weast 1986)
ρ_{forage} = density of forage, 770 g/L (McCrady and Maggard, 1993)
f_{wc} = fraction of forage that is water, 0.85 (McCrady and Maggard, 1993)

Bidleman, T.F. 1988. "Atmospheric Processes." *Environmental Science and Technology*. Volume 22. Number 4. Pages 361-367.

TABLE B-3-2

PLANT CONCENTRATION DUE TO AIR-TO-PLANT TRANSFER (TERRESTRIAL PLANT EQUATIONS)

(Page 5 of 5)

This is the reference for the statement that the equation used to calculate the fraction of air concentration in vapor phase (F_v) assumes that the variable c (the Junge constant) is constant for all chemicals; however, this reference notes that the value of c depends on the chemical (sorbate) molecular weight, the surface concentration for monolayer coverage, and the difference between the heat of desorption from the particle surface and the heat of vaporization of the liquid-phase sorbate.

This document is also cited by U.S. EPA (1994b) and NC DEHNR (1997) for calculating the variable F_v.

NC DEHNR. 1997. *NC DEHNR Protocol for Performing Indirect Exposure Risk Assessments for Hazardous Waste Combustion Units*. January.

Taiz, L., and E. Geiger. 1991. *Plant Physiology*. Benjamin/Cammius Publishing Co. Redwood City, California. 559 pp.

U.S. EPA. 1990. *Interim Final Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions*. Environmental Criteria and Assessment Office. Office of Research and Development. EPA-600-90-003. January.

This document is a source of air density values.

U.S. EPA. 1993. *Review Draft Addendum to the Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions*. Office of Health and Environmental Assessment. Office of Research and Development. EPA-600-AP-93-003. November 10.

Based on attempts to model background concentrations of dioxin-like compounds in beef on the basis of known air concentrations, this document recommends reducing, by a factor of 10, *Bv* values calculated by using the Bacci, Cerejeira, Gaggi, Chemello, Calamari, and Vighi (1992) algorithm The use of this factor “made predictions [of beef concentrations] come in line with observations.”

U.S. EPA. 1994a. *Estimating Exposure to Dioxin-Like Compounds. Volume II: Properties, Sources, Occurrence, and Background Exposures. Review Draft*. Office of Research and Development. Washington, DC. EPA/600/6-88/005Cb. June.

U.S. EPA. 1994b. *Revised Draft Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes. Attachment C, Draft Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities*. Office of Emergency and Remedial Response. Office of Solid Waste. December 14.

This is one of the source documents for Equation B-2-8. This document also presents a range (0.27 to 1) of F_v values for organic COPCs, based on the work of Bidleman (1988); F_v for all inorganics is set equal to zero.

Weast, R.C. 1981. *Handbook of Chemistry and Physics*. 62nd Edition. Cleveland, Ohio. CRC Press.

This document is a reference for air density values.

Weast, R.C. 1986. *Handbook of Chemistry and Physics*. 66th Edition. Cleveland, Ohio. CRC Press.

This document is a reference for air density values, and is an update of Weast (1981).

Wipf, H.K., E. Homberger, N. Neuner, U.B. Ranalder, W. Vetter, and J.P. Vuilleumier. 1982. “TCDD Levels in Soil and Plant Samples from the Seveso Area.” *In: Chlorinated Dioxins and Related Compounds: Impact on the Environment*. Eds. Hutzinger, O. and others. Pergamon, NY.

TABLE B-3-3

PLANT CONCENTRATION DUE TO ROOT UPTAKE (TERRESTRIAL PLANT EQUATIONS)

(Page 1 of 3)

Description

This equation calculates the COPC concentration in plants, resulting from direct uptake of COPCs from soil through plant roots.

The limitations and uncertainty associated with calculating this value include the following:

(1) The availability of site-specific information, such as meteorological data, may affect the accuracy of Cs estimates.
(2) Estimated COPC-specific soil-to-plant bioconcentration factors (BCF_r) may not reflect site-specific conditions.

Equation

$$Pr = Cs \cdot BCF_r \cdot 0.12$$

For mercury modeling:

$$Pr_{(Hg^{2+})} = Cs_{(Hg^{2+})} \cdot BCF_{r\,(Hg^{2+})} \cdot 0.12$$

$$Pr_{(MHg)} = Cs_{(MHg)} \cdot BCF_{r\,(MHg)} \cdot 0.12$$

Plant concentration due to root uptake is calculated using the respective Cs and BCF_r values for divalent mercury (Hg^{2+}) and methyl mercury (MHg).

Variable	Description	Units	Value
Pr	Plant concentration due to root uptake	mg/kg WW	
Cs	COPC concentration in soil	mg/kg	**Varies (calculated - Table B-1-1)** This value is COPC-and site-specific and should be calculated using the equation in Table B-1-1. Uncertainties associated with this variable are site-specific.

TABLE B-3-3

PLANT CONCENTRATION DUE TO ROOT UPTAKE (TERRESTRIAL PLANT EQUATIONS)

(Page 2 of 3)

Variable	Description	Units	Value
0.12	Dry weight to wet weight conversion factor	unitless	**0.12** U.S. EPA OSW recommends using the value of 0.12. This default value is based on the average rounded value from the range of 80 to 95 percent water content in herbaceous plants and nonwoody plant parts (Taiz et al. 1991). The following uncertainty is associated with this variable: (1) The plant species considered in determining the default value may be different from plant varieties actually present at a site.
BCF_r	Plant-soil biotransfer factor	unitless [(mg/kg plant DW)/(mg/kg soil)]	**Varies (see Appendix C)** This variable is COPC-specific. Discussion of this variable and COPC-specific values are presented in Appendix C. Uncertainties associated with this variable include the following: (1) Estimates of BCF_r for some inorganic COPCs, based on plant uptake response slope factors, may be more accurate than those based on BCF values from Baes, Sharp, Sjoreen, and Shor (1984). (2) U.S. EPA OSW recommends that uptake of organic COPCs from soil and transport of the COPCs to the aboveground portions of the plant be calculated on the basis of a regression equation developed in a study of the uptake of 29 organic compounds. This regression equation, developed by Travis and Arms (1988), may not accurately represent the behavior of all organic COPCs under site-specific conditions.

TABLE B-3-3

PLANT CONCENTRATION DUE TO ROOT UPTAKE (TERRESTRIAL PLANT EQUATIONS)

(Page 3 of 3)

REFERENCES AND DISCUSSION

Baes, C.F., R.D. Sharp, A.L. Sjoreen, and R.W. Shor. 1984. *Review and Analysis of Parameters and Assessing Transport of Environmentally Released Radionuclides through Agriculture.* ORNL-5786. Oak Ridge National Laboratory. Oak Ridge, Tennessee. September.

Taiz, L., and E. Geiger. 1991. *Plant Physiology*. Benjamin/Cammius Publishing Co. Redwood City, California. 559 pp.

Travis, C.C. and A.D. Arms. 1988. "Bioconcentration of Organics in Beef, Milk, and Vegetation." *Environmental Science and Technology*. 22:271 to 274.

Based on paired soil and plant concentration data for 29 organic compounds, this document developed a regression equation relating soil-to-plant BCF to K_{ow};

$$\log BCF_r = 1.588 - 0.578 \log K_{ow}$$

U.S. EPA. 1995. *Review Draft Development of Human Health-Based and Ecologically-Based Exit Criteria for the Hazardous Waste Identification Project*. Volumes I and II. Office of Solid Waste. March 3.

This document recommended using the BCFs, *Bv* and *Br*, from Baes, Sharp, Sjoreen, and Shor (1984), for calculating the uptake of inorganics into vegetative growth (stems and leaves) and nonvegetative growth (fruits, seeds, and tubers), respectively.

Although most BCFs used in this document come from Baes, Sharp, Sjoreen, and Shor (1984), values for some inorganics were apparently obtained from plant uptake response slope factors. These uptake response slope factors were calculated from field data, such as metal methodologies, and references used to calculate the uptake response slope factors are not clearly identified.

APPENDIX C

MEDIA-TO-RECEPTOR BIOCONCENTRATION FACTORS (*BCF*s)

Screening Level Ecological Risk Assessment Protocol

August 1999

APPENDIX C

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APPENDIX C

MEDIA-TO-RECEPTOR *BCF*s

Appendix C provides recommended guidance for determining values for media-to-receptor bioconcentration factors (*BCF*s) based on values reported in the scientific literature, or estimated using physical and chemical properties of the compound. Guidance on use of *BCF* values in the screening level ecological risk assessment is provided in Chapter 5.

Section C-1.0 provides the general guidance recommended to select or estimate *BCF* values. Sections C-1.1 through C-1.7 further discuss determination of *BCF*s for specific media and receptors. References cited in Sections C-1.1 through C-1.7 are located following Section C-1.7.

For the compounds commonly identified in risk assessments for combustion facilities (identified in Chapter 2), *BCF* values have been determined following the guidance in Sections C-1.1 through C-1.7. *BCF* values for these limited number of compounds are included in this appendix in Tables C-1 through C-7 to facilitate the completion of screening ecological risk assessments. However, it is expected that additional compounds may require evaluation on a site specific basis, and in such cases, *BCF* values for these additional compounds could be determined following the same guidance (Sections C-1.1 through C-1.7) used in determination of the *BCF* values reported in this appendix. For reproducibility and to facilitate comparison of new data and values as they become available, all data reviewed in the selection of the *BCF* values provided at the end of this appendix are also included in Tables C-1 through C-7. References cited in Tables C-1 through C-7 (Media-to-Receptor *BCF* Values) are located following Table C-7.

For additional discussion on some of the references and equations cited in Sections C-1.1 through C-1.7, the reader is recommended to review the Human Health Risk Assessment Protocol (HHRAP) (U.S. EPA 1998) (see Appendix A-3), and the source documents cited in the reference section of this appendix.

C-1.0 GENERAL GUIDANCE

This section summarizes the recommended general guidance for determining compound-specific *BCF* values (media-to-receptors) provided in Tables C-1 through C-7. As a preference, *BCF* values were selected from empirical field and/or laboratory data generated from reviewed studies that are published in the scientific literature. Information used from these studies included calculated *BCF* values, as well as, collocated media and organism concentration data from which *BCF* values could be calculated. If two or more *BCF* values, or two or more sets of collocated data, were available in the published scientific literature, the geometric mean of the values was used.

Field-derived *BCF* values were considered more indicative of the level of bioconcentration occurring in the natural environment than laboratory-derived values. Therefore, when available and appropriate, field-derived *BCF* values were given priority over laboratory-derived values. In some cases, confidence in the methods used to determine or report field-derived *BCF* values was less than for the laboratory-derived values. In those cases, the laboratory-derived values were used for the recommended *BCF* values.

When neither field or laboratory data were available for a specific compound, data from a potential surrogate compound were evaluated. The appropriateness of the surrogate was determined by comparing the structures of the two compounds. Where an appropriate surrogate was not identified, a regression equation based on the compound's log K_{ow} value was used to calculate the recommended *BCF* value.

With the exception of the air-to-plant biotransfer factors (*Bv*), recommended *BCF* values provided in the tables at the end of this appendix are based on wet tissue weight and dry media weight (except for water). As necessary, reported values were converted to these units using the referenced tissue or media wet weight percentages. The conversion factors, equations, and references for these conversions are discussed in Sections C-1.1 through C-1.7 where appropriate, and are presented at the end of each table (Tables C-1 through C-7).

C-1.1 SOIL-TO-SOIL INVERTEBRATE BIOCONCENTRATION FACTORS

Soil-to-soil invertebrate *BCF* values (see Table C-1) were developed mainly from data for earthworms. Measured experimental results were primarily in the form of ratios of compound concentrations in a earthworm and the compound concentrations in the soil in which the earthworm was exposed. As necessary, values were converted to wet tissue and dry media weight assuming a moisture content (by mass) of 83.3 percent for earthworms and 20 percent for soil (Pietz et al. 1984).

<u>Organics</u> For organic compounds with no field or laboratory data available, recommended *BCF* values were estimated using the following regression equation**:**

$$\log BCF = 0.819 \log K_{ow} - 1.146 \qquad \text{Equation C-1-1}$$

- Southworth, G.R., J.J. Beauchamp, and P.K. Schmieder. 1978. "Bioaccumulation Potential of Polycyclic Aromatic Hydrocarbons in *Daphnia Pulex.*" *Water Research.* Volume 12. Pages 973-977.

<u>Inorganics</u> For inorganic compounds with no field or laboratory data available, the recommended *BCF* value is equal to the arithmetic average of the available *BCF* values for other inorganics as specified in Table C-1.

C-1.2 SOIL-TO-PLANT AND SEDIMENT-TO-PLANT BIOCONCENTRATION FACTORS

Soil-to-plant *BCF* values (see Table C-2) account for plant uptake of compounds from soil. Data for a variety of plants and food crops were used to determine recommended *BCF* values.

<u>Organics</u> For all organics (including PCDDs and PCDFs) with no available field or laboratory data, the following regression equation was used to calculate recommended values:

$$\log BCF = 1.588 - 0.578 \log K_{ow} \qquad \text{Equation C-1-2}$$

- Travis, C.C. and A.D. Arms. 1988. "Bioconcentration of Organics in Beef, Milk, and Vegetation." *Environmental Science and Technology.* 22:271-274.

<u>Inorganics</u> For most metals, *BCF* values were based on empirical data reported in the following:

- Baes, C.F., R.D. Sharp, A.L. Sjoreen, and R.W. Shor. 1984. "Review and Analysis of Parameters and Assessing Transport of Environmentally Released Radionuclides Through Agriculture." Oak Ridge National Laboratory, Oak Ridge, Tennessee.

The scientific literature also was searched to identify studies. Although U.S. EPA (1995a) provides values for certain metals calculated on the basis of plant uptake response slope factors, it is unclear how the *BCF* values were calculated or which sources or references were used. Therefore, values reported in U.S. EPA (1995a) were not used.

C-1.3 WATER-TO-AQUATIC INVERTEBRATE BIOCONCENTRATION FACTORS

Experimental data for crustaceans, aquatic insects, bivalves, and other aquatic invertebrates were used to determine recommended *BCF* values for water-to-aquatic invertebrate (see Table C-3). Both marine and freshwater exposures were reviewed. As necessary, available results were converted to wet tissue weight assuming that invertebrate moisture content (by mass) is 83.3 percent (Pietz et al. 1984).

<u>Organics</u> Reported field values for organic compounds were assumed to be total compound concentrations in water and, therefore, were converted to dissolved compound concentrations in water using the following equation from U.S. EPA (1995b):

$$BCF\text{ (dissolved)} = (BCF\text{ (total)} / f_{fd}) - 1 \qquad \text{Equation C-1-3}$$

where

BCF (dissolved) = BCF based on dissolved concentration of compound in water
BCF (total) = BCF based on the field derived data for total concentration of compound in water
f_{fd} = Fraction of compound that is freely dissolved in the water

and,

f_{fd} = $1 / [1 + ((DOC \times K_{ow}) / 10) + (POC \times K_{ow})]$
DOC = Dissolved organic carbon, kilograms of organic carbon / liter of water (2.0×10^{-06} Kg/L)
K_{ow} = Octanol-water partition coefficient of the compound, as reported in U.S. EPA (1994a)
POC = Particulate organic carbon, kilograms of organic carbon / liter of water (7.5×10^{-09} Kg/L)

Laboratory data were assumed to be based on dissolved compound concentrations.

For organic compounds with no field or laboratory data available, *BCF* values were determined from surrogate compounds or calculated using the following regression equation:

$$\log BCF = 0.819 \times \log K_{ow} - 1.146 \qquad \text{Equation C-1-4}$$

- Southworth, G.R., J.J. Beauchamp, and P.K. Schmieder. 1978. "Bioaccumulation Potential of Polycyclic Aromatic Hydrocarbons in *Daphnia Pulex.*" *Water Research*. Volume 12. Pages 973-977.

<u>Inorganics</u> For inorganic compounds with no field or laboratory data available, the recommended *BCF* values were estimated as the arithmetic average of the available *BCF* values for other inorganics, as specified in Table C-3.

C-1.4 WATER-TO-ALGAE BIOCONCENTRATION FACTORS

Experimental data for both marine and freshwater algal species were reviewed. As necessary, available results were converted to wet tissue weight assuming that algae moisture content (by mass) is 65.7 percent (Isensee et al. 1973).

<u>*Organics*</u> For organic compounds with no field or laboratory data available, *BCF* values were calculated using the following regression equation:

$$\log BCF = 0.819 \times \log K_{ow} - 1.146 \qquad \text{Equation C-1-5}$$

- Southworth, G.R., J.J. Beauchamp, and P.K. Schmieder. 1978. "Bioaccumulation Potential of Polycyclic Aromatic Hydrocarbons in *Daphnia Pulex.*" *Water Research*. Volume 12. Pages 973-977.

<u>*Inorganics*</u> For inorganics, available field or laboratory data were evaluated for each compound.

C-1.5 WATER-TO-FISH BIOCONCENTRATION FACTORS

Experimental data for a variety of marine and freshwater fish were used to determine recommended *BCF* values (see Table C-5). As necessary, values were converted to wet tissue weight assuming that fish moisture content (by mass) is 80.0 percent (Holcomb et al. 1976).

For both organic and inorganic compounds, reported field values were considered bioaccumulation factors (*BAF*s) based on contributions of compounds from food sources as well as media. Therefore, field values were converted to *BCF*s based on the trophic level of the test organism using the following equation:

$$BCF = (BAF_{TLn} / FCM_{TLn}) - 1 \qquad \text{Equation C-1-6}$$

where

BAF_{TLn} = The reported field bioaccumulation factor for the trophic level "n" of the study species.
FCM_{TLn} = The food chain multiplier for the trophic level "n" of the study species.

<u>*Organics*</u> Reported field values for organic compounds were assumed to be total compound concentrations in water and, therefore, were converted to dissolved compound concentrations in water using the following equation from U.S. EPA (1995b):

$$BAF\ (\text{dissolved}) = (BAF\ (\text{total}) / f_{fd}) - 1 \qquad \text{Equation C-1-7}$$

where

BAF (dissolved) = *BAF* based on dissolved concentration of compound in water
BAF (total) = *BAF* based on the field derived data for total concentration of compound in water
f_{fd} = Fraction of compound that is freely dissolved in the water

and,

f_{fd} = $1 / [1 + ((DOC \times K_{ow}) / 10) + (POC \times K_{ow})]$
DOC = Dissolved organic carbon, Kg of organic carbon / L of water (2.0×10^{-06} Kg/L)
K_{ow} = Octanol-water partition coefficient of the compound, as reported in U.S. EPA (1994a)
POC = Particulate organic carbon, Kg of organic carbon / L of water (7.5×10^{-09} Kg/L)

Laboratory data were assumed to be based on dissolved compound concentrations.

For organics for which no field or laboratory data were available, the following regression equation was used to calculate the recommended *BCF* values:

$$\log BCF = 0.91 \times \log K_{ow} - 1.975 \times \log (6.8E\text{-}07 \times K_{ow} + 1.0) - 0.786 \qquad \text{Equation C-1-8}$$

- Bintein, S., J. Devillers, and W. Karcher. 1993. "Nonlinear Dependence of Fish Bioconcentrations on n-Octanol/Water Partition Coefficients." *SAR and QSAR in Environmental Research*. Vol. 1. Pages 29-39.

Inorganics For inorganic compounds with no available field or laboratory data, the recommended *BCF* values were estimated as the arithmetic average of the available *BCF* values reported for other inorganics.

C-1.6 SEDIMENT-TO-BENTHIC INVERTEBRATE BIOCONCENTRATION FACTORS

Experimental data for a variety of benthic infauna, worms, insects, and other invertebrates were used to determine the recommended *BCF* values for sediment-to-benthic invertebrate (see Table C-6). As necessary, values were converted to wet tissue weight assuming that benthic invertebrate moisture content (by mass) is 83.3 percent (Pietz et al. 1984).

Organics For organic compound (including PCDDs and PCDFs) with no available field or laboratory data, the recommended *BCF* values were determined using the following regression equation:

$$\log BCF = 0.819 \times \log K_{ow} - 1.146 \qquad \text{Equation C-1-9}$$

- Southworth, G.R., J.J. Beauchamp, and P.K. Schmieder. 1978. "Bioaccumulation Potential of Polycyclic Aromatic Hydrocarbons in *Daphnia Pulex.*" *Water Research*. Volume 12. Pages 973-977.

Inorganics For inorganic compound with no available field or laboratory data, the recommended *BCF* values were estimated as the arithmetic average of the available *BCF* values for other inorganics.

C-1.7 AIR-TO-PLANT BIOCONCENTRATION FACTORS

The air-to-plant bioconcentration (*Bv*) factor (see Table C-7) is defined as the ratio of compound concentrations in exposed aboveground plant parts to the compound concentration in air. Bv values in Table C-7 are reported on dry-weight basis since the plant concentration equations (see Chapter 3) already include a dry-weight to wet-weight conversion factor.

Organics For organics (excluding PCDDs and PCDFs), the air-to-plant bioconcentration factor was calculated using regression equations derived for azalea leaves in the following documents:

- Bacci E., D. Calamari, C. Gaggi, and M. Vighi. 1990. "Bioconcentration of Organic Chemical Vapors in Plant Leaves: Experimental Measurements and Correlation." *Environmental Science and Technology*. Volume 24. Number 6. Pages 885-889.
- Bacci E., M. Cerejeira, C. Gaggi, G. Chemello, D. Calamari, and M. Vighi. 1992. "Chlorinated Dioxins: Volatilization from Soils and Bioconcentration in Plant Leaves." *Bulletin of Environmental Contamination and Toxicology*. Volume 48. Pages 401-408.

Bacci et al. (1992) developed a regression equation using empirical data collected for the uptake of 1,2,3,4-TCDD in azalea leaves and data obtained from Bacci et al. (1990). The bioconcentration factor obtained was included in a series of 14 different organic compounds to develop a correlation equation with K_{ow} and H (defined below). Bacci et al. (1992) derived the following equations:

$$\log B_{vol} = 1.065 \log K_{ow} - \log \left(\frac{H}{RT}\right) - 1.654 \qquad (r = 0.957) \qquad \text{Equation C-1-10}$$

$$Bv = \frac{\rho_{air} \cdot B_{vol}}{(1 - f_{water}) \cdot \rho_{forage}} \qquad \text{Equation C-1-11}$$

where

B_{vol} = Volumetric air-to-plant biotransfer factor (fresh-weight basis)
Bv = Air-to-plant biotransfer factor (dry-weight basis)
ρ_{air} = 1.19 g/L (Weast 1986)
ρ_{forage} = 770 g/L (Macrady and Maggard 1993)
f_{water} = 0.85 (fraction of forage that is water—Macrady and Maggard [1993])
H = Henry's Law constant (atm-m^3/mole)
R = Universal gas constant (atm-m^3/mole °K)
T = Temperature (25°C, 298°K)

Equations C-1-10 and C-1-11 are used to calculate *Bv* values (see Table C-7) using the recommended values of H and K_{ow} provided in Appendix A at a temperature (T) of 25 °C or 298.1 K. The following uncertainty should be noted with use of *Bv* values calculated using these equations:

- For organics (except PCDDs and PCDFs), U.S. EPA (1993) recommended that *Bv* values be reduced by a factor of 10 before use. This was based on the work conducted by U.S. EPA (1993) for U.S. EPA (1994b) as an interim correction factor. Welsch-Pausch, McLachlan, and Umlauf (1995) conducted experiments to determine concentrations of PCDDs and PCDFs in air and resulting biotransfer to welsh ray grass. This was documented in the following:

  - Welsch-Pausch, K.M. McLachlan, and G. Umlauf. 1995. "Determination of the Principal Pathways of Polychlorinated Dibenzo-p-dioxins and Dibenzofurans to Lolium Multiflorum (Welsh Ray Grass)". *Environmental Science and Technology*. 29: 1090-1098.

  A follow-up study based on Welsch-Pausch, McLachlan, and Umlauf (1995) experiments was conducted by Lorber (1995) (see discussion below for PCDDs and PCDFs). In a following publication, Lorber (1997) concluded that the Bacci factor reduced by a factor of 100 was close in line with observations made by him through various studies, including the Welsch-Pausch, McLachlan, and Umlauf (1995) experiments. Therefore, this guidance recommends that *Bv* values be calculated using the Bacci, Cerejeira, Gaggi, Chemello, Calamari, and Vighi (1992) correlation equations and then reduced by a factor of 100 for all organics, excluding PCDDs and PCDFs.

<u>PCDDs and PCDFs</u> For PCDDs and PCDFs, *Bv* values, on a dry weight basis, were obtained from the following:

- Lorber, M., and P. Pinsky. 1999. "An Evaluation of Three Empirical Air-to-Leaf Models for Polychlorinated Dibenzo-p-Dioxins and Dibenzofurans." National Center for Environmental Assessment (NCEA). U. S. EPA, 401 M St. SW, Washington, DC. *Accepted for Publication in Chemosphere.*

U.S. EPA (1993) stated that, for dioxin-like compounds, the use of the Bacci, Cerejeira, Gaggi, Chemello, Calamari, and Vighi (1992) equations may overpredict *Bv* values by a factor of 40. This was because the Bacci, Calamari, Gaggi, and Vighi (1990) and Bacci, Cerejeira, Gaggi, Chemello, Calamari, and Vighi (1992) experiments did not take photodegradation effects into account. Therefore, *Bv* values calculated using Equations C-10 and C-11 were recommended to be reduced by a factor of 40 for dioxin-like compounds.

However, according to Lorber (1995), the Bacci algorithm divided by 40 may not be appropriate because (1) the physical and chemical properties of dioxin congeners are generally outside the range of the 14 organic compounds used by Bacci, Calamari, Gaggi, and Vighi (1990), and (2) the factor of 40 derived from one experiment on 2,3,7,8-TCDD may not apply to all dioxin congeners.

Welsch-Pausch, McLachlan, and Umlauf (1995) conducted experiments to obtain data on uptake of PCDDs and PCDFs from air to *Lolium Multiflorum* (Welsh Ray grass). The data includes grass concentrations and air concentrations for dioxin-congener groups, but not the invidual congeners. Lorber (1995) used data from Welsch-Pausch, McLachlan, and Umlauf (1995) to develop an air-to-leaf transfer factor for each dioxin-congener group. *Bv* values developed by Lorber (1995) were about an order of magnitude less than values that would have been calculated using the Bacci, Calamari, Gaggi, and Vighi (1990; 1992) correlation equations. Lorber (1995) speculated that this difference could be attributed to several factors including experimental design, climate, and lipid content of plant species used.

Lorber (1999) conducted an evaluation of three empirical air-to-leaf models for estimating grass concentraions of PCDDs and PCDFs from air concentrations of these compounds described and tested against field data. *Bv* values recommended for PCDDs and PCDFs in this guidance were obtained from the experimentally derived values of Lorber (1999).

Metals For metals, no literature sources were available for *Bv* values. U.S. EPA (1995a) quoted from the following document, that metals were assumed not to experience air to leaf transfer:

- Belcher, G.D., and C.C. Travis. 1989. "Modeling Support for the RURA and Municipal Waste Combustion Projects: Final Report on Sensitivity and Uncertainty Analysis for the Terrestrial Food Chain Model." Interagency Agreement No. 1824-A020-A1. Office of Risk Analysis, Health and Safety Research Division. Oak Ridge National Laboratory. Oak Ridge, Tennessee. October.

Consistent with the above references, *Bv* values for metals (excluding elemental mercury) were assumed to be zero (see Table C-7).

Mercuric Compounds Mercury emissions are assumed to consist of both the elemental and divalent forms. However, only small amounts of elemental mercury is assumed to be deposited (see Chapter 2). Elemental mercury either dissipates into the global cycle or is converted to the divalent form. Methyl mercury is assumed not to exist in the stack emissions or in the air phase. Consistent with various discussions in Chapter 2 concerning mercury, (1) elemental mercury reaching or depositing onto the plant surfaces is negligible, and (2) biotransfer of methyl mercury from air is zero. This is based on assumptions made regarding speciation and fate and transport of mercury from stack emissions. Therefore, the *Bv* value for (1) elemental mercury was assumed to be zero, and (2) methyl mercury was assumed not to be applicable. *Bv* values for mercuric chloride (dry weight basis) were obtained from U.S. EPA (1997).

It should be noted that uptake of mercury from air into the aboveground plant tissue is primarily in the divalent form. A part of the divalent form of mercury is assumed to be converted to the methyl mercury form once in the plant tissue.

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MEDIA-TO-RECEPTOR *BCF* VALUES

Screening Level Ecological Risk Assessment Protocol

August 1999

TABLE C-1

SOIL-TO-SOIL INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC/kg wet tissue) / (mg COPC/kg dry soil)

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15Reported Values[a]	References	Experimental Parameters	Species
Dioxins and Furans			
Compound: 2,3,7,8-tetrachlorodibenzo-p-dioxin			Recommended BCF Value: 1.59
The BCF was calculated using the geometric mean of 5 laboratory values for 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) as follows:			
14.5	Martinucci, Crespi, Omodeo, Osella, and Traldi (1983)	20-day exposure	Not specified
9.41 0.64 0.68 0.17	Reinecke and Nash (1984)	20-day exposure	*Allolobaphora caliginosa* *Lumbricus rubellus*
Compound: 1,2,3,7,8-pentachlorodibenzo-p-dioxin			Recommended Value: 1.46
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =1.59 x 0.92 =1.46			
Compound: 1,2,3,4,7,8-hexachlorodibenzo-p-dioxin			Recommended Value: 0.49
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =1.59 x 0.31 =0.49			
Compound: 1,2,3,6,7,8-hexachlorodibenzo-p-dioxin			Recommended Value: 0.19
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =1.59 x 0.12 = 0.19			
Compound: 1,2,3,7,8,9-hexachlorodibenzo-p-dioxin			Recommended Value: 0.22
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =1.59 x 0.14 = 0.22			
Compound: 1,2,3,4,6,7,8,-heptachlorodibenzo-p-dioxin			Recommended Value: 0.081
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =1.59 x 0.051 = 0.081			
Compound: Octachlorodibenzo-p-dioxin			Recommended Value: 0.019
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =1.59 x 0.012 = 0.019			
Compound: 2,3,7,8-tetrachlorodibenzofuran			Recommended BCF Value: 1.27
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =1.59 x 0.80 =1.27			
Compound: 1,2,3,7,8-pentachlorodibenzofuran			Recommended BCF Value: 0.32

TABLE C-1

SOIL-TO-SOIL INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC/kg wet tissue) / (mg COPC/kg dry soil)

(Page 2 of 14)

16Reported Values[a]	References	Experimental Parameters	Species
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =1.59 x 0.22 = 0.32			
Compound: 2,3,4,7,8-pentachlorodibenzofuran			Recommended BCF Value: 2.54
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =1.59 x 1.6 =2.54			
Compound: 1,2,3,4,7,8-hexachlorodibenzofuran			Recommended BCF Value: 0.121
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =1.59 x 0.076 = 0.121			
Compound: 1,2,3,6,7,8-hexachlorodibenzofuran			Recommended BCF Value: 0.30
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =1.59 x 0.19 = 0.30			
Compound: 2,3,4,6,7,8-hexachlorodibenzofuran			Recommended BCF Value: 1.07
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =1.59 x 0.67 =1.07			
Compound: 1,2,3,7,8,9-hexachlorodibenzofuran			Recommended BCF Value: 1.00
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =1.59 x 0.63 = 1.00			
Compound: 1,2,3,4,6,7,8-heptachlorodibenzofuran			Recommended BCF Value: 0.017
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =1.59 x 0.011 = 0.017			
Compound: 1,2,3,4,7,8,9-heptachlorodibenzofuran			Recommended BCF Value: 0.62
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =1.59 x 0.39 = 0.62			
Compound: Octochlorodibenzofuran			Recommended BCF Value: 0.025
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =1.59 x 0.016 = 0.025			
Polynuclear Aromatic Hydrocarbons (PAHs)			
Compound: Benzo(a)pyrene			Recommended BCF Value: 0.07
The BCF was calculated using the geometric mean of 6 laboratory values for benzo(a)pyrene. The values reported in Rhett, Simmers, and Lee (1988) were converted to earthworm wet weight over soil dry weight using a conversion factor of 5.99[a].			

TABLE C-1

SOIL-TO-SOIL INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC/kg wet tissue) / (mg COPC/kg dry soil)

(Page 3 of 14)

17Reported Values[a]	References	Experimental Parameters	Species
0.12 0.14 0.05 0.04 0.06 0.06	Rhett, Simmers, and Lee (1988)	28-day exposure	*Eisenia foetida*
Compoound: Benzo(a)anthracene			Recommended BCF Value: 0.03
The BCF was calculated using the geometric mean of 15 values for benzo(a)anthracene. The values reported in Marquenie, Simmers, and Kay (1987) were converted to wet weight over dry weight using a conversion factor of 5.99 [a].			
0.07 0.02 0.08 0.02 0.05 0.07 0.07 0.003 0.07 0.05 0.02 0.01 0.01 0.01 0.09	Marquenie, Simmers, and Kay (1987)	32-day exposure	*Eisenia foetida*
Compound: Benzo(b)fluoranthene			Recommended BCF Value: 0.07
The BCF was calculated using the geometric mean of 6 laboratory values for benzo(b)fluoranthene. The values reported in Rhett, Simmers, and Lee (1988) were converted to wet weight over dry weight using a conversion factor of 5.99 [a].			
0.11 0.16 0.06 0.04 0.06 0.05	Rhett, Simmers, and Lee (1988)	28-day exposure	*Eisenia foetida*
Compound: Benzo(k)fluoranthene			Recommended BCF Value: 0.08
The BCF was calculated using the geometric mean of 15 laboratory values for benzo(k)fluoranthene. The values reported in Marquenie, Simmers, and Kay (1987) were converted to wet weight over dry weight using a conversion factor of 5.99[a].			
0.13 0.15 0.12 0.11 0.07 0.24 0.12 0.02 0.10 0.03 0.07 0.03 0.06 0.04	Marquenie, Simmers, and Kay (1987)	32-day exposure	*Eisenia foetida*

TABLE C-1

SOIL-TO-SOIL INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC/kg wet tissue) / (mg COPC/kg dry soil)

18Reported Values[a]	References	Experimental Parameters	Species
Compound: Chrysene			Recommended BCF Value: 0.04
The BCF was calculated using the geometric mean of 15 laboratory values for chrysene. The values reported in Marquenie, Simmers, and Kay (1987) were converted to wet weight over dry weight using a conversion factor of 5.99 [a].			
0.06 0.03 0.09 0.04 0.09 0.07 0.14 0.007 0.14 0.02 0.04 0.02 0.03 0.01 0.10	Marquenie, Simmers, and Kay (1987)	32-day exposure	*Eisenia foetida*
Compound: Dibenzo(a,h)anthracene			Recommended BCF Value: 0.07
The BCF was calculated using the geometric mean of 15 laboratory values for Dibenz(a,h)anthrcene. The values reported in Marquenie, Simmers, and Kay (1987) were converted to wet weight over dry weight using a conversion factor of 5.99 [a].			
0.18 0.13 0.10 0.06 0.06 0.07 0.04 0.10 0.12 0.05 0.07 0.04 0.04 0.05 0.05	Marquenie, Simmers, and Kay (1987)	32-day exposure	*Eisenia foetida*
Compound: Indeno(1,2,3-cd)pyrene			Recommended BCF Value: 0.08
The BCF was calculated using the geometric mean of 6 laboratory values for indeno(1,2,3-cd)pyrene. The values reported in Rhett, Simmers, and Lee (1988) were converted to wet weight over dry weight using a conversion factor of 5.99[a].			
0.07 0.13 0.08 0.09 0.06 0.05	Rhett, Simmers, and Lee (1988)	28-day exposure	*Eisenia foetida*
Polychlorinated Biphenyls (PCBs)			
Compound: Aroclor 1016			Recommended BCF Value: 1.13

TABLE C-1

SOIL-TO-SOIL INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC/kg wet tissue) / (mg COPC/kg dry soil)

19Reported Values[a]	References	Experimental Parameters	Species
The BCF was calculated using the geometric mean of 7 laboratory values for a mixture of PCB congeners. The values reported in Rhett, Simmers, and Lee (1988) and Kreis, Edwards, Cuendet, and Tarradellas (1987) were converted to wet weight over dry weight using a conversion factor of 5.99 [a].			
1.43 0.81 0.75 1.07 1.17	Rhett, Simmers, and Lee (1988)	28-day exposure	*Eisenia foetida*
1.92 1.16	Kreis, Edwards, Cuendet, and Tarradellas (1987)	Chronic exposure	*Nicodrilus* sp.
Compound: Aroclor 1254			Recommended BCF Value: 1.13
The BCF was calculated using the geometric mean of 7 laboratory values for a mixture of PCB congeners. The values reported in Rhett, Simmers, and Lee (1988) and Kreis, Edwards, Cuendet, and Tarradellas (1987) were converted to wet weight over dry weight using a conversion factor of 5.99 [a].			
1.43 0.81 0.75 1.07 1.17	Rhett, Simmers, and Lee (1988)	28-day exposure	*Eisenia foetida*
1.92 1.16	Kreis, Edwards, Cuendet, and Tarradellas (1987)	Chronic exposure	*Nicodrilus* sp.

TABLE C-1

SOIL-TO-SOIL INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC/kg wet tissue) / (mg COPC/kg dry soil)

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20Reported Values[a]	References	Experimental Parameters	Species
Nitroaromatics			
Compound: 1,3-Dinitrobenzene			Recommended BCF Value: 1.19
No empirical data were available for 1,3-dinitrobenzene or for a structurally-similar surrogate compound. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 1.491 (U.S. EPA 1994b).			
Compound: 2,4-Dinitrotoluene			Recommended BCF Value: 3.08
No empirical data were available for 2,4-dinitrotoluene or for a structurally-similar surrogate compound. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 1.996 (U.S. EPA 1994b).			
Compound: 2,6-Dinitrotoluene			Recommended BCF Value: 2.50
No empirical data were available for 2,6-dinitrotoluene or for a structurally-similar surrogate compound. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 1.886 (U.S. EPA 1994b).			
Compound: Nitrobenzene			Recommended BCF Value: 2.26
No empirical data were available for nitrobenzene or for a structurally-similar surrogate compound. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 1.833 (U.S. EPA 1994b).			
Compound: Pentachloronitrobenzene			Recommended BCF Value: 451
No empirical data were available for pentachloronitrobenzene or for a structurally-similar surrogate compound. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 4.640 (U.S. EPA 1994b).			
Phthalate Esters			
Compound: Bis(2-ethylhexyl)phthalate			Recommended BCF Value: 1,309
No empirical data were available for bis(2-ethylhexyl)phthalate or for a structurally-similar surrogate compound. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 5.205 (U.S. EPA 1994b).			
Compound: Di(n)octyl phthalate			Recommended BCF Value: 3,128,023
No empirical data were available for di(n)octyl phthalate or for a structurally-similar surrogate compound. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 9.330 (U.S. EPA 1994b).			

TABLE C-1

SOIL-TO-SOIL INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC/kg wet tissue) / (mg COPC/kg dry soil)

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21Reported Values[a]	References	Experimental Parameters	Species
Volatile Organic Compounds			
Compound: Acetone			Recommended BCF Value: 0.05
No empirical data were available for acetone or for a structurally-similar surrogate compound.The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder (1978), where log K_{ow} = -0.222 (Karickoff and Long 1995).			
Compound: Acrylonitrile			Recommended BCF Value: 0.11
No empirical data were available for acrylonitrile or for a structurally-similar surrogate compound. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 0.250 (Karickoff and Long 1995).			
Compound: Chloroform			Recommended BCF Value: 2.82
No empirical data were available for chloroform or for a structurally-similar surrogate compound. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 1.949 (U.S. EPA 1994b).			
Compound: Crotonaldehyde			Recommended BCF Value: 0.20
No empirical data were available for crotonaldehyde or for a structurally-similar surrogate compound. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 0.55 (Based on equations developed by Hansch and Leo 1979, calculated in NRC (1981)).			
Compound: 1,4-Dioxane			Recommended BCF Value: 0.04
No empirical data were available for 1,4-dioxane or for a structurally-similar surrogate compound. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = -0.268 (U.S. EPA 1995a).			
Compound: Formaldehyde			Recommended BCF Value: 0.14
No empirical data were available for formaldehyde or for a structurally-similar surrogate compound. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 0.342 (U.S. EPA 1995a).			
Compound: Vinyl chloride			Recommended BCF Value: 0.62
No empirical data were available for vinyl chloride or for a structurally-similar surrogate compound. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 1.146 (U.S. EPA 1994b).			

TABLE C-1

SOIL-TO-SOIL INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC/kg wet tissue) / (mg COPC/kg dry soil)

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22Reported Values[a]	References	Experimental Parameters	Species
Other Chlorinated Organics			
Compound: Carbon Tetrachloride			Recommended BCF Value: 12.0
No empirical data were available for carbon tetrachloride or for a structurally-similar surrogate compound. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 2.717 (U.S. EPA 1994b).			
Compound: Hexachlorobenzene			Recommended BCF Value: 2,296
No empirical data were available for hexachlorobenzene or for a structurally-similar surrogate compound. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 5.503 (U.S. EPA 1994b).			
Compound: Hexachlorobutadiene			Recommended BCF Value: 535
No empirical data were available for hexachlorobutadiene or for a structurally-similar surrogate compound. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978) where log K_{ow} = 4.731 (U.S. EPA 1994b).			
Compound: Hexachlorocyclopentadiene			Recommended BCF Value: 745
No empirical data were available for hexachlorocyclopentadiene or for a structurally-similar surrogate compound. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder (1978), where log K_{ow} = 4.907 (U.S. EPA 1994b).			
Compound: Pentachlorobenzene			Recommended BCF Value: 1,050
No empirical data were available for pentachlorobenzene or for a structurally-similar surrogate compound. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder (1978), where log K_{ow} = 5.088 (U.S. EPA 1994b).			
Compound: Pentachlorophenol			Recommended BCF Value: 1,034
No empirical data were available for pentachlorophenol or for a structurally-similar surrogate compound. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder (1978), where log K_{ow} = 5.080 (U.S. EPA 1994b).			
Pesticides			
Compound: 4,4'-DDE			Recommended BCF Value: 1.26
Empirical data for 4,4'-DDE were not available. The BCF was calculated using the geometric mean of 13 laboratory values for 4,4'-DDT. The first six values reported in Gish (1970), Davis (1971), and Beyer and Gish (1980) were converted to wet weight over dry weight using a conversion factor of 5.99[a].			
0.08 0.39 0.29 0.41	Davis (1971)	Chronic exposure	*Lumbricus terrestris*

TABLE C-1

SOIL-TO-SOIL INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC/kg wet tissue) / (mg COPC/kg dry soil)

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23Reported Values[a]	References	Experimental Parameters	Species
0.83	Beyer and Gish (1980)	Chronic exposure	*Aporrectodea trapezoides* *Aparrectodea turgida* *Allolobophora chlorotica* *Lumbricus terrestris*
0.85 1.20 2.40 4.60 2.50 1.60	Wheatley and Hardman (1968)	Chronic exposure	Not specified
10.00 14.46	Yadav, Mittad, Agarwal, and Pillai (1981)	Chronic exposure	*Pheretima posthuma*
Compound: Heptachlor			Recommended BCF Value: 1.40
Empirical data for heptachlor were not available. The BCF was calculated using 1 laboratory value for heptachlor epoxide. The value reported in Beyer and Gish (1980) was converted to wet weight over dry weight using a conversion factor of 5.99[a].			
1.40	Beyer and Gish (1980)	Chronic exposure	*Aporrectodea trapezoides* *Aparrectodea turgida* *Allolobophora chlorotica* *Lumbricus terrestris*
Compound: Hexachlorophene			Recommended BCF Value: 106,970
No empirical data were available for hexachlorophene or for a structurally-similar surrogate compound. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder (1978), where log K_{ow} = 7.540 (Karickoff and Long 1995).			
Inorganics			
Compound: Aluminum			Recommended BCF Value: 0.22
Empirical data for aluminum were not available. The recommended BCF is the arithmetic mean of the recommended values for those inorganics with empirical data available (arsenic, cadmium, chromium, copper, lead, inorganic mercury, nickel, and zinc).			
Compound: Antimony			Recommended BCF Value: 0.22
Empirical data for antimony were not available. The recommended BCF is the arithmetic mean of the recommended values for those inorganics with empirical data available (arsenic, cadmium, chromium, copper, lead, inorganic mercury, nickel, and zinc).			
Compound: Arsenic			Recommended BCF Value: 0.11

TABLE C-1

SOIL-TO-SOIL INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC/kg wet tissue) / (mg COPC/kg dry soil)

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24Reported Values[a]	References	Experimental Parameters	Species
The BCF was calculated using the geometric mean of 5 laboratory values for arsenic as listed below. The values reported in Rhett, Simmers, and Lee (1988) were converted to wet weight over dry weight using a conversion factor of 5.99 [a].			
0.14 0.10 0.10 0.17 0.06	Rhett, Simmers, and Lee (1988)	28-day exposure	*Eisenia foetida*
Compound: Barium			Recommended BCF Value: 0.22
Empirical data for barium were not available. The recommended BCF is the arithmetic mean of the recommended values for those inorganics with empirical data available (arsenic, cadmium, chromium, copper, lead, inorganic mercury, nickel, and zinc).			
Compound: Beryllium			Recommended BCF Value: 0.22
Empirical data for beryllium were not available. The recommended BCF is the arithmetic mean of the recommended values for those inorganics with empirical data available (arsenic, cadmium, chromium, copper, lead, inorganic mercury, nickel, and zinc).			
Compound: Cadmium			Recommended BCF Value: 0.96
The BCF was calculated using the geometric mean of 22 laboratory values for cadmium. The values reported in Rhett, Simmers, and Lee (1988) and Simmers, Rhett, and Lee (1983) were converted to wet weight over dry weight using a conversion factor of 5.99[a].			
0.33 0.72 0.25 0.19 3.17 0.55 0.70 0.35	Rhett, Simmers, and Lee (1988)	28-day exposure	*Eisenia foetida*
0.13 0.50 0.29 8.77 1.25 7.86 0.17 6.67 0.11 3.95 8.01 1.50 4.39 2.10	Simmers, Rhett, and Lee (1983)	Chronic exposure	*Allolobophora longa* *A. caliginosa* *A. rosea* *A. chlorotica* *Lumbricus terrestris* *A. lumbricus* *Octolasium* sp.
Compound: Chromium (total)			Recommended BCF Value: 0.01
The BCF was calculated using the geometric mean of 3 laboratory values for chromium. The values reported in Rhett, Simmers, and Lee (1988) were converted to wet weight over dry weight using a conversion factor of 5.99[a].			

TABLE C-1

SOIL-TO-SOIL INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC/kg wet tissue) / (mg COPC/kg dry soil)

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25Reported Values[a]	References	Experimental Parameters	Species
0.004 0.004 0.05	Rhett, Simmers, and Lee (1988)	28-day exposure	*Eisenia foetida*
Compound: Copper			Recommended BCF Value: 0.04
The BCF was calculated using the geometric mean of 9 laboratory values for copper. The values reported in Rhett, Simmers, and Lee (1988) were converted to wet weight over dry weight using a conversion factor of 5.99[a].			
0.02 0.03 0.01 0.03 0.20 0.03 0.04 0.04	Rhett, Simmers, and Lee (1988)	28-day exposure	*Eisenia foetida*
0.24	Ma (1987)	Chronic exposure	*Lumbricus rubellus*

TABLE C-1

SOIL-TO-SOIL INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC/kg wet tissue) / (mg COPC/kg dry soil)

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26Reported Values[a]	References	Experimental Parameters	Species
Compound: Cyanide (total)			Recommended BCF Value: 1.12
Empirical data for cyanide were not available. The recommended BCF is the arithmetic mean of the recommended values for those inorganics with empirical data available (arsenic, cadmium, chromium, copper, lead, inorganic mercury, methyl mercury, nickel, and zinc).			
Compound: Lead			Recommended BCF Value: 0.03
The BCF was calculated using the geometric mean of 6 laboratory values for lead. The values reported in Rhett, Simmers, and Lee (1988), Ma (1987), and Van Hook (1974) were converted to wet weight over dry weight using a conversion factor of 5.99[a].			
0.02 0.006 0.07	Rhett, Simmers, and Lee (1988)	28-day exposure	*Eisenia foetida*
0.19	Ma (1987)	Chronic exposure	Not specified
0.12	Ma (1982)		Not specified
0.03	Van Hook (1974)	Chronic exposure	*Alabophera* sp. *Lumbricus* sp. *Octolasium* sp.
Compound: Mercuric chloride			Recommended BCF Value: 0.04
The BCF was calculated using the geometric mean of 5 laboratory values for mercuric chloride. The values reported in Rhett, Simmers, and Lee (1988) were converted to wet weight over dry weight using a conversion factor of 5.99[a].			
0.04 0.04 0.06 0.04 0.02	Rhett, Simmers, and Lee (1988)	28-day exposure; tissue concentrations of <0.05 were reported for the first three ratios, however, a concentration of 0.05 was used in order to calculate a conservative BCF value.	*Eisenia foetida*
Compound: Methyl mercury			Recommended BCF Value: 8.50
The BCF was calculated using the geometric mean of 3 laboratory values as presented below. The values reported in Beyer, Cromartie, and Moment (1985) were earthworm wet weight over soil wet weight with 60 percent soil moisture. The soil weight was converted to dry weight to result in the values presented below:			
8.25 8.31 8.95	Beyer, Cromartie, and Moment (1985)	6 to 12-week exposure	*Eisenia foetida*

TABLE C-1

SOIL-TO-SOIL INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC/kg wet tissue) / (mg COPC/kg dry soil)

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27Reported Values[a]	References	Experimental Parameters	Species
Compound: Nickel			Recommended BCF Value: 0.02
The BCF was calculated using the geometric mean of 3 laboratory values for nickel. The values reported in Rhett, Simmers, and Lee (1988) were converted to wet weight over dry weight using a conversion factor of 5.99[a].			
0.03 0.01 0.04	Rhett, Simmers, and Lee 1988	28-day exposure	*Eisenia foetida*
Compound: Selenium			Recommended BCF Value: 0.22
Empirical data for selenium were not available. The recommended BCF is the arithmetic mean of the recommended values for those inorganics with empirical data available (arsenic, cadmium, chromium, copper, lead, inorganic mercury, nickel, and zinc).			
Compound: Silver			Recommended BCF Value: 0.22
Empirical data for silver were not available. The recommended BCF is the arithmetic mean of the recommended values for those inorganics with empirical data available (arsenic, cadmium, chromium, copper, lead, inorganic mercury, nickel, and zinc).			
Compound: Thallium			Recommended BCF Value: 0.22
Empirical data for thallium were not available. The recommended BCF is the arithmetic mean of the recommended values for those inorganics with empirical data available (arsenic, cadmium, chromium, copper, lead, inorganic mercury, nickel, and zinc).			

TABLE C-1

SOIL-TO-SOIL INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC/kg wet tissue) / (mg COPC/kg dry soil)

28Reported Values[a]	References	Experimental Parameters	Species
Compound: Zinc			Recommended BCF Value: 0.56
The BCF was calculated using the geometric mean of 5 laboratory values for zinc. The values reported in Rhett, Simmers, and Lee (1988), Ma (1987), and Van Hook (1974) were converted to wet weight over dry weight using a conversion factor of 5.99 [a].			
0.11 0.06 0.58	Rhett, Simmers, and Lee (1988)	28-day exposure	*Eisenia foetida*
10.79	Ma (1987)	Chronic exposure	Not specified
1.28	Van Hook (1974)	Chronic exposure	*Alabophera* sp. *Lumbricus* sp. *Octolasium* sp.

Notes:

(a) The reported values are presented as the amount of COPC in invertebrate tissue divided by the amount of COPC in the soil. If the values reported in the studies were presented as dry tissue weight over dry soil weight, they were converted to wet weight over dry weight by dividing the concentration in dry earthworm tissue weight by 5.99. This conversion factor assumes an earthworm's total weight is 83.3 percent moisture (Pietz et al. 1984).

The conversion factor was calculated as follows:

$$Conversion\ factor = \frac{1.0\ gram\ (g)\ earthworm\ total\ weight}{1.0\ g\ earthworm\ total\ weight\ -\ 0.833\ g\ earthworm\ wet\ weight}$$

TABLE C-2

SOIL-TO-PLANT AND SEDIMENT-TO- PLANT BIOCONCENTRATION FACTORS
(mg COPC/kg dry tissue) / (mg COPC/kg dry soil or sediment)

(Page 1 of 7)

<table>
<tr><th>Reported Values</th><th>References</th><th>Experimental Parameters</th><th>Species</th></tr>
<tr><td colspan="4">Dioxins and Furans</td></tr>
<tr><td colspan="3">Compound: 2,3,7,8-Tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD)</td><td>Recommended BCF Value: 0.0056</td></tr>
<tr><td colspan="4">The BCF for these constituents were calculated using the following regression equation: log BCF = 1.588 - 0.578 x log K_{ow} (Travis and Arms 1988), where log K_{ow} = 6.64 (U.S. EPA 1994a).</td></tr>
<tr><td colspan="3">Compound: 1,2,3,7,8-Tetrachlorodibenzo-p-dioxin (1,2,3,7,8-PeCDD)</td><td>Recommended BCF Value: 0.0052</td></tr>
<tr><td colspan="4">The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF = 0.0056 x 0.92 =0.0052</td></tr>
<tr><td colspan="3">Compound: 1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (1,2,3,4,7,8-HxCDD)</td><td>Recommended BCF Value: 0.0017</td></tr>
<tr><td colspan="4">The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF = 0.0056 x0.31 = 0.0017</td></tr>
<tr><td colspan="3">Compound: 1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (1,2,3,6,7,8-HxCDD)</td><td>Recommended BCF Value: 0.00067</td></tr>
<tr><td colspan="4">The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF = 0.0056 x0.12 = 0.00067</td></tr>
<tr><td colspan="3">Compound: 1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (1,2,3,7,8,9-HxCDD)</td><td>Recommended BCF Value: 0.00078</td></tr>
<tr><td colspan="4">The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF = 0.0056 x 0.14 = 0.00078</td></tr>
<tr><td colspan="3">Compound: 1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (1,2,3,4,6,7,8-HpCDD)</td><td>Recommended BCF Value: 0.00029</td></tr>
<tr><td colspan="4">The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF = 0.0056 x0.051 = 0.00029</td></tr>
<tr><td colspan="3">Compound: Octachlorodibenzo-p-dioxin (OCDD)</td><td>Recommended BCF Value: 0.000067</td></tr>
<tr><td colspan="4">The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF = 0.0056 x 0.012 = 0.000067</td></tr>
<tr><td colspan="3">Compound: 2,3,7,8-Tetrachlorodibenzo-p-furan (2,3,7,8-TCDF)</td><td>Recommended BCF Value: 0.0045</td></tr>
<tr><td colspan="4">The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF = 0.0056 x0.80 = 0.0045</td></tr>
<tr><td colspan="3">Compound: 1,2,3,7,8-Pentachlorodibenzo-p-furan (1,2,3,7,8-PeCDF)</td><td>Recommended BCF Value: 0.0011</td></tr>
<tr><td colspan="4">The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF = 0.0056 x0.22 = 0.0011</td></tr>
<tr><td colspan="3">Compound: 2,3,4,7,8-Pentachlorodibenzo-p-furan (2,3,4,7,8-PeCDF)</td><td>Recommended BCF Value: 0.0090</td></tr>
<tr><td colspan="4">The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF = 0.0056 x1.6 = 0.0090</td></tr>
</table>

TABLE C-2

SOIL-TO-PLANT AND SEDIMENT-TO- PLANT BIOCONCENTRATION FACTORS
(mg COPC/kg dry tissue) / (mg COPC/kg dry soil or sediment)

(Page 2 of 7)

Reported Values	References	Experimental Parameters	Species
Compound: 1,2,3,4,7,8-Hexachlorodibenzo-p-furan (1,2,3,4,7,8-HxCDF)			Recommended BCF Value: 0.00043
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF = 0.0056 x 0.076 = 0.00043			
Compound: 1,2,3,6,7,8-Hexachlorodibenzo-p-furan (1,2,3,6,7,8-HxCDF)			Recommended BCF Value: 0.0011
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF = 0.0056 x0.19 = 0.0011			
Compound: 2,3,4,6,7,8-Hexachlorodibenzo-p-furan (2,3,4,6,7,8-HxCDF)			Recommended BCF Value: 0.0038
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF = 0.0056 x0.67 = 0.0038			
Compound: 1,2,3,7,8,9-Hexachlorodibenzo-p-furan (1,2,3,7,8,9-HxCDF)			Recommended BCF Value: 0.0035
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF = 0.0056 x0.63 = 0.0035			
Compound: 1,2,3,4,6,7,8-Heptachlorodibenzo-p-furan (1,2,3,4,6,7,8-HpCDF)			Recommended BCF Value: 0.000062
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =0.0056 x0.011 = 0.00062			
Compound: 1,2,3,4,7,8,9-Heptachlorodibenzo-p-furan (1,2,3,4,7,8,9-HpCDF)			Recommended BCF Value: 0.0022
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF = 0.0056 x0.39 = 0.0022			
Compound: Octachlorodibenzo-p-furan (OCDF)			Recommended BCF Value: 0.000090
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF = 0.0056 x0.016 = 0.000090			
Polynuclear Aromatic Hydrocarbons (PAH)			
Compound: Benzo(a)pyrene			Recommended BCF Value: 0.0
The BCF was calculated using the following regression equation: log BCF = 1.588 - 0.578 x log K_{ow} (Travis and Arms 1988), where log K_{ow} = 6.129 (U.S. EPA 1994b).			
Compound: Benzo(a)anthracene			Recommended BCF Value: 0.0202
The BCF was calculated using the following regression equation: log BCF = 1.588 - 0.578 x log K_{ow} (Travis and Arms 1988), where log K_{ow} = 5.679 (U.S. EPA 1994b).			
Compound Benzo(b)fluoranthene			Recommended BCF Value: 0.0101
The BCF was calculated using the following regression equation: log BCF = 1.588 - 0.578 x log K_{ow} (Travis and Arms 1988), where log K_{ow} = 6.202 (U.S. EPA 1994b).			
Compound: Benzo(k)fluoranthene			Recommended BCF Value: 0.0101

TABLE C-2

SOIL-TO-PLANT AND SEDIMENT-TO- PLANT BIOCONCENTRATION FACTORS (mg COPC/kg dry tissue) / (mg COPC/kg dry soil or sediment)

(Page 3 of 7)

Reported Values	References	Experimental Parameters	Species
The BCF was calculated using the following regression equation: log BCF = 1.588 - 0.578 x log K_{ow} (Travis and Arms 1988), where log K_{ow} = 6.2 (Karickhoff and Long 1995).			
Compound: Chrysene			Recommended BCF Value: 0.0187
The BCF was calculated using the following regression equation: log BCF = 1.588 - 0.578 x log K_{ow} (Travis and Arms 1988), where log K_{ow} = 5.739 (U.S. EPA 1994b).			
Compound: Dibenzo(a,h)anthracene			Recommended BCF Value: 0.0064
The BCF was calculated using the following regression equation: log BCF = 1.588 - 0.578 x log K_{ow} (Travis and Arms 1988), where log K_{ow} = 6.547 (U.S. EPA 1994b).			
Compound: Indeno(1,2,3-cd)pyrene			Recommended BCF Value: 0.0039
The BCF was calculated using the following regression equation: log BCF = 1.588 - 0.578 x log K_{ow} (Travis and Arms 1988), where log K_{ow} = 6.915 (U.S. EPA 1994b).			
Polychlorinated Biphenyls (PCBs)			
Compound: Aroclor 1016			Recommended BCF Value: 0.01
The BCF was calculated using the following regression equation: log BCF = 1.588 - 0.578 x log K_{ow} (Travis and Arms 1988); using the log K_{ow} for Aroclor 1254, where log K_{ow}= 6.207 (U.S. EPA 1994b).			
Compound: Aroclor 1254			Recommended BCF Value: 0.01
The BCF was calculated using the following regression equation: log BCF = 1.588 - 0.578 x log K_{ow} (Travis and Arms 1988); using the log K_{ow} for Aroclor 1254, where log K_{ow}= 6.207 (U.S. EPA 1994b).			
Nitroaromatics			
Compound: 1,3-Dinitrobenzene			Recommended BCF Value: 5.32
The BCF was calculated using the following regression equation: log BCF = 1.588 - 0.578 x log K_{ow} (Travis and Arms 1988), where log K_{ow} = 1.491 (U.S. EPA 1994b).			
Compound: 2,4-Dinitrotoluene			Recommended BCF Value: 2.72
The BCF was calculated using the following regression equation: log BCF = 1.588 - 0.578 x log K_{ow} (Travis and Arms 1988), where log K_{ow} =1.996 (U.S. EPA 1994b).			
Compound 2,6-Dinitrotoluene			Recommended BCF Value: 3.15
The BCF was calculated using the following regression equation: log BCF = 1.588 - 0.578 x log K_{ow} (Travis and Arms 1988), where log K_{ow} = 1.886 (U.S. EPA 1994b).			
Compound: Nitrobenzene			Recommended BCF Value: 3.38

TABLE C-2

SOIL-TO-PLANT AND SEDIMENT-TO- PLANT BIOCONCENTRATION FACTORS
(mg COPC/kg dry tissue) / (mg COPC/kg dry soil or sediment)

(Page 4 of 7)

Reported Values	References	Experimental Parameters	Species
The BCF was calculated using the following regression equation: log BCF = 1.588 - 0.578 x log K_{ow} (Travis and Arms 1988), where log K_{ow} = 1.833 (U.S. EPA 1994b).			
Compound: Pentachloronitrobenzene			Recommended BCF Value: 0.08
The BCF was calculated using the following regression equation: log BCF = 1.588 - 0.578 x log K_{ow} (Travis and Arms 1988), where log K_{ow} = 4.640 (U.S. EPA 1994b).			
Phthalate Esters			
Compound: Bis(2-ethylhexyl)phthalate			Recommended BCF Value: 0.038
The BCF was calculated using the following regression equation: log BCF = 1.588 - 0.578 x log K_{ow} (Travis and Arms 1988), where log K_{ow} = 5.205 (U.S. EPA 1994b).			
Compound: Di(n)octyl phthalate			Recommended BCF Value: 0.000157
The BCF was calculated using the following regression equation: log BCF = 1.588 - 0.578 x log K_{ow} (Travis and Arms 1988), where log K_{ow} = 9.33 (U.S. EPA 1994b).			
Volatile organic compounds			
Compound: Acetone			Recommended BCF Value: 52
The BCF was calculated using the following regression equation: log BCF = 1.588 - 0.578 x log K_{ow} (Travis and Arms 1988), where log K_{ow} = -0.222 (U.S. EPA 1994c).			
Compound: Acrylonitrile			Recommended BCF Value: 27.77
The BCF was calculated using the following regression equation: log BCF = 1.588 - 0.578 x log K_{ow} (Travis and Arms 1988), where log K_{ow} = 0.250 (Karickhoff and Long 1995).			
Compound: Chloroform			Recommended BCF Value: 2.9
The BCF was calculated using the following regression equation: log BCF = 1.588 - 0.578 x log K_{ow} (Travis and Arms 1988), where log K_{ow} = 1.949 (U.S. EPA 1994b).			
Compound: Crotonaldehyde			Recommended BCF Value: 18.63
The BCF was calculated using the following regression equation: log BCF = 1.588 - 0.578 x log K_{ow} (Travis and Arms 1988), where log K_{ow} = 0.55 (Hansch and Leo 1979).			
Compound: 1,4-Dioxane			Recommended BCF Value: 55.32
The BCF was calculated using the following regression equation: log BCF = 1.588 - 0.578 x log K_{ow} (Travis and Arms 1988), where log K_{ow} = -0.268 (U.S. EPA 1995c).			
Compound: Formaldehyde			Recommended BCF Value: 24.57
The BCF was calculated using the following regression equation: log BCF = 1.588 - 0.578 x log K_{ow} (Travis and Arms 1988), where log K_{ow} = 0.342 (U.S. EPA (1995c).			
Compound: Vinyl chloride			Recommended BCF Value: 8.43

TABLE C-2

SOIL-TO-PLANT AND SEDIMENT-TO- PLANT BIOCONCENTRATION FACTORS
(mg COPC/kg dry tissue) / (mg COPC/kg dry soil or sediment)

(Page 5 of 7)

Reported Values	References	Experimental Parameters	Species
The BCF was calculated using the following regression equation: log BCF = 1.588 - 0.578 x log K_{ow} (Travis and Arms 1988). where log K_{ow} = 1.146 (U.S. EPA 1994b).			
Other Chlorinated Organics			
Compound: Carbon tetrachloride			Recommended BCF Value: 1.04
The BCF was calculated using the following regression equation: log BCF = 1.588 - 0.578 x log K_{ow} (Travis and Arms 1988), where log K_{ow} = 2.717 (U.S. EPA 1994b).			
Compound: Hexachlorobenzene			Recommended BCF Value: 0.0255
The BCF was calculated using the following regression equation: log BCF = 1.588 - 0.578 x log K_{ow} (Travis and Arms 1988), where log K_{ow} = 5.503 (U.S. EPA 1994b).			
Compound: Hexachlorobutadiene			Recommended BCF Value: 0.0714
The BCF was calculated using the following regression equation: log BCF = 1.588 - 0.578 x log K_{ow} (Travis and Arms 1988), where log K_{ow} = 4.731 (U.S. EPA 1994b).			
Compound: Hexachlorocyclopentadiene			Recommended BCF Value: 0.0565
The BCF was calculated using the following regression equation: log BCF = 1.588 - 0.578 x log K_{ow} (Travis and Arms 1988), where log K_{ow} = 4.907 (U.S. EPA 1994b).			
Compound: Pentachlorobenzene			Recommended BCF Value: 0.044
The BCF was calculated using the following regression equation: log BCF = 1.588 - 0.578 x log K_{ow} (Travis and Arms 1988), where log K_{ow} = 5.088 (U.S. EPA 1994b).			
Compound: Pentachlorophenol			Recommended BCF Value: 0.0449
The BCF was calculated using the following regression equation: log BCF = 1.588 - 0.578 x log K_{ow} (Travis and Arms 1988), where log K_{ow} = 5.08 (U.S. EPA 1994b).			
Pesticides			
Compound: 4,4-DDE			Recommended BCF Value: 0.00937
The BCF for these constituents were calculated using the following regression equation: log BCF = 1.588 - 0.578 x log K_{ow} (Travis and Arms 1988)., where log K_{ow} = 6.256 (U.S. EPA 1994b).			
Compound: Heptachlor			Recommended BCF Value: 0.0489
The BCF for these constituents were calculated using the following regression equation: log BCF = 1.588 - 0.578 x log K_{ow} (Travis and Arms 1988)., where log K_{ow} = 5.015 (U.S. EPA 1994b).			
Compound: Hexachlorophene			Recommended BCF Value: 0.0017

TABLE C-2

SOIL-TO-PLANT AND SEDIMENT-TO- PLANT BIOCONCENTRATION FACTORS
(mg COPC/kg dry tissue) / (mg COPC/kg dry soil or sediment)

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<table>
<tr><th>Reported Values</th><th>References</th><th>Experimental Parameters</th><th>Species</th></tr>
<tr><td colspan="4">The BCF for these constituents were calculated using the following regression equation: log BCF = 1.588 - 0.578 x log K_{ow} (Travis and Arms 1988)., where log K_{ow} = 7.54 (Karickhoff and Long 1995).</td></tr>
<tr><td colspan="4">Inorganics</td></tr>
<tr><td colspan="3">Compound: Aluminum</td><td>Recommended BCF Value: 0.004</td></tr>
<tr><td colspan="4">The BCF for this constituent was based on empirical data reported in Baes, Sharp, Sjoreen and Shor (1984). Experimental parameters were not reported.</td></tr>
<tr><td colspan="3">Compound: Antimony</td><td>Recommended BCF Value: 0.2</td></tr>
<tr><td colspan="4">The BCF for this constituent was based on empirical data reported in Baes, Sharp, Sjoreen and Shor (1984). Experimental parameters were not reported.</td></tr>
<tr><td colspan="3">Compound: Arsenic</td><td>Recommended BCF Value: 0.036</td></tr>
<tr><td colspan="4">The BCF for this constituent was based on empirical data reported in U.S. EPA (1992c). Experimental parameters were not reported.</td></tr>
<tr><td colspan="3">Compound Barium</td><td>Recommended BCF Value: 0.15</td></tr>
<tr><td colspan="4">The BCF for this constituent was based on empirical data reported in Baes, Sharp, Sjoreen and Shor (1984). Experimental parameters were not reported.</td></tr>
<tr><td colspan="3">Compound: Beryllium</td><td>Recommended BCF Value: 0.01</td></tr>
<tr><td colspan="4">The BCF for this constituent was based on empirical data reported in Baes, Sharp, Sjoreen and Shor (1984). Experimental parameters were not reported.</td></tr>
<tr><td colspan="3">Compound: Cadmium</td><td>Recommended BCF Value: 0.364</td></tr>
<tr><td colspan="4">The BCF for this constituent was based on empirical data reported in U.S. EPA (1992c). Experimental parameters were not reported.</td></tr>
<tr><td colspan="3">Compound: Chromium (total)</td><td>Recommended BCF Value: 0.0075</td></tr>
<tr><td colspan="4">The BCF for this constituent was based on empirical data reported in Baes, Sharp, Sjoreen and Shor (1984). Experimental parameters were not reported.</td></tr>
<tr><td colspan="3">Compound: Copper</td><td>Recommended BCF Value: 0.4</td></tr>
<tr><td colspan="4">The BCF for this constituent was based on empirical data reported in Baes, Sharp, Sjoreen and Shor (1984). Experimental parameters were not reported.</td></tr>
<tr><td colspan="3">Compound: Cyanide (total)</td><td>Recommended BCF Value: No data</td></tr>
<tr><td colspan="4">No empirical or K_{ow} data were available for this constituent.</td></tr>
<tr><td colspan="3">Compound: Lead</td><td>Recommended BCF Value: 0.045</td></tr>
</table>

TABLE C-2

SOIL-TO-PLANT AND SEDIMENT-TO- PLANT BIOCONCENTRATION FACTORS
(mg COPC/kg dry tissue) / (mg COPC/kg dry soil or sediment)

(Page 7 of 7)

Reported Values	References	Experimental Parameters	Species
The BCF for this constituent was based on empirical data reported in Baes, Sharp, Sjoreen and Shor (1984). Experimental parameters were not reported.			
Compound: Mercuric chloride			Recommended BCF Value: 0.0375
The BCF was calculated using the geometric mean of 3 values for mercuric chloride ($HgCl_2$).			
0.022 0.032 0.075	Cappon (1981)	The values were derived from studies during one growing season using 20 food crop vegetables.	Not specified.
Compound: Methyl mercury			Recommended BCF Value: 0.137
The BCF was calculated using the geometric mean of 3 values for methyl mercury.			
0.062 0.149 0.277	Cappon (1981)	The values were derived from studies during one growing season using 20 food crop vegetables.	Not specified.
Compound: Nickel			Recommended BCF Value: 0.032
The BCF for this constituent was based on empirical data reported in U.S. EPA (1992c). Experimental parameters were not reported.			
Compound: Selenium			Recommended BCF Value: 0.016
The BCF for this constituent was based on empirical data reported in U.S. EPA (1992c). Experimental parameters were not reported.			
Compound: Silver			Recommended BCF Value: 0.4
The BCF for this constituent was based on empirical data reported in Baes, Sharp, Sjoreen and Shor (1984). Experimental parameters were not reported.			
Compound: Thallium			Recommended BCF Value: 0.004
The BCF for this constituent was based on empirical data reported in Baes, Sharp, Sjoreen and Shor (1984). Experimental parameters were not reported.			
Compound: Zinc			Recommended BCF Value: 0.0000000000012
The BCF for this constituent was based on empirical data reported in U.S. EPA (1992c). Experimental parameters were not reported.			

TABLE C-3

WATER-TO-AQUATIC INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

(Page 1 of 18)

<table>
<tr><th>Reported Values[a]</th><th>Reference</th><th>Experimental Parameters</th><th>Species</th></tr>
<tr><td colspan="4">Dioxins and Furans</td></tr>
<tr><td colspan="3">Compound: 2,3,7,8-Tetrachlorodibenzo(p)dioxin (2,3,7,8-TCDD)</td><td>Recommended BCF Value: 1,560</td></tr>
<tr><td colspan="4">The BCF value was calculated using the geometric mean of 2 values from data reported for 2,3,7,8-tetrachlorodibenzo(p)dioxin (2,3,7,8-TCDD).</td></tr>
<tr><td>1,762
1,381</td><td>Yockim, Isensee, and Jones (1978)</td><td>32-day exposure duration</td><td>Daphnid; <i>Heliosoma</i> sp.</td></tr>
<tr><td colspan="3">Compound: 1,2,3,7,8-Pentachlorodibenzo(p)dioxin (1,2,3,7,8-PeCDD)</td><td>Recommended BCF Value: 1,435</td></tr>
<tr><td colspan="4">The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =1,560 x 0.92 =1,435</td></tr>
<tr><td colspan="3">Compound: 1,2,3,4,7,8-Hexachlorodibenzo(p)dioxin (1,2,3,4,7,8-HxCDD)</td><td>Recommended BCF Value: 483.6</td></tr>
<tr><td colspan="4">The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =1,560 x 0.31 =483.6</td></tr>
<tr><td colspan="3">Compound: 1,2,3,6,7,8-Hexachlorodibenzo(p)dioxin (1,2,3,6,7,8-HxCDD)</td><td>Recommended BCF Value: 187.2</td></tr>
<tr><td colspan="4">The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =1,560 x 0.12 =187.2</td></tr>
<tr><td colspan="3">Compound: 1,2,3,7,8,9-Hexachlorodibenzo(p)dioxin (1,2,3,7,8,9-HxCDD)</td><td>Recommended BCF Value: 218.4</td></tr>
<tr><td colspan="4">The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =1,560 x 0.14 = 218.4</td></tr>
<tr><td colspan="3">Compound: 1,2,3,4,6,7,8-Heptachlorodibenzo(p)dioxin (1,2,3,4,6,7,8-HpCDD)</td><td>Recommended BCF Value: 79.6</td></tr>
<tr><td colspan="4">The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =1,560 x 0.051 = 79.6</td></tr>
<tr><td colspan="3">Compound: Octachlorodibenzo(p)dioxin (OCDD)</td><td>Recommended BCF Value: 18.7</td></tr>
<tr><td colspan="4">The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =1,560 x 0.012 = 18.7</td></tr>
<tr><td colspan="3">Compound: 2,3,7,8-Tetrachlorodibenzofuran (2,3,7,8-TCDF)</td><td>Recommended BCF Value: 1248</td></tr>
<tr><td colspan="4">The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =1,560 x 0.80 = 124</td></tr>
<tr><td colspan="3">Compound: 1,2,3,7,8-Pentachlorodibenzofuran (1,2,3,7,8-PeCDF)</td><td>Recommended BCF Value: 343.2</td></tr>
<tr><td colspan="4">The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =1,560 x 0.22 = 343.2</td></tr>
<tr><td colspan="3">Compound: 2,3,4,7,8-Pentachlorodibenzofuran (2,3,4,7,8-PeCDF)</td><td>Recommended BCF Value: 2,496</td></tr>
</table>

TABLE C-3

WATER-TO-AQUATIC INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

Reported Values[a]	Reference	Experimental Parameters	Species
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =1,560 x 1.6 = 2,496			
Compound: 1,2,3,4,7,8-Hexachlorodibenzofuran (1,2,3,4,7,8-HxCDF)			Recommended BCF Value: 118.6
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =1,560 x 0.076 = 118.6			
Compound: 1,2,3,6,7,8-Hexachlorodibenzofuran (1,2,3,6,7,8-HxCDF)			Recommended BCF Value: 296.4
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =1,560 x 0.19 = 296.4			
Compound: 2,3,4,6,7,8-Hexachlorodibenzofuran (2,3,4,6,7,8-HxCDF)			Recommended BCF Value: 1,045
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =1,560 x 0.67 = 1,045			
Compound: 1,2,3,7,8,9-Hexachlorodibenzofuran (1,2,3,7,8,9-HxCDF)			Recommended BCF Value: 982.8
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =1,560 x 0.63 = 982.8			
Compound: 1,2,3,4,6,7,8-Heptachlorodibenzofuran (1,2,3,4,6,7,8-HpCDF)			Recommended BCF Value: 17.2
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =1,560 x 0.011 = 17.2			
Compound: 1,2,3,4,7,8,9-Heptachlorodibenzofuran (1,2,3,4,7,8,9-HpCDF)			Recommended BCF Value: 608.4
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =1,560 x 0.39 = 608.4			
Compound: Octachlorodibenzofuran (OCDF)			Recommended BCF Value: 25.0
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =1,560 x 0.016 = 25.0			
Polynuclear Aromatic Hydrocarbons (PAHs)			
Compound: Benzo(a)pyrene			Recommended BCF Value: 4,697
The BCF value was calculated using the geometric mean of 6 laboratory values as follows:			
55,000	Eadie, Landrum, and Faust (1982)	Reported as the mean of the measured PAH concentrations in the test species and the sediment	*Pontoporcia hoyi*
12,761	Newsted and Giesy (1987)	24-hour exposure duration	*Daphnia magna*

TABLE C-3

WATER-TO-AQUATIC INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

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Reported Values[a]	Reference	Experimental Parameters	Species
861	Roesijadi, Anderson, and Blaylock (1978)	7-day exposure duration	*Macoma inquinata*
3,000	Lee, Gardner, Anderson, Blaytock, and Barwell-Clarke (1978)	8-day exposure duration. The reported value was calculated by dividing the wet tissue concentration by the medium concentration [(μg/g)/(μg/L)] conversion factor of 1 x 10^3 was applied to the value.	*Crassostrea virginica*
2,745 2,158	Leversee, Landrum, Giesy, and Fannin (1983)	6-hour exposure duration; 0.2 ppm concentrated humic acid added to test medium	*Daphnia magna*
Compound: Benzo(a)anthracene			Recommended BCF Value: 12,299
The BCF value was calculated using the geometric mean of 3 laboratory values as follows:			
18,000	Lee, Gardner, Anderson, Blaytock, and Barwell-Clarke (1978)	8-day exposure duration; The reported value was calculated by dividing the wet tissue concentration by the medium concentration [(μg/g)/(μg/L)] conversion factor of 1 x 10^3 was applied to the value.	*Crassostrea virginica*
10,225	Newsted and Giesy (1987)	24-hour exposure duration	*Daphnia magna*
10,109	Southworth, Beauchamp, and Schmieder (1978)	24-hour exposure duration	*Daphnia pulex*
Compound: Benzo(b)fluoranthene			Recommended BCF Value: 4,697
Laboratory data were not available for this constituent. The BCF for benzo(a)pyrene was used as a surrogate.			
Compound: Benzo(k)fluoranthene			Recommended BCF Value: 13,225
The BCF value was based on one laboratory value as follows:			
13,225	Newsted and Giesy (1987)	24-hour exposure duration	*Daphnia magna*
Compound: Chrysene			Recommended BCF Value: 980
The BCF value was calculated using the geometric mean of 7 laboratory values as follows:			
5,500	Eastmond, Booth, and Lee (1984)	Not reported	*Daphnia magna*

WATER-TO-AQUATIC INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

Reported Values[a]	Reference	Experimental Parameters	Species
248 199 1,809 418	Millea, Corliss, Farragut, and Thompson (1982)	28-day exposure duration; reported values were based on accumulation in the cephalothorax and abdomen at exposures of 1 or 5 µg/L in a cloed seawater system.	*Penaeus duorarum*
6,088	Newsted and Giesy (1987)	24-hour exposure duration	*Daphnia magna*
694	Roesijadi, Anderson, and Blaylock (1978)	7-day exposure duration	*Macoma inquinata*
Compound: Dibenzo(a,h)anthracene			Recommended BCF Value: 710
The BCF value was calculated using the geometric mean of 2 laboratory values as follows:			
652 773	Leversee, Landrum, Giesy, and Fannin (1983)	6-hour exposure duration	*Daphnia magna*
Compound: Indeno(1,2,3-cd)pyrene			Recommended BCF Value: 4,697
Laboratory data were not available for this constituent. The BCF for benzo(a)pyrene was used as a surrogate.			
Polychlorinated Biphenyls (PCBs)			
Compound: Aroclor 1016			Recommended BCF Value: 13,000
The BCF value for Aroclor 1016 was calulated using one laboratory value as follows:			
13,000	Parrish et al. (1974) as cited in EPA (1980b)	84 day exposure Edible portion	*Crassostrea virginica*
Compound: Aroclor 1254			Recommended BCF Value: 5,538
The BCF value for Aroclor 1254 was calulated using the geometric mean 13 laboratory values as follows:			
41,857 6,900 5,679	Rice and White (1987)	Field study	*Sphaerium striatum*

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WATER-TO-AQUATIC INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

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Reported Values[a]	Reference	Experimental Parameters	Species
750 740 3,800 1,500 6,200 3,500 2,600 2,700	Mayer, Mehrle, and Sanders (1977)	4 to 21-day exposure	*Orconectes nais; Daphnia magna; Gammarus pseudolimnaeus; Palaemontes kadiakensis; Corydalus cornutus; Culex tarsalis; Chaoborus punctipennis*
120,000	Veith, Kuehl, Puglisi, Glass, and Eaton (177)	Field samples	Zooplankton
340,000 in lipid 51,000 dry tissue	Scura and Theilacker (1977)	45 days exposure	*Brachionus plicatilis*
>27,000	Nimmo et al. (1977) as cited in EPA (1980b)	Field data Whole body	Invertebrates
740	Mayer et al. (1977) as cited in EPA (1980b)	21 days exposure	*Pteronarcys dorsata*
1,500	Mayer et al. (1977) as cited in EPA (1980b)	7 days exposre	*Corydalus cornutus*
750	Mayer et al. (1977) as cited in EPA (1980b)	21 days exposure	*Orconectes nais*
373	Mayer et al. (1977) as cited in EPA (1980b)	5 days exposure	*Nereis diversicolor*
140	Duke et al. (1970) as cited in EPA (1980b)	2 day exposure	*Penaeus duorarum*
8,100	Duke et al. (1970) as cited in EPA (1980b)	2 days exposure	*Crassostrea virginica*
236	Courtney and Langston (1978) as cited in EPA (1980b)	5 days exposure	*Arenicola marina*
Nitroaromatics			
Compound: 1,3-Dinitrobenzene			Recommended BCF Value: 13

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WATER-TO-AQUATIC INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

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Reported Values[a]	Reference	Experimental Parameters	Species
Laboratory data were not available for this constituent. BCF for 2,4-dinitrotoluene was used as a surrogate.			
Compound: 2,4-Dinitrotoluene			Recommended BCF Value: 13
The recommended BCF value is based on one study as follows:			
13	Liu, Bailey, and Pearson (1983)	4-day exposure duration	*Daphnia magna*
Compound: 2,6-Dinitrotoluene			Recommended BCF Value: 13
Laboratory data were not available for this constituent. BCF for 2,4-dinitrotoluene was used as a surrogate.			
Compound: Nitrobenzene			Recommended BCF Value: 13
Laboratory data were not available for this constituent. BCF for 2,4-dinitrotoluene was used as a surrogate.			
Compound: Pentachloronitrobenzene			Recommended BCF Value: 13
Laboratory data were not available for this constituent. BCF for 2,4-dinitrotoluene was used as a surrogate.			
Phthalate Esters			
Compound: Bis(2-ethylhexyl)phthalate			Recommended BCF Value: 318
The BCF value was calculated using the geometric mean of 12 laboratory values as follows:			
2,497	Brown and Thompson (1982)	14 to 28-day exposure duration	*Mytilus edulis*
257	Perez, Davey, Lackie, Morrison, Murphy, Soper, and Winslow (1983)	30-day exposure duration	*Pitar morrhauna*
48 2237	Sanders, Mayer, and Walsh (1973)	14-day exposure duration; The reported value was calculated by dividing the wet tissue concentration by the medium concentration [(µg/g)/(µg/L)], and a conversion factor of 1 x 10^3 was applied to the value. The reported value was also converted from dry weight to wet weight using a conversion factor of 5.99[a].	*Gammarus pseudolimnacus*
1,214 17,473 2,271 24,456	Sodergren (1982)	27-day exposure duration	*Chironomus* sp.; *Sialis* sp.; *Phanorbis corneus*; *Gammarus pulex*

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WATER-TO-AQUATIC INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

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Reported Values[a]	Reference	Experimental Parameters	Species
11 10 7 17	Wofford, Wilsey, Neff, Giam, and Neff (1981)	24-hour exposure duration	*Crassostrea virginica*; *Penaeus aztecus*
Compound: Di(n)octyl phahalate			Recommended BCF Value: 5,946
The BCF value was calculated using the geometric mean of 2 laboratory values as follows:			
13,600 2,600	Sanborn, Metcalf, Yu, and Lu (1975)	Not reported	*Physia* sp.; *Daphnia* sp.
Volatile Organic Compounds			
Compound: Acetone			Recommended BCF Value: 0.05
Laboratory data were not available for this constituent. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = -0.222 (Karickoff and Long 1995).			
Compound: Acrylonitrile			Recommended BCF Value: 0.11
Laboratory data were not available for this constituent. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where Log K_{ow} = 0.250 (Karickoff and Long 1995).			
Compound: Chloroform			Recommended BCF Value: 2.82
Laboratory data were not available for this constituent. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 1.949 (U.S. EPA 1994b).			
Compound: Crotonaldehyde			Recommended BCF Value: 0.20
Laboratory data were not available for this constituent. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978) where, log K_{ow} = 0.55 (Based on equation developed by Hansch and Leo (1979), as calculated in NRC (1981)).			
Compound: 1,4-Dioxane			Recommended BCF Value: 0.043
Laboratory data were not available for this constituent. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978) where, log K_{ow} = -0.268 (U.S. EPA 1995a).			
Compound: Formaldehyde			Recommended BCF Value: 0.14
Laboratory data were not available for this constituent. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978) where, log K_{ow} = 0.342 (U.S. EPA 1995a).			

TABLE C-3

WATER-TO-AQUATIC INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

Reported Values[a]	Reference	Experimental Parameters	Species
Compound: Vinyl chloride			Recommended BCF Value: 0.62
Laboratory data were not available for this constituent.The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978) where, log K_{ow} = 1.146 (U.S. EPA 1994b).			
Other Chlorinated Organics			
Compound: Carbon tetrachloride			Recommended BCF Value: 12
Laboratory data were not available for this constituent. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978) where, log K_{ow} = 2.717 (U.S. EPA 1994b).			
Compound: Hexachlorobenzene			Recommended BCF Value: 2,595
The BCF value was calculated using the geometric mean of 16 laboratory values as follows:			
215,331 8,051 11,064	Baturo and Lagadic (1996)	48 to 120-hour exposure duration	*Lymnaea palustris*
1,360 770 1,510 940 1,630 1,030	Isensee, Holden, Woolson, and Jones (1976)	31-day exposure duration	*Heliosoma* sp.; *Daphnia magna*
287 1,247	Metcalf, Kapoor, Lu, Schuth, and Sherman (1973)	1 to 33-day exposure duration	*Daphnia magna; Physa* sp.
17,140 21,820 5,000	Nebeker, Griffis, Wise, Hopkins, and Barbitta (1989)	28-day exposure duration	*Oligochaete*
24,000	Oliver (1987)	79-day exposure duration	*Oligochaete*
5.5	Schauerte, Lay, Klein, and Korte (1982)	4 to 6-week exposure duration	*Dytiscus marginalis*
Compound: Hexachlorobutadiene			Recommended BCF Value: 10.5
The BCF value was based on four laboratory values from one study as follows:			

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WATER-TO-AQUATIC INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

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Reported Values[a]	Reference	Experimental Parameters	Species
6.27 45.4 11.1 3.86	Laseter, Bartell, Laska, Holmquist, Condie, Brown, and Evans (1976)	10-day exposure duration	*Procambarus clarki*
Compound:	Hexachlorocyclopentadiene		Recommended BCF Value: 1,232
The BCF value was calculated using the geometric mean of 2 laboratory values as follows:			
929 1,634	Lu, Metcalf, Hirwe, and Williams (1975)	Not reported	*Physa* sp. *Culex* sp.
Compound:	Pentachlorobenzene		Recommended BCF Value: 2,595
Laboratory data were not available for this constituent. The BCF for hexachlorobenzene was used as a surrogate.			
Compound:	Pentachlorophenol		Recommended BCF Value: 52
The BCF value was calculated using the geometric mean of 13 laboratory values as follows:			
145 342	Makela and Oikari (1990)	1-day exposure duration	*Anodonta anatina*
165	Lu and Metcalf (1975)	1-day exposure duration	*Daphnia magna*
81 461	Makela, Petanen, Kukkonen, and Oikari (1991)	Multiple exposure durations	*Anodonta anatina*
80 61 121 85	Makela and Oikari (1995)	2 to 36-week exposure duration	*Anodonta anatina*; *Pseudanodonta complanta*
42 0.26 72 1.7	Schimmel, Patrick, and Faas (1978)	28-day exposure duration	*Crassostrea virginica*; *Penaeus aztecus*; *Palaemonetes pugio*
Pesticides			
Compound:	4,4'-DDE		Recommended BCF Value: 11,930
The recommended BCF value was calculated using the geometric mean of 14 field values(b) (Reich, Perkins, and Cutter 1986).			

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WATER-TO-AQUATIC INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

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Reported Values[a]	Reference	Experimental Parameters	Species
19,400 4,421 207,070 8,782 67,641 2,374 5,099 2,197 8,344 46,953 15,369 35,373 4,983 3,972	Reich, Perkins, and Cutter (1986)	Field samples.	*Tubificidae; Chironomidae; Corixidae*
36,342 39,390	Metcalf, Sanborn, Lu, and Nye (1975)	33-day exposure duration	*Physa* sp.; *Culex pipiens quinquefasciatus*
28,600 1310 63,500 51,600 36,400	Hamelink, Waybrant, and Yant (1977)	Not reported	Zooplankton
19,528 5,024	Metcalf, Sangha, and Kapoor (1971)	33-day exposure duration; The value reported in Hamelink and Waybrant (1976) was converted to wet weight over dry weight using a conversion factor was 5.99[a].	*Physa* sp.; *Culex pipiens quinquefasciatus*
19,529	Metcalf, Kapoor, Lu, Schuth, and Sherman (1973)	33-day exposure duration	*Physa* sp.
Compound: Heptachlor			Recommended BCF Value: 3,807
The BCF value was calculated using the geometric mean of 4 laboratory values as follows:			
37,153 31,403	Lu, Metcalf, Plummer, and Mandel (1975)	Not reported	*Physa* sp. *Culex* sp.
300 600	Schimmel, Patrick, and Forester (1976)	96 hour exposure duration	*Penaeus duorarum*
Compound: Hexachloropehene			Recommended BCF Value: 970
The BCF value was based on one study as follows:			
970	Sanborn (1974)	Not reported	*Physa* sp.
Inorganics			
Compound: Aluminum			Recommended BCF Value: 4,066

TABLE C-3

WATER-TO-AQUATIC INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

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Reported Values[a]	Reference	Experimental Parameters	Species
Laboratory data were not available for this constituent. The recommended BCF is the arithmetic mean of the recommended values for 14 inorganics with laboratory data available (antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc).			
Compound: Antimony			Recommended BCF Value: 7
The BCF value was calculated using the geometric means of 2 laboratory values as follows:			
10	Thompson, Burton, Quinn, and Ng (1972)	Not reported	Freshwater and marine invertebrates
Compound: Arsenic			Recommended BCF Value: 73
The BCF value was calculated using the geometric mean of 5 laboratory values as follows:			
33 45 131 50 219	Spehar, Fiandt, Anderson, and DeFoe (1980)	21 to 28-day exposure duration	*Pteronarcys dorsata*; *Daphnia magna*
Compound: Barium			Recommended BCF Value: 200
The BCF was based on one study as follows:			
200	Thompson, Burton, Quinn and Ng (1972)	Not reported	Freshwater invertebrate
Compound: Beryllium			Recommended BCF Value: 45
The BCF value was calculated using the geometric mean of 2 laboratory values as follows:			
10 200	Thompson, Burton, Quinn and Ng (1972)	Not reported	Freshwater invertebrate
Compound: Cadmium			Recommended BCF Value: 3,461
The BCF value was calculated using the geometric mean of 8 field values as follows:			
238 894 11,383 9,897 549 3,577 15,936 27,427	Saiki, Castleberry, May, Martin, and Bullard (1995)	Field samples.	*Chironomidea; Ephermeroptera*

TABLE C-3

WATER-TO-AQUATIC INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

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Reported Values[a]		Reference	Experimental Parameters	Species
1,490 2,460 720		Eisler, Zaroogian, and Hennekey (1972)	3-week exposure duration	*Crassostrea virginica*; *Aquipecten irradians*; *Homarus americanus*
165		George and Coombs (1977)	28-day exposure duration	*Mytilus edulis*
1,359 2,939 615 573 1,082 775	137 217 1,850 1,530 781 553	Giesy, Kanio, Boling, Knight, Mashburn, and Clarkin (1977)	52-week exposure duration; the reported value was calculated by dividing the dry tissue concentration by the medium concentration [(µg/g)/(µg/L)] conversion factor of 1 x 10^3 was applied to the value. A conversion factor or 5.99(a) was used to convert dry weight to wet weight.	*Ceratopogonidae; Chironomidae;* Beetle*; Anisotptera; Zygoptera; Ephemeroptera*
1,840		Gillespie, Reisine, and Massaro (1977)	8-day exposure duration; the reported value was calculated by dividing the dry tissue concentration by the medium concentration [(ppm)/(ppb)] and a conversion factor of 1 x 10^3 was applied to the value.	*Orconectes propinquos propinquos*
3,770 1,752		Graney, Cherry, and Cairns (1983)	28-day exposure duration	*Corbicula fluminea*
1.86 6.88 7.18		Jennings and Rainbow (1979)	40-day exposure duration; the reported value was calculated by dividing the dry tissue concentration by the medium concentration [(mg/g)/(ppm)] conversion factor of 1 x 10^3 was applied to the value. A conversion factor or 5.99(a) was used to convert dry weight to wet weight.	*Carcinus maenas*
660 3400		Klockner (1979)	64-day exposure duration	*Ophryothochadiadema* sp.
48 57 55	33 34 23	Nimmo, Lightner, and Bahner (1977)	28 to 30-day exposure duration	*Penaeus duorarum*
1,023 1,477 2,412 3,406	17.7 17.5 30 28.7 37.2	Pesch and Stewart (1980)	42-day exposure duration; the values reported in Pesch and Stewart (1980) were converted to wet weight using a conversion factor of 5.99(a).	*Argopecten irradians*; *Palaemonetes pugio*

TABLE C-3

WATER-TO-AQUATIC INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

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Reported Values[a]	Reference	Experimental Parameters	Species
57 301 341 167	Phillips (1976)	35-day exposure duration; the reported value was calculated by dividing the wet tissue concentration by the medium concentration [(µg/g)/(µg/L)] conversion factor of 1 x 10^3 was applied to the value.	*Mytilus edulis*
160	Pringle, Hissong, Katz, and Mulawka (1968)	70-day exposure duration	*Mya arenaria*
3,500	Sundelin (1983)	66-week exposure duration	*Pontoporeia affinis*
123 89 93 67 48 115	Theede, Scholz, and Fischer (1979)	7 and 10-day exposure duration; the reported value was calculated by dividing the dry tissue concentration by the medium concentration [(µg/g)/(µg/L)] conversion factor of 1 x 10^3 was applied to the value. A conversion factor or 5.99[a] was used to convert dry weight to wet weight.	*Laomedea loveni*
2,150 13,600	Zaroogian and Cheer (1976)	40-week exposure	*Crassostrea virginica*
Compound: Chromium (total)			Recommended BCF Value: 3,000
The BCF value was based on 1 field value as follows:			
3,000	Namminga and Wilhm (1977)	Field samples.	*Chironomidae*
1,900	NAS (1974)	Not reported	Zooplankton
2,000	Thompson, Burton, Quinn, and Ng (1972)	Not reported	Freshwater invertebrates
Compound: Copper			Recommended BCF Value: 3,718
The BCF value was calculated using the geometric mean of 9 field values as follows:			
546	Namminga and Wilhm (1977)	Field samples.	*Chironomidae*
2,896 3,066 5,111 4,940 11,130 4,174 8,347 2,862	Saiki, Castleberry, May, Martin, and Bullard (1995)	Field samples.	*Chironomidae*; *Ephemeroptera*

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WATER-TO-AQUATIC INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

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Reported Values[a]		Reference	Experimental Parameters	Species
373		Eisler (1977)	14-day exposure duration	*Mya arenara*
17,720 22,571		Graney, Cherry, and Cairns (1983)	28-day exposure duration	*Corbicula fluminea*
54 87 70 35	53 48 57 44	Jones, Jones and Radlett (1976)	25-day exposure duration	*Nereis diversicolor*
800		Majori and Petronio (1973)	8-day exposure duration	*Mytilus galloprovincialis*
104 2,792		McLusky and Phillips (1975)	21-day exposure duration	*Phylloduce maculata*
37 43	40 42	Nehring (1976)	14-day exposure duration; the value reported was converted to wet weight using a conversion factor of 5.99(a).	*Pteronarcys californica*
2,462		Pesch and Morgan (1978)	28-day exposure duration	*Nereis arenaceodentata*
35 69	185.5 26.5	Phillips (1976)	35-day exposure duration; the reported value was calculated by dividing the wet tissue concentration by the medium concentration [(µg/g)/(µg/L)], a conversion factor of 1 x 10^3 was applied to the value.	*Mytilus edulis*
5,160 6,800 11,560 12,540	11,800 19,000 27,800 22,500	Shuster and Pringle (1968)	35, 70, 105, and 140-day exposure duration	*Crassostrea virginica*
160		Pringle, Hissong, Katz, and Mulawka (1968)	70-day exposure duration	*Mya arenaria*
Compound: Cyanide (total)				Recommended BCF Value: 4,066
Laboratory data were not available for this constituent. The recommended BCF is the arithmetic mean of the recommended values for 14 inorganics with laboratory data available (antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc).				
Compound: Lead				Recommended BCF Value: 5,059
The BCF value was calculated using the geometric mean of 6 field values as follows:				

TABLE C-3

WATER-TO-AQUATIC INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

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Reported Values[a]	Reference	Experimental Parameters	Species
8,076 7,237 3,636 3,575 5,671 3,890	Nehring, Nisson, and Minasian (1979)	Field samples.	*Tipulidae*; *Para quetina* sp.; *Heptageniidae; Nemoura* sp.; *Macronenum* sp.; *Anisoptera*
2500	Borgmann, Kramar, and Loveridge (1978)	120-day exposure duration	*Lymnaea palustris*
357	Eisler (1977)	14-day exposure duration	*Mya arenara*
111 50 63 71 63	Nehring (1976)	14-day exposure duration; the reported value was converted from dry weight to wet weight using a conversion factor of 5.99(a).	*Petronarcys californica*
1520 502.5 765 555	Phillips (1976)	35-day exposure duration; the reported value was calculated by dividing the wet tissue concentration by the medium concentration [(µg/g)/(µg/L)], and an unit conversion factor of 1 x 10^3 was applied to the value.	*Mytilus edulis*
578 1,097	Zaroogian, Morrison, Heltshe (1979)	20-day exposure duration; The reported value was calculated by dividing the dry tissue concentration by the medium concentration [(µg/g)/(µg/kg)], and an unit conversion factor of 1 x 10^3 was applied to the value. A conversion factor or 5.99(a) was used to convert dry weight to wet weight.	*Crassostrea virginica*
Compound: Mercuric chloride			Recommended BCF Value: 20,184
The BCF value was based on 6 laboratory values as follows:			
100,000	Thompson, Burton, Quinn, and Ng (1972)	Not reported	Marine and freshwater invertebrates
12,000	Kopfter (1974)	74-day exposure duration; the reported value was calculated by dividing the dry tissue concentration by the medium concentration [(ppm)/(ppb)], and an unit conversion factor of 1 x 10^3 was applied to the value.	*Crassostrea virginica*
13,633 14,600 14,217 19,916	Thurberg, Calabrese, Gould, Greig, Dawson, and Tucker (1977)	30 to 60-day exposure duration; The reported value was calculated by dividing the dry tissue concentration by the medium concentration [(ppm)/(ppb)], and an unit conversion factor of 1 x 10^3 was applied to the value.	*Homarus americanus*

TABLE C-3

WATER-TO-AQUATIC INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

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Reported Values[a]	Reference	Experimental Parameters	Species
Compound: Methyl mercury			Recommended BCF Value: 55,000
The BCF value was based on 1 laboratory value as follows:			
55,000	Kopfter (1974)	74-day exposure duration; The reported value was calculated by dividing the dry tissue concentration by the medium concentration [(ppm)/(ppb)] and a conversion factor of 1 x 10^3 was applied to the value.	*Crassostrea virginica*
Compound: Nickel			Recommended BCF Value: 28
The BCF value was calculated using the geometric mean of 4 laboratory values as follows:			
100 250	Thompson, Burton, Quinn, and Ng (1972)	Not reported	Freshwater and marine invertebrates
2 12	Watras, MacFarlane, and Morel (1985)	Reported values adopted from a high and low range.	*Daphnia magna*
Compound: Selenium			Recommended BCF Value: 1,262
The BCF value was calculated using the geometric mean of 5 laboratory values as follows:			
229,000	Besser, Canfield, and LaPoint (1993)	96-hour exposure duration	*Daphnia magna*
90 930	Hermanutz, Allen, Roush, and Hedtke (1992)	365-day exposure duration	*Lepomis macrochirus*
167 1,000	Thompson, Burton, Quinn, and Ng (1972)	Not reported	Freshwater and marine invertebrates
Compound: Silver			Recommended BCF Value: 298
The BCF value was calculated using the geometric mean of 12 laboratory values as follows:			
1,391 5,100 2,203 1,056 6,500 1,435	Calabrese, MacInnes, Nelson, Greig, and Yevich (1984)	540 to 630 day exposure duration; he reported value was calculated by dividing the wet tissue concentration by the medium concentration [(mg/kg)/(µg/L)], and an unit conversion factor of 1 x 10^3 was applied to the value.	*Mytilus edulis*

TABLE C-3

WATER-TO-AQUATIC INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

Reported Values[a]		Reference	Experimental Parameters	Species
1,711		Metayer, Amiard-Triquet and Baud (1990)	14-day exposure duration	*Crassostrea gigas*
30 22 18	13 12	Nehring (1976)	14-day exposure duration; the reported value in Nehring (1976) was converted from dry weight to wet weight using a conversion factor of 5.99(a).	*Pteronarcys californica*
Compound: Thallium				Recommended BCF Value: 15,000
The BCF value was calculated using the geometric mean of 2 laboratory values as follows:				
15,000 15,000		Thompson, Burton, Quinn, and Ng (1972)	Not reported	Freshwater and marine invertebrates
Compound: Zinc				Recommended BCF Value: 4,578
The BCF value was calculated using the geometric mean of 9 field values as follows:				
30,036		Namminga and Wilhm (1977)	Field samples.	*Chironomidae* sp.
2,613 2,199 1,282 3,210	4,718 6,625 3,876 10,274	Saiki, Castleberry, May, Martin, and Bullard (1995)	Field samples; the reported value was converted from dry weight to wet weight using a conversion factor of 5.99(a).	*Chironomidae* sp.; *Ephemeroptera* sp.
50 3,000		Deutch, Borg, Kloster, Meyer, and Moller (1980)	9-day exposure duration	Marine invertebrates
143		Eisler (1977)	14-day exposure duration	*Mya arenaria*
358 511 631		Graney, Cherry, and Cairns (1983)	28-day exposure duration	*Corbicula fluminea*
499 326 159 92 43	95 53 25 15 7	Nehring (1976)	14-day exposure duration; the reported value was converted from dry weight to wet weight using a conversion factor of 5.99(a).	*Ephemerella grandis*; *Pteronarcys californica*

TABLE C-3

WATER-TO-AQUATIC INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

(Page 18 of 18)

Reported Values[a]	Reference	Experimental Parameters	Species
519 2,615 315 184	Phillips (1976)	35-day exposure duration	Mytilus edulis
85	Pringle, Hissong, Katz, and Mulawka (1968)	50-day exposure duration	*Mya arenaria*

Notes:

(a) The reported values are presented as the amount of COPC in invertebrate tissue divided by the amount of COPC in the water. If the values reported in the studies were presented as dry tissue weight over amount of COPC in water, they were converted to wet weight by dividing the concentration in dry invertebrate tissue weight by 5.99. This conversion factor assumes an invertebrate's total weight is 83.3 percent moisture, which is based on the moisture content of the earthworm (Pietz et al. 1984).

The conversion factor was calculated as follows:

$$\text{Conversion factor} = \frac{1.0 \text{ gram } (g) \text{ invertebrate total weight}}{1.0 \text{ gram } (g) \text{ invertebrate total weight} - 0.833 \text{ g invertebrate wet weight}}$$

(b) Reported field values for organic COPCs are assumed to be total COPC concentration in water and, therefore, were converted to dissolved COPC concentration in water using the following equation from U.S.EPA (1995b):

BCF (dissolved) = (BCF (total) / f_{fd}) - 1

where: BCF (dissolved) = BCF based on dissolved concentration of COPC in water
BCF (total) = BCF based on the field derived data for total concentration of COPC in water
f_{fd} = Fraction of COPC that is freely dissolved in the water

where: f_{fd} = 1 / [1 + ((DOC x K_{ow}) / 10) + (POC x K_{ow})]
DOC = Dissolved organic carbon, kilograms of organic carbon / liter of water (2.0 x 10^{-06} Kg/L)
K_{ow} = Octanol-water partition coefficient of the COPC, as reported in U.S. EPA (1994b)
POC = Particulate organic carbon, kilograms of organic carbon / liter of water (7.5 x 10^{-09} Kg/L)

TABLE C-4

WATER-TO-ALGAE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

(Page 1 of 12)

Reported Values[a]	Reference	Experimental Parameters	Species
Dioxins and Furans			
Compound: 2,3,7,8-Tetrachlorodibenzo(p)dioxin (2,3,7,8-TCDD)			Recommended BCF value: 3,302
The recommended BCF value was calculated using the geometric mean of 3 laboratory values as follows:			
4,000 9,000	Yockim, Isensee, and Jones (1978)	Values adopted from a high to low range; reported values were for 2,3,7,8-tetrachlorodibenzo(p)dioxin (2,3,7,8-TCDD).	*Leona minor*
1,000	Yockim, Isensee, and Jones (1978)	32-day exposure duration; reported values were for 2,3,7,8-TCDD.	*Oedogonium cardiacum*
Compound: 1,2,3,7,8-Pentachlorodibenzo(p)dioxin (1,2,3,7,8-PeCDD)			Recommended BCF value: 3,038
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF = 3,302 x 0.92 = 3,038			
Compound: 1,2,3,4,7,8-Hexachlorodibenzo(p)dioxin (1,2,3,4,7,8-HxCDD)			Recommended BCF value: 1,024
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF = 3,302 x0.31 = 1,024			
Compound: 1,2,3,6,7,8-Hexachlorodibenzo(p)dioxin (1,2,3,6,7,8-HxCDD)			Recommended BCF value: 396.2
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF = 3,302 x0.12 = 396.2			
Compound: 1,2,3,7,8,9-Hexachlorodibenzo(p)dioxin (1,2,3,7,8,9-HxCDD)			Recommended BCF value: 462.3
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF = 3,302 x0.14 = 462.3			
Compound: 1,2,3,4,6,7,8-Heptachlorodibenzo(p)dioxin (1,2,3,4,6,7,8-HpCDD)			Recommended BCF value: 168.4
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF = 3,302 x0.051 = 168.4			
Compound: Octachlorodibenzo(p)dioxin (OCDD)			Recommended BCF value: 39.6
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF = 3,302 x0.012 = 39.6			
Compound: 2,3,7,8-Tetrachlorodibenzofuran (2,3,7,8-TCDF)			Recommended BCF value: 2,642
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF = 3,302 x0.80 = 2,642			
Compound: 1,2,3,7,8-Pentachlorodibenzofuran 1,(2,3,7,8-PeCDF)			Recommended BCF value: 726.4
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF = 3,302 x0.22 =726.4			

TABLE C-4

WATER-TO-ALGAE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

(Page 2 of 12)

Reported Values[a]	Reference	Experimental Parameters	Species
Compound:	2,3,4,7,8-Pentachlorodibenzofuran (2,3,4,7,8-PeCDF)		Recommended BCF value: 5,283
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF = 3,302 x1.6 = 5,283			
Compound:	1,2,3,4,7,8-Hexachlorodibenzofuran (1,2,3,4,7,8-HxCDF)		Recommended BCF value: 251.0
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF = 3,302 x 0.076 = 251.0			
Compound:	1,2,3,6,7,8-Hexachlorodibenzofuran (1,2,3,6,7,8-HxCDF)		Recommended BCF value: 627.4
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF = 3,302 x0.19 = 627.4			
Compound:	2,3,4,6,7,8-Hexachlorodibenzofuran (2,3,4,6,7,8-HxCDF)		Recommended BCF value: 2,212
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF = 3,302 x0.67 = 2,212			
Compound:	1,2,3,7,8,9-Hexachlorodibenzofuran (1,2,3,7,8,9-HxCDF)		Recommended BCF value: 2,080
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF = 3,302 x 0.63 = 2,080			
Compound:	1,2,3,4,6,7,8-Heptachlorodibenzofuran (1,2,3,4,6,7,8-HpCDF)		Recommended BCF value: 36.3
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF = 3,302 x0.011 = 36.3			
Compound:	1,2,3,4,7,8,9-Heptachlorodibenzofuran (1,2,3,4,7,8,9-HpCDF)		Recommended BCF value: 1,288
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF = 3,302 x0.39 = 1,288			
Compound:	Octachlorodibenzofuran (OCDF)		Recommended BCF value: 52.8
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF = 3,302 x 0.016 = 52.8			
Polynuclear Aromatic Hydrocarbons (PAHs)			
Compound:	Benzo(a)pyrene		Recommended BCF value: 5,258
The recommended BCF value was based on a single measured value for benzo(a)pyrene. This value was also used as a surrogate for all high molecular weight PAHs for which laboratory data were not available.			
5,258	Lu, Metcalf, Plummer, and Mandel (1977)	3-day exposure duration	*Oedogonium cardiacum*
Compound:	Benzo(a)anthracene		Recommended BCF value: 5,258

TABLE C-4

WATER-TO-ALGAE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

(Page 3 of 12)

Reported Values[a]	Reference	Experimental Parameters	Species
Laboratory data were not available for this compound. The BCF for benzo(a)pyrene was used as a surrogate.			
Compound:	Benzo(b)fluoranthene		Recommended BCF value: 5,258
Laboratory data were not available for this compound. The BCF for benzo(a)pyrene was used as a surrogate.			
Compound:	Benzo(k)fluoranthene		Recommended BCF value: 5,258
Laboratory data were not available for this compound. The BCF for benzo(a)pyrene was used as a surrogate.			
Compound:	Chrysene		Recommended BCF value: 5,258
Laboratory data were not available for this compound. The BCF for benzo(a)pyrene was used as a surrogate.			
Compound:	Dibenz(a,h)anthracene		Recommended BCF value: 5,258
Laboratory data were not available for this compound. The BCF for benzo(a)pyrene was used as a surrogate.			
Compound:	Indeno(1,2,3-cd)pyrene		Recommended BCF value: 5,258
Laboratory data were not available for this compound. The BCF for benzo(a)pyrene was used as a surrogate.			
Polychlorinated Biphenyls (PCBs)			
Compound:	Aroclor 1016		Recommended BCF value: 476,829
The reported value was calculated by dividing the wet tissue concentration by the medium concentration (ppm/pptr). A conversion factor of 1 x 10^6 was applied to the value. The BCF value is based on Aroclor 1254 since there was no available data for total PCB.			
476,829	Scura and Theilacker (1977)	45-day exposure to Aroclor 1254	*Dunaliella* sp.
Compound:	Aroclor 1254		Recommended BCF value: 476,829
The reported value was calculated by dividing the wet tissue concentration by the medium concentration (ppm/pptr). A conversion factor of 1 x 10^6 was applied to the value. The BCF value is based on Aroclor 1254 since there was no available data for total PCB.			
476,829	Scura and Theilacker (1977)	45-day exposure to Aroclor 1254	*Dunaliella* sp.

TABLE C-4

WATER-TO-ALGAE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

(Page 4 of 12)

Reported Values[a]	Reference	Experimental Parameters	Species
Nitroaromatics			
Compound: 1,3-Dinitrobenzene			Recommended BCF value: 2,507
Laboratory data were not available for this compound. The BCF for 2,4-dinitrotoluene was used as a surrogate.			
Compound: 2,4-Dinitrotoluene			Recommended BCF value: 2,507
The recommended BCF value was based on one study as follows:			
2,507	Liu, Bailey, and Pearson (1983)	4-day exposure duration	*Selanastrum capricornatum*
Compound: 2,6-Dinitrobenzene			Recommended BCF value: 2,507
Laboratory data were not available for this compound. The BCF for 2,4-dinitrotoluene was used as a surrogate.			
Compound: Nitrobenzene			Recommended BCF value: 24
The recommended BCF value was based on one study as follows:			
24	Geyer, Viswanathan, Freitag, and Korte (1981)	1-day exposure duration	*Chlorella fusca*
Compound: Pentachloronitrobenzene			Recommended BCF value: 4,740
The recommended BCF value calculated using the geometric mean of 4 laboratory values as follows:			
3,100	Geyer, Viswanathan, Freitag, and Korte (1981)	1-day exposure duration	*Chlorella fusca*
4,795 7,534	Korte, Freitag, Geyer, Klein, Kraus, and Lahaniatis (1978)	1-day exposure duration; The values reported in Korte, Freitag, Geyer, Klein, Kraus, and Lahaniatis (1978) were converted to wet weight using a conversion factor of 2.92 [a].	*Chlorella fusca*
4,508	Wang, Harada, Watanabe, Koshikawa, and Geyer (1996)	Not reported	*Chlorella fusca*
Phthalate Esters			
Compound: Bis(2-ethylhexyl)phthalate			Recommended BCF value: 9,931

TABLE C-4

WATER-TO-ALGAE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

(Page 5 of 12)

Reported Values[a]	Reference	Experimental Parameters	Species
The recommended BCF value was calculated using the geometric mean of 2 laboratory values as follows:			
5,400	Geyer, Viswanathan, Freitag, and Korte (1981)	1-day exposure duration	*Chlorella fusca*
18,263	Sodergren (1982)	27-day exposure duration	*Chara chara*
Compound: Di(n)octyl phthalate			Recommended BCF value: 28,500
The recommended BCF value was based on one study as follows:			
28,500	Sanborn, Metcalf, Yu, and Lu (1975)	33-day exposure duration	*Oedogonium cardiacum*
Volatile Organic Compounds			
Compound: Acetone			Recommended BCF value: 0.05
Laboratory data were not available for this compound. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = -0.222 (Karickoff and Long 1995)			
Compound: Acrylonitrile			Recommended BCF value: 0.11
Laboratory data are not available for this compound. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 0.250 (Karickoff and Long 1995)			
Compound: Chloroform			Recommended BCF value: 2.82
Laboratory data for this compound were not available. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 1.949 (U.S. EPA 1994b)			
Compound: Crotonaldehyde			Recommended BCF value: 0.20
Laboratory data for this compound were not available. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 0.55 (based on equation developed by Hansch and Leo 1979, calculated in NRC (1981))			
Compound: 1,4-Dioxane			Recommended BCF value: 0.04
Laboratory data for this compound were not available. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = -0.268 (U.S. EPA 1995a)			
Compound: Formaldehyde			Recommended BCF value: 0.14

TABLE C-4

WATER-TO-ALGAE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

(Page 6 of 12)

Reported Values[a]	Reference	Experimental Parameters	Species
Laboratory data for this compound were not available. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 0.342 (U.S. EPA 1995a)			
Compound: Vinyl chloride			Recommended BCF value: 0.62
Laboratory data for this compound were not available. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 1.146 (U.S. EPA 1994b)			
Other Chlorinated Organics			
Compound: Carbon tetrachloride			Recommended BCF value: 300
The recommended BCF value was based on laboratory data as follows:			
300	Geyer, Politzki and Freitag (1984)	1-day exposure duration	*Chlorella fusca*
Compound: Hexachlorobenzene			Recommended BCF value: 11,134
The recommended BCF value was calculated using the geometric mean of 4 laboratory values as follows:			
24,800	Geyer, Politzki, and Freitag (1984)	1-day exposure duration	*Chlorella fusca*
610	Isensee, Holden, Woolson and Jones (1976)	31-day exposure duration	*Oedogonium cardiacum*
41,096	Korte, Freitag, Geyer, Klein, Kraus, and Lahaniatis (1978)	1-day exposure duration; the values reported in Korte, Freitag, Geyer, Klein, Kraus, and Lahaniatis (1978) were converted to wet weight using an unit conversion factor of 2.92 [a] .	*Chlorella fusca*
24,717	Wang, Harada, Watanabe, Koshikawa, and Geyer (1996)	Not reported	*Chlorella fusca*
Compound: Hexachlorobutadiene			Recommended BCF value: 160
The recommended BCF value calculated using the geometric mean of 2 laboratory values as follows:			
160	Laseter, Bartell, Laska, Holmquist, Condie, Brown, and Evans (1976)	7-day exposure duration	*Oedogonium cardiacum*
160	U.S. EPA (1976)	Not reported	Algae
Compound: Hexachlorocyclopentadiene			Recommended BCF value: 610

TABLE C-4

WATER-TO-ALGAE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

Reported Values[a]	Reference	Experimental Parameters	Species
The recommended BCF value was calculated using the geometric mean of 2 laboratory values as follows:			
1,090	Geyer, Viswanathan, Freitag, and Korte (1981)	Not reported	*Chlorella fusca*
341	Lu, Metcalf, Hirwe, and Williams (1975)	Not reported	*Oedogonium cardiacum*
Compound: Pentachlorobenzene			Recommended BCF value: 4,000
The recommended BCF value was based on one study as follows:			
4,000	Geyer, Politzki, and Freitag (1984)	1-day exposure duration	*Chlorella fusca*
Compound: Pentachlorophenol			Recommended BCF value: 1,711
The recommended BCF value calculated using the geometric mean of 4 laboratory values as follows:			
1,250	Geyer, Viswanathan, Freitag, and Korte (1981)	1-day exposure duration	*Chlorella fusca*
2,055 2,534 1,781	Korte, Freitag, Geyer, Klein, Kraus, and Lahaniatis (1978)	1-day exposure duration; the values reported in Korte, Freitag, Geyer, Klein, Kraus, and Lahaniatis (1978) were converted to wet weight using an unit conversion factor of 2.92 [a].	*Chlorella fusca*
1,266	Wang, Harada, Watanabe, Koshikawa, and Geyer (1996)	Not reported	*Chlorella fusca*
Pesticides			
Compound: 4,4'-DDE			Recommended BCF value: 11,251
The recommended BCF value was based on one study as follows:			
11,251	Metcalf, Sanborn, Lu, and Nye (1975)	33-day exposure duration	*Oedogonium cardiacum*
Compound: Heptachlor			Recommended BCF value: 21,000
The recommended BCF value was based on one study as follows:			
21,000	U.S. EPA (1979)	Not reported	Algae

TABLE C-4

WATER-TO-ALGAE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

Reported Values[a]	Reference	Experimental Parameters	Species
Compound: Hexachlorophene			Recommended BCF value: 1,500
The recommended BCF value was based on one study as follows:			
1,500	Sanborn (1974)	Not reported	Algae
Inorganics			
Compound: Aluminum			Recommended BCF value: 833
The recommended BCF value was based on one study as follows:			
600	Thompson, Burton, Quinn, and Ng (1972)	Not reported	Algae (marine plants)
Compound: Antimony			Recommended BCF value: 1,475
The recommended value was calculated using the geometric mean of 2 laboratory values as follows:			
1,500 1,450	Thompson, Burton, Quinn, and Ng (1972)	Not reported	Not reported
Compound: Arsenic			Recommended BCF value: 293
The recommended value was calculated using the geometric mean of 3 laboratory values as follows:			
5	Anderson et al. (1979)	42-day exposure duration	*Lemna minor*
3,000 1,670	Thompson, Burton, Quinn, and Ng 1972	Not reported	Not reported
Compound: Barium			Recommended BCF value: 260
The recommended BCF value was based on one study as follows:			
260	Schroeder (1970)	Not reported	Brown algae
Compound: Beryllium			Recommended BCF value: 141
The recommended value was calculated using the geometric mean of 2 laboratory values as follows:			
20 1,000	Thompson, Burton, Quinn, and Ng (1972)	Not reported	Not reported

TABLE C-4

WATER-TO-ALGAE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

(Page 9 of 12)

Reported Values[a]	Reference	Experimental Parameters	Species
Compound: Cadmium			Recommended BCF value: 782
The recommended BCF value was calculated using the geometric mean of 6 laboratory values as follows:			
300 1,000 370 1,000	Fisher, Bohe, and Teyessie (1984)	Not reported	*Thalassiosira pseudonana* *Dunaliella tertiolecta* *Emiliania huxleyi* *Oscillatoria woronichinii*
2,065	Hutchinson and Czyrska (1972)	21-day exposure duration; The values reported in Hutchinson and Czyrska (1972) were converted to wet weight using a conversion factor of 2.92 [a].	*Lemna valdiviana*
1,000	Thompson, Burton, Quinn, and Ng (1972)	Not reported	Not reported
Compound: Chromium (total)			Recommended BCF value: 4,406
The recommended BCF value was calculated using the geometric mean of 8 laboratory values as follows:			
343	Jouany, Vasseur, and Ferard (1982)	28-day exposure duration; the values reported in Jouany, Vasseur, and Ferard (1982) were converted to wet weight using an unit conversion factor of 2.92 [a].	*Chlorella vulgaris*
1,600	NAS (1974)	Not reported	Benthic algae
26,316 8,485 29,000 5,000	Patrick, Bott, and Larson (1975)	4 experiments consisting of 1-month exposure durations	Mixed algae
4,000 2,000	Thompson, Burton, Quinn, and Ng (1972)	Not reported	Not reported
Compound: Copper			Recommended BCF value: 541
The recommended BCF value was calculated using the geometric mean of 5 laboratory values as follows:			
17	Bastien and Cote (1989)	50-day exposure duration	*Scenedesmus quadricauda*
827 1,644	Stokes, Hutchinson, and Krauter (1973)	2-day exposure duration	*Scenedesmus* sp.

TABLE C-4

WATER-TO-ALGAE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

(Page 10 of 12)

Reported Values[a]	Reference	Experimental Parameters	Species
2,000 1,000	Thompson, Burton, Quinn, and Ng (1972)	Not reported	Freshwater and marine plants
Compound: Cyanide (total)			Recommended BCF value: 22
The recommended BCF value was based on one study as follows:			
22	Low and Lee (1981)	72-hour exposure duration	*Eichhornia crassipes*
Compound: Lead			Recommended BCF value: 1,706
The recommended BCF value was calculated using the geometric mean of 3 laboratory values as follows:			
100 5,000	Thompson, Burton, Quinn, and Ng (1972)	Not reported	Not reported
9,931	Vighi (1981)	28-day exposure duration; the values reported in Vighi (1981) were converted to wet weight using an unit conversion factor of 2.92 [a].	*Selenastrum capricornutum*
Compound: Mercury chloride			Recommended BCF value: 24,762
The recommended BCF value was based on one study as follows:			
24,762	Watras and Bloom (1992)	Field samples	Phytoplankton
Compound: Methyl mercury			Recommended BCF value: 80,000
The recommended BCF value was based on one study as follows:			
80,000	Watras and Bloom (1992)	Field samples	Phytoplankton
Compound: Nickel			Recommended BCF value: 61
The recommended BCF value was calculated using the geometric mean of 4 laboratory values as follows:			
32 34	Hutchinson and Stokes (1975)	6-day exposure duration	*Scenedesmus* sp.
50 250	Thompson, Burton, Quinn, and Ng (1972)	Not reported	Not reported

TABLE C-4

WATER-TO-ALGAE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

(Page 11 of 12)

Reported Values[a]	Reference	Experimental Parameters	Species
Compound: Selenium			Recommended BCF value: 1,845
The recommended BCF value was calculated using the geometric mean of 3 laboratory values as follows:			
15,700	Besser, Canfield, and LaPoint (1993)	24-hour exposure duration	*Chlamydomonas reinhardtii*
400	Dobbs, Cherry, and Cairns (1996)	25-day exposure duration	*Chlorella vulgaris*
1,000	Thompson, Burton, Quinn, and Ng (1972)	Not reported	Not reported
Compound: Silver			Recommended BCF value: 10,696
The recommended BCF value was calculated using the geometric mean of 5 laboratory values as follows:			
34,000 13,000 24,000 66,000	Fisher, Bohe, and Teyssie (1984)	Not reported	*Thalassiosira pseudonana* *Dunaliella tertiolecta* *Emiliania huxleyi* *Oscillatoria woronichinii*
200	Thompson, Burton, Quinn, and Ng (1972)	Not reported	Not reported
Compound: Thallium			Recommended BCF value: 15,000
The recommendedBCF was based on one study as follows:			
15,000	Thompson, Burton, Quinn, and Ng (1972)	Not reported	Not reported
Compound: Zinc			Recommended BCF value: 2,175
The recommended BCF value was calculated using the geometric mean of 17 laboratory values as follows:			
285 4,395	Andryushhenko and Polikarpou (1973)	5-day exposure duration	*Ulva rigida*
4,680	Baudin (1974)	34-day exposure duration	*Cladophoea*
70 600 1,200 1,400 170,000	Deutch, Borg, Kloster, Meyer, and Moller (1980)	9-day exposure duration	*Codium fragile* *Enteromorpha* sp. *Ulva lactuca* *Fucus serratus* Marine plankton

TABLE C-4

WATER-TO-ALGAE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

(Page 12 of 12)

Reported Values[a]	Reference	Experimental Parameters	Species
12,000 10,000 4,600 5,200	Fisher, Bohe, and Teyssie (1984)	Not reported	*Thalassiosira pseudonana* *Dunaliella tertiolecta* *Emiliania huxleyi* *Oscillatoria woronichinii*
524 1,015	Munda (1979)	12-day exposure; The values reported in Munda (1979) were converted to wet weight using a conversion factor of 2.92 [a].	*Enteromorpha prolifera* *Fucus vivsoides*
255	U.S. EPA (1987a)	6-day exposure duration	*Ulva lactuca*
20,000 1,000	Thompson, Burton, Quinn, and Ng (1972)	Not reported	Not reported

Notes:

(a) The reported values are presented as the amount of COPC in algae divided by the amount of COPC in water. If the values reported in the studies were presented as dry tissue weight over the amount of COPC in water, they were converted to wet weight over dry weight by dividing the concentration in dry algae tissue weight by 2.92. This conversion factor assumes an algae total weight is 65.7 percent moisture (Isensee, Kearney, Woolson, Jones and Williams 1973). The conversion factor was calculated as follows:

$$Conversion\ factor = \frac{1.0\ g\ algae\ total\ weight}{1.0\ g\ algae\ total\ weight - 0.675\ g\ algae\ wet\ weight}$$

TABLE C-5

WATER-TO-FISH BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

(Page 1 of 19)

Reported Values	Reference	Experimental Parameters	Species
Dioxins and Furans			
Compound: 2,3,7,8-Tetrachlorinated dibenzo(p)dioxin (2,3,7,8-TCDD)			Recommended BCF value: 4,235
The recommended value was calculated using the geometric mean of 12 laboratory values for several PCDD compounds as follows:			
5,800	Adams, DeGraeve, Sabourin, Cooney, and Mosher (1986)	28-day exposure duration, 20-day elimination; reported data were for 2,3,7,8-tetrachlorodibenzo(p)dioxin (2,3,7,8-TCDD)	*Pimephales promelas*
9,270	Branson, Takahashi, Parker, and Blau (1985)	6-hour exposure duration, 139-day depuration	*Oncorhynchus mykiss*
39,000	Mehrle, Buckler, Little, Smith, Petty, Peterman, Stalling, DeGraeve, Coyle, and Adams (1988)	28-day exposure duration	*Oncorhynchus mykiss*
810 2,840 513 5,834	Muir, Marshall, and Webster (1985)	4 to 5-day exposure duration, 24 to 28-day depuration; values are based on a high to low range of reported values.	*Oncorhynchus mykiss* *Pimephales promelas*
2,769 2,269	Yockim, Isensee, and Jones (1978)	15-day exposure duration	*Gambusia affinis* *Ictalurus* sp.
5,000 9,300 7,900	U.S. EPA (1985)	Not reported	*Pimephales promelas*
Compound: 1,2,3,7,8-Pentachlorodibenzo(p)dioxin (1,2,3,7,8-PeCDD)			Recommended BCF value: 3,896
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =4,235 x 0.92 =3,896			
Compound: 1,2,3,4,7,8-Hexachlorodibenzo(p)dioxin (1,2,3,4,7,8-HxCDD)			Recommended BCF value: 1,313
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =4,235 x 0.31 =1313			
Compound: 1,2,3,6,7,8-Hexachlorodibenzo(p)dioxin (1,2,3,6,7,8-HxCDD)			Recommended BCF value: 508.2
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =4,235 x 0.12 =508.2			

TABLE C-5

WATER-TO-FISH BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

(Page 2 of 19)

Reported Values	Reference	Experimental Parameters	Species
Compound:	1,2,3,7,8,9-Hexachlorodibenzo(p)dioxin (1,2,3,7,8,9-HxCDD)		Recommended BCF value: 592.9
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =4,235 x 0.14 =592.9			
Compound:	1,2,3,4,6,7,8-Heptachlorodibenzo(p)dioxin (1,2,3,4,6,7,8-HpCDD)		Recommended BCF value: 215.9
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =4,235 x 0.051 =215.9			
Compound:	Octachlorodibenzo(p)dioxin (OCDD)		Recommended BCF value: 50.8
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =4,235 x 0.012 =50.8			
Compound:	2,3,7,8-Tetrachlorinated dibenzofuran (2,3,7,8-TCDF)Compound:		Recommended BCF value: 3,388
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =4,235 x 0.80 =3,388			
Compound:	1,2,3,7,8-Pentachlorodibenzo(p)furan (1,2,3,7,8-PeCDF)		Recommended BCF value: 931.7
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =4,235 x 0.22 =931.7			
Compound:	2,3,4,7,8-Pentachlorodibenzo(p)furan (2,3,4,7,8-PeCDF)		Recommended BCF value: 6,776
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =4,235 x1.6 =6,776			
Compound:	1,2,3,4,7,8-Hexachlorodibenzo(p)furan (1,2,3,4,7,8-HxCDF)		Recommended BCF value: 3,21.9
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =4,235 x 0.076 =3,21.9			
Compound:	1,2,3,6,7,8-Hexachlorodibenzo(p)furan (1,2,3,6,7,8-HxCDF)		Recommended BCF value: 804.7
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =4,235 x 0.19 =804.7			
Compound:	2,3,4,6,7,8-Hexachlorodibenzo(p)furan (2,3,4,6,7,8-HxCDF)		Recommended BCF value: 2,837
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =4,235 x 0.67 = 2,837			
Compound:	1,2,3,7,8,9-Hexachlorodibenzo(p)furan (1,2,3,7,8,9-HxCDF)		Recommended BCF value: 2,668
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =4,235 x 0.63 =2,668			

TABLE C-5

WATER-TO-FISH BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

Reported Values	Reference	Experimental Parameters	Species
Compound: 1,2,3,4,6,7,8,-Heptachlorodibenzo(p)furan (1,2,3,4,6,7,8-HpCDF)			Recommended BCF value: 46.6
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =4,235 x 0.011 =46.6			
Compound: 1,2,3,4,7,8,9-Heptachlorodibenzo(p)furan (1,2,3,4,7,8,9-HpCDF)			Recommended BCF value: 1,651
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =4,235 x 0.39 =1,651			
Compound: Octachlorodibenzo(p)furan (OCDF)			Recommended BCF value: 67.8
The BCF was calculated using the TCDD BCF and a bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =4,235 x 0.016 =67.8			
Polynuclear Aromatic Hydrocarbons (PAHs)			
Compound: Benzo(a)pyrene			Recommended BCF value: 500
The recommended value is that presented in Stephan (1993), which was the geometric mean of 16 laboratory values. This BCF for benzo(a)pyrene is also recommended for high molecular weight PAH for which empirical data are not available.			
500	Stephan (1993)	Not reported	Not reported
Compound: Benzo(a)anthracene			Recommended BCF value: 500
Empirical data were not available for this compound. The BCF for benzo(a)pyrene was used as a surrogate.			
Compound: Benzo(b)fluoranthene			Recommended BCF value: 500
Empirical data were not available for this compound. The BCF for benzo(a)pyrene was used as a surrogate.			
Compound: Benzo(k)fluoranthene			Recommended BCF value: 500
Empirical data were not available for this compound. The BCF for benzo(a)pyrene was used as a surrogate.			
Compound: Chrysene			Recommended BCF value: 500
Empirical data were not available for this compound. The BCF for benzo(a)pyrene was used as a surrogate.			
Compound: Dibenz(a,h)anthracene			Recommended BCF value: 500
Empirical data were not available for this compound. The BCF for benzo(a)pyrene was used as a surrogate.			

TABLE C-5

WATER-TO-FISH BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

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Reported Values	Reference	Experimental Parameters	Species
Compound: Indeno(1,2,3-cd)pyrene			Recommended BCF value: 500
Empirical data were not available for this compound. The BCF for benzo(a)pyrene was used as a surrogate.			
Polychlorinated Biphenyls (PCBs)			
Compound: Aroclor 1016			Recommended BCF value: 22,649
The recommended BCF value was calculated using the geometric mean of 4 field values as follows[b, c, d]:			
25,000	Hansen et al. (1975) as cited in U.S. EPA (1980b)	28 days exposure 1.1 percent lipid Adult	*Cyprinodon variegatus*
43,000	Hansen et al. (1975) as cited in U.S. EPA (1980b)	28 days exposure Whole body Juvenile	*Cyprinodon variegatus*
14,400	Hansen et al. (1975) as cited in U.S. EPA (1980b)	28 days exposure Whole body Fry	*Cyprinodon variegatus*
17,000	Hansen et al. (1974) as cited in U.S. EPA (1980b)	21 to 28 days exposure Whole body	*Lagodon rhomboides*
Compound: Aroclor 1254			Recommended BCF value: 230,394
The recommended BCF value was calculated using the geometric mean of 7 field values as follows[b, c, d]:			
238,000 females 235,000 males	Nebeker, Puglisi, and DeFoe (1974)	Fish exposed for eight months. Residues measured in males and females.	*Pimephales promeles*
35,481 354,813 281,838	Rice and White (1987)	Field study	*Pimephales promeles*
46,000	Bills and Marking (1987)	30-day exposure duration Whole body	*Oncorhynchus mykiss*

TABLE C-5

WATER-TO-FISH BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

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Reported Values	Reference	Experimental Parameters	Species
13,000,000 in lipid 1,030,000 dry tissue	Scura and Theilacker (1977)	45 days exposure	*Engraulis mordex*
370,000 1,200,000	Veith et al. (1977)	Field samples	Sculpins (bottom fish) Pelagic fish
47,000	Mauck et al. (1978) as cited in U.S. EPA (1980b)	118 days exposure Whole body	*Salvellnus fontinalis*
42,000	Snarski and Puglisi (1976) as cited in U.S. EPA (1980b)	500 days exposure Body lipid 2.9 percent Whole body	*Salvellnus fontinalis*
37,000	Hansen et al. (1971) as cited in EPA (1980b)	28 days exposure 1.1 percent lipid Whole body	*Leiostomus xanthurus*
30,000	Hansen et al. (1973) as cited in EPA (1980b)	28 days exposure 3.6 percent lipid Whole body	*Cyprinodon variegatus*
>670,00	Duke et al. (1970) and Nimmo et al. (1977) as cited in EPA (1980b)	Field data Whole body	*Cynoscion nebulosus*
>133,000	Nimmo et al. (1977) as cited in EPA (1980b)	Field data	Fishes
38,000	Halter (1974) as cited in EPA (1980b)	24 days exposure	*Salmo gairdneri*
61,200	Mayer et al. (1977) as cited in EPA (1980b)	77 days exposure Whole body	*Ictalurus punctatus*
Nitroaromatics			
Compound: 1,3-Dinitrobenzene			Recommended BCF value: 74
The BCF for 1,3 -dinitrobenzene was based on one laboratory value as follows:			
74	Deener, Sinnige, Seinen, and Hemens (1987)	3-day exposure duration	*Poecilia reticulata*
Compound: 2,4-Dinitrotoluene			Recommended BCF value: 21.04

TABLE C-5

WATER-TO-FISH BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

(Page 6 of 19)

Reported Values	Reference	Experimental Parameters	Species
Empirical data for this compound were not available. The BCF for nitrobenzene was used as a surrogate.			
Compound: 2,6-Dinitrotoluene			Recommended BCF value: 21.04
Empirical data for this compound were not available. The BCF for nitrobenzene used as a surrogate.			
Compound: Nitrobenzene			Recommended BCF value: 21.04
The recommended BCF value was calculated using the geometric mean of 2 laboratory values as follows:			
29.5	Deneer, Sinnige, Seinen, and Hermens (1987)	3-day exposure duration	*Poecilia reticulata*
15	Veith, DeFoe, and Bergstedt (1979)	28-day exposure duration	*Pimephales promelas*
Compound: Pentachloronitrobenzene			Recommended BCF value: 214
The recommended BCF value was calculated using the geometric mean of 7 laboratory values as follows:			
238	Kanazawa (1981)	Continuous flow test	*Pseudorasbora parva*
250 320 380	Korte, Freitag, Geyer, Klein, Kraus, and Lahaniatis (1978)	24-hr exposure duration	*Leucisens idus melanotus*
114 147 169	Niimi, Lee, and Kissoon (1989)	20, 28, and 36-day exposure duration	*Oncorhynchus mykiss*
Phthalate Esters			
Compound: Bis(2-ethylhexyl)phthalate			Recommended BCF value: 70
The recommended BCF value was calculated using the geometric mean of 14 laboratory values as follows:			
91 569	Mayer (1976)	56-day exposure duration; based on a high to low range of reported values.	*Pimephales promelas*
155 42	Mehrle and Mayer (1976)	36 to 56-day exposure	*Pimephales promelas* *Oncorhynchus mykiss*

TABLE C-5

WATER-TO-FISH BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

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Reported Values	Reference	Experimental Parameters	Species
178 10,563 306	Sodergren (1982)	27-day exposure duration	*Phoxinus phoxinus* *Lampetra planeri* *Pungitis pungitis*
51.5 8.9 1.6	Tarr, Barron, and Hayton (1990)	Not reported	*Salmo gairdneri*
4	U.S. EPA (1992a)	Not reported	Fish
851	Veith, DeFoe, and Bergstedt (1979)	Not reported	*Pimephales promelas*
10.7 13.5	Wofford, Wilsey, Neff, Giam, and Neff (1981)	24-hour exposure duration	*Cypinodon variegatus*
Compound: Di(n)octyl phthalate			Recommended BCF value: 9,400
The recommended BCF value was based on data from one study as follows:			
9,400	Sanborn, Metcalf, Yu, and Lu (1975)	Not reported	*Gambusia affinis*
Volatile Organic Compounds			
Compound: Acetone			Recommended BCF value: 0.10
Empirical data were not available for this compound. The BCF was calculated using the following regression equation: log BCF = 0.91 x log K_{ow} - 1.975 x log(6.8E-07 x K_{ow} + 1.0) - 0.786 (Bintein et al. 1993), where log K_{ow} = -0.222 (Karickoff and Long 1995)			
Compound: Acrylonitrile			Recommended BCF value: 48
The recommended BCF value was based on data from one study as follows:			
48	Barrows, Petrocelli, Macek, and Carroll (1978)	28-day exposure duration	*Lepomis macrochirus*
Compound: Chloroform			Recommended BCF value: 3.59
The recommended BCF value was calculated using the geometric mean of 3 laboratory values follows:			
5.6 3.44 2.4	Anderson and Lusty (1980)	24-hr exposure, 24-hr depuration	*Oncorhynchus mykiss* *Leponis macrochinus* *Micropterus salmoides*

TABLE C-5

WATER-TO-FISH BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

(Page 8 of 19)

Reported Values	Reference	Experimental Parameters	Species
Compound: Crotonaldehyde			Recommended BCF value: 0.52
Empirical data were not available for this compound. The BCF was calculated using the following regression equation: log BCF = 0.91 x log K_{ow} - 1.975 x log(6.8E-07 x K_{ow} + 1.0) - 0.786 (Bintein et al. 1993), where log K_{ow} = 0.55 (based on equation in Hansch and Leo 1979, as calculated in NRC (1981)).			
Compound: Formaldehyde			Recommended BCF value: 0.34
Empirical data were not available for this compound. The BCF was calculated using the following regression equation: log BCF = 0.91 x log K_{ow} - 1.975 x log(6.8E-07 x K_{ow} + 1.0) - 0.786 (Bintein et al. 1993), where log K_{ow} = 0.342 (U.S. EPA 1995a)			
Compound: Vinyl chloride			Recommended BCF value: 1.81
Empirical data were not available for this compound. The BCF was calculated using the following regression equation: log BCF = 0.91 x log K_{ow} - 1.975 x log(6.8E-07 x K_{ow} + 1.0) - 0.786 (Bintein et al. 1993), where log K_{ow} =1.146 (U.S. EPA 1994b)			
Other Chlorinated Organics			
Compound: Carbon tetrachloride			Recommended BCF value: 30
The recommended BCF value was based on 1 laboratory values as follows:			
30	Barrows, Petrocelli, Macek, and Carroll (1978)	28-day exposure duration	*Lepomis macrochirus*
Compound: Hexachlorobenzene			Recommended BCF value: 253
The recommended BCF value on 1 field value as follows[b, c]			
253	Oliver and Niimi (1988)	Field samples.	Freshwater fish
22,000	Carlson and Kosian (1987)	32-day exposure duration	*Pimephales promelas*
1,260 2,040 6,160 15,850	Isensee, Holden, Woolson, and Jones (1976)	31-day exposure duration	*Gambusia affinis* *Ictalurus punctatus*
290,000	Koneman and van Leeuwen (1980)	Not reported	*Poecilia reticulata*
400 420	Korte, Freitag, Geyer, Klein, Kraus, and Lahaniatis (1978)	1-day exposure duration	*Zeucisens idus melanotus*

TABLE C-5

WATER-TO-FISH BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

Reported Values	Reference	Experimental Parameters	Species
32,000 39,000	Kosian, Lemke, Studders, and Veith (1981)	28-day exposure duration	*Pimephales promelas*
5,200 6,970	Lores, Patrick, and Summers (1993)	30-day exposure duration; based on a high to low range of reported values.	*Cyprinodon variegatus*
93 287	Metcalf, Kapoor, Lu, Schuth, and Sherman (1973)	3 to 32-day exposure duration	*Gambusia affinis*
12,240 12,600 15,250 13,330 21,140	Nebeker, Griffis, Wise, Hopkins, and Barbittas (1989)	28-day exposure duration	*Pimephales promelas*
253,333	Oliver and Niimi (1983)	119-day exposure duration	*Oncorhynchus mykiss*
27,000	Schrap and Opperhuizen (1990)	Not reported	*Poecilia reticulata*
18,500	Veith, DeFoe, and Bergstedt (1979)	32-day exposure duration	*Pimephales promelas*
7,800	U.S. EPA (1987)	Not reported	*Oncorhynchus mykiss*
8,690	U.S. EPA (1980h)	Not reported	*Pimephales promelas*
253	Oliver and Niimi (1988)	Field samples.	Freshwater fish
Compound: Hexachlorobutadiene			Recommended BCF value: 783
The recommended BCF value was calculated using the geometric mean of 3 laboratory values as follows:			
920 1,200	Leeuwangh, Bult, and Schneiders (1975)	49-day exposure duration; 15-day depuration. The values reported in Leeuwangh, Bult, and Schneiders (1975) were converted to wet weight using an unit conversion factor of 5.0 [a].	*Carassius auratus*
435	Laska, Bartell, Laseter (1976)	Not reported	*Gambusia affinis*
Compound: Hexachlorocyclopentadiene			Recommended BCF value: 165
The recommended BCF value was calculated using the geometric mean of 6 laboratory values as follows:			

TABLE C-5

WATER-TO-FISH BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

Reported Values	Reference	Experimental Parameters	Species
1,230	Freitag, Geyer, Kraus, Viswanathan, Kotzias, Attar, Klein, and Korte (1982)	3-day exposure duration	*Leuciscus idus*
448	Lu and Metcalf (1975)	Not reported. The values reported in Lu and Metcalf (1975) were converted to wet weight using an unit conversion factor of 5.0 [a]	*Gambusia affinis*
100 1,148	Podowski and Khan (1984)	16-day exposure duration	*Carassius auratus*
11	Spehar, Veith, DeFoe, and Bergstedt (1979)	30-day exposure duration	*Pimephales promelas*
29	Veith, DeFoe, and Bergstedt (1979)	32-day exposure duration	*Pimephales promelas*
Compound: Pentachlorobenzene			Recommended BCF value: 12,690
The recommended BCF value was calculated using the geometric mean of 12 laboratory values as follows:			
5,100 7,100 7,300	Banerjee, Suggatt, and O'Grady (1984)	2-day exposure duration	*Lepomis macrochirus* *Oncorynchus mykiss* *Poecilia reticulata*
26,000	Bruggeman, Oppenhuizen, Wijbenga, and Hutzinger (1984)	Not reported	*Poecilia reticulata*
8,400	Carlson and Kosian (1987)	31-day exposure duration	*Pimephales promelas*
28,183	Ikemoto, Motoba, Suzuki, Uchida (1992)	24-hour exposure duration	*Oryzias latipes*
260,000	Konemann and van Leeuwen (1980)	Not reported	*Poecilia reticulata*
17,000	Opperhuizen, Velde, Gobas, Liem, and Steen (1985)	Multiple exposure durations	*Poecilia reticulata*
6,600	Qiao and Farrell (1996)	10-day exposure duration	*Oncorhynchus mykiss*
23,000	Schrap and Opperhuizen (1990)	Not reported	*Poecilia reticulata*
4,700	Van Hoogen and Opperhuizen (1988)	5-day exposure duration; 21-day depuration	*Poecilia reticulata*
3,400	Veith, Macek, Petrocelli, and Carroll (1980)	28-day exposure duration	*Lepomis macrochirus*

TABLE C-5

WATER-TO-FISH BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

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Reported Values	Reference	Experimental Parameters	Species
Compound: Pentachlorophenol			Recommended BCF value: 109
The recommended BCF value was calculated using the geometric mean of 20 laboratory values as follows:			
128 776	Garten and Trabalka (1983)	Not reported	Fish
189.5	Gates and Tjeerdema (1993)	1-day exposure duration	*Morone saxatilis*
2 131	Kobayashi and Kishino (1980)	1-hour exposure duration	*Carassius auratus*
350	Korte, Freitag, Geyer, Klein, Karus, and Lahaniatis (1978)	1-day exposure duration	*Zeucisens idus melanotus*
16 48 5 27	Parrish, Dyar, Enos, and Wilson (1978)	28 to 151-day exposure duration	*Cyprinodon variegatus*
30 38	Schimmel, Patrick, and Faas (1978)	28-day exposure duration	*Funidulus similis* *Mugil cephalus*
216	Smith, Bharath, Mallard, Orr, McCarty, and Ozburn (1990)	28-day exposure; 14-day depuration	*Jordanella floridae*
1,066 434 426 281	Spehar , Nelson, Swanson, and Renoos (1985)	32-day exposure duration	*Pimephales promelas*
52.3 607	Stehly and Hayton (1990)	96-hour exposure	*Carassius auratus*
770	Veith, DeFoe, and Bergstedt (1979)	32-day exposure	*Pimephales promelas*
Pesticides			
Compound: 4,4-DDE			Recommended BCF value: 25,512

TABLE C-5

WATER-TO-FISH BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

Reported Values	Reference	Experimental Parameters	Species
The recommended BCF value was calculated using the geometric mean of 11 laboratory values as follows:			
12,037	Metcalf, Sanborn, Lu, and Nye (1975)	Not reported	Fish
51,285 27,542	Garten and Trabalka (1983)	Freshwater	Fish
5,010 110,000 106,000 181,000	Hamelink and Waybrant (1976)	Not reported	*Lepomis macrochirus* *Oncorhynchus mykiss*
27,358	Metcalf, Sangha, and Kapoor (1971)	33-day exposure duration	*Gambusia affinis*
217 27,358	Metcalf, Kapoor, Lu, Schuth, and Sherman (1973)	3 to 33-day exposure duration	*Gambusia affinis*
81,000	Oliver and Niimi (1985)	96-day exposure duration	*Oncorhynchus mykiss*
51,000	Veith, DeFoe, and Bergstedt (1979)	32-day exposure duration	*Pimephales promelas*
Compound: Heptachlor			Recommended BCF value: 5,522
The recommended BCF value was calculated using the geometric mean of 7 laboratory values as follows:			
3,700 2,400 4,600	Goodman, Hansen, Couch, and Forester (1978)	28-day exposure duration	*Cyprinodon variegatus*
3,600 10,000	Schimmel, Patrick, and Forester (1976)	96-hour exposure duration	*Leiostomus xanthurus*
11,200	U.S. EPA (1980a)	Not reported	Fish
9,500	Veith, DeFoe, and Bergstedt (1979)	32-day exposure duration	*Pimephales promelas*
Compound: Hexachlorophene			Recommended BCF value: 278
The recommended BCF value was based on data from one study as follows:			
278	Sanborn (1974)	Not reported	*Oncorhychus mykiss*

TABLE C-5

WATER-TO-FISH BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

Reported Values	Reference	Experimental Parameters	Species
Inorganics			
Compound: Aluminum			Recommended BCF value: 2.70
The recommended BCF value was calculated using the geometric mean of 7 laboratory values as follows:			
0.05 1.25 0.05 0.35	Cleveland, Little, Hamilton, Buckler, and Hunn (1986)	37-day exposure duration	*Salvelinus fontinalis*
36 123 215	Cleveland, Buckler, and Brumbaugh (1991)	56-day exposure duration; 28-day depuration	*Salvelinus fontinalis*
Compound: Antimony			Recommended BCF value: 40
The recommended BCF value was based on one study as follows:			
40	Thompson, Burton, Quinn, and Ng (1972)	Not reported	Fish
Compound: Arsenic			Recommended BCF value: 114
The recommended BCF value was calculated using the geometric mean of 3 laboratory values as follows:			
333 100	Thompson, Burton, Quinn, and Ng (1972)	Not reported	Fish
44	U.S. EPA (1992b)	Not reported	Fish
Compound: Barium			Recommended BCF value: 633
Empirical data for this compound were not available. The recommended BCF is the arithmetic mean of the recommended values for 14 inorganics with empirical data available (aluminum, antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc).			
Compound: Beryllium			Recommended BCF value: 62
The recommended BCF value was calculated using the geometric mean of 4 laboratory values as follows:			

TABLE C-5

WATER-TO-FISH BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

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Reported Values	Reference	Experimental Parameters	Species
200 200	Thompson, Burton, Quinn, and Ng (1972)	Not reported	Fish
19	U.S. EPA (1992b)	Not reported	Fish
19	U.S. EPA (1978)	28-day exposure duration	Fish
Compound: Cadmium			Recommended BCF value: 907
The recommended BCF value was calculated using the geometric mean of 4 field values.			
558 1,295 729 1,286	Saiki, Castleberry, May, Martin, and Ballard (1995)	Field samples. The field values reported in Saiki, Castleberry, May, Martin, and Ballard (1995) were converted to wet weight using a conversion factor of 5.0[a]. The field values are also based on mean values calculated for each of the 4 fish species.	*Catostomus occidentalis* *Gasterosteus aculeatus* *Ptychocheilus grandis* *Oncorhynchus tshawytasch*
716	Benoit, Leonard, Christensen, and Fiandt (1976)	38-week exposure duration; based on mean values calculated from various tissue concentrations in the kidney, liver, spleen, gonad, gills, and muscle/red blood cells. A unit conversion of 1,000 was applied to the value.	*Salvelinus fontanilis*
480	Eisler, Zaroogian, and Hennekey (1972)	3-week exposure duration	*Fundulus heteroclitus*
161 51	Harrison and Klaverkamp (1989)	72-day exposure duration, 25 and 63-day depuration	*Oncorhynchus mykiss* *Coregonus clupeatormis*
33	Kumada, Kimura, and Yokote (1980)	10 week exposure duration	*Oncorhynchus mykiss*
8 3,333	Kumada, Kimura, Yokote, and Matida (1973)	280-day exposure; values are based on a high to low range of values. The values reported in Kumada, Kimura, Yokote, and Matida (1973) were converted to wet weight using a conversion factor of 5.0[a].	*Oncorhynchus mykiss*
4.4	Spehar (1976)	30-day exposure duration	*Jordanella floridae*
3,000 200	Thompson, Burton, Quinn and Ng (1972)	Not reported	Fish

TABLE C-5

WATER-TO-FISH BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

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Reported Values	Reference	Experimental Parameters	Species
4,100	Williams and Giesy (1979)	56-day exposure duration	Fish
Compound: Chromium (total)			Recommended BCF value: 19
The recommended BCF value was calculated using the geometric mean of 4 laboratory values as follows:			
1.27 1.34	Fromm and Stokes (1962)	30-day exposure duration; values are based on a high to low range of reported values.	*Oncorhynchus mykiss*
200 400	Thompson, Burton, Quinn, and Ng (1972)	Not reported	Fish
Compound: Copper			Recommended BCF value: 710
The recommended BCF value was calculated using the geometric mean of 4 field values as follows:			
761 697 1,236 387	Saiki, Castleberry, May, Martin, and Ballard (1995)	Field samples	*Catostomus occidentalis* *Gasterosteus aculeatus* *Ptychocheilus grandis* *Oncorhynchus tshawytasch*
50 500 667	Thompson, Burton, Quinn, and Ng (1972)	Not reported	Fish
36	U.S. EPA (1992b)	Not reported	Fish

TABLE C-5

WATER-TO-FISH BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

(Page 16 of 19)

Reported Values	Reference	Experimental Parameters	Species
Compound: Cyanide (total)			Recommended BCF value: 633
Empirical data for this compound were not available. The recommended BCF is the arithmetic mean of the recommended values for 14 inorganics with empirical data available (aluminum, antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc).			
Compound: Lead			Recommended BCF value: 0.09
The recommended BCF value based on one field value:			
0.09	Atchinson, Murphy, Bishop, McIntosh, and Mayes (1977)	Field samples. The values reported in Atchinson, Murphy, Bishop, McIntosh, and Mayes (1977) were converted to wet weight using a conversion factor of 5.0[a].	*Lepomis macrochiras*
0.15 0.17	Holcombe, Benoit, Leonard, and McKim (1976)	266-day exposure duration. The values reported in Holcombe, Benoit, Leonard, and McKim (1976) were converted to wet weight using a conversion factor of 5.0[a]. Mean values were calculated based on tissue concentrations in the red blood cells, kidney, and muscle.	*Salvelinus fontanilis*
300 100	Thompson, Burton, Quinn, and Ng (1972)	Not reported	Fish
Compound: Mercuric chloride			Recommended BCF value: 3,530
The recommended BCF value was calculated using the geometric mean of 3 laboratory values as follows:			
1,800	Boudou and Ribeyre (1984)	60-day exposure duration	*Oncorhynchus mykiss*
4,380 5,580	Snarski and Olson (1982)	287-day exposure duration; values are based on a high to low range of reported values.	*Pimephales promelas*
Compound: Methyl mercury			Recommended BCF value: 11,168
The recommended BCF value was calculated using the geometric mean of 3 laboratory values as follows:			
11,000	Boudou and Ribeyre (1984)	60-day exposure duration	*Oncorhynchus mykiss*

TABLE C-5

WATER-TO-FISH BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

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Reported Values	Reference	Experimental Parameters	Species
10,800 11,724	McKim, Olson, Holcome, and Hunt (1976)	756-day exposure duration	*Salvelinus fontinalis*
Compound: Nickel			Recommended BCF value: 78
The recommended BCF value was calculated using the geometric mean of 3 laboratory values as follows:			
100 100	Thompson, Burton, Quinn, and Ng (1972)	Not reported	Fish
47	U.S. EPA (1992b)	Not reported	Fish
Compound: Selenium			Recommended BCF value: 129
The recommended BCF value was calculated using the geometric mean of 12 laboratory values as follows:			
18	Adams (1976)	96-day exposure duration	Fish
4,900	Besser, Canfield, and LaPoint (1993)	30-day exposure duration	*Lepomis reinhardtii*
5 7	Cleveland , Little, Buckler, and Wiedmeyer (1993)	60-day exposure duration; values are based on a high to low range of reported values.	*Lepomis macrochirus*
154 711	Dobbs, Cherry, and Cairns (1996)	25-day exposure duration	*Pimephales promelas*
3 240	Hodson, Spry, and Blunt (1980)	351-day exposure duration; values represent a high to low range of reported values based on BCFs for peritoneal fat and the liver.	*Oncorhynchus mykiss*
285 465	Lemly (1982)	120-day exposure duration	*Micropterus salmoides* *Lepomis macrochirus*
4,000 167	Thompson, Burton, Quinn, and Ng (1972)	Not reported	Fish
Compound: Silver			Recommended BCF value: 87.71
The recommended BCF value was calculated using the geometric mean of 2 laboratory values as follows:			
3,330	Thompson, Burton, Quinn, and Ng (1972)	Not reported	Fish

TABLE C-5

WATER-TO-FISH BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

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Reported Values	Reference	Experimental Parameters	Species
Compound: Thallium			Recommended BCF value: 10,000
The recommended BCF value was calculated using the geometric mean of 2 laboratory values as follows:			
10,000 10,000	Thompson, Burton, Quinn, and Ng (1972)	Not reported	Fish
Compound: Zinc			Recommended BCF value: 2,059
The recommended BCF value was calculated using the geometric mean of 4 field values as follows:			
2,299 2,265 4,290 804	Saiki, Castleberry, May, Martin, and Ballard (1995)	Field samples.	*Catostomus occidentalis* *Gasteroteus aculeatus* *Ptychocheilus grandis* *Oncorhynchus tshawytasch*
50 130 130 200	Deutch, Borg, Kloster, Meyer, and Moller (1980)	9-day exposure duration	*Spinachia vulgaris* *Gasterosteus acul.* *Pungitius pungitius* *Cottus scorpius*
373 8,853	Pentreath (1973)	180-day exposure duration; values are based on a high to low range of reported values	*Pleuronectes platessa*
1,000 2,000 2,000	Thompson, Burton, Quinn and Ng (1972)	Not reported	Fish
47	U.S. EPA (1992b)	Not reported	Fish

Notes:

(a) The reported values are presented as the amount of COPC in fish tissue divided by the amount of COPC in water. If the values reported in the studies were presented as dry tissue weight, they were converted to wet weight by dividing the concentration in dry fish tissue weight by 5.0. This conversion factor assumes a fish's total weight is 80.0 percent moisture (Holcomb, Benoit, Leonard, and McKim 1976).

TABLE C-5

WATER-TO-FISH BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg dissolved COPC / L water)

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The conversion factor was calculated as follows:

$$\text{Conversion factor} = \frac{1.0 \; g \; \text{fish total weight}}{1.0 \; g \; \text{fish total weight} - 0.80 \; g \; \text{fish wet weight}}$$

(b) The equation used to convert the total organic COPC concentrations in field samples to dissolved COPC concentrations is from U.S. EPA (1995a) as follows:

$BAF\ (dissolved) = (BAF\ (total) / f_{fd}) - 1$

where: $BAF\ (dissolved)$ = BAF based on dissolved concentration of COPC in water
$BAF\ (total)$ = BAF based on the field derived data for total concentration of COPC in water
f_{fd} = Fraction of COPC that is freely dissolved in the water
where: $f_{fd} = 1 / [1 + ((DOC \times K_{ow}) / 10) + (POC \times K_{ow})]$
DOC = Dissolved organic carbon, Kg of organic carbon / L of water (2.0×10^{-06} kg/L)
K_{ow} = Octanol-water partition coefficient of the COPC, as reported in U.S. EPA (1994b)
POC = Particulate organic carbon, Kg of organic carbon / L of water (7.5×10^{-09} Kg/L)

(c) The reported field *BAF*s were converted to *BCF*s as follows:

$BCF = (BAF_{TLn} / FCM_{TLn}) - 1$

where: BAF_{TLn} = The reported field bioaccumulation factor for the trophic level “n” of the study species.
FCM_{TLn} = The food chain multiplier for the trophic level “n” of the study species.

(d) PCB values were converted to dissolved COPC BCFs based on the K_{ow} for Aroclor 1254.

(e) The geometric mean of the converted field derived BCFs was compared to the geometric mean of the laboratory derived BCFs. The higher of the two values was selected as the COPC BCF.

TABLE C-6

SEDIMENT-TO-BENTHIC INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg COPC / kg dry sediment)

(Page 1 of 11)

Reported Values[a]	Reference	Experimental Parameters	Species
Dioxins and Furans			
Compound: 2,3,7,8-Tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD)			Recommended BCF value: 19,596
Empirical data for this compound were not available. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 6.64 (U.S. EPA 1994a)			
Compound: 1,2,3,7,8-Pentachlorodibenzo(p)dioxin (1,2,3,7,8-PeCDD)			Recommended BCF value: 18,023
The BCF was calculated using the TCDD BCF and a congener-speccific bioaccumulation equivalency factor (BEF) (U.S. EPA 1995b) as follows: BCF =19,596 x 0.92 =3,896			
Compound: 1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (1,2,3,4,7,8-HxCDD)			Recommended BCF value: 6,075
The BCF was calculated using the TCDD BCF and a congener-specific BEF (U.S. EPA 1995b) as follows: BCF =19,596 x 0.31 =1313			
Compound: 1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (1,2,3,6,7,8-HxCDD)			Recommended BCF value: 2,351
The BCF was calculated using the TCDD BCF and a congener-specific BEF (U.S. EPA 1995b) as follows: BCF =19,596 x 0.12 =2,351			
Compound: 1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (1,2,3,7,8,9-HxCDD)			Recommended BCF value: 2,743
The BCF was calculated using the TCDD BCF and a congener-specific BEF (U.S. EPA 1995b) as follows: BCF =19,596 x 0.14 =2,743			
Compound: 1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (1,2,3,4,6,7,8-HpCDD)			Recommended BCF value: 99.4
The BCF was calculated using the TCDD BCF and a congener-specific BEF (U.S. EPA 1995b) as follows: BCF =19,596 x 0.051 =99.4			
Compound: Octachlorodibenzo-p-dioxin (OCDD)			Recommended BCF value: 23.5
The BCF was calculated using the TCDD BCF and a congener-specific BEF (U.S. EPA 1995b) as follows: BCF =19,596 x 0.012 =23.5			
Compound: 2,3,7,8-Tetrachlorodibenzofuran (2,3,7,8-TCDF)			Recommended BCF value: 2,642
The BCF was calculated using the TCDD BCF and a congener-specific BEF (U.S. EPA 1995b) as follows: BCF = 3,302 x0.80 = 2,642			
Compound: 1,2,3,7,8-Pentachlorodibenzo-p-furan (1,2,3,7,8-PeCDF)			Recommended BCF value: 4,311
The BCF was calculated using the TCDD BCF and a congener-specific BEF (U.S. EPA 1995b) as follows: BCF =19,596 x 0.22 =4,311			
Compound: 2,3,4,7,8-Pentachlorodibenzo-p-furan (2,3,4,7,8-PeCDF)			Recommended BCF value: 31,354
The BCF was calculated using the TCDD BCF and a congener-specific BEF (U.S. EPA 1995b) as follows: BCF =19,596 x 1.6 =31,354			

TABLE C-6

SEDIMENT-TO-BENTHIC INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg COPC / kg dry sediment)

(Page 2 of 11)

Reported Values[a]	Reference	Experimental Parameters	Species
Compound:	1,2,3,4,7,8-Hexachlorodibenzo-p-furan (1,2,3,4,7,8-HxCDF)		Recommended BCF value: 1,489
The BCF was calculated using the TCDD BCF and a congener-specific BEF (U.S. EPA 1995b) as follows: BCF =19,596 x 0.076 =1,489			
Compound:	1,2,3,6,7,8-Hexachlorodibenzo-p-furan (1,2,3,6,7,8-HxCDF)		Recommended BCF value: 3,723
The BCF was calculated using the TCDD BCF and a congener-specific BEF (U.S. EPA 1995b) as follows: BCF =19,596 x 0.19 =3,723			
Compound:	2,3,4,6,7,8-Hexachlorodibenzo-p-furan (2,3,4,6,7,8-HxCDF)		Recommended BCF value: 13,129
The BCF was calculated using the TCDD BCF and a congener-specific BEF (U.S. EPA 1995b) as follows: BCF =19,596 x 0.67 = 13,129			
Compound:	1,2,3,7,8,9-Hexachlorodibenzo-p-furan (1,2,3,7,8,9-HxCDF)		Recommended BCF value: 12,345
The BCF was calculated using the TCDD BCF and a congener-specific BEF (U.S. EPA 1995b) as follows: BCF =19,596 x 0.63 =12,345			
Compound:	1,2,3,4,6,7,8,-Heptachlorodibenzo-p-furan (1,2,3,4,6,7,8-HpCDF)		Recommended BCF value: 215.6
The BCF was calculated using the TCDD BCF and a congener-specific BEF (U.S. EPA 1995b) as follows: BCF =19,596 x 0.011 =215.6			
Compound:	1,2,3,4,7,8,9-Heptachlorodibenzo-p-furan (1,2,3,4,7,8,9-HpCDF)		Recommended BCF value: 7,642
The BCF was calculated using the TCDD BCF and a congener-specific (U.S. EPA 1995b) as follows: BCF =19,596 x 0.39 =7,642			
Compound:	Octachlorodibenzo-p-furan (OCDF)		Recommended BCF value: 313.5
The BCF was calculated using the TCDD BCF and a congener-specific BEF (U.S. EPA 1995b) as follows: BCF =19,596 x 0.016 =313.5			
Polynuclear Aromatic Hydrocarbons (PAHs)			
Compound:	Benzo(a)pyrene		Recommended BCF value: 1. 59
The recommended BCF value was calculated using the geometric mean of 8 values as follows:			
5.2 2.8	Augenfeld, Anderson, Riley, and Thomas (1982)	60-day exposure duration	*Macoma inquinata* *Abarenicola pacifica*
0.4 0.65 7.4	Driscoll and McElroy (1996)	6 to 12-day exposure duration	*Nereis diversicolor* *Scolecolipides virdis* *Leitoscoloplos fragilis*

TABLE C-6

SEDIMENT-TO-BENTHIC INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg COPC / kg dry sediment)

(Page 3 of 11)

Reported Values[a]	Reference	Experimental Parameters	Species
2.3 6.9	Landrum, Eadie, and Faust (1991)	Mixture of PAH at four concentrations	*Diporeia* sp.
0.09	Roesijadi, Anderson, and Blaylock (1978)	7-day exposure duration	*Macoma inquinata*
Compound: Benzo(a)anthracene			Recommended BCF value: 1.45
Empirical data for this compound were not available. Therefore, the BCF for benzo(a)pyrene was used as a surrogate.			
Compound: Benzo(b)fluoranthene			Recommended BCF value: 1.61
Empirical data for this compound were not available. Therefore, the BCF for benzo(a)pyrene was used as a surrogate.			
Compound: Benzo(k)fluoranthene			Recommended BCF value: 1.61
Empirical data for this compound were not available. Therefore, the BCF for benzo(a)pyrene was used as a surrogate.			
Compound: Chrysene			Recommended BCF value: 1.38
BCF value was calculated using the geometric mean of 3 values as follows:			
0.04	Roesijadi, Anderson, and Blaylock (1978)	7-day exposure duration	*Macoma inquinata*
11.6 5.64	Augenfeld, Anderson, Riley, and Thomas (1982)	60-day exposure duration	*Macoma inquinata* *Abarenicola pacifica*
Compound: Dibenz(a,h)anthracene			Recommended BCF value: 1.61
Empirical data for this compound were not available. Therefore, the BCF for benzo(a)pyrene was used as a surrogate.			
Compound: Indeno(1,2,3-cd)pyrene			Recommended BCF value: 1.61
Empirical data for this compound were not available. Therefore, the BCF for benzo(a)pyrene was used as a surrogate.			
Polychlorinated Biphenyls (PCBs)			
Compound: Aroclor 1016			Recommended BCF value: 0.53
The recommended BCF value was calculated using the geometric mean of 2 empirical values as follows:			

TABLE C-6

SEDIMENT-TO-BENTHIC INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg COPC / kg dry sediment)

(Page 4 of 11)

Reported Values[a]	Reference	Experimental Parameters	Species
0.2 1.4	Wood, O'Keefe, and Bush (1997)	12-day exposure duration; 1-day depuration	*Chironomus tentans*
Compound: Aroclor 1254			Recommended BCF value: 0.53
The recommended BCF value was calculated using the geometric mean of 2 empirical values as follows:			
0.2 1.4	Wood, O'Keefe, and Bush (1997)	12-day exposure duration; 1-day depuration	*Chironomus tentans*
Nitroaromatics			
Compound: 1,3-Dinitrobenzene			Recommended BCF value: 1.19
Empirical data for this compound were not available. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 1.491 (U.S. EPA 1994b)			
Compound: 2,4-Dinitrotoluene			Recommended BCF value: 58
The recommended BCF value was based on 1 study as follows:			
58	Liu, Bailey, and Pearson (1983)	4-day exposure duration	*Lumbriculus variegatus*
Compound: 2,6-Dinitrotoluene			Recommended BCF value: 2.50
Empirical data for this compound were not available. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 1.886 (U.S. EPA 1994b)			
Compound: Nitrobenzene			Recommended BCF value: 2.27
Empirical data were not available for this compound. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 1.833 (U.S. EPA 1994b)			
Compound: Pentachloronitrobenzene			Recommended BCF value: 451
Empirical data for this compound were not available. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 4.640 (U.S. EPA 1994b)			
Phthalate Esters			
Compound: Bis(2-ethylhexyl)phthalate			Recommended BCF value: 1,309

TABLE C-6

SEDIMENT-TO-BENTHIC INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg COPC / kg dry sediment)

(Page 5 of 11)

Reported Values[a]	Reference	Experimental Parameters	Species
Empirical data for this compound were not available. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 5.205 (U.S. EPA 1994b)			
Compound: Di(n)octyl phthalate			Recommended BCF value: 3,128,023
Empirical data for this compound were not available. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 9.330 (U.S. EPA 1994b)			
Volatile Organic Compounds			
Compound: Acetone			Recommended BCF value: 0.05
Empirical data for this compound were not available. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = -0.222 (Karickoff and Long 1995)			
Compound: Acrylonitrile			Recommended BCF value: 0.11
Empirical data for this compound were not available. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 0.250 (Karickoff and Long 1995)			
Compound: Chloroform			Recommended BCF value: 2.82
Empirical data for this compound were not available. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 1.949 (U.S. EPA 1994b)			
Compound: Crotonaldehyde			Recommended BCF value: 0.20
Empirical data for this compound were not available. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 0.55 (based on equations developed by Hansch and Leo 1979, as calculated in NRC 1981)			
Compound: 1,4-Dioxane			Recommended BCF value: 0.04
Empirical data for this compound were not available. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = -0.268 (U.S. EPA 1995a)			
Compound: Formaldehyde			Recommended BCF value: 0.14
Empirical data for this compound were not available.The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 0.342 (U.S. EPA 1995a)			
Compound: Vinyl chloride			Recommended BCF value: 0.62

TABLE C-6

SEDIMENT-TO-BENTHIC INVERTEBRATE BIOCONCENTRATION FACTORS (mg COPC / kg wet tissue) / (mg COPC / kg dry sediment)

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Reported Values[a]	Reference	Experimental Parameters	Species
Empirical data for this compound were not available. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 1.146 (U.S. EPA 1994b)			
Other Chlorinated Organics			
Compound: Carbon tetrachloride			Recommended BCF value: 12
Empirical data for this compound were not available. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 2.717 (U.S. EPA 1994b)			
Compound: Hexachlorobenzene			Recommended BCF value: 2,296
Empirical data for this compound were not available. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 5.503 (U.S. EPA 1994b)			
Compound: Hexachlorobutadiene			Recommended BCF value: 0.44
The recommended BCF value was based on empirical data from one study as follows:			
0.44	Oliver (1987)	79-day exposure duration; The values reported in Oliver (1987) were converted to wet weight over dry weight using a conversion factor of 5.99[a].	Oligochaetes
Compound: Hexachlorocyclopentadiene			Recommended BCF value: 746
Empirical data for this compound were not available. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 4.907 (U.S. EPA 1994b)			
Compound: Pentachlorobenzene			Recommended BCF value: 0.32
The recommended BCF value is based on 1 study as follows:			
0.32	Oliver (1987)	79-day exposure duration; The values reported in Oliver (1987) were converted to wet weight over dry weight using a conversion factor of 5.99[a].	Oligochaetes
Compound: Pentachlorophenol			Recommended BCF value: 1,034
Empirical data for this compound were not available. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 5.080 (U.S. EPA 1994b)			

TABLE C-6

SEDIMENT-TO-BENTHIC INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg COPC / kg dry sediment)

(Page 7 of 11)

Reported Values[a]	Reference	Experimental Parameters	Species
Pesticides			
Compound: 4,4'-DDE			Recommended BCF value: 0.95
The recommended BCF value was calculated using the geometric mean of 13 values as follows:			
2.9 1.3 0.4 0.2 2.2 0.1 1.2 9.6 2.1 24.6 1.8 0.1 0.07	Reich, Perkins, and Cutter (1986)	Field samples	Tubificidae Chironomidae Croixidae
Compound: Heptachlor			Recommended BCF value: 1.67
Empirical data for heptachlor were not available. The BCF was calculated from 1 field-derived value for heptachlor epoxide as follows:			
10.0	Beyer and Gish (1980)	Field samples; The value reported in Beyer and Gish (1980) was converted to wet weight over dry weight using a conversion factor of 5.99[a].	*Aporrectodea trapezoides* *Aparrectodea turgida* *Allolobophora chlorotica* *Lumbricus terrestris*
Compound: Hexachlorophene			Recommended BCF value: 106,970
Empirical data for this compound were not available. The BCF was calculated using the following regression equation: log BCF = 0.819 x log K_{ow} - 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K_{ow} = 7.540 (Karickoff and Long 1995)			
Inorganics			
Compound: Aluminum			Recommended BCF value: 0.90
Empirical data for this compound were not available. The recommended BCF value is the arithmetic average of 6 recommended values for those metals with empirical data (cadmium, chromium, copper, lead, inorganic mercury, and zinc).			
Compound: Antimony			Recommended BCF value: 0.90
Empirical data for this compound were not available. The recommended BCF value is the arithmetic average of 6 recommended values for those metals with empirical data (cadmium, chromium, copper, lead, inorganic mercury, and zinc).			

TABLE C-6

SEDIMENT-TO-BENTHIC INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg COPC / kg dry sediment)

(Page 8 of 11)

Reported Values[a]		Reference	Experimental Parameters	Species
Compound:	Arsenic			Recommended BCF value: 0.90
Empirical data for this compound were not available. The recommended BCF value is the arithmetic average of 6 recommended values for those metals with empirical data (cadmium, chromium, copper, lead, inorganic mercury, and zinc).				
Compound:	Barium			Recommended BCF value: 0.90
Empirical data for this compound were not available. The recommended BCF value is the arithmetic average of 6 recommended values for those metals with empirical data (cadmium, chromium, copper, lead, inorganic mercury, and zinc).				
Compound:	Beryllium			Recommended BCF value: 0.90
Empirical data for this compound were not available. The recommended BCF value is the arithmetic average of 6 recommended values for those metals with empirical data (cadmium, chromium, copper, lead, inorganic mercury, and zinc).				
Compound:	Cadmium			Recommended BCF value: 3.4
The recommended BCF value was calculated using the geometric mean of 8 field-derived values as follows:				
3.33 1.79 1.67 2.27	7.68 7.15 2.34 6.29	Saiki, Castleberry, May, Martin, and Bullard (1995)	Field samples; The values reported in Saiki, Castleberry, May, Martin, and Bullard (1995) were converted to wet weight over dry weight using a conversion factor of 5.99[a].	Chironomidae Epheroptera
Compound:	Chromium (total)			Recommended BCF value: 0.39
The recommended BCF value was based on 1 field-derived value as follows:				
0.39		Namminga and Wilhm (1977)	Field samples	Chironomidae
0.03 0.001	0.07 0.003	Capuzzo and Sasner (1977)	168-day exposure duration; The reported value was calculated by dividing the tissue concentration by the media concentration [(µg/g)/(mg/g)] and a conversion factor of $1x10^{-3}$ was applied to the value. A conversion factor of 5.99[a] was applied to convert dry tissue weight to wet weight.	*Mya arenaria*
Compound:	Copper			Recommended BCF value: 0.30

TABLE C-6

SEDIMENT-TO-BENTHIC INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg COPC / kg dry sediment)

(Page 9 of 11)

Reported Values[a]	Reference	Experimental Parameters	Species
The recommended BCF value was calculated using the geometric mean of 9 field values as follows:			
0.11 0.13 0.22 0.32	Jones, Jones, and Radlett (1976)	25-day exposure duration; The values reported in Jones, Jones, and Radlett (1976) were converted to wet weight over dry weight using a conversion factor of 5.99[a].	*Nereis diveriscolor*
1.1	Namminga and Wilhm (1977)	Field samples	Chironomidae
0.29 0.31 0.36 0.36 0.16 0.06 0.73 0.25	Saiki, Castleberry, May, Martin and Bullard (1995)	Field samples; The values reported in Saiki, Castleberry, May, Martin and Bullard (1995) were converted to wet weight over dry weight using a conversion factor of 5.99[a].	Chironomidae Ephemeroptera
Compound: Cyanide (total)			Recommended BCF value: 0.90
Empirical data were not available for this compound. The recommended BCF value is the arithmetic average of 6 recommended values for those metals with empirical data (cadmium, chromium, copper, lead, inorganic mercury, and zinc).			
Compound: Lead			Recommended BCF value: 0.63
The recommended BCF value was based on 1 study follows:			
0.4 1.0	Harrahy and Clements (1997)	14-day exposure duration	*Chironomus tentans*
Compound: Mercuric chloride			Recommended BCF value: 0.068
The recommended BCF value was based on 6 field values as follows:			
0.08	Saouter, Hare, Campbell, Boudou, and Ribeyre (1993)	9-day exposure duration	*Hexagenia rigida*
0.16 0.04 0.08 0.08 0.04 0.06	Hildebrand, Strand, and Huckabee (1980)	Field samples	Hydropsychidae, Corydalus, Decapoda, Aterix, Psephenidae, and unspecified other benthic invertebrates
Compound: Methyl mercury			Recommended BCF value: 0.48
The recommended BCF value was based on 6 field values as follows:			

TABLE C-6

SEDIMENT-TO-BENTHIC INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg COPC / kg dry sediment)

(Page 10 of 11)

Reported Values[a]	Reference	Experimental Parameters	Species
4.0	Saouter, Hare, Campbell, Boudou, and Ribeyre (1993)	9-day exposure duration	*Hexagenia rigida*
1.45 0.41 0.50 0.37 0.26 0.44	Hildebrand, Strand, and Huckabee (1980)	Field samples	Hydropsychidae, Corydalus, Decapoda, Aterix, Psephenidae, and unspecified other benthic invertebrates
Compound: Nickel			Recommended BCF value: 0.90
Empirical data for this compound were not available. The recommended BCF value is the arithmetic average of 6 recommended values for those metals with empirical data (cadmium, chromium, copper, lead, inorganic mercury, and zinc).			
Compound: Selenium			Recommended BCF value: 0.90
Empirical data for this compound were not available. The recommended BCF value is the arithmetic average of 6 recommended values for those metals with empirical data (cadmium, chromium, copper, lead, inorganic mercury, and zinc).			
Compound: Silver			Recommended BCF value: 0.90
Empirical data for this compound were not available. The recommended BCF value is the arithmetic average of 6 recommended values for those metals with empirical data (cadmium, chromium, copper, lead, inorganic mercury, and zinc).			
Compound: Thallium			Recommended BCF value: 0.90
Empirical data for this compound were not available. The recommended BCF value is the arithmetic average of 6 recommended values for those metals with empirical data (cadmium, chromium, copper, lead, inorganic mercury, and zinc).			
Compound: Zinc			Recommended BCF value: 0.57
The recommended BCF value was calculated using the geometric mean of 8 field values as follows:			
3.6	Namminga and Wilhm (1977)	Not reported	Chironomidae
0.46 0.83 0.38 1.16 0.13 0.39 0.79 1.57	Saiki, Castleberry, May, Martin, and Bullard (1995)	Field samples; the values reported in Saiki, Castleberry, May, Martin and Bullard (1995) were converted to wet weight over dry weight using an unit conversion factor of 5.99[a].	Chironomidae Ephemeroptera

TABLE C-6

SEDIMENT-TO-BENTHIC INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg COPC / kg dry sediment)

(Page 11 of 11)

Notes:

(a) The reported values are presented as the amount of compound in invertebrate tissue divided by the amount of compound in the sediment. If the values reported in the studies were presented as dry tissue weight over dry sediment weight, they were converted to wet weight over dry weight by dividing the concentration in dry invertebrate tissue weight by 5.99. This conversion factor assumes an earthworm’s total weight is 83.3 percent moisture (Pietz et al. 1984).

The conversion factor was calculated as follows:

$$Conversion\ factor = \frac{1.0\ g\ invertebrate\ total\ weight}{1.0\ g\ invertebrate\ total\ weight - 0.833\ g\ invertebrate\ wet\ weight}$$

TABLE C-7

AIR-TO-PLANT BIOTRANSFER FACTORS
(µg COPC / g dry plant) / (µg COPC / g air)

(Page 1 of 3)

Compound	*Bv* Value[a]	Compound	*Bv* Value
Dioxins and furans			
2,3,7,8-Tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD)	6.55E+04	1,2,3,7,8-Pentachlorodibenzo-p-furan (1,2,3,7,8-PeCDF)	9.75E+04
1,2,3,7,8-Pentachlorodibenzo(p)dioxin (1,2,3,7,8-PeCDD)	2.39E+05	2,3,4,7,8-Pentachlorodibenzo-p-furan (2,3,4,7,8-PeCDF)	9.75E+04
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (1,2,3,4,7,8-HxCDD)	5.20E+05	1,2,3,4,7,8-Hexachlorodibenzo-p-furan (1,2,3,4,7,8-HxCDF)	1.62E+05
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (1,2,3,6,7,8-HxCDD)	5.20E+05	1,2,3,6,7,8-Hexachlorodibenzo-p-furan (1,2,3,6,7,8-HxCDF)	1.62E+05
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (1,2,3,7,8,9-HxCDD)	5.20E+05	2,3,4,6,7,8-Hexachlorodibenzo-p-furan (2,3,4,6,7,8-HxCDF)	1.62E+05
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (1,2,3,4,6,7,8-HpCDD)	9.10E+05	1,2,3,7,8,9-Hexachlorodibenzo-p-furan (1,2,3,7,8,9-HxCDF)	1.62E+05
Octachlorodibenzo-p-dioxin (OCDD)	2.36E+06	1,2,3,4,6,7,8,-Heptachlorodibenzo-p-furan (1,2,3,4,6,7,8-HpCDF)	8.30E+05
2,3,7,8-Tetrachlorodibenzofuran (2,3,7,8-TCDF)	4.57E+04	1,2,3,4,7,8,9-Heptachlorodibenzo-p-furan (1,2,3,4,7,8,9-HpCDF)	8.30E+05
Octachlorodibenzo-p-furan (OCDF)	2.28E+06		
Polynuclear aromatic hydrocarbons (PAHs)			
Benzo(a)pyrene	2.25E+05	Chrysene	5.97E+04
Benzo(a)anthracene	1.72E+04	Dibenzo(a,h)anthracene	4.68E+07
Benzo(b)fluoranthene	3.65E+04	Ideno(1,2,3-cd)pyrene	2.67E+08
Benzo(k)fluoranthene	5.40E+05		
Polychlorinated biphenyls (PCBs)			
Aroclor 1016	7.52E+01	Aroclor 1254	3.09E+02
Nitroaromatics			
1,3-Dinitrobenzene	1.74E+01	Nitrobenzene	2.43E-01
2,4-Dintrotoluene	5.10E+01	Pentachloronitrobenzene	1.71E-01

TABLE C-7

AIR-TO-PLANT BIOTRANSFER FACTORS
(µg COPC / g dry plant) / (µg COPC / g air)

(Page 2 of 3)

Compound	*Bv* Value[a]	Compound	*Bv* Value
2,6-Dinitrotoluene	4.41E+01		
Phthalate esters			
Bis(2-ethylhexyl)phthalate	2.33E+03	Di(n)octyl phthalate	6.30E+08
Volatile organic compounds			
Acetone	1.13E-03	1,4-Dioxane	5.93E-03
Acrylonitrile	1.04E-03	Formaledehyde	4.65E-04
Chloroform	1.65E-03	Vinyl chloride	2.95E-06
Crotonaldehyde	Not Available		
Other chlorinated organics			
Carbon Tetrachloride	1.52E-03	Pentachlorphenol	1.02E+03
Hexachlorbenzene	7.57E+01	4,4'-DDE	2.08E+03
Hexachlorobutadiene	2.55E-01	Heptachlor	2.09E+03
Hexachlorocyclopentadiene	5.47E-01	Hexachlorophene	1.23E+10
Pentachlorobenzene	6.04E-01		
Inorganics			
Aluminum	0	Lead	0
Antimony	0	Mercuric chloride	1.80E+03
Arsenic	0	Methyl mercury	Not Applicable
Barium	0	Nickel	0
Beryllium	0	Selenium	0

TABLE C-7

AIR-TO-PLANT BIOTRANSFER FACTORS
(µg COPC / g dry plant) / (µg COPC / g air)

(Page 3 of 3)

Compound	*Bv* Value[a]	Compound	*Bv* Value
Cadmium	0	Silver	0
Chromium (hexavalent)	0	Thallium	0
Copper	0	Zinc	0
Cyanide (total)	0		

Notes:

(a) The reported values were obtained from the references cited in Section C-1.7, and are consistent with the values provided in U.S. EPA (1998). Values for dioxin and furan congeners were obtained from the following:

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APPENDIX D

BIOCONCENTRATION FACTORS (*BCF*s) FOR WILDLIFE MEASUREMENT RECEPTORS

Screening Level Ecological Risk Assessment Protocol

August 1999

APPENDIX D

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APPENDIX D

WILDLIFE MEASUREMENT RECEPTOR *BCF*s

Appendix D provides recommended guidance for determining values for compound-specific, media to receptor, bioconcentration factors (*BCF*s) for wildlife measurement receptors. Wildlife measurement receptor *BCF*s should be based on values reported in the scientific literature, or estimated using physical and chemical properties of the compound. Guidance on use of *BCF* values in the screening level ecological risk assessment is provided in Chapter 5.

Section D-1.0 provides the general guidance recommended to select or estimate compound *BCF* values for wildlife measurement receptors. Sections D-1.0 through D-1.3 further discuss determination of *BCF*s for specific media and receptors. References cited in Sections D-1.1 through D-1.3 are located following Section D-1.3.

For the compounds commonly identified in risk assessments for combustion facilities (identified in Chapter 2) and the mammal and bird example measurement receptors listed in Chapter 4, *BCF* values have been determined following the guidance in Sections D-1.0 through D-1.3. *BCF* values for these limited number of compounds and pathways are included in this appendix (see Tables D-1 through D-3) to facilitate the completion of screening ecological risk assessments. However, it is expected that *BCF* values for additional compounds and receptors may be required for evaluation on a site specific basis. In such cases, *BCF* values for these additional compounds could be determined following the same guidance (Sections D-1.0 through D-1.3) used in determination of the *BCF* values reported in this appendix. For the calculation of *BCF* values for measurement receptors not represented in Sections D-1.1 through D1-3 (e.g., amphibians and reptiles), an approach consistent to that presented in this appendix could be utilized by applying data applicable to those measurement receptors being evaluated.

For additional discussion on some of the references and equations cited in Sections D-1.0 through D-1.3, the reader is recommended to review the Human Health Risk Assessment Protocol (HHRAP) (U.S. EPA 1998) (see Appendix A-3), and the source documents cited in the reference section of this appendix.

D-1.0 GENERAL GUIDANCE

This section describes general procedures for developing compound-specific *BCF*s from biotransfer factors (*Ba*) for assessing exposure of measurement receptors. A biotransfer factor is the ratio of the compound concentration in fresh (wet) weight animal tissue to the daily intake of compound by the animal through ingestion of food items and media (soil, sediment, surface water). Therefore, as discussed in Chapter 5, biotransfer factors and receptor-specific ingestion rates can be used to calculate food item- and media-to-animal *BCF*s. This approach provides an estimate of biotransfer of compounds from applicable food items and media to measurement receptors ingesting these items.

Biotransfer factors could also be used directly in equations to calculate dose to measurement receptors. However, in order to promote consistency in evaluating exposure across all trophic levels within complex food webs, *BCF*s calculated from *Ba* values are recommended in this guidance for evaluating measurement receptors. The use of *Ba* values to determine *BCF* values, and the use of *BCF* values in general, for the estimation of compound concentrations in measurement receptors may introduce uncertainty. Major factors that influence the uptake of a compound by an animal, and therefore uncertainty, include bioavailability, metabolic rate, type of digestive system, and feeding behavior. Uncertainties also should be considered regarding the development of biotransfer values in comparison to how they are being applied for estimating exposure. For example, biotransfer values may be used to estimate contaminant uptake to species from items ingested that differ from the species and intakes used to empirically develop the values. Also, biotransfer data reported in literature may be specific to tissue or organ analysis versus whole body. As a result, *BCF*s may be under- or over-estimated to an unknown degree.

BCFs for Measurement Receptors Ingesting Food Items *BCF* values for measurement receptors ingesting food items (plants or prey) can be calculated using the compound specific *Ba* value applicable to the animal (e.g., mammal, bird, etc.) and the measurement receptor-specific ingestion rate as follows:

$$BCF_{F-A} = Ba_A \cdot IR_F \qquad \text{Equation D-1-1}$$

where

BCF_{F-A} = Bioconcentration factor for food item (plant or prey)-to-animal (measurement receptor) [(mg COPC/kg FW tissue)/(mg COPC/kg FW food item)]
Ba_A = COPC-specific biotransfer factor applicable for the animal (day/kg FW tissue)
IR_F = Measurement receptor food item ingestion rate (kg FW/day)

As an example of applying the above equation, *BCF* values for plants-to-wildlife measurement receptors listed in Chapter 4 are provided in Table D-1 at the end of this appendix. Measurement-receptor specific ingestion rates used to calculate *BCF*s are presented in Table 5-1. *Ba* values applicable to the mammal and bird measurement receptors in Table D-1 are discussed in Sections D-1.1 and D-1.2, respectively.

BCFs for Measurement Receptors Ingesting Media *BCF* values for measurement receptors in trophic levels 2, 3, and 4 ingesting media (i.e., soil, surface water, and sediment) can be calculated using the compound specific *Ba* value applicable to the animal (e.g., mammal, bird, etc.) and the measurement receptor-specific ingestion rate as follows:

$$BCF_{M-A} = Ba_A \cdot IR_M \qquad \text{Equation D-1-2}$$

where

BCF_{M-A} = Bioconcentration factor for media-to-animal (measurement receptor) [(mg COPC/kg FW tissue)/(mg COPC/kg WW or DW media)]
Ba_A = COPC-specific biotransfer factor applicable for the animal (day/kg FW tissue)

IR_M = Measurement receptor media ingestion rate (WW or DW kg/day)

Equation D-1-2 assumes that Ba_A provides a reasonable estimate of the uptake of a compound from incidental ingestion of abiotic media during foraging.

As an example of applying the above equation, *BCF* values for various wildlife measurement receptors listed in Chapter 4 are provided in Table D-2 (water) and Table D-3 (soil and sediment). Measurement-receptor specific ingestion rates used to calculate *BCF*s are presented in Table 5-1. *Ba* values applicable to the mammal and bird measurement receptors for which values were calculated are discussed in Sections D-1.1 and D-1.2, respectively.

BCFs for Dioxins and Furans As discussed in Chapter 2, the *BCF* values for PCDDs and PCDFs are calculated using bioaccumulation equivalency factors (*BEF*s). Consistent with U.S. EPA (1995b), *BEF*s are expressed relative to the *BCF* for 2,3,7,8-TCDD as follows:

$$BCF_j = BCF_{2,3,7,8-TCDD} \cdot BEF_j \qquad \text{Equation D-1-3}$$

where

BCF_j = Food item-to-animal or media-to-animal *BCF* for *j*th PCDD or PCDF congener for food item-to-animal pathway [(mg COPC/kg FW tissue)/(mg COPC/kg FW plant)]or media-to-animal pathway [(mg COPC/kg FW tissue)/(mg COPC/kg WW media)]

$BCF_{2,3,7,8\text{-}TCDD}$ = Food item-to-animal or media-to-animal *BCF* for 2,3,7,8-TCDD

$BEFj$ = Bioaccumulation equivalency factor for *j*th PCDD or PCDF congener (unitless)

The use of *BEF*s for dioxin and furan congeners is further discussed in Chapter 2.

D-1.1 BIOTRANSFER FACTORS FOR MAMMALS (Ba_{mammal})

As discussed in Section D-1.0, calculation of *BCF* values to be used in pathways for mammals ingesting food items and media requires the determination of COPC-specific biotransfer factors for mammal measurement receptors (Ba_{mammal}). This section discusses selection of the Ba_{mammal} values used to calculate the COPC and measurement receptor specific BCF values presented in Tables D-1 through D-3.

Organics For organics (except PCDDs and PCDFs), the following correlation equation from Travis and Arms (1988) was used to derrive Ba_{mammal} values on a FW basis:

$$\log Ba_{mammal} = -7.6 + \log K_{ow} \qquad \text{Equation D-1-4}$$

where

Ba_{mammal} = Biotransfer factor for mammals (day/kg FW tissue)
K_{ow} = Octanol-water partition coefficient (unitless)

To calculate the values presented in Tables D-1 through D-3, COPC-specific K_{ow} values were obtained from Appendix A-2.

Biotransfer factors obtained from Travis and Arms (1988) were derived from correlation equations developed from data on experiments conducted with beef cattle ingesting food items and media containing compound classes such as DDT, pesticides, PCDDs, PCDFs, and PCBs. As further literature is developed for other species and compounds, the Travis and Arms (1988) correlation equation should be compared for applicability to species and compound, and best fit correlation for estimation of uptake.

PCDDs and PCDFs Ba_{mammal} values for PCDD and PCDFs were derrived from *Ba* values for cattle as presented in:

- U.S. EPA 1995a. "Further Studies for Modeling the Indirect Exposure Impacts from Combustor Emissions." Memorandum from Matthew Lorber, Exposure Assessment Group, and Glenn Rice, Environmental Criteria and Assessment Office, Washington, D.C. January 20.

U.S. EPA (1995a) determined *Ba* values for cattle from McLachlan, Thoma, Reissinger, and Hutzinger (1990). These empirically determined *Ba* values were recommended by U.S. EPA (1995a) over the Travis and Arms (1988) correlation equation for dioxins and furans.

Inorganics For metals (except cadmium, mercury, selenium, and zinc), *Ba* values on a fresh weight basis were obtained from Baes, Sharp, Sjoreen, and Shor (1984). For cadmium, selenium, and zinc, U.S. EPA (1995a) indicated that *Ba* values were derived by dividing uptake slopes [(g compound/kg DW tissue)/(g compound/kg DW feed)], obtained from U.S. EPA (1992), by a daily consumption rate of 20 kilograms DW per day by cows.

For use in calculating *BCF* values presented in Tables D-1 through D-3 of this appendix, dry weight *Ba* values were converted to fresh weight basis by assuming a tissue moisture content (by mass) of 70 percent for cows. Moisture content information was obtained from the following:

- U.S. EPA. 1997a. *Exposure Factors Handbook.* "Food Ingestion Factors". Volume II. EPA/600/P-95/002Fb. August.

- Pennington, J.A.T. 1994. *Food Value of Portions Commonly Used*. Sixteenth Edition. J.B. Lippincott Company, Philadelphia.

Mercuric Compounds Based on assumptions made regarding speciation and fate and transport of mercury from stack emissions (as discussed in Chapter 2), elemental mercury is assumed not to deposit onto soils, water, or plants. Therefore, it is also not available in food items or media for ingestion and subsequent uptake by measurement receptors. As a result, no *BCF* values for elemental mercury are presented in Tables D-1 through D-3 of this appendix. If site-specific field data suggest otherwise, *Ba* values for elemental mercury can be derived from uptake slope factors provided in U.S. EPA (1992) and U.S. EPA (1995a), using the same consumption rates as were discussed earlier for the metals like cadmium, selenium, and zinc.

Ba_{mammal} values for mercuric chloride and methyl mercury were derived from data in U.S. EPA (1997b). U.S. EPA (1997b) provides *Ba* values for mercury in cows, but does not specify the form of mercury. To obtain the *Ba* values for mercuric chloride and methyl mercury presented in Tables D-1 through D-3 of this guidance, consistent with U.S. EPA (1997b) total mercury was assumed to be composed of 87 percent divalent mercury (as mercuric chloride) and 13 percent methyl mercury in herbivore animal tissue. Also, assuming that the *Ba* value provided in U.S. EPA (1997b) is for the total mercury in the animal tissue, then biotransfer factors in U.S. EPA (1997b) can be determined for mercuric chloride and methyl mercury, as follows:

- The default *Ba* value of 0.02 day/kg DW for total mercury obtained from U.S. EPA (1997b) was converted to a fresh weight basis assuming a 70 percent moisture content in cow tissue (U.S. EPA 1997a; Pennington 1994). The fresh weight *Ba* value for total mercury was multiplied by 0.13 to obtain a Ba_{mammal} value for methyl mercury, and by 0.87 to obtain a Ba_{mammal} value for mercuric chloride.

D-1.2 BIOTRANSFER FACTORS FOR BIRDS (Ba_{bird})

As discussed in Section D-1.0, calculation of *BCF* values to be used in pathways for birds ingesting food items and media requires the determination of COPC-specific biotransfer factors for bird measurement receptors (Ba_{bird}). This section discusses selection of the Ba_{bird} values used to calculate the COPC and measurement receptor specific *BCF* values presented in Tables D-1 through D-3.

Organics Ba_{bird} values for organic compounds (except PCDDs and PCDFs) were derived from Ba_{mammal} values by assuming that the lipid content (by mass) of birds and mammals is 15 and 19 percent, respectively. Therefore, Ba_{bird} values presented in Tables D-1 through D-3 were determined by multiplying Ba_{mammal} values by the bird and mammal fat content ratio of 0.8 (15/19).

Notable uncertainties associated with this approach include (1) extent to which specific organic compounds bioconcentrate in fatty tissues, and (2) differences in lipid content, metabolism, and feeding characteristics between species.

PCDDs and PCDFs Ba_{bird} values presented in Tables D-1 through D-3 for PCDD and PCDF congeners were derrived from data provided in the following:

- Stephens, R.D., M. Petreas, and G.H. Hayward. 1995. "Biotransfer and Bioaccumulation of Dioxins and Furans from Soil: Chickens as a Model for Foraging Animals." *The Science of the Total Environment.* Volume 175. Pages 253-273.

Stephens, Petreas, and Hayward (1995) conducted experiments to determine the bioavailability and the rate of PCDDs and PCDFs uptake from soil by foraging chickens. Three groups of White Leghorn chickens were studied─control group, low exposure group, and high exposure group. Eggs, tissues (liver, adipose, and thigh), feed, and feces were analyzed.

Congener specific Ba_{bird} values were derrived from the Stephens, Petreas, and Hayward (1995) study by dividing estimated whole body bioconcentration values for the high exposure group by a daily consumption rate of soil. If congener specific *BCF* values were not reported for the high exposure group, then estimated whole body values were determined using reported data for the low exposure group, if available. A default consumption rate of soil by chicken of 0.02 kg DW/day was determined as follows:

(1) Consumption rate of feed by chicken was obtained from U.S. EPA (1995a), which cites a value of 0.2 kg (DW) feed/day obtained from various literature sources.

(2) The fraction of feed that is soil (0.1) was obtained from Stephens, Petreas, and Hayward (1995).

(3) Feed consumption rate of 0.2 kg/day was multiplied by fraction of feed that is soil (0.1), to obtain the soil consumption rate by chicken of 0.2 x 0.1 = 0.02 kg DW soil/day.

<u>Inorganics</u> For metals (except cadmium, selenium, and zinc), Ba_{bird} values were not available in the literature. For cadmium, selenium, and zinc, U.S. EPA (1995a) cites *Ba* values that were derived by dividing uptake slopes [(g compound/kg dry DW tissue)/(g compound/kg DW feed)], obtained from U.S. EPA (1992), by a daily ingestion rate of 0.2 kilograms DW per day by poultry. To determine *BCF* values presented in Tables D-1 through D-3 in this appendix, reported dry weight *Ba* values were converted to fresh weight basis by assuming a tissue moisture content (by mass) of 75 percent for poultry (U.S. EPA 1997a; Pennington 1994).

<u>Mercuric Compounds</u> Based on assumptions made regarding speciation and fate and transport of mercury from stack emissions (as discussed in Chapter 2), elemental mercury is assumed not to deposit onto soils, water, or plants. Therefore, it is also not available in food items or media for ingestion and subsequent uptake by measurement receptors. As a result, no *BCF* values for elemental mercury are presented in Tables D-1 through D-3 of this appendix. If site-specific field data suggest otherwise, *Ba* values for elemental mercury can be derived from uptake slope factors provided in U.S. EPA (1992) and U.S. EPA (1995a), using the same consumption rates as were discussed earlier for the metals like cadmium, selenium, and zinc.

Ba_{bird} values for mercuric chloride and methyl mercury were derived from data in U.S. EPA (1997b). U.S. EPA (1997b) provides *Ba* values for mercury in poultry, but does not specify the form of mercury. To obtain the *Ba* values for mercuric chloride and methyl mercury presented in Tables D-1 through D-3 of this guidance, consistent with U.S. EPA (1997b) total mercury was assumed to be composed of 87 percent divalent mercury (as mercuric chloride) and 13 percent methyl mercury in herbivore animal tissue. Also, assuming that the *Ba* value provided in U.S. EPA (1997b) is for the total mercury in the animal tissue, then biotransfer factors in U.S. EPA (1997b) can be determined for mercuric chloride and methyl mercury, as follows:

- The default *Ba* value of 0.02 day/kg DW for total mercury obtained from U.S. EPA (1997b) was converted to a fresh weight basis assuming a 75 percent moisture content in poultry tissue (U.S. EPA 1997a; Pennington 1994). The fresh weight *Ba* value for total mercury was multiplied by 0.13 to obtain a Ba_{bird} value for methyl mercury, and by 0.87 to obtain a Ba_{bird} value for mercuric chloride.

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TABLES OF MEASUREMENT RECEPTOR *BCF* VALUES

Screening Level Ecological Risk Assessment Protocol

August 1999

TABLE D-1

BIOCONCENTRATION FACTORS FOR PLANTS TO WILDLIFE MEASUREMENT RECEPTORS

(Page 1 of 3)

	Measurement Receptor													
Compound	**American Robin (BCF$_{TP-OB}$)**	**Canvas Back (BCF $_{TP-HB}$)**	**Deer Mouse (BCF$_{TP-HM}$)**	**Least Shrew (BCF$_{TP-OM}$)**	**Mallard Duck (BCF$_{TP-OB}$)**	**Marsh Rice Rat (BCF$_{TP-OM}$)**	**Marsh Wren (BCF$_{TP-OB}$)**	**Mourning Dove (BCF$_{TP-HB}$)**	**Muskrat (BCF$_{TP-OM}$)**	**Northern Bobwhite (BCF$_{TP-OB}$)**	**Salt-marsh Harvest Mouse (BCF$_{TP-HM}$)**	**Short-tailed Shrew (BCF$_{TP-OM}$)**	**Western Meadow Lark (BCF$_{TP-OM}$)**	**White-footed Mouse (BCF$_{TP-OM}$)**
Dioxins and Furans														
2,3,7,8-TCDD	1.53e+02	6.85e+01	3.25e-02	3.37e-02	6.16e+01	2.39e-02	3.19e+02	1.20e+02	1.45e-02	1.20e+02	4.02e-02	3.37e-02	1.45e+02	3.33e-02
1,2,3,7,8-PeCDD	1.41e+02	6.30e+01	2.99e-02	3.10e-02	5.67e+01	2.20e-02	2.93e+02	1.11e+02	1.33e-02	1.11e+02	3.70e-02	3.10e-02	1.33e+02	3.07e-02
1,2,3,4,7,8-HxCDD	4.74e+01	2.12e+01	1.01e-02	1.04e-02	1.91e+01	7.41e-03	9.88e+01	3.72e+01	4.50e-03	3.72e+01	1.25e-02	1.04e-02	4.49e+01	1.03e-02
1,2,3,6,7,8-HxCDD	1.83e+01	8.22e+00	3.91e-03	4.04e-03	7.39e+00	2.87e-03	3.83e+01	1.44e+01	1.74e-03	1.44e+01	4.83e-03	4.04e-03	1.74e+01	4.00e-03
1,2,3,7,8,9-HxCDD	2.14e+01	9.59e+00	4.56e-03	4.71e-03	8.63e+00	3.35e-03	4.46e+01	1.68e+01	2.03e-03	1.68e+01	5.63e-03	4.71e-03	2.03e+01	4.67e-03
1,2,3,4,6,7,8-HpCDD	7.79e+00	3.49e+00	1.66e-03	1.72e-03	3.14e+00	1.22e-03	1.63e+01	6.13e+00	7.40e-04	6.13e+00	2.05e-03	1.72e-03	7.39e+00	1.70e-03
OCDD	1.83e+00	8.22e-01	3.91e-04	4.04e-04	7.39e-01	2.87e-04	3.83e+00	1.44e+00	1.74e-04	1.44e+00	4.83e-04	4.04e-04	1.74e+00	4.00e-04
2,3,7,8-TCDF	1.22e+02	5.48e+01	2.60e-02	2.69e-02	4.93e+01	1.91e-02	2.55e+02	9.61e+01	1.16e-02	9.61e+01	3.22e-02	2.69e-02	1.16e+02	2.67e-02
1,2,3,7,8-PeCDF	3.36e+01	1.51e+01	7.16e-03	7.41e-03	1.36e+01	5.26e-03	7.01e+01	2.64e+01	3.19e-03	2.64e+01	8.85e-03	7.41e-03	3.19e+01	7.34e-03
2,3,4,7,8-PeCDF	2.44e+02	1.10e+02	5.21e-02	5.39e-02	9.86e+01	3.83e-02	5.10e+02	1.92e+02	2.32e-02	1.92e+02	6.44e-02	5.39e-02	2.32e+02	5.34e-02
1,2,3,4,7,8-HxCDF	1.16e+01	5.21e+00	2.47e-03	2.56e-03	4.68e+00	1.82e-03	2.42e+01	9.13e+00	1.10e-03	9.13e+00	3.06e-03	2.56e-03	1.10e+01	2.53e-03
1,2,3,6,7,8-HxCDF	2.90e+01	1.30e+01	6.18e-03	6.40e-03	1.17e+01	4.54e-03	6.06e+01	2.28e+01	2.76e-03	2.28e+01	7.64e-03	6.40e-03	2.75e+01	6.34e-03
2,3,4,6,7,8-HxCDF	1.02e+02	4.59e+01	2.18e-02	2.26e-02	4.13e+01	1.60e-02	2.14e+02	8.05e+01	9.72e-03	8.05e+01	2.70e-02	2.26e-02	9.70e+01	2.23e-02
1,2,3,7,8,9-HxCDF	9.63e+01	4.32e+01	2.05e-02	2.12e-02	3.88e+01	1.51e-02	2.01e+02	7.57e+01	9.14e-03	7.57e+01	2.53e-02	2.12e-02	9.13e+01	2.10e-02
1,2,3,4,6,7,8-HpCDF	1.68e+00	7.54e-01	3.58e-04	3.70e-04	6.78e-01	2.63e-04	3.51e+00	1.32e+00	1.60e-04	1.32e+00	4.43e-04	3.70e-04	1.59e+00	3.67e-04
1,2,3,4,7,8,9-HpCDF	5.96e+01	2.67e+01	1.27e-02	1.31e-02	2.40e+01	9.33e-03	1.24e+02	4.69e+01	5.66e-03	4.69e+01	1.57e-02	1.31e-02	5.65e+01	1.30e-02
OCDF	2.44e+00	1.10e+00	5.21e-04	5.39e-04	9.86e-01	3.83e-04	5.10e+00	1.92e+00	2.32e-04	1.92e+00	6.44e-04	5.39e-04	2.32e+00	5.34e-04
Polynuclear Aromatic Hydrocarbons (PAHs)														
Benzo(a)pyrene	1.19e-02	5.32e-03	2.03e-02	2.10e-02	4.78e-03	1.49e-02	2.47e-02	9.32e-03	9.03e-03	9.32e-03	2.50e-02	2.10e-02	1.12e-02	2.08e-02
Benzo(a)anthracene	4.20e-03	1.88e-03	7.19e-03	7.44e-03	1.69e-03	5.28e-03	8.76e-03	3.30e-03	3.21e-03	3.30e-03	8.89e-03	7.44e-03	3.98e-03	7.37e-03
Benzo(b)fluoranthene	1.40e-02	6.29e-03	2.40e-02	2.48e-02	5.66e-03	1.76e-02	2.93e-02	1.10e-02	1.07e-02	1.10e-02	2.96e-02	2.48e-02	1.33e-02	2.46e-02
Benzo(k)fluoranthene	1.39e-02	6.25e-03	2.39e-02	2.47e-02	5.62e-03	1.75e-02	2.91e-02	1.10e-02	1.06e-02	1.10e-02	2.95e-02	2.47e-02	1.32e-02	2.44e-02
Chrysene	4.84e-03	2.17e-03	8.27e-03	8.56e-03	1.95e-03	6.08e-03	1.01e-02	3.81e-03	3.69e-03	3.81e-03	1.02e-02	8.56e-03	4.59e-03	8.47e-03
Dibenz(a,h)anthracene	3.11e-02	1.39e-02	5.31e-02	5.49e-02	1.25e-02	3.90e-02	6.48e-02	2.44e-02	2.37e-02	2.44e-02	6.57e-02	5.49e-02	2.95e-02	5.44e-02
Indeno(1,2,3-cd)pyrene	7.24e-02	3.25e-02	1.24e-01	1.28e-01	2.92e-02	9.12e-02	1.51e-01	5.69e-02	5.53e-02	5.69e-02	1.53e-01	1.28e-01	6.86e-02	1.27e-01
Polychlorinated Biphenyls (PCBs)														
Aroclor, 1016	2.23e-03	1.00e-03	3.82e-03	3.95e-03	9.01e-04	2.81e-03	4.66e-03	1.76e-03	1.70e-03	1.76e-03	4.72e-03	3.95e-03	2.12e-03	3.91e-03
Aroclor, 1254	1.42e-02	6.35e-03	2.43e-02	2.51e-02	5.71e-03	1.78e-02	2.96e-02	1.11e-02	1.08e-02	1.11e-02	3.00e-02	2.51e-02	1.34e-02	2.49e-02
Nitroaromatics														
1,3-Dinitrobenzene	2.73e-07	1.22e-07	4.67e-07	4.83e-07	1.10e-07	3.43e-07	5.70e-07	2.15e-07	2.08e-07	2.15e-07	5.77e-07	4.83e-07	2.59e-07	4.78e-07
2,4-Dinitrotoluene	8.70e-07	3.90e-07	1.49e-06	1.54e-06	3.51e-07	1.10e-06	1.82e-06	6.84e-07	6.65e-07	6.84e-07	1.85e-06	1.54e-06	8.25e-07	1.53e-06

TABLE D-1

BIOCONCENTRATION FACTORS FOR PLANTS TO WILDLIFE MEASUREMENT RECEPTORS

(Page 2 of 3)

	Measurement Receptor													
Compound	**American Robin (BCF$_{TP-OB}$)**	**Canvas Back (BCF $_{TP-HB}$)**	**Deer Mouse (BCF$_{TP-HM}$)**	**Least Shrew (BCF$_{TP-OM}$)**	**Mallard Duck (BCF$_{TP-OB}$)**	**Marsh Rice Rat (BCF$_{TP-OM}$)**	**Marsh Wren (BCF$_{TP-OB}$)**	**Mourning Dove (BCF$_{TP-HB}$)**	**Muskrat (BCF$_{TP-OM}$)**	**Northern Bobwhite (BCF$_{TP-OB}$)**	**Salt-marsh Harvest Mouse (BCF$_{TP-HM}$)**	**Short-tailed Shrew (BCF$_{TP-OM}$)**	**Western Meadow Lark (BCF$_{TP-OM}$)**	**White-footed Mouse (BCF$_{TP-OM}$)**
2,6-Dinitrotoluene	6.79e-07	3.05e-07	1.16e-06	1.20e-06	2.74e-07	8.50e-07	1.42e-06	5.34e-07	5.16e-07	5.34e-07	1.43e-06	1.20e-06	6.44e-07	1.19e-06
Nitrobenzene	5.99e-07	2.69e-07	1.03e-06	1.06e-06	2.42e-07	7.53e-07	1.25e-06	4.71e-07	4.57e-07	4.71e-07	1.27e-06	1.06e-06	5.68e-07	1.05e-06
Pentachloronitrobenzene	3.85e-04	1.72e-04	6.59e-04	6.82e-04	1.55e-04	4.84e-04	8.02e-04	3.02e-04	2.94e-04	3.02e-04	8.15e-04	6.82e-04	3.65e-04	6.76e-04
Phthalate Esters														
Bis(2-ethylhexyl)phthalate	1.41e-03	6.33e-04	2.42e-03	2.50e-03	5.69e-04	1.77e-03	2.95e-03	1.11e-03	1.08e-03	1.11e-03	2.99e-03	2.50e-03	1.34e-03	2.47e-03
Di(n)octyl phthalate	1.88e+01	8.44e+00	3.22e+01	3.33e+01	7.59e+00	2.36e+01	3.93e+01	1.48e+01	1.43e+01	1.48e+01	3.98e+01	3.33e+01	1.78e+01	3.30e+01
Volatile Organic Compounds														
Acetone	5.28e-09	2.37e-09	9.05e-09	9.36e-09	2.13e-09	6.65e-09	1.10e-08	4.15e-09	4.03e-09	4.15e-09	1.12e-08	9.36e-09	5.01e-09	9.27e-09
Acrylonitrile	1.57e-08	7.03e-09	2.68e-08	2.77e-08	6.32e-09	1.97e-08	3.27e-08	1.23e-08	1.19e-08	1.23e-08	3.31e-08	2.77e-08	1.49e-08	2.75e-08
Chloroform	7.82e-07	3.50e-07	1.34e-06	1.39e-06	3.15e-07	9.87e-07	1.63e-06	6.14e-07	5.98e-07	6.14e-07	1.66e-06	1.39e-06	7.41e-07	1.38e-06
Crotonaldehyde	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,4-Dioxane	4.75e-09	2.13e-09	8.15e-09	8.43e-09	1.92e-09	5.99e-09	9.91e-09	3.74e-09	3.63e-09	3.74e-09	1.01e-08	8.43e-09	4.50e-09	8.35e-09
Formaldehyde	1.94e-08	8.68e-09	3.31e-08	3.43e-08	7.81e-09	2.44e-08	4.04e-08	1.52e-08	1.48e-08	1.52e-08	4.10e-08	3.43e-08	1.84e-08	3.40e-08
Vinyl chloride	1.23e-07	5.53e-08	2.11e-07	2.18e-07	4.98e-08	1.55e-07	2.58e-07	9.71e-08	9.40e-08	9.71e-08	2.61e-07	2.18e-07	1.17e-07	2.16e-07
Other Chlorinated Organics														
Hexachlorobenzene	2.80e-03	1.26e-03	4.79e-03	4.95e-03	1.13e-03	3.52e-03	5.85e-03	2.20e-03	2.13e-03	2.20e-03	5.92e-03	4.95e-03	2.66e-03	4.91e-03
Hexachlorobutadiene	4.75e-04	2.13e-04	8.09e-04	8.37e-04	1.92e-04	5.95e-04	9.91e-04	3.74e-04	3.61e-04	3.74e-04	1.00e-03	8.37e-04	4.50e-04	8.29e-04
Hexachlorocyclopentadiene	7.11e-04	3.19e-04	1.22e-03	1.26e-03	2.87e-04	8.94e-04	1.48e-03	5.59e-04	5.42e-04	5.59e-04	1.50e-03	1.26e-03	6.74e-04	1.25e-03
Pentachlorobenzene	1.08e-03	4.84e-04	1.84e-03	1.90e-03	4.35e-04	1.35e-03	2.25e-03	8.48e-04	8.20e-04	8.48e-04	2.27e-03	1.90e-03	1.02e-03	1.89e-03
Pentachlorophenol	1.06e-03	4.76e-04	1.81e-03	1.87e-03	4.28e-04	1.33e-03	2.21e-03	8.34e-04	8.07e-04	8.34e-04	2.24e-03	1.87e-03	1.01e-03	1.85e-03
Pesticides														
4,4-DDE	1.59e-02	7.13e-03	2.72e-02	2.81e-02	6.41e-03	2.00e-02	3.32e-02	1.25e-02	1.21e-02	1.25e-02	3.36e-02	2.81e-02	1.51e-02	2.78e-02
Heptachlor	9.10e-04	4.08e-04	1.56e-03	1.61e-03	3.67e-04	1.15e-03	1.90e-03	7.16e-04	6.95e-04	7.16e-04	1.93e-03	1.61e-03	8.63e-04	1.60e-03
Hexachlorophene	3.06e-01	1.37e-01	5.22e-01	5.40e-01	1.23e-01	3.84e-01	6.37e-01	2.40e-01	2.33e-01	2.40e-01	6.45e-01	5.40e-01	2.90e-01	5.35e-01
Inorganics														
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Antimony	NA	NA	5.99e-04	6.20e-04	NA	4.40e-04	NA	NA	2.67e-04	NA	7.41e-04	6.20e-04	NA	6.14e-04
Arsenic	NA	NA	1.20e-03	1.24e-03	NA	8.81e-04	NA	NA	5.34e-04	NA	1.48e-03	1.24e-03	NA	1.23e-03
Barium	NA	NA	8.99e-05	9.30e-05	NA	6.61e-05	NA	NA	4.01e-05	NA	1.11e-04	9.30e-05	NA	9.21e-05
Beryllium	NA	NA	5.99e-04	6.20e-04	NA	4.40e-04	NA	NA	2.67e-04	NA	7.41e-04	6.20e-04	NA	6.14e-04
Cadmium	4.71e-02	2.11e-02	7.19e-05	7.44e-05	1.90e-02	5.28e-05	9.82e-02	3.70e-02	3.21e-05	3.70e-02	8.89e-05	7.44e-05	4.46e-02	7.37e-05
Chromium (hexavalent)	NA	NA	3.30e-03	3.41e-03	NA	2.42e-03	NA	NA	1.47e-03	NA	4.08e-03	3.41e-03	NA	3.38e-03

TABLE D-1

BIOCONCENTRATION FACTORS FOR PLANTS TO WILDLIFE MEASUREMENT RECEPTORS

(Page 3 of 3)

	Measurement Receptor													
Compound	**American Robin (BCF$_{TP\text{-}OB}$)**	**Canvas Back (BCF $_{TP\text{-}HB}$)**	**Deer Mouse (BCF$_{TP\text{-}HM}$)**	**Least Shrew (BCF$_{TP\text{-}OM}$)**	**Mallard Duck (BCF$_{TP\text{-}OB}$)**	**Marsh Rice Rat (BCF$_{TP\text{-}OM}$)**	**Marsh Wren (BCF$_{TP\text{-}OB}$)**	**Mourning Dove (BCF$_{TP\text{-}HB}$)**	**Muskrat (BCF$_{TP\text{-}OM}$)**	**Northern Bobwhite (BCF$_{TP\text{-}OB}$)**	**Salt-marsh Harvest Mouse (BCF$_{TP\text{-}HM}$)**	**Short-tailed Shrew (BCF$_{TP\text{-}OM}$)**	**Western Meadow Lark (BCF$_{TP\text{-}OM}$)**	**White-footed Mouse (BCF$_{TP\text{-}OM}$)**
Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Cyanide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	NA	NA	1.80e-04	1.86e-04	NA	1.32e-04	NA	NA	8.02e-05	NA	2.22e-04	1.86e-04	NA	1.84e-04
Mercuric chloride	1.06e-02	4.76e-03	3.13e-03	3.24e-03	4.28e-03	2.30e-03	2.21e-02	8.34e-03	1.39e-03	8.34e-03	3.87e-03	3.24e-03	1.01e-02	3.21e-03
Methylmercury	1.59e-03	7.13e-04	4.68e-04	4.84e-04	6.41e-04	3.44e-04	3.32e-03	1.25e-03	2.08e-04	1.25e-03	5.78e-04	4.84e-04	1.51e-03	4.79e-04
Nickel	NA	NA	3.60e-03	3.72e-03	NA	2.64e-03	NA	NA	1.60e-03	NA	4.45e-03	3.72e-03	NA	3.68e-03
Selenium	5.02e-01	2.25e-01	1.36e-03	1.41e-03	2.02e-01	1.00e-03	1.05e+00	3.95e-01	6.07e-04	3.95e-01	1.68e-03	1.41e-03	4.76e-01	1.39e-03
Silver	NA	NA	1.80e-03	1.86e-03	NA	1.32e-03	NA	NA	8.02e-04	NA	2.22e-03	1.86e-03	NA	1.84e-03
Thallium	NA	NA	2.40e-02	2.48e-02	NA	1.76e-02	NA	NA	1.07e-02	NA	2.96e-02	2.48e-02	NA	2.46e-02
Zinc	3.89e-03	1.74e-03	5.39e-05	5.58e-05	1.57e-03	3.96e-05	8.11e-03	3.05e-03	2.40e-05	3.05e-03	6.67e-05	5.58e-05	3.68e-03	5.53e-05

Notes:

NA - Indicates insufficient data to determine value

HB - Herbivorous bird
HM - Herbivorous mammal
OB - Omnivorous bird
OM - Omnivorous mammal
TP - Terrestrial plant

– Values provided were determined as specified in the text of Appendix D. *BCF* values for omnivores were determined based on an equal diet. *BCF* values for dioxin and furan congeners determined using BEF values specified in Chapter 2.

Table D-2

Bioconcentration Factors for Water to Wildlife Measurement Receptors

(Page 1 of 6)

	Measurement Receptors										
Compound	**American Kestrel (BCF$_{W\text{-}CB}$)**	**American Robin (BCF$_{W\text{-}OB}$)**	**Canvas Back (BCF$_{W\text{-}HB}$)**	**Deer Mouse (BCF$_{W\text{-}HM}$)**	**Least Shrew (BCF$_{W\text{-}OM}$)**	**Long-tailed Weasel (BCF$_{W\text{-}OM}$)**	**Mallard Duck (BCF$_{W\text{-}OB}$)**	**Marsh Rice Rat (BCF$_{W\text{-}OM}$)**	**Marsh Wren (BCF$_{W\text{-}OB}$)**	**Mink (BCF$_{W\text{-}CM}$)**	**Mourning Dove (BCF$_{W\text{-}OM}$)**
Dioxins and Furans											
2,3,7,8-TCDD	4.30e+01	4.71e+01	2.21e+01	8.19e-03	9.34e-03	6.88e-03	2.00e+01	1.03e-02	9.46e+01	5.39e-03	3.75e+01
1,2,3,7,8-PeCDD	3.96e+01	4.34e+01	2.04e+01	7.54e-03	8.59e-03	6.33e-03	1.84e+01	9.44e-03	8.70e+01	4.96e-03	3.45e+01
1,2,3,4,7,8-HxCDD	1.33e+01	1.46e+01	6.86e+00	2.54e-03	2.89e-03	2.13e-03	6.21e+00	3.18e-03	2.93e+01	1.67e-03	1.16e+01
1,2,3,6,7,8-HxCDD	5.16e+00	5.66e+00	2.65e+00	9.83e-04	1.12e-03	8.25e-04	2.40e+00	1.23e-03	1.14e+01	6.47e-04	4.50e-01
1,2,3,7,8,9-HxCDD	6.02e+00	6.60e+00	3.10e+00	1.15e-03	1.31e-03	9.63e-04	2.80e+00	1.44e-03	1.32e+01	7.55e-04	5.25e+00
1,2,3,4,6,7,8-HpCDD	2.19e+00	2.40e+00	1.13e+00	4.18e-04	4.76e-04	3.51e-04	1.02e+00	5.23e-04	4.82e+00	2.75e-04	1.91e+00
OCDD	5.16e-01	5.66e-01	2.65e-01	9.83e-05	1.12e-04	8.25e-05	2.40e-01	1.23e-04	1.14e+00	6.47e-05	4.50e-01
2,3,7,8-TCDF	3.44e+01	3.77e+01	1.77e+01	6.55e-03	7.47e-03	5.50e-03	1.60e+01	8.21e-03	7.57e+01	4.31e-03	3.00e+01
1,2,3,7,8-PeCDF	9.46e+00	1.04e+01	4.87e+00	1.80e-03	2.05e-03	1.51e-03	4.40e+00	2.26e-03	2.08e+01	1.19e-03	8.25e+00
2,3,4,7,8-PeCDF	6.88e+01	7.54e+01	3.54e+01	1.31e-02	1.49e-02	1.10e-02	3.20e+01	1.64e-02	1.51e+02	8.62e-03	6.00e+01
1,2,3,4,7,8-HxCDF	3.27e+00	3.58e+00	1.68e+00	6.23e-04	7.10e-04	5.23e-04	1.52e+00	7.80e-04	7.19e+00	4.10e-04	2.85e+00
1,2,3,6,7,8-HxCDF	8.17e+00	8.95e+00	4.20e+00	1.56e-03	1.77e-03	1.31e-03	3.80e+00	1.95e-03	1.80e+01	1.02e-03	7.12e+00
2,3,4,6,7,8-HxCDF	2.88e+01	3.16e+01	1.48e+01	5.49e-03	6.26e-03	4.61e-03	1.34e+01	6.88e-03	6.34e+01	3.61e-03	2.51e+01
1,2,3,7,8,9-HxCDF	2.71e+01	2.97e+01	1.39e+01	5.16e-03	5.88e-03	4.33e-03	1.26e+01	6.47e-03	5.96e+01	3.40e-03	2.36e+01
1,2,3,4,6,7,8-HpCDF	4.73e-01	5.18e-01	2.43e-01	9.01e-05	1.03e-04	7.57e-05	2.20e-01	1.13e-04	1.04e+00	5.93e-05	4.12e-01
1,2,3,4,7,8,9-HpCDF	1.68e+01	1.84e+01	8.63e+00	3.20e-03	3.64e-03	2.68e-03	7.81e+00	4.00e-03	3.69e+01	2.10e-03	1.46e+01
OCDF	6.88e-01	7.54e-01	3.54e-01	1.31e-04	1.49e-04	1.10e-04	3.20e-01	1.64e-04	1.51e+00	8.62e-05	6.00e-01
Polynuclear Aromatic Hydrocarbons (PAHs)											
Benzo(a)pyrene	3.34e-03	3.67e-03	1.72e-03	5.10e-03	5.81e-03	4.28e-03	1.55e-03	3.75e-03	7.35e-03	3.36e-03	2.92e-03
Benzo(a)anthracene	1.18e-03	1.30e-03	6.08e-04	1.81e-03	2.06e-03	1.52e-03	5.50e-04	1.33e-03	2.60e-03	1.19e-03	1.03e-03
Benzo(b)fluoranthene	3.95e-03	4.34e-03	2.03e-03	6.03e-03	6.88e-03	5.07e-03	1.84e-03	4.44e-03	8.70e-03	3.97e-03	3.46e-03
Benzo(k)fluoranthene	3.92e-03	4.31e-03	2.02e-03	6.00e-03	6.84e-03	5.04e-03	1.83e-03	4.41e-03	8.64e-03	3.95e-03	3.43e-03
Chrysene	1.36e-03	1.50e-03	7.01e-04	2.08e-03	2.37e-03	1.75e-03	6.34e-04	1.53e-03	3.00e-03	1.37e-03	1.19e-03
Dibenz(a,h)anthracene	8.74e-03	9.61e-03	4.50e-03	1.34e-02	1.52e-02	1.12e-02	4.07e-03	9.84e-03	1.93e-02	8.79e-03	7.66e-03
Indeno(1,2,3-cd)pyrene	2.04e-02	2.24e-02	1.05e-02	3.12e-02	3.56e-02	2.62e-02	9.48e-03	2.29e-02	4.49e-02	2.05e-02	1.78e-02
Polychlorinated Biphenyls (PCBs)											
Aroclor 1016	6.28e-04	6.91e-04	3.24e-04	9.61e-04	1.10e-03	8.07e-04	2.93e-04	7.07e-04	1.38e-03	6.32e-04	5.50e-04
Aroclor 1254	3.98e-03	4.38e-03	2.05e-03	6.11e-03	6.96e-03	5.13e-03	1.86e-03	4.48e-03	8.78e-03	4.02e-03	3.49e-03
Nitroaromatics											
1,3-Dinitrobenzene	7.68e-08	8.45e-08	3.96e-08	1.18e-07	1.34e-07	9.87e-08	3.58e-08	8.65e-08	1.69e-07	7.73e-08	6.73e-08
2,4-Dinitrotoluene	2.45e-07	2.69e-07	1.26e-07	3.76e-07	4.28e-07	3.15e-07	1.14e-07	2.76e-07	5.39e-07	2.47e-07	2.14e-07

Table D-2

Bioconcentration Factors for Water to Wildlife Measurement Receptors

(Page 2 of 6)

	Measurement Receptors										
Compound	American Kestrel (BCF$_{W-CB}$)	American Robin (BCF$_{W-OB}$)	Canvas Back (BCF$_{W-HB}$)	Deer Mouse (BCF$_{W-HM}$)	Least Shrew (BCF$_{W-OM}$)	Long-tailed Weasel (BCF$_{W-OM}$)	Mallard Duck (BCF$_{W-OB}$)	Marsh Rice Rat (BCF$_{W-OM}$)	Marsh Wren (BCF$_{W-OB}$)	Mink (BCF$_{W-CM}$)	Mourning Dove (BCF$_{W-OM}$)
2,6-Dinitrotoluene	1.91e-07	2.10e-07	9.84e-08	2.91e-07	3.32e-07	2.44e-07	8.90e-08	2.15e-07	4.21e-07	1.92e-07	1.67e-07
Nitrobenzene	1.69e-07	1.85e-07	8.68e-08	2.58e-07	2.94e-07	2.17e-07	7.86e-08	1.90e-07	3.72e-07	1.70e-07	1.48e-07
Pentachloronitrobenzene	1.08e-04	1.19e-04	5.57e-05	1.66e-04	1.89e-04	1.39e-04	5.04e-05	1.22e-04	2.38e-04	1.09e-04	9.47e-05
Phthalate Esters											
Bis(2-ethylhexyl)phthalate	3.97e-04	4.37e-04	2.05e-04	6.08e-04	6.93e-04	5.11e-04	1.85e-04	4.47e-04	8.75e-04	4.00e-04	3.48e-04
Di(n)octyl phthalate	5.30e+00	5.82e+00	2.73e+00	8.10e+00	9.23e+00	6.80e+00	2.47e+00	5.96e+00	1.17e+01	5.33e+00	4.64e+00
Volatile Organic Compounds											
Acetone	1.49e-09	1.63e-09	7.65e-10	2.28e-09	2.60e-09	1.91e-09	6.92e-10	1.67e-09	3.28e-09	1.50e-09	1.30e-09
Acrylonitrile	4.41e-09	4.84e-09	2.27e-09	6.74e-09	7.69e-09	5.66e-09	2.05e-09	1.27e-09	9.71e-09	4.44e-09	3.85e-09
Chloroform	2.20e-07	2.42e-07	1.13e-07	3.38e-07	3.85e-07	2.84e-07	1.02e-07	2.47e-07	4.84e-07	2.22e-07	1.93e-07
Crotonaldehyde	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,4-Dioxane	1.34e-09	1.47e-09	6.88e-10	2.05e-09	2.34e-09	1.72e-09	6.23e-10	1.50e-09	2.95e-09	1.35e-09	1.17e-09
Formaldehyde	5.45e-09	5.99e-09	2.80e-09	8.34e-09	9.51e-09	7.01e-09	2.54e-09	6.13e-09	1.20e-08	5.49e-09	4.77e-09
Vinyl chloride	3.47e-08	3.82e-08	1.79e-08	5.31e-08	6.05e-08	4.46e-08	1.62e-08	3.91e-08	7.65e-08	3.49e-08	3.04e-08
Other Chlorinated Organics											
Hexachlorobenzene	7.88e-04	8.67e-04	4.06e-04	1.21e-03	1.37e-03	1.01e-03	3.67e-04	8.87e-04	1.74e-03	7.93e-04	6.90e-04
Hexachlorobutadiene	1.34e-04	1.47e-04	6.88e-05	2.04e-04	2.32e-04	1.71e-04	6.23e-05	1.51e-04	2.94e-04	1.34e-04	1.17e-04
Hexachlorocyclopentadiene	2.00e-04	2.20e-04	1.03e-04	3.06e-04	3.49e-04	2.57e-04	9.31e-05	2.25e-04	4.40e-04	2.02e-04	1.75e-04
Pentachlorobenzene	3.04e-04	3.34e-04	1.56e-04	4.63e-04	5.28e-04	3.89e-04	1.41e-04	3.42e-04	6.69e-04	3.05e-04	2.66e-04
Pentachlorophenol	2.99e-04	3.28e-04	1.54e-04	4.56e-04	5.19e-04	3.83e-04	1.39e-04	3.36e-04	6.58e-04	3.00e-04	2.61e-04
Pesticides											
4,4-DDE	4.47e-03	4.92e-03	2.30e-03	6.83e-03	7.79e-03	5.74e-03	2.08e-03	5.03e-03	9.85e-03	4.50e-03	3.92e-03
Heptachlor	2.56e-04	2.82e-04	1.32e-04	3.92e-04	4.47e-04	3.29e-04	1.19e-04	2.88e-04	5.64e-04	2.58e-04	2.24e-04
Hexachlorophene	8.59e-02	9.45e-02	4.42e-02	1.31e-01	1.50e-01	1.10e-01	4.00e-02	9.67e-02	1.89e-01	8.65e-02	7.53e-02
Inorganics											
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Antimony	NA	NA	NA	1.51e-04	1.72e-04	1.27e-04	NA	NA	NA	9.93e-05	NA
Arsenic	NA	NA	NA	3.02e-04	3.44e-04	2.53e-04	NA	NA	NA	1.99e-04	NA
Barium	NA	NA	NA	2.26e-05	2.58e-05	1.90e-05	NA	NA	NA	1.49e-05	NA
Beryllium	NA	NA	NA	1.51e-04	1.72e-04	1.27e-04	NA	NA	NA	9.93e-05	NA
Cadmium	1.32e-02	1.46e-02	6.82e-03	1.81e-05	2.06e-05	1.52e-05	6.17e-03	1.49e-02	2.92e-02	1.19e-05	1.16e-02
Chromium (hexavalent)	NA	NA	NA	8.30e-04	9.46e-04	6.97e-04	NA	NA	NA	5.46e-04	NA

Table D-2

Bioconcentration Factors for Water to Wildlife Measurement Receptors

(Page 3 of 6)

Compound	Measurement Receptors										
	American Kestrel (BCF_{W-CB})	American Robin (BCF_{W-OB})	Canvas Back (BCF_{W-HB})	Deer Mouse (BCF_{W-HM})	Least Shrew (BCF_{W-OM})	Long-tailed Weasel (BCF_{W-OM})	Mallard Duck (BCF_{W-OB})	Marsh Rice Rat (BCF_{W-OM})	Marsh Wren (BCF_{W-OB})	Mink (BCF_{W-CM})	Mourning Dove (BCF_{W-OM})
Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Cyanide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	NA	NA	NA	4.53e-05	5.16e-05	3.80e-05	NA	NA	NA	2.98e-05	NA
Mercuric Chloride	2.99e-03	3.27e-03	1.54e-03	7.88e-04	8.98e-04	6.63e-04	1.39e-03	2.99e-03	6.57e-03	5.18e-04	2.61e-03
Methylmercury	4.48e-04	4.90e-04	2.30e-04	1.18e-04	1.34e-04	9.91e-05	2.08e-04	5.05e-04	9.85e-04	7.74e-05	3.90e-04
Nickel	NA	NA	NA	9.05e-04	1.03e-03	7.60e-04	NA	NA	NA	5.96e-04	NA
Selenium	1.41e-01	1.55e-01	7.27e-02	3.42e-04	3.90e-04	2.88e-04	6.58e-02	1.59e-01	3.11e-01	2.25e-04	1.24e-01
Silver	NA	NA	NA	4.53e-04	5.16e-04	3.80e-04	NA	NA	NA	2.98e-04	NA
Thallium	NA	NA	NA	6.03e-03	6.88e-03	5.07e-03	NA	NA	NA	3.97e-03	NA
Zinc	1.09e-03	1.20e-03	5.63e-04	1.36e-05	1.55e-05	1.14e-05	5.09e-04	1.23e-03	2.41e-03	8.93e-06	9.57e-04

Notes:

NA	- Indicates insufficient data to determine value
HB	- Herbivorous bird
HM	- Herbivorous mammal
OB	- Omnivorous bird
OM	- Omnivorous mammal
TP	- Terrestrial plant
–	Values provided were determined as specified in the text of Appendix D. *BCF* values for omnivores were determined based on an equal diet. *BCF* values for dioxin and furan congeners determined using BEF values specified in Chapter 2.

Table D-2

Bioconcentration Factors for Water to Wildlife Measurement Receptors

(Page 4 of 6)

	Measurement Receptors										
Compound	**Muskrat ($BCF_{W\text{-}OM}$)**	**Northern Bobwhite ($BCF_{W\text{-}OB}$)**	**Northern Harrier ($BCF_{W\text{-}CM}$)**	**Red Fox ($BCF_{W\text{-}CM}$)**	**Red-tailed Hawk ($BCF_{W\text{-}HM}$)**	**Salt-marsh Harvest Mouse ($BCF_{W\text{-}HM}$)**	**Short-tailed Shrew ($BCF_{W\text{-}OM}$)**	**Spotted Sandpiper ($BCF_{W\text{-}CSB}$)**	**Swift Fox ($BCF_{W\text{-}OM}$)**	**Western Meadow Lark ($BCF_{W\text{-}OM}$)**	**White-footed Mouse ($BCF_{W\text{-}OM}$)**
Dioxins and Furans											
2,3,7,8-TCDD	5.33e-03	3.75e+01	2.06e+01	4.69e-03	2.06e+01	8.60e-03	8.18e-03	5.99e+01	5.07e-03	4.51e+01	8.24e-03
1,2,3,7,8-PeCDD	4.90e-03	3.45e+01	1.90e+01	4.31e-03	1.90e+01	7.91e-03	7.53e-03	5.51e+01	4.66e-03	4.15e+01	7.58e-03
1,2,3,4,7,8-HxCDD	1.65e-03	1.16e+01	6.39e+00	1.45e-03	6.39e+00	2.67e-03	2.54e-03	1.86e+01	1.57e-03	1.40e+01	2.55e-03
1,2,3,6,7,8-HxCDD	6.40e-05	4.50e+00	2.47e+00	5.62e-04	2.47e+00	1.03e-03	9.82e-04	7.18e+00	6.08e-04	5.41e+00	9.89e-04
1,2,3,7,8,9-HxCDD	7.46e-04	5.25e+00	2.88e+00	6.56e-04	2.88e+00	1.20e-03	1.15e-03	8.38e+00	7.10e-04	6.31e+00	1.15e-03
1,2,3,4,6,7,8-HpCDD	2.72e-04	1.91e+00	1.05e+00	2.39e-04	1.05e+00	4.39e-04	4.17e-04	3.05e+00	2.59e-04	2.30e+00	4.20e-04
OCDD	6.40e-05	4.50e-01	2.47e-01	5.62e-05	2.47e-01	1.03e-04	9.82e-05	7.18e-01	6.08e-05	5.41e-01	9.89e-05
2,3,7,8-TCDF	4.26e-03	3.00e+01	1.65e+01	3.75e-03	1.65e+01	6.88e-03	6.55e-03	4.79e+01	4.06e-03	3.61e+01	6.59e-03
1,2,3,7,8-PeCDF	1.17e-03	8.25e+00	4.53e+00	1.03e-03	4.53e+00	1.89e-03	1.80e-03	1.32e+01	1.12e-03	9.91e+00	1.81e-03
2,3,4,7,8-PeCDF	8.53e-03	6.00e+01	3.30e+01	7.50e-03	3.30e+01	1.38e-02	1.31e-02	9.58e+01	8.11e-03	7.21e+01	1.32e-02
1,2,3,4,7,8-HxCDF	4.05e-04	2.85e+00	1.57e+00	3.56e-04	1.57e+00	6.54e-04	6.22e-04	4.55e+00	3.85e-04	3.42e+00	6.26e-04
1,2,3,6,7,8-HxCDF	1.01e-03	7.12e+00	3.92e+00	8.91e-04	3.92e+00	1.63e-03	1.55e-03	1.14e+01	9.63e-04	8.56e+00	1.57e-03
2,3,4,6,7,8-HxCDF	3.57e-03	2.51e+01	1.38e+01	3.14e-03	1.38e+01	5.76e-03	5.48e-03	4.01e+01	3.40e-03	3.02e+01	5.52e-03
1,2,3,7,8,9-HxCDF	3.36e-03	2.36e+01	1.30e+01	2.95e-03	1.30e+01	5.42e-03	5.15e-03	3.77e+01	3.19e-03	2.84e+01	5.19e-03
1,2,3,4,6,7,8-HpCDF	5.86e-05	4.12e-01	2.27e-01	5.16e-05	2.27e-01	9.46e-05	9.00e-05	6.58e-01	5.58e-05	4.96e-01	9.06e-05
1,2,3,4,7,8,9-HpCDF	2.08e-03	1.46e+01	8.04e+00	1.83e-03	8.04e+00	0.00e+00	3.19e-03	2.33e+01	1.98e-03	1.76e+01	3.21e-03
OCDF	8.53e-05	6.00e-01	3.30e-01	7.50e-05	3.30e-01	1.38e-04	1.31e-04	9.58e-01	8.11e-05	7.21e-01	1.32e-04
Polynuclear aromatic hydrocarbons (PAHs)											
Benzo(a)pyrene	3.32e-03	2.92e-03	1.60e-03	2.92e-03	1.60e-03	5.35e-03	5.09e-03	4.64e-03	3.16e-03	3.49e-03	5.13e-03
Benzo(a)anthracene	1.18e-03	1.03e-03	5.66e-04	1.04e-03	5.66e-04	1.90e-03	1.81e-03	1.64e-03	1.12e-03	1.24e-03	1.82e-03
Benzo(b)fluoranthene	3.93e-03	3.46e-03	1.89e-03	3.45e-03	1.89e-03	6.34e-03	6.03e-03	5.49e-03	3.73e-03	4.13e-03	6.07e-03
Benzo(k)fluoranthene	3.91e-03	3.43e-03	1.88e-03	3.44e-03	1.88e-03	6.30e-03	6.00e-03	5.46e-03	3.72e-03	4.10e-03	6.04e-03
Chrysene	1.35e-03	1.19e-03	6.53e-04	1.19e-03	6.53e-04	2.19e-03	2.08e-03	1.89e-03	1.29e-03	1.42e-03	2.09e-03
Dibenz(a,h)anthracene	8.70e-03	7.66e-03	4.19e-03	7.65e-03	4.19e-03	1.40e-02	1.33e-02	1.22e-02	8.27e-03	9.14e-03	1.34e-02
Indeno(1,2,3-cd)pyrene	2.03e-02	1.78e-02	9.76e-03	1.79e-02	9.76e-03	3.28e-02	3.12e-02	2.83e-02	1.93e-02	2.13e-02	3.14e-02
Polychlorinated biphenyls (PCBs)											
Aroclor 1016	6.25e-04	5.50e-04	3.01e-04	5.50e-04	3.01e-04	1.01e-03	9.60e-04	8.74e-04	5.95e-04	6.57e-04	9.66e-04
Aroclor 1254	3.98e-03	3.49e-03	1.91e-03	3.50e-03	1.91e-03	6.41e-03	6.10e-03	5.54e-03	3.78e-03	4.16e-03	6.14e-03
Nitroaromatics											
1,3-Dinitrobenzene	7.65e-08	6.73e-08	3.68e-08	6.72e-08	3.68e-08	1.23e-07	1.17e-07	1.07e-07	7.27e-08	8.03e-08	1.18e-07
2,4-Dinitrotoluene	2.44e-07	2.14e-07	1.17e-07	2.15e-07	1.17e-07	3.94e-07	3.75e-07	3.41e-07	2.32e-07	2.56e-07	3.78e-07

Table D-2

Bioconcentration Factors for Water to Wildlife Measurement Receptors

(Page 5 of 6)

	Measurement Receptors										
Compound	Muskrat ($\text{BCF}_{\text{W-OM}}$)	Northern Bobwhite ($\text{BCF}_{\text{W-OB}}$)	Northern Harrier ($\text{BCF}_{\text{W-CM}}$)	Red Fox ($\text{BCF}_{\text{W-CM}}$)	Red-tailed Hawk ($\text{BCF}_{\text{W-HM}}$)	Salt-marsh Harvest Mouse ($\text{BCF}_{\text{W-HM}}$)	Short-tailed Shrew ($\text{BCF}_{\text{W-OM}}$)	Spotted Sandpiper ($\text{BCF}_{\text{W-CSB}}$)	Swift Fox ($\text{BCF}_{\text{W-OM}}$)	Western Meadow Lark ($\text{BCF}_{\text{W-OM}}$)	White-footed Mouse ($\text{BCF}_{\text{W-OM}}$)
2,6-Dinitrotoluene	1.89e-07	1.67e-07	9.16e-08	1.67e-07	9.16e-08	3.06e-07	2.91e-07	2.66e-07	1.80e-07	2.00e-07	2.93e-07
Nitrobenzene	1.68e-07	1.48e-07	8.08e-08	1.48e-07	8.08e-08	2.71e-07	2.58e-07	2.35e-07	1.60e-07	1.76e-07	2.59e-07
Pentachloronitrobenzene	1.08e-04	9.47e-05	5.18e-05	9.49e-05	5.18e-05	1.74e-04	1.66e-04	1.50e-04	1.03e-04	1.13e-04	1.67e-04
Phthalate Esters											
Bis(2-ethylhexyl)phthalate	3.96e-04	3.48e-04	1.90e-04	3.48e-04	1.90e-04	6.38e-04	6.07e-04	5.52e-04	3.76e-04	4.15e-04	6.11e-04
Di(n)octyl phthalate	5.27e+00	4.64e+00	2.54e+00	4.64e+00	2.54e+00	8.51e+00	8.09e+00	7.37e+00	5.01e+00	5.54e+00	8.15e+00
Volatile Organic Compounds											
Acetone	1.48e-09	1.30e-09	7.12e-10	1.30e-09	7.12e-10	2.39e-09	2.28e-09	2.07e-09	1.41e-09	1.55e-09	2.29e-09
Acrylonitrile	4.39e-09	3.85e-09	2.11e-09	3.86e-09	2.11e-09	7.08e-09	6.73e-09	6.14e-09	4.17e-09	4.62e-09	6.78e-09
Chloroform	2.20e-07	1.93e-07	1.05e-07	1.93e-07	1.05e-07	3.55e-07	3.38e-07	3.06e-07	2.09e-07	2.30e-07	3.40e-07
Crotonaldehyde	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,4-Dioxane	1.33e-09	1.17e-09	6.41e-10	1.17e-09	6.41e-10	2.15e-09	2.05e-09	1.86e-09	1.27e-09	1.40e-09	2.06e-09
Formaldehyde	5.43e-09	4.77e-09	2.61e-09	4.77e-09	2.61e-09	8.76e-09	8.33e-09	7.58e-09	5.16e-09	5.69e-09	8.39e-09
Vinyl chloride	3.45e-08	3.04e-08	1.66e-08	3.04e-08	1.66e-08	5.58e-08	5.30e-08	4.83e-08	3.29e-08	3.63e-08	5.34e-08
Other Chlorinated Organics											
Hexachlorobenzene	7.84e-04	6.90e-04	3.78e-04	6.90e-04	3.78e-04	1.27e-03	1.20e-03	1.10e-03	7.46e-04	8.24e-04	1.21e-03
Hexachlorobutadiene	1.33e-04	1.17e-04	6.41e-05	1.17e-04	6.41e-05	2.13e-04	2.04e-04	1.86e-04	1.26e-04	1.40e-04	2.05e-04
Hexachlorocyclopentadiene	1.99e-04	1.75e-04	9.58e-05	1.75e-04	9.58e-05	3.22e-04	3.06e-04	2.78e-04	1.90e-04	2.09e-04	3.08e-04
Pentachlorobenzene	3.01e-04	2.66e-04	1.45e-04	2.65e-04	1.45e-04	4.86e-04	4.63e-04	4.22e-04	2.87e-04	3.17e-04	4.66e-04
Pentachlorophenol	2.96e-04	2.61e-04	1.43e-04	2.61e-04	1.43e-04	4.78e-04	4.55e-04	4.15e-04	2.82e-04	3.12e-04	4.58e-04
Pesticides											
4,4-DDE	4.45e-03	3.92e-03	2.14e-03	3.91e-03	2.14e-03	7.18e-03	6.83e-03	6.22e-03	4.23e-03	4.67e-03	6.87e-03
Heptachlor	2.55e-04	2.24e-04	1.23e-04	2.24e-04	1.23e-04	4.12e-04	3.92e-04	3.56e-04	2.43e-04	2.68e-04	3.94e-04
Hexachlorophene	8.55e-02	7.53e-02	4.12e-02	7.52e-02	4.12e-02	1.38e-01	1.31e-01	1.20e-01	8.13e-02	8.98e-02	1.32e-01
Inorganics											
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Antimony	9.82e-05	NA	NA	8.63e-05	NA	1.58e-04	1.51e-04	NA	9.33e-05	NA	1.52e-04
Arsenic	1.96e-04	NA	NA	1.73e-04	NA	3.17e-04	3.01e-04	NA	1.87e-04	NA	3.03e-04
Barium	1.47e-05	NA	NA	1.29e-05	NA	2.38e-05	2.26e-05	NA	1.40e-05	NA	2.28e-05
Beryllium	9.82e-05	NA	NA	8.63e-05	NA	1.58e-04	1.51e-04	NA	9.33e-05	NA	1.52e-04
Cadmium	1.18e-05	1.16e-02	6.35e-03	1.04e-05	6.35e-03	1.90e-05	1.81e-05	1.84e-02	1.12e-05	1.38e-02	1.82e-05
Chromium (hexavalent)	5.40e-04	NA	NA	4.75e-04	NA	8.71e-04	8.29e-04	NA	5.13e-04	NA	8.34e-04

Table D-2

Bioconcentration Factors for Water to Wildlife Measurement Receptors

(Page 6 of 6)

	Measurement Receptors										
Compound	Muskrat ($BCF_{W\text{-}OM}$)	Northern Bobwhite ($BCF_{W\text{-}OB}$)	Northern Harrier ($BCF_{W\text{-}CM}$)	Red Fox ($BCF_{W\text{-}CM}$)	Red-tailed Hawk ($BCF_{W\text{-}HM}$)	Salt-marsh Harvest Mouse ($BCF_{W\text{-}HM}$)	Short-tailed Shrew ($BCF_{W\text{-}OM}$)	Spotted Sandpiper ($BCF_{W\text{-}CSB}$)	Swift Fox ($BCF_{W\text{-}OM}$)	Western Meadow Lark ($BCF_{W\text{-}OM}$)	White-footed Mouse ($BCF_{W\text{-}OM}$)
Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Cyanide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	2.94e-05	NA	NA	2.59e-05	NA	4.75e-05	4.52e-05	NA	2.80e-05	NA	4.55e-05
Mercuric chloride	5.13e-04	2.61e-03	1.43e-03	4.50e-04	1.43e-03	8.25e-04	7.88e-04	4.16e-03	4.88e-04	3.13e-03	2.99e-03
Methylmercury	7.66e-05	3.90e-04	2.14e-04	6.73e-05	2.14e-04	1.24e-04	1.18e-04	6.23e-04	7.28e-05	4.69e-04	1.18e-04
Nickel	5.89e-04	NA	NA	5.18e-04	NA	9.50e-04	9.04e-04	NA	5.60e-04	NA	9.10e-04
Selenium	2.23e-04	1.24e-01	6.76e-02	1.96e-04	6.76e-02	3.60e-04	3.42e-04	1.96e-01	2.12e-04	1.48e-01	3.44e-04
Silver	2.94e-04	NA	NA	2.59e-04	NA	4.75e-04	4.52e-04	NA	2.80e-04	NA	4.55e-04
Thallium	3.93e-03	NA	NA	3.45e-03	NA	6.34e-03	6.03e-03	NA	3.73e-03	NA	6.07e-03
Zinc	8.83e-06	9.57e-04	5.24e-04	7.77e-06	5.24e-04	1.43e-05	1.36e-05	1.52e-03	8.40e-06	1.14e-03	1.37e-05

Notes:

NA	- Indicates insufficient data to determine value
HB	- Herbivorous bird
HM	- Herbivorous mammal
OB	- Omnivorous bird
OM	- Omnivorous mammal
TP	- Terrestrial plant
–	Values provided were determined as specified in the text of Appendix D. *BCF* values for omnivores were determined based on an equal diet. *BCF* values for dioxin and furan congeners determined using BEF values specified in Chapter 2.

TABLE D-3

BIOCONCENTRATION FACTORS FOR SOIL/SEDIMENT TO WILDLIFE MEASUREMENT RECEPTORS

(Page 1 of 6)

Compound	Measurement Receptors										
	American Kestrel (BCF$_{S\text{-}CB}$)	American Robin (BCF$_{S\text{-}OB}$)	Canvas Back (BCF$_{S\text{-}HB}$)	Deer Mouse (BCF$_{S\text{-}HM}$)	Least Shrew (BCF$_{S\text{-}OM}$)	Long-tailed Weasel (BCF$_{S\text{-}OM}$)	Mallard Duck (BCF$_{S\text{-}OB}$)	Marsh Rice Rat (BCF$_{S\text{-}OM}$)	Marsh Wren (BCF$_{S\text{-}OB}$)	Mink (BCF$_{S\text{-}CM}$)	Mourning Dove (BCF$_{S\text{-}OM}$)
Dioxins and Furans											
2,3,7,8-TCDD	4.78e-01	4.92e+00	6.26e-01	7.81e-05	7.41e-04	1.62e-04	1.09e+00	1.70e-04	6.74e+00	1.05e-04	2.41e+00
1,2,3,7,8-PeCDD	4.40e-01	4.53e+00	5.76e-01	7.19e-05	6.81e-04	1.49e-04	1.01e+00	1.56e-04	6.20e+00	9.66e-05	2.22e+00
1,2,3,4,7,8-HxCDD	1.48e-01	1.53e+00	1.94e-01	2.42e-05	2.30e-04	5.02e-05	3.39e-01	5.26e-05	2.09e+00	3.25e-05	7.48e-01
1,2,3,6,7,8-HxCDD	5.74e-02	5.90e-01	7.51e-02	9.37e-06	8.89e-05	1.94e-05	1.31e-01	2.04e-05	8.09e-01	1.26e-05	2.89e-02
1,2,3,7,8,9-HxCDD	6.69e-02	6.89e-01	8.77e-02	1.09e-05	1.04e-04	2.27e-05	1.53e-01	2.38e-05	9.44e-01	1.47e-05	3.38e-01
1,2,3,4,6,7,8-HpCDD	2.44e-02	2.51e-01	3.19e-02	3.98e-06	3.78e-05	8.26e-06	5.58e-02	8.66e-06	3.44e-01	5.35e-06	1.23e-01
OCDD	5.74e-03	5.90e-02	7.51e-03	9.37e-07	8.89e-06	1.94e-06	1.31e-02	2.04e-06	8.09e-02	1.26e-06	2.89e-02
2,3,7,8-TCDF	3.83e-01	3.94e+00	5.01e-01	6.25e-05	5.93e-04	1.30e-04	8.75e-01	1.36e-04	5.39e+00	8.40e-05	1.93e+00
1,2,3,7,8-PeCDF	1.05e-01	1.08e+00	1.38e-01	1.72e-05	1.63e-04	3.56e-05	2.41e-01	3.74e-05	1.48e+00	2.31e-05	5.31e-01
2,3,4,7,8-PeCDF	7.65e-01	7.87e+00	1.00e+00	1.25e-04	1.19e-03	2.59e-04	1.75e+00	2.72e-04	1.08e+01	1.68e-04	3.86e+00
1,2,3,4,7,8-HxCDF	3.63e-02	3.74e-01	4.76e-02	5.94e-06	5.63e-05	1.23e-05	8.31e-02	1.29e-05	5.12e-01	7.98e-06	1.83e-01
1,2,3,6,7,8-HxCDF	9.09e-02	9.35e-01	1.19e-01	1.48e-05	1.41e-04	3.08e-05	2.08e-01	3.23e-05	1.28e+00	1.99e-05	4.58e-01
2,3,4,6,7,8-HxCDF	3.20e-01	3.30e+00	4.19e-01	5.23e-05	4.96e-04	1.09e-04	7.33e-01	1.14e-04	4.52e+00	7.03e-05	1.62e+00
1,2,3,7,8,9-HxCDF	3.01e-01	3.10e+00	3.94e-01	4.92e-05	4.67e-04	1.02e-04	6.89e-01	1.07e-04	4.25e+00	6.61e-05	1.52e+00
1,2,3,4,6,7,8-HpCDF	5.26e-03	5.41e-02	6.89e-03	8.59e-07	8.15e-06	1.78e-06	1.20e-02	1.87e-06	7.42e-02	1.15e-06	2.65e-02
1,2,3,4,7,8,9-HpCDF	1.86e-01	1.92e+00	2.44e-01	3.05e-05	2.89e-04	6.32e-05	4.27e-01	6.62e-05	2.63e+00	4.09e-05	9.40e-01
OCDF	7.65e-03	7.87e-02	1.00e-02	1.25e-06	1.19e-05	2.59e-06	1.75e-02	2.72e-06	1.08e-01	1.68e-06	3.86e-02
Polynuclear Aromatic Hydrocarbons (PAHs)											
Benzo(a)pyrene	3.71e-05	3.81e-04	4.85e-05	4.86e-05	4.61e-04	1.01e-04	8.50e-05	6.21e-05	5.22e-04	6.53e-05	1.87e-04
Benzo(a)anthracene	1.32e-05	1.35e-04	1.72e-05	1.73e-05	1.64e-04	3.58e-05	3.01e-05	2.20e-05	1.85e-04	2.32e-05	6.63e-05
Benzo(b)fluoranthene	4.39e-05	4.50e-04	5.74e-05	5.75e-05	5.46e-04	1.19e-04	1.01e-04	7.35e-05	6.18e-04	7.73e-05	2.22e-04
Benzo(k)fluoranthene	4.36e-05	4.48e-04	5.71e-05	5.73e-05	5.43e-04	1.19e-04	1.00e-04	7.30e-05	6.14e-04	7.69e-05	2.20e-04
Chrysene	1.52e-05	1.55e-04	1.98e-05	1.99e-05	1.88e-04	4.12e-05	3.47e-05	2.54e-05	2.13e-04	2.67e-05	7.64e-05
Dibenz(a,h)anthracene	9.73e-05	9.98e-04	1.27e-04	1.27e-04	1.21e-03	2.64e-04	2.23e-04	1.63e-04	1.37e-03	1.71e-04	4.91e-04
Indeno(1,2,3-cd)pyrene	2.27e-04	2.32e-03	2.96e-04	2.98e-04	2.82e-03	6.18e-04	5.19e-04	3.79e-04	3.19e-03	4.00e-04	1.14e-03
Polychlorinated Biphenyls (PCBs)											
Aroclor 1016	6.99e-06	7.17e-05	9.14e-06	9.16e-06	8.69e-05	1.90e-05	1.60e-05	1.17e-05	9.83e-05	1.23e-05	3.53e-05
Aroclor 1254	4.43e-05	4.55e-04	5.80e-05	5.83e-05	5.52e-04	1.21e-04	1.02e-04	7.42e-05	6.24e-04	7.83e-05	2.24e-04
Nitroaromatics											
1,3-Dinitrobenzene	8.55e-10	8.77e-09	1.12e-09	1.12e-09	1.06e-08	2.32e-09	1.96e-09	1.43e-09	1.20e-08	1.51e-09	4.31e-09
2,4-Dinitrotoluene	2.72e-09	2.79e-08	3.56e-09	3.58e-09	3.40e-08	7.43e-09	6.24e-09	4.56e-09	3.83e-08	4.81e-09	1.37e-08
2,6-Dinitrotoluene	2.13e-09	2.18e-08	2.78e-09	2.78e-09	2.63e-08	5.76e-09	4.87e-09	3.56e-09	2.99e-08	3.73e-09	1.07e-08

TABLE D-3

BIOCONCENTRATION FACTORS FOR SOIL/SEDIMENT TO WILDLIFE MEASUREMENT RECEPTORS

(Page 2 of 6)

	Measurement Receptors										
Compound	American Kestrel (BCF_{S-CB})	American Robin (BCF_{S-OB})	Canvas Back (BCF_{S-HB})	Deer Mouse (BCF_{S-HM})	Least Shrew (BCF_{S-OM})	Long-tailed Weasel (BCF_{S-OM})	Mallard Duck (BCF_{S-OB})	Marsh Rice Rat (BCF_{S-OM})	Marsh Wren (BCF_{S-OB})	Mink (BCF_{S-CM})	Mourning Dove (BCF_{S-OM})
Nitrobenzene	1.88e-09	1.92e-08	2.45e-09	2.46e-09	2.33e-08	5.10e-09	4.30e-09	3.14e-09	2.64e-08	3.31e-09	9.47e-09
Pentachloronitrobenzene	1.20e-06	1.23e-05	1.57e-06	1.58e-06	1.50e-05	3.28e-06	2.76e-06	2.01e-06	1.69e-05	2.13e-06	6.07e-06
Phthalate Esters											
Bis(2-ethylhexyl)phthalate	4.42e-06	4.53e-05	5.78e-06	5.80e-06	5.50e-05	1.20e-05	1.01e-05	7.40e-06	6.22e-05	7.79e-06	2.23e-05
Di(n)octyl phthalate	5.89e-02	6.04e-01	7.71e-02	7.72e-02	7.32e-01	1.60e-01	1.35e-01	9.86e-02	8.29e-01	1.04e-01	2.97e-01
Volatile Organic Compounds											
Acetone	1.65e-11	1.70e-10	2.16e-11	2.17e-11	2.06e-10	4.51e-11	3.79e-11	2.77e-11	2.33e-10	2.92e-11	8.34e-11
Acrylonitrile	4.91e-11	5.05e-10	6.42e-11	6.43e-11	6.10e-10	1.33e-10	1.12e-10	2.11e-11	6.92e-10	8.64e-11	2.47e-10
Chloroform	2.45e-09	2.51e-08	3.20e-09	3.22e-09	3.06e-08	6.68e-09	5.60e-09	4.09e-09	3.44e-08	4.33e-09	1.23e-08
Crotonaldehyde	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,4-Dioxane	1.49e-11	1.53e-10	1.94e-11	1.96e-11	1.86e-10	4.06e-11	3.41e-11	2.49e-11	2.09e-10	2.63e-11	7.50e-11
Formaldehyde	6.06e-11	6.21e-10	7.92e-11	7.95e-11	7.54e-10	1.65e-10	1.39e-10	1.01e-10	8.52e-10	1.07e-10	3.06e-10
Vinyl chloride	3.86e-10	3.96e-09	5.05e-10	5.06e-10	4.80e-09	1.05e-09	8.85e-10	6.47e-10	5.44e-09	6.80e-10	1.95e-09
Other Chlorinated Organics											
Hexachlorobenzene	8.77e-06	8.99e-05	1.15e-05	1.15e-05	1.09e-04	2.38e-05	2.01e-05	1.47e-05	1.23e-04	1.54e-05	4.42e-05
Hexachlorobutadiene	1.49e-06	1.53e-05	1.95e-06	1.94e-06	1.84e-05	4.02e-06	3.40e-06	2.49e-06	2.10e-05	2.61e-06	7.50e-06
Hexachlorocyclopentadiene	2.22e-06	2.28e-05	2.91e-06	2.92e-06	2.77e-05	6.06e-06	5.09e-06	3.72e-06	3.13e-05	3.92e-06	1.12e-05
Pentachlorobenzene	3.38e-06	3.46e-05	4.42e-06	4.42e-06	4.19e-05	9.16e-06	7.74e-06	5.65e-06	4.75e-05	5.93e-06	1.70e-05
Pentachlorophenol	3.32e-06	3.41e-05	4.34e-06	4.34e-06	4.12e-05	9.01e-06	7.61e-06	5.56e-06	4.67e-05	5.84e-06	1.68e-05
Pesticides											
4,4-DDE	4.98e-05	5.10e-04	6.51e-05	6.52e-05	6.18e-04	1.35e-04	1.14e-04	8.33e-05	7.00e-04	8.76e-05	2.51e-04
Heptachlor	2.85e-06	2.92e-05	3.73e-06	3.74e-06	3.55e-05	7.76e-06	6.53e-06	4.77e-06	4.01e-05	5.03e-06	1.44e-05
Hexachlorophene	9.56e-04	9.81e-03	1.25e-03	1.25e-03	1.19e-02	2.60e-03	2.19e-03	1.60e-03	1.35e-02	1.68e-03	4.82e-03
Inorganics											
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Antimony	NA	NA	NA	1.44e-06	1.36e-05	2.98e-06	NA	NA	NA	1.93e-06	NA
Arsenic	NA	NA	NA	2.88e-06	2.73e-05	5.97e-06	NA	NA	NA	3.87e-06	NA
Barium	NA	NA	NA	2.16e-07	2.05e-06	4.48e-07	NA	NA	NA	2.90e-07	NA
Beryllium	NA	NA	NA	1.44e-06	1.36e-05	2.98e-06	NA	NA	NA	1.93e-06	NA
Cadmium	1.47e-04	1.51e-03	1.93e-04	1.73e-07	1.64e-06	3.58e-07	3.37e-04	2.47e-04	2.07e-03	2.32e-07	7.43e-04
Chromium (hexavalent)	NA	NA	NA	7.91e-06	7.50e-05	1.64e-05	NA	NA	NA	1.06e-05	NA
Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Cyanide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

TABLE D-3

BIOCONCENTRATION FACTORS FOR SOIL/SEDIMENT TO WILDLIFE MEASUREMENT RECEPTORS

(Page 3 of 6)

Compound	Measurement Receptors										
	American Kestrel (BCF$_{S\text{-}CB}$)	American Robin (BCF$_{S\text{-}OB}$)	Canvas Back (BCF$_{S\text{-}HB}$)	Deer Mouse (BCF$_{S\text{-}HM}$)	Least Shrew (BCF$_{S\text{-}OM}$)	Long-tailed Weasel (BCF$_{S\text{-}OM}$)	Mallard Duck (BCF$_{S\text{-}OB}$)	Marsh Rice Rat (BCF$_{S\text{-}OM}$)	Marsh Wren (BCF$_{S\text{-}OB}$)	Mink (BCF$_{S\text{-}CM}$)	Mourning Dove (BCF$_{S\text{-}OM}$)
Lead	NA	NA	NA	4.32e-07	4.09e-06	8.95e-07	NA	NA	NA	5.80e-07	NA
Mercuric chloride	3.32e-05	3.42e-04	4.35e-05	7.52e-06	7.10e-05	1.56e-05	7.60e-05	5.57e-05	4.68e-04	1.01e-05	1.68e-04
Methylmercury	4.98e-06	5.12e-05	6.52e-06	1.12e-06	1.06e-05	2.33e-06	1.14e-05	8.34e-06	7.02e-05	1.51e-06	2.51e-05
Nickel	NA	NA	NA	8.63e-06	8.18e-05	1.79e-05	NA	NA	NA	1.16e-05	NA
Selenium	1.57e-03	1.61e-02	2.05e-03	3.27e-06	3.10e-05	6.77e-06	3.60e-03	2.63e-03	2.21e-02	4.39e-06	7.92e-03
Silver	NA	NA	NA	4.32e-06	4.09e-05	8.95e-06	NA	NA	NA	5.80e-06	NA
Thallium	NA	NA	NA	5.75e-05	5.46e-04	1.19e-04	NA	NA	NA	7.73e-05	NA
Zinc	1.22e-05	1.25e-04	1.59e-05	1.29e-07	1.23e-06	2.69e-07	2.79e-05	2.04e-05	1.71e-04	1.74e-07	6.13e-05

Notes:

NA - Indicates insufficient data to determine value

HB	- Herbivorous bird
HM	- Herbivorous mammal
OB	- Omnivorous bird
OM	- Omnivorous mammal
S	- Soil/Sediment

– Values provided were determined as specified in the text of Appendix D. *BCF* values for omnivores were determined based on an equal diet. *BCF* values for dioxin and furan congeners determined using BEF values specified in Chapter 2.

TABLE D-3

BIOCONCENTRATION FACTORS FOR SOIL/SEDIMENT TO WILDLIFE MEASUREMENT RECEPTORS

(Page 4 of 6)

Compound	Measurement Receptors										
	Muskrat (BCF$_{S-OM}$)	Northern Bobwhite (BCF$_{S-OB}$)	Northern Harrier (BCF$_{S-CM}$)	Red Fox (BCF$_{S-CM}$)	Red-tailed Hawk (BCF$_{S-HM}$)	Salt-marsh Harvest Mouse (BCF$_{S-HM}$)	Short-tailed Shrew (BCF$_{S-OM}$)	Spotted Sandpiper (BCF$_{S-CSB}$)	Swift Fox (BCF$_{S-OM}$)	Western Meadow Lark (BCF$_{S-OM}$)	White-footed Mouse (BCF$_{S-OM}$)
Dioxins and Furans											
2,3,7,8-TCDD	3.48e-05	4.13e+00	3.42e+00	8.19e-05	3.42e+00	9.66e-05	7.41e-04	1.43e+01	9.41e-05	4.78e+00	1.47e-04
1,2,3,7,8-PeCDD	3.20e-05	3.80e+00	3.15e+00	7.53e-05	3.15e+00	8.88e-05	6.81e-04	1.31e+01	8.66e-05	4.40e+00	1.35e-04
1,2,3,4,7,8-HxCDD	1.08e-05	1.28e+00	1.06e+00	2.54e-05	1.06e+00	2.99e-05	2.30e-04	4.43e+00	2.92e-05	1.48e+00	4.55e-05
1,2,3,6,7,8-HxCDD	4.18e-07	4.95e-01	4.11e-01	9.82e-06	4.11e-01	1.16e-05	8.89e-05	1.71e+00	1.13e-05	5.74e-01	1.76e-05
1,2,3,7,8,9-HxCDD	4.87e-06	5.78e-01	4.79e-01	1.15e-05	4.79e-01	1.35e-05	1.04e-04	2.00e+00	1.32e-05	6.69e-01	2.05e-05
1,2,3,4,6,7,8-HpCDD	1.78e-06	2.11e-01	1.75e-01	4.17e-06	1.75e-01	4.92e-06	3.78e-05	7.28e-01	4.80e-06	2.44e-01	7.48e-06
OCDD	4.18e-07	4.95e-02	4.11e-02	9.82e-07	4.11e-02	1.16e-06	8.89e-06	1.71e-01	1.13e-06	5.74e-02	1.76e-06
2,3,7,8-TCDF	2.79e-05	3.30e+00	2.74e+00	6.55e-05	2.74e+00	7.72e-05	5.93e-04	1.14e+01	7.53e-05	3.83e+00	1.17e-04
1,2,3,7,8-PeCDF	7.66e-06	9.08e-01	7.53e-01	1.80e-05	7.53e-01	2.12e-05	1.63e-04	3.14e+00	2.07e-05	1.05e+00	3.23e-05
2,3,4,7,8-PeCDF	5.57e-05	6.60e+00	5.48e+00	1.31e-04	5.48e+00	1.55e-04	1.19e-03	2.28e+01	1.51e-04	7.65e+00	2.35e-04
1,2,3,4,7,8-HxCDF	2.65e-06	3.14e-01	2.60e-01	6.22e-06	2.60e-01	7.34e-06	5.63e-05	1.09e+00	7.15e-06	3.63e-01	1.12e-05
1,2,3,6,7,8-HxCDF	6.62e-06	7.84e-01	6.50e-01	1.56e-05	6.50e-01	1.83e-05	1.41e-04	2.71e+00	1.79e-05	9.09e-01	2.79e-05
2,3,4,6,7,8-HxCDF	2.33e-05	2.77e+00	2.29e+00	5.48e-05	2.29e+00	6.47e-05	4.96e-04	9.56e+00	6.30e-05	3.20e+00	9.83e-05
1,2,3,7,8,9-HxCDF	2.19e-05	2.60e+00	2.16e+00	5.16e-05	2.16e+00	6.08e-05	4.67e-04	8.99e+00	5.93e-05	3.01e+00	9.24e-05
1,2,3,4,6,7,8-HpCDF	3.83e-07	4.54e-02	3.77e-02	9.00e-07	3.77e-02	1.06e-06	8.15e-06	1.57e-01	1.04e-06	5.26e-02	1.61e-06
1,2,3,4,7,8,9-HpCDF	1.36e-05	1.61e+00	1.33e+00	3.19e-05	1.33e+00	0.00e+00	2.89e-04	5.57e+00	3.67e-05	1.86e+00	5.72e-05
OCDF	5.57e-07	6.60e-02	5.48e-02	1.31e-06	5.48e-02	1.55e-06	1.19e-05	2.28e-01	1.51e-06	7.65e-02	2.35e-06
Polynuclear aromatic hydrocarbons (PAHs)											
Benzo(a)pyrene	2.17e-05	3.19e-04	2.66e-04	5.10e-05	2.66e-04	6.01e-05	4.61e-04	1.11e-03	5.86e-05	3.72e-04	9.13e-05
Benzo(a)anthracene	7.69e-06	1.13e-04	9.41e-05	1.81e-05	9.41e-05	2.13e-05	1.64e-04	3.93e-04	2.08e-05	1.32e-04	3.24e-05
Benzo(b)fluoranthene	2.57e-05	3.78e-04	3.14e-04	6.03e-05	3.14e-04	7.11e-05	5.46e-04	1.31e-03	6.93e-05	4.40e-04	1.08e-04
Benzo(k)fluoranthene	2.55e-05	3.75e-04	3.12e-04	6.00e-05	3.12e-04	7.08e-05	5.43e-04	1.30e-03	6.90e-05	4.37e-04	1.08e-04
Chrysene	8.85e-06	1.30e-04	1.08e-04	2.08e-05	1.08e-04	2.45e-05	1.88e-04	4.53e-04	2.39e-05	1.52e-04	3.73e-05
Dibenz(a,h)anthracene	5.68e-05	8.37e-04	6.97e-04	1.34e-04	6.97e-04	1.58e-04	1.21e-03	2.91e-03	1.54e-04	9.75e-04	2.39e-04
Indeno(1,2,3-cd)pyrene	1.33e-04	1.95e-03	1.62e-03	3.12e-04	1.62e-03	3.68e-04	2.82e-03	6.77e-03	3.59e-04	2.27e-03	5.59e-04
Polychlorinated biphenyls (PCBs)											
Aroclor 1016	4.08e-06	6.01e-05	5.01e-05	9.60e-06	5.01e-05	1.13e-05	8.69e-05	2.09e-04	1.10e-05	7.01e-05	1.72e-05
Aroclor 1254	2.60e-05	3.81e-04	3.17e-04	6.11e-05	3.17e-04	7.20e-05	5.52e-04	1.32e-03	7.02e-05	4.44e-04	1.09e-04
Nitroaromatics											
1,3-Dinitrobenzene	5.00e-10	7.35e-09	6.12e-09	1.17e-09	6.12e-09	1.39e-09	1.06e-08	2.55e-08	1.35e-09	8.57e-09	2.10e-09
2,4-Dinitrotoluene	1.60e-09	2.34e-08	1.95e-08	3.75e-09	1.95e-08	4.43e-09	3.40e-08	8.14e-08	4.32e-09	2.73e-08	6.73e-09

TABLE D-3

BIOCONCENTRATION FACTORS FOR SOIL/SEDIMENT TO WILDLIFE MEASUREMENT RECEPTORS

(Page 5 of 6)

	Measurement Receptors										
Compound	**Muskrat ($BCF_{S\text{-}OM}$)**	**Northern Bobwhite ($BCF_{S\text{-}OB}$)**	**Northern Harrier ($BCF_{S\text{-}CM}$)**	**Red Fox ($BCF_{S\text{-}CM}$)**	**Red-tailed Hawk ($BCF_{S\text{-}HM}$)**	**Salt-marsh Harvest Mouse ($BCF_{S\text{-}HM}$)**	**Short-tailed Shrew ($BCF_{S\text{-}OM}$)**	**Spotted Sandpiper ($BCF_{S\text{-}CSB}$)**	**Swift Fox ($BCF_{S\text{-}OM}$)**	**Western Meadow Lark ($BCF_{S\text{-}OM}$)**	**White-footed Mouse ($BCF_{S\text{-}OM}$)**
2,6-Dinitrotoluene	1.24e-09	1.83e-08	1.52e-08	2.91e-09	1.52e-08	3.43e-09	2.63e-08	6.35e-08	3.34e-09	2.13e-08	5.21e-09
Nitrobenzene	1.10e-09	1.61e-08	1.34e-08	2.58e-09	1.34e-08	3.04e-09	2.33e-08	5.61e-08	2.96e-09	1.88e-08	4.62e-09
Pentachloronitrobenzene	7.05e-07	1.04e-05	8.62e-06	1.66e-06	8.62e-06	1.96e-06	1.50e-05	3.60e-05	1.91e-06	1.21e-05	2.97e-06
Phthalate esters											
Bis(2-ethylhexyl)phthalate	2.58e-06	3.80e-05	3.16e-05	6.07e-06	3.16e-05	7.17e-06	5.50e-05	1.32e-04	6.98e-06	4.43e-05	1.09e-05
Di(n)octyl phthalate	3.44e-02	5.07e-01	4.22e-01	8.09e-02	4.22e-01	9.55e-02	7.32e-01	1.76e+00	9.31e-02	5.91e-01	1.45e-01
Volatile organic compounds											
Acetone	9.68e-12	1.42e-10	1.18e-10	2.28e-11	1.18e-10	2.69e-11	2.06e-10	4.94e-10	2.62e-11	1.66e-10	4.08e-11
Acrylonitrile	2.87e-11	4.42e-10	3.51e-11	6.74e-11	3.51e-10	7.95e-11	6.10e-10	1.46e-09	7.75e-11	4.91e-10	1.21e-10
Chloroform	1.44e-09	2.10e-08	1.75e-08	3.38e-09	1.75e-08	3.98e-09	3.06e-08	7.31e-08	3.88e-09	2.45e-08	6.05e-09
Crotonaldehyde	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,4-Dioxane	8.72e-12	1.28e-10	1.06e-10	2.05e-11	1.06e-10	2.42e-11	1.86e-10	4.44e-10	2.36e-11	1.49e-10	3.67e-11
Formaldehyde	3.55e-11	5.21e-10	4.34e-10	8.34e-11	4.34e-10	9.83e-11	7.54e-10	1.81e-09	9.58e-11	6.07e-10	1.49e-10
Vinyl chloride	2.26e-10	3.32e-09	2.77e-09	5.31e-10	2.77e-09	6.26e-10	4.80e-09	1.15e-08	6.10e-10	3.87e-09	9.51e-10
Other chlorinated organics											
Hexachlorobenzene	5.12e-06	7.54e-05	6.28e-05	1.20e-05	6.28e-05	1.42e-05	1.09e-04	2.62e-04	1.38e-05	8.79e-05	2.16e-05
Hexachlorobutadiene	8.65e-07	1.28e-05	1.06e-05	2.04e-06	1.06e-05	2.40e-06	1.84e-05	4.44e-05	2.34e-06	1.49e-05	3.65e-06
Hexachlorocyclopentadiene	1.30e-06	1.91e-05	1.59e-05	3.06e-06	1.59e-05	3.61e-06	2.77e-05	6.64e-05	3.52e-06	2.23e-05	5.49e-06
Pentachlorobenzene	1.97e-06	2.90e-05	2.42e-05	4.63e-06	2.42e-05	5.46e-06	4.19e-05	1.01e-04	5.32e-06	3.39e-05	8.30e-06
Pentachlorophenol	1.94e-06	2.86e-05	2.38e-05	4.55e-06	2.38e-05	5.37e-06	4.12e-05	9.93e-05	5.23e-06	3.33e-05	8.16e-06
Pesticides											
4,4-DDE	2.90e-05	4.28e-04	3.56e-04	6.83e-05	3.56e-04	8.06e-05	6.18e-04	1.49e-03	7.85e-05	4.99e-04	1.22e-04
Heptachlor	1.67e-06	2.45e-05	2.04e-05	3.92e-06	2.04e-05	4.62e-06	3.55e-05	8.51e-05	4.51e-06	2.86e-05	7.03e-06
Hexachlorophene	5.59e-04	8.22e-03	6.85e-03	1.31e-03	6.85e-03	1.55e-03	1.19e-02	2.86e-02	1.51e-03	9.58e-03	2.35e-03
Inorganics											
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Antimony	6.41e-07	NA	NA	1.51e-06	NA	1.78e-06	1.36e-05	NA	1.73e-06	NA	2.70e-06
Arsenic	1.28e-06	NA	NA	3.01e-06	NA	3.56e-06	2.73e-05	NA	3.47e-06	NA	5.40e-06
Barium	9.62e-08	NA	NA	2.26e-07	NA	2.67e-07	2.05e-06	NA	2.60e-07	NA	4.05e-07
Beryllium	6.41e-07	NA	NA	1.51e-06	NA	1.78e-06	1.36e-05	NA	1.73e-06	NA	2.70e-06
Cadmium	7.69e-08	1.27e-03	1.05e-03	1.81e-07	1.05e-03	2.13e-07	1.64e-06	4.40e-03	2.08e-07	1.48e-03	3.24e-07
Chromium (hexavalent)	3.53e-06	NA	NA	8.29e-06	NA	9.78e-06	7.50e-05	NA	9.53e-06	NA	1.49e-05

TABLE D-3

BIOCONCENTRATION FACTORS FOR SOIL/SEDIMENT TO WILDLIFE MEASUREMENT RECEPTORS

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	Measurement Receptors										
Compound	**Muskrat (BCF_{S-OM})**	**Northern Bobwhite (BCF_{S-OB})**	**Northern Harrier (BCF_{S-CM})**	**Red Fox (BCF_{S-CM})**	**Red-tailed Hawk (BCF_{S-HM})**	**Salt-marsh Harvest Mouse (BCF_{S-HM})**	**Short-tailed Shrew (BCF_{S-OM})**	**Spotted Sandpiper (BCF_{S-CSB})**	**Swift Fox (BCF_{S-OM})**	**Western Meadow Lark (BCF_{S-OM})**	**White-footed Mouse (BCF_{S-OM})**
Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Cyanide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	1.92e-07	NA	NA	4.52e-07	NA	5.33e-07	4.09e-06	NA	5.20e-07	NA	8.11e-07
Mercuric chloride	3.35e-06	2.87e-04	2.38e-04	7.88e-06	2.38e-04	9.29e-06	7.10e-05	9.92e-04	9.03e-06	3.32e-04	1.41e-05
Methylmercury	5.00e-07	4.30e-05	3.56e-05	1.18e-06	3.56e-05	1.39e-06	1.06e-05	1.49e-04	1.35e-06	4.98e-05	2.11e-06
Nickel	3.85e-06	NA	NA	9.04e-06	NA	1.07e-05	8.18e-05	NA	1.04e-05	NA	1.62e-05
Selenium	1.46e-06	1.35e-02	1.12e-02	3.42e-06	1.12e-02	4.04e-06	3.10e-05	4.69e-02	3.93e-06	1.57e-02	6.13e-06
Silver	1.92e-06	NA	NA	4.52e-06	NA	5.33e-06	4.09e-05	NA	5.20e-06	NA	8.11e-06
Thallium	2.57e-05	NA	NA	6.03e-05	NA	7.11e-05	5.46e-04	NA	6.93e-05	NA	1.08e-04
Zinc	5.77e-08	1.05e-04	8.71e-05	1.36e-07	8.71e-05	1.60e-07	1.23e-06	3.63e-04	1.56e-07	1.22e-04	2.43e-07

Notes:

NA - Indicates insufficient data to determine value

HB	- Herbivorous bird
HM	- Herbivorous mammal
OB	- Omnivorous bird
OM	- Omnivorous mammal
S	- Soil/Sediment

– Values provided were determined as specified in the text of Appendix D. *BCF* values for omnivores were determined based on an equal diet. *BCF* values for dioxin and furan congeners determined using BEF values specified in Chapter 2.

APPENDIX E

TOXICITY REFERENCE VALUES

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APPENDIX E

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APPENDIX E

TOXICITY REFERENCE VALUES

Appendix E presents implementation of the recommended approach (described in Chapter 5) for identifying toxicity reference values (*TRV*s) for measurement receptors. Discussion is provided for determining compound-specific *TRV* values for community and wildlife measurement receptors.

Following the guidance in Sections E-1.0 through E-1.2, U.S. EPA OSW has identified default *TRV* values for the measurement receptors of the seven example food webs (listed in Chapter 4) and the compounds commonly identified in ecological risk assessments for combustion facilities (identified in Chapter 2). Section E-1.0 describes the determination of *TRV* values for surface water, sediment, and soil community measurement receptors in the example food webs. Section E-2.0 describes determination of *TRV* values for wildlife measurement receptors in the example food webs. Tables E-1 through E-8 present the default *TRV* values selected, the basis for selection of each value, and the references evaluated in determination of each value.

TRV values for a limited number of compounds are included in this appendix (see Tables E-1 through E-3) to facilitate the completion of screening ecological risk assessments. However, it is expected that *TRV* values for additional compounds and receptors may be required for evaluation on a site specific basis. In such cases, *TRV* values for these additional compounds could be determined following the same guidance used in determination of the *TRV* values reported in this appendix. For the determination of *TRV* values for measurement receptors not specifically represented in Sections E-1.0 through E-2.0 (e.g., amphibians and reptiles), an approach consistent to that presented in this appendix could be utilized by applying data applicable to those measurement receptors being evaluated.

The default *TRV*s provided in Tables E-1 through E-8 are based on values reported in available scientific literature. Toxicity values identified in secondary reference sources were verified, where possible, by reviewing the primary reference source. As noted in Chapter 5, *TRV* values may change as additional toxicity research is conducted and the availability of toxicity data in the scientific literature increases. As a result, U.S. EPA OSW recommends evaluating the latest toxicity data before completing a risk assessment to ensure that the toxicity data used in the risk assessment is the most current. If more appropriate *TRV* values can be documented, they should be used presented to the respective permitting authority for approval.

*TRV*s were not identified for amphibians and reptiles because of the paucity of toxicological information on these receptors. Additional guidance on determination and use of *TRV* values in the screening level ecological risk assessment is provided in Chapter 5.

E-1.0 *TRVs* FOR COMMUNITY MEASUREMENT RECEPTORS IN SURFACE WATER, SEDIMENT, AND SOIL

TRV values provided in this appendix for community measurement receptors in surface water, sediment, and soil were identified from screening toxicity values developed and/or adopted by federal and/or state regulatory agencies. As discussed in Chapter 5, these screening toxicity values are generally provided in the form of standards, criteria, guidance, or benchmarks. For compounds with no available screening toxicity value, *TRV*s were determined using toxicity values from available scientific literature. The equilibrium partitioning (EqP) approach was used to compute several sediment *TRV*s. Uncertainty factors (UFs) were applied to toxicity values, as necessary, to meet the *TRV* criteria discussed in Chapter 5. The following sections discuss determination of *TRV* values for community receptors in surface water, sediment, and soil.

Freshwater TRVs Freshwater *TRV*s should be used for freshwater and estuarine ecosystems with a salinity less than 5 parts per thousand. Freshwater *TRV*s, based on the dissolved concentration of the compound in surface water, are listed in Table E-1. *TRV*s were identified using the following hierarchy:

1. Federal chronic ambient water quality criteria (AWQC) calculated for with no final residue value (U.S. EPA 1999; 1996b). Federal AWQC for cadmium, copper, lead, nickel, and zinc were multiplied by a chemical-specific conversion factor to determine a *TRV* based on dissolved concentration (U.S. EPA 1999; 1996b).

2. Final chronic values (FCV) for COPCs for which their AWQC included a final residue value (U.S. EPA 1996b).

3. If inadequate data (insufficient number of families of aquatic life with toxicity data) were available to compute an AWQC or FCV, U.S. EPA (1999; 1996b) also reported secondary chronic values (SCV) calculated using the Tier II method in the Great Lakes Water Quality Initiative (GLWQI) (reported in 40 CFR Part 122). This method is similar to the procedures for calculating an FCV. It uses statistically-derived “adjustment factors” to address deficiencies in available data. The adjustment factor decreases as the number of representative families increases.

4. If an AWQC, FCV, or GLWQI Tier II SCV value were not available, toxicity values cited by U.S. EPA (1987) were identified. These toxicity values represent the lowest available values. Further, additional toxicity values available from the AQUIRE database in U.S. EPA’s *ECOTOXicology Database System* (U.S. EPA 1996a) were identified. If collected from a secondary source (such as AQUIRE), original studies were obtained and reviewed for accuracy. The toxicity values reported in Table E-1 represent the lowest (most conservative), ecologically relevant, available value.

5. If toxicity data were unavailable, a surrogate *TRV* from a COPC with a similar structure was identified.

6. If no surrogate was available, a *TRV* was not listed. The potential toxicity of a COPC with no *TRV* should be addressed as an uncertainty (see Chapter 6)

Standard AQUIRE report summaries on tests were screened for duration, endpoint, effect, and concentration. Studies were also screened for ecologically relevant effects by focusing on studies that evaluated effects on survival, reproduction, and growth. Aspects of endpoint, duration, and test organism in each toxicity study were evaluated to identify the most appropriate study. Several compounds, most notably metals, had a large number of toxicity values based on various endpoints, organisms, and exposure durations. In these instances, best scientific judgment was used to identify the most appropriate toxicity value (see Chapter 5).

Chronic NOAEL-based values were not adjusted, but rather were carried through unchanged to become the *TRV*. Toxicity values identified as "less than" a particular concentration were divided by 2 to represent an average value because the true value is unknown, and it occurs between 0 and the noted concentration. *UF*s discussed in Chapter 5 were applied to toxicity values not meeting *TRV* criteria.

Saltwater TRVs Saltwater *TRV*s are applicable to marine water bodies and estuarine systems with a salinity greater than 5 ppt. Saltwater *TRV*s are listed in Table E-2. Saltwater water *TRV* development followed the same procedure as described above for freshwater receptors, except no GLWQI Tier II SCVs were available. In addition, if no saltwater *TRV* for a surrogate compound was available, the corresponding freshwater *TRV* was adopted.

Freshwater Sediment TRVs Freshwater sediment *TRV*s are listed in Table E-3. They are applicable to water bodies with a salinity less than 5 ppt. Freshwater sediment *TRV*s were identified from various sets of screening values and ecotoxicity review documents. The lowest available screening values among the following sources were identified:

1. No effect level (NEL) and lowest effect level (LEL) values from "Ontario's Approach to Sediment Assessment and Remediation" (Persaud et al. 1993)

2. Apparent effects threshold (AET) values for the amphipod, *Hyallela azteca*, reported in "Creation of Freshwater Sediment Quality Database and Preliminary Analysis of Freshwater Apparent Effects Thresholds" (Washington State Department of Ecology 1994)

3. Sediment effect concentrations jointly published by the National Biological Service and the U.S. EPA (Ingersoll et al. 1996).

If a screening value was not available in the sources listed above, toxicity studies and other values compiled and reported by Jones, Hull, and Suter (1997) were reviewed to identify possible *TRV*s. Relevant studies were prioritized based on the criteria listed in Chapter 5, and uncertainty factors were applied, as applicable, based on criteria presented (see Chapter 5).

If a screening or sediment toxicity value was not available for an organic COPC, a freshwater sediment *TRV* was computed, using the EqP approach (see Chapter 5), from the compounds corresponding freshwater *TRV* and K_{oc} value. The U.S. EPA Office of Water utilizes the EqP approach to develop sediment quality criteria for nonionic (neutral) organic chemicals (U.S. EPA 1993). The EqP approach assumes that the toxicity of a compound in sediment is a function of the concentration in pore water and that to be nontoxic, the pore water must meet the surface water final chronic value. The EqP approach also assumes that the concentration of a compound in sediment pore water depends on the carbon content of the sediment and the compound's organic carbon partitioning coefficient (U.S. EPA 1993). A *TRV* may be calculated using the following equation (U.S. EPA 1993):

$$TRV_{sed} = K_{oc} \cdot f_{oc} \cdot TRV_{sw} \qquad \text{Equation E-1}$$

where

TRV_{sed} = Sediment *TRV* (µg/kg)

K_{oc} = Organic carbon partition coefficient (L/kg)
f_{oc} = Fraction of organic carbon in sediment (unitless)—default value = 4% (0.04)
TRV_{sw} = Corresponding surface water *TRV* (µg/L)

Marine Sediment TRVs Marine sediment *TRV*s are listed in Table E-4. They are applicable to sediments of marine water bodies and estuarine systems with a salinity greater than 5 ppt. Marine sediment *TRV*s were developed following the procedures used to identify the freshwater sediment *TRV*s. Screening values were compiled from the following sources:

1. No observed effect level (NOEL) sediment quality assessment guidelines for State of Florida coastal waters (MacDonald 1993).

2. Marine and estuarine effects range low (ERL) values from "Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments" (Long et al. 1995)

3. ERL values from "The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program" (Long and Morgan 1991)

4. Marine sediment quality criteria from "Sediment Management Standards" (Washington State Department of Ecology 1991)

Screening values were adopted directly as *TRV*s. If a screening value was not available in the sources listed above, toxicity values from a search of the scientific literature and those compiled and reported by Hull and Suter (1994) were reviewed to identify possible *TRV*s. Original studies were obtained, where possible, and toxicity values were verified. Relevant studies were prioritized based on the criteria listed in Chapter 5, and uncertainty factors were applied, as appropriate, based on criteria (see Chapter 5). If a screening or ecologically relevant sediment toxicity value from the scientific literature were not available for an organic COPC, a marine sediment *TRV* was computed, using the EqP approach, from the COPC's corresponding saltwater *TRV* and K_{oc} value (see Equation E-1).

Terrestrial Plant TRVs The terrestrial plant *TRV*s listed in Table E-5 are based on bulk soil exposures. Available terrestrial plant toxicity values from the scientific literature were used to develop presented *TRV* values. Toxicity values were first identified from the following secondary sources:

1. Studies cited in *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants: 1997 Revision* (Efroymson, Will, Suter, and Wooten 1997). Available studies were obtained and reviewed for accuracy of toxicity values. UFs were applied depending on study endpoint and available information.

2. Toxicity values in the Phytotox database in U.S. EPA's *ECOTOXicology Database* System. Available studies were obtained and toxicity values were verified. UFs were applied depending on study endpoint and available information.

3. Toxicity values in U.S. EPA Region 5 *Ecological Data Quality Levels (EDQL) Database* (PRC 1995). The database contains media-specific EDQLs for the RCRA Appendix IX constituents (40 CFR Part 264). The EDQLs represent conservative media concentrations

protective of media receptors and wildlife that might be exposed through food chains based in these media. Available studies were obtained and toxicity values were verified. UFs were applied depending on study endpoint and available information.

Original studies were obtained, where possible, and prioritized based on criteria listed in Chapter 5. Uncertainty factors were applied, as appropriate, based on criteria (discussed in Chapter 5) to develop *TRV* values. For COPCs without toxicity data, the *TRV* for a surrogate COPC was adopted. If an appropriate surrogate *TRV* was not available, no *TRV* value was identified. Generally, review of toxicity data available in the scientific literature indicates that limited *TRV*s are available for organic compounds; while *TRV*s for metals are available.

Soil Invertebrate TRVs The soil invertebrate *TRV*s listed in Table E-6 are based on bulk soil exposures. Available soil invertebrate toxicity values from the scientific literature were used to develop *TRV*s for these receptors. Soil invertebrate toxicity values were first identified from the following secondary sources:

1. Studies cited in *Toxicological Benchmarks for Potential Contaminants of Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process* (Will and Suter II 1995a). Available studies were obtained and toxicity values were verified. UFs were applied depending on study endpoint and available information.

2. Scientific literature was searched for toxicity values for outstanding compounds. Relevant studies were obtained, toxicity values were verified, and UFs were applied as described.

Original studies were obtained, where possible, and prioritized based on criteria listed in Chapter 5. Uncertainty factors were applied, as appropriate, based on criteria to develop *TRV*s. If no toxicity value was available for a COPC, the *TRV* for a surrogate COPC was adopted.

E-2.0 *TRVs* FOR WILDLIFE MEASUREMENT RECEPTORS

TRV values for wildlife measurement receptors are listed in Tables E-7 (mammals) and E-8 (birds). *TRVs* were not developed for each avian and mammalian measurement receptor in the seven example food webs because of the paucity of species-specific data. Rather, U.S. EPA OSW focused on identifying a set of avian *TRV*s and a set of mammalian *TRV*s for the classes of compounds listed in Section 2.3. U.S. EPA OSW assumed that, among the literature reviewed for a particular guild, the lowest available toxicity value across orders in class Aves and across orders in class Mammalia would provide a conservative estimate of toxicity. Available mammalian and avian toxicity values from the scientific literature were used to develop *TRVs* for these receptors. Also, as previously noted, *TRV* values were not identified for amphibians and reptiles because of the paucity of toxicological information on these receptors. Wildlife measurement receptors *TRV* values were first identified from the following secondary sources:

1. Toxicity values compiled in *Toxicological Benchmarks for Wildlife: 1996 Revision* (Sample, Opresko, and Suter 1996).

2. Toxicity values listed in the Terretox database of U.S. EPA's *ECOTOXicology Database System* (U.S. EPA 1996b) were screened to identify studies potentially meeting the criteria listed in Chapter 5.

Original studies were compiled, where possible, and reviewed to verify their accuracy based on criteria listed in Chapter 5. In many cases, best scientific judgement was used to screen out studies with poor experimental design (see Chapter 5). Uncertainty factors were applied, as appropriate, to develop *TRVs* based on criteria presented in Chapter 5.

Conversions Some avian and mammalian toxicity data are expressed in terms of compound concentration in the food of the test organism. To convert to daily dose, it is necessary to determine the exposure duration and organism body weight. If the study does not report this information, the results should not be used to compute a *TRV*. If information on exposure duration and organism body weight is available, dietary concentration can be computed to dose using the following generic equation:

$$DD = \frac{C \cdot IR}{BW} \qquad \text{Equation E-2}$$

where

DD = COPC dose (mg COPC/kg BW/day)
C = Concentration of COPC in diet (mg COPC/kg food)
IR = Food ingestion rate (kg/day)
BW = Test organism body weight (kg)

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TABLES OF TOXICITY REFERENCE (*TRV*) VALUES

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TABLE E-1

FRESHWATER TOXICITY REFERENCE VALUES

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Compound	Toxicity Value		Uncertainty Factor[b]	TRV[c]	Reference and Notes [d]
	Duration and Endpoint[a]	Concentration			
Polychlorinateddibenzo-p-dioxins (μg/L)					
2,3,7,8-TCDD	Chronic LOEL	0.000038	0.1	0.0000038	Mehrle et al. (1988). 2,3,7,8-TCDD toxicity value for rainbow trout (*Oncorhynchus mykiss*).
Polynuclear aromatic hydrocarbons (PAH) (μg/L)					
Total high molecular weight (HMW) PAHs	--	--	--	0.014	Benzo(a)pyrene toxicity used as surrogate measure of toxicity. This TRV should be used if assessing the risk of total HMW PAHs.
Benzo(a)pyrene	Tier II value	0.014	Not applicable	0.014	U.S. EPA (1996). Calculated using Great Lakes Water Quality Initiative Tier II methodology.
Benzo(a)anthracene	Tier II SCV	0.027	Not applicable	0.027	Suter and Tsao (1996). Calculated using Great Lakes Water Quality Initiative Tier II methodology.
Benzo(b)fluoranthene	--	--	--	0.027	Toxicity value not available. Benzo(a)anthracene used as surrogate.
Benzo(k)fluoranthene	--	--	--	0.027	Toxicity value not available. Benzo(a)anthracene used as surrogate.
Chrysene	--	--	--	0.027	Toxicity value not available. Benzo(a)anthracene used as surrogate.
Dibenz(a,h)anthracene	--	--	--	0.027	Toxicity value not available. Benzo(a)anthracene used as surrogate.
Indeno(1,2,3-cd)pyrene	--	--	--	0.027	Toxicity value not available. Benzo(a)anthracene used as surrogate.
Polychlorinated biphenyls (PCB) (μg/L)					
Aroclor 1016	--	0.19	Not applicable	0.19	Adopted from U.S. EPA (1996) value for Total PCB. Calculated using Great Lakes Water Quality Initiative Tier II methodology.

TABLE E-1

FRESHWATER TOXICITY REFERENCE VALUES

(Page 2 of 8)

Compound	Toxicity Value		Uncertainty Factor[b]	TRV[c]	Reference and Notes [d]
	Duration and Endpoint[a]	Concentration			
Aroclor 1254	--	0.19	Not applicable	0.19	Adopted from U.S. EPA (1996) value for Total PCB. Calculated using Great Lakes Water Quality Initiative Tier II methodology.
Nitroaromatics (μg/L)					
1,3-Dinitrobenzene	Subchronic NOEC	260	0.1	26	van der Schalie (1983). Algal growth test with *Selenastrum capricornutum*.
2,4-Dinitrotoluene	Chronic LOEL	230	0.1	23	U.S. EPA (1987)
2,6-Dinitrotoluene	Chronic NOEC	60	Not applicable	60	Kuhn et al. (1989). Toxicity value for water flea (*Daphnia magna*).
Nitrobenzene	Acute LOEL	27,000	0.01[e]	270	U.S. EPA (1987)
Pentachloronitrobenzene	LC50	1,000	0.01	10	Hashimoto and Nishiuchi (1981). Toxicity value for common carp (*Cyprinus carpio*).
Phthalate esters (μg/L)					
Bis(2-ethylhexyl)phthalate	Tier II SCV	3.0	Not applicable	3.0	Suter and Tsao (1996). Calculated using Great Lakes Water Quality Initiative Tier II methodology.
Di(n)octyl phthalate	Chronic NOEL	320	Not applicable	320	McCarthy and Whitmore (1985). Toxicity value for water flea (*D. magna*).
Volatile organic compounds (μg/L)					
Acetone	Tier II SCV	1,500	Not applicable	1,500	Suter and Tsao (1996). Calculated using Great Lakes Water Quality Initiative Tier II methodology.
Acrylonitrile	Chronic LOEL	2,600	0.1	260	U.S. EPA (1987)
Chloroform	Tier II SCV	28	Not applicable	28	Suter and Tsao (1996). Calculated using Great Lakes Water Quality Initiative Tier II methodology.

TABLE E-1

FRESHWATER TOXICITY REFERENCE VALUES

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Compound	Toxicity Value		Uncertainty Factor[b]	TRV[c]	Reference and Notes [d]
	Duration and Endpoint[a]	Concentration			
Crotonaldehyde	Acute LC50	3,500	0.01	35	Dawson et al. (1977). Toxicity value for bluegill sunfish (*Lepomis macrochirus*).
1,4-Dioxane	Acute EC0	6,210,000	0.01	62,100	Bringmann and Kühn (1982). Toxicity value for water flea (*D. magna*).
Formaldehyde	Acute LC50	4,960	0.01	49.6	Reardon and Harrell (1990). No data available for formalehyde. Formalin containing 37 percent formaldehyde used as a surrogate. Endpoint based on formaldehyde concentration.
Vinyl chloride	Subchronic LC100	388,000	0.01[e]	3,880	Brown et al. (1977)
Other chlorinated organics (μg/L)					
Hexachlorobenzene	Proposed chronic criterion	3.68	Not applicable	3.68	U.S. EPA (1987)
Hexachlorobutadiene	Chronic LOEL	9.3	0.1	0.93	U.S. EPA (1987)
Hexachlorocyclopentadiene	Chronic LOEL	5.2	0.1	0.52	U.S. EPA (1987)
Pentachlorobenzene	Tier II value	0.47	Not applicable	0.47	U.S. EPA (1996). Calculated using Great Lakes Water Quality Initiative Tier II methodology.
Pentachlorophenol	Chronic criterion	15	Not applicable	15	U.S. EPA (1999). Value expressed as a function of pH and calculated as follows: TRV = exp(1.005(pH)-5.134). A pH of 7.8 is assumed to calculate the displayed value.
Pesticides (μg/L)					
4,4'-DDE	Acute LOEL	1,050	0.01[e]	10.5	U.S. EPA (1987)
Heptachlor	Chronic criterion	0.0038	Not applicable	0.0038	U.S. EPA (1987)

TABLE E-1

FRESHWATER TOXICITY REFERENCE VALUES

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Compound	Toxicity Value		Uncertainty Factor[b]	TRV[c]	Reference and Notes [d]
	Duration and Endpoint[a]	Concentration			
Hexachlorophene	Subchronic NOEC	8.8	0.1	0.88	Call et al. (1989). Toxicity value for fathead minnow (*P. promelas*).
Inorganics (mg/L) [f]					
Aluminum	FCV	0.087	Not applicable	0.087	U.S. EPA (1988)
Antimony	Proposed chronic criterion	0.03	Not applicable	0.03	U.S. EPA (1987)
Arsenic (trivalent)	Chronic criterion	0.15	Not applicable	0.15	U.S. EPA (1999)
Barium	Tier II SCV	0.004	Not applicable	0.004	Suter and Tsao (1996). Calculated using Great Lakes Water Quality Initiative Tier II methodology.
Beryllium	Tier II SCV	0.00066	Not applicable	0.00066	Suter and Tsao (1996). Calculated using Great Lakes Water Quality Initiative Tier II methodology.
Cadmium	Chronic criterion	0.0022 (dissolved)	Not applicable	0.0022	U.S. EPA (1999). Value expressed as a function of water hardness and calculated as follows: TRV = exp(m_c[ln(hardness)]+b_c) where m_c = 0.7852 and b_c = -2.715. Criterion was converted to dissolved concentration using the following conversion factor: 1.101672-[(ln hardness)(0.041838]. A assumed hardness of 100 mg/L and a conversion from mg/L to μg/L were used to calculate the displayed value.
Chromium (hexavalent)	Chronic criterion	0.011	Not applicable	0.011	U.S. EPA (1999).
Copper	Chronic criterion	0.009 (dissolved)	Not applicable	0.009	U.S. EPA (1999). Value expressed as a function of water hardness and calculated as follows: TRV = exp(m_c[ln(hardness)]+b_c) where m_c = 0.8545 and b_c = -1.702. Criterion was converted to dissolved concentration using a conversion factor of 0.960. A assumed hardness of 100 mg/L and a conversion from mg/L to μg/L were used to calculate the displayed value.

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FRESHWATER TOXICITY REFERENCE VALUES

(Page 5 of 8)

Compound	Toxicity Value		Uncertainty Factor[b]	TRV[c]	Reference and Notes [d]
	Duration and Endpoint[a]	Concentration			
Total Cyanide	Chronic criterion	0.0052	Not applicable	0.0052	U.S. EPA (1999). This value is expressed as mg free cyanide (as CN)/L.
Lead	Chronic criterion	0.0025 (dissolved)	Not applicable	0.0025	U.S. EPA (1999). Value expressed as a function of water hardness and calculated as follows: TRV = exp(m_c[ln(hardness)]+b_c) where m_c = 1.273 and b_c = -4.705. Criterion was converted to dissolved concentration using the following conversion factor: 1.46203-[(ln hardness)(0.145712]. A assumed hardness of 100 mg/L and a conversion from mg/L to μg/L were used to calculate the displayed value.
Mercuric chloride	Chronic criterion	0.00077	Not applicable	0.00077	U.S. EPA (1999). This value was from data for inorganic mercury (II).
Methyl mercury	Tier II SCV	0.0000028	Not applicable	0.0000028	Suter and Tsao (1996). Calculated using Great Lakes Water Quality Initiative Tier II methodology.
Nickel	Chronic criterion	0.052 (dissolved)	Not applicable	0.052	U.S. EPA (1999). Value expressed as a function of water hardness and calculated as follows: TRV = exp(m_c[ln(hardness)]+b_c) where m_c = 0.8460 and b_c = 0.0584. Criterion was converted to dissolved concentration using a conversion factor of 0.997. A assumed hardness of 100 mg/L and a conversion from mg/L to μg/L were used to calculate the displayed value.
Selenium	Chronic criterion	0.005	Not applicable	0.005	U.S. EPA (1999)
Silver	Proposed chronic criterion	0.00012	Not applicable	0.00012	U.S. EPA (1987)
Thallium	Chronic LOEL	0.04	0.1	0.004	U.S. EPA (1987)

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FRESHWATER TOXICITY REFERENCE VALUES

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Compound	Toxicity Value		Uncertainty Factor[b]	TRV[c]	Reference and Notes [d]
	Duration and Endpoint[a]	Concentration			
Zinc	Chronic criterion	0.118 (dissolved)	Not applicable	0.118	U.S. EPA (1999). Value expressed as a function of water hardness and calculated as follows: TRV = exp(m_c[ln(hardness)]+b_c) where m_c = 0.8473 and b_c = 0.884. Criterion was converted to dissolved concentration using a conversion factor of 0.986. A assumed hardness of 100 mg/L and a conversion from mg/L to μg/L were used to calculate the displayed value.

Notes:

a The duration of exposure is defined as chronic if it represents about 10 percent or more of the test animals lifetime expectancy. Acute exposures represent single exposures or multiple exposures occurring within a short time. For evaluating exposure duration, the following general guidelines were used. For invertebrates and other lower trophic level aquatic biota: (1) chronic duration lasted for 7 or more days, (2) subchronic duration lasted from 3 to 6 days, and (3) acute duration lasted 2 days or less. For fish: (1) chronic duration lasted for more than 90 days, (2) subchronic duration lasted from 14 to 90 days, and (3) acute duration lasted less than 2 weeks.

b Uncertainty factors are used to extrapolate a toxicity value to a chronic NOAEL TRV. See Chapter 5 (Section 5.4) of the SLERAP for a discussion of the use of uncertainty factors.

c TRV was calculated by multiplying the toxicity value with the uncertainty factor.

d The references refer to the source of the toxicity value. Complete reference citations are provided below.

e Best scientific judgment used to identify uncertainty factor. See Chapter 5 (Section 5.4.1.2) for a discussion the use of best scientific judgement. Factors evaluated include test duration, ecological relevance of endpoint, experimental design, and availability of toxicity data.

f TRVs for metals are based on the dissolved metal concentration. According to U.S. EPA (1993) policy, concentrations of dissolved metal more closely approximate the bioavailable fraction of metal in the water column.

EC0 = Effective concentration for zero percent of the test organisms.
FCV = Final Chronic Value
HMW = High molecular weight
LC50 = Lethal concentration for 50 percent of the test organisms.
LC100 = Lethal concentration for 100 percent of the test organisms.
LOEL = Lowest Observed Effect Level
NOEC = No Observed Effect Concentration
NOEL = No Observed Effect Level
SCV = Secondary Chronic Value
TRV = Toxicity Reference Value

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TABLE E-2

MARINE/ESTUARINE SURFACE WATER TOXICITY REFERENCE VALUES

(Page 1 of 8)

Compound	Toxicity Value		Uncertainty Factor[b]	Toxicity Reference Value[c]	Reference and Notes [d]
	Duration and Endpoint[a]	Concentration			
Polychlorinateddibnzo-p-dioxins (μg/L)					
2,3,7,8-TCDD	LOEC	0.000038	0.1	0.0000038	No saltwater data were available, therefore, corresponding freshwater toxicity value was used (rainbow trout, *Oncorhynchus mykiss*) from Mehrle et al. (1988). 2,3,4,5-TCDD toxicity value used.
Polynuclear aromatic hydrocarbons (PAH) (μg/L)					
Total high molecular weight (HMW) PAHs	Acute LC50	>50	0.01[e]	0.5	Rossi and Neff (1978) evaluated toxicity of three HMW (three or more aromatic rings) PAHs to the polychaete, *Neanthes arenaceodentata*. LC50 of each HMW PAH exceeded 50 μg/L. This TRV should be used if assessing the risk of total HMW PAHs.
Benzo(a)pyrene	Acute LC50	>50	0.01[e]	0.5	Rossi and Neff (1978). Toxicity value for polychaete (*N. arenaceodentata*).
Benzo(a)anthracene	Acute LC50	>50	0.01[e]	0.5	Toxicity value not available. TRV for benzo(a)pyrene used as surrogate.
Benzo(b)fluoranthene	Acute LC50	>50	0.01[e]	0.5	Toxicity value not available. TRV for benzo(a)pyrene used as surrogate.
Benzo(k)fluoranthene	Acute LC50	>50	0.01[e]	0.5	Toxicity value not available. TRV for benzo(a)pyrene used as surrogate.
Chrysene	Acute LC50	>50	0.01[e]	0.5	Rossi and Neff (1978). Toxicity of several PAHs was evaluted. LC50 of each individual HMW PAH exceeded 50 μg/L.
Dibenz(a,h)anthracene	Acute LC50	>50	0.01[e]	0.5	Rossi and Neff (1978). Toxicity of several PAHs was evaluted. LC50 of individual HMW PAHs exceeded 50 μg/L.
Indeno(1,2,3-cd)pyrene	Acute LC50	>50	0.01[e]	0.5	Toxicity value not available. TRV for benzo(a)pyrene used as surrogate.
Polychlorinated biphenyls (PCB) (μg/L)					
Aroclor 1016	--	0.03	Not applicable	0.03	U.S. EPA (1987) chronic criterion for ambient water quality.

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MARINE/ESTUARINE SURFACE WATER TOXICITY REFERENCE VALUES

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Compound	Toxicity Value		Uncertainty Factor[b]	Toxicity Reference Value[c]	Reference and Notes [d]
	Duration and Endpoint[a]	Concentration			
Aroclor 1254	--	0.03	Not applicable	0.03	U.S. EPA (1987) chronic criterion for ambient water quality.
Nitroaromatics (μg/L)					
1,3-Dinitrobenzene	--	--	--	66.8	Toxicity data not available. TRV for nitrobenzene used as surrogate.
2,4-Dinitrotoluene	Chronic criterion	370	Not applicable	370	U.S. EPA (1987)
2,6-Dinitrotoluene	--	--	--	370	Toxicity data not available. TRV for 2,4-dinitrotoluene used as surrogate.
Nitrobenzene	Acute criterion	6,680	0.01	66.8	U.S. EPA (1987)
Pentachloronitrobenzene	Acute LC50	1,000	0.01	10	No toxicity value or surrogate TRV available, therefore, corresponding freshwater toxicity value (common carp, *Cyprinus carpio*) from Hashimoto and Nishiuchi (1981) adopted.
Phthalate esters (μg/L)					
Bis(2-ethylhexyl)phthalate	Acute LC50	>170	0.01	1.7	Adams et al. (1995). Toxicity value for sheepshead minnow (*Cyprinodon variegatus*).
Di(n)octyl phthalate	NOEL	320	Not applicable	320	No toxicity value or surrogate TRV available, therefore, corresponding freshwater toxicity value used (water flea, *D. magna*) from McCarthy and Whitmore (1985).
Volatile organic compounds (μg/L)					
Acetone	Acute LC50	2,100,000	0.01	21,000	Price et al. (1974). Toxicity value for brine shrimp (*Artemia* sp.).
Acrylonitrile	Acute LC50	10,000	0.01	100	Portmann and Wilson (1971). Toxicity value for common shrimp (*Crangon crangon*).

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MARINE/ESTUARINE SURFACE WATER TOXICITY REFERENCE VALUES

(Page 3 of 8)

Compound	Toxicity Value		Uncertainty Factor[b]	Toxicity Reference Value[c]	Reference and Notes [d]
	Duration and Endpoint[a]	Concentration			
Chloroform	Acute LC 50	18,000	0.01	180	Anderson and Luster (1980). Toxicity value for Rainbow trout (*Salmo gairdnari*).
Crotonaldehyde	Acute LC50	1,300	0.01	13	Dawson et al. (1977). Toxicity value for inland silverside (*Menidia beryllina*).
1,4-Dioxane	Acute LC50	6,700,000	0.01	67,000	Dawson et al. (1977). Toxicity value for inland silverside (*M. beryllina*).
Formaldehyde	Acute LC50	4,960	0.01	49.6	No toxicity value or surrogate TRV available for this constituent, therefore, corresponding freshwater toxicity value used (Striped bass, *Morone saxatilis*) from Reardon and Harell (1990). No data available for formadehyde. Formalin containing 37 percent formaldehyde used as surrogate. TRV expressed on formaldehyde basis.
Vinyl chloride	Subchronic LC100	388,000	0.01[e]	3,880	No toxicity value of surrogate TRV available, therefore, corresponding freshwater toxicity value used (Northern pike, *Esox lucius*) from Brown et al. (1977).
Other chlorinated organics (μg/L)					
Hexachlorobenzene	Acute EC50	>1,000	0.01	10	Zaroogian (1981). Toxicity value for American oyster (*Crassostrea virginica*).
Hexachlorobutadiene	Acute LOEL	32	0.01[e]	0.32	U.S. EPA (1987)
Hexachlorocyclopentadiene	Acute LOEL	7.0	0.01[e]	0.07	U.S. EPA (1987)
Pentachlorobenzene	Subchronic NOEC	18	0.1	1.8	Hansen and Cripe (1991). Toxicity value for sheepshead minnow (*Cyprinodon variegatus*).
Pentachlorophenol	Chronic criterion	7.9	Not applicable	7.9	U.S. EPA (1987)
Pesticides (μg/L)					

TABLE E-2

MARINE/ESTUARINE SURFACE WATER TOXICITY REFERENCE VALUES

(Page 4 of 8)

Compound	Toxicity Value		Uncertainty Factor[b]	Toxicity Reference Value[c]	Reference and Notes [d]
	Duration and Endpoint[a]	Concentration			
4,4'-DDE	Acute LOEL	14	0.01[e]	0.14	U.S. EPA (1987)
Heptachlor	Chronic criterion	0.0036	Not applicable	0.0036	U.S. EPA (1987)
Hexachlorophene	Acute LC50	3.3	0.01	0.033	Calleja et al. (1994). Toxicity value for brine shrimp (*Artemia salina*).
Inorganics (mg/L)					
Aluminum	Acute LT50	0.271	0.01	0.00271	Study examined influence of pH and temperature on acute (48-hour) toxicity (as time to mortality) of aluminum to smoltifying Atlantic salmon (*Salmo salar*). Endpoint concentration based on sum of inorganic and organic aluminum for exposure at pH 6.5 (Poleo and Muniz 1993).
Antimony	Proposed chronic criterion	0.5	Not applicable	0.5	U.S. EPA (1987)
Arsenic (trivalent)	Chronic criterion	0.036	Not applicable	0.036	U.S. EPA (1987)
Barium	Subchronic LC50	>500.	0.01[e]	5.0	U.S. EPA (1978)
Beryllium	Tier II SCV	0.00066	Not applicable	0.00066	No toxicity value or surrogate TRV available, therefore, corresponding freshwater TRV adopted. Suter and Tsao (1996); value calculated using Great Lakes Water Quality Initiative Tier II methodology.
Cadmium	Chronic criterion	0.0093	Not applicable	0.0093	U.S. EPA (1987)
Chromium (hexavalent)	Chronic criterion	0.05	Not applicable	0.05	U.S. EPA (1987)
Copper	Chronic criterion	0.0031	Not applicable	0.0031	U.S. EPA 1999. When the concentration of dissolved organic carbon is elevated, copper is substantially less toxic and use of a water effects ratio may be appropriate.

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MARINE/ESTUARINE SURFACE WATER TOXICITY REFERENCE VALUES

(Page 5 of 8)

Compound	Toxicity Value		Uncertainty Factor[b]	Toxicity Reference Value[c]	Reference and Notes [d]
	Duration and Endpoint[a]	Concentration			
Total Cyanide	Chronic criterion	0.001	Not applicable	0.001	U.S. EPA (1987)
Lead	Chronic criterion	0.0081	Not applicable	0.0081	U.S. EPA (1999)
Mercuric chloride	Chronic criterion	0.00094	Not applicable	0.00094	U.S. EPA (1999). This value was from data for inorganic mercury (II).
Methyl mercury	Subchronic NOAEL	0.030	0.1	0.003	Sharp and Neff (1982). Toxicity value for mummichog (*Fundulus heteroclitus*).
Nickel	Chronic criterion	0.0082	Not applicable	0.0082	U.S. EPA (1999)
Selenium	Chronic criterion	0.071	Not applicable	0.071	U.S. EPA (1987)
Silver	Chronic criterion/ proposed criterion	0.0023	Not applicable	0.0023	U.S. EPA (1987)
Thallium	Acute LOEL	2.13	0.01[e]	0.02	U.S. EPA (1987)
Zinc	Chronic criterion	0.081	1.0	0.081	U.S. EPA (1999)

TABLE E-2

MARINE/ESTUARINE SURFACE WATER TOXICITY REFERENCE VALUES

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Notes:

a The duration of exposure is defined as chronic if it represents about 10 percent or more of the test animals lifetime expectancy. Acute exposures represent single exposures or multiple exposures occurring within a short time. For evaluating exposure duration, the following general guidelines were used. For invertebrates and other lower trophic level aquatic biota: (1) chronic duration lasted for 7 or more days, (2) subchronic duration lasted from 3 to 6 days, and (3) acute duration lasted 2 days or less. For fish: (1) chronic duration lasted for more than 90 days, (2) subchronic duration lasted from 14 to 90 days, and (3) acute duration lasted less than 2 weeks.
b Uncertainty factors are used to extrapolate a toxicity value to a chronic NOAEL TRV. See Chapter 5 (Section 5.4) of the SLERAP for a discussion of the use of uncertainty factors.
c TRV was calculated by multiplying the toxicity value with the uncertainty factor.
d The references refer to the source of the toxicity value. Complete reference citations are provided at the end of this appendix.
e Best scientific judgment used to identify uncertainty factor. See Chapter 5 (Section 5.4.1.2) for a discussion of the use of best scientific judgement. Factors evaluated include test duration, ecological relevance of endpoint, experimental design, and availability of toxicity data.

EC50 = Effective concentration for 50 percent of the test organisms.
FCV = Final Chronic Values
HMV = High molecular weight
LC50 = Lethal concentration for 50 percent of the test organisms.
LC100 = Lethal concentration for 100 percent of the test organisms.
LOEC = Lowest Observed Effect Concentration
LOEL = Lowest Observed Effect Level
LT50 = Lethal threshold concentration for 50 percent of the test organisms.
NOAEL = No Observed Adverse Effect Level
NOEL = No Observed Effect Level
SCV = Secondary Chronic Value
TRV = Toxicity Reference Value

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MARINE/ESTUARINE SURFACE WATER TOXICITY REFERENCE VALUES

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TABLE E-2

MARINE/ESTUARINE SURFACE WATER TOXICITY REFERENCE VALUES

(Page 8 of 8)

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TABLE E-3

FRESHWATER SEDIMENT TOXICITY REFERENCE VALUES

(Page 1 of 7)

Compound	Freshwater TRV [a]	K_{oc} Value [b]	Bed Sediment TRV (dry weight)	Reference and Notes [c]
Polychlorinateddibenzo-p-dioxins (μg/kg)				
2,3,7,8-TCDD	0.0000038	2,691,535	0.41	TRV was calculated using equilibrium partitioning (EqP) approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Polynuclear aromatic hydrocarbons (PAH) (μg/kg)				
Total high molecular weight (HMW) PAH	Not applicable	Not applicable	170	TRV is ERL value computed by Ingersoll et al. (1996) based on 28-day amphipod (*Hyalella azteca*) toxicity tests. This TRV may be used if risk of total HMW PAHs is assessed.
Benzo(a)pyrene	Not applicable	Not applicable	84	TRV is an ERL value calculated by Ingersoll et al. (1996) based on 28-day *H. azteca* toxicity tests.
Benzo(a)anthracene	Not applicable	Not applicable	19	TRV is an ERL value calculated by Ingersoll et al. (1996) based on 28-day *H. azteca* toxicity tests.
Benzo(b)fluoranthene	Not applicable	Not applicable	37	TRV is an ERL value calculated by Ingersoll et al. (1996) based on 28-day *H. azteca* toxicity tests.
Benzo(k)fluoranthene	Not applicable	Not applicable	37	TRV is an ERL value calculated by Ingersoll et al. (1996) based on 28-day *H. azteca* toxicity tests.
Chrysene	Not applicable	Not applicable	30	TRV is an ERL value calculated by Ingersoll et al. (1996) based on 28-day *H. azteca* toxicity tests.
Dibenz(a,h)anthracene	Not applicable	Not applicable	10	TRV is an ERL value calculated by Ingersoll et al. (1996) based on 28-day *H. azteca* toxicity tests.
Indeno(1,2,3-cd)pyrene	Not applicable	Not applicable	30	TRV is an ERL value calculated by Ingersoll et al. (1996) based on 28-day *H. azteca* toxicity tests.

TABLE E-3

FRESHWATER SEDIMENT TOXICITY REFERENCE VALUES

(Page 2 of 7)

Compound	Freshwater TRV [a]	K_{oc} Value [b]	Bed Sediment TRV (dry weight)	Reference and Notes [c]
Polychlorinated biphenyls (PCB) (μg/kg)				
Aroclor 1016	Not applicable	Not applicable	50	TRV is an ERL value for Total PCB calculated by Ingersoll et al. (1996) based on 28-day *H. azteca* toxicity tests.
Aroclor 1254	Not applicable	Not applicable	50	TRV is an ERL value for Total PCB calculated by Ingersoll et al. (1996) based on 28-day *H. azteca* toxicity tests.
Nitroaromatics (μg/kg)				
1,3-Dinitrobenzene	26	20.6	21.4	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
2,4-Dinitrotoluene	23	51	46.9	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
2,6-Dinitrotoluene	60	41.9	100.6	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Nitrobenzene	270	119	1285.2	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Pentachloronitrobenzene	10	5,890	2356	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Phthalate esters (μg/kg)				
Bis(2-ethylhexyl)phthalate	3	111,000	1.33×10^{4}	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Di(n)octyl phthalate	320	9.03×10^{8}	1.16×10^{10}	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]

TABLE E-3

FRESHWATER SEDIMENT TOXICITY REFERENCE VALUES

(Page 3 of 7)

Compound	Freshwater TRV [a]	K_{oc} Value [b]	Bed Sediment TRV (dry weight)	Reference and Notes [c]
Volatile organic compounds (μg/kg)				
Acetone	1,500	0.951	57.1	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Acrylonitrile	260	2.22	23.1	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Chloroform	28	53.0	59.4	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Crotonaldehyde	35	Not available	Not calculated	No TRV was calculated because no K_{oc} or K_{ow} values were identified for this constituent.
1,4-Dioxane	62,100	0.876	2176.0	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Formaldehyde	49.6	2.62	5.2	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Vinyl chloride	3,880	11.1	1722.7	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Other chlorinated organics (μg/kg)				
Hexachlorobenzene	Not applicable	Not applicable	20	TRV is an LEL value (Persaud et al. 1993).
Hexachlorobutadiene	0.93	6,940	258.2	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Hexachlorocyclopentadiene	0.52	9,510	197.8	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]

TABLE E-3

FRESHWATER SEDIMENT TOXICITY REFERENCE VALUES

(Page 4 of 7)

Compound	Freshwater TRV [a]	K_{oc} Value [b]	Bed Sediment TRV (dry weight)	Reference and Notes [c]
Pentachlorobenzene	0.47	32,148	604.4	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Pentachlorophenol	Not applicable	Not applicable	7,000	TRV is an AET value for *H. azteca* (Washington State Department of Ecology 1994).
Pesticides (μg/kg)				
4,4'-DDE	Not applicable	Not applicable	5	TRV is an LEL value (Persaud et al. 1993). p,p’-DDE used as a surrogate.
Heptachlor	Not applicable	Not applicable	0.3	TRV is an NEL value (Persaud et al. 1993). The NEL was selected because no LEL was available.
Hexachlorophene	0.88	1,800,000	63,360	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Inorganics (mg/kg)				
Aluminum	Not applicable	Not applicable	14,000	TRV is an ERL value calculated by Ingersoll et al. (1996) based on 28-day *H. azteca* toxicity tests.
Antimony	Not applicable	Not applicable	64.0	TRV is an AET for *H. azteca* (Washington State Department of Ecology 1994).
Arsenic	Not applicable	Not applicable	6.0	TRV is an LEL value (Persaud et al. 1993).
Barium	Not applicable	Not applicable	20	TRV is a U.S. EPA Region 5 guideline value for classification of sediments for determining the suitability of dredged sediments for open water disposal, as cited in Hull and Suter II (1994).
Beryllium	Not applicable	Not applicable	Not available	Regulatory or toxicity value not available.
Cadmium	Not applicable	Not applicable	0.6	TRV is an LEL value (Persaud et al. 1993).

TABLE E-3

FRESHWATER SEDIMENT TOXICITY REFERENCE VALUES

(Page 5 of 7)

Compound	Freshwater TRV [a]	K_{oc} Value [b]	Bed Sediment TRV (dry weight)	Reference and Notes [c]
Chromium (total)	Not applicable	Not applicable	26	TRV is an LEL value (Persaud et al. 1993).
Copper	Not applicable	Not applicable	16	TRV is an LEL value (Persaud et al. 1993).
Total Cyanide	Not applicable	Not applicable	0.1	TRV is a U.S. EPA Region 5 guideline value for classification of sediments for determining the suitability of dredged sediments for open water disposal, as cited in Hull and Suter II (1994).
Lead	Not applicable	Not applicable	31	TRV is an LEL value (Persaud et al. 1993).
Mercuric chloride	Not applicable	Not applicable	0.2	No toxicity data available for divalent inorganic mercury. Total mercury used as surrogate for divalent inorganic mercury. TRV is an LEL value (Persaud et al. 1993).
Methyl mercury	Not applicable	Not applicable	0.2	No toxicity data available for methyl mercury. Total mercury used as surrogate for methylmercury. TRV is an LEL value (Persaud et al. 1993).
Nickel	Not applicable	Not applicable	16	TRV is an LEL value (Persaud et al. 1993).
Selenium	Not applicable	Not applicable	0.1	TRV is an AET for *H. azteca* (Washington State Department of Ecology 1994).
Silver	Not applicable	Not applicable	4.5	TRV is an AET for *H. azteca* (Washington State Department of Ecology 1994).
Thallium	Not applicable	Not applicable	Not available	Regulatory value or toxicity value not available.
Zinc	Not applicable	Not applicable	110	TRV is an ERL value calculated by Ingersoll et al. (1996) based on 28-day *H. azteca* toxicity tests.

TABLE E-3

FRESHWATER SEDIMENT TOXICITY REFERENCE VALUES

(Page 6 of 7)

Notes:

a Toxicity reference values are in units of micrograms per kilogram (μg/kg) and milligrams per kilograms (mg/kg) for organic and inorganic constituents, respectively.
b Values are in units of liters per kilogram (L/kg). K_{oc} = Organic carbon normalized sorption coefficient. References and equations used to calculate K_{oc} values are provided in Appendix A.
c The references refer to the study from which the TRV was identified. Complete reference citations are provided below.
d Freshwater sediment TRV calculated with the following equation:

Freshwater sediment TRV = Freshwater TRV (Table E-1) * K_{oc} * $f_{oc,bs}$

where,
K_{oc} = organic carbon partition coefficient, and
$f_{oc,bs}$= fraction of organic carbon in bed sediment, assumed to be 4 percent = 0.04.

K_{oc} values discussed in Appendix A.

AET = Apparent Effects Threshold
ERL = Effects Range-Low
EqP = Equilibrium Partitioning
HMV = High molecular weight
LEL = Lowest Effect Level
NEL = No Effect Level
TRV = Toxicity Reference Value

TABLE E-3

FRESHWATER SEDIMENT TOXICITY REFERENCE VALUES

(Page 7 of 7)

REFERENCES

Default TRVs for sediments in freshwater habitats were identified from the three sets of freshwater toxicity values presented below. While some compound-specific freshwater sediment toxicity information is available in the scientific literature, available toxicity values were not used because of the compexity in understanding the role of naturally-occurring sediment features (such as grain size, ammonia, sulfide, soil type, and organic carbon content) in toxicity to benthic invertebrates. Among these sets of value, the lowest available toxicity value for a particular compound was adopted as the TRV. In many cases, a default TRV was calculated from the corresponding freshwater TRV using EPA's equilibrium partitioning approach, assuming a 4 percent organic carbon content.

Hull, R.N. and G.W. Suter II. 1994. *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1994 Revision.* ES/ER/TM-95/R1. Environmental Sciences Division, Oak Ridge National Laboratory. Oak Ridge, Tennessee. June.

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TABLE E-4

MARINE/ESTUARINE SEDIMENT TOXICITY REFERENCE VALUES

(Page 1 of 8)

Compound	Marine/Estuarine Surface Water TRV[a]	K_{oc} Value[b]	Bed Sediment TRV (dry weight)	Reference and Notes [c]
Ploychlorinateddibenzo-p-dioxins (μg/kg)				
2,3,7,8-TCDD	0.0000038	2,691,535	0.41	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Polynuclear aromatic hydrocarbons (PAH) (μg/kg)				
Total high molecular weight (HMW) PAH	Not applicable	Not applicable	870	Recommended NOEL for Florida Department of Environmental Regulation (DER) (MacDonald 1993). This TRV may be used in risk of total HMW PAHs is assessed.
Benzo(a)pyrene	Not applicable	Not applicable	230	Recommended NOEL for Florida DER (MacDonald 1993).
Benzo(a)anthracene	Not applicable	Not applicable	160	Recommended NOEL for Florida DER (MacDonald 1993).
Benzo(b)fluoranthene	0.5	836,000	418,000	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Benzo(k)fluoranthene	Not applicable	Not applicable	240	TRV is a LEL value from Persaud et al. (1993).
Chrysene	Not applicable	Not applicable	220	Recommended NOEL for Florida DER (MacDonald 1993).
Dibenz(a,h)anthracene	Not applicable	Not applicable	31	Recommended NOEL for Florida DER (MacDonald 1993).
Indeno(1,2,3-cd)pyrene	Not applicable	Not applicable	1,360	TRV was computed from OC-based marine sediment quality criterion from Washington State Department of Ecology (1991) and fractional organic carbon content of 0.04, as follows: TRV = 34 mg/kg * 0.04 * 1000 μg/mg.

TABLE E-4

MARINE/ESTUARINE SEDIMENT TOXICITY REFERENCE VALUES

(Page 2 of 8)

Compound	Marine/Estuarine Surface Water TRV[a]	K_{oc} Value[b]	Bed Sediment TRV (dry weight)	Reference and Notes [c]
Polychlorinated biphenyls (PCB) (μg/kg)				
Aroclor 1016	Not applicable	Not applicable	22.7	TRV is an ERL value for Total PCB from Long et al. (1995).
Aroclor 1254	Not applicable	Not applicable	22.7	TRV is an ERL value for Total PCB from Long et al. (1995).
Nitroaromatics (μg/kg)				
1,3-Dinitrobenzene	66.8	20.6	55.0	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
2,4-Dinitrotoluene	370	51	754.8	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
2,6-Dinitrotoluene	370	41.9	620.1	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Nitrobenzene	66.8	119	318.0	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Pentachloronitrobenzene	10	5,890	2356	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]

TABLE E-4

MARINE/ESTUARINE SEDIMENT TOXICITY REFERENCE VALUES

(Page 3 of 8)

Compound	Marine/Estuarine Surface Water TRV[a]	K_{oc} Value[b]	Bed Sediment TRV (dry weight)	Reference and Notes [c]
Phthalate esters (μg/kg)				
Bis(2-ethylhexyl)phthalate	Not applicable	Not applicable	470	TRV was calculated using OC-based marine sediment quality criterion from Washington State Department of Ecology (1991) and fractional organic carbon content of 0.04, as follows: TRV = 47 mg/kg * 0.04 * 1000 μg/mg.
Di(n)octyl phthalate	Not applicable	Not applicable	580	TRV was calculated using OC-based marine sediment quality criterion from Washington State Department of Ecology (1991) and fractional organic carbon content of 0.04, as follows: TRV = 58 mg/kg * 0.04 * 1000 μg/mg.
Volatile organic compounds (μg/kg)				
Acetone	21,000	0.951	798.8	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Acrylonitrile	100	2.22	8.88	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Chloroform	180	53.0	381.6	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Crotonaldehyde	13	Not available	Not computed	No TRV was calculated because no K_{oc} or K_{ow} value was identified.
1,4-Dioxane	67,000	0.876	2348	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Formaldehyde	49.6	2.62	5.2	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]

TABLE E-4

MARINE/ESTUARINE SEDIMENT TOXICITY REFERENCE VALUES

(Page 4 of 8)

Compound	Marine/Estuarine Surface Water TRV[a]	K_{oc} Value[b]	Bed Sediment TRV (dry weight)	Reference and Notes [c]
Vinyl chloride	3,880	11.1	1722.7	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Other chlorinated organics (μg/kg)				
Hexachlorobenzene	Not applicable	Not applicable	15.2	TRV was calculated using OC-based marine sediment quality criterion from Washington State Department of Ecology (1991) and a fractional OC content of 0.04, as follows: TRV = 0.38 mg/kg * 0.04 * 1000 μg/mg.
Hexachlorobutadiene	Not applicable	Not applicable	156	TRV was calculated using OC-based marine sediment quality criterion from Washington State Department of Ecology (1991) and a fractional OC content of 0.04, as follows: TRV = 3.9 mg/kg * 0.04 * 1000 μg/mg.
Hexachlorocyclopentadiene	0.07	9,510	26.6	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Pentachlorobenzene	1.8	32,148	2315	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Pentachlorophenol	Not applicable	Not applicable	360	TRV is marine sediment quality criterion from Washington State Department of Ecology (1991).
Pesticides (μg/kg)				
4,4'-DDE	Not applicable	Not applicable	1.7	Recommended NOEL for p,p'-DDE for Florida DER (MacDonald 1993).
Heptachlor	0.0036	9,530	1.37	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Hexachlorophene	0.033	1,800,000	2376	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]

TABLE E-4

MARINE/ESTUARINE SEDIMENT TOXICITY REFERENCE VALUES

(Page 5 of 8)

Compound	Marine/Estuarine Surface Water TRV[a]	K_{oc} Value[b]	Bed Sediment TRV (dry weight)	Reference and Notes [c]
Inorganics (mg/kg)				
Aluminum	Not applicable	Not applicable	Not available	Screening or toxicity value not available.
Antimony	Not applicable	Not applicable	2	TRV is an ERL value (Long and Morgan 1991).
Arsenic	Not applicable	Not applicable	6	TRV is an LEL value for Province of Ontario (Persaud et al. 1993).
Barium	Not applicable	Not applicable	20	TRV is a U.S. EPA Region 5 guideline value for classification of sediments for determining the suitability of dredged material for open water disposal, as cited in Hull and Suter II (1994).
Beryllium	Not applicable	Not applicable	Not available	Screening or toxicity value not available.
Cadmium	Not applicable	Not applicable	1.0	Recommended NOEL for Florida DER (MacDonald 1993).
Chromium (hexavalent)	Not applicable	Not applicable	8.1	TRV is an ERL value for total chromium (Long et al. 1995).
Copper	Not applicable	Not applicable	28	Recommended NOEL for Florida DER (MacDonald 1993).
Total Cyanide	Not applicable	Not applicable	0. 1	TRV is a U.S. EPA Region V guideline value for classification of sediments for determining the suitability of dredged material for open water disposal, as cited in Hull and Suter II (1994).

TABLE E-4

MARINE/ESTUARINE SEDIMENT TOXICITY REFERENCE VALUES

(Page 6 of 8)

Compound	Marine/Estuarine Surface Water TRV[a]	K_{oc} Value[b]	Bed Sediment TRV (dry weight)	Reference and Notes [c]
Lead	Not applicable	Not applicable	21.0	Recommended NOEL for Florida DER (MacDonald 1993).
Mercuric chloride	Not applicable	Not applicable	0.1	No toxicity data available for divalent inorganic mercury. Total mercury is used as surrogate. Recommended NOEL for Florida DER (MacDonald 1993).
Methyl mercury	Not applicable	Not applicable	0.1	No toxicity data available for methyl mercury. Total mercury is used as surrogate. Recommended NOEL for Florida DER (MacDonald 1993).
Nickel	Not applicable	Not applicable	20.9	TRV is an ERL value (Long et al. 1995).
Selenium	Not applicable	Not applicable	Not Available	Screening or toxicity value not available.
Silver	Not applicable	Not applicable	0.5	Recommended NOEL for Florida DER (MacDonald 1993).
Thallium	Not appliable	Not applicable	Not available	Screening or toxicity value not available.
Zinc	Not applicable	Not applicable	68	Recommended NOEL for Florida DER (MacDonald 1993).

TABLE E-4

MARINE/ESTUARINE SEDIMENT TOXICITY REFERENCE VALUES

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Notes:

a Sediment TRVs are in units of micrograms per kilogram (μg/kg) and milligrams per kilograms (mg/kg) for organic and inorganic constituents, respectively.
b Values are in units of liters per kilogram (L/kg). K_{oc} = Organic carbon normalized sorption coefficient. References and equations used to calculate values are provided in Appendix A.
c The references refer to the study or studies from which the endpoint and concentrations were identified. Complete reference citations are provided below.
d Sediment TRV calculated with the following equation:

$$\text{Sediment TRV} = \text{Marine/estuarine surface water TRV (Table E-2)} * K_{oc} * f_{oc,bs}$$

where,

K_{oc} = organic carbon partition coefficient, and
$f_{oc,bs}$= fraction of organic carbon in bed sediment, assumed to be 1 percent = 0.01.

K_{oc} values are discussed in Appendix A.

EqP = Equilibrium Partitioning
ERL = Effects Range-Low
HMW = High molecular weight
LEL = Lowest Effect Level
NOEL = No Observed Effect Level
TRV = Toxicity Reference Value

TABLE E-4

MARINE/ESTUARINE SEDIMENT TOXICITY REFERENCE VALUES

(Page 8 of 8)

REFERENCES

Default TRVs for sediments in marine and estuarine habitats were identified from several sets of toxicity values (standards, benchmarks, and guidelines) presented below. While some compound-specific marine/estuarine sediment toxicity information is available in the scientific literature, available toxicity values were not used because of the compexity in understanding the role of naturally-occurring sediment features (such as grain size, ammonia, sulfide, soil type, and organic carbon content) in toxicity to benthic invertebrates. Among these sets of value, the lowest available toxicity value for a particular compound was adopted as the TRV. In many cases, a default TRV was calculated from the corresponding freshwater TRV using EPA's equilibrium partitioning approach, assuming a 4 percent organic carbon content.

Hull, R.N. and G.W. Suter II. 1994. *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1994 Revision.* ES/ER/TM-95/R1. Environmental Sciences Division, Oak Ridge National Laboratory. Oak Ridge, Tennessee. June.

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TERRESTRIAL PLANT TOXICITY REFERENCE VALUES

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Compound	Basis for TRV				TRV [c]	Reference and Notes [d]
	Duration and Endpoint [a]	Test Organism	Concentration	Uncertainty Factor [b]		
Polychlorinateddibenzo-p-dioxins (μg/kg)						
2,3,7,8-TCDD	--	--	--	--	--	Toxicity value not identified.
Polynuclear aromatic hydrocarbons (PAH) (μg/kg)						
Total high molecular weight (HMW) PAH	Chronic NOAEL	Wheat	1,200	Not applicable	1,200	Benzo(a)pyrene toxicity used as representative toxicity of all HMW PAHs. This TRV may be used to characterize risk of total HMW PAHs to terrestrial plants.
Benzo(a)pyrene	Chronic NOAEL	Wheat	1,200	Not applicable	1,200	Sims and Overcash (1983)
Benzo(a)anthracene	Not available	--	--	--	1,200	Toxicity value not available. Benzo(a)pyrene used as surrogate.
Benzo(b)fluoranthene	Chronic NOAEL	Wheat	1,200	Not applicable	1,200	Sims and Overcash (1983).
Benzo(k)fluoranthene	Not available	--	--	--	1,200	Toxicity value not available. Benzo(a)pyrene used as surrogate.
Chrysene	Not available	--	--	--	1,200	Toxicity value not available. Benzo(a)pyrene used as surrogate.
Dibenz(a,h)anthracene	Not available	--	--	--	1,200	Toxicity value not available. Benzo(a)pyrene used as surrogate.

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TERRESTRIAL PLANT TOXICITY REFERENCE VALUES

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Compound	Basis for TRV				TRV [c]	Reference and Notes [d]
	Duration and Endpoint [a]	Test Organism	Concentration	Uncertainty Factor [b]		
Indeno(1,2,3-cd)pyrene	Not available	--	--	--	1,200	Toxicity value not available. Benzo(a)pyrene used as surrogate.
Polychlorinated biphenyls (PCB) (μg/kg)						
Aroclor 1016	--	--	--	--	10,000	No toxicity value available. Aroclor 1254 TRV adopted as surrogate.
Aroclor 1254	Chronic NOAEL	Soybean shoot weight	10,000	Not applicable	10,000	Value for toxicity of Aroclor 1254 (Weber and Mrozek 1979).
Nitroaromatics (μg/kg)						
1,3-Dinitrobenzene	--	--	--	--	--	Toxicity value not available.
2,4-Dinitrotoluene	--	--	--	--	--	Toxicity value not available.
2,6-Dinitrotoluene	--	--	--	--	--	Toxicity value not available.
Nitrobenzene	--	--	--	--	--	Toxicity value not available.
Pentachloronitrobenzene	--	--	--	--	--	Toxicity value not available.
Phthalate esters (μg/kg)						
Bis(2-ethylhexyl)phthalate	--	--	--	--	--	Toxicity value not available.
Di(n)octyl phthalate	--	--	--	--	--	Toxicity value not available.
Volatile organic compounds (μg/kg)						

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Compound	Basis for TRV				TRV [c]	Reference and Notes [d]
	Duration and Endpoint [a]	Test Organism	Concentration	Uncertainty Factor [b]		
Acetone	--	--	--	--	--	Toxicity value not available.
Acrylonitrile	--	--	--	--	--	Toxicity value not available.
Chloroform	--	--	--	--	--	Toxicity value not available.
Crotonaldehyde	--	--	--	--	--	Toxicity value not available.
1,4-Dioxane	--	--	--	--	--	Toxicity value not available.
Formaldehyde	--	--	--	--	--	Toxicity value not available.
Vinyl chloride	--	--	--	--	--	Toxicity value not available.
Other chlorinated organics (μg/kg)						
Hexachlorobenzene	--	--	--	--	--	Toxicity value not available.
Hexachlorobutadiene	--	--	--	--	--	Toxicity value not available.
Hexachlorocyclopentadiene	Acute EC50	Lettuce growth	10,000	0.01	100	Hulzebos et al. (1993)
Pentachlorobenzene	--	--	--	--	--	Toxicity value not available.
Pentachlorophenol	Chronic LOAEL	Rice	17,300	0.1	1,730	Nagasawa et al. (1981)
Pesticides (μg/kg)						
4,4'-DDE	--	--	--	--	--	Toxicity value not available.

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Compound	Basis for TRV				TRV [c]	Reference and Notes [d]
	Duration and Endpoint [a]	Test Organism	Concentration	Uncertainty Factor [b]		
Heptachlor	Chronic NOAEL	Carrot	1,000	Not applicable	1,000	Ahrens and Kring (1968)
Hexachlorophene	--	--	--	--	--	Toxicity value not available.
Inorganics (mg/kg)						
Aluminum	Subchronic NOAEL	White clover seedling establishment	50	0.1[e]	5	Mackay et al. (1990)
Antimony	Not specified	Not specified	5	0.1[e]	0.5	Kabata-Pendias and Pendias (1992)
Arsenic	Chronic LOAEL	Corn yield (weight)	10	0.1	1	Woolson et al. (1971)
Barium	Chronic LOAEL	Barley shoot growth	500	0.01[e]	5	Chaudry et al. (1977)
Beryllium	Not specified	Not specified	10	0.01[e]	0.1	Kabata-Pendias and Pendias (1992)
Cadmium	Chronic LOAEL	Spruce seedling growth	2	0.1[e]	0.2	Burton et al. (1984)
Chromium (hexavalent)	Subchronic EC50	Lettuce growth	1.8	0.01	0.018	Adema and Hazen (1989)
Copper	Chronic LOAEL	Barley	10	0.1	1.0	Toivonem and Hofstra (1979)

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Compound	Basis for TRV				TRV [c]	Reference and Notes [d]
	Duration and Endpoint [a]	Test Organism	Concentration	Uncertainty Factor [b]		
Cyanide, total	--	--	--	--	--	Toxicity value not available.
Lead	Chronic LOAEL	Senna	46	0.1	4.6	Krishnayya and Bedi (1986)
Mercuric chloride	Acute NOEC	Barley	34.9	0.01[e]	0.349	Panda et al. (1992)
Methyl mercury	--	--	--	--	--	Toxicity value not available.
Nickel	Chronic NOAEL	Bush bean shoot growth	25	Not applicable	25	Wallace et al. (1977)
Selenium	Subchronic NOAEL	Alfalfa shoot weight	0.5	0.1	0.05	Wan et al. (1988)
Silver	Not specified	Not specified	2	0.01[e]	0.02	Kabata-Pendias and Pendias (1992)
Thallium	Not specified	Not specified	1	0.01[e]	0.01	Kabata-Pendias and Pendias (1992)
Zinc	Chronic LOAEL	Spring barley	9	0.1	0.9	Davis, Beckett, and Wollan (1978)

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Notes:

a To evaluate exposure duration, the following general guidelines were used: Chronic duration represents exposures occurring about 10 or more days, including exposure during a critical life stage, such as germination and shoot development. Subchronic duration generally lasts 2 days through several days, however a sensitive life stage is not exposed. Acute duration generally includes exposures occurring 0 to 2 days.

b Uncertainty factors are used to extrapolate a toxicity value to a chronic NOAEL TRV. See Chapter 5 (Section 5.4) of the SLERAP for a discussion on the use of uncertainty factors.

c TRV was calculated by multiplying the toxicity value with the uncertainty factor.

d The references refer to the source of the toxicity value. Complete reference citations are provided below.

e Best scientific judgment was used to identify uncertainty factor. See Chapter 5 (Section 5.4.1.2) for a discussion on the use of best scientific judgement. Factors evaluated include test duration, ecological relevance of endpoint, and experimental design.

EC50 = Effective concentration for 50 percent of the test organisms.
HWC = High molecular weight
LOAEL = Lowest Observed Adverse Effects Level
NOAEL = No Observed Adverse Effects Level
NOEC = No Observed Effects Concentration
TRV = Toxicity Reference Value

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Efroymson, Will, Suter II, and Wooten (1997) provides a comprehensive review of ecologically-relevant terrestrial plant toxicity information. This source was reviewed to identify studies to develop TRVs for terrestrial plant. Based on the information presented, one or more references were obtained and reviewed to identify compound-specific toxicity values. For some compounds, the available information identified a single study meeting the requirements for a TRV, as discussed in Chapter 5 (Section 5.4) of the SLERAP. In most cases, each reference was obtained and reviewed to identify a single toxicity value to develop a TRV for each compound. In a few cases where a primary study could not be obtained, a toxicity value is based on a secondary source. As noted below, additional compendia were reviewed to identify toxicity studies to review. For compounds not discussed in Efroymson, Will, Suter II, and Wooten (1997), the scientific literature was searched, and relevant studies were obtained and reviewed. The references reviewed are listed below. The study selected for the TRV is highlighted in bold.

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TABLE E-6

SOIL INVERTEBRATE TOXICITY REFERENCE VALUES

(Page 1 of 12)

Compound	TRV				TRV [c]	Reference and Notes [d]
	Duration and Endpoint [a]	Test Species	Concentration	Uncertainty Factor [b]		
Polychlorinateddibenzo-p-dioxins (μg/kg)						
2,3,7,8-TCDD	Chronic (85-day); no mortality reported at 5,000 μg/kg	Earthworm (*Allolobophora caliginosa*)	5,000	0.1[e]	500	Toxicity value for 2,3,7,8-TCDD (Reinecke and Nash 1984). UF applied to concentration because mortality only endpoint available and data not subjected to statistical analysis.
Polynuclear aromatic hydrocarbons (PAH) (μg/kg)						
Total HMW PAH	Not available	--	--	--	25,000	Benzo(a) pyrene used as surrogate for HMW PAH compounds.
Benzo(a)pyrene	Chronic (28-day) NOAEL for growth	Woodlouse (*Porcellio scaber*)	25,000	Not applicable	25,000	van Straalen and Verweij (1991)
Benzo(a)anthracene	Not available	--	--	--	25,000	Toxicity value not available. TRV for benzo(a)pyrene used as surrogate.
Benzo(b)fluoranthene	Not available	--	--	--	25,000	Toxicity value not available. TRV for benzo(a)pyrene used as surrogate.
Benzo(k)fluoranthene	Not available	--	--	--	25,000	Toxicity value not available. TRV for benzo(a)pyrene used as surrogate.
Chrysene	Not available	--	--	--	25,000	Toxicity value not available. TRV for benzo(a)pyrene used as surrogate.
Dibenz(a,h)anthracene	Not available	--	--	--	25,000	Toxicity value not available. TRV for benzo(a)pyrene used as surrogate.
Indeno(1,2,3-cd)pyrene	Not available	--	--	--	25,000	Toxicity value not available. TRV for benzo(a)pyrene used as surrogate.

TABLE E-6

SOIL INVERTEBRATE TOXICITY REFERENCE VALUES

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Compound	TRV Duration and Endpoint [a]	 Test Species	 Concentration	 Uncertainty Factor [b]	TRV [c]	Reference and Notes [d]
Polychlorinated biphenyls (PCB) (μg/kg)						
Aroclor 1016	Acute median LC50	Earthworm (*Eisenia foetida*)	251,000	0.01	2,510	Rhett et al. (1989).
Aroclor 1254	Acute median LC50	Earthworm (*Eisenia foetida*)	251,000	0.01	2,510	Rhett et al. (1989).
Nitroaromatics (μg/kg)						
1,3-Dinitrobenzene	--	--	--	--	2,260	Toxicity value not available. Nitrobenzene used as surrogate.
2,4-Dinitrotoluene	--	--	--	--	--	Toxicity value not available.
2,6-Dinitrotoluene	--	--	--	--	--	Toxicity value not available.
Nitrobenzene	Subchronic (14-day) LC50	Earthworm (species uncertain)	226,000	0.01[e]	2,260	Neuhauser et al. (1986).
Pentachloronitrobenzene	--	--	--	--		Toxicity value not available.
Phthalate esters (μg/kg)						
Bis(2-ethylhexyl)phthalate	--	--	--	--	--	Toxicity value not available.
Di(n)octyl phthalate	--	--	--	--	--	Toxicity value not available.
Volatile organic compounds (μg/kg)						
Acetone	--	--	--	--	--	Toxicity value not available.
Acrylonitrile	--	--	--	--	--	Toxicity value not available.

TABLE E-6

SOIL INVERTEBRATE TOXICITY REFERENCE VALUES

(Page 3 of 12)

Compound	TRV				TRV [c]	Reference and Notes [d]
	Duration and Endpoint [a]	Test Species	Concentration	Uncertainty Factor [b]		
Chloroform	--	--	--	--	--	Toxicity value not available.
Crotonaldehyde	--	--	--	--	--	Toxicity value not available.
1,4-Dioxane	--	--	--	--	--	Toxicity value not available.
Formaldehyde	--	--	--	--	--	Toxicity value not available.
Vinyl chloride	--	--	--	--	--	Toxicity value not available.
Other chlorinated organics (μg/kg)						
Hexachlorobenzene	--	--	--	--	--	Toxicity value not available.
Hexachlorobutadiene	--	--	--	--	--	Toxicity value not available.
Hexachlorocyclopentadiene	--	--	--	--	--	Toxicity value not available.
Pentachlorobenzene	LC50 of unspecified duration	Earthworm (species uncertain)	115,000	0.01[e]	1,150	van Gestel et al. (1991)
Pentachlorophenol	Chronic (21-day) NOAEL for hatching success	Earthworm (*Eisenia andrei*)	10,000	Not applicable	10,000	van Gestel et al. (1988)
Pesticides (μg/kg)						
4,4'-DDE	--	--	--	--	--	Toxicity value not available.
Heptachlor	--	--	--	--	--	Toxicity value not available.
Hexachlorophene	--	--	--	--	--	Toxicity value not available.
Inorganics (mg/kg)						

TABLE E-6

SOIL INVERTEBRATE TOXICITY REFERENCE VALUES

(Page 4 of 12)

Compound	TRV				TRV [c]	Reference and Notes [d]
	Duration and Endpoint [a]	Test Species	Concentration	Uncertainty Factor [b]		
Aluminum	--	--	--	--	--	Toxicity value not available.
Antimony	--	--	--	--	--	Toxicity value not available.
Arsenic	Chronic (56-day); reduced cocoon production reported at single concentration tested	Earthworm (*Eisenia fetida*)	25	0.01[e]	0.25	Fischer and Koszorus (1992)
Barium	--	--	--	--	--	Toxicity value not available.
Beryllium	--	--	--	--	--	Toxicity value not available.
Cadmium	Chronic (4-month) NOAEL for cocoon production	Earthworm (*Dendrobaena rubida*)	10	Not applicable	10	Bengtsson and et al. (1986)
Chromium (hexavalent)	Chronic (60-day); survival reduced 25 percent at lowest tested concentration	Earthworm (*Octochaetus pattoni*)	2	0.1[e]	0.2	Abbasi and Soni (1983)
Copper	Chronic (56-day) NOAEL for cocoon production	Earthworm (*Eisenia fetida*)	32.0	Not applicable	32.0	Spurgeon et al. (1994)
Cyanide, total	--	--	--	--	--	Toxicity value not available.
Lead	Chronic (4-month) NOAEL for cocoon production	Earthworm (*Dendrobaena rubida*)	100	Not applicable	100	Bengtsson et al. 1986

TABLE E-6

SOIL INVERTEBRATE TOXICITY REFERENCE VALUES

(Page 5 of 12)

Compound	TRV				TRV[c]	Reference and Notes[d]
	Duration and Endpoint[a]	Test Species	Concentration	Uncertainty Factor[b]		
Mercuric chloride	Not available	--	--	--	2.5	Toxicity value not available. TRV for methyl mercury used as a surrogate.
Methyl mercury	Chronic (12-week) NOAEL for segment regeneration and survival	Earthworm (*Eisenia foetida*)	2.5	Not applicable	2.5	Beyer et al. (1985). Wet weight NOAEL of 1 mg/kg converted to corresponding dry weight NOAEL based on 60 percent moisture content. Uncertainty factor of 0.1 used because segment regeneration may not be a sensitive endpoint.
Nickel	Chronic (20-week) NOAEL for cocoon production	Earthworm (*Eisenia foetida*)	100	Not applicable	100	Malecki et al. (1982)
Selenium	Chronic; reduced cocoon production at single tested concentration	Earthworm (*Eisenia foetida*)	77	0.1[e]	7.7	Fischer and Koszorus (1992)
Silver	--	--	--	--	--	Toxicity value not available.
Thallium	--	--	--	--	--	Toxicity value not available.
Zinc	Chronic (56-day) NOEC for cocoon production	Earthworm (*Eisenia fetida*)	199	Not applicable	199	Spurgeon et al. (1994)

TABLE E-6

SOIL INVERTEBRATE TOXICITY REFERENCE VALUES

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Notes:

a - duration, the following general guidelines were used: Chronic duration represents exposures occurring about 10 or more days, including exposure during a critical life stage encompassing a sensitive endpoint. Subchronic duration generally lasts 2 days through several days, however a sensitive life stage is not exposed. Acute duration generally includes exposures from 0 to 2 days.

b Uncertainty factors are used to extrapolate a toxicity value to a chronic NOAEL TRV. See Chapter 5 (Section 5.4) of the SLERAP for a discussion on the use of uncertainty factors.

c TRV was calculated by multiplying the toxicity value with the uncertainty factor.

d The references refer to the source of the toxicity value. Complete reference citations are provided below.

e Best scientific judgment used to identify uncertainty factor. See Chapter 5 (Section 5.4.1.2) for a discussion on the use of best scientific judgement. Factors evaluated include test duration, ecological relevance of measured effect, experimental design, and availability of toxicity data.

HMW = High molecular weight
LC50 = Concentration lethal to 50 percent of the test organisms.
NOAEL = No Observed Adverse Effects Level
NOEC = No Observed Effects Level
UF = Uncertainty Factor
TRV = Toxicity Reference Value

TABLE E-6

SOIL INVERTEBRATE TOXICITY REFERENCE VALUES

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REFERENCES

Efroymson, Will, and Suter II (1997) provides a comprehensive review of ecologically-relevant soil invertebrate toxicity information. This source was reviewed to identify studies to develop TRVs for invertebrates. Effects of compounds on microbial communities were not considered. Based on the information presented, one or more references were obtained and reviewed to identify compound-specific toxicity values. For some compounds, the available information identified a single study meeting the requirements for a TRV, as discussed in Section 5.4. In most cases, each reference was obtained and reviewed to identify a single toxicity value to develop a TRV for each compound. In a few cases where a primary study could not be obtained, a toxicity value is based on a secondary source. As noted below, additional compendia were reviewed to identify toxicity studies to review. For compounds not discussed in Efroymson, Will, and Suter II (1997), the scientific literature was searched, and relevant studies were obtained and reviewed. The references reviewed are listed below. The study selected for the TRV is highlighted in bold.

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Polychlorinated biphenyls

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Nitrobenzene

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Arsenic

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Cadmium

TABLE E-6

SOIL INVERTEBRATE TOXICITY REFERENCE VALUES

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Chromium (Hexavalent)

Abbasi, S.A. and R. Soni. 1983. "Stress-Induced Enhancement of Reproduction in Earthworm, *Octochaetus pattoni*, Exposed to Chromium (VI) and Mercury (II)—Implications in Environmental Management." *International Journal of Environmental Studies*. Volume 22. Pages 43-47.

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Copper

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Mercuric chloride

TABLE E-6

SOIL INVERTEBRATE TOXICITY REFERENCE VALUES

(Page 11 of 12)

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Methyl mercury

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Nickel

Malecki, M.R., E.F. Neuhauser, and R.C. Loehr. 1982. "The Effect of Metals on the Growth and Reproduction of *Eisenia foetida* (Oligochaeta, Lumbricidae)." *Pedobiologia*. Volume 24. Pages 129-137.

Selenium

Malecki, M.R., E.F. Neuhauser, and R.C. Loehr. 1982. "The Effect of Metals on the Growth and Reproduction of *Eisenia foetida* (Oligochaeta, Lumbricidae)." *Pedobiologia*. Volume 24. Pages 129-137.

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Zinc

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TABLE E-6

SOIL INVERTEBRATE TOXICITY REFERENCE VALUES

(Page 12 of 12)

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TABLE E-7

MAMMAL TOXICITY REFERENCE VALUES

(Page 1 of 15)

Compound	Basis for Toxicity Reference Value (TRV)				TRV	Reference and Notes [d]
	Duration and Endpoint [a]	Test Organism	Dose [b]	Uncertainty Factor [c]		
Polychlorinateddibenzo-p-dioxins (μg/kg BW-day)						
2,3,7,8-TCDD	Chronic (multigenerational) NOAEL for reproduction	Rat	0.001	Not applicable	0.001	Murray et al. (1979). TRV based on toxicity of 2,3,7,8-TCDD.
Polynuclear aromatic hydrocarbons (PAH) (μg/kg BW-day)						
Total high molecular weight (HMW) PAH	--	--	--	--	100	TRV based on benzo(a)pyrene toxicity. This TRV should be assessing the risk of Total HMW PAH.
Benzo(a)pyrene	Acute (10 days) LOAEL (reproductive effects)	Mouse	10,000	0.01	100	Mackenzie and Angevine (1981)
Benzo(a)anthracene	Single dose LOAEL (gastrointestinal effects)	Mouse	16,666	0.01	167	Bock and King (1959)
Benzo(b)fluoranthene	--	--	--	--	--	Toxicity value not available.
Benzo(k)fluoranthene	--	--	--	--	--	Toxicity value not available.
Chrysene	--	--	--	--	--	Toxicity value not available.
Dibenz(a,h)anthracene	Subchronic (15 days) LOAEL (reduced growth rate)	Rat	200	0.01[e]	2	Haddow et al. (1937)
Indeno(1,2,3-cd)pyrene	--	--	--	--	--	Toxicity value not available.

TABLE E-7

MAMMAL TOXICITY REFERENCE VALUES

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Compound	Basis for Toxicity Reference Value (TRV)				TRV	Reference and Notes [d]
	Duration and Endpoint [a]	Test Organism	Dose [b]	Uncertainty Factor [c]		
Polychlorinated biphenyls (PCB) (μg/kg BW-day)						
Aroclor 1016	Subchronic (14.5 weeks) LOAEL (mortality)	Mink	20.6	0.01	0.206	Aulerich et al. (1985). TRV based on toxicity of 3,4,5-hexachlorobiphenyl.
Aroclor 1254	Subchronic (14.5 weeks) LOAEL (mortality)	Mink	20.6	0.01	0.206	Aulerich et al. (1985). TRV based on toxicity of 3,4,5-hexachlorobiphenyl.
Nitroaromatics (μg/kg BW-day)						
1,3-Dinitrobenzene	Chronic (16 weeks) NOAEL	Rat	1,051	1.0	1,051	Cody et al. (1981)
2,4-Dinitrotoluene	Chronic (24 months) NOAEL	Dog	700	1.0	700	Ellis et al. (1979)
2,6-Dinitrotoluene	Single dose LOAEL (mortality)	Dog	4,000	0.01	400	Lee et al. (1976)
Nitrobenzene	--	--	--	--	--	Toxicity value not available.
Pentachloronitrobenzene	Chronic (2 years) NOAEL	Mouse	458,333	1.0	458,333	National Toxicology Program (1987)
Phthalate esters (μg/kg BW-day)						
Bis(2-ethylhexyl)phthalate	Chronic (2 years) NOAEL	Rat	60,000	1.0	60,000	Carpenter et al. (1953)
Di(n)octyl phthalate	Chronic (105 days) NOAEL	Mouse	7,500,000	1.0	7,500,000	Heindel et al. (1989)
Volatile organic compounds (μg/kg BW-day)						
Acetone	Subchronic (90 days) NOAEL	Albino Rat, male	100,000	0.1	10,000	U.S. EPA (1986)
Acrylonitrile	Chronic (2 years) LOAEL (lesions and other organ effects)	Rat	4,600	0.1	460	Quast et al. (1980)
Chloroform	Chronic (80 weeks) NOAEL	Mouse	60,000	1.0	60,000	Roe et al. (1979)

TABLE E-7

MAMMAL TOXICITY REFERENCE VALUES

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Compound	Basis for Toxicity Reference Value (TRV)				TRV	Reference and Notes [d]
	Duration and Endpoint [a]	Test Organism	Dose [b]	Uncertainty Factor [c]		
Crotonaldehyde	Acute (4-hour) LD50	Rat	8,000	0.01	80	Rinehart (1967)
1,4-Dioxane	Chronic (23 months) LOAEL (lung tumors)	Guinea Pig	1,069,767	0.1	106,777	Hoch-Ligeti and Argus (1970)
Formaldehyde	Acute (single dose) LOAEL (mortality)	Rat	230,000	0.01	2,300	Tsuchiya et al. (1975)
Vinyl chloride	Chronic (2 years) NOAEL	Rat	1,700	0.1	170	Feron et al. (1981)
Other chlorinated organics (μg/kg BW-day)						
Hexachlorobenzene	Chronic (>247 days) NOAEL	Rat	1,600	1.0	1,600	Grant et al. (1977)
Hexachlorobutadiene	Chronic (2 years) NOAEL	Rat	200	1.0	200	Kociba et al. (1977)
Hexachlorocyclopentadiene	Subchronic (13 weeks) NOAEL	Rat	38,000	0.1	3,800	Abdo et al. (1984)
Pentachlorobenzene	Chronic (180 days) NOAEL	Rat	7,250	1.0	7,250	Linder et al. (1980)
Pentachlorophenol	Subchronic (62 days) NOAEL	Rat	3,000	0.1	300	Schwetz et al. (1978)
Pesticides (μg/kg BW-day)						
4,4'-DDE	Subchronic (5 weeks) NOAEL	Rat	10,000	0.1	1,000	Kornburst et al. (1986)
Heptachlor	Subchronic (60 days) LOAEL (mortality)	Rat	250	0.01	2.5	Green (1970)
Hexachlorophene	Acute LD50	Rat	560,000	0.01	5600	Meister (1994)
Inorganics (mg/kg BW-day)						
Aluminum	Chronic (>1 year) LOAEL (growth)	Rat	19.3	0.1	1.93	Ondreicka et al. (1966)

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Compound	Basis for Toxicity Reference Value (TRV)				TRV	Reference and Notes [d]
	Duration and Endpoint [a]	Test Organism	Dose [b]	Uncertainty Factor [c]		
Antimony	Chronic (4 years) LOAEL (mortality)	Rat	0.66	0.1	0.066	Schroeder et al. (1970)
Arsenic	Chronic (2 years) NOAEL	Dog	1.25	1.0	1.25	Byron et al. (1967)
Barium	Chronic (16 months) NOAEL	Rat	0.51	1.0	0.51	Perry et al. (1983)
Beryllium	Chronic (>1 year) NOAEL	Rat	0.66	1.0	0.66	Schroeder and Mitchner (1975)
Cadmium	Chronic (>150 days) LOAEL (reproduction)	Mouse	2.52	0.01	0.0252	Schroeder and Mitchner (1971)
Chromium (hexavalent)	Chronic (1 year) NOAEL	Rat	3.5	1.0	3.5	MacKenzie et al. (1958)
Copper	Chronic (357 days) NOAEL	Mink	12.0	1.0	12.0	Aulerich et al. (1982)
Total Cyanide	Chronic (2 years) NOAEL	Rat	24	1.0	24	Howard and Hanzal (1955)
Lead	Chronic (>150 days) LOAEL (mortality)	Mouse	3.75	0.01	0.0375	Schroeder and Mitchner (1971)
Mercuric chloride	Chronic (6 months) NOAEL (reproduction)	Mink	1.01	1.0	1.01	Aulerich et al. (1974)
Methyl mercury	Subchronic (93 days) NOAEL	Rat	0.032	1.0	0.032	Verschuuren et al. (1976)
Nickel	Chronic (2 years) NOAEL	Rat	50	1.0	50	Ambrose et al. (1976)
Selenium	Chronic (>150 days) LOAEL (mortality)	Mouse	0.76	0.1	0.076	Schroeder and Mitchner (1971)
Silver	Chronic (125 days) LOAEL (hypoactivity)	Mouse	3.75	0.1	0.375	Rungby and Danscher (1984)

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Compound	Basis for Toxicity Reference Value (TRV)				TRV	Reference and Notes [d]
	Duration and Endpoint [a]	Test Organism	Dose [b]	Uncertainty Factor [c]		
Thallium	Subchronic (60 days) LOAEL (testicular function)	Rat	1.31	0.01[h]	0.0131	Formigli et al. (1986)
Zinc	Subchronic (13 weeks) NOAEL	Mouse	104	0.1	10.4	Maita et al. (1981)

Notes:

a The duration of exposure is defined as chronic if it represents about 10 percent or more of the test animal's lifetime expectancy. Acute exposures represent single exposure or multiple exposures occurring within about two weeks or less. Subchronic exposures are defined as multiple exposures occurring for less than 10 percent of the test animal's lifetime expectancy but more that 2 weeks.

b Reported values, which were dose in food or diet, were converted to dose based on body weight and intake rate using Opresko, Sample, and Suter 1996.

c Uncertainty factors are used to extrapolate a toxicity value to a chronic NOAEL TRV. See Chapter 5 (Section 5.4) for a discussion on the use of uncertainty factors. The TRV was calculated by multiplying the toxicity value by the uncertainty factor.

d The references refer to the study or studies from which the endpoint and doses were identified. Complete reference citations are provided at the end of this table.

e Best scientific judgement used to identify uncertainty factor. See Chapter 5 (Section 5.4.1.2) for a discussion of the use of best scientific judgement. Factors evaluated include test duration, ecological relevance of endpoint, experimental design, and availability of toxicity data.

HMW = High molecular weight
LD50 = Lethal dose to 50 percent of the test organisms.
LOAEL = Lowest Observed Adverse Effect Level
NOAEL = No Observed Adverse Effect Level
TRV = Toxicity Reference Value

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REFERENCES

Sample, Opresko, and Suter II (1996) provides a comprehensive review of ecologically-relevant mammal toxicity information. This source was reviewed to identify studies to develop TRVs for mammals. Based on the information presented, one or more references were obtained and reviewed to identify compound-specific toxicity values. For some compounds, the available information identified a single study meeting the requirements for a TRV, as discussed in Section 5.4. In most cases, each reference was obtained and reviewed to identify a single toxicity value to develop a TRV for each compound. In a few cases where a primary study could not be obtained, a toxicity value is based on a secondary source. As noted below, additional compendia were reviewed to identify toxicity studies to review. For compounds not discussed in Sample, Opresko, and Suter II (1996), the scientific literature was searched, and relevant studies were obtained and reviewed. The references reviewed are listed below. The study selected for the TRV is highlighted in bold.

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Murray, F.J., F.A. Smith, K.D. Nitschke, C.G. Humiston, R.J. Kociba, and B.A.Schwetz. 1979. “Three-Generation Reproduction Study of Rats Given 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD) in the Diet.” *Toxicology and Applied Pharmacology*. Volume 50. Pages 241-252.

U.S. EPA. 1993. *Interim Report on Data and Methods for Assessment of 2,3,7,8-Tetrachlorodibenzop-dioxin Risks to Aquatic Life and Associated Wildlife.* EPA/600/R-93/055. Office of Research and Development. Washington, D.C. March. This report identified the four studies listed below.

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Aulerich, R.J., S.J. Bursian, and A.C. Napolitano. 1988. "Biological Effects of Epidermal Growth Factor and 2,3,7,8-Tetrachlorodibenzo-p-dioxin on Developmental Parameters of Neonatal Mink." *Archives of Environmental Contamination and Toxicology*. Volume 17. Pages 27-31.

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Dibenz(a,h)anthracene

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Polychlorinated biphenyls

Aulerich, R.J., S.J. Bursian, W.J. Breslin, B.A. Olson, and R.K. Ringer. 1985. "Toxicological Manifestations of 2,4,5-, 2',4',5'-, 2,3,6-, 2',3',6'- and 3,4,5-, 3',4',5'- Hexachlorobiphenyl and Aroclor 1254 in Mink." ***Journal of Toxicology and Environmental Health*****. Volume 15. Pages 63-79.**

Aulerich, R. J. and R. K. Ringer. 1977. "Current Status of PCB Toxicity, Including Reproduction in Mink." *Archives of Environmental Containation and Toxicology*. Volume 6. Page 279.

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Barsotti, D. A., R. J. Marlar and J. R. Allen. 1976. "Reproductive Dysfunction in Rhesus Monkeys Exposed to Low Llevels of Polychlorinated Biphenyls (Aroclor 1248)." *Food and Cosmetics Toxicology*. Volume 14. Pages 99-103.

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Villeneuve, D.C., D.L. Grant, K. Khera, D.J. Klegg, H. Baer, and W.E.J. Phillips. 1971. "The Fetotoxicity of a Polychlorinated Biphenyl Mixture (Aroclor 1254) in the Rabbit and in the Rat." *Environmental Physiology*. Volume 1. Pages 67-71.

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Cody, T.E., S. Witherup, L. Hastings, K. Stemmer, and R.T. Christian. 1981. "1,3-Dinitrobenzene: Toxic Effects in Vivo and in Vitro." *Journal of Toxicology and Environmental Health*. Volume 7. Pages 829-847.

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Bleavins, M. R., R. J. Aulerich, and R. K. Ringer. 1984. Effects of chronic dietary hexachlorobenzene exposure on the reproductive performance and survivability of mink and European ferrets. *Arch. Environ. Contam. Toxicol.* 13: 357-365.

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(Page 1 of 13)

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Compound	Basis for TRV				TRV	Reference and Notes [d]
	Duration and Endpoint [a]	Test Organism	Dose[b]	Uncertainty Factor [c]		
Polychlorinateddibenzo(p)dioxins (μg/kg BW-day)						
2,3,7,8-TCDD	Subchronic (10 weeks) NOAEL	Ring-necked pheasant hen	0.01	Not applicable	0.01	Nosek et al. (1992). TRV based on toxicity of 2,3,7,8-TCDD.
Polynuclear aromatic hydrocarbons (PAH) (μg/kg BW-day)						
Total high molecular weight (HMW) PAH	--	--	--	--	0.14	TRV based on toxicity of benzo(k)fluoranthene. If TRVs are not available for all individual HMW PAHs, this TRV should be used to assess potential risk of Total HMW PAH.
Benzo(a)pyrene	Acute NOAEL	Chicken embryo	100	0.01	1.0	Brunström et al. (1991).
Benzo(a)anthracene	Acute LD50	Chicken embryo	79	0.01	0.79	Brunström et al. (1991).
Benzo(b)fluoranthene	--	--	--	--	0.14	No toxicity data available for benzo(b) fluoranthene. Benzo(k)fluoranthene used as surrogate.
Benzo(k)fluoranthene	Acute LD50	Chicken embryo	14	0.01	0.14	Brunström et al. (1991).
Chrysene	Acute LOAEL	Chicken embryo	100	0.01	1.0	Brunström et al. (1991).
Dibenz(a,h)anthracene	Acute LD50	Chicken embryo	39	0.01	0.39	Brunström et al. (1991).

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Compound	Basis for TRV				TRV	Reference and Notes [d]
	Duration and Endpoint [a]	Test Organism	Dose[b]	Uncertainty Factor [c]		
Indeno(1,2,3-cd)pyrene	Acute LOAEL	Chicken embryo	100	0.01	1.0	Brunström et al. (1991).
Polychlorinated biphenyls (PCB) (μg/kg BW-day)						
Aroclor 1016	--	--	--	--	--	No toxicity data available. Aroclor 1254 TRV used as surrogate.
Aroclor 1254	Chronic (3 months) LOAEL (embryonic mortality)	Ring dove	720	0.1	72	Peakall et al. (1972). TRV based on toxicity of Aroclor 1254.
Nitroaromatics (μg/kg BW-day)						
1,3-Dinitrobenzene	Acute LD50	Redwing blackbird	42.2	0.01	0.422	Schafer (1972)
2,4-Dinitrotoluene	--	--	--	--	--	Toxicity value not available.
2,6-Dinitrotoluene	--	--	--	--	--	Toxicity value not available.
Nitrobenzene	--	--	--	--	--	Toxicity value not available.
Pentachloronitrobenzene	Chronic (35 weeks) NOAEL	Chicken	68,750	Not applicable	68,750	Dunn et al. (1979)
Phthalate esters (μg/kg BW-day)						
Bis(2-ethylhexyl)phthalate	Subchronic (4 weeks) NOAEL	Ring dove	1,110	0.1	111	Peakall (1974)
Di(n)octyl phthalate	--	--	--	--	--	Toxicity value not available.
Volatile organic compounds (μg/kg BW-day)						

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Compound	Basis for TRV				TRV	Reference and Notes [d]
	Duration and Endpoint [a]	Test Organism	Dose[b]	Uncertainty Factor [c]		
Acetone	Acute (5 days) NOAEL	Coturnix quail	5,200,000	0.01[h]	52,000	Hill and Camardese (1986)
Acrylonitrile	--	--	--	--	--	Toxicity value not available.
Chloroform	--	--	--	--	--	Toxicity value not available.
Crotonaldehyde	--	--	--	--	--	Toxicity value not available.
1,4-Dioxane	--	--	--	--	--	Toxicity value not available.
Formaldehyde	--	--	--	--	--	Toxicity value not available.
Vinyl chloride	--	--	--	--	--	Toxicity value not available.
Other chlorinated organics (μg/kg BW-day)						
Hexachlorobenzene	Acute (5 days) NOAEL	Coturnix quail	22,500	0.01	225	Hill and Camardese (1986)
Hexachlorobutadiene	Chronic (3 months) NOAEL	Japanese quail	3185	Not applicable	3185	Schwertz et al. (1974)
Hexachlorocyclopentadiene	--	--	--	--	--	Toxicity value not available.
Pentachlorobenzene	--	--	--	--	--	Toxicity value not available.
Pentachlorophenol	Acute (5 days) NOAEL	Quail	403,000	0.01	4,030	Hill and Camardese (1986)
Pesticides (μg/kg BW-day)						
4,4'-DDE	Acute (5 days) LOAEL (mortality)	Coturnix quail	84,500	0.01	845	Hill and Camardese (1986). Test data for 1,1'-DDE used as a surrogate for 4,4'-DDE.

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Compound	Basis for TRV				TRV	Reference and Notes [d]
	Duration and Endpoint [a]	Test Organism	Dose[b]	Uncertainty Factor [c]		
Heptachlor	Acute (5 days) LOAEL (mortality)	Quail	6,500	0.01	65	Hill and Camardese (1986)
Hexachlorophene	Acute LD50	Bobwhite quail	575,000	0.01	5,750	Meister (1994)
Inorganics (mg/kg BW-day)						
Aluminum	Chronic (4 -months) NOAEL (reproduction)	Ringed Turtle Dove	110	1.0	100	Carriere et al. (1986)
Antimony	--	--	--	--	--	Toxicity value not available. Ridgeway and Karnofsky (1952) reported LD50 for doses to eggs; however, that value could not be converted to a dose based on post-hatching environmental exposure.
Arsenic	Chronic (7 months) NOAEL	Brown-headed cowbird	2.46	1.0	2.46	U.S. Fish and Wildlife Service (1969)
Barium	Subchronic (4 weeks) NOAEL	One day old chick	208.26	0.1	20.8	Johnson et al. (1960)
Beryllium	--	--	--	--	--	Toxicity value not available.
Cadmium	Chronic (90 days) NOAEL	Mallard drake	1.45	Not applicable	1.45	White and Finley (1978)
Chromium (hexavalent)	Chronic (5 months) NOAEL	Black duck	1.0	Not applicable	1.0	Haseltine et al. (1985). TRV based on trivalent chromium.
Copper	Chronic (10 weeks) NOAEL (growth)	1-day old chicks	46.97	1.0	46.97	Mehring et al. (1960)

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Compound	Basis for TRV				TRV	Reference and Notes [d]
	Duration and Endpoint [a]	Test Organism	Dose[b]	Uncertainty Factor [c]		
Total Cyanide	Acute LD50	American kestrel	4	0.01	0.04	Wiemeyer et al. (1986). Sodium cyanide is used as a surrogate for total cyanides.
Lead	Acute (7 days) LOAEL (altered enzyme levels)	Ringed turtle dove	25	0.001	0.025	Kendall and Scanlon (1982)
Mercuric chloride	Acute (5 days) LOAEL (mortality)	Coturnix quail	325	0.01	3.25	Hill and Camardese (1986)
Methyl mercury	Chronic (3 generations) LOAEL (mortality)	Mallard	0.064	0.1	0.0064	Heinz (1979)
Nickel	Subchronic (5 days) NOAEL	Coturnix quail	650	0.1	65	Hill and Camardese (1986)
Selenium	Chronic (78 days) NOAEL	Mallard	0.5	1.0	0.5	Heinz et al. (1987)
Silver	Subchronic (14 days) NOAEL	Mallard	1,780	0.1	178	U.S. EPA (1997)
Thallium	Acute LD50	Starling	35	0.01	0.35	Schafer (1972)
Zinc	Chronic (44 weeks) NOAEL	Leghorn hen and New Hampshire rooster	130.9	1.0	130.9	Stahl et al. (1990)

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Notes:

a	The duration of exposure is defined as chronic if it represents about 10 percent or more of the test animal's lifetime expectancy. Acute exposures represent single exposure or multiple exposures occurring within about two weeks or less. Subchronic exposures are defined as multiple exposures occurring for less than 10 percent of the test animal's lifetime expectancy but more that 2 weeks.
b	Reported value which were dose in diet or water were converted to dose based on body weight and intake rate using Opresko, Sample, and Suter (1996).
c	Uncertainty factors are used to extrapolate a reported toxicity value to a chronic NOAEL TRV. See Chapter 5 (Section 5.4) of the SLERAP for a discussion on the use of uncertainty factors. The TRV was calculated by multiplying the toxicity value by the uncertainty factor. A "not applicable" uncertainty factor is equivalent to a value equal to 1.0.
d	The references refer to the study from which the endpoint and doses were identified. Complete reference citations are provided below.
e	Best scientific judgement used to identify uncertainty factor. See Chapter 5 (Section 5.4.1.2) for a discussion on the use of best scientific judgement. Factors evaluated include test duration, ecological relevance of endpoint, experimental design, and availability of toxicity data.

HMW = High molecular weight
LOAEL = Lowest Observed Adverse Effect Level
LD50 = Concentration lethal to 50 percent of the test organisms.
NOAEL = No Observed Adverse Effect Level
TRV = Toxicity Reference Value

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REFERENCES

Sample, Opresko, and Suter II (1996) provides a comprehensive review of bird toxicity information. This source was reviewed to identify studies to develop TRVs for birds. Based on the information presented, one or more references were obtained and reviewed to identify compound-specific toxicity values. For some compounds, the available information identified a single study meeting the requirements for a TRV, as discussed in Chapter 5 (Section 5.4) of the SLERAP. In most cases, each reference was obtained and reviewed to identify a single toxicity value to develop a TRV for each compound. As noted below, additional compendia were reviewed to identify toxicity studies to review. In a few cases where a primary study could not be obtained, a toxicity value is based on a secondary source. For compounds not discussed in Sample, Opresko, and Suter II (1996), the scientific literature was searched, and relevant studies were obtained and reviewed. The references reviewed are listed below. The study selected for the TRV is highlighted in bold.

Polychlorinated dibenzo(p)dioxins

Nosek, J.A., S.R. Craven, J.R. Sullivan, S.S. Hurley, and R.E. Peterson. 1992. "Toxicity and Reproductive Effects of 2,3,7,8-Tetrachlorodibenzo-p-dioxin in Ring-Necked Pheasant Hens." ***Journal of Toxicology and Environmental Health*****. Volume 35. Pages 187-198.**

U.S. EPA. 1993. *Interim Report on Data and Methods for Assessment of 2,3,7,8-Tetrachlorodibenzop-dioxin Risks to Aquatic Life and Associated Wildlife.* EPA/600/R-93/055. Office of Research and Development. Washington, D.C. March. This report identified the two studies listed below.

Greig, J.B., G. Jones, W.H. Butler, and J.M. Barnes. 1973. "Toxic Effects of 2,3,7,8-Tetrachlorodibenzo-p-dioxins. *Food and Cosmetics Toxicology*. Volume 11. Pages 585-595.

Hudson, R., R.Tucker, and M. Haegele. 1984. *Handbook of Toxicity of Pesticides to Wildlife*. Second Ed. U.S. Fish and Wildlife, Resources Publication No. 153. Washington, D.C.

Benzo(a)pyrene

Brunström, B., D. Broman, and C. Näf. 1991. "Toxicity and EROD-Inducing Potency of 24 Polycyclic Aromatic Hydrocarbons (PAHs) in Chick Embryos." ***Archives of Toxicology*****. Volume 65. Pages 485-489.**

Benzo(a)anthracene

Brunström, B., D. Broman, and C. Näf. 1991. "Toxicity and EROD-Inducing Potency of 24 Polycyclic Aromatic Hydrocarbons (PAHs) in Chick Embryos." ***Archives of Toxicology*****. Volume 65. Pages 485-489.**

Benzo(k)fluoranthene

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Brunström, B., D. Broman, and C. Näf. 1991. "Toxicity and EROD-Inducing Potency of 24 Polycyclic Aromatic Hydrocarbons (PAHs) in Chick Embryos." *Archives of Toxicology*. Volume 65. Pages 485-489.

Chyrsene

Brunström, B., D. Broman, and C. Näf. 1991. "Toxicity and EROD-Inducing Potency of 24 Polycyclic Aromatic Hydrocarbons (PAHs) in Chick Embryos." *Archives of Toxicology*. Volume 65. Pages 485-489.

Dibenz(a,h)anthracene

Brunström, B., D. Broman, and C. Näf. 1991. "Toxicity and EROD-Inducing Potency of 24 Polycyclic Aromatic Hydrocarbons (PAHs) in Chick Embryos." *Archives of Toxicology*. Volume 65. Pages 485-489.

Indeno(1,2,3-cd)pyrene

Brunström, B., D. Broman, and C. Näf. 1991. "Toxicity and EROD-Inducing Potency of 24 Polycyclic Aromatic Hydrocarbons (PAHs) in Chick Embryos." *Archives of Toxicology*. Volume 65. Pages 485-489.

Polychlorinated Biphenyls

Peakall, D.B., J.L. Lincer, S.E. Bloom. 1972. "Embryonic Mortality and Chromosomal Alterations Caused by Aroclor 1254 in Ring Doves." *Environmental Health Perspectives*. Volume 1. Pages 103-104.

Dahlgren, R.B., R.L. Linder, and C.W. Carlson. 1972. "Polychlorinated Biphenyls: Their Effects on Penned Pheasants." *Environmental Health Perspectives*. Volume 1. Pages 89-101.

McLane, M.A.R., and D.L. Hughes. 1980. "Reproductive Success of Screech Owls Fed Aroclor 1248." *Archives of Environmental Contamination and Toxicolog*. Volume 9. Pages 661-665.

1,3-Dinitrobenzene

Schafer, E.W. 1972. "The Acute Oral Toxicity of 369 Pesticidal, Pharmaceutical and Other Chemicals to Wild Birds." *Toxicological and Applied Pharmacology*. Volume 21. Pages 315-330.

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Pentachloronitrobenzene

Dunn, J. S., P. B. Bush, N. H. Booth, R.L. Farrell, D. M. Thomason, and D. D. Goetsch. 1979. Effect of Pentachloronitrobenzene upon Egg Production, Hatchability, and Residue Accumulation in the Tissues of White Leghorn Hens. *Toxicology and Applied Pharmacology.* Volume 48. Pages 425-433.

Bis(2-ethylhexyl)phthalate

Peakall, D.B. 1974. "Effects of Di-n-butyl and Di-2-ethylhexyl Phthalate on the Eggs of Ring Doves. *Bulletin of Environmental Contamination and Toxicology.*" Volume 12. Pages 698-702.

Acetone

Hill, E.F., and M.B. Camardese. 1986. "Lethal Dietary Toxicities of Environmental Contaminants and Pesticides to Coturnix." Fish and Wildlife Service. Technical Report 2.

1,4-Dioxane

Giavini, E., C. Vismara, and L. Broccia. 1985. "Teratogenesis Study of Dioxane in Rats." *Toxicology Letters*. Volume 26. Pages 85-88. This study did not evaluate an ecologically relevant endpoint. Therefore, the data were not used to develop a TRV.

Hexachlorobenzene

Hill, E.F., and M.B. Camardese. 1986. "Lethal Dietary Toxicities of Environmental Contaminants and Pesticides to Coturnix." Fish and Wildlife Service. Technical Report 2.

Hexachlorobutadiene

Schwetz, B.A., J.M. Norris, R.J. Kociba, P.A. Keeler, R.F. Cornier, and P.J. Gehring. 1974. "Reproduction Study in Japanese Quail Fed Hexachlorobutadiene for 90 Days." *Toxicology and Applied Pharmacology*. Volume 30. Pages 255-265.

Pentachlorophenol

Hill, E.F., and M.B. Camardese. 1986. "Lethal Dietary Toxicities of Environmental Contaminants and Pesticides to Coturnix." Fish and Wildlife Service. Technical Report 2.

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4,4'-DDE

Hill, E.F., and M.B. Camardese. 1986. "Lethal Dietary Toxicities of Environmental Contaminants and Pesticides to Coturnix." Fish and Wildlife Service. Technical Report 2.

Mendenhall, V.M., E.E. Klaas, and M.A.R. McLane. 1983. "Breeding Success of Barn Owls (*Tyto alba*) Fed Low Levels of DDE and Dieldrin." *Archives of Environmental Contamination and Toxicology*. *Volume*12. Pages 235-240.

Shellenberger, T.E. 1978. "A Multi-Generation Toxicity Evaluation of P-P'-DDT and Dieldrin with Japanese Quail. I. Effects on Growth and Reproduction." *Drug Chemistry and Toxicology*. *Volume* 1. Pages 137-146

Heptachlor

Hill, E.F., and M.B. Camardese. 1986. "Lethal Dietary Toxicities of Environmental Contaminants and Pesticides to Coturnix." Fish and Wildlife Service. Technical Report 2.

Hexachlorophene

Meister, R.J. (ed.) 1994. *Farm Chemicals Handbook '94*. Meister Publishing Company, Willoughby, Ohio. Volume 80. Page C189.

Aluminum

Carriere, D., K.L. Fischer, D.B. Peakall, and P. Anghern. 1986. "Effects of Dietary Aluminum Sulphate on Reproductive Success and Growth of Ringed Turtle Doves (*Streptopelia risoria*)." *Canadian Journal of Zoology*. Volume 64. Pages 1500-1505.

Carriere, D., K. Fischer, D. Peakall, and P. Angehrn. 1986. "Effects of Dietary Aluminum in Combination with Reduced Calcium and Phosphorus on the Ring Dove (*Streptopelia risoria*)." *Water, Air, and Soil Pollution*. Volume 30. Pages 757-764.

Antimony

Ridgeway, L.P. and D.A. Karnofsky. 1952. "The Effects of Metals on the Chick Embryo: Toxicity and Production of Abnormalities in Development." *Annals of New York Academy of Sciences*. Volume 55. Pages 203-215.

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Arsenic

U.S. Fish and Wildlife Service. 1969. "Publication 74." Bureau of Sport Fisheries and Wildlife. As cited in Sample, Opresko, and Suter II (1996).

Barium

Johnson, D., Jr., A.L. Mehring, Jr., and H.W. Titus. 1960. "Tolerance of Chickens for Barium." *Proceedings o fthe Society for Experimental Biology and Medicine.* Volume 104. Pages 436-438.

Cadmium

White, D.H., and M.T. Finley. 1978. "Uptake and Retention of Dietary Cadmium in Mallard Ducks." *Environmental Research*. Volume 17. Pages 53-59.

Chromium

Haseltine, S.D., and others. 1985. "Effects of Chromium on Reproduction and Growth of Black Ducks." As cited in U.S. Fish and Wildlife Service. 1986. *Chromium Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review*. January. Page 38.

Copper

Mehring, A.L.Jr., J.H. Brumbaugh, A.J. Sutherland, and H.W. Titus. 1960. "The Tolerance of Growing Chickens for Dietary Copper." *Poultry Science.* Volume 39. Pages 713-719.

Cyanide

Wiemeyer, S.N., E.F. Hill, J.W. Carpenter, and A.J. Krynitsky. 1986. "Acute Oral Toxicity of Sodium Cyanide in Birds." *Journal of Wildlife Diseases*. Volume 22. Pages 538-46.

Lead

Kendall, R.J., and P.F. Scanlon. 1982. "The Toxicology of Ingested Lead Acetate in Ringed Turtle Doves *Stretopelia risoria*." *Environmental Pollution.* Volume 27. Pages 255-262.

Edens, F., W.E. Benton, S J. Bursian, and G.W. Morgan. 1976. “Effect of Dietary Lead on Reproductive Performance in Japanese Quail, *Coturnix coturnix japonica*.” *Toxicology and Applied Pharmacology*. Volume 38. Pages 307-314.

Pattee, O.H. 1984. "Eggshell Thickness and Reproduction in American Kestrels Exposed to Chronic Dietary Lead." *Archives of Environmental Contamination and Toxicology*. Volume 13. Pages 29-34.

Mercuric chloride

Hill, E.F., and M.B. Camardese. 1986. "Lethal Dietary Toxicities of Environmental Contaminants and Pesticides to Coturnix." Fish and Wildlife Service. Technical Report 2.

Hill, E. F. and C. S. Schaffner. 1976. “Sexual Maturation and Productivity of Japanese Quail Fed Graded Concentrations of Mercuric Chloride.” *Poultry Science.* Volume 55. Pages 1449-1459.

Methyl mercury

Heinz, G.H. 1979. "Methylmercury: Reproductive and Behavioral Effects on Three Generations of Mallard Ducks." ***Journal of Wildlife Management*****. Volume 43. Pages 394-401.**

Spann, J.W., G.H. Heinz, M.B. Camardese, E.F. Hill, J.F. Moore, and H.C. Murray. 1986. “Differences in Mortality Among Bobwhite Fed Methylmercury Chloride Dissolved in Various Carriers.” *Environmental Toxicology and Chemistry*. Volume 5. Pages 721-724.

Nickel

Hill, E.F., and M.B. Camardese. 1986. "Lethal Dietary Toxicities of Environmental Contaminants and Pesticides to Coturnix." Fish and Wildlife Service. Technical Report 2.

Cain, B.W., and E.A. Pafford. 1981. "Effects of Dietary Nickel on Survival and Growth of Mallard Ducklings." *Archives of Environmental Contamination and Toxicology*. Volume 10. Pages 737-745.

Selenium

Heinz, G., and others. 1987. "Research at Patuxent Wildlife Research Center." As cited in Sample, Opresko, and Suter II (1996).

Heinz, G.H., D.J. Hoffman, A.J. Krynitsky, and D.M.G. Weller. 1987. "Reproduction in Mallards Fed Selenium." *Environmental Toxicology and Chemistry*. Volume 6. Page 423-433.

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APPENDIX F

EQUATIONS FOR COMPUTING COPC CONCENTRATIONS AND COPC DOSE INGESTED TERMS

Screening Level Ecological Risk Assessment Protocol

August 1999

APPENDIX F

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EQUATIONS FOR COMPUTING COPC CONCENTRATIONS

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EQUATIONS FOR COMPUTING COPC DOSE INGESTED TERMS

APPENDIX F

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TABLE F-1-1

COPC CONCENTRATIONS IN TERRESTRIAL PLANTS FOR TERRESTRIAL FOOD WEBS

(Page 1 of 2)

Description

This equation calculates the COPC concentration in plants due to: (1) *Pd* - wet and dry deposition of COPCs onto plant surfaces, (2) *Pv* - uptake of vapor phase COPCs onto plant surfaces, (3) *Pr* uptake of COPCs from soil through plant roots. Uncertainties associated with the use of this equation include the following:

Uncertainties introduced by this variable include the following:

(1) Some of the variables in the equations in Tables B-3-7, B-3-8, and B-3-9—including *Cs*, *Cyv*, *Q*, *Dydp*, and *Dywp*—are COPC- and site-specific. Uncertainties associated with these variables are site-specific.

(2) In the equation in Table B-3-7, uncertainties associated with other variables include the following: F_w (values for organic compounds estimated on the basis of the behavior of polystyrene microspheres), *Rp* (estimated on the basis of a generalized empirical relationship), *kp* (estimation process does not consider chemical degradation). All of these uncertainties contribute to the overall uncertainty associated with C_{TP}.

Equation

$$C_{TP} = (Pd + Pv + Pr)$$

Variable	Description	Units	Value
C_{TP}	COPC concentration in terrestrial plants	mg COPC/kg WW	

TABLE F-1-1

COPC CONCENTRATIONS IN TERRESTRIAL PLANTS FOR TERRESTRIAL FOOD WEBS

(Page 2 of 2)

Variable	Description	Units	Value
Pd	Plant concentration due to direct deposition	mg COPC/kg WW	**Varies** This variable is calculated with the equation in Table B-3-1. This variable represents the COPC concentration in plants due to wet and dry deposition of COPCs onto plant surfaces. The limitations and uncertainty introduced in calculating this variable include the following: (1) Variables *Q*, *Dydp*, and *Dywp* are COPC- and site-specific. Uncertainties associated with these variables are site-specific. (2) In calculating the variable *Fw*, values of *r* assumed for most organic compounds—based on the behavior of insoluble polystyrene microspheres tagged with radionuclides— may accurately represent the behavior of organic compounds under site-specific conditions. (3) The empirical relationship used to calculate the variable *Rp*, and the empirical constant for use in the relationship, may not accurately represent site-specific plant types. (4) The recommended procedure for calculating the variable *kp* does not consider chemical degradation processes. This conservative approach contributes to the possible overestimation of plant concentrations.
Pv	Plant concentration due to air-to-plant transfer	mg COPC/kg WW	**Varies** This variable is calculated with the equation in Table B-3-2. Uncertainties associated with the use of this equation include the following: (1) The algorithm used to calculate values for the variable F_v assumes a default value for the parameter S_T (Whitby's average surface area of particulates [aerosols]) of background plus local sources, rather than an S_T value for urban sources. If a specific site is located in an urban area, the use of the latter S_T value may be more appropriate. The S_T value for urban sources is about one order of magnitude greater than that for background plus local sources and would result in a lower *Fv* value; however, the F_v value is likely to be only a few percent lower.
Pr	Plant concentration due to root uptake	mg COPC/kg WW	**Varies** This variable is calculated with the equation in Table B-3-3. *Cs* is the COPC concentration in soil due to deposition. This variable is calculated using emissions data, ISCST3 air dispersion and deposition model, and soil fate and transport equations (presented in Appendix B). Uncertainties associated with the use of this equation include the following: (1) The availability of site-specific information, such as meteorological data, will affect the accuracy of *Cs* estimates.

TABLE F-1-2

COPC CONCENTRATIONS IN HERBIVOROUS MAMMALS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 1 of 4)

Description

This equation calculates the COPC concentration in herbivorous mammals through the ingestion of plants, soil, and water in the forest, shortgrass prairie, tallgrass prairie, and shrub/scrub food webs. The limitations and uncertainty introduced in calculating this variable include the following:

(1) Variables: C_{TP}, C_S, and C_{wctot} are COPC- and site-specific. Uncertainties associated with these variables are site-specific.
(2) Variables: $BCF_{TP\text{-}HM}$, $BCF_{S\text{-}HM}$ and $BCF_{W\text{-}HM}$ are based on biotransfer factors for beef cattle (Ba_{beef}), and receptor specific ingestion rates, and therefore may introduce uncertainty when used to compute concentrations in site-specific herbivorous mammals.

Equation

$$C_{HM} = (C_{TP} \cdot BCF_{TP-HM} \cdot P_{TP} \cdot F_{TP}) + (C_S \cdot BCF_{S-HM} \cdot P_S) + (C_{wctot} \cdot BCF_{W-HM} \cdot P_W)$$

Variable	Description	Units	Value
C_{HM}	COPC concentration in herbivorous mammals	mg COPC/kg FW tissue	
C_{TP}	COPC concentration in terrestrial plants	mg COPC/kg WW	**Varies** This variable is site- and COPC-specific; it is calculated using the equation in Table F-1-1. Uncertainties introduced by this variable include the following: (1) Some of the variables in the equations in Tables B-3-1, B-3-2, and B-3-3—including *Cs*, *Cyv*, *Q*, *Dydp*, and *Dywp*—are COPC- and site-specific. (2) In the equation in Table B-3-1, uncertainties associated with other variables include the following: F_w (values for organic compounds estimated on the basis of the behavior of polystyrene microspheres), *Rp* (estimated on the basis of a generalized empirical relationship), and *kp* (estimation process does not consider chemical degradation). All of these uncertainties contribute to the overall uncertainty associated with C_{TP}. (3) In the equation in Table B-3-3, COPC-specific soil-to-plant bioconcentration factors (BCF_{TP}) may not reflect site-specific conditions.

TABLE F-1-2

COPC CONCENTRATIONS IN HERBIVOROUS MAMMALS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

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Variable	Description	Units	Value
BCF_{TP-HM}	Bioconcentration factor for terrestrial plant-to-herbivorous mammal	unitless [(mg COPC/kg FW tissue)/(mg COPC/kg WW)]	**Varies** This variable is COPC-, site-, and receptor-specific, and is calculated using the following equation to compute the COPC concentration in herbivorous mammals through dietary exposure. BCF_{TP-HM} values are provided in Appendix D.
P_{TP}	Proportion of terrestrial plant in diet that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{TP}	Fraction of diet comprised of terrestrial plants	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of terrestrial plants. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-1-2

COPC CONCENTRATIONS IN HERBIVOROUS MAMMALS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 3 of 4)

Variable	Description	Units	Value
C_S	COPC concentration in soil	mg COPC /kg DW soil	**Varies** This variable is COPC- and site-specific, and should be calculated using the equation in Table B-1-1. This variable is calculated using emissions data, ISCST3 air dispersion and deposition model, and soil fate and transport equations (presented in Appendix B). C_S is expressed on a dry weight basis. Uncertainties associated with this variable include: (1) For soluble COPCs, leaching might lead to movement to below 1 centimeter in untilled soils, resulting a greater mixing depth. This uncertainty may overestimate *Cs*. (2) Deposition to hard surfaces may result in dust residues that have negligible dilution (as a result of potential mixing with *in situ* materials) in comparison to that of other residues. This uncertainty may underestimate *Cs*. (3) Modeled soil concentrations may not accurately represent site-specific conditions. As a result, the actual COPC concentration in soil may be under- or overestimated to an unknown degree.
$BCF_{S\text{-}HM}$	Bioconcentration factor for soil-to-herbivorous mammal	unitless [(mg COPC/kg FW tissue)/(mg COPC/kg DW soil)]	**Varies** This variable is COPC-, site-, and receptor-specific, and is calculated using the following equation to compute the COPC concentration in herbivorous mammals through soil exposure. $BCF_{S\text{-}HM}$ values are provided in Appendix D.
P_S	Proportion of ingested soil that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of soil ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for a screening level risk assessment when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated soil ingested by species depends on site-specific information, receptor home range, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of soil ingested that is contaminated will likely be overestimated.

TABLE F-1-2

COPC CONCENTRATIONS IN HERBIVOROUS MAMMALS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 4 of 4)

Variable	Description	Units	Value
C_{wctot}	Total COPC concentration in water column	mg COPC/L water (or g COPC/m^3 water)	**Varies (calculated - Table B-2-17)** This variable is COPC- and site-specific and is calculated using Table B-2-17. Uncertainties associated with this equation include the following: (1) All of the variables in the equation in Table B-2-17 are COPC- and site-specific. Therefore, the use of default values rather than site-specific values, for any or all of these variables, will contribute to the under- or overestimation of C_{wctot}. (2) Uncertainty associated with f_{wc} is largely the result of uncertainty associated with default OC content values and may be significant in specific instances. Uncertainties associated with the variable L_T and K_{wt} may also be significant because of many variable-specific uncertainties. The degree of uncertainly associated with the variables d_{wc} and d_{bs} is expected to be minimal either because information for estimating a variable (d_{wc}) is generally available or because the probable range for a variable (d_{bs}) is narrow. The uncertainty associated with the variables f_{wc} and C_{wtot} is associated with estimates of *OC* content. Because *OC* content values can vary widely for different locations in the same media, the uncertainty associated with using default *OC* values may be significant in specific cases.
BCF_{W-HM}	Bioconcentration factor for water-to-herbivorous mammal pathways	unitless [(mg COPC/kg FW tissue)/(mg COPC/L water)]	**Varies** This variable is COPC-, site-, and receptor-specific, and is calculated using the following equation to compute the COPC concentration in herbivorous mammals through indirect water exposure (total water body concentration). BCF_{W-HM} values are provided in Appendix D.

TABLE F-1-3

COPC CONCENTRATIONS IN INVERTEBRATES IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 1 of 2)

Variable	Description	Units	Value
P_W	Proportion of ingested water that is contaminated	unitless	**0 to 1** **Default: 1.0** This OSW variable is species- and site-specific, and depends on the percentage of water ingested that is contaminated. U.S. EPA recommend that a default value of 1.0 be used when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated water ingested by species depends on site-specific information, receptor home range, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of ingested water that is contaminated will likely be overestimated.

Description

This equation calculates the COPC concentration in invertebrates through exposure to soil in the forest, shortgrass prairie, tallgrass prairie, and shrub/scrub food webs. The limitations and uncertainty introduced in calculating this variable include the following:

(1) C_S values are COPC- and site-specific. Uncertainties associated with these variables are site specific.
(2) $BCF_{S\text{-}INV}$ values are intended to represent "generic invertebrate species", and therefore may over- or under-estimate exposure for site-specific organisms.

Equation

$$C_{INV} = C_S \cdot BCF_{S-INV}$$

Variable	Description	Units	Value
C_{INV}	COPC concentration in invertebrates	mg COPC/kg FW	

TABLE F-1-3

COPC CONCENTRATIONS IN INVERTEBRATES IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 2 of 2)

Variable	Description	Units	Value
C_S	COPC concentration in soil	mg COPC /kg DW soil	**Varies** This variable is COPC- and site-specific, and should be calculated using the equation in Table B-1-1. This variable is calculated using emissions data, ISCST3 air dispersion and deposition model, and soil fate and transport equations (presented in Appendix B). C_S is expressed on a dry weight basis. Uncertainties associated with this variable include: (1) For soluble COPCs, leaching might lead to movement to below 1 centimeter in untilled soils, resulting a greater mixing depth. This uncertainty may overestimate Cs. (2) Deposition to hard surfaces may result in dust residues that have negligible dilution (as a result of potential mixing with *in situ* materials) in comparison to that of other residues. This uncertainty may underestimate Cs. (3) Modeled soil concentrations may not accurately represent site-specific conditions. As a result, the actual COPC concentration in soil may be under- or overestimated to an unknown degree.
BCF_{S-INV}	Bioconcentration factor for soil-to-invertebrate	unitless [(mg COPC/kg FW tissue)/(mg COPC/kg DW soil)]	**Varies** This variable is COPC-, site- and species-specific, and is provided in Appendix C. The following uncertainties are associated with this variable: (1) The COPC specific BCF_{S-INV} values may not accurately represent site-specific soil conditions which could influence the bioavailability of COPCs, therefore over-or under-estimating C_{INV} to an unknown degree. (2) The data set used to calculate BCF_{S-INV} is based on a limited number of test organism. The uncertainty associated with calculating concentrations using BCF_{S-INV} in site-specific organisms is unknown and may over- or under-estimate C_{INV}.

TABLE F-1-4

COPC CONCENTRATIONS IN HERBIVOROUS BIRDS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

Description

This equation calculates the COPC concentration in herbivorous birds through the ingestion of plants, soil, and water in the forest, shortgrass prairie, tallgrass prairie, and shrub/scrub food webs. The limitations and uncertainty introduced in calculating this variable include the following:

(1) Variables: C_{TP}, C_S, and C_{wctot} are COPC- and site-specific. Uncertainties associated with these variables are site specific.
(2) Variables: $BCF_{TP\text{-}HB}$, $BCF_{S\text{-}HB}$, and $BCF_{W\text{-}HB}$ are calculated based on biotransfer factors for chicken ($Ba_{chicken}$), and receptor specific ingestion rates, and therefore may introduce uncertainty when used to compute concentrations in site-specific herbivorous birds.
(3) The use of a single $Ba_{chicken}$ value for each COPC may not accurately reflect site-specific conditions. The default values may under- or overestimate C_{HB}.

Equation

$$C_{HB} = (C_{TP} \cdot BCF_{TP-HB} \cdot P_{TP} \cdot F_{TP}) + (C_S \cdot BCF_{S-HB} \cdot P_S) + (C_{wctot} \cdot BCF_{W-HB} \cdot P_W)$$

Variable	Description	Units	Value
C_{HB}	COPC concentration in herbivorous birds	mg COPC/kg FW tissue	
C_{TP}	COPC concentration in terrestrial plants	mg COPC/kg WW	**Varies** This variable is site- and COPC-specific; it is calculated using the equation in Table F-1-1. Uncertainties introduced by this variable include the following: (1) Some of the variables in the equations in Tables B-3-1, B-3-2, and B-3-3—including *Cs, Cyv, Q, Dydp*, and *Dywp*—are COPC- and site-specific. (2) In the equation in Table B-3-1, uncertainties associated with other variables include the following: F_w (values for organic compounds estimated on the basis of the behavior of polystyrene microspheres), *Rp* (estimated on the basis of a generalized empirical relationship), and *kp* (estimation process does not consider chemical degradation). All of these uncertainties contribute to the overall uncertainty associated with C_{TP}.

TABLE F-1-4

COPC CONCENTRATIONS IN HERBIVOROUS BIRDS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 2 of 4)

Variable	Description	Units	Value
$BCF_{TP\text{-}HB}$	Bioconcentration factor for plant-to-herbivorous bird	unitless [(mg COPC/kg FW tissue)/(mg COPC/kg WW)]	**Varies** This variable is COPC-, site-, habitat- and receptor-specific, and is calculated using the following equation to compute the COPC concentration in herbivorous birds through dietary exposure. $BCF_{TP\text{-}HB}$ values are porvided in Appendix D.
P_{TP}	Proportion of terrestrial plant in diet that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{TP}	Fraction of diet comprised of terrestrial plants	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of terrestrial plants. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces significant uncertaintiy and may over-estimate exposure from ingestion of a single dietary item. (3) The defalut value for an equal diet introduces significant uncertainity and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-1-4

COPC CONCENTRATIONS IN HERBIVOROUS BIRDS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 3 of 4)

Variable	Description	Units	Value
C_S	COPC concentration in soil	mg COPC /kg DW soil	**Varies** This variable is COPC- and site-specific, and should be calculated using the equation in Table B-1-1. C_S is expressed on a dry weight basis. Uncertainties associated with this variable include: (1) For soluble COPCs, leaching might lead to movement to below 1 centimeter in untilled soils, resulting a greater mixing depth. This uncertainty may overestimate *Cs*. (2) Deposition to hard surfaces may result in dust residues that have negligible dilution (as a result of potential mixing with *in situ* materials) in comparison to that of other residues. This uncertainty may underestimate *Cs*. (3) Modeled soil concentrations may not accurately represent site-specific conditions. As a result, the actual COPC concentration in soil may be under- or overestimated to an unknown degree.
BCF_{S-HB}	Bioconcentration factor for soil-to-herbivorous bird	unitless [(mg COPC/kg FW tissue)/(mg COPC/kg DW soil)]	**Varies** This variable is COPC-, site-, habitat- and receptor-specific, and is calculated using the following equation to compute the COPC concentration in herbivorous birds through soil exposure. BCF_{S-HB} values are provided in Appendix D.
P_S	Proportion of ingested soil that is contamanted	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of soil ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for a screening level risk assessment when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated soil ingested by species depends on site-specific information, receptor home range, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of soil ingested that is contaminated will likely be overestimated.

TABLE F-1-4

COPC CONCENTRATIONS IN HERBIVOROUS BIRDS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 4 of 4)

Variable	Description	Units	Value
C_{wctot}	Total COPC concentration in water column	mg COPC/L water (or g COPC/m^3 water)	**Varies (calculated - Table B-2-17)** This variable is COPC- and site-specific and is calculated using Table B-2-17. Uncertainties associated with this equation include the following: (1) All of the variables in the equation in Table B-2-17 are COPC- and site-specific. Therefore, the use of default values rather than site-specific values, for any or all of these variables, will contribute to the under- or overestimation of C_{wctot}. (2) Uncertainty associated with f_{wc} is largely the result of uncertainty associated with default OC content values and may be significant in specific instances. Uncertainties associated with the variable L_T and K_{wt} may also be significant because of many variable-specific uncertainties. The degree of uncertainly associated with the variables d_{wc} and d_{bs} is expected to be minimal either because information for estimating a variable (d_{wc}) is generally available or because the probable range for a variable (d_{bs}) is narrow. The uncertainty associated with the variables f_{wc} and C_{wtot} is associated with estimates of *OC* content. Because *OC* content values can vary widely for different locations in the same media, the uncertainty associated with using default *OC* values may be significant in specific cases.
$BCF_{W\text{-}HB}$	Bioconcentration factor for water-to-herbivorous bird	unitless [(mg COPC/kg FW tissue)/(mg COPC/L water)]	**Varies** This variable is COPC-, site-, and receptor-specific, and is calculated using the following equation to compute the COPC concentration in herbivorous birds through indirect exposure to water. $BCF_{W\text{-}HB}$ values are provided in Appendix D.
P_W	Proportion of ingested water that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of water ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated water ingested by species depends on site-specific information, receptor homerange, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of ingested water that is contaminated will likely be overestimated.

TABLE F-1-5

COPC CONCENTRATIONS IN OMNIVOROUS MAMMALS IN FOREST, TALLGRASS PRAIRIE, SHORTGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 1 of 9)

Description

This equation calculates the COPC concentration in omnivorous mammals through ingestion of plants, soil, and water in the forest, shortgrass prairie, tallgrass prairie, and shrub/scrub food webs. The limitations and uncertainty introduced in calculating this variable include the following:

(1) Variables C_S, and C_{wctot} are COPC- and site-specific. Uncertainties associated with these variables are site specific.

(2) Variables: $BCF_{W\text{-}OM}$ and $BCF_{S\text{-}OM}$ are calculated based on biotransfer factors for beef cattle (Ba_{beef}), and receptor specific ingestion rates, and may introduce significant uncertainty when used to compute concentrations in site-specific omnivorous mammals.

(3) *FCMs* are COPC- and site-specific and may introduce uncertainty when applied to terrestrial environments to account for COPC bioaccumulation between trophic level (see Chapter 5 for further discussion).

Equation

$$C_{OM} = \left(C_{INV} \cdot \frac{FCM_{TL3}}{FCM_{TL2}} \cdot P_{INV} \cdot F_{INV} \right) + \left(C_{TP} \cdot BCF_{TP-OM} \cdot P_{TP} \cdot F_{TP} \right) + \left(C_{HM} \cdot \frac{FCM_{TL3}}{FCM_{TL2}} \cdot P_{HM} \cdot F_{HM} \right)$$

$$+ \left(C_{HB} \cdot \frac{FCM_{TL3}}{FCM_{TL2}} \cdot P_{HB} \cdot F_{HB} \right) + \left(C_S \cdot BCF_{S-OM} \cdot P_S \right) + \left(C_{wctot} \cdot BCF_{W-OM} \cdot P_W \right)$$

Variable	Description	Units	Value
C_{OM}	COPC concentration in omnivorous mammals	mg COPC/kg FW tissue	

TABLE F-1-5

COPC CONCENTRATIONS IN OMNIVOROUS MAMMALS IN FOREST, TALLGRASS PRAIRIE, SHORTGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 2 of 9)

Variable	Description	Units	Value
C_{INV}	COPC concentration in invertebrates	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-3)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-3. Uncertainties associated with this variable include: (1) Modeled soil concentrations may not accurately represent site-specific conditions. As a result, the actual COPC concentration in soil used to calculate the COPC concentration in invertebrates may be under- or overestimated to an unknown degree. (2) $BCF_{S\text{-}INV}$ values may not accurately represent site-specific soil conditions and therefore, may over- or under-estimate C_{INV}.
$\underline{FCM}_{TL3}$ FCM_{TL2}	Food chain multiplier for trophic level 3 predator consuming trophic level 2 prey	unitless	**Varies** This variable is COPC- and trophic level-specific and are provided in Chapter 5. The following uncertainties are associated with this variable: (1) *FCMs* do not account for metabolism, thus for COPCs with significant metabolism concentrations may be over-estimated to an unknown degree. (2) The application of *FCMs* for computing concentration in terrestrial food webs may introduce significant uncertainty (see Chapter 5) *FCMs* are obtained from the U.S. EPA (1995) "Great Lakes Water Quality Initiative Technical Support Document for the Procedure to Determine Bioaccumulation Factors."
P_{INV}	Proportion of invertebrate in diet that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.

TABLE F-1-5

COPC CONCENTRATIONS IN OMNIVOROUS MAMMALS IN FOREST, TALLGRASS PRAIRIE, SHORTGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

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Variable	Description	Units	Value
F_{INV}	Fraction of diet comprised of invertebrates	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of invertebrates. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces significant uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces significant uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.
C_{TP}	COPC concentration in terrestrial plants ingested by the animal	mg COPC/kg WW	**Varies** This variable is site- and COPC-specific; it is calculated using the equation in Table F-1-1. Uncertainties introduced by this variable include the following: (1) Some of the variables in the equations in Tables B-3-1, B-3-2, and B-3-3—including *Cs, Cyv, Q, Dydp*, and *Dywp*—are COPC- and site-specific. (2) In the equation in Table B-3-1, uncertainties associated with other variables include the following: F_w (values for organic compounds estimated on the basis of the behavior of polystyrene microspheres), *Rp* (estimated on the basis of a generalized empirical relationship), *kp* (estimation process does not consider chemical degradation), and *Yp* (estimated on the basis of national harvest yield and area planted values). All of these uncertainties contribute to the overall uncertainty associated with C_{TP}. (3) In the equation in Table B-3-3, COPC-specific soil-to-plant bioconcentration factors (BCF_{TP}) may not reflect site-specific conditions.
$BCF_{TP\text{-}OM}$	Bioconcentration factor for terrestrial plant-to-omnivorous mammal	unitless [(mg COPC/kg FW tissue)/(mg COPC/kg WW)]	**Varies** This variable is COPC-, site-, habitat- and receptor-specific, and is calculated using the following equation to compute the COPC concentration in omnivorous mammals through dietary exposure. $BCF_{TP\text{-}OM}$ values are provided in Appendix D.

TABLE F-1-5

COPC CONCENTRATIONS IN OMNIVOROUS MAMMALS IN FOREST, TALLGRASS PRAIRIE, SHORTGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

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Variable	Description	Units	Value
P_{TP}	Proportion of terrestrial plant in diet that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{TP}	Fraction of diet comprised of terrestrial plants	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of terrestrial plants. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.
C_{HM}	COPC concentration in herbivorous mammals	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-2)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-2. Uncertainties associated with this variable include: (1) Variables: C_{TP}, C_S, and C_{wctot} are COPC- and site-specific. (2) Variables: $BCF_{TP\text{-}HM}$, $BCF_{S\text{-}HM}$, and $BCF_{W\text{-}HM}$ are based on biotransfer factors for beef cattle (Ba_{beef}), and receptor specific ingestion rates, and therefore may introduce uncertainty when used to compute concentrations in site-specific mammals.

TABLE F-1-5

COPC CONCENTRATIONS IN OMNIVOROUS MAMMALS IN FOREST, TALLGRASS PRAIRIE, SHORTGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 5 of 9)

Variable	Description	Units	Value
P_{HM}	Proportion of herbivorous mammal in diet that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{HM}	Fraction of diet comprised of herbivorous mammals	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of herbivorous mammal. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces significant uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces significant uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.
C_{HB}	COPC concentration in herbivorous birds	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-4)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-4. Uncertainties associated with this variable include: (1) Variables: C_{TP}, C_S, and C_{wctot} are COPC- and site-specific. (2) Variables: $BCF_{TP\text{-}HB}$, $BCF_{S\text{-}HB}$, and $BCF_{W\text{-}HB}$ are based on biotransfer factors for chicken ($Ba_{Chicken}$), and receptor specific ingestion rates, and therefore may introduce uncertainty when used to compute concentrations for site-specific herbivorous birds.

TABLE F-1-5

COPC CONCENTRATIONS IN OMNIVOROUS MAMMALS IN FOREST, TALLGRASS PRAIRIE, SHORTGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

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Variable	Description	Units	Value
P_{HB}	Proportion of herbivorous birds in diet that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{HB}	Fraction of diet comprised of herbivorous birds	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of herbivorous birds. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-1-5

COPC CONCENTRATIONS IN OMNIVOROUS MAMMALS IN FOREST, TALLGRASS PRAIRIE, SHORTGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

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Variable	Description	Units	Value
C_S	COPC concentration in soil	mg COPC /kg DW soil	**Varies** This variable is COPC- and site-specific, and should be calculated using the equation in Table B-1-1. C_S is expressed on a dry weight basis. Uncertainties associated with this variable include: (1) For soluble COPCs, leaching might lead to movement to below 1 centimeter in untilled soils, resulting a greater mixing depth. This uncertainty may overestimate *Cs*. (2) Deposition to hard surfaces may result in dust residues that have negligible dilution (as a result of potential mixing with *in situ* materials) in comparison to that of other residues. This uncertainty may underestimate *Cs*. (3) Modeled soil concentrations may not accurately represent site-specific conditions. As a result, the actual COPC concentration in soil may be under- or overestimated to an unknown degree.
$BCF_{S\text{-}OM}$	Bioconcentration factor for soil-to-omnivorous mammal	unitless [(mg COPC/kg FW tissue)/(mg COPC/kg DW soil)]	**Varies** This variable is COPC-, site-, and receptor-specific, and is calculated using the following equation to compute the COPC concentration in omnivorous mammals through indirect soil exposure. $BCF_{S\text{-}OM}$ values are provided in Appendix D.
P_S	Proportion of ingested soil that is contamanted	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of soil ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for a screening level risk assessment when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated soil ingested by species depends on site-specific information, receptor home range, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of soil ingested that is contaminated will likely be overestimated.

TABLE F-1-5

COPC CONCENTRATIONS IN OMNIVOROUS MAMMALS IN FOREST, TALLGRASS PRAIRIE, SHORTGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

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Variable	Description	Units	Value
C_{wctot}	Total COPC concentration in water column	mg COPC/L water (or g COPC/m^3 water)	**Varies (calculated - Table B-2-17)** This variable is COPC- and site-specific and is calculated using Table B-2-17. Uncertainties associated with this equation include the following: (1) All of the variables in the equation in Table B-2-17 are COPC- and site-specific. Therefore, the use of default values rather than site-specific values, for any or all of these variables, will contribute to the under- or overestimation of C_{wctot}. (2) Uncertainty associated with f_{wc} is largely the result of uncertainty associated with default *OC* content values and may be significant in specific instances. Uncertainties associated with the variable L_T and K_{wt} may also be significant because of many variable-specific uncertainties. The degree of uncertainly associated with the variables d_{wc} and d_{bs} is expected to be minimal either because information for estimating a variable (d_{wc}) is generally available or because the probable range for a variable (d_{bs}) is narrow. The uncertainty associated with the variables f_{wc} and C_{wtot} is associated with estimates of *OC* content. Because *OC* content values can vary widely for different locations in the same media, the uncertainty associated with using default *OC* values may be significant in specific cases.
$BCF_{W\text{-}OM}$	Bioconcentration factor for water-to-omnivorous mammal pathways	unitless [(mg COPC/kg FW tissue)/(mg COPC/L water)]	**Varies** This variable is COPC-, site-, and receptor-specific, and is calculated using the following equation to compute the COPC concentration in herbivorous mammals through indirect water exposure (total water body concentration). $BCF_{W\text{-}OM}$ values are provided in Appendix D.
P_W	Proportion of ingested water that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of water ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated water ingested by species depends on site-specific information, receptor homerange, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of ingested water that is contaminated will likely be overestimated.

TABLE F-1-5

COPC CONCENTRATIONS IN OMNIVOROUS MAMMALS IN FOREST, TALLGRASS PRAIRIE, SHORTGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

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REFERENCES AND DISCUSSIONS

U.S. EPA (1995) “Great Lakes Water Quality Initiative Technical Support Document for the Procedure to Determine Bioaccumulation Factors.”

TABLE F-1-6

COPC CONCENTRATIONS IN OMNIVOROUS BIRDS IN FOREST, TALLGRASS PRAIRIE, SHORTGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 1 of 7)

Description

This equation calculates the COPC concentration in omnivorous birds through the ingestion of plants, soil, and water in the forest, shortgrass prairie, tallgrass prairie, and shrub/scrub food webs. The limitations and uncertainty introduced in calculating this variable include the following:

(1) Variables C_S, and C_{wctot} are COPC- and site-specific. Uncertainties associated with these variables are site specific.
(2) Variables: $BCF_{W\text{-}OB}$, and $BCF_{S\text{-}OB}$ are calculated based on biotransfer factors for chicken ($Ba_{Chicken}$), and receptor specific ingestion rates, and may introduce uncertainty when used to compute concentrations in site-specific omnivorous birds.
(3) *FCMs* are COPC- and site-specific and may introduce uncertainty when applied to terrestrial environments to account for COPC bioaccumulation between trophic (see Chapter 5).

Equation

$$C_{OB} = \left(C_{INV} \cdot \frac{FCM_{TL3}}{FCM_{TL2}} \cdot P_{INV} \cdot F_{INV} \right) + \left(C_{TP} \cdot BCF_{TP-OM} \cdot P_{TP} \cdot F_{TP} \right) + \left(C_S \cdot BCF_{S-OB} \cdot P_S \right) + \left(C_{wctot} \cdot BCF_{W-OB} \cdot P_W \right)$$

Variable	Description	Units	Value
C_{OB}	COPC concentration in omnivorous birds	mg COPC/kg FW tissue	
C_{INV}	COPC concentration in invertebrates	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-3)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-3. Uncertainties associated with this variable include: (1) Modeled soil concentrations may not accurately represent site-specific conditions. As a result, the actual COPC concentration in soil used to calculate the COPC concentration in invertebrates may be under- or overestimated to an unknown degree. (2) $BCF_{S\text{-}INV}$ values may not accurately represent site-specific soil conditions and therefore, may over- or under-estimate C_{INV}.

TABLE F-1-6

COPC CONCENTRATIONS IN OMNIVOROUS BIRDS IN FOREST, TALLGRASS PRAIRIE, SHORTGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

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Variable	Description	Units	Value
$\frac{FCM_{TL3}}{FCM_{TL2}}$	Food chain multiplier for trophic level 3 predator consuming trophic level 2 prey	unitless	**Varies** This variable is COPC- and trophic level-specific and is provided in Chapter 5 Table 5-2. The following uncertainties are associated with this variable: (1) *FCMs* do not account for metabolism, thus for COPCs with metabolism concentrations may be over-estimated to an unknown degree. (2) The application of *FCMs* for computing concentration in terrestrial food webs may introduce uncertainty (see Chapter 5) *FCMs* are obtained from the U.S. EPA 1995 “Great Lakes Water Quality Initiative Technical Support Document for the Procedure to Determine Bioaccumulation Factors.”
P_{INV}	Proportion of invertebrates in diet that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.

TABLE F-1-6

COPC CONCENTRATIONS IN OMNIVOROUS BIRDS IN FOREST, TALLGRASS PRAIRIE, SHORTGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

Variable	Description	Units	Value
F_{INV}	Fraction of diet comprised of invertebrates	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of invertebrates. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.
C_{TP}	COPC concentration in terrestrial plants	mg COPC/kg WW	**Varies** This variable is site- and COPC-specific; it is calculated using the equation in Table F-1-1. Uncertainties introduced by this variable include the following: (1) Some of the variables in the equations in Tables B-3-1, B-3-2, and B-3-3—including *Cs, Cyv, Q, Dydp*, and *Dywp*—are COPC- and site-specific. (2) In the equation in Table B-3-1, uncertainties associated with other variables include the following: F_w (values for organic compounds estimated on the basis of the behavior of polystyrene microspheres), *Rp* (estimated on the basis of a generalized empirical relationship), *kp* (estimation process does not consider chemical degradation). All of these uncertainties contribute to the overall uncertainty associated with C_{TP}. (3) In the equation in Table B-3-3, COPC-specific soil-to-plant bioconcentration factors (BCF_{TP}) may not reflect site-specific conditions.
$BCF_{TP\text{-}OB}$	Bioconcentration factor for plant-to-omnivorous bird	unitless [(mg COPC/kg FW tissue)/(mg COPC/kg WW)]	**Varies** This variable is COPC-, site-, habitat- and receptor-specific, and is calculated using the following equation to compute the COPC concentration in omnivorous birds through indirect dietary exposure. $BCF_{TP\text{-}OB}$ values are provided in Appendix D.

TABLE F-1-6

COPC CONCENTRATIONS IN OMNIVOROUS BIRDS IN FOREST, TALLGRASS PRAIRIE, SHORTGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 4 of 7)

Variable	Description	Units	Value
P_{TP}	Proportion of terrestrial plant in diet that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommend that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{TP}	Fraction of diet comprised of terrestrial plants	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of terrestrial plants. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-1-6

COPC CONCENTRATIONS IN OMNIVOROUS BIRDS IN FOREST, TALLGRASS PRAIRIE, SHORTGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 5 of 7)

Variable	Description	Units	Value
C_S	COPC soil concentration	mg COPC /kg DW soil	**Varies** This variable is COPC- and site-specific, and should be calculated using the equation in Table B-1-1. C_S is expressed on a dry weight basis. Uncertainties associated with this variable include: (1) For soluble COPCs, leaching might lead to movement to below 1 centimeter in untilled soils, resulting a greater mixing depth. This uncertainty may overestimate *Cs*. (2) Deposition to hard surfaces may result in dust residues that have negligible dilution (as a result of potential mixing with *in situ* materials) in comparison to that of other residues. This uncertainty may underestimate *Cs*. (3) Modeled soil concentrations may not accurately represent site-specific conditions. As a result, the actual COPC concentration in soil may be under- or overestimated to an unknown degree.
$BCF_{S\text{-}OB}$	Bioconcentration factor for soil-to-omnivorous bird pathways	unitless [(mg COPC/kg FW tissue)/(mg COPC/kg DW soil)]	**Varies** This variable is COPC-, site-, habitat- and receptor-specific, and is calculated using the following equation to compute the COPC concentration in omnivorous birds through indirect soil exposure. $BCF_{S\text{-}OB}$ values are provided in Appendix D.
P_S	Proportion of ingested soil that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of soil ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for a screening level risk assessment when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated soil ingested by species depends on site-specific information, receptor home range, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of soil ingested that is contaminated will likely be overestimated.

TABLE F-1-6

COPC CONCENTRATIONS IN OMNIVOROUS BIRDS IN FOREST, TALLGRASS PRAIRIE, SHORTGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 6 of 7)

Variable	Description	Units	Value
C_{wctot}	Total COPC concentration in water column	mg COPC/L water (or g COPC/m^3 water)	**Varies (calculated - Table B-2-17)** This variable is COPC- and site-specific and is calculated using Table B-2-17. Uncertainties associated with this equation include the following: (1) All of the variables in the equation in Table B-2-17 are COPC- and site-specific. Therefore, the use of default values rather than site-specific values, for any or all of these variables, will contribute to the under- or overestimation of C_{wctot}. (2) Uncertainty associated with f_{wc} is largely the result of uncertainty associated with default OC content values and may be significant in specific instances. Uncertainties associated with the variable L_T and K_{wt} may also be significant because of many variable-specific uncertainties. The degree of uncertainly associated with the variables d_{wc} and d_{bs} is expected to be minimal either because information for estimating a variable (d_{wc}) is generally available or because the probable range for a variable (d_{bs}) is narrow. The uncertainty associated with the variables f_{wc} and C_{wtot} is associated with estimates of *OC* content. Because *OC* content values can vary widely for different locations in the same media, the uncertainty associated with using default *OC* values may be significant in specific cases.
BCF_{W-OB}	Bioconcentration factor for water-to-omnivorous bird	unitless [(mg COPC/kg FW tissue)/(mg COPC/L water)]	**Varies** This variable is COPC-, site-, and receptor-specific, and is calculated using the following equation to compute the COPC concentration in omnivorous birds through indirect exposure to water. BCF_{W-OB} values are provided in Appendix D.
P_W	Proportion of ingested water that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of water ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated water ingested by species depends on site-specific information, receptor home range, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of ingested water that is contaminated will likely be overestimated.

TABLE F-1-6

COPC CONCENTRATIONS IN OMNIVOROUS BIRDS IN FOREST, TALLGRASS PRAIRIE, SHORTGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

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REFERENCES AND DISCUSSIONS

U.S. EPA 1995 “Great Lakes Water Quality Initiative Technical Support Document for the Procedure to Determine Bioaccumulation Factors.”

TABLE F-1-7

COPC CONCENTRATIONS IN AQUATIC VEGETATION IN THE FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 1 of 2)

Description

This equation calculates the COPC concentration in aquatic vegetation through direct sediment exposure in the freshwater/wetland, brackish/intermediate marsh, and saltmarsh food webs. The limitations and uncertainty introduced in calculating this variable include the following:

(1) C_{sed} values are COPC- and site-specific. Uncertainties associated with these variables are site specific.
(2) $BCF_{W\text{-}AV}$ values are intended to represent "generic benthic invertebrate species", and therefore may over- or under-estimate exposure when applied to site-specific organisms.

Equation

$$C_{AV} = C_{sed} \cdot BCF_{S-AV}$$

Variable	Description	Units	Value
C_{AV}	COPC concentration in aquatic vegetation	mg COPC/kg WW	
C_{sed}	COPC concentration in bed sediment	mg COPC/kg DW sediment	**Varies (calculated - Table B-2-19)** This equation calculates the concentration of contaminants sorbed to bed sediments. Uncertainties associated with this equation include the following: (1) The default variable values recommended for use in the equation in Table B-2-19 may not accurately represent site-specific water body conditions. The degree of uncertainty associated with variables θ_{bs}, C_{sed}, d_{wc}, and d_{bs} is expected to be limited either because the probable ranges for these variables are narrow or because information allowing reasonable estimates is generally available. (2) Uncertainties associated with variables f_{bs}, C_{wctot} and Kd_{bs} are largely associated with the use of default *OC* content values in their calculation. The uncertainty may be significant in specific instances, because *OC* content is known to vary widely in different locations in the same medium. This variable is site-specific.

TABLE F-1-7

COPC CONCENTRATIONS IN AQUATIC VEGETATION IN THE FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 2 of 2)

Variable	Description	Units	Value
$BCF_{S\text{-}AV}$	Bioconcentration factor for sediment-to-aquatic vegetation	unitless [(mg COPC/kg WW)/(mg COPC/kg DW sediment)]	**Varies** This variable is COPC-, site- and species-specific, and is provided in Appendix C. This variable is calculated using laboratory and field measured values as discussed in Appendix C. The following uncertainties are associated with this variable: (1) The COPC specific $BCF_{S\text{-}AV}$ values may not accurately represent site-specific sediment conditions which could strongly influence the bioavailability of COPCs, therefore over-or under-estimating C_{AV} to an unknown degree. (2) The data set used to calculate $BCF_{S\text{-}AV}$ is based on soil-to-plant bioconcentration studies. The uncertainty associated with calculating concentrations using $BCF_{BS\text{-}AV}$ in site-specific organisms is unknown and may over- or under-estimate C_{AV}.

TABLE F-1-8

COPC CONCENTRATIONS IN ALGAE IN THE FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 1 of 2)

Description

This equation calculates the COPC concentration in algae through direct water exposure in the freshwater/wetland, brackish/intermediate marsh, and saltmarsh food webs. The limitations and uncertainty introduced in calculating this variable include the following:

(1) C_{dw} values are COPC- and site-specific. Uncertainties associated with these variables are site specific.
(2) $BCF_{W\text{-}AL}$ values are intended to represent "generic algae species", and therefore may over- or under-estimate exposure when applied to site-specific organisms.

Equation

$$C_{AL} = C_{dw} \cdot BCF_{W-AL}$$

Variable	Description	Units	Value
C_{AL}	COPC concentration in algae	mg COPC/kg WW	
C_{dw}	Dissolved phase water concentration	mg COPC/ L water	**Varies** This variable is COPC- and site-specific, and is calculated by using the equation in Table B-2-18. Uncertainties associated with this variable include the following: (1) The variables in the equation in Table B-2-18 are site-specific. Therefore, the use of default values rather than site-specific values, for any or all of these variables, will contribute to the under- or overestimation of C_{dw}. The degree of uncertainty associated with *TSS* is expected to be relatively small, because information regarding reasonable site-specific values for this variable is generally available or can be easily measured. (2) The uncertainty associated with the variables C_{wctot} and Kd_{sw} is dependent on estimates of *OC* content. Because *OC* content values can vary widely for different locations in the same medium, the uncertainty associated with using different *OC* content values may be significant in specific cases.

TABLE F-1-8

COPC CONCENTRATIONS IN ALGAE IN THE FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 2 of 2)

Variable	Description	Units	Value
BCF_{WAL}	Bioconcentration factor for water-to-algae	unitless [(mg COPC/kg WW)/(mg COPC/L water)]	**Varies** This variable is COPC-, site- and species-specific, and is provided in Appendix C. This variable is computed using laboratory and field measured values as discussed in Appendix C. The following uncertainties are associated with this variable: (1) The COPC specific $BCF_{W\text{-}AL}$ values may not accurately represent site-specific sediment conditions, therefore over-or under-estimating C_{AL} to an unknown degree. (2) The data set used to calculate $BCF_{W\text{-}AL}$ is based on a limited number of test organisms. The uncertainty associated with calculating concentrations using $BCF_{W\text{-}AL}$ in site-specific organisms is unknown and may over-or under-estimate C_{AL}.

TABLE F-1-9

COPC CONCENTRATIONS IN HERBIVOROUS MAMMALS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 1 of 5)

Description

This equation calculates the COPC concentration in aquatic herbivorous mammals through the ingestion of plants, sediment, and water in the freshwater/wetland, brackish/intermediate marsh, and saltmarsh food webs. The limitations and uncertainty introduced in calculating this variable include the following:

(1) Variables: C_{AV}, C_{sed}, and C_{wtot} are COPC- and site-specific. Uncertainties associated with these variables are site specific.
(2) Variables: $BCF_{TP\text{-}HM}$, $BCF_{bS\text{-}HM}$, and $BCF_{W\text{-}HM}$ are based on biotransfer factors for beef cattle (Ba_{beef}), and receptor specific ingestion rates, and therefore may introduce uncertainty when used to compute concentrations in site-specific herbivorous mammals.
(3) The use of single Ba_{beef} value for each COPC may not accurately reflect site-specific conditions, and may under- or overestimate C_{HM}.

Equation

$$C_{HM} = (C_{AV} \cdot BCF_{HM} \cdot P_{AV} \cdot F_{AV}) + (C_{AL} \cdot BCF_{HM} \cdot P_{AL} \cdot F_{AL}) + (C_{sed} \cdot BCF_{BS-HM} \cdot P_{BS}) + (C_{wctot} \cdot BCF_{W-HM} \cdot P_{W})$$

Variable	Description	Units	Value
C_{HM}	COPC concentration in herbivorous mammals	mg COPC/kg FW tissue	
C_{AV}	COPC concentration in aquatic vegetation	mg COPC/kg WW	**Varies (calculated - Table F-1-7)** This variable is site- and COPC-specific; it is calculated using the equation in Table F-1-7. Uncertainties associated with this variable include: (1) C_{sed} values are COPC- and site-specific. (2) $BCF_{BS\text{-}AV}$ values are intended to represent "generic aquatic vegetation species", and therefore may over- or under-estimate exposure when applied to site-specific vegetation.
$BCF_{AV\text{-}HM}$	Bioconcentration factor for aquatic vegetation -to-aquatic herbivorous mammals	unitless [(mg COPC/kg FW tissue)/(mg COPC/kg WW)]	**Varies** This variable is COPC-, site-, habitat- and receptor-specific, and is calculated using the following equation to compute the COPC concentration in aquatic herbivorous mammals through indirect dietary exposure. $BCF_{AV\text{-}HM}$ values are provided in Appendix D.

TABLE F-1-9

COPC CONCENTRATIONS IN HERBIVOROUS MAMMALS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 2 of 5)

Variable	Description	Units	Value
P_{AV}	Proportion of aquatic vegetation in diet that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{AV}	Fraction of diet comprised of aquatic vegetation	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of aquatic vegetation. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.
C_{AL}	COPC concentration in algae	mg COPC/kg WW	**Varies (calculated - Table F-1-8)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-8. Uncertainties associated with this variable include: (1) C_{dw} values are COPC- and site-specific. (2) $BCF_{W\text{-}AL}$ values are intended to represent "generic algae species", and therefore may over- or under-estimate exposure when applied to site-specific species.

TABLE F-1-9

COPC CONCENTRATIONS IN HERBIVOROUS MAMMALS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 3 of 5)

Variable	Description	Units	Value
BCF_{AL-HM}	Bioconcentration factor for algae - to-aquatic herbivorous mammals	unitless [(mg COPC/kg FW tissue)/(mg COPC/kg WW)]	**Varies** This variable is COPC-, site-, habitat- and receptor-specific, and is calculated using the following equation to compute the COPC concentration in aquatic herbivorous mammals through indirect dietary exposure. BCF_{AL-HM} values are provided in Appendix D.
P_{AL}	Proportion of algae in diet that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{AL}	Fraction of diet comprised of algae	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of algae. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-1-9

COPC CONCENTRATIONS IN HERBIVOROUS MAMMALS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 4 of 5)

Variable	Description	Units	Value
C_{sed}	COPC concentration in bed sediment	mg COPC/kg DW sediment	**Varies (calculated - Table B-2-19)** This equation calculates the concentration of contaminants sorbed to bed sediments. Uncertainties associated with this equation include the following: (1) The default variable values recommended for use in the equation in Table B-2-19 may not accurately represent site-specific water body conditions. The degree of uncertainty associated with variables θ_{bs}, $C_{sed,\ wtotc}$, and d_{bs} is expected to be limited either because the probable ranges for these variables are narrow or because information allowing reasonable estimates is generally available. (2) Uncertainties associated with variables f_{bs}, C_{wtot} and Kd_{bs} are largely associated with the use of default *OC* content values in their calculation. The uncertainty may be significant in specific instances, because *OC* content is known to vary widely in different locations in the same medium. This variable is site-specific.
$BCF_{BS\text{-}HM}$	Bioconcentration factor for bed sediment-to-aquatic herbivorous mammal	unitless [(mg COPC/kg FW tissue)/(mg COPC/kg DW sediment)]	**Varies** This variable is COPC-, site-, and receptor-specific, and is calculated using the following equation to compute the COPC concentration in aquatic herbivorous mammals through indirect sediment exposure. $BCF_{BS\text{-}HM}$ values are provided in Appendix D.
P_{BS}	Proportion of ingested bed sediment that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of sediment ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for a screening level risk assessment when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated soil ingested by species depends on site-specific information, receptor home range, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of soil ingested that is contaminated will likely be overestimated.

TABLE F-1-9

COPC CONCENTRATIONS IN HERBIVOROUS MAMMALS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 5 of 5)

Variable	Description	Units	Value
C_{wctot}	Total COPC concentration in water column	mg COPC/L water (or g COPC/m^3 water)	**Varies (calculated - Table B-2-17**) This variable is COPC- and site-specific and is calculated using Table B-2-17. Uncertainties associated with this equation include the following: (1) All of the variables in the equation in Table B-2-17 are COPC- and site-specific. Therefore, the use of default values rather than site-specific values, for any or all of these variables, will contribute to the under- or overestimation of C_{wctot}. (2) Uncertainty associated with f_{wc} is largely the result of uncertainty associated with default OC content values and may be significant in specific instances. Uncertainties associated with the variable L_T and K_{wt} may also be significant because of many variable-specific uncertainties. The degree of uncertainty associated with the variables d_{wc} and d_{bs} is expected to be minimal either because information for estimating a variable (d_{wc}) is generally available or because the probable range for a variable (d_{bs}) is narrow. The uncertainty associated with the variables f_{wc} and C_{wtot} is associated with estimates of *OC* content. Because *OC* content values can vary widely for different locations in the same media, the uncertainty associated with using default *OC* values may be significant in specific cases.
BCF_{W-HM}	Bioconcentration factor for water-to-aquatic herbivorous mammal pathways	unitless [(mg COPC/kg FW tissue)/(mg COPC/L water)]	**Varies** This variable is COPC-, site-, and receptor-specific, and is calculated using the following equation to compute the COPC concentration in aquatic herbivorous mammals through indirect water exposure. BCF_{W-HM} values are provided in Appendix D.
P_W	Proportion of ingested water that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of water ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated water ingested by species depends on site-specific information, receptor home range, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of ingested water that is contaminated will likely be overestimated.

TABLE F-1-10

COPC CONCENTRATIONS IN HERBIVOROUS BIRDS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 1 of 5)

Description

This equation calculates the COPC concentration in aquatic herbivorous birds through ingestion of contaminated plants, sediment, and water in the freshwater/wetland, brackish/intermediate marsh, and saltmarsh food webs. The limitations and uncertainty introduced in calculating this variable include the following:

(1) Variables: C_{AV}, C_{sed}, and C_{wctot} are COPC- and site-specific. Uncertainties associated with these variables are site specific.
(2) Variables: $BCF_{AV\text{-}HB}$, $BCF_{BS\text{-}HB}$, and $BCF_{W\text{-}HB}$ are calculated based on biotransfer factors for chicken ($Ba_{chicken}$), and receptor specific ingestion rates, and therefore may introduce uncertainty when used to compute concentrations for site-specific herbivorous birds.
(3) The use of single $Ba_{chicken}$ value for each COPC may not accurately reflect site-specific conditions; and may under- or overestimate C_{HB}.

Equation

$$C_{HB} = (C_{AV} \cdot BCF_{HB} \cdot P_{AV} \cdot F_{AV}) + (C_{AL} \cdot BCF_{HB} \cdot P_{AL} \cdot F_{AL}) + (C_{sed} \cdot BCF_{BS-HB} \cdot P_{BS}) + (C_{wctot} \cdot BCF_{W-HB} \cdot P_{W})$$

Variable	Description	Units	Value
C_{HB}	COPC concentration in herbivorous birds	mg COPC/kg FW tissue	
C_{AV}	COPC concentration in aquatic vegetation	mg COPC/kg WW	**Varies (calculated - Table F-1-7)** This variable is site- and COPC-specific; it is calculated using the equation in Table F-1-7. Uncertainties associated with this variable include: (1) C_{sed} values are COPC- and site-specific. (2) $BCF_{BS\text{-}AV}$ values are intended to represent "generic aquatic vegetation species", and therefore may over- or under-estimate exposure when applied to site-specific vegetation.
$BCF_{AV\text{-}HB}$	Bioconcentration factor for aquatic vegetation -to-aquatic herbivorous birds	unitless [(mg COPC/kg FW tissue)/(mg COPC/kg WW)]	**Varies** This variable is COPC-, site-, habitat- and receptor-specific, and is calculated using the following equation to compute the COPC concentration in aquatic herbivorous birds through indirect dietary exposure. $BCF_{AV\text{-}HB}$ values are provided in Appendix D.

TABLE F-1-10

COPC CONCENTRATIONS IN HERBIVOROUS BIRDS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 2 of 5)

Variable	Description	Units	Value
P_{AV}	Proportion of aquatic vegetation in diet that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{AV}	Fraction of diet comprised of aquatic vegetation	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of aquatic vegetation. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.
C_{AL}	COPC concentration in algae	mg COPC/kg WW	**Varies (calculated - Table F-1-8)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-8. Uncertainties associated with this variable include: (1) C_{dw} values are COPC- and site-specific. (2) $BCF_{W\text{-}AL}$ values are intended to represent “generic algae species”, and therefore may over- or under-estimate exposure when applied to site-specific species.

TABLE F-1-10

COPC CONCENTRATIONS IN HERBIVOROUS BIRDS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 3 of 5)

Variable	Description	Units	Value
$BCF_{AL\text{-}HB}$	Bioconcentration factor for algae -to-aquatic herbivorous birds	unitless [(mg COPC/kg FW tissue)/(mg COPC/kg WW)]	**Varies** This variable is COPC-, site-, habitat- and receptor-specific, and is calculated using the following equation to compute the COPC concentration in aquatic herbivorous birds through indirect dietary exposure: $BCF_{AL\text{-}HB}$ values are provided in Appendix D.
P_{AL}	Proportion of algae in diet that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{AL}	Fraction of diet comprised of algae	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of algae. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-1-10

COPC CONCENTRATIONS IN HERBIVOROUS BIRDS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 4 of 5)

Variable	Description	Units	Value
C_{sed}	COPC concentration in bed sediment	mg COPC/kg DW sediment	**Varies (calculated - Table B-2-19)** This equation calculates the concentration of COPSs in bed sediments. Uncertainties associated with this equation include the following: (1) The default variable values recommended for use in the equation in Table B-2-19 may not accurately represent site-specific water body conditions. The degree of uncertainty associated with variables θ_{bs}, C_{sed}, $_{wtotc}$, and d_{bs} is expected to be limited either because the probable ranges for these variables are narrow or because information allowing reasonable estimates is generally available. (2) Uncertainties associated with variables f_{bs}, C_{wtot} and Kd_{bs} are largely associated with the use of default *OC* content values in their calculation. The uncertainty may be significant in specific instances, because *OC* content is known to vary widely in different locations in the same medium. This variable is site-specific.
BCF_{BS-HB}	Bioconcentration factor for bed sediment-to-aquatic herbivorous bird	unitless [(mg COPC/kg FW tissue)/(mg COPC/kg DW sediment)]	**Varies** This variable is COPC-, site-, habitat- and receptor-specific, and is calculated using the following equation to compute the COPC concentration in aquatic herbivorous birds through indirect sediment exposure. BCF_{BS-HB} values are provided in Appendix D.
P_{BS}	Proportion of ingested bed sediment that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of soil ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for a screening level risk assessment when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated soil ingested by species depends on site-specific information, receptor home range, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of soil ingested that is contaminated will likely be overestimated.

TABLE F-1-10

COPC CONCENTRATIONS IN HERBIVOROUS BIRDS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 5 of 5)

Variable	Description	Units	Value
C_{wctot}	Total COPC concentration in water column	mg COPC/L water (or g COPC/m^3 water)	**Varies (calculated - Table B-2-17)** This variable is COPC- and site-specific and is calculated using Table B-2-17. Uncertainties associated with this equation include the following: (1) All of the variables in the equation in Table B-2-17 are COPC- and site-specific. Therefore, the use of default values rather than site-specific values, for any or all of these variables, will contribute to the under- or overestimation of C_{wctot}. (2) Uncertainty associated with f_{wc} is largely the result of uncertainty associated with default OC content values and may be significant in specific instances. Uncertainties associated with the variable L_T and K_{wt} may also be significant because of many variable-specific uncertainties. The degree of uncertainty associated with the variables d_{wc} and d_{bs} is expected to be minimal either because information for estimating a variable (d_{wc}) is generally available or because the probable range for a variable (d_{bs}) is narrow. The uncertainty associated with the variables f_{wc} and C_{wtot} is associated with estimates of OC content. Because OC content values can vary widely for different locations in the same medium, the uncertainty associated with using default OC values may be significant in specific cases.
$BCF_{W\text{-}HB}$	Bioconcentration factor for water-to-aquatic herbivorous bird	unitless [(mg COPC/kg FW tissue)/(mg COPC/L water)]	**Varies** This variable is COPC-, site-, and receptor-specific, and is calculated using the following equation to compute the COPC concentration in aquatic herbivorous birds through indirect exposure to water. $BCF_{W\text{-}HB}$ values are provided in Appendix D.
P_W	Proportion of ingested water that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of water ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated water ingested by species depends on site-specific information, receptor home range, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of ingested water that is contaminated will likely be overestimated.

TABLE F-1-11

COPC CONCENTRATIONS IN BENTHIC INVERTEBRATES IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 1 of 2)

Description

This equation calculates the COPC concentration in benthic invertebrates through direct exposure to benthic sediment in the freshwater/wetland, brackish/intermediate marsh, and saltmarsh food webs. The limitations and uncertainty introduced in calculating this variable include the following:

(1) C_{sed} values are COPC- and site-specific. Uncertainties associated with these variables are site specific.
(2) $BCF_{BS\text{-}BI}$ values are intended to represent "generic benthic invertebrate species", and therefore may over- or under-estimate exposure when applied to site-specific organisms.

Equation

$$C_{BI} = C_{sed} \cdot BCF_{BS-BI}$$

Variable	Description	Units	Value
C_{BI}	COPC concentration in benthic invertebrates	mg COPC/kg FW tissue	
C_{sed}	COPC concentration in bed sediment	mg COPC/kg DW sediment	**Varies (calculated - Table B-2-19)** This equation calculates the concentration of COPCs in bed sediments. Uncertainties associated with this equation include the following: (1) The default variable values recommended for use in the equation in Table B-2-19 may not accurately represent site-specific water body conditions. The degree of uncertainty associated with variables θ_{bs}, C_{sed}, d_{wc}, and d_{bs} is expected to be limited either because the probable ranges for these variables are narrow or because information allowing reasonable estimates is generally available. (2) Uncertainties associated with variables f_{bs}, C_{wtot} and Kd_{bs} are largely associated with the use of default *OC* content values in their calculation. The uncertainty may be significant in specific instances, because *OC* content is known to vary widely in different locations in the same medium. This variable is site-specific.

TABLE F-1-11

COPC CONCENTRATIONS IN BENTHIC INVERTEBRATES IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 2 of 2)

Variable	Description	Units	Value
$BCF_{BS\text{-}BI}$	Bioconcentration factor for sediment-to-benthic invertebrate	unitless [(mg COPC/kg FW tissue)/(mg COPC/kg DW sediment)]	**Varies** This variable is COPC-, site- and species-specific, and is provided in Appendix C. This variable is calculated using laboratory and field measured values as discussed in Appendix C. The following uncertainties are associated with this variable: (1) The COPC specific $BCF_{BS\text{-}BI}$ values may not accurately represent site-specific sediment conditions which could strongly influence the bioavailability of COPCs, therefore over-or under-estimating C_{BI} to an unknown degree. (2) The data set used to calculate $BCF_{BS\text{-}BI}$ is based on a limited number of test organisms. The uncertainty associated with calculating concentrations using $BCF_{BS\text{-}BI}$ in site-specific organisms is unknown and may over- or under-estimate C_{BI}.

TABLE F-1-12

COPC CONCENTRATIONS IN WATER INVERTEBRATE IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 1 of 2)

Description

This equation calculates the COPC concentration in water invertebrates through direct water exposure in the freshwater/wetland, brackish/intermediate marsh, and saltmarsh food webs. The limitations and uncertainty introduced in calculating this variable include the following:

(1) C_{dw} values are COPC- and site-specific. Uncertainties associated with these variables are site specific.
(2) BCF_{WI} values are intended to represent "generic water invertebrate species", and therefore may over- or under-estimate exposure when applied to site-specific organisms.

Equation

$$C_{WI} = C_{dw} \cdot BCF_{W-WI}$$

Variable	Description	Units	Value
C_{WI}	COPC concentration in water invertebrates	mg COPC/kg FW tissue	
C_{dw}	Dissolved phase water concentration	mg COPC/L water	**Varies (calculated - Table B-2-18)** This variable is COPC- and site-specific. This equation calculates the concentration of COPC dissolved in the water column. Uncertainties associated with this equation include the following: (1) The variables in the equation in Table B-2-18 are site-specific. Therefore, the use of default values rather than site-specific values, for any or all of these variables, will contribute to the under- or overestimation of C_{dw}. The degree of uncertainty associated with *TSS* is expected to be relatively small, because information regarding reasonable site-specific values for this variable are generally available or it can be easily measured. On the other hand, the uncertainty associated with the variables C_{wctot} and Kd_{sw} is associated with estimates of *OC* content. Because *OC* content values can vary widely for different locations in the same medium, using default *OC* values may result in significant uncertainty in specific cases.

TABLE F-1-12

COPC CONCENTRATIONS IN WATER INVERTEBRATE IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 2 of 2)

Variable	Description	Units	Value
$BCF_{W\text{-}WI}$	Bioconcentration factor for water-to-invertebrate	unitless [(mg COPC/kg FW tissue)/(mg COPC/L water)]	**Varies** This variable is COPC-, site- and species-specific, and should be determined using Appendix C. This variable is calculated using laboratory and field measured values as discussed in Appendix C. The following uncertainties are associated with this variable: (1) The COPC specific $BCF_{W\text{-}WI}$ values may not accurately represent site-specific conditions, therefore over-or under-estimating C_{WI} to an unknown degree. (2) The data set used to calculate $BCF_{W\text{-}WI}$ is based on a limited number of test organisms. The uncertainty associated with calculating concentrations using $BCF_{W\text{-}WI}$ in site-specific organisms is unknown and may over- or under-estimate C_{WI}.

TABLE F-1-13

COPC CONCENTRATIONS IN HERBIVOROUS AND PLANKTIVOROUS FISH IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 1 of 3)

Description

This equation calculates the COPC concentration in herbivorous/planktivorous fish through ingestion of contaminated food and direct water exposure in the freshwater/wetland, brackish/intermediate marsh, and saltmarsh food webs. The limitations and uncertainty introduced in calculating this variable include the following:

(1) C_{dw} values are COPC- and site-specific. Uncertainties associated with these variables are site specific.
(2) The data set used to calculate BCF_f is based on a limited number of test organisms and therefore may over- or under-estimate exposure when applied to site-specific organisms.

Equation

$$C_{HF} = C_{dw} \cdot BCF_f \cdot FCM_{TL2}$$

Variable	Description	Units	Value
C_{HF}	COPC concentration in herbivorous and planktivorous fish	mg COPC/kg FW tissue	
C_{dw}	Dissolved phase water concentration	mg COPC/L water	**Varies (calculated - Table B-2-18)** This variable is COPC- and site-specific. This equation calculates the concentration of COPC dissolved in the water column. Uncertainties associated with this equation include the following: (1) The variables in the equation in Table B-2-18 are site-specific. Therefore, the use of default values rather than site-specific values, for any or all of these variables, will contribute to the under- or overestimation of C_{dw}. The degree of uncertainty associated with *TSS* is expected to be relatively small, because information regarding reasonable site-specific values for this variable are generally available or it can be easily measured. On the other hand, the uncertainty associated with the variables C_{wctot} and Kd_{sw} is associated with estimates of *OC* content. Because *OC* content values can vary widely for different locations in the same medium, using default *OC* values may result in significant uncertainty in specific cases.

TABLE F-1-13

COPC CONCENTRATIONS IN HERBIVOROUS AND PLANKTIVOROUS FISH IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

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Variable	Description	Units	Value
BCF_f	Bioconcentration factor for water-to-fish pathways	unitless [(mg COPC/kg FW tissue)/(mg COPC/L water)]	**Varies** This variable is COPC-, site- and species-specific, and is provided in Appendix C. This variable is calculated using laboratory and field measured values as discussed in Appendix C. The following uncertainties are associated with this variable: (1) The COPC specific BCF_f values may not accurately represent site-specific conditions, therefore over-or under-estimating C_{HF} to an unknown degree. (2) The data set used to calculate BCF_f is based on a limited number of test species. The uncertainty associated with calculating concentrations using BCF_f in site-specific organisms is unknown and may over- or under-estimate C_{HF}.
FCM_{TL2}	Food chain multiplier for trophic level 2 predator	unitless	**Varies** This variable is COPC- and trophic level-specific and is provided in Chapter 5, Table 5-2. The following uncertainties are associated with this variable: (1) *FCMs* do not account for metabolism, thus for COPCs with significant metabolism concentrations may be over-estimated to an unknown degree. (2) The application of *FCMs* for computing concentration in terrestrial food webs introduce uncertainty (see Chapter 5). *FCMs* are obtained from the U.S. EPA (1995) “Great Lakes Water Quality Initiative Technical Support Document for the Procedure to Determine Bioaccumulation Factors.”

TABLE F-1-13

COPC CONCENTRATIONS IN HERBIVOROUS AND PLANKTIVOROUS FISH IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

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REFERENCES AND DISCUSSIONS

U.S. EPA. 1995. *Great Lakes Water Quality Initiative Technical Support Document for the Procedure to Determine Bioaccumulation Factors.* Office of Water. EPA-820-B-95-005.

TABLE F-1-14

COPC CONCENTRATIONS IN OMNIVOROUS MAMMALS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 1 of 10)

Description

This equation calculates the COPC concentration in aquatic omnivorous mammals through ingestion of plants, sediment, and water in the freshwater/wetland, brackish/intermediate marsh, and saltmarsh food webs. The limitations and uncertainty introduced in calculating this variable include the following:

(1) Variables: C_{sed}, and C_{wctot} are COPC- and site-specific. Uncertainties associated with these variables are site specific.

(2) Variables: $BCF_{BS\text{-}OM}$, and $BCF_{W\text{-}OM}$ are based on biotransfer factors for beef cattle (Ba_{beef}), and receptor specific ingestion rates, and therefore may introduce uncertainty when used to compute concentrations in site-specific omnivorous mammals.

Equation

$$C_{OM} = (C_{BI} \cdot \frac{FCM_{TL3}}{FCM_{TL2}} \cdot P_{BI} \cdot F_{BI}) + (C_{WI} \cdot \frac{FCM_{TL3}}{FCM_{TL2}} \cdot P_{WI} \cdot F_{WI}) + (C_{HM} \cdot \frac{FCM_{TL3}}{FCM_{TL2}} \cdot P_{HM} \cdot F_{HM})$$

$$+ (C_{HB} \cdot \frac{FCM_{TL3}}{FCM_{TL2}} \cdot P_{HB} \cdot F_{HB}) + (C_{AL} \cdot BCF_{AL-OM} \cdot P_{AL} \cdot F_{AL}) + (C_{AV} \cdot BCF_{AV-OM} \cdot P_{AV} \cdot F_{AV})$$

$$+ (C_{sed} \cdot BCF_{BS-OM} \cdot P_{BS}) + (C_{wctot} \cdot BCF_{W-OM} \cdot P_{W})$$

Variable	Description	Units	Value
C_{OM}	COPC concentration in omnivorous mammals	mg COPC/kg FW tissue	

TABLE F-1-14

COPC CONCENTRATIONS IN OMNIVOROUS MAMMALS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

Variable	Description	Units	Value
C_{BI}	COPC concentration in benthic invertebrates	mg COPC/kg FW tissue	**Varies** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-11. Uncertainties associated with this variable include the following: (1) C_{sed} values are COPC- and site-specific. (2) BCF_{BS-BI} values are intended to represent “generic benthic invertebrate species”, and therefore may over- or under-estimate exposure when applied to site-specific organisms.
$\underline{FCM_{TL3}}$ FCM_{TL2}	Food chain multiplier for trophic level 3 predator consuming trophic level 2 prey	unitless	**Varies** This variable is COPC- and trophic level-specific and is provided in Chapter 5, Table 5-2. The following uncertainties are associated with this variable: (1) *FCMs* do not account for metabolism, thus for COPCs with significant metabolism, concentrations may be over-estimated to an unknown degree. (2) The application of *FCMs* for computing concentration in terrestrial food webs may introduce uncertainty (see Chapter 5) *FCMs* are obtained from the U.S. EPA 1995 “Great Lakes Water Quality Initiative Technical Support Document for the Procedure to Determine Bioaccumulation Factors.”
P_{BI}	Proportion of benthic invertebrate in diet that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.

TABLE F-1-14

COPC CONCENTRATIONS IN OMNIVOROUS MAMMALS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 3 of 10)

Variable	Description	Units	Value
F_{BI}	Fraction of diet comprised of benthic invertebrates	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of benthic invertebrates. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.
C_{WI}	COPC concentration in water invertebrates	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-12)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-12. Uncertainties associated with this variable include: (1) C_{dw} values are COPC- and site-specific. (2) $BCF_{W\text{-}WI}$ values are intended to represent "generic water invertebrate species", and therefore may over- or under-estimate exposure when applied to site-specific organisms.
P_{WI}	Proportion of water invertebrate in diet that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.

TABLE F-1-14

COPC CONCENTRATIONS IN OMNIVOROUS MAMMALS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

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Variable	Description	Units	Value
F_{WI}	Fraction of diet comprised of water invertebrates	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of water invertebrates. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.
C_{HM}	Concentration of COPC in herbivorous mammals	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-9)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-9. Uncertainties associated with this variable include: (1) Variables: C_{AV}, C_{AL},C_{sed}, and C_{wctot} are COPC- and site-specific. (2) Variables: BCF_{BS-HM} and BCF_{W-HM} are based on biotransfer factors for beef cattle (Ba_{beef}), and receptor specific ingestion rates, and therefore may introduce uncertainty when used to compute concentrations for site-specific herbivorous mammals.
P_{HM}	Proportion of aquatic herbivorous mammal in diet that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.

TABLE F-1-14

COPC CONCENTRATIONS IN OMNIVOROUS MAMMALS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 5 of 10)

Variable	Description	Units	Value
F_{HM}	Fraction of diet comprised of aquatic herbivorous mammals	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of aquatic herbivorous mammals. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.
C_{HB}	COPC concentration in herbivorous birds	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-10)** This variable is site-specific and chemical-specific; it is calculated using the equation in Table F-1-10. Uncertainties associated with this variable include: (1) Variables: C_{AV}, C_{AL},C_{sed}, and C_{wctot} are COPC- and site-specific. (2) Variables: $BCF_{BS\text{-}HB}$ and $BCF_{W\text{-}HB}$ are based on biotransfer factors for chicken ($Ba_{chicken}$), and receptor specific ingestion rates, and therefore may introduce uncertainty when used to compute concentrations for site-specific herbivorous birds.
P_{HB}	Proportion of herbivorous birds in diet that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.

TABLE F-1-14

COPC CONCENTRATIONS IN OMNIVOROUS MAMMALS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

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Variable	Description	Units	Value
F_{HB}	Fraction of diet comprised of herbivorous birds	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of aquatic herbivorous birds. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.
C_{AL}	COPC concentration in algae	mg COPC/kg WW	**Varies (calculated - Table F-1-8)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-8. Uncertainties associated with this variable include: (1) C_{dw} values are COPC- and site-specific. (2) BCF_{W-AL} values are intended to represent “generic algae species”, and therefore may over- or under-estimate exposure when applied to site-specific species.
BCF_{AL-OM}	Bioconcentration factor for algae-to-omnivorous mammal	unitless [(mg COPC/kg FW tissue)/(mg COPC/kg WW)]	**Varies** This variable is COPC-, site-, habitat- and receptor-specific, and is calculated using the following equation to compute the COPC concentration in aquatic omnivorous mammals through indirect dietary exposure. BCF_{AL-OM} values are provided in Appendix D.

TABLE F-1-14

COPC CONCENTRATIONS IN OMNIVOROUS MAMMALS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

Variable	Description	Units	Value
P_{AL}	Proportion of algae in diet that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{AL}	Fraction of diet comprised of algae	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of algae. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.
C_{AV}	COPC concentration in aquatic vegetation ingested by the animal	mg COPC/kg WW	**Varies (calculated - Table F-1-7)** This variable is site- and COPC-specific; it is calculated using the equation in Table F-1-7. Uncertainties associated with this variable include: (1) C_{sed} values are COPC- and site-specific. Uncertainties associated with this variable may be significant, and should be summarized as part of each SLERA report. (2) BCF_{BS-AV} values are intended to represent "generic aquatic vegetation species", and therefore may over- or under-estimate exposure when applied to site-specific vegetation.

TABLE F-1-14

COPC CONCENTRATIONS IN OMNIVOROUS MAMMALS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

Variable	Description	Units	Value
BCF_{AV-OM}	Bioconcentration factor for aquatic vegetation-to-aquatic omnivorous mammal	unitless [(mg COPC/kg FW tissue)/(mg COPC/kg WW)]	**Varies** This variable is COPC-, site-, habitat- and receptor-specific, and is calculated using the following equation to compute the COPC concentration in aquatic omnivorous mammals through indirect dietary exposure. BCF_{AV-OM} values are provided in Appendix D.
P_{AV}	Proportion of aquatic vegetation in diet that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{AV}	Fraction of diet comprised of aquatic vegetation	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of aquatic vegetation. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-1-14

COPC CONCENTRATIONS IN OMNIVOROUS MAMMALS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

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Variable	Description	Units	Value
C_{sed}	COPC concentration sorbed to bed sediment	mg COPC/kg DW sediment	**Varies (calculated - Table B-2-19)** This equation calculates the concentration of contaminants sorbed to bed sediments. Uncertainties associated with this equation include the following: (1) The default variable values recommended for use in the equation in Table B-2-19 may not accurately represent site-specific water body conditions. The degree of uncertainty associated with default variable values is expected to be limited either because the probable ranges for these variables are narrow or because information allowing reasonable estimates is generally available. (2) Uncertainties associated with variables f_{bs}, C_{wtot} and Kd_{bs} are largely associated with the use of default *OC* content values in their calculation. The uncertainty may be significant in specific instances, because *OC* content is known to vary widely in different locations in the same medium. This variable is site-specific.
$BCF_{BS\text{-}OM}$	Bioconcentration factor for bed sediment-to-aquatic omnivorous mammal pathways	unitless [(mg COPC/kg FW tissue)/(mg COPC/kg DW sediment)]	**Varies** This variable is COPC-, site-, and receptor-specific, and is calculated using the following equation to compute the COPC concentration in aquatic omnivorous mammals through indirect sediment exposure. $BCF_{BS\text{-}OM}$ values are provided in Appendix D.
P_{BS}	Portion of ingested bed sediment that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of soil ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for a screening level risk assessment when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated soil ingested by species depends on site-specific information, receptor home range, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of soil ingested that is contaminated will likely be overestimated.

TABLE F-1-14

COPC CONCENTRATIONS IN OMNIVOROUS MAMMALS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

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Variable	Description	Units	Value
C_{wctot}	Total COPC concentration in water column	mg COPC/L water (or g COPC/m^3 water)	**Varies (calculated - Table B-2-17)** This variable is COPC- and site-specific and is calculated using Table B-2-17. Uncertainties associated with this equation include the following: (1) All of the variables in the equation in Table B-2-17 are COPC- and site-specific. Therefore, the use of default values rather than site-specific values, for any or all of these variables, will contribute to the under- or overestimation of C_{wctot}. (2) Uncertainty associated with f_{wc} is largely the result of uncertainty associated with default *OC* content values and may be significant in specific instances. Uncertainties associated with the variable L_T and K_{wt} may also be significant because of many variable-specific uncertainties. The degree of uncertainly associated with the variables d_{wc} and d_{bs} is expected to be minimal either because information for estimating a variable (d_{wc}) is generally available or because the probable range for a variable (d_{bs}) is narrow. The uncertainty associated with the variables f_{wc} and C_{wtot} is associated with estimates of *OC* content. Because *OC* content values can vary widely for different locations in the same medium, the uncertainty associated with using default *OC* values may be significant in specific cases.
$BCF_{W\text{-}OM}$	Bioconcentration factor for water-to-aquatic omnivorous mammal	unitless [(mg COPC/kg FW tissue)/(mg COPC/L water)]	**Varies** This variable is COPC-, site-, and receptor-specific, and is calculated using the following equation to compute the COPC concentration in aquatic omnivorous mammals through indirect water exposure. $BCF_{W\text{-}OM}$ values are provided in Appendix D.
P_W	Portion of ingested water that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of water ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated water ingested by species depends on site-specific information, receptor homerange, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of ingested water that is contaminated will likely be overestimated.

TABLE F-1-15

COPC CONCENTRATIONS IN OMNIVOROUS BIRDS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 1 of 9)

Description

This equation calculates the COPC concentration in aquatic omnivorous birds through ingestion of plants, sediment, and water in the freshwater/wetland, brackish/intermediate marsh, and saltmarsh food webs. The limitations and uncertainty introduced in calculating this variable include the following:

(1) Variables: C_{sed}, and C_{wctot} are COPC- and site-specific. Uncertainties associated with these variables are site specific.
(2) Variables: $BCF_{BS\text{-}OB}$, and $BCF_{W\text{-}OB}$ are calculated based on biotransfer factors for chicken ($Ba_{chicken}$), and receptor specific ingestion rates, and therefore may introduce uncertainty when used to compute concentrations for site-specific omnivorous birds.

Equation

$$C_{OB} = \left(C_{BI} \cdot \frac{FCM_{TL3}}{FCM_{TL2}} \cdot P_{BI} \cdot F_{BI} \right) + \left(C_{WI} \cdot \frac{FCM_{TL3}}{FCM_{TL2}} \cdot P_{WI} \cdot F_{WI} \right) + \left(C_{AV} \cdot BCF_{AV-OM} \cdot P_{AV} \cdot F_{AV} \right)$$

$$+ \left(C_{AL} \cdot BCF_{AL-OM} \cdot P_{AL} \cdot F_{AL} \right) + \left(C_{sed} \cdot BCF_{BS-OB} \cdot P_{BS} \right) + \left(C_{wctot} \cdot BCF_{W-OB} \cdot P_{W} \right)$$

Variable	Description	Units	Value
C_{OB}	COPC concentration in omnivorous birds	mg COPC/kg FW tissue	
C_{BI}	COPC concentration in benthic invertebrates	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-11)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-11. Uncertainties associated with this variable include the following: (1) C_{sed} values are COPC- and site-specific. (2) $BCF_{BS\text{-}BI}$ values are intended to represent "generic benthic invertebrate species", and therefore may over- or under-estimate exposure when applied to site-specific organisms.

TABLE F-1-15

COPC CONCENTRATIONS IN OMNIVOROUS BIRDS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 2 of 9)

Variable	Description	Units	Value
$\underline{FCM_{TL3}}$ FCM_{TL2}	Food chain multiplier for trophic level 3 predator consuming trophic level 2 prey	unitless	**Varies** This variable is COPC- and trophic level-specific and is provided in Chapter 5, Table 5-2. The following uncertainties are associated with this variable: (1) *FCMs* do not account for metabolism, thus for COPCs with significant metabolism, concentrations may be over-estimated to an unknown degree. (2) The application of *FCMs* for computing concentration in terrestrial food webs may introduce uncertainty (see Chapter 5) *FCMs* are obtained from the U.S. EPA 1995 "Great Lakes Water Quality Initiative Technical Support Document for the Procedure to Determine Bioaccumulation Factors."
P_{BI}	Proportion of benthic invertebrate in diet that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{BI}	Fraction of diet comprised of benthic invertebrates	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of benthic invertebrates. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-1-15

COPC CONCENTRATIONS IN OMNIVOROUS BIRDS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 3 of 9)

Variable	Description	Units	Value
C_{WI}	COPC concentration in water invertebrates	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-12)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-12. Uncertainties associated with this variable include: (1) C_{dw} values are COPC- and site-specific. (2) BCF_{W-WI} values are intended to represent "generic water invertebrate species", and therefore may over- or under-estimate exposure when applied to site-specific organisms.
P_{WI}	Proportion of water invertebrate in diet that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{WI}	Fraction of diet comprised of water invertebrates	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of water invertebrates. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-1-15

COPC CONCENTRATIONS IN OMNIVOROUS BIRDS
IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 4 of 9)

Variable	Description	Units	Value
C_{AV}	COPC concentration in aquatic vegetation ingested by the animal	mg COPC/kg WW	**Varies (calculated - Table F-1-7)** This variable is site- and COPC-specific; it is calculated using the equation in Table F-1-7. Uncertainties associated with this variable include: (1) $C_{sed\text{-}AV}$ values are COPC- and site-specific. (2) $BCF_{BS\text{-}AV}$ values are intended to represent "generic aquatic vegetation species", and therefore may over- or under-estimate exposure when applied to site-specific vegetation.
$BCF_{AV\text{-}OB}$	Bioconcentration factor for aquatic vegetation-to-aquatic omnivorous bird	unitless [(mg COPC/kg FW tissue)/(mg COPC/kg WW)]	**Varies** This variable is COPC-, site-, habitat- and receptor-specific, and is calculated using the following equation to compute the COPC concentration in aquatic omnivorous birds through indirect dietary exposure. $BCF_{AV\text{-}OB}$ values are provided in Appendix D.
P_{AV}	Proportion of aquatic vegetation in diet that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.

TABLE F-1-15

COPC CONCENTRATIONS IN OMNIVOROUS BIRDS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 5 of 9)

Variable	Description	Units	Value
F_{AV}	Fraction of diet comprised of aquatic vegetation	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of aquatic vegetation. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.
C_{AL}	COPC concentration in algae	mg COPC/kg WW	**Varies (calculated - Table F-1-8)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-8. Uncertainties associated with this variable include: (1) C_{dw} values are COPC- and site-specific. (2) BCF_{W-AL} values are intended to represent "generic algae species", and therefore may over- or under-estimate exposure when applied to site-specific species.
BCF_{AL-OB}	Bioconcentration factor for algae-to-aquatic omnivorous bird	unitless [(mg COPC/kg FW tissue)/(mg COPC/kg WW)]	**Varies** This variable is COPC-, site-, habitat- and receptor-specific, and is calculated using the following equation to compute the COPC concentration in aquatic omnivorous birds through indirect dietary exposure. BCF_{AL-OB} values are provided in Appendix D.

TABLE F-1-15

COPC CONCENTRATIONS IN OMNIVOROUS BIRDS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

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Variable	Description	Units	Value
P_{AL}	Proportion of algae in diet that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommend that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{AL}	Fraction of diet comprised of algae	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of algae. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-1-15

COPC CONCENTRATIONS IN OMNIVOROUS BIRDS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 7 of 9)

Variable	Description	Units	Value
C_{sed}	COPC concentration in bed sediment	mg COPC/kg DW sediment	**Varies (calculated - Table B-2-19)** This equation calculates the concentration of contaminants sorbed to bed sediments. Uncertainties associated with this equation include the following: (1) The default variable values recommended for use in the equation in Table B-2-19 may not accurately represent site-specific water body conditions. The degree of uncertainty associated with default variable values is expected to be limited either because the probable ranges for these variables are narrow or because information allowing reasonable estimates is generally available. (2) Uncertainties associated with variables f_{bs}, C_{wtot} and Kd_{bs} are largely associated with the use of default *OC* content values in their calculation. The uncertainty may be significant in specific instances, because *OC* content is known to vary widely in different locations in the same medium. This variable is site-specific. It is the maximum COPC concentration in sediment in the assessment area and is computed from soil and surface water concentrations using the ISCST3 air dispersion and deposition model, and fate and transport equations presented in Chapter 3.
$BCF_{BS\text{-}HB}$	Bioconcentration factor for bed sediment-to-aquatic omnivorous bird pathways	unitless [(mg COPC/kg FW tissue)/(mg COPC/kg DW sediment)]	**Varies** This variable is COPC-, site-, habitat- and receptor-specific, and is calculated using the following equation to compute the COPC concentration in aquatic herbivorous birds through indirect sediment exposure. $BCF_{BS\text{-}OB}$ values are provided in Appendix D.
P_{BS}	Portion of ingested bed sediment that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of soil ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for a screening level risk assessment when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated soil ingested by species depends on site-specific information, receptor home range, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of soil ingested that is contaminated will likely be overestimated.

TABLE F-1-15

COPC CONCENTRATIONS IN OMNIVOROUS BIRDS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 8 of 9)

Variable	Description	Units	Value
C_{wctot}	Total COPC concentration in water column	mg COPC/L water (or g COPC/m^3 water)	**Varies (calculated - Table B-2-17)** This variable is COPC- and site-specific and is calculated using Table B-2-17. Uncertainties associated with this equation include the following: (1) All of the variables in the equation in Table B-2-17 are COPC- and site-specific. Therefore, the use of default values rather than site-specific values, for any or all of these variables, will contribute to the under- or overestimation of C_{wctot}. (2) Uncertainty associated with f_{wc} is largely the result of uncertainty associated with default OC content values and may be significant in specific instances. Uncertainties associated with the variable L_T and K_{wt} may also be significant because of many variable-specific uncertainties. The degree of uncertainly associated with the variables d_{wc} and d_{bs} is expected to be minimal either because information for estimating a variable (d_{wc}) is generally available or because the probable range for a variable (d_{bs}) is narrow. The uncertainty associated with the variables f_{wc} and C_{wtot} is associated with estimates of *OC* content. Because *OC* content values can vary widely for different locations in the same medium, the uncertainty associated with using default *OC* values may be significant in specific cases.
BCF_{W-OB}	Bioconcentration factor for water-to-aquatic omnivorous bird	unitless [(mg COPC/kg FW tissue)/(mg COPC/L water)]	**Varies** This variable is COPC-, site-, and receptor-specific, and is calculated using the following equation to compute the COPC concentration in aquatic omnivorous birds through indirect exposure to water. BCF_{W-OB} values are provided in Appendix D.
P_W	Portion of ingested water that is contaminated	unitless	**0 to 1** **Default: 1.0** This variable is species- and site-specific, and depends on the percentage of water ingested that is contaminated. U.S. EPA OSW recommend that a default value of 1.0 be used when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated water ingested by species depends on site-specific information, receptor home range, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of ingested water that is contaminated will likely be overestimated.

TABLE F-1-15

COPC CONCENTRATIONS IN OMNIVOROUS BIRDS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 9 of 9)

REFERENCES AND DISCUSSIONS

U.S. EPA. 1995. *Great Lakes Water Quality Initiative Technical Support Document for the Procedure to Determine Bioaccumulation Factors.* Office of Water. EPA-820-B-95-005.

TABLE F-1-16

COPC CONCENTRATIONS IN OMNIVOROUS FISH IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 1 of 3)

Description

This equation calculates the COPC concentration in omnivorous fish through ingestion of contaminated food and water exposure in the freshwater/wetland, brackish/intermediate marsh, and saltmarsh food webs. The limitations and uncertainty introduced in calculating this variable include the following:

(1) C_{dw} values are COPC- and site-specific.
(2) The data set used to calculate BCF_f is based on a limited number of test organisms and therefore may over- or under-estimate exposure when representing site-specific organisms.

Equation

$$C_{OF} = C_{dw} \cdot BCF_f \cdot FCM_{TL3}$$

Variable	Description	Units	Value
C_{OF}	COPC concentration in omnivorous fish	mg COPC/kg FW tissue	
C_{dw}	Dissolved phase water concentration	mg COPC/L water	**Varies (calculated - Table B-2-18)** This variable is COPC- and site-specific. This equation calculates the concentration of COPC dissolved in the water column. Uncertainties associated with this equation include the following: (1) The variables in the equation in Table B-2-18 are site-specific. Therefore, the use of default values rather than site-specific values, for any or all of these variables, will contribute to the under- or overestimation of C_{dw}. The degree of uncertainty associated with *TSS* is expected to be relatively small, because information regarding reasonable site-specific values for this variable are generally available or it can be easily measured. On the other hand, the uncertainty associated with the variables C_{wctot} and Kd_{sw} is associated with estimates of *OC* content. Because *OC* content values can vary widely for different locations in the same media, using default *OC* values may result in uncertainty in specific cases.

TABLE F-1-16

COPC CONCENTRATIONS IN OMNIVOROUS FISH IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 2 of 3)

Variable	Description	Units	Value
BCF_f	Bioconcentration factor for water-to-fish	unitless [(mg COPC/kg FW tissue)/(mg COPC/L water)]	**Varies** This variable is COPC-, site- and species-specific, and is provided in Appendix C. This variable is calculated using laboratory and field measured values as discussed Appendix C. The following uncertainties are associated with this variable: (1) The COPC specific BCF_f values may not accurately represent site-specific conditions, therefore over-or under-estimating C_{OF} to an unknown degree. (2) The data set used to calculate BCF_f is based on a limited number of test species. The uncertainty associated with calculating concentrations using BCF_f in site-specific organisms is unknown and may over- or under-estimate C_{OF}.
FCM_{TL3}	Food chain multiplier for trophic level 3 predator	unitless	**Varies** This variable is COPC- and trophic level-specific, and is provided in Chapter 5, Table 5-2. The following uncertainties are associated with this variable: (1) FCMs do not account for metabolism, thus for COPCs with significant metabolism concentrations may be over-estimated to an unknown degree. (2) The application of *FCMs* for computing concentration in terrestrial food webs introduce uncertainty (see Chapter 5). *FCMs* are obtained from the U.S. EPA 1995 “Great Lakes Water Quality Initiative Technical Support Document for the Procedure to Determine Bioaccumulation Factors.”

TABLE F-1-16

COPC CONCENTRATIONS IN OMNIVOROUS FISH IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 3 of 3)

REFERENCES AND DISCUSSIONS

U.S. EPA. 1995. *Great Lakes Water Quality Initiative Technical Support Document for the Procedure to Determine Bioaccumulation Factors.* Office of Water. EPA-820-B-95-005.

TABLE F-1-17

COPC CONCENTRATIONS IN CARNIVOROUS FISH IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 1 of 3)

Description

This equation calculates the COPC concentration in carnivorous fish through ingestion of contaminated prey and water exposure in the freshwater/wetland, brackish/intermediate marsh, and saltmarsh food webs. The limitations and uncertainty introduced in calculating this variable include the following:

(1) C_{dw} values are COPC- and site-specific.
(2) The data set used to calculate BCF_f is based on a limited number of test organisms and therefore may over- or under-estimate exposure when representing site-specific organisms.

Equation

$$C_{CF} = C_{dw} \cdot BCF_f \cdot FCM_{TL4}$$

Variable	Description	Units	Value
C_{CF}	COPC concentration in carnivorous fish	mg COPC/kg FW tissue	**Varies** Tissue concentration is expressed on a wet weight basis (mg COPC/kg wet tissue).
C_{dw}	Dissolved phase water concentration	mg COPC/L water	**Varies (calculated - Table B-2-18)** This variable is COPC- and site-specific. This equation calculates the concentration of COPC dissolved in the water column. Uncertainties associated with this equation include the following: (1) The variables in the equation in Table B-2-18 are site-specific. Therefore, the use of default values rather than site-specific values, for any or all of these variables, may contribute to the under- or overestimation of C_{dw}. The uncertainty associated with the variables C_{wctot} and Kd_{sw} is associated with estimates of OC content. Because OC content values can vary widely for different locations in the same media, using default OC values may result in uncertainty in specific cases.

TABLE F-1-17

COPC CONCENTRATIONS IN CARNIVOROUS FISH IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 2 of 3)

Variable	Description	Units	Value
BCF_f	Bioconcentration factor for water-to-fish	unitless [(mg COPC/kg FW tissue)/(mg COPC/L water)]	**Varies** This variable is COPC-, site- and species-specific, and is provided in Appendix C. This variable is calculated using laboratory and field measured values as discussed in Appendix C. The following uncertainties are associated with this variable: (1) The COPC specific BCF_f values may not accurately represent site-specific conditions, therefore over-or under-estimating C_{CF} to an unknown degree. (2) The data set used to calculate BCF_f is based on a limited number of test species. The uncertainty associated with calculating concentrations using BCF_f in site-specific organisms is unknown and may over- or under-estimate C_{CF}.
FCM_{TL4}	Food chain multiplier for trophic level 4 predator	unitless	**Varies** This variable is COPC- and trophic level-specific and is provided in Chapter 5, Table 5-2. The following uncertainties are associated with this variable: (1) *FCMs* do not account for metabolism, thus for COPCs with significant metabolism concentrations may be over-estimated to an unknown degree. (2) The application of *FCMs* for computing concentration in terrestrial food webs introduce uncertainty (see Chapter 5). *FCMs* are obtained from the U.S. EPA 1995 "Great Lakes Water Quality Initiative Technical Support Document for the Procedure to Determine Bioaccumulation Factors."

TABLE F-1-17

COPC CONCENTRATIONS IN CARNIVOROUS FISH IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 3 of 3)

REFERENCES AND DISCUSSIONS

U.S. EPA. 1995. *Great Lakes Water Quality Initiative Technical Support Document for the Procedure to Determine Bioaccumulation Factors.* Office of Water. EPA-820-B-95-005.

TABLE F-2-1

COPC DOSE INGESTED TERMS IN HERBIVOROUS MAMMALS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

Description

This equation calculates the daily dose through exposure to contaminated food or prey, soil, and water in herbivorous mammals in upland forest, shortgrass prairie, tallgrass prairie, and shrub/scrub food webs. The limitations and uncertainties introduced in calculating this variable include the following:

(1) Variables Cs and C_{wctot} are COPC- and site-specific. Uncertainties associated with these variables will be site specific.
(2) Variables $BCF_{S\text{-}HM}$ and $BCF_{W\text{-}HM}$ are based on biotransfer factors for beef cattle (Ba_{beef}), and receptor-specific ingestion rates, and therefore may introduce uncertainty when used to compute a daily dose for representative site-specific herbivorous mammals.

Equation

$$D_{HM} = \left(C_{TP} \cdot IR_{HM} \cdot P_{TP} \cdot F_{TP}\right) + \left(Cs \cdot IR_{S-HM} \cdot P_S\right) + \left(C_{wctot} \cdot IR_{W-HM} \cdot P_W\right)$$

Variable	Description	Units	Value
D_{HM}	Dose COPC ingested for herbivorous mammals	mg COPC/kg BW-day	
C_{TP}	COPC concentration in terrestrial plants	mg COPC/kg WW	**Varies** This variable is site- and COPC-specific; it is calculated using the equation in Table F-1-1. Uncertainties introduced by this variable include the following: (1) Some of the variables in the equations in Tables B-3-1, B-3-2, and B-3-3—including Cs, Cyv, Q, $Dydp$, and $Dywp$—are COPC- and site-specific. (2) In the equation in Table B-3-1, uncertainties associated with other variables include the following: F_w (values for organic compounds estimated on the basis of the behavior of polystyrene microspheres), Rp (estimated on the basis of a generalized empirical relationship), kp (estimation process does not consider chemical degradation). All of these uncertainties contribute to the overall uncertainty associated with C_{TP}.

TABLE F-2-1

COPC DOSE INGESTED TERMS IN HERBIVOROUS MAMMALS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 2 of 4)

Variable	Description	Units	Value
IR_{HM}	Food ingestion rate of herbivorous mammal	kg WW/kg BW-day	**Varies** Food ingestion rates (IR_{HM}) are site-, receptor-, and habitat-specific and are provided in Chapter 5, Table 5-1. (1) Food ingestion rates are influenced by several factors including: metabolic rate, energy requirements for growth and reproduction, and dietary composition. Ingestion rates are also influenced by ambient temperature, receptor activity level and body weight (U.S. EPA 1993). These factors introduce an unknown degree of uncertainty when used to estimate daily dose.
P_{TP}	Proportion of terrestrial plant in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{TP}	Fraction of diet comprised of terrestrial plants	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of terrestrial plants. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-1

COPC DOSE INGESTED TERMS IN HERBIVOROUS MAMMALS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 3 of 4)

Variable	Description	Units	Value
Cs	COPC concentration in soil	mg COPC /kg DW soil	**Varies** This variable is COPC- and site-specific, and should be calculated using the equation in Table B-1-1. C_S is expressed on a dry weight basis. Uncertainties associated with this variable include: (1) For soluble COPCs, leaching might lead to movement to below 1 centimeter in untilled soils, resulting a greater mixing depth. This uncertainty may overestimate Cs. (2) Deposition to hard surfaces may result in dust residues that have negligible dilution (as a result of potential mixing with *in situ* materials) in comparison to that of other residues. This uncertainty may underestimate Cs (3) Modeled soil concentrations may not accurately represent site-specific conditions. As a result, the actual COPC concentration in soil may be under- or overestimated to an unknown degree.
$IR_{S\text{-}HM}$	Soil ingestion rate of omnivorous mammal	kg DW/kg BW-day	**Varies** This variable is site-, receptor-, and habitat-specific, and is discussed in Chapter 5. Ingestion rates for example measurement receptors are presented in Chapter 5, Table 5-1. Uncertainties associated with this variable include the following: (1) IR_S values may under- or over-estimate BCF_S when applied for site-specific organisms.
P_S	Proportion of ingested soil that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of soil ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for a screening level risk assessment when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated soil ingested by species depends on site-specific information, receptor homerange, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of soil ingested that is contaminated will likely be overestimated.

TABLE F-2-1

COPC DOSE INGESTED TERMS IN HERBIVOROUS MAMMALS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 4 of 4)

Variable	Description	Units	Value
C_{wctot}	Total COPC concentration in water column	mg COPC/L water	**Varies (calculated - Table B-2-17)** This variable is COPC- and site-specific and is calculated using Table B-2-17. Uncertainties associated with this equation include the following: (1) All of the variables in the equation in Table B-2-17 are COPC- and site-specific. Therefore, the use of default values rather than site-specific values, for any or all of these variables, will contribute to the under- or overestimation of C_{wctot}. (2) Uncertainty associated with f_{wc} is largely the result of uncertainty associated with default OC content values and may be significant in specific instances. Uncertainties associated with the variable L_T and k_{wt} may also be significant because of many variable-specific uncertainties. The degree of uncertainly associated with the variables d_{wc} and d_{bs} is expected to be minimal either because information for estimating a variable (d_{wc}) is generally available or because the probable range for a variable (d_{bs}) is narrow. The uncertainty associated with the variables f_{wc} and C_{wctot} is associated with estimates of *OC* content. Because *OC* content values can vary widely for different locations in the same media, using default *OC* values may result in uncertainty in specific cases.
$IR_{W\text{-}HM}$	Water ingestion rate of herbivorous mammal	L/kg BW-day	**Varies** This variable is receptor- and habitat-specific, and is discussed in Chapter 5. Ingestion rates for example measurement receptors are presented in Chapter 5, Table 5-1. The following uncertainty is associated with this variable: (1) Water ingestion rates are strongly influenced by animal behavior and environmental factors and may over- or under- estimate $BCF_{W\text{-}HM}$ to an unknown degree.
P_W	Proportion of ingested water that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of water ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated water ingested by species depends on site-specific information, receptor homerange, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of ingested water that is contaminated will likely be overestimated.

TABLE F-2-2

COPC DOSE INGESTED TERMS IN HERBIVOROUS BIRDS IN FOREST, SHRUB/SCRUB, SHORTGRASS PRAIRIE, AND TALLGRASS PRAIRIE FOOD WEBS

(Page 1 of 5)

Description

This equation calculates the daily dose through exposure to contaminated food/prey, soil, and water in herbivorous birds in upland forest, shortgrass prairie, tallgrass prairie, and shrub/scrub food webs. The limitations and uncertainties introduced in calculating this variable include the following:

(1) Variables C_S, and C_{HB} are COPC- and site-specific. Uncertainties associated with these variables will be site-specific.
(2) Variables $BCF_{S\text{-}HB}$, and $BCF_{W\text{-}HB}$ are based on biotransfer factors for chicken ($Ba_{chicken}$), and receptor specific ingestion rates, and therefore may introduce uncertainty when used to compute a daily dose representing site-specific herbivorous birds.

Equation

$$D_{HB} = \left(C_{TP} \cdot IR_{HB} \cdot P_{TP} \cdot F_{TP}\right) + \left(Cs \cdot IR_{S-HB} \cdot P_S\right) + \left(C_{wctot} \cdot IR_{W-HB} \cdot P_W\right)$$

Variable	Description	Units	Value
D_{HB}	Dose COPC ingested for herbivorous birds	mg/kg BW-day	
C_{TP}	Concentration of COPC in terrestrial plants ingested by the animal	mg COPC/kg WW	**Varies** This variable is site- and COPC-specific; it is calculated using the equation in Table F-1-1. Uncertainties introduced by this variable include the following: (1) Some of the variables in the equations in Tables B-3-1, B-3-2, and B-3-3—including *Cs*, *Cyv*, *Q*, *Dydp*, and *Dywp*—are COPC- and site-specific. Uncertainties associated with these variables may be significant, and should be summarized as part of each SLERA report. (2) In the equation in Table B-3-1, uncertainties associated with other variables include the following: F_w (values for organic compounds estimated on the basis of the behavior of polystyrene microspheres), *Rp* (estimated on the basis of a generalized empirical relationship), and *kp* (estimation process does not consider chemical degradation). All of these uncertainties contribute to the overall uncertainty associated with C_{TP}.

TABLE F-2-2

COPC DOSE INGESTED TERMS IN HERBIVOROUS BIRDS IN FOREST, SHRUB/SCRUB, SHORTGRASS PRAIRIE, AND TALLGRASS PRAIRIE FOOD WEBS

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Variable	Description	Units	Value
IR_{HB}	Food ingestion rate of herbivorous bird	kg WW/kg BW-day	**Varies** This variable is receptor-specific, and is discussed in Chapter 5. Ingestion rates for example measurement receptors are provided in Chapter 5, Table 5-1. Uncertainties associated with this variable include: (1) Food ingestion rates are influenced by several factors including: metabolic rate, energy requirements for growth and reproduction, and dietary composition. Ingestion rates are also influenced by ambient temperature, receptor activity level and body weight U.S. EPA (1993). These factors introduce an unknown degree of uncertainty when used to estimate daily dose. (2) IR values may over- or under- estimate exposure when applied to site-specific receptors.
P_{TP}	Proportion of terrestrial plant diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{TP}	Fraction of diet comprised of terrestrial plants	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of terrestrial plants. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applided to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertaintiy and may over-estimate exposure from ingestion of a single dietary item. (3) The defalut value for an equal diet introduces uncertainity and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-2

COPC DOSE INGESTED TERMS IN HERBIVOROUS BIRDS IN FOREST, SHRUB/SCRUB, SHORTGRASS PRAIRIE, AND TALLGRASS PRAIRIE FOOD WEBS

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Variable	Description	Units	Value
Cs	COPC soil concentration	mg COPC /kg DW soil	**Varies** This variable is COPC- and site-specific, and should be calculated using the equation in Table B-1-1. This variable is calculated from stack emissions using the ISCST3 air dispersion and deposition model and soil fate and transport equations presented in Appendix B. C_S is expressed on a dry weight basis. Uncertainties associated with this variable include: (1) For soluble COPCs, leaching might lead to movement to below 1 centimeter in untilled soils, resulting a greater mixing depth. This uncertainty may overestimate Cs and Cs_{tD}. (2) Deposition to hard surfaces may result in dust residues that have negligible dilution (as a result of potential mixing with *in situ* materials) in comparison to that of other residues. This uncertainty may underestimate Cs (3) Modeled soil concentrations may not accurately represent site-specific conditions. As a result, the actual COPC concentration in soil may be under- or overestimated to an unknown degree.
$IR_{S\text{-}HB}$	Soil ingestion rate for herbivorous bird	kg DW/kg BW-day	**Varies** This variable is site-, receptor-, and habitat-specific, and is discussed in Chapter 5. Ingestion rates for example measurement receptors are presented in Chapter 5, Table 5-1. Uncertainties associated with this variable include the following: (1) IR_S values may under- or over-estimate BCF_S when applied for site-specific organisms.
P_S	Proportion of ingested soil that is contamanted	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of soil ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for a screening level risk assessment when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated soil ingested by species depends on site-specific information, receptor homerange, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of soil ingested that is contaminated will likely be overestimated.

TABLE F-2-2

COPC DOSE INGESTED TERMS IN HERBIVOROUS BIRDS IN FOREST, SHRUB/SCRUB, SHORTGRASS PRAIRIE, AND TALLGRASS PRAIRIE FOOD WEBS

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Variable	Description	Units	Value
C_{wctot}	Total COPC concentration in water column	mg COPC/L water (or g COPC/m^3 water)	**Varies (calculated - Table B-2-16)** This variable is COPC- and site-specific and is calculated using Table B-2-16. Uncertainties associated with this equation include the following: (1) All of the variables in the equation in Table B-2-16. are COPC- and site-specific. Therefore, the use of default values rather than site-specific values, for any or all of these variables, will contribute to the under- or overestimation of C_{wctot}. (2) Uncertainty associated with f_{wc} is largely the result of uncertainty associated with default OC content values and may be significant in specific instances. Uncertainties associated with the variable L_T and K_{wt} may also be significant because of many variable-specific uncertainties. The degree of uncertainly associated with the variables d_{wc} and d_{bs} is expected to be minimal either because information for estimating a variable (d_{wc}) is generally available or because the probable range for a variable (d_{bs}) is narrow. The uncertainty associated with the variables f_{wc} and C_{wctot} is associated with estimates of *OC* content. Because *OC* content values can vary widely for different locations in the same medium, the uncertainty associated with using default *OC* values may be significant in specific cases.
IR_{W-HB}	Water ingestion rate for herbivorous bird	kg WW/kg BW-day	**Varies** This variable is receptor- and habitat-specific, and is discussed in Chapter 5. Ingestion rates for example measurement receptors are presented in Chapter 5, Table 5-1. The following uncertainty is associated with this variable: (1) Water ingestion rates are strongly influenced by animal behavior and environmental factors and may over- or under- estimate BCF_{W-HB} to an unknown degree.
P_W	Proportion of ingested water that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of water ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated water ingested by species depends on site-specific information, receptor homerange, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of ingested water that is contaminated will likely be overestimated.

TABLE F-2-2

COPC DOSE INGESTED TERMS IN HERBIVOROUS BIRDS IN FOREST, SHRUB/SCRUB, SHORTGRASS PRAIRIE, AND TALLGRASS PRAIRIE FOOD WEBS

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REFERENCES AND DISCUSSIONS

U.S. EPA. 1993. *Wildlife Exposure Factor Handbook.* Volumes I and II. Office of Research and Development. EPA/600/R-93/187a.

TABLE F-2-3

COPC DOSE INGESTED TERMS IN OMNIVOROUS MAMMALS IN FOREST, SHRUB/SCRUB, SHORTGRASS PRAIRIE, AND TALLGRASS PRAIRIE FOOD WEBS

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Description

This equation calculates the daily dose through exposure to contaminated food/prey, soil, and water in omnivorous mammals in upland forest, shortgrass prairie, tallgrass prairie, and shrub/scrub food webs. The limitations and uncertainties introduced in calculating this variable include the following:

(1) Variables C_s and C_{wctot} are COPC- and site-specific. Uncertainties associated with these variables will be site-specific.
(2) Variables $BCF_{S\text{-}OM}$, and $BCF_{W\text{-}OM}$ are based on biotransfer factors for beef cattle (Ba_{beef}), and receptor-specific ingestion rates, and therefore may introduce uncertainty when used to compute a representative daily dose for site-specific omnivorous mammals.

Equation

$$D_{OM} = \left(C_{HM} \cdot IR_{OM} \cdot P_{HM} \cdot F_{HM}\right) + \left(C_{HB} \cdot IR_{OM} \cdot P_{HB} \cdot F_{HB}\right) + \left(C_{INV} \cdot IR_{OM} \cdot P_{INV} \cdot F_{INV}\right)$$
$$+ \left(C_{TP} \cdot IR_{OM} \cdot P_{TP} \cdot F_{TP}\right) + \left(C_s \cdot IR_{S-OM} \cdot P_S\right) + \left(C_{wctot} \cdot IR_{W-OM} \cdot P_W\right)$$

Variable	Description	Units	Value
D_{OM}	Dose COPC ingested for omnivorous mammals	mg COPC/kg BW-day	
C_{HM}	Concentration of COPC in herbivorous mammals	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-2)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-9. Uncertainties associated with this variable include: (1) Variables C_{sed} and C_{wctot} are COPC- and site-specific. (2) Variables $BCF_{S\text{-}HM}$ and $BCF_{W\text{-}HM}$ are based on biotransfer factors for beef cattle (Ba_{beef}), and receptor-specific ingestion rates, and therefore may introduce uncertainty when used to compute concentrations for site-specific herbivorous mammals.

TABLE F-2-3

COPC DOSE INGESTED TERMS IN OMNIVOROUS MAMMALS IN FOREST, SHRUB/SCRUB, SHORTGRASS PRAIRIE, AND TALLGRASS PRAIRIE FOOD WEBS

(Page 2 of 8)

Variable	Description	Units	Value
IR_{OM}	Food ingestion rate of omnivorous mammal	kg WW/kg BW-day	**Varies** This variable is receptor-specific, and is discussed in Chapter 5. Ingestion rates for example measurement receptors are provided in Chapter 5, Table 5-1. Uncertainties associated with this variable include: (1) Food ingestion rates are influenced by several factors including: metabolic rate, energy requirements for growth and reproduction, and dietary composition. Ingestion rates are also influenced by ambient temperature, receptor activity level and body weight U.S. EPA (1993). These factors introduce an unknown degree of uncertainty when used to estimate daily dose. (2) *IR* values may over- or under- estimate exposure when applied to site-specific receptors.
P_{HM}	Proportion of herbivorous mammal in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommend that a default value of 1.0 be used for all food types when site specific information is not available. Uncertainties associated with this variable include: The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{HM}	Fraction of diet comprised of herbivorous mammals	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of herbivorous mammals. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. The application of an equal diet is further discussed in section Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of herbivorous mammals depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. Therefore a default value of 100 percent for the exclusive diet, may over-estimate dietary exposure.

TABLE F-2-3

COPC DOSE INGESTED TERMS IN OMNIVOROUS MAMMALS IN FOREST, SHRUB/SCRUB, SHORTGRASS PRAIRIE, AND TALLGRASS PRAIRIE FOOD WEBS

(Page 3 of 8)

Variable	Description	Units	Value
C_{HB}	Concentration of COPC in herbivorous birds	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-10)** This variable is site-specific and chemical-specific; it is calculated using the equation in Table F-1-10. Uncertainties associated with this variable include: (1) Variables: C_{sed}, and C_{wctot} are COPC- and site-specific. (2) Variables: $BCF_{S\text{-}HB}$ and $BCF_{W\text{-}HB}$ are based on biotransfer factors for beef cattle ($Ba_{chicken}$), and receptor-specific ingestion rates, and therefore may introduce uncertainty when used to compute concentrations for site-specific herbivorous mammals.
P_{HB}	Proportion of herbivorous birds in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{HB}	Fraction of diet comprised of herbivorous birds	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of herbivorous birds. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-3

COPC DOSE INGESTED TERMS IN OMNIVOROUS MAMMALS IN FOREST, SHRUB/SCRUB, SHORTGRASS PRAIRIE, AND TALLGRASS PRAIRIE FOOD WEBS

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Variable	Description	Units	Value
C_{INV}	Concentration of COPC in invertebrates	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-3)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-3. Uncertainties associated with this variable include: (1) Modeled soil concentrations may not accurately represent site-specific conditions. As a result, the actual COPC concentration in soil used to calculate the COPC concentration in invertebrates may be under- or overestimated to an unknown degree. (2) BCF_{S-INV} values may not accurately represent site-specific soil conditions and therefore, may over- or under-estimate C_{INV}.
P_{INV}	Proportion of invertebrate in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{INV}	Fraction of diet comprised of invertebrates	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of invertebrates. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-3

COPC DOSE INGESTED TERMS IN OMNIVOROUS MAMMALS IN FOREST, SHRUB/SCRUB, SHORTGRASS PRAIRIE, AND TALLGRASS PRAIRIE FOOD WEBS

(Page 5 of 8)

Variable	Description	Units	Value
C_{TP}	COPC concentration in terrestrial plants	mg COPC/kg WW	**Varies** This variable is site- and COPC-specific; it is calculated using the equation in Table F-1-1. Uncertainties introduced by this variable include the following: (1) Some of the variables in the equations in Tables B-3-1, B-3-2, and B-3-3—including *Cs*, *Cyv*, *Q*, *Dydp*, and *Dywp*—are COPC- and site-specific. (2) In the equation in Table B-3-1, uncertainties associated with other variables include the following: F_w (values for organic compounds estimated on the basis of the behavior of polystyrene microspheres), *Rp* (estimated on the basis of a generalized empirical relationship), and *kp* (estimation process does not consider chemical degradation). All of these uncertainties contribute to the overall uncertainty associated with C_{TP}.
P_{TP}	Proportion of terrestrial plant in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{TP}	Fraction of diet comprised of terrestrial plants	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of terrestrial plants. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-3

COPC DOSE INGESTED TERMS IN OMNIVOROUS MAMMALS IN FOREST, SHRUB/SCRUB, SHORTGRASS PRAIRIE, AND TALLGRASS PRAIRIE FOOD WEBS

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Variable	Description	Units	Value
Cs	COPC concentration in soil	mg COPC /kg DW soil	**Varies** This variable is COPC- and site-specific, and should be calculated using the equation in Table B-1-1. C_S is expressed on a dry weight basis. Uncertainties associated with this variable include: (1) For soluble COPCs, leaching might lead to movement to below 1 centimeter in untilled soils, resulting a greater mixing depth. This uncertainty may overestimate *Cs*. (2) Deposition to hard surfaces may result in dust residues that have negligible dilution (as a result of potential mixing with *in situ* materials) in comparison to that of other residues. This uncertainty may underestimate *Cs* (3) Modeled soil concentrations may not accurately represent site-specific conditions. As a result, the actual COPC concentration in soil may be under- or overestimated to an unknown degree.
$IR_{S\text{-}OM}$	Soil ingestion rate of omnivorous mammal	kg DW/kg BW-day	**Varies** This variable is site-, receptor-, and habitat-specific, and is discussed in Chapter 5. Ingestion rates for example measurement receptors are presented in Chapter 5, Table 5-1. Uncertainties associated with this variable include the following: (1) IR_S values may under- or over-estimate BCF_S when applied for site-specific organisms.
P_S	Proportion of ingested soil that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of soil ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for a screening level risk assessment when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated soil ingested by species depends on site-specific information, receptor homerange, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of soil ingested that is contaminated will likely be overestimated.

TABLE F-2-3

COPC DOSE INGESTED TERMS IN OMNIVOROUS MAMMALS IN FOREST, SHRUB/SCRUB, SHORTGRASS PRAIRIE, AND TALLGRASS PRAIRIE FOOD WEBS

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Variable	Description	Units	Value
C_{wctot}	Total COPC concentration in water column	mg COPC/L water (or g COPC/m^3 water)	**Varies (calculated - Table B-2-17)** This variable is COPC- and site-specific and is calculated using Table B-2-17. Uncertainties associated with this equation include the following: (1) All of the variables in the equation in Table B-2-17 are COPC- and site-specific. Therefore, the use of default values rather than site-specific values, for any or all of these variables, will contribute to the under- or overestimation of C_{wctot}. (2) Uncertainty associated with f_{wc} is largely the result of uncertainty associated with default OC content values and may be significant in specific instances. Uncertainties associated with the variable L_T and K_{wt} may result because of many variable-specific uncertainties. The degree of uncertainly associated with the variables d_{wc} and d_{bs} is expected to be minimal either because information for estimating a variable (d_{wc}) is generally available or because the probable range for a variable (d_{bs}) is narrow. The uncertainty associated with the variables f_{wc} and C_{wctot} is associated with estimates of *OC* content. Because *OC* content values can vary widely for different locations in the same media, using default *OC* values may result in uncertainty in specific cases.
$IR_{W\text{-}OM}$	Water ingestion rate for omnivorous mammal	L/kg DW-day	**Varies** This variable is receptor- and habitat-specific, and is discussed in Chapter 5. Ingestion rates for example measurement receptors are presented in Chapter 5, Table 5-1. The following uncertainty is associated with this variable: (1) Water ingestion rates are influenced by animal behavior and environmental factors and may over- or under-estimate $BCF_{W\text{-}OM}$ to an unknown degree.
P_W	Proportion of ingested water that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of water ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated water ingested by species depends on site-specific information, receptor homerange, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of ingested water that is contaminated will likely be overestimated.

TABLE F-2-3

COPC DOSE INGESTED TERMS IN OMNIVOROUS MAMMALS IN FOREST, SHRUB/SCRUB, SHORTGRASS PRAIRIE, AND TALLGRASS PRAIRIE FOOD WEBS

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REFERENCES AND DISCUSSIONS

U.S. EPA. 1993. *Wildlife Exposure Factor Handbook.* Volumes I and II. Office of Research and Development. EPA/600/R-93/187a

TABLE F-2-4

COPC DOSE INGESTED TERMS IN OMNIVOROUS BIRDS IN FOREST, SHRUB/SCRUB, TALLGRASS PRAIRIE, AND SHORTGRASS PRAIRIE FOOD WEBS

(Page 1 of 6)

Description

This equation calculates the daily dose through exposure to contaminated food/prey, soil, and water in omnivorous birds in upland forest, shortgrass prairie, tallgrass prairie, and shrub/scrub food webs. The limitations and uncertainties introduced in calculating this variable include the following:

(1) Variables C_s and C_{wctot} are COPC- and site-specific. Uncertainties associated with these variables will be site specific.
(2) Variables $BCF_{S\text{-}OB}$, and $BCF_{W\text{-}OB}$ are based on biotransfer factors for chicken ($Ba_{chicken}$), and receptor specific ingestion rates, and therefore may introduce uncertainty when used to compute a daily dose for site-specific omnivorous birds.

Equation

$$D_{OB} = \left(C_{INV} \cdot IR_{OB} \cdot P_{INV} \cdot F_{INV}\right) + \left(C_{TP} \cdot IR_{OB} \cdot P_{TP} \cdot F_{TP}\right) + \left(C_s \cdot IR_{S-OB} \cdot P_S\right) + \left(C_{wctot} \cdot IR_{W-OB} \cdot P_W\right)$$

Variable	Description	Units	Value
D_{OB}	Dose COPC ingested for omnivorous birds	mg COPC/kg BW-day	
C_{INV}	Concentration of COPC in invertebrates	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-3)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-3. Uncertainties associated with this variable include: (1) Modeled soil concentrations may not accurately represent site-specific conditions. As a result, the actual COPC concentration in soil used to calculate the COPC concentration in invertebrates may be under- or overestimated to an unknown degree. (2) $BCF_{S\text{-}INV}$ values may not accurately represent site-specific soil conditions and therefore, may over- or under-estimate C_{INV}.

TABLE F-2-4

COPC DOSE INGESTED TERMS IN OMNIVOROUS BIRDS IN FOREST, SHRUB/SCRUB, TALLGRASS PRAIRIE, AND SHORTGRASS PRAIRIE FOOD WEBS

(Page 2 of 6)

Variable	Description	Units	Value
IR_{OB}	Food ingestion rate of omnivorous bird	kg WW/kg BW-day	**Varies** This variable is receptor-specific, and is discussed in Chapter 5. Ingestion rates for example measurement receptors are provided in Chapter 5, Table 5-1. Uncertainties associated with this variable include: (1) Food ingestion rates are influenced by several factors including: metabolic rate, energy requirements for growth and reproduction, and dietary composition. Ingestion rates are also influenced by ambient temperature, receptor activity level and body weight U.S. EPA (1993). These factors introduce an unknown degree of uncertainty when used to estimate daily dose. (2) IR values may over- or under- estimate exposure when applied to site-specific receptors.
P_{INV}	Proportion of invertebrate in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{INV}	Fraction of diet comprised of invertebrates	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of invertebrates. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-4

COPC DOSE INGESTED TERMS IN OMNIVOROUS BIRDS IN FOREST, SHRUB/SCRUB, TALLGRASS PRAIRIE, AND SHORTGRASS PRAIRIE FOOD WEBS

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Variable	Description	Units	Value
C_{TP}	COPC concentration in terrestrial plants	mg COPC/kg WW	**Varies** This variable is site- and COPC-specific; it is calculated using the equation in Table F-1-1. Uncertainties introduced by this variable include the following: (1) Some of the variables in the equations in Tables B-3-1, B-3-2, and B-3-3—including *Cs*, *Cyv*, *Q*, *Dydp*, and *Dywp*—are COPC- and site-specific. (2) In the equation in Table B-3-1, uncertainties associated with other variables include the following: F_w (values for organic compounds estimated on the basis of the behavior of polystyrene microspheres), *Rp* (estimated on the basis of a generalized empirical relationship), and *kp* (estimation process does not consider chemical degradation).
P_{TP}	Proportion of terrestrial plant in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{TP}	Fraction of diet comprised of terrestrial plants	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of terrestrial plants. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-4

COPC DOSE INGESTED TERMS IN OMNIVOROUS BIRDS IN FOREST, SHRUB/SCRUB, TALLGRASS PRAIRIE, AND SHORTGRASS PRAIRIE FOOD WEBS

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Variable	Description	Units	Value
Cs	COPC concentration in soil	mg COPC /kg DW soil	**Varies** This variable is COPC- and site-specific, and should be calculated using the equation in Table B-1-1. C_S is expressed on a dry weight basis. Uncertainties associated with this variable include: (1) For soluble COPCs, leaching might lead to movement to below 1 centimeter in untilled soils, resulting a greater mixing depth. This uncertainty may overestimate Cs. (2) Deposition to hard surfaces may result in dust residues that have negligible dilution (as a result of potential mixing with *in situ* materials) in comparison to that of other residues. This uncertainty may underestimate Cs. (3) Modeled soil concentrations may not accurately represent site-specific conditions. As a result, the actual
$IR_{S\text{-}OB}$	Soil ingestion rate for omnivorous bird	kg DW/kg BW-day	**Varies** This variable is site-, receptor-, and habitat-specific, and is discussed in Chapter 5. Ingestion rates for example measurement receptors are presented in Chapter 5, Table 5-1. Uncertainties associated with this variable include the following: (1) IR_S values may under- or over-estimate BCF_S when applied to site-specific organisms.
P_S	Proportion of ingested soil that is contamanted	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of soil ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for a screening level risk assessment when site-specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated soil ingested by species depends on site-specific information, receptor homerange, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of soil ingested that is contaminated may be overestimated.

TABLE F-2-4

COPC DOSE INGESTED TERMS IN OMNIVOROUS BIRDS IN FOREST, SHRUB/SCRUB, TALLGRASS PRAIRIE, AND SHORTGRASS PRAIRIE FOOD WEBS

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Variable	Description	Units	Value
C_{wctot}	Total COPC concentration in water column	mg COPC/L water (or g COPC/m^3 water)	**Varies (calculated - Table B-2-17)** This variable is COPC- and site-specific and is calculated using Table B-2-17. Uncertainties associated with this equation include the following: (1) All of the variables in the equation in Table B-2-17 are COPC- and site-specific. Therefore, the use of default values rather than site-specific values, for any or all of these variables, will contribute to the under- or overestimation of C_{wctot}. (2) Uncertainty associated with f_{wc} is largely the result of uncertainty associated with default OC content values and may be significant in specific instances. Uncertainties associated with the variable L_T and K_{wt} may also be significant because of many variable-specific uncertainties. The degree of uncertainly associated with the variables d_{wc} and d_{bs} is expected to be minimal either because information for estimating a variable (d_{wc}) is generally available or because the probable range for a variable (d_{bs}) is narrow. The uncertainty associated with the variables f_{wc} and C_{wctot} is associated with estimates of *OC* content. Because *OC* content values can vary widely for different locations in the same media, default *OC* values will result in uncertainty in specific cases.
$IR_{W\text{-}OB}$	Water ingestion rate for omnivorous bird	L/kg BW-day	**Varies** This variable is receptor- and habitat-specific, and is discussed in Chapter 5. Ingestion rates for example measurement receptors are presented in Chapter 5, Table 5-1. The following uncertainty is associated with this variable: (1) Water ingestion rates are influenced by animal behavior and environmental factors and may over- or under-estimate $BCF_{W\text{-}OB}$ to an unknown degree.
P_W	Proportion of ingested water that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of water ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated water ingested by species depends on site-specific information, receptor homerange, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of ingested water that is contaminated may be overestimated.

TABLE F-2-4

COPC DOSE INGESTED TERMS IN OMNIVOROUS BIRDS IN FOREST, SHRUB/SCRUB, TALLGRASS PRAIRIE, AND SHORTGRASS PRAIRIE FOOD WEBS

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REFERENCES AND DISCUSSIONS

U.S. EPA. 1993. *Wildlife Exposure Factor Handbook.* Volumes I and II. Office of Research and Development. EPA/600/R-93/187a.

TABLE F-2-5

COPC DOSE INGESTED TERMS IN CARNIVOROUS MAMMALS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

Description

This equation calculates the daily dose through exposure to food/prey, soil, and water in carnivorous mammal in upland forest, shortgrass prairie, tallgrass prairie, and shrub/scrub food webs. The limitations and uncertainties introduced in calculating this variable include the following:

(1) Variables C_s and C_{wctot} are COPC- and site-specific. Uncertainties associated with these variables will be site-specific
(2) Variables $BCF_{S\text{-}CM}$, and $BCF_{W\text{-}CM}$ are based on biotransfer factors for beef cattle (Ba_{beef}), and receptor-specific ingestion rates, and therefore may introduce uncertainty when used to compute a representative daily dose for site-specific carnivorous mammals.

Equation

$$D_{CM} = \left(C_{HB} \cdot IR_{CM} \cdot P_{HB} \cdot F_{HB}\right) + \left(C_{OB} \cdot IR_{CM} \cdot P_{OB} \cdot F_{OB}\right) + \left(C_{OM} \cdot IR_{CM} \cdot P_{OM} \cdot F_{OM}\right) + \left(C_{HM} \cdot IR_{CM} \cdot P_{HM} \cdot F_{HM}\right)$$
$$+ \left(C_s \cdot IR_{S-CM} \cdot P_S\right) + \left(C_{wctot} \cdot IR_{W-CM} \cdot P_W\right)$$

Variable	Description	Units	Value
D_{CM}	Dose COPC ingested for carnivorous mammals	mg COPC/kg BW-day	
C_{HB}	Concentration of COPC in herbivorous birds	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-10)** This variable is site-specific and chemical-specific; it is calculated using the equation in Table F-1-10. Uncertainties associated with this variable include: (1) Variables Cs and C_{wctot} are COPC- and site-specific. (2) Variables $BCF_{S\text{-}HB}$ and $BCF_{W\text{-}HB}$ are based on biotransfer factors for chicken ($Ba_{chicken}$), and receptor-specific ingestion rates, and therefore may introduce uncertainty when used to compute concentrations for site-specific herbivorous birds.

TABLE F-2-5

COPC DOSE INGESTED TERMS IN CARNIVOROUS MAMMALS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

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Variable	Description	Units	Value
IR_{CM}	Food ingestion rate of carnivorous mammal	kg WW/kg BW-day	**Varies** This variable is receptor-specific, and is discussed in Chapter 5, Table 5-1. Uncertainties associated with this variable include: (1) Food ingestion rates are influenced by several factors including: metabolic rate, energy requirements for growth and reproduction, and dietary composition. Ingestion rates are also influenced by ambient temperature, receptor activity level and body weight U.S. EPA (1993). These factors introduce an unknown degree of uncertainty when used to estimate daily dose. (2) *IR* values may over- or under- estimate exposure when applied for site-specific receptors.
P_{HB}	Proportion of herbivorous birds in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{HB}	Fraction of diet comprised of herbivorous birds	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of herbivorous birds. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-5

COPC DOSE INGESTED TERMS IN CARNIVOROUS MAMMALS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

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Variable	Description	Units	Value
C_{OB}	Concentration of COPC in omnivorous birds	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-6)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-6. Uncertainties associated with this variable include: (1) Variables Cs and C_{wctot} are COPC- and site-specific. Uncertainties associated with these variables will be site-specific. (2) Variables $BCF_{S\text{-}OB}$ and $BCF_{W\text{-}OB}$ are based on biotransfer factors for chicken ($Ba_{chicken}$), and receptor-specific ingestion rates, and therefore may introduce uncertainty when used to compute concentrations for site-specific omnivorous birds.
P_{OB}	Proportion of omnivorous bird diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommend that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{OB}	Fraction of diet comprised of omnivorous birds	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of omnivorous birds. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-5

COPC DOSE INGESTED TERMS IN CARNIVOROUS MAMMALS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

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Variable	Description	Units	Value
C_{OM}	Concentration of COPC in omnivorous mammals	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-5)** This variable is site-specific and COPC-specific, and is calculated using the equation in Table F-1-5. Uncertainties associated with this variable include: (1) Variables Cs and C_{wctot} are COPC- and site-specific. Uncertainties associated with these variables will be site-specific. (2) Variables $BCF_{S\text{-}OM}$ and $BCF_{W\text{-}OM}$ are based on biotransfer factors for beef (Ba_{beef}), and receptor specific ingestion rates, and therefore may introduce uncertainty when used to compute concentrations for site-specific omnivorous mammals.
P_{OM}	Proportion of omnivorous mammal diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{OM}	Fraction of diet comprised of omnivorous mammals	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of omnivorous mammals. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-5

COPC DOSE INGESTED TERMS IN CARNIVOROUS MAMMALS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

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Variable	Description	Units	Value
C_{HM}	Concentration of COPC in herbivorous mammals	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-9)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-9. Uncertainties associated with this variable include: (1) Variables Cs and C_{wctot} are COPC- and site-specific. (2) Variables $BCF_{S\text{-}HM}$ and $BCF_{W\text{-}HM}$ are based on biotransfer factors for beef cattle (Ba_{beef}), and receptor specific ingestion rates, and therefore may introduce uncertainty when used to compute concentrations for site-specific herbivorous mammals.
P_{HM}	Proportion of herbivorous mammal in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommend that a default value of 1.0 be used for all food types when site specific information is not available. Uncertainties associated with this variable include: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{HM}	Fraction of diet comprised of herbivorous mammals	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of herbivorous mammals. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of herbivorous mammals depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. Therefore a default value of 100 percent for the exclusive diet, may over-estimate dietary exposure.

TABLE F-2-5

COPC DOSE INGESTED TERMS IN CARNIVOROUS MAMMALS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

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Variable	Description	Units	Value
Cs	COPC concentration in soil	mg COPC /kg DW soil	**Varies** This variable is COPC- and site-specific, and should be calculated using the equation in Table B-1-1. *Cs* is expressed on a dry weight basis. Uncertainties associated with this variable include: (1) For soluble COPCs, leaching might lead to movement to below 1 centimeter in untilled soils, resulting a greater mixing depth. This uncertainty may overestimate *Cs*. (2) Deposition to hard surfaces may result in dust residues that have negligible dilution (as a result of potential mixing with *in situ* materials) in comparison to that of other residues. This uncertainty may underestimate *Cs* (3) Modeled soil concentrations may not accurately represent site-specific conditions. As a result, the actual COPC concentration in soil may be under- or overestimated to an unknown degree.
$IR_{S\text{-}CM}$	Soil ingestion rate for carnivorous mammal	kg DW/kg BW-day	**Varies** This variable is site-, receptor-, and habitat-specific, and is discussed in Chapter 5; Table 5-1. Uncertainties associated with this variable include the following: (1) IR_S values may under- or over-estimate BCF_S when applied to site-specific organisms.
P_S	Proportion of ingested soil that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of soil ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for a screening level risk assessment when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated soil ingested by species depends on site-specific information, receptor homerange, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of soil ingested that is contaminated may be overestimated.

TABLE F-2-5

COPC DOSE INGESTED TERMS IN CARNIVOROUS MAMMALS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

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Variable	Description	Units	Value
C_{wctot}	Total COPC concentration in water column	mg COPC/L water (or g COPC/m^3 water)	**Varies (calculated - Table B-2-17)** This variable is COPC- and site-specific and is calculated using Table B-2-17. Uncertainties associated with this equation include the following: (1) All of the variables in the equation in Table B-2-17 are COPC- and site-specific. Therefore, the use of default values rather than site-specific values, for any or all of these variables, will contribute to the under- or overestimation of C_{wctot}. (2) Uncertainty associated with f_{wc} is largely the result of uncertainty associated with default OC content values. Uncertainties may also be associated with the variable L_T and K_{wt}. The degree of uncertainly associated with the variables d_{wc} and d_{bs} is expected to be minimal either because information for estimating a variable (d_{wc}) is generally available or because the probable range for a variable (d_{bs}) is narrow. The uncertainty associated with the variables f_{wc} and C_{wctot} is associated with estimates of *OC* content. Because *OC* content values can vary widely for different locations in the same medium, the uncertainty associated with using default *OC* values may be significant in specific cases.
$IR_{W\text{-}CM}$	Water ingestion rate for carnivorous mammal	L/kg BW-day	**Varies** This variable is receptor- and habitat-specific, and is discussed in Chapter 5. Ingestion rates for example measurement receptors are presented in, Table 5-1. The following uncertainty is associated with this variable: (1) Water ingestion rates are strongly influenced by animal behavior and environmental factors and may over- or under- estimate $BCF_{W\text{-}CM}$ to an unknown degree.
P_W	Proportion of ingested water that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of water ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated water ingested by species depends on site-specific information, receptor homerange, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of ingested water that is contaminated may be overestimated.

TABLE F-2-5

COPC DOSE INGESTED TERMS IN CARNIVOROUS MAMMALS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

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REFERENCES AND DISCUSSIONS

U.S. EPA. 1993. *Wildlife Exposure Factor Handbook.* Volumes I and II. Office of Research and Development. EPA/600/R-93/187a

TABLE F-2-6

COPC DOSE INGESTED TERMS IN CARNIVOROUS BIRDS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

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Description

This equation calculates the potential daily dose through exposure to contaminated food/prey, soil, and water in carnivorous birds in upland forest, shortgrass prairie, tallgrass prairie, and shrub/scrub food webs. The limitations and uncertainties introduced in calculating this variable include the following:

(1) Variables Cs and C_{wctot} are COPC- and site-specific. Uncertainties associated with these variables will be site-specific.
(2) Variables $BCF_{S\text{-}CB}$ and $BCF_{W\text{-}CB}$ are based on biotransfer factors for chicken ($Ba_{chicken}$), and receptor-specific ingestion rates, and therefore may introduce uncertainty when used to compute a representative daily dose for site-specific carnivorous birds.

Equation

$$D_{CB} = \left(C_{HB} \cdot IR_{CB} \cdot P_{HB} \cdot F_{HB}\right) + \left(C_{OM} \cdot IR_{CB} \cdot P_{OM} \cdot F_{OM}\right) + \left(C_{HM} \cdot IR_{CB} \cdot P_{HM} \cdot F_{HM}\right) + \left(C_{OB} \cdot IR_{CB} \cdot P_{OB} \cdot F_{OB}\right) + \left(C_{s} \cdot IR_{S-CB} \cdot P_{S}\right) + \left(C_{wctot} \cdot IR_{W-CB} \cdot P_{W}\right)$$

Variable	Description	Units	Value
D_{CB}	Dose COPC ingested for carnivorous birds	mg COPC/kg BW-day	
C_{HB}	Concentration of COPC in herbivorous birds	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-10)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-10. Uncertainties associated with this variable include: (1) Variables Cs and C_{wctot} are COPC- and site-specific. (2) Variables $BCF_{S\text{-}HB}$ and $BCF_{W\text{-}HB}$ are based on biotransfer factors for chicken ($Ba_{chicken}$), and receptor-specific ingestion rates, and therefore may introduce uncertainty when used to compute concentrations for site-specific herbivorous birds.

TABLE F-2-6

COPC DOSE INGESTED TERMS IN CARNIVOROUS BIRDS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

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Variable	Description	Units	Value
IR_{CB}	Food ingestion rate of carnivorous bird	kg WW/kg DW-day	**Varies** This variable is receptor-specific, and is discussed in Chapter 5. Ingestion rates for example measurement receptors are provided in Table 5-1. Uncertainties associated with this variable include: (1) Food ingestion rates are influenced by several factors including: metabolic rate, energy requirements for growth and reproduction, and dietary composition. Ingestion rates are also influenced by ambient temperature, receptor activity level and body weight U.S. EPA (1993). These factors introduce an unknown degree of uncertainty when used to estimate daily dose. (2) IR values may over- or under- estimate exposure when applied for site-specific receptors.
P_{HB}	Proportion of herbivorous birds in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{HB}	Fraction of diet comprised of herbivorous birds	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of herbivorous birds. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-6

COPC DOSE INGESTED TERMS IN CARNIVOROUS BIRDS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

Variable	Description	Units	Value
C_{OM}	Concentration of COPC in omnivorous mammals	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-5)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-5. Uncertainties associated with this variable include: (1) Variables Cs and C_{wctot} are COPC- and site-specific. Uncertainties associated with these variables will be site-specific. (2) Variables BCF_{S-OM} and BCF_{W-OM} are based on biotransfer factors for beef (Ba_{beef}), and receptor specific ingestion rates, and therefore may introduce uncertainty when used to compute concentrations for site-specific omnivorous mammals.
P_{OM}	Proportion of omnivorous mammal diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{OM}	Fraction of diet comprised of omnivorous mammals	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of omnivorous mammals. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-6

COPC DOSE INGESTED TERMS IN CARNIVOROUS BIRDS
IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 4 of 8)

Variable	Description	Units	Value
C_{HM}	Concentration of COPC in herbivorous mammals	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-9)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-9. Uncertainties associated with this variable include: (1) Variables Cs and C_{wctot} are COPC- and site-specific. Uncertainties associated with these variables will be site-specific. (2) Variables $BCF_{S\text{-}HM}$ and $BCF_{W\text{-}HM}$ are based on biotransfer factors for beef cattle (Ba_{beef}), and receptor-specific ingestion rates, and therefore may introduce uncertainty when used to compute concentrations for site-specific herbivorous mammals.
P_{HM}	Proportion of herbivorous mammal in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. Uncertainties associated with this variable include: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{HM}	Fraction of diet comprised of herbivorous mammals	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of herbivorous mammals. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of herbivorous mammals depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. Therefore a default value of 100 percent for the exclusive diet, may over-estimate dietary exposure.

TABLE F-2-6

COPC DOSE INGESTED TERMS IN CARNIVOROUS BIRDS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 5 of 8)

Variable	Description	Units	Value
C_{OB}	Concentration of COPC in omnivorous birds	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-6)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-6. Uncertainties associated with this variable include: (1) Variables Cs and C_{wctot} are COPC- and site-specific. Uncertainties associated with these variables will be site-specific. (2) Variables BCF_{S-OB} and BCF_{W-OB} are based on biotransfer factors for chicken ($Ba_{chicken}$), and receptor specific ingestion rates, and therefore may introduce uncertainty when used to compute concentrations for site-specific omnivorous birds.
P_{OB}	Proportion of omnivorous bird diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{OB}	Fraction of diet comprised of omnivorous birds	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of omnivorous birds. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-6

COPC DOSE INGESTED TERMS IN CARNIVOROUS BIRDS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

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Variable	Description	Units	Value
Cs	COPC concentration in soil	mg COPC /kg DW soil	**Varies** This variable is COPC- and site-specific, and should be calculated using the equation in Table B-1-1. *Cs* is expressed on a dry weight basis. Uncertainties associated with this variable include: (1) For soluble COPCs, leaching might lead to movement to below 1 centimeter in untilled soils, resulting a greater mixing depth. This uncertainty may overestimate *Cs*. (2) Deposition to hard surfaces may result in dust residues that have negligible dilution (as a result of potential mixing with *in situ* materials) in comparison to that of other residues. This uncertainty may underestimate *Cs* (3) Modeled soil concentrations may not accurately represent site-specific conditions. As a result, the actual COPC concentration in soil may be under- or overestimated to an unknown degree.
$IR_{S\text{-}CB}$	Soil ingestion rate for carnivorous bird	kg DW/kg BW-day	**Varies** This variable is site-, receptor-, and habitat-specific, and is discussed in Chapter 5. Ingestion rates for example measurement receptors are presented in Chapter 5, Table 5-1. Uncertainties associated with this variable include the following: (1) IR_S values may under- or over-estimate BCF_S when applied for site-specific organisms.
P_S	Proportion of ingested soil that is contamanted	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of soil ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for a screening level risk assessment when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated soil ingested by species depends on site-specific information, receptor homerange, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of soil ingested that is contaminated will likely be overestimated.

TABLE F-2-6

COPC DOSE INGESTED TERMS IN CARNIVOROUS BIRDS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 7 of 8)

Variable	Description	Units	Value
C_{wctot}	Total COPC concentration in water column	mg COPC/L water (or g COPC/m^3 water)	**Varies (calculated - Table B-2-17)** This variable is COPC- and site-specific and is calculated using Table B-2-17. Uncertainties associated with this equation include the following: (1) All of the variables in the equation in Table B-2-17 are COPC- and site-specific. Therefore, the use of default values rather than site-specific values, for any or all of these variables, will contribute to the under- or overestimation of C_{wctot}. (2) Uncertainty associated with f_{wc} is largely the result of uncertainty associated with default OC content values. The degree of uncertainly associated with the variables d_{wc} and d_{bs} is expected to be minimal either because information for estimating a variable (d_{wc}) is generally available or because the probable range for a variable (d_{bs}) is narrow. The uncertainty associated with the variables f_{wc} and C_{wctot} is associated with estimates of *OC* content. Because *OC* content values can vary widely for different locations in the same medium, the uncertainty associated with using default *OC* values may be significant in specific cases.
IR_{W-CB}	Water ingestion rate for carnivorous bird	L/kg DW-day	**Varies** This variable is receptor- and habitat-specific, and is discussed in Chapter 5.. Ingestion rates for example measurement receptors are presented in Chapter 5, Table 5-1. The following uncertainty is associated with this variable: (1) Water ingestion rates are strongly influenced by animal behavior and environmental factors and may over- or under- estimate BCF_{W-CB} to an unknown degree.
P_W	Proportion of ingested water that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of water ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated water ingested by species depends on site-specific information, receptor homerange, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of ingested water that is contaminated will likely be overestimated.

TABLE F-2-6

COPC DOSE INGESTED TERMS IN CARNIVOROUS BIRDS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

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REFERENCES AND DISCUSSIONS

U.S. EPA. 1993. *Wildlife Exposure Factor Handbook.* Volumes I and II. Office of Research and Development. EPA/600/R-93/187a

TABLE F-2-7

COPC DOSE INGESTED TERMS IN HERBIVOROUS MAMMALS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 1 of 6)

Description

This equation calculates the daily dose through the ingestion of contaminated food/prey, sediment, and water in aquatic herbivorous mammals in freshwater marsh, brackish/intermediate marsh, and saltwater marsh food webs. The limitations and uncertainties introduced in calculating this variable include the following:

(1) Variables C_{sed} and C_{wctot} are COPC- and site-specific. Uncertainties associated with these variables will be site-specific.
(2) Variables $BCF_{BS\text{-}HM}$, and $BCF_{W\text{-}HM}$ are based on biotransfer factors for beef cattle (Ba_{beef}), and receptor specific ingestion rates, and therefore may introduce uncertainty when used to compute a representative daily dose for site-specific herbivorous mammals.

Equation

$$D_{HM} = \left(C_{AV} \cdot IR_{HM} \cdot P_{AV} \cdot F_{AV}\right) + \left(C_{AL} \cdot IR_{HM} \cdot P_{AL} \cdot F_{AL}\right) + \left(C_{sed} \cdot IR_{S-HM} \cdot P_S\right) + \left(C_{wctot} \cdot IR_{W-HM} \cdot P_W\right)$$

Variable	Description	Units	Value
D_{HM}	Dose COPC ingested for aquatic herbivorous mammals	mg COPC/kg BW-day	
C_{AV}	Concentration of COPC in aquatic vegetation	mg COPC/kg WW	**Varies (calculated - Table F-1-7)** This variable is site- and COPC-specific; it is calculated using the equation in Table F-1-7. Uncertainties associated with this variable include: (1) C_{sed} values are COPC- and site-specific. Uncertainties associated with this variable will be site-specific. (2) $BCF_{S\text{-}AV}$ values are intended to represent "generic aquatic vegetation species", and therefore may over- or under-estimate exposure when applied to site-specific vegetation.

TABLE F-2-7

COPC DOSE INGESTED TERMS IN HERBIVOROUS MAMMALS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 2 of 6)

Variable	Description	Units	Value
IR_{HM}	Food ingestion rate of aquatic herbivorous mammal	kg WW/kg BW-day	**Varies** This variable is receptor-specific, and is discussed in Chapter 5. Ingestion rates for example measurement receptors are provided in Chapter 5, Table 5-1. Uncertainties associated with this variable include: (1) Food ingestion rates are influenced by several factors including: metabolic rate, energy requirements for growth and reproduction, and dietary composition. Ingestion rates are also influenced by ambient temperature, receptor activity level and body weight U.S. EPA (1993). These factors introduce an unknown degree of uncertainty when used to estimate daily dose. (2) IR values may over- or under- estimate exposure when applied for site-specific receptors.
P_{AV}	Proportion of aquatic vegetation in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{AV}	Fraction of diet comprised of aquatic vegetation	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of aquatic vegetation. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-7

COPC DOSE INGESTED TERMS IN HERBIVOROUS MAMMALS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 3 of 6)

Variable	Description	Units	Value
C_{AL}	Concentration of COPC in algae	mg COPC/kg WW	**Varies (calculated - Table F-1-8)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-8. Uncertainties associated with this variable include: (1) C_{dw} values are COPC- and site-specific. Uncertainties associated with this variable will be site-specific. (2) $BCF_{W\text{-}AL}$ values are intended to represent "generic algae species", and therefore may over- or under-estimate exposure when applied to site-specific species.
P_{AL}	Proportion of algae in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{AL}	Fraction of diet comprised of algae	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of algae. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-7

COPC DOSE INGESTED TERMS IN HERBIVOROUS MAMMALS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 4 of 6)

Variable	Description	Units	Value
C_{sed}	COPC concentration in bed sediment	mg COPC/kg DW sediment	**Varies (calculated - Table B-2-19)** This equation calculates the concentration of COPCs in bed sediments. Uncertainties associated with this equation include the following: (1) The default variable values recommended for use in the equation in Table B-2-19 may not accurately represent site-specific water body conditions. The degree of uncertainty associated with default variable values is expected to be limited either because the probable ranges for these variables are narrow or because information allowing reasonable estimates is generally available. (2) Uncertainties associated with variables f_{bs}, C_{wctot} and Kd_{bs} are largely associated with the use of default *OC* content values in their calculation. The uncertainty may be significant in specific instances, because *OC* content is known to vary widely in different locations in the same medium. This variable is site-specific.
$IR_{S\text{-}HM}$	Sediment ingestion rate for aquatic herbivorous mammal	kg DW/kg BW-day	**Varies** This variable is site-, receptor-, and habitat-specific, and is discussed in Chapter 5. Ingestion rates for example measurement receptors are presented in Chapter 5, Table 5-1. Uncertainties associated with this variable include the following: (1) IR_S values may under- or over-estimate BCF_S when applied for site-specific organisms.
P_S	Proportion of ingested bed sediment that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of sediment ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for a screening level risk assessment when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated soil ingested by species depends on site-specific information, receptor homerange, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of soil ingested that is contaminated will likely be overestimated.

TABLE F-2-7

COPC DOSE INGESTED TERMS IN HERBIVOROUS MAMMALS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 5 of 6)

Variable	Description	Units	Value
C_{wctot}	Total COPC concentration in water column	mg COPC/L water (or g COPC/m^3 water)	**Varies (calculated - Table B-2-17)** This variable is COPC- and site-specific and is calculated using Table B-2-17. Uncertainties associated with this equation include the following: (1) All of the variables in the equation in Table B-2-17 are COPC- and site-specific. Therefore, the use of default values rather than site-specific values, for any or all of these variables, will contribute to the under- or overestimation of C_{wctot}. (2) Uncertainty associated with f_{wc} is largely the result of uncertainty associated with default OC content values. Uncertainties may also be associated with the variable L_T and k_{wt}. The degree of uncertainly associated with the variables d_{wc} and d_{bs} is expected to be minimal either because information for estimating a variable (d_{wc}) is generally available or because the probable range for a variable (d_{bs}) is narrow. The uncertainty associated with the variables f_{wc} and C_{wctot} is associated with estimates of *OC* content. Because *OC* content values can vary widely for different locations in the same medium, the uncertainty associated with using default *OC* values may be significant in specific cases.
IR_{W-HM}	Water ingestion rate for aquatic herbivorous mammal	L/kg-BW-day	**Varies** This variable is receptor- and habitat-specific, and is discussed in Chapter 5.. Ingestion rates for example measurement receptors are presented in Chapter 5, Table 5-1. The following uncertainty is associated with this variable: (1) Water ingestion rates are influenced by animal behavior and environmental factors and may over- or under-estimate BCF_{W-HM} to an unknown degree.
P_W	Proportion of ingested water that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of water ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated water ingested by species depends on site-specific information, receptor homerange, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of ingested water that is contaminated will likely be overestimated.

TABLE F-2-7

COPC DOSE INGESTED TERMS IN HERBIVOROUS MAMMALS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

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REFERENCES AND DISCUSSIONS

U.S. EPA. 1993. *Wildlife Exposure Factor Handbood.* Volumes I and II. Office of Research and Development. EPA/600/R-93/187a

TABLE F-2-8

COPC DOSE INGESTED TERMS IN HERBIVOROUS BIRDS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 1 of 6)

Description

This equation calculates the daily dose through ingestion of contaminated food/prey, sediment, and water in aquatic herbivorous birds in freshwater marsh, brackish/intermediate marsh, and saltwater marsh food webs. The limitations and uncertainties introduced in calculating this variable include the following:

(1) Variables C_{sed} and C_{wctot} are COPC- and site-specific. Uncertainties associated with these variables will be site-specific.
(2) Variables BCF_{S-HB} and BCF_{W-HB} are based on biotransfer factors for chicken ($Ba_{chicken}$), and receptor-specific ingestion rates, and therefore may introduce uncertainty when used to compute a representative daily dose for site-specific herbivorous birds.

Equation

$$D_{HB} = \left(C_{AV} \cdot IR_{HB} \cdot P_{AV} \cdot F_{AV}\right) + \left(C_{AL} \cdot IR_{HB} \cdot P_{AL} \cdot F_{AL}\right) + \left(C_{sed} \cdot IR_{S-HB} \cdot P_{S}\right) + \left(C_{wctot} \cdot IR_{W-HB} \cdot P_{W}\right)$$

Variable	Description	Units	Value
D_{HB}	Dose ingested for herbivorous birds	mg/kg BW-day	
C_{AV}	Concentration of COPC in aquatic vegetation	mg COPC/kg WW	**Varies (calculated - Table F-1-7)** This variable is site- and COPC-specific; it is calculated using the equation in Table F-1-7. Uncertainties associated with this variable include: (1) C_{sed} values are COPC- and site-specific. (2) BCF_{S-AV} values are intended to represent "generic aquatic vegetation species", and therefore may over- or under-estimate exposure when applied to site-specific vegetation.
IR_{HB}	Food ingestion rate of aquatic herbivorous bird	kg WW/kg BW-day	**Varies** This variable is receptor-specific, and is discussed in Chapter 5. Ingestion rates for example measurement receptors are provided in Chapter 5, Table 5-1. Uncertainties associated with this variable include: (1) Food ingestion rates are influenced by several factors including: metabolic rate, energy requirements for growth and reproduction, and dietary composition. Ingestion rates are also influenced by ambient temperature, receptor activity level and body weight U.S. EPA (1993). These factors introduce an unknown degree of uncertainty when used to estimate daily dose. (2) IR values may over- or under- estimate exposure when applied for site-specific receptors.

TABLE F-2-8

COPC DOSE INGESTED TERMS IN HERBIVOROUS BIRDS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 2 of 6)

Variable	Description	Units	Value
P_{AV}	Proportion of aquatic vegetation in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{AV}	Fraction of diet comprised of aquatic vegetation	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of aquatic vegetation. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.
C_{AL}	Concentration of COPC in algae	mg COPC/kg WW	**Varies (calculated - Table F-1-8)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-8. Uncertainties associated with this variable include: (1) C_{dw} values are COPC- and site-specific. Uncertainties associated with this variable will be site-specific. (2) BCF_{W-AL} values are intended to represent "generic algae species", and therefore may over- or under-estimate exposure when applied to site-specific species.

TABLE F-2-8

COPC DOSE INGESTED TERMS IN HERBIVOROUS BIRDS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 3 of 6)

Variable	Description	Units	Value
P_{AL}	Proportion of algae in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{AL}	Fraction of diet comprised of algae	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of algae. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-8

COPC DOSE INGESTED TERMS IN HERBIVOROUS BIRDS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 4 of 6)

Variable	Description	Units	Value
C_{sed}	COPC concentration in bed sediment	mg COPC/kg DW sediment	**Varies (calculated - Table B-2-19)** This equation calculates the concentration of COPCs in bed sediments. Uncertainties associated with this equation include the following: (1) The default variable values recommended for use in the equation in Table B-2-19 may not accurately represent site-specific water body conditions. The degree of uncertainty associated with default variable values is expected to be limited either because the probable ranges for these variables are narrow or because information allowing reasonable estimates is generally available. (2) Uncertainties associated with variables f_{bs}, C_{wctot} and Kd_{bs} are largely associated with the use of default *OC* content values in their calculation. The uncertainty may be significant in specific instances, because *OC* content is known to vary widely in different locations in the same medium. This variable is site-specific.
$IR_{S\text{-}HB}$	Sediment ingestion rate for herbivorous bird	kg DW/kg BW-day	**Varies** This variable is site-, receptor-, and habitat-specific, and is discussed in Chapter 5. Ingestion rates for example measurement receptors are presented in Chapter 5, Table 5-1. Uncertainties associated with this variable include the following: (1) IR_S values may under- or over-estimate BCF_S when applied for site-specific organisms.
P_S	Proportion of ingested bed sediment that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of soil ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for a screening level risk assessment when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated soil ingested by species depends on site-specific information, receptor homerange, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of soil ingested that is contaminated will likely be overestimated.

TABLE F-2-8

COPC DOSE INGESTED TERMS IN HERBIVOROUS BIRDS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

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Variable	Description	Units	Value
C_{wctot}	Total COPC concentration in water column	mg COPC/L water (or g COPC/m^3 water)	**Varies (calculated - Table B-2-17)** This variable is COPC- and site-specific and is calculated using Table B-2-17. Uncertainties associated with this equation include the following: (1) All of the variables in the equation in Table B-2-17 are COPC- and site-specific. Therefore, the use of default values rather than site-specific values, for any or all of these variables, will contribute to the under- or overestimation of C_{wctot}. (2) Uncertainty associated with f_{wc} is largely the result of uncertainty associated with default OC content values. Uncertainties may also be associated with the variable L_T and k_{wt}. The degree of uncertainly associated with the variables d_{wc} and d_{bs} is expected to be minimal either because information for estimating a variable (d_{wc}) is generally available or because the probable range for a variable (d_{bs}) is narrow. The uncertainty associated with the variables f_{wc} and C_{wctot} is associated with estimates of *OC* content. Because *OC* content values can vary widely for different locations in the same medium, the uncertainty associated with using default *OC* values may be significant in specific cases.
IR_{W-HB}	Water ingestion rate for aquatic herbivorous bird	L/kg BW-day	**Varies** This variable is receptor- and habitat-specific, and is discussed in Chapter 5, Section 5. Ingestion rates for example measurement receptors are presented in Chapter 5, Table 5-1. The following uncertainty is associated with this variable: (1) Water ingestion rates are influenced by animal behavior and environmental factors and may over- or under-estimate BCF_{W-HB} to an unknown degree.
P_W	Proportion of ingested water that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of water ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated water ingested by species depends on site-specific information, receptor homerange, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of ingested water that is contaminated will likely be overestimated.

TABLE F-2-8

COPC DOSE INGESTED TERMS IN HERBIVOROUS BIRDS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

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REFERENCES AND DISCUSSIONS

U.S. EPA. 1993. *Wildlife Exposure Factor Handbook.* Volumes I and II. Office of Research and Development. EPA/600/R-93/187a

TABLE F-2-9

COPC DOSE INGESTED TERMS IN OMNIVOROUS MAMMALS IN FRESHWATER/WETLAND MARSH, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

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Description

This equation calculates the daily dose through ingestion of contaminated food/prey, sediment, and water in aquatic omnivorous mammals in freshwater marsh, brackish/intermediate marsh, and saltwater marsh food webs. The limitations and uncertainties introduced in calculating this variable include the following:

(1) Variables C_{sed} and C_{wctot} are COPC- and site-specific. Uncertainties associated with these variables will be site-specific .
(2) Variables $BCF_{S\text{-}OM}$ and $BCF_{W\text{-}OM}$ are based on biotransfer factors for beef cattle (Ba_{beef}), and receptor specific ingestion rates, and therefore may introduce uncertainty when used to compute a representative daily dose for site-specific omnivorous mammals.

Equation

$$D_{OM} = (C_{HM} \cdot IR_{OM} \cdot P_{HM} \cdot F_{HM}) + (C_{HB} \cdot IR_{OM} \cdot P_{HB} \cdot F_{HB}) + (C_{BI} \cdot IR_{OM} \cdot P_{BI} \cdot F_{BI}) + (C_{WI} \cdot IR_{OM} \cdot P_{WI} \cdot F_{WI})$$
$$+ (C_{AV} \cdot IR_{OM} \cdot P_{AV} \cdot F_{AV}) + (C_{AL} \cdot IR_{OM} \cdot P_{AL} \cdot F_{AL}) + (C_{sed} \cdot IR_{S-OM} \cdot P_S) + (C_{wctot} \cdot IR_{W-OM} \cdot P_W)$$

Variable	Description	Units	Value
D_{OM}	Dose ingested for omnivorous mammals	mg/kg BW-day	
C_{HM}	Concentration of COPC in aquatic herbivorous mammals	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-9)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-9. Uncertainties associated with this variable include: (1) Variables C_{sed} and C_{wctot} are COPC- and site-specific. (2) Variables $BCF_{S\text{-}HM}$ and $BCF_{W\text{-}HM}$ are based on biotransfer factors for beef cattle (Ba_{beef}), and receptor-specific ingestion rates, and therefore may introduce uncertainty when used to compute concentrations for site-specific omnivorous mammals.

TABLE F-2-9

COPC DOSE INGESTED TERMS IN OMNIVOROUS MAMMALS IN FRESHWATER/WETLAND MARSH, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

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Variable	Description	Units	Value
IR_{OM}	Food ingestion rate of aquatic omnivorous mammal	kg WW/kg BW-day	**Varies** This variable is receptor-specific, and is discussed in Chapter 5. Ingestion rates for example measurement receptors are provided in Chapter 5, Table 5-1. Uncertainties associated with this variable include: (1) Food ingestion rates are influenced by several factors including: metabolic rate, energy requirements for growth and reproduction, and dietary composition. Ingestion rates are also influenced by ambient temperature, receptor activity level and body weight U.S. EPA (1993). These factors introduce an unknown degree of uncertainty when used to estimate daily dose. (2) IR values may over- or under- estimate exposure when applied for site-specific receptors.
P_{HM}	Proportion of aquatic herbivorous mammal in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{HM}	Fraction of diet comprised of aquatic herbivorous mammals	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of aquatic herbivorous mammals. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-9

COPC DOSE INGESTED TERMS IN OMNIVOROUS MAMMALS IN FRESHWATER/WETLAND MARSH, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

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Variable	Description	Units	Value
C_{HB}	Concentration of COPC in aquatic herbivorous birds	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-10)** This variable is site-specific and COPC-specific, and is calculated using the equation in Table F-1-10. Uncertainties associated with this variable include: (1) Variables C_{sed} and C_{wctot} are COPC- and site-specific. (2) Variables $BCF_{S\text{-}HB}$ and $BCF_{W\text{-}HB}$ are based on biotransfer factors for chicken ($Ba_{chicken}$), and receptor specific ingestion rates, and therefore may introduce uncertainty when used to compute concentrations for site-specific aquatic herbivorous birds.
P_{HB}	Proportion of aquatic herbivorous birds in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{HB}	Fraction of diet comprised of aquatic herbivorous birds	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of aquatic herbivorous birds. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-9

COPC DOSE INGESTED TERMS IN OMNIVOROUS MAMMALS IN FRESHWATER/WETLAND MARSH, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

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Variable	Description	Units	Value
C_{BI}	Concentration of COPC in benthic invertebrates	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-11)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-11. Uncertainties associated with this variable include the following: (1) C_{sed} values are COPC- and site-specific. Uncertainties associated with this variable will be site-specific. (2) BCF_{S-BI} values are intended to represent "generic benthic invertebrate species", and therefore may over- or under-estimate exposure when applied to site-specific organisms.
P_{BI}	Proportion of benthic invertebrate in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{BI}	Fraction of diet comprised of benthic invertebrates	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of benthic invertebrates. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-9

COPC DOSE INGESTED TERMS IN OMNIVOROUS MAMMALS IN FRESHWATER/WETLAND MARSH, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

Variable	Description	Units	Value
C_{WI}	Concentration of COPC in water invertebrates	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-12)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-12. Uncertainties associated with this variable include: (1) C_{dw} values are COPC- and site-specific. (2) $BCF_{W\text{-}WI}$ values are intended to represent "generic water invertebrate species", and therefore may over- or under-estimate exposure when applied to site-specific organisms.
P_{WI}	Proportion of water invertebrate in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{WI}	Fraction of diet comprised of water invertebrates	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of water invertebrates. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-9

COPC DOSE INGESTED TERMS IN OMNIVOROUS MAMMALS IN FRESHWATER/WETLAND MARSH, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

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Variable	Description	Units	Value
C_{AV}	Concentration of COPC in aquatic vegetation	mg COPC/kg WW	**Varies (calculated - Table F-1-7)** This variable is site- and COPC-specific; it is calculated using the equation in Table F-1-7. Uncertainties associated with this variable include: (1) C_{sed} values are COPC- and site-specific. (2) $BCF_{S\text{-}AV}$ values are intended to represent "generic aquatic vegetation species", and therefore may over- or under-estimate exposure when applied to site-specific vegetation.
P_{AV}	Proportion of aquatic vegetation in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{AV}	Fraction of diet comprised of aquatic vegetation	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of aquatic vegetation. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-9

COPC DOSE INGESTED TERMS IN OMNIVOROUS MAMMALS IN FRESHWATER/WETLAND MARSH, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

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Variable	Description	Units	Value
C_{AL}	Concentration of COPC in algae	mg COPC/kg WW	**Varies (calculated - Table F-1-8)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-8. Uncertainties associated with this variable include: (1) C_{dw} values are COPC- and site-specific. (2) BCF_{W-AL} values are intended to represent "generic algae species", and therefore may over- or under-estimate exposure when applied to site-specific species.
P_{AL}	Proportion of algae in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{AL}	Fraction of diet comprised of algae	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of algae. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-9

COPC DOSE INGESTED TERMS IN OMNIVOROUS MAMMALS IN FRESHWATER/WETLAND MARSH, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

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Variable	Description	Units	Value
C_{sed}	COPC concentration in bed sediment	mg COPC/kg DW sediment	**Varies (calculated - Table B-2-19)** This equation calculates the concentration of contaminants sorbed to bed sediments. Uncertainties associated with this equation include the following: (1) The default variable values recommended for use in the equation in Table B-2-19 may not accurately represent site-specific water body conditions. The degree of uncertainty associated with default variable values is expected to be limited either because the probable ranges for these variables are narrow or because information allowing reasonable estimates is generally available. (2) Uncertainties associated with variables f_{bs}, C_{wctot} and Kd_{bs} are largely associated with the use of default *OC* content values in their calculation. The uncertainty may be significant in specific instances, because *OC* content is known to vary widely in different locations in the same media. This variable is site-specific.
$IR_{S\text{-}OM}$	Sediment ingestion rate for aquatic omnivorous mammal	kg DW/kg BW-day	**Varies** This variable is site-, receptor-, and habitat-specific, and is discussed in Chapter 5. Ingestion rates for example measurement receptors are presented in Chapter 5, Table 5-1. Uncertainties associated with this variable include the following: (1) IR_S values may under- or over-estimate BCF_S when applied to site-specific organisms.
P_S	Portion of ingested bed sediment that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of soil ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for a screening level risk assessment when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated soil ingested by species depends on site-specific information, receptor homerange, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of soil ingested that is contaminated will likely be overestimated.

TABLE F-2-9

COPC DOSE INGESTED TERMS IN OMNIVOROUS MAMMALS IN FRESHWATER/WETLAND MARSH, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

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Variable	Description	Units	Value
C_{wctot}	Total COPC concentration in water column	mg COPC/L water (or g COPC/m^3 water)	**Varies (calculated - Table B-2-17)** This variable is COPC- and site-specific and is calculated using Table B-2-17. Uncertainties associated with this equation include the following: (1) All of the variables in the equation in Table B-2-17 are COPC- and site-specific. Therefore, the use of default values rather than site-specific values, for any or all of these variables, will contribute to the under- or overestimation of C_{wctot}. (2) Uncertainty associated with f_{wc} is largely the result of uncertainty associated with default OC content values. Uncertainties may also be associated with the variable L_T and k_{wt} The degree of uncertainly associated with the variables d_{wc} and d_{bs} is expected to be minimal either because information for estimating a variable (d_{wc}) is generally available or because the probable range for a variable (d_{bs}) is narrow. The uncertainty associated with the variables f_{wc} and C_{wctot} is associated with estimates of *OC* content. Because *OC* content values can vary widely for different locations in the same media, the uncertainty associated with using default *OC* values may be significant in specific cases.
$IR_{W\text{-}OM}$	Water ingestion rate for aquatic omnivorous mammal	L/kg BW-day	**Varies** This variable is receptor- and habitat-specific, and is discussed in Chapter 5. Ingestion rates for example measurement receptors are presented in Chapter 5, Table 5-1. The following uncertainty is associated with this variable: (1) Water ingestion rates are strongly influenced by animal behavior and environmental factors and may over- or under- estimate $BCF_{W\text{-}OM}$ to an unknown degree.
P_W	Portion of ingested water that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of water ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated water ingested by species depends on site-specific information, receptor homerange, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of ingested water that is contaminated will likely be overestimated.

TABLE F-2-9

COPC DOSE INGESTED TERMS IN OMNIVOROUS MAMMALS IN FRESHWATER/WETLAND MARSH, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

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REFERENCES AND DISCUSSIONS

U.S. EPA. 1993. *Wildlife Exposure Factor Handbood.* Volumes I and II. Office of Research and Development. EPA/600/R-93/187a

TABLE F-2-10

COPC DOSE INGESTED TERMS IN OMNIVOROUS BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

Description

This equation calculates the daily dose through ingestion of contaminated food/prey, sediment, and water in aquatic omnivorous birds in freshwater marsh, brackish/intermediate marsh, and saltwater marsh food webs. The limitations and uncertainties introduced in calculating this variable include the following:

(1) Variables C_{sed} and C_{wctot} are COPC- and site-specific. Uncertainties associated with these variables will be site-specific .

(2) Variables $BCF_{S\text{-}OB}$ and $BCF_{W\text{-}OB}$ are based on biotransfer factors for chicken ($Ba_{chicken}$), and receptor specific ingestion rates, and therefore may introduce uncertainty when used to compute a representative daily dose for site-specific omnivorous birds.

Equation

$$D_{OB} = \left(C_{BI} \cdot IR_{OB} \cdot P_{BI} \cdot F_{BI}\right) + \left(C_{WI} \cdot IR_{OB} \cdot P_{WI} \cdot F_{WI}\right) + \left(C_{AV} \cdot IR_{OB} \cdot P_{AV} \cdot F_{AV}\right)$$
$$+ \left(C_{AL} \cdot IR_{OB} \cdot P_{AL} \cdot F_{AL}\right) + \left(C_{sed} \cdot IR_{S-OB} \cdot P_{S}\right) + \left(C_{wctot} \cdot IR_{W-OB} \cdot P_{W}\right)$$

Variable	Description	Units	Value
D_{OB}	Dose ingested for aquatic omnivorous birds	mg/kg BW-day	
C_{BI}	Concentration of COPC in benthic invertebrates	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-11)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-11. Uncertainties associated with this variable include the following: (1) C_{sed} values are COPC- and site-specific. (2) $BCF_{S\text{-}BI}$ values are intended to represent “generic benthic invertebrate species”, and therefore may over- or under-estimate exposure when applied to site-specific organisms.

TABLE F-2-10

COPC DOSE INGESTED TERMS IN OMNIVOROUS BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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Variable	Description	Units	Value
IR_{OB}	Food ingestion rate of aquatic omnivorous bird	kg WW/kg BW-day	**Varies** This variable is receptor-specific, and is discussed in Chapter 5. Ingestion rates for example measurement receptors are provided in Chapter 5, Table 5-1. Uncertainties associated with this variable include: (1) Food ingestion rates are influenced by several factors including: metabolic rate, energy requirements for growth and reproduction, and dietary composition. Ingestion rates are also influenced by ambient temperature, receptor activity level and body weight U.S. EPA (1993). These factors introduce an unknown degree of uncertainty when used to estimate daily dose. (2) IR values may over- or under- estimate exposure when applied for site-specific receptors.
P_{BI}	Proportion of benthic invertebrate in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{BI}	Fraction of diet comprised of benthic invertebrates	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of benthic invertebrates. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-10

COPC DOSE INGESTED TERMS IN OMNIVOROUS BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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Variable	Description	Units	Value
C_{WI}	Concentration of COPC in water invertebrates	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-12)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-12. Uncertainties associated with this variable include: (1) C_{dw} values are COPC- and site-specific. (2) $BCF_{W\text{-}WI}$ values are intended to represent "generic water invertebrate species", and therefore may over- or under-estimate exposure when applied to site-specific organisms.
P_{WI}	Proportion of water invertebrate in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{WI}	Fraction of diet comprised of water invertebrates	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of water invertebrates. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-10

COPC DOSE INGESTED TERMS IN OMNIVOROUS BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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Variable	Description	Units	Value
C_{AV}	Concentration of COPC in aquatic vegetation ingested by the animal	mg COPC/kg WW	**Varies (calculated - Table F-1-7)** This variable is site- and COPC-specific; it is calculated using the equation in Table F-1-7. Uncertainties associated with this variable include: (1) C_{sed} values are COPC- and site-specific. (2) $BCF_{S\text{-}AV}$ values are intended to represent "generic aquatic vegetation species", and therefore may over- or under-estimate exposure when applied to site-specific vegetation.
P_{AV}	Proportion of aquatic vegetation in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{AV}	Fraction of diet comprised of aquatic vegetation	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of aquatic vegetation. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-10

COPC DOSE INGESTED TERMS IN OMNIVOROUS BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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Variable	Description	Units	Value
C_{sed}	COPC concentration in bed sediment	mg COPC/kg DW sediment	**Varies (calculated - Table B-2-19)** This equation calculates the concentration of COPCs in bed sediments. Uncertainties associated with this equation include the following: (1) The default variable values recommended for use in the equation in Table B-2-19 may not accurately represent site-specific water body conditions. The degree of uncertainty associated with default variable values is expected to be limited either because the probable ranges for these variables are narrow or because information allowing reasonable estimates is generally available. (2) Uncertainties associated with variables f_{bs}, C_{wctot} and Kd_{bs} are largely associated with the use of default *OC* content values in their calculation. The uncertainty may be significant in specific instances, because *OC* content is known to vary widely in different locations in the same medium. This variable is site-specific.
IR_{SOB}	Sediment ingestion rate for aquatic omnivorous bird	kg DW/kg BW-day	**Varies** This variable is site-, receptor-, and habitat-specific, and is discussed in Chapter 5. Ingestion rates for example measurement receptors are presented in Chapter 5, Table 5-1. Uncertainties associated with this variable include the following: (1) IR_S values may under- or over-estimate BCF_S when applied to site-specific organisms.
P_S	Portion of ingested bed sediment that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of soil ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for a screening level risk assessment when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated soil ingested by species depends on site-specific information, receptor homerange, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of soil ingested that is contaminated will likely be overestimated.

TABLE F-2-10

COPC DOSE INGESTED TERMS IN OMNIVOROUS BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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Variable	Description	Units	Value
C_{wctot}	Total COPC concentration in water column	mg COPC/L water (or g COPC/m^3 water)	**Varies (calculated - Table B-2-17)** This variable is COPC- and site-specific and is calculated using Table B-2-17. Uncertainties associated with this equation include the following: (1) All of the variables in the equation in Table B-2-17 are COPC- and site-specific. Therefore, the use of default values rather than site-specific values, for any or all of these variables, will contribute to the under- or overestimation of C_{wctot}. (2) Uncertainty associated with f_{wc} is largely the result of uncertainty associated with default OC content values. Uncertainties may also be associated with the variable L_T and k_{wt}. The degree of uncertainly associated with the variables d_{wc} and d_{bs} is expected to be minimal either because information for estimating a variable (d_{wc}) is generally available or because the probable range for a variable (d_{bs}) is narrow. The uncertainty associated with the variables f_{wc} and C_{wtot} is associated with estimates of *OC* content. Because *OC* content values can vary widely for different locations in the same media, the uncertainty associated with using default *OC* values may be significant in specific cases.
I.W.-OB	Water ingestion rate for aquatic omnivorous bird	L/kg BW-day	**Varies** This variable is receptor- and habitat-specific, and is discussed in Chapter 5. Ingestion rates for example measurement receptors are presented in Chapter 5, Table 5-1. The following uncertainty is associated with this variable: (1) Water ingestion rates are influenced by animal behavior and environmental factors and may over- or under-estimate BCF_{W-HM} to an unknown degree.
P	Portion of ingested water that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of water ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated water ingested by species depends on site-specific information, receptor homerange, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of ingested water that is contaminated may be overestimated.

TABLE F-2-10

COPC DOSE INGESTED TERMS IN OMNIVOROUS BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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REFERENCES AND DISCUSSIONS

U.S. EPA. 1993. *Wildlife Exposure Factor Handbook.* Volumes I and II. Office of Research and Development. EPA/600/R-93/187a.

TABLE F-2-11

EQUATIONS FOR COMPUTING COPC DOSE INGESTED TERMS IN CARNIVOROUS MAMMALS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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Description

This equation calculates the daily dose through exposure to food/prey, sediment, and water in aquatic carnivorous mammals in freshwater marsh, brackish/intermediate marsh, and saltwater marsh food webs. The limitations and uncertainties introduced in calculating this variable include the following:

(1) Variables C_{sed} and C_{wctot} are COPC- and site-specific. Uncertainties associated with these variables will be site-specific

(2) Variables $BCF_{S\text{-}CM}$, and $BCF_{W\text{-}CM}$ are based on biotransfer factors for beef cattle (Ba_{beef}), and receptor specific ingestion rates, and therefore may introduce uncertainty when used to compute a representative daily dose for site-specific carnivorous mammals.

Equation

$$D_{CM} = \left(C_{HB} \cdot IR_{CM} \cdot P_{HB} \cdot F_{HB}\right) + \left(C_{OF} \cdot IR_{CM} \cdot P_{OF} \cdot F_{OF}\right) + \left(C_{CF} \cdot IR_{CM} \cdot P_{CF} \cdot F_{CF}\right) + \left(C_{OB} \cdot IR_{CM} \cdot P_{OB} \cdot F_{OB}\right)$$
$$+ \left(C_{OM} \cdot IR_{CM} \cdot P_{OM} \cdot F_{OM}\right) + \left(C_{HM} \cdot IR_{CM} \cdot P_{HM} \cdot F_{HM}\right) + \left(C_{sed} \cdot IR_{S-CM} \cdot P_{S}\right) + \left(C_{wctot} \cdot IR_{W-CM} \cdot P_{W}\right)$$

Variable	Description	Units	Value
D_{CM}	Dose ingested for carnivorous mammals	mg/kg BW-day	
C_{HB}	Concentration of COPC in herbivorous birds	mg COPC/kg FW tissue	**Varies** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-10. Uncertainties associated with this variable include: (1) Variables C_{sed} and C_{wctot} are COPC- and site-specific. (2) Variables $BCF_{S\text{-}HB}$ and $BCF_{W\text{-}HB}$ are based on biotransfer factors for chicken ($Ba_{chicken}$), and receptor specific ingestion rates, and therefore may introduce uncertainty when used to compute concentrations for site-specific herbivorous birds.

TABLE F-2-11

EQUATIONS FOR COMPUTING COPC DOSE INGESTED TERMS IN CARNIVOROUS MAMMALS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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Variable	Description	Units	Value
IR_{CM}	Food ingestion rate of carnivorous mammal	kg WW/kg BW-day	**Varies** This variable is receptor-specific, and is discussed in Chapter 5. Ingestion rates for example measurement receptors are provided in Chapter 5, Table 5-1. Uncertainties associated with this variable include: (1) Food ingestion rates are influenced by several factors including: metabolic rate, energy requirements for growth and reproduction, and dietary composition. Ingestion rates are also influenced by ambient temperature, receptor activity level and body weight U.S. EPA (1993). These factors introduce an unknown degree of uncertainty when used to estimate daily dose. (2) IR values may over- or under- estimate exposure when applied for site-specific receptors.
P_{HB}	Proportion of herbivorous birds in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{HB}	Fraction of diet comprised of herbivorous birds	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of aquatic herbivorous birds. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-11

EQUATIONS FOR COMPUTING COPC DOSE INGESTED TERMS IN CARNIVOROUS MAMMALS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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Variable	Description	Units	Value
C_{OF}	Concentration of COPC in omnivorous fish	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-16)** This variable is site-specific and COPC-specific; it is calculated using the equation in F-1-16. Uncertainties associated with this variable include: (1) C_{dw} values are COPC- and site-specific. (2) The data set used to calculate BCF_{fish} is based on a limited number of test organisms and therefore may over- or under-estimate exposure when applied for site-specific organisms.
P_{OF}	Proportion of omnivorous fish diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{OF}	Fraction of diet comprised of omnivorous fish	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of omnivorous fish. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-11

EQUATIONS FOR COMPUTING COPC DOSE INGESTED TERMS IN CARNIVOROUS MAMMALS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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Variable	Description	Units	Value
C_{CF}	Concentration in carnivorous fish	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-17)** This variable is site-specific and COPC-specific; it is calculated using the equation in F-1-17. Uncertainties associated with this variable include: (1) C_{dw} values are COPC- and site-specific. (2) The data set used to calculate BCF_{fish} is based on a limited number of test organisms and therefore may over- or under-estimate exposure when applied to site-specific organisms.
P_{CF}	Proportion of carnivorous fish in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{CF}	Fraction of diet comprised of carnivorous fish	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of carnivorous fish. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-11

EQUATIONS FOR COMPUTING COPC DOSE INGESTED TERMS IN CARNIVOROUS MAMMALS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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Variable	Description	Units	Value
C_{OB}	Concentration of COPC in omnivorous birds	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-15)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-6. Uncertainties associated with this variable include: (1) Variables C_{sed} and C_{wctot} are COPC- and site-specific. (2) Variables BCF_{S-OB} and BCF_{W-OB} are based on biotransfer factors for chicken ($Ba_{chicken}$), and receptor specific ingestion rates, and therefore may introduce uncertainty when used to compute concentrations for site-specific aquatic omnivorous birds.
P_{OB}	Proportion of omnivorous bird diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{OB}	Fraction of diet comprised of omnivorous birds	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of aquatic omnivorous birds. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-11

EQUATIONS FOR COMPUTING COPC DOSE INGESTED TERMS IN CARNIVOROUS MAMMALS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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Variable	Description	Units	Value
C_{OM}	Concentration of COPC in omnivorous mammals	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-5)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-5. Uncertainties associated with this variable include: (1) Variables C_{sed} and C_{wctot} are COPC- and site-specific. (2) Variables $BCF_{S\text{-}OM}$ and $BCF_{W\text{-}OM}$ are based on biotransfer factors for beef (Ba_{beef}), and receptor-specific ingestion rates, and therefore may introduce uncertainty when used to compute concentrations for site-specific omnivorous mammals.
P_{OM}	Proportion of omnivorous mammal diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{OM}	Fraction of diet comprised of omnivorous mammals	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of omnivorous mammals. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-11

EQUATIONS FOR COMPUTING COPC DOSE INGESTED TERMS IN CARNIVOROUS MAMMALS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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Variable	Description	Units	Value
C_{HM}	Concentration of COPC in herbivorous mammals	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-9)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-9. Uncertainties associated with this variable include: (1) Variables C_{sed} and C_{wctot} are COPC- and site-specific. (2) Variables $BCF_{S\text{-}HM}$ and $BCF_{W\text{-}HM}$ are based on biotransfer factors for beef cattle (Ba_{beef}), and receptor specific ingestion rates, and therefore may introduce uncertainty when used to compute concentrations for site-specific aquatic herbivorous mammals.
P_{HM}	Proportion of herbivorous mammal in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. Uncertainties associated with this variable include: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{HM}	Fraction of diet comprised of herbivorous mammals	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of aquatic herbivorous mammals. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of herbivorous mammals depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. Therefore a default value of 100 percent for the exclusive diet, may over-estimate dietary exposure.

TABLE F-2-11

EQUATIONS FOR COMPUTING COPC DOSE INGESTED TERMS IN CARNIVOROUS MAMMALS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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Variable	Description	Units	Value
C_{sed}	COPC concentration in bed sediment	mg COPC/kg DW sediment	**Varies (calculated - Table B-2-19)** This equation calculates the concentration of contaminants sorbed to bed sediments. Uncertainties associated with this equation include the following: (1) The default variable values recommended for use in the equation in Table B-2-19 may not accurately represent site-specific water body conditions. The degree of uncertainty associated with default variable values is expected to be limited either because the probable ranges for these variables are narrow or because information allowing reasonable estimates is generally available. (2) Uncertainties associated with variables f_{bs}, C_{wctot} and Kd_{bs} are largely associated with the use of default *OC* content values in their calculation. The uncertainty may be significant in specific instances, because *OC* content is known to vary widely in different locations in the same medium. This variable is site-specific.
$IR_{S\text{-}CM}$	Sediment ingestion rate for carnivorous mammal	kg DW/kg BW-day	**Varies** This variable is site-, receptor-, and habitat-specific, and is discussed in Chapter 5. Ingestion rates for example measurement receptors are presented in Chapter 5, Table 5-1. Uncertainties associated with this variable include the following: (1) IR_S values may under- or over-estimate BCF_S when applied to site-specific organisms.
P_S	Portion of ingested bed sediment that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of soil ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for a screening level risk assessment when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated soil ingested by species depends on site-specific information, receptor homerange, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of soil ingested that is contaminated will likely be overestimated.

TABLE F-2-11

EQUATIONS FOR COMPUTING COPC DOSE INGESTED TERMS IN CARNIVOROUS MAMMALS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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Variable	Description	Units	Value
C_{wctot}	Total COPC concentration in water column	mg COPC/L water (or g COPC/m^3 water)	**Varies (calculated - Table B-2-17)** This variable is COPC- and site-specific and is calculated using Table B-2-17. Uncertainties associated with this equation include the following: (1) All of the variables in the equation in Table B-2-17 are COPC- and site-specific. Therefore, the use of default values rather than site-specific values, for any or all of these variables, will contribute to the under- or overestimation of C_{wctot}. (2) Uncertainty associated with f_{wc} is largely the result of uncertainty associated with default OC content values. Uncertainties may also be associated with the variable L_T and k_{wt}. The degree of uncertainly associated with the variables d_{wc} and d_{bs} is expected to be minimal either because information for estimating a variable (d_{wc}) is generally available or because the probable range for a variable (d_{bs}) is narrow. The uncertainty associated with the variables f_{wc} and C_{wctot} is associated with estimates of *OC* content. Because *OC* content values can vary widely for different locations in the same medium, the uncertainty associated with using default *OC* values may be significant in specific cases.
IR_{W-CM}	Water ingestion rate for carnivorous mammal	kg WW/kg BW-day	**Varies** This variable is receptor- and habitat-specific, and is discussed in Chapter 5. Ingestion rates for example measurement receptors are presented in Chapter 5, Table 5-1. The following uncertainty is associated with this variable: (1) Water ingestion rates are strongly influenced by animal behavior and environmental factors and may over- or under- estimate BCF_{W-HM} to an unknown degree.
P_W	Portion of ingested water that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of water ingested that is contaminated. U.S. EPA OSW rsecommends that a default value of 1.0 be used when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated water ingested by species depends on site-specific information, receptor homerange, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of ingested water that is contaminated will likely be overestimated.

TABLE F-2-11

EQUATIONS FOR COMPUTING COPC DOSE INGESTED TERMS IN CARNIVOROUS MAMMALS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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REFERENCES AND DISCUSSION

U.S. EPA. 1993. *Wildlife Exposure Factor Handbood.* Volumes I and II. Office of Research and Development. EPA/600/R-93/187a

TABLE F-2-12

COPC DOSE INGESTED TERMS IN CARNIVOROUS BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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Description

This equation calculates the daily dose through exposure to contaminated food/prey, soil, and water in aquatic carnivorous birds in freshwater marsh, brackish/intermediate marsh, and saltwater marsh food webs. The limitations and uncertainties introduced in calculating this variable include the following:

(1) Variables C_{sed}, and C_{wctot} are COPC- and site-specific. Uncertainties associated with these variables will be site-specific.
(2) Variables $BCF_{BS\text{-}CB}$, and $BCF_{W\text{-}CB}$ are based on biotransfer factors for chicken ($Ba_{chicken}$), and receptor specific ingestion rates, and therefore may introduce uncertainty when used to compute a representative daily dose for site-specific carnivorous birds.

Equation

$$D_{CB} = \left(C_{OF} \cdot IR_{CB} \cdot P_{OF} \cdot F_{OF}\right) + \left(C_{CF} \cdot IR_{CB} \cdot P_{CF} \cdot F_{CF}\right) + \left(C_{OM} \cdot IR_{CB} \cdot P_{OM} \cdot F_{OM}\right) + \left(C_{HM} \cdot IR_{CB} \cdot P_{HM} \cdot F_{HM}\right)$$
$$+ \left(C_{OB} \cdot IR_{CB} \cdot P_{OB} \cdot F_{OB}\right) + \left(C_{HB} \cdot IR_{CB} \cdot P_{HB} \cdot F_{HB}\right) + \left(C_{sed} \cdot IR_{S-CB} \cdot P_{S}\right) + \left(C_{wctot} \cdot IR_{W-CB} \cdot P_{W}\right)$$

Variable	Description	Units	Value
D_{CB}	Dose ingested for carnivorous birds	mg/kg BW-day	
C_{OF}	Concentration of COPC in omnivorous fish	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-16)** This variable is site-specific and COPC-specific; it is calculated using the equation in F-1-16. Uncertainties associated with this variable include: (1) C_{dw} values are COPC- and site-specific. (2) The data set used to calculate BCF_{fish} is based on a limited number of test organisms and therefore may over- or under-estimate exposure when applied to site-specific organisms.

TABLE F-2-12

COPC DOSE INGESTED TERMS IN CARNIVOROUS BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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Variable	Description	Units	Value
IR_{CB}	Food ingestion rate of carnivorous birds	kg WW/kg BW-day	**Varies** This variable is receptor-specific, and is discussed in Chapter 5. Ingestion rates for example measurement receptors are provided in Chapter 5, Table 5-1. Uncertainties associated with this variable include: (1) Food ingestion rates are influenced by several factors including: metabolic rate, energy requirements for growth and reproduction, and dietary composition. Ingestion rates are also influenced by ambient temperature, receptor activity level and body weight U.S. EPA (1993). These factors introduce an unknown degree of uncertainty when used to estimate daily dose. (2) IR values may over- or under- estimate exposure when applied to site-specific receptors.
P_{OF}	Proportion of omnivorous fish diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{OF}	Fraction of diet comprised of omnivorous fish	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of omnivorous fish. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-12

COPC DOSE INGESTED TERMS IN CARNIVOROUS BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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Variable	Description	Units	Value
C_{CF}	Concentration in carnivorous fish	mg COPC/kg FW tissue	**Varies** This variable is site-specific and COPC-specific; it is calculated using the equation in F-1-17. Uncertainties associated with this variable include: (1) C_{dw} values are COPC- and site-specific. (2) The data set used to calculate BCF_{fish} is based on a limited number of test organisms and therefore may over- or under-estimate exposure when applied to site-specific organisms.
P_{CF}	Proportion of carnivorous fish diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{CF}	Fraction of diet comprised of carnivorous fish	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of carnivorous fish. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-12

COPC DOSE INGESTED TERMS IN CARNIVOROUS BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

Variable	Description	Units	Value
C_{OM}	Concentration of COPC in omnivorous mammals	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-5)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-5. Uncertainties associated with this variable include: (1) Variables C_{sed} and C_{wctot} are COPC- and site-specific. (2) Variables $BCF_{S\text{-}OM}$ and $BCF_{W\text{-}OM}$ are based on biotransfer factors for beef (Ba_{beef}), and receptor specific ingestion rates, and therefore may introduce uncertainty when used to compute concentrations for site-specific aquatic omnivorous mammals.
P_{OM}	Proportion of aquatic omnivorous mammal in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{OM}	Fraction of diet comprised of omnivorous mammals	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of aquatic omnivorous mammals. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-12

COPC DOSE INGESTED TERMS IN CARNIVOROUS BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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Variable	Description	Units	Value
C_{HM}	Concentration of COPC in herbivorous mammals	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-9)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-9. Uncertainties associated with this variable include: (1) Variables C_{sed} and C_{wctot} are COPC- and site-specific. (2) Variables $BCF_{S\text{-}HM}$ and $BCF_{W\text{-}HM}$ are based on biotransfer factors for beef cattle (Ba_{beef}), and receptor specific ingestion rates, and therefore may introduce uncertainty when used to compute concentrations for site-specific aquatic herbivorous mammals.
P_{HM}	Proportion of aquatic herbivorous mammal in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. Uncertainties associated with this variable include: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{HM}	Fraction of diet comprised of herbivorous mammals	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of aquatic herbivorous mammals. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of herbivorous mammals depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. Therefore a default value of 100 percent for the exclusive diet, may over-estimate dietary exposure.

TABLE F-2-12

COPC DOSE INGESTED TERMS IN CARNIVOROUS BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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Variable	Description	Units	Value
C_{OB}	Concentration of COPC in omnivorous birds	mg COPC/kg FW tissue	**Varies** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-6. Uncertainties associated with this variable include: (1) Variables C_{sed} and C_{wctot} are COPC- and site-specific. (2) Variables $BCF_{S\text{-}OB}$ and $BCF_{W\text{-}OB}$ are based on biotransfer factors for chicken ($Ba_{chicken}$), and receptor specific ingestion rates, and therefore may introduce uncertainty when used to compute concentrations for site-specific aquatic omnivorous birds.
P_{OB}	Proportion of omnivorous bird in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{OB}	Fraction of diet comprised of omnivorous birds	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of aquatic omnivorous birds. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-12

COPC DOSE INGESTED TERMS IN CARNIVOROUS BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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Variable	Description	Units	Value
C_{HB}	Concentration of COPC in herbivorous birds	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-10)** This variable is site-specific and chemical-specific; it is calculated using the equation in Table F-1-10. Uncertainties associated with this variable include: (1) Variables C_{sed} and C_{wctot} are COPC- and site-specific. (2) Variables BCF_{S-HB} and BCF_{W-HB} are based on biotransfer factors for chicken ($Ba_{chicken}$), and receptor-specific ingestion rates, and therefore may introduce uncertainty when used to compute concentrations for site-specific aquatic herbivorous birds.
P_{HB}	Proportion of herbivorous birds in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{HB}	Fraction of diet comprised of herbivorous birds	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of aquatic herbivorous birds. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-12

COPC DOSE INGESTED TERMS IN CARNIVOROUS BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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Variable	Description	Units	Value
C_{sed}	COPC concentration in bed sediment	mg COPC/kg DW sediment	**Varies (calculated - Table B-2-19)** This equation calculates the concentration of COPCs in bed sediments. Uncertainties associated with this equation include the following: (1) The default variable values recommended for use in the equation in Table B-2-19 may not accurately represent site-specific water body conditions. The degree of uncertainty associated with default variable values is expected to be limited either because the probable ranges for these variables are narrow or because information allowing reasonable estimates is generally available. (2) Uncertainties associated with variables f_{bs}, C_{wctot} and Kd_{bs} are largely associated with the use of default *OC* content values in their calculation. The uncertainty may be significant in specific instances, because *OC* content is known to vary widely in different locations in the same medium. This variable is site-specific.
$IR_{S\text{-}CB}$	Sediment ingestion rate for carnivorous bird	kg DW/kg BW-day	**Varies** This variable is site-, receptor-, and habitat-specific, and is discussed in Chapter 5. Ingestion rates for example measurement receptors are presented in Chapter 5, Table 5-1. Uncertainties associated with this variable include the following: (1) IR_S values may under- or over-estimate BCF_S when applied to site-specific organisms.
P_S	Portion of ingested bed sediment that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of soil ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for a screening level risk assessment when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated soil ingested by species depends on site-specific information, receptor homerange, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of soil ingested that is contaminated will likely be overestimated.

TABLE F-2-12

COPC DOSE INGESTED TERMS IN CARNIVOROUS BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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Variable	Description	Units	Value
C_{wctot}	Total COPC concentration in water column	mg COPC/L water (or g COPC/m^3 water)	**Varies (calculated - Table B-2-17)** This variable is COPC- and site-specific and is calculated using Table B-2-17. Uncertainties associated with this equation include the following: (1) All of the variables in the equation in Table B-2-17 are COPC- and site-specific. Therefore, the use of default values rather than site-specific values, for any or all of these variables, will contribute to the under- or overestimation of C_{wctot}. (2) Uncertainty associated with f_{wc} is largely the result of uncertainty associated with default OC content values. Uncertainties may also be associated with the variable L_T and k_{wt} The degree of uncertainly associated with the variables d_{wc} and d_{bs} is expected to be minimal either because information for estimating a variable (d_{wc}) is generally available or because the probable range for a variable (d_{bs}) is narrow. The uncertainty associated with the variables f_{wc} and C_{wtot} is associated with estimates of *OC* content. Because *OC* content values can vary widely for different locations in the same medium, the uncertainty associated with using default *OC* values may be significant in specific cases.
$IR_{W\text{-}CB}$	Water ingestion rate for aquatic carnivorous bird	L/kg BW-day	**Varies** This variable is receptor- and habitat-specific, and is discussed in Chapter 5. Ingestion rates for example measurement receptors are presented in Chapter 5, Table 5-1. The following uncertainty is associated with this variable: (1) Water ingestion rates are strongly influenced by animal behavior and environmental factors and may over- or under- estimate $BCF_{W\text{-}HM}$ to an unknown degree.

TABLE F-2-12

COPC DOSE INGESTED TERMS IN CARNIVOROUS BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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Variable	Description	Units	Value
P_W	Portion of ingested water that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of water ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated water ingested by species depends on site-specific information, receptor homerange, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of ingested water that is contaminated will likely be overestimated.

TABLE F-2-12

COPC DOSE INGESTED TERMS IN CARNIVOROUS BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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REFERENCES AND DISCUSSIONS

U.S. EPA. 1993. *Wildlife Exposure Factor Handbook.* Volumes I and II. Office of Research and Development. EPA/600/R-93/187a

TABLE F-2-13

COPC DOSE INGESTED TERMS IN CARNIVOROUS SHORE BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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Description

This equation calculates the daily dose through exposure to contaminated food/prey, sediment, and water in carnivorous shore birds in freshwater marsh, brackish/intermediate marsh, and saltwater marsh food webs. The limitations and uncertainties introduced in calculating this variable include the following:

(1) Variables C_{sed} and C_{wctot} are COPC- and site-specific. Uncertainties associated with these variables will be site-specific
(2) Variables $BCF_{S\text{-}CSB}$, and $BCF_{W\text{-}CSB}$ are based on biotransfer factors for chicken ($Ba_{chicken}$), and receptor-specific ingestion rates, and therefore may introduce uncertainty when used to compute a representative daily dose for site-specific carnivorous birds.

Equation

$$D_{CSB} = \left(C_{BI} \cdot IR_{CSB} \cdot P_{BI} \cdot F_{BI}\right) + \left(C_{WI} \cdot IR_{CSB} \cdot P_{WI} \cdot F_{WI}\right) + \left(C_{HPF} \cdot IR_{CSB} \cdot P_{HPF} \cdot F_{HPF}\right)$$
$$+ \left(C_{OF} \cdot IR_{CSB} \cdot P_{OF} \cdot F_{OF}\right) + \left(C_{OB} \cdot IR_{CSB} \cdot P_{OB} \cdot F_{OB}\right) + \left(C_{sed} \cdot IR_{S-CSB} \cdot P_{S}\right) + \left(C_{wctot} \cdot IR_{W-CSB} \cdot P_{W}\right)$$

Variable	Description	Units	Value
D_{CSB}	Dose ingested for carnivorous shore birds	mg/kg BW-day	
C_{BI}	Concentration of COPC in benthic invertebrates	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-11)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-11. Uncertainties associated with this variable include the following: (1) C_{sed} values are COPC- and site-specific. (2) $BCF_{S\text{-}BI}$ values are intended to represent "generic benthic invertebrate species", and therefore may over- or under-estimate exposure when applied to site-specific organisms.

TABLE F-2-13

COPC DOSE INGESTED TERMS IN CARNIVOROUS SHORE BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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Variable	Description	Units	Value
IR_{CSB}	Food ingestion rate of carnivorous shore birds	kg WW/kg BW-day	**Varies** This variable is receptor-specific, and is discussed in Chapter 5. Ingestion rates for example measurement receptors are provided in Chapter 5, Table 5-1. Uncertainties associated with this variable include: (1) Food ingestion rates are influenced by several factors including: metabolic rate, energy requirements for growth and reproduction, and dietary composition. Ingestion rates are also influenced by ambient temperature, receptor activity level and body weight U.S. EPA (1993). These factors introduce an unknown degree of uncertainty when used to estimate daily dose. (2) *IR* values may over- or under- estimate exposure when applied to site-specific receptors.
P_{BI}	Proportion of benthic invertebrate in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.

TABLE F-2-13

COPC DOSE INGESTED TERMS IN CARNIVOROUS SHORE BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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Variable	Description	Units	Value
F_{BI}	Fraction of diet comprised of benthic invertebrates	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of benthic invertebrates. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applided to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertaintiy and may over-estimate exposure from ingestion of a single dietary item. (3) The defalut value for an equal diet introduces uncertainity and may over- or under- estimate exposure when applied to site-specific receptors.
C_{WI}	Concentration of COPC in water invertebrates	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-12)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-12. Uncertainties associated with this variable include: (1) C_{dw} values are COPC- and site-specific. (2) $BCF_{W\text{-}WI}$ values are intended to represent "generic water invertebrate species", and therefore may over- or under-estimate exposure when applied to site-specific organisms.
P_{WI}	Proportion of water invertebrate in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.

TABLE F-2-13

COPC DOSE INGESTED TERMS IN CARNIVOROUS SHORE BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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Variable	Description	Units	Value
F_{WI}	Fraction of diet comprised of water invertebrates	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of water invertebrates. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applided to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertaintiy and may over-estimate exposure from ingestion of a single dietary item. (3) The defalut value for an equal diet introduces uncertainity and may over- or under- estimate exposure when applied to site-specific receptors.
C_{HPF}	Concentration in herbivorous and planktivorous fish	mg/kg	**Varies (calculated - Table F-1-13)** This variable is site-specific and COPC-specific; it is calculated using the equation in F-1-16. Uncertainties associated with this variable include: (1) C_{dw} values are COPC- and site-specific. (2) The data set used to calculate BCF_{fish} is based on a limited number of test organisms and therefore may over- or under-estimate exposure when applied to site-specific organisms.
P_{HPF}	Proportion of herbivorous and planktivorous fish diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.

TABLE F-2-13

COPC DOSE INGESTED TERMS IN CARNIVOROUS SHORE BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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Variable	Description	Units	Value
F_{HPF}	Fraction of diet comprised of herbivorous and planktivorous fish	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of herbivorous/piscivorous fish. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applided to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertaintiy and may over-estimate exposure from ingestion of a single dietary item. (3) The defalut value for an equal diet introduces uncertainity and may over- or under- estimate exposure when applied to site-specific receptors.
C_{OB}	Concentration of COPC in omnivorous birds	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-6)** This variable is site-specific and COPC-specific; it is calculated using the equation in Table F-1-6. Uncertainties associated with this variable include: (1) Variables C_{sed} and C_{wctot} are COPC- and site-specific. (2) Variables BCF_{S-OB} and BCF_{W-OB} are based on biotransfer factors for chicken ($Ba_{chicken}$), and receptor specific ingestion rates, and therefore may introduce uncertainty when used to compute concentrations for site-specific omnivorous birds.

TABLE F-2-13

COPC DOSE INGESTED TERMS IN CARNIVOROUS SHORE BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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Variable	Description	Units	Value
P_{OB}	Proportion of omnivorous bird in diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{OB}	Fraction of diet comprised of omnivorous birds	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of omnivorous birds. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.
C_{OF}	Concentration of COPC in omnivorous fish	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-16)** This variable is site-specific and COPC-specific; it is calculated using the equation in F-1-16. Uncertainties associated with this variable include: (1) C_{dw} values are COPC- and site-specific. (2) The data set used to calculate BCF_{fish} is based on a limited number of test organisms and therefore may over- or under-estimate exposure when applied to site-specific organisms.

TABLE F-2-13

COPC DOSE INGESTED TERMS IN CARNIVOROUS SHORE BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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Variable	Description	Units	Value
P_{OF}	Proportion of omnivorous fish diet that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of the dietary food item that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for all food types when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated food ingested by a species depends on food availability, diet composition, and animal behavior. Therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and may overestimate the proportion of contaminated food ingested.
F_{OF}	Fraction of diet comprised of omnivorous fish	unitless	**0 to 1** This variable is species- and site-specific, and depends on the percentage of the diet that is comprised of omnivorous fish. The default value for a screening level ecological risk assessment is 100 percent for computing concentration based on an exclusive diet. For calculating an equal diet, F_{diet} is determined based on the number of dietary components in the total diet. The application of an equal diet is further discussed in Chapter 5. Uncertainties associated with this variable include: (1) The actual proportion of the diet that is comprised of a specific dietary item depends on several factors including: food availability, animal behavior, species composition, and seasonal influences. These uncertainties may over- or under- estimate F_{diet} when applied to site-specific receptors. (2) The default value of 100 percent for an exclusive diet introduces uncertainty and may over-estimate exposure from ingestion of a single dietary item. (3) The default value for an equal diet introduces uncertainty and may over- or under- estimate exposure when applied to site-specific receptors.

TABLE F-2-13

COPC DOSE INGESTED TERMS IN CARNIVOROUS SHORE BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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Variable	Description	Units	Value
C_{sed}	COPC concentration in bed sediment	mg COPC/kg DW sediment	**Varies (calculated - Table B-2-19)** This equation calculates the concentration of COPCs in bed sediments. Uncertainties associated with this equation include the following: (1) The default variable values recommended for use in the equation in Table B-2-19 may not accurately represent site-specific water body conditions. The degree of uncertainty associated with default variable values is expected to be limited either because the probable ranges for these variables are narrow or because information allowing reasonable estimates is generally available. (2) Uncertainties associated with variables f_{bs}, C_{wctot} and Kd_{bs} are largely associated with the use of default OC content values in their calculation. The uncertainty may be significant in specific instances, because OC content is known to vary widely in different locations in the same medium. This variable is site-specific.
$IR_{S\text{-}CSB}$	Sediment ingestion rate for carnivorous shorebird	kg DW/kg BW-day	**Varies** This variable is site-, receptor-, and habitat-specific, and is discussed in Chapter 5. Ingestion rates for example measurement receptors are presented in Chapter 5, Table 5-1. Uncertainties associated with this variable include the following: (1) IR_S values may under- or over-estimate BCF_S when applied to site-specific organisms.
P_S	Portion of ingested bed sediment that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of soil ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used for a screening level risk assessment when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated soil ingested by species depends on site-specific information, receptor homerange, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of soil ingested that is contaminated will likely be overestimated.

TABLE F-2-13

COPC DOSE INGESTED TERMS IN CARNIVOROUS SHORE BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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Variable	Description	Units	Value
C_{wctot}	Total COPC concentration in water column	mg COPC/L water (or g COPC/m^3 water)	**Varies (calculated - Table B-2-17)** This variable is COPC- and site-specific and is calculated using Table B-2-17. Uncertainties associated with this equation include the following: (1) All of the variables in the equation in Table B-2-17 are COPC- and site-specific. Therefore, the use of default values rather than site-specific values, for any or all of these variables, will contribute to the under- or overestimation of C_{wctot}. (2) Uncertainty associated with f_{wc} is largely the result of uncertainty associated with default OC content values. Uncertainties may also be associated with the variable L_T and k_{wt}. The degree of uncertainly associated with the variables d_{wc} and d_{bs} is expected to be minimal either because information for estimating a variable (d_{wc}) is generally available or because the probable range for a variable (d_{bs}) is narrow. The uncertainty associated with the variables f_{wc} and C_{wctot} is associated with estimates of *OC* content. Because *OC* content values can vary widely for different locations in the same medium, the uncertainty associated with using default *OC* values may be significant in specific cases.
$IR_{W\text{-}CSB}$	Water ingestion rate for carnivorous shorebird	L/kg BW-day	**Varies** This variable is receptor- and habitat-specific, and is discussed in Chapter 5. Ingestion rates for example measurement receptors are presented in Chapter 5, Table 5-1. The following uncertainty is associated with this variable: (1) Water ingestion rates are strongly influenced by animal behavior and environmental factors and may over- or under- estimate $BCF_{W\text{-}CSB}$ to an unknown degree.
P_W	Portion of ingested water that is contaminated	unitless	**0 to 1** **Default: 1** This variable is species- and site-specific, and depends on the percentage of water ingested that is contaminated. U.S. EPA OSW recommends that a default value of 1.0 be used when site specific information is not available. The following uncertainty is associated with this variable: (1) The actual amount of contaminated water ingested by species depends on site-specific information, receptor homerange, and animal behavior; therefore, the default value of 100 percent may not accurately reflect site-specific conditions, and the proportion of ingested water that is contaminated will likely be overestimated.

TABLE F-2-13

COPC DOSE INGESTED TERMS IN CARNIVOROUS SHORE BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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Alabama Natural Heritage Program
Huntingdon College
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Montgomery, AL 36106
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334-834-5439 (Fax)

Department of Conservation & Natural Resources
Game and Fish Divison
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334-242-0098 (Fax)

Alaska Natural Heritage Program
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Anchorage, AK 99501
907-257-2702
907-258-9139 (Fax)

Arizona Heritage Data Management System
Arizona Game & Fish Department
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Arkansas Natural Heritage Commission
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California Natural Heritage Division
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Connecticut Natural Diversity Database
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Delaware Natural Heritage Program
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Environmental Control
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District of Columbia Natural Heritage Program
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Florida Natural Areas Inventory
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Georgia Natural Heritage Program
Wildlife Resources Division
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Hawaii Natural Heritage Program
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Illinois Natural Heritage Division
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Indiana Natural Heritage Data Center
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Department of Natural Resources
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Maryland Heritage & Biodiversity Conservation Programs Department of Natural Resources Tawes State Office Building, E-1 Annapolis, MD 21401 410-974-2870 410-974-5590 (Fax)	Massachusetts Natural Heritage & Endangered Species Program Division of Fisheries & Wildlife Route 135 Westborough, MA 01581 508-792-7270 508-792-7275 (Fax)	Michigan Natural Features Inventory Mason Building, 5th Floor Box 30444 (FedEx/UPS: 530 W. Allegan, 48933) Lansing, MI 48909-7944 517-373-1552 517-373-6705 (Fax)	Minnesota Natural Heritage & Nongame Research Department of Natural Resources 500 Lafayette Road, Box 7 St. Paul, MN 51555 612-297-4964 612-297-4961 (Fax)
Mississippi Natural Heritage Program Museum of Natural Science 111 North Jefferson Street Jackson, MS 39201 601-354-7303 601-354-7227 (Fax)	Missouri Natural Heritage Division Missouri Department of Conservation P.O. Box 180 (FedEx: 2901 West Truman Blvd.) Jefferson City, MO 65102-0180 573-751-4115 573-526-5582 (Fax)	Montana Natural Heritage Program State Library Building 1515 E. 6th Avenue Helena, MT 59620 406-444-3009 406-444-0581 (Fax)	Nebraska Natural Heritage Program Game and Parks Commission 2200 North 33rd Street P.O. Box 30370 Lincoln, NE 68503 402-471-5421 402-471-5528 (Fax)
Nevada Natural Heritage Program Department of Conservation & Natural Resources 1550 E. College Parkway, Suite 145 Carson City, NV 89710 702-687-4245 702-885-0868 (Fax)	New Hampshire Natural Heritage Inventory Department of Resources & Economic Development 172 Pembroke Street P.O. Box 1856 Concord, NH 03302 603-271-3623 603-271-2629 (Fax)	New Jersey Natural Heritage Program Office of Natural Lands Management 22 South Clinton Ave., CN404 Trenton, NJ 08625-0404 609-984-1339 609-984-1427 (Fax)	New Mexico Natural Heritage Program University of New Mexico 2500 Yale Boulevard, SE, Suite 100 Albuquerque, NM 87131-1091 505-277-1991 505-277-7587 (Fax)
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Oklahoma Natural Heritage Inventory Oklahoma Biological Survey 111 East Chesapeake Street University of Oklahoma Norman, OK 73019-0575 405-325-1985 405-325-7702 (Fax)	Oregon Natural Heritage Program Oregon Field Office 821 SE 14th Avenue Portland, OR 97214 503-731-3070; 230-1221 503-230-9639 (Fax)	Pennsylvania Natural Diversity Inventory PNDI - East The Nature Conservancy 34 Airport Drive Middletown, PA 17057 717-948-3962 717-948-3957 (Fax)	PNDI - West Western Pennsylvania Conservancy Natural Areas Program 316 Fourth Avenue Pittsburgh, PA 15222 412-288-2777 412-281-1792 (Fax)
PNDI Central Bureau of Forestry P.O. Box 8552 Harrisburg, PA 17105-8552 717-783-0388 717-783-5109 (Fax)	Rhode Island Natural Heritage Program Department of Environmental Management Division of Planning & Development 83 Park Street Providence, RI 02903 401-277-2776 x4308 401-277-2069 (Fax)	South Carolina Heritage Trust SC Department of Natural Resources P.O. Box 167 Columbia, SC 29202 803-734-3893 803-734-6310 (Call first fax)	South Dakota Natural Heritage Data Base SD Department of Game, Fish & Parks Wildlife Division 523 E. Capitol Avenue Pierre, SD 57501-3182 605-773-4227 605-773-6245 (Fax)
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ACETONE

1.0 SUMMARY

Acetone is a highly volatile organic compound. Volatilization and biodegradation are the major fate processes affecting acetone released to soil, surface water, and sediment. Routes of exposure for wildlife include ingestion, inhalation, and dermal uptake. Acetone is not bioconcentrated by aquatic organisms, and is not bioaccumulated by mammals and birds. Therefore, it does not bioaccumulate in aquatic or terrestrial food chains.

The following is a profile of the fate of acetone in soil, surface water and sediment; and the fate after uptake by ecological receptors. Section 2 discusses the environmental fate and transport in soil, water and sediment. Section 3 discusses the fate in ecological receptors.

2.0 FATE IN SOIL, SURFACE WATER AND SEDIMENT

Volatilization and leaching are the two primary transport properties affecting the fate of acetone in soils (HSDB 1997). Volatilization is more significant than leaching. The extent of leaching depends on soil characteristics. Evidence also suggests that acetone rapidly degrades in soil (HSDB 1997).

Volatilization and biodegradation are the major fate processes affecting the fate of acetone in surface water. The volatilization half-life for acetone from a model river is approximately 18 hours when estimated using 1-meter depth, a current of 1 m/second, and wind velocity of 3 m/second (Thomas 1982). In addition, acetone does not partition well to sediments because it is highly soluble in water. Dispersion of acetone from the water column to sediment and suspended solids in water is likely to be insignificant, due to the complete miscibility of acetone in water.

Biodegredation is the most significant degradation process of acetone in water (Rathbun et al. 1982). Studies on wastewater have shown that aquatic microbial communities quickly acclimate to acetone, and rapidly biodegrade it (Urano and Kato 1986a,b). When tested in seawater, acetone was biodegraded much slower than when tested in freshwater (Takemoto et al. 1981).

Photolysis as a degradation process for acetone in water is insignificant. Studies have shown that photodecomposition was not observed when acetone contaminated distilled or natural water was exposed to sunlight for 2-3 days (Rathbun et al. 1982).

3.0 FATE IN ECOLOGICAL RECEPTORS

For most aquatic systems, acetone will exist in water rather than sediment, due to acetone's high water solubility and low sediment adsorption coefficient. Bioaccumulation does not occur in aquatic organisms as suggested by the low log K_{ow} value for acetone (Rathbun et al. 1982). Adult haddock tested under static conditions at 7.9°C showed a bioconcentration factor of 1 for acetone (Rustung et al. 1931). Biomagnification along the aquatic food chain is also considered insignificant for acetone as suggested by the low K_{ow} value.

Acetone is a highly volatile compound and may be inhaled in large quantities. Acetone is very water soluble, so it is quickly absorbed following inhalation into the blood stream and dispersed throughout the body. A large portion of acetone is excreted primarily unchanged through the lungs and urine, with only a small portion reduced and excreted as carbon dioxide (Encyclopedia of Occupational Health and Safety 1983). Because acetone is quickly eliminated, wildlife receptors will not accumulate it in tissues.

No information was available on the fate of acetone after exposure by birds or plants.

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ACRYLONITRILE

1.0 SUMMARY

Acrylonitrile is a highly water soluble volatile organic compound. Volatilization and biodegradation are the major fate processes affecting acrylonitrile released to surface soil, surface water, and sediment. Routes of exposure for wildlife include ingestion, inhalation, and dermal uptake. Acrylonitrile is not bioconcentrated by aquatic organisms, and is not bioaccumulated by mammals and birds. Therefore, it does not bioaccumulate in aquatic or terrestrial food chains.

The following is a profile of the fate of acrylonitrile in soil, surface water, and sediment; and the fate after uptake by ecological receptors. Section 2 discusses the environmental fate and transport in surface soil, surface water, and sediment. Section 3 discusses the fate in ecological receptors.

2.0 FATE IN SOIL, SURFACE WATER, AND SEDIMENT

Due to its high water solubility, acrylonitrile is highly mobile in moist soils (EPA 1987). Adsorption into the soil is considered insignificant (Kenaga 1980). Evaporation of acrylonitrile from dry soils is expected to occur rapidly because of its high vapor pressure (Norris 1967; EPA 1987) and high Henry's Law constant (Meylan 1991).

Acrylonitrile is readily soluble in water and does not strongly adsorb to soil or sediment (Klein et al. 1957; ATSDR 1990). Acrylonitrile biodegrades rapidly in water (Miller and Villaume 1978; EPA 1987). Aerobic microorganisms readily degrade acrylonitrile, particularly if acclimation time is allowed (Cherry et al. 1956; Stover and Kincannon 1983; Mills and Stack 1954, 1955).

Acrylonitrile rapidly volatilizes from surface water. A volatilization half-life of 1-6 days in water has been estimated (Thomas 1982; HSDB 1997).

3.0 FATE IN ECOLOGICAL RECEPTORS

Based on experimental and estimated bioconcentration factors, the bioconcentration of acrylonitrile in aquatic organisms is not believed to be significant (Kenaga 1980). A steady-state bioconcentration factor

(BCF) of 48 was measured in bluegill sunfish (Barrows et al. 1978). The estimated average BCF for edible portions of freshwater and marine species was approximately 30 based on the relative proportion of fat in sunfish and other organisms (EPA 1980). Also, based on a low log K_{ow}, acrylonitrile is estimated to show low bioconcentration in aquatic organisms (Verschueren 1983; Kenaga 1980).

Acrylonitrile is readily absorbed into the body through lung and intestinal mucosa following inhalation, ingestion, or dermal contact (Clayton and Clayton 1982). Once absorbed into the body, acrylonitrile is distributed throughout the body to the major organs (Pilon et al. 1988a). Following a single oral dose of radiolabeled acrylonitrile, rapid distribution of acrylonitrile and its metabolites was shown in all tissues of rats (Ahmed et al. 1982, 1983; Silver et al. 1987; Young et al. 1968). Another metabolic pathway includes the formation of CO_2 which is excreted via the lungs (Young et al. 1968). The rate of acrylonitrile metabolism is inconclusive; however, evidence suggests that it is rapid (Pilon et al. 1988b; Ghanayem and Ahmed 1982; Miller and Villaume 1978). Values representing the amount of acrylonitrile metabolized range from 4% to 30% (IARC 1979).

No information was available on the fate of acrylonitrile after exposure by birds or plants.

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ALUMINUM

1.0 SUMMARY

In nature, aluminum does not exist in the elemental state, but partitions between the liquid and solid phases by forming complexes with various compounds. Aluminum adsorbs to clays and suspended solids in water. Exposure routes for aquatic organisms include ingestion, gill uptake and dermal contact. Aluminum bioconcentrates in aquatic organisms. Exposure routes for mammals include ingestion, inhalation and dermal exposure; however, regardless of the route of exposure, aluminum is poorly absorbed by mammals. Aluminum is not readily metabolized. Aluminum causes pulmonary and developmental effects. Aluminum uptake by plants varies between species, resulting in differing rates of bioconcentration in plant tissues.

The following is a profile of the fate of aluminum in soil, surface water and sediment; and the fate after uptake by ecological receptors. Section 2 discusses the environmental fate and transport in soil, surface water and sediment. Section 3 discusses the fate in ecological receptors.

2.0 FATE IN SOIL, SURFACE WATER AND SEDIMENT

Aluminum does not exist as a free metal in nature due to its reactivity, but rather partitions between the solid and liquid phases by reacting with water, chloride, fluoride, sulfate, nitrate, phosphate, humic materials and clay (Bodek et al. 1988). Soils with a greater mineral content result in reduced mobility of aluminum (James and Riha 1989).

In water, aluminum forms relatively water-insoluble complexes, or is found as a water-soluble complex. Aluminum adsorbs to suspended solids and sediment. If large amounts of organic matter or fulvic acid are present, aluminum binds to them (Brusewitz 1984). In water, aluminum undergoes hydrolysis to form hydroxy aluminum species (Snoeyink and Jenkins 1980). The pH of the water determines which hydrolysis products are formed.

3.0 ECOLOGICAL RECEPTORS

Exposure routes for aquatic organisms include ingestion, gill uptake, and dermal absorption. Aluminum bioconcentrates in aquatic species (Cleveland et al. 1989).

Exposure routes for mammals include ingestion, inhalation and dermal exposure. Aluminum is poorly absorbed. Aluminum is distributed to the brain (Santos et al. 1987), bone, muscle and kidneys (Greger and Donnaubauer 1986). No studies were located that described excretion of aluminum in animals; however in humans, absorbed aluminum is excreted primarily through the kidney (Gorsky et al. 1979).

Information was not available on the fate of aluminum in birds.

Aluminum is taken up by plants (Brusewitz 1984). Some plants bioaccumulate aluminum in the root tissues. Plant uptake of aluminum and the transport to stems and leaves varies considerably between species (Kabata-Pendias and Pendias 1984).

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ANTIMONY

1.0 SUMMARY

Antimony binds to soil and particulates and is oxidized by bacteria in soil. Exposure routes for aquatic organisms include ingestion and gill uptake. Antimony bioconcentrates in aquatic organisms. Exposure routes for mammals include ingestion and inhalation. It does not biomagnify in terrestrial food chains. Antimony is not significantly metabolized and is excreted in the urine and the feces. Antimony causes reproductive, pulmonary and hepatic effects in mammals. Antimony uptake by plants occurs following surface deposition.

The following is a profile of the fate of antimony in soil, surface water and sediment; and the fate after uptake by ecological receptors. Section 2 discusses the environmental fate and transport in soil, surface water and sediment. Section 3 discusses the fate in ecological receptors.

2.0 FATE IN SOIL, SURFACE WATER AND SEDIMENT

Antimony binds to soil, particularly to particles containing iron, manganese, or aluminum Ainsworth 1988). In water, antimony is oxidized when exposed to atmospheric oxygen (Parris and Brinckman 1976).

3.0 ECOLOGICAL RECEPTORS

Exposure routes for aquatic organisms include ingestion and gill uptake. Antimony bioconcentrates in aquatic organisms (ACQUIRE 1989; Callahan et al. 1979; EPA 1980).

Exposure routes for mammals include ingestion and inhalation (Groth et al. 1986, EPA 1988). Dermal absorption is low (Myers et al. 1978) and absorption from the respiratory tract is dependent on particle size (Thomas et al. 1973). Following absorption, antimony is distributed to the liver, kidney, bone, lung, spleen and thyroid (Sunagawa 1981; Ainsworth 1988). Antimony is excreted in the urine and the feces (Felicetti et al. 1974). Antimony does not biomagnify in the food chain (Ainsworth 1988). Data regarding the amount of antimony that reaches the site of action and assimilation efficiency were not available.

Information was not available on the fate of antimony in birds.

Antimony is taken up by plants following surface deposition, with uptake from soil dependent on the solubility of the antimony in the soil (Ainsworth 1988).

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ARSENIC

1.0 SUMMARY

Arsenic, because of its complex chemistry, exists in the environment in many different inorganic and organic forms, which have different toxicological and physicochemical properties. Inorganic arsenic exists as either the trivalent (3+) form or the pentavalent (5+) form. The inorganic trivalent arsenic forms are more toxic than the pentavalent forms. Elemental arsenic (the metalloid -0+) is essentially nontoxic even at high intakes.

Arsenic in soil is usually tightly bound. The bioconcentration potential in soil invertebrates and aquatic species is low. Biomagnification through the food chain is minimal because once ingested, arsenic is metabolized to methylated compounds that are rapidly excreted. Absorbed arsenic is distributed to all tissues where it interferes with normal enzymatic activity or disrupts the functioning of other cellular macromolecules. Evaluation of the potential for toxicity from exposure to low levels of arsenic is complicated by the current understanding that arsenic is an essential element in some mammalian species, and that arsenic deficiency may result in adverse reproductive and developmental effects.

The following is a profile of the fate of arsenic in soil, surface water and sediment; and the fate after uptake by ecological receptors. Section 2 discusses the environmental fate and transport in soil, surface water and sediment. Section 3 discusses the fate in ecological receptors.

2.0 FATE IN SOIL, SURFACE WATER, AND SEDIMENT

The dominant form of arsenic in soil and its transport are largely dependent on the physical characteristics of the soil matrix. Insoluble arsenic compounds, such as arsenic trioxide, bind tightly to organic matter in soil or sediment (EPA 1984; ATSDR 1993). Various forms of arsenic in soil are interconverted by chemical reactions and microbial activity. Soil microorganisms convert small amounts of arsenic to volatile arsines. These volatile arsines are released to the air, become adsorbed to particles, and are redeposited (ATSDR 1993) or, under certain conditions, react to form oxides (Ghassemi et al. 1981).

The bioavailability of arsenic in soil is inversely proportional to the organic carbon and clay content of the soil matrix. Arsenic in soil is directly taken up by plants and soil microbes and invertebrates, and indirectly taken up by terrestrial receptors via ingestion.

In surface water, soluble inorganic arsenate (As5+) predominates under normal conditions and is more stable than arsenite (EPA 1980a). Movement and partitioning of arsenic in water depends on the chemical form of arsenic and on interactions with other materials present (Callahan et al. 1979). Soluble forms of arsenic remain dissolved in the water column or adsorb onto sediments or soils, especially those containing clays, iron oxides, aluminum hydroxides, manganese compounds, and organic matter (Callahan et al. 1979; Welch et al. 1988). Sediment bound arsenic is released back into the water by chemical or biological interconversions. This interconversion is influenced by the Eh (the oxidation-reduction potential), pH, temperature, other metals, salinity, and biota (Callahan et al. 1979). Arsenate is transformed by microbes to arsenite and methylated arsenicals (Benson 1989; Braman and Foreback 1973).

3.0 ECOLOGICAL RECEPTORS

Exposure routes for aquatic organisms include gill uptake, ingestion of arsenic suspended on particles in the water column or deposited in sediment, and ingestion of plant matter and lower trophic level aquatic species. Arsenic bioconcentration in aquatic organisms is low (Spehar et al. 1980; EPA 1980b). Fish and shellfish rapidly metabolize arsenic to non-toxic forms (EPA 1984, Garcia-Vargas and Cebrian 1996; ATSDR 1993). Biomagnification does not readily occur in aquatic food chains (Callahan et al. 1979).

Soil invertebrates are directly exposed to arsenic found in soil and soil pore water. Exposure routes for soil invertebrates include ingestion and dermal absorption. Arsenic bioconcentration in soil invertebrates is low (Rhett et al. 1988).

The majority of ecological mammalian exposure occurs through ingestion. The oral absorption efficiency is dependent on the form of arsenic, its solubility, and the media ingested. Soluble arsenic compounds in aqueous solution are more readily absorbed from the gastrointestinal tract than insoluble compounds. Absorption from water ingested is approximately 85%. Inorganic arsenic in food sources is expected to be readily bioavailable with absorption rates of greater than 85% expected. Once absorbed, arsenic is readily transported throughout the body with little tendency to accumulate preferentially in any one internal organ

(ATSDR 1993). Dermal absorption is a minor route of exposure with absorption estimated at 0.1% (ATSDR 1993).

Metabolism of arsenic occurs primarily in the liver. The methylated metabolites are less toxic than the inorganic precursors, and metabolism results in lower tissue retention of inorganic arsenic (Marafante and Vahter 1984, 1986, 1987; Marafante et al. 1985). Inorganic arsenic and its methylated products are rapidly eliminated.

The toxicokinetic data for arsenic indicate there is little potential for bioaccumulation in animal tissue exposed to doses that are below the level required to saturate detoxifying methylation reactions. The level of biomagnification in mammals depends on the diet of the animal. Herbivores have a low arsenic biomagnification rate due to the general lack of transport of arsenic from soil to above ground plant parts. Omnivores have a higher biomagnification rate based on the higher proportion of soil invertebrates in their diet. Carnivores have the highest biomagnification rate due to their diet of aquatic invertebrates, small mammals, and fish and the incidental ingestion of soil. However, arsenic is rapidly metabolized in mammalian species, therefore, arsenic does not readily bioaccumulate in mammals.

Exposure routes for avian receptors include ingestion of surface water, soil, soil and aquatic invertebrates, and plant material. Absorption studies specific to avian species are not available. Based on mammalian absorption (ATSDR 1993), avian absorption can be assumed to be 85% absorption from water, 30% to 40% absorption from soil, and 85% absorption from food sources.

Arsenic uptake by plants depends on the form of arsenic and the type of soil. The higher the soil's organic carbon and clay content the more the arsenic will bind to the soil and, therefore, less arsenic is available for uptake by plant roots. That which is readily taken up by the plant is accumulated in the roots. Arsenite (3+) is highly toxic to cell membranes and, therefore, not readily translocated once taken up; arsenate (5+) is less toxic and, therefore, more readily translocated after uptake (ORNL 1996; Speer 1973). Rice, most legumes, and members of the bean family are sensitive to arsenic in most forms, with spinach being the most sensitive plant (Woolson et al 1975).

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BERYLLIUM

1.0 SUMMARY

In environmental media, beryllium usually exists as beryllium oxide. Beryllium has limited solubility and mobility in sediment and soil. Exposure routes for aquatic organisms include ingestion and gill uptake. Beryllium does not bioconcentrate in aquatic organisms. Beryllium is toxic to warm water fish, especially in soft water. Exposure routes for mammalian species include inhalation. Mammals exposed via inhalation exhibit pulmonary effects which may last long after exposure ceases.

The following is a profile of the fate of beryllium in soil, surface water and sediment, and the fate after uptake by biological receptors. Section 2 discusses the environmental fate and transport in soil, surface water and sediment. Section 3 discusses the fate in ecological receptors.

2.0 FATE IN SOIL, SURFACE WATER, AND SEDIMENT

Beryllium adsorbs to clays at low pH, precipitates as insoluble complexes at higher pH, and has limited solubility in soil (Callahan et al. 1979). Chemical reactions in soil transform one beryllium compound into another (ATSDR 1993). Reactions in soil include hydrolysis of soluble salts, anion exchange, and complexation with ligands such as humic substances (ATSDR 1993).

In water, beryllium is speciated often by hydrolysis in which soluble beryllium salts are hydrolyzed to form relatively insoluble beryllium hydroxide (Callahan et al. 1979). Beryllium is not volatilized from water (ATSDR 1993). Beryllium is retained in an insoluble and immobile form in sediment (EPA 1980).

3.0 ECOLOGICAL RECEPTORS

Beryllium uptake from water is low, resulting in low bioconcentration rates (EPA 1980; Callahan et al. 1979). Biomagnification of beryllium in aquatic food chains does not occur (Fishbein 1981).

In mammals, beryllium compounds are absorbed primarily through the lung (ATSDR 1993). Beryllium is poorly absorbed from the gastrointestinal tract, and is not absorbed through intact skin to any significant degree

(ATSDR 1993). Beryllium is distributed to the liver, skeleton, tracheobronchial lymph nodes, and blood (Finch et al. 1990). Beryllium is not biotransformed, but soluble beryllium salts are partially converted to less soluble forms in the lung (Reeves and Vorwald 1967). Excretion is predominantly via the feces (Finch et al. 1990). Data regarding the amount of beryllium that reaches the site of action or assimilation efficiency were not located.

Information was not available on the fate of beryllium in birds.

Beryllium uptake by plants occurs when beryllium is present in the soluble form. The highest levels of beryllium are found in the roots, with lower levels in the stems and foliage (EPA 1985).

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BIS(2-ETHYLHEXYL)PHTHALATE

1.0 SUMMARY

Bis(2-ethylhexyl)phthalate (BEHP) is a high molecular weight, semi-volatile organic compound. BEHP adsorbs strongly to soil and sediment, and it may be biodegraded in aerobic environments. It has a low water solubility and low vapor pressure. It does not undergo significant photolysis, hydrolysis, or volatilization in soil or water. Receptors may be exposed to BEHP by the oral, inhalation, and dermal routes. BEHP bioconcentration in aquatic organisms is generally low, therefore significant food chain biomagnification in upper-trophic-level fish is unlikely. Mammalian and avian wildlife can metabolize and eliminate BEHP, therefore, it does not biomagnify in these receptors.

The following summarizes the fate of BEHP in surface soil, surface water and sediment; and the fate after uptake by ecological receptors. Section 2 discusses the environmental fate after released to surface soil, surface water, and sediment. Section 3 discusses the fate in ecological receptors.

2.0 FATE IN SOIL, SURFACE WATER AND SEDIMENT

BEHP adsorbs strongly to soil and does not undergo significant volatilization or photolysis (HSDB 1997). Limited information indicates that, under aerobic conditions, degradation in soil may occur (Hutchins et al. 1983; Mathur 1974). However, because BEHP adsorbs strongly to soil, biodegradation is slow (Wams 1987). Biodegradation in anaerobic conditions is slower than under aerobic conditions (Johnson et al. 1984).

BEHP has a low water solubility. In surface water environments, adsorption is the major mechanism affecting the concentration of BEHP. BEHP strongly adsorbs to suspended solids and sediments (Al-Omran and Preston 1987; Sullivan et al. 1982; Wolfe et al. 1980). However, in marine environments, adsorption to sediments may be decreased because BEHP is not as soluble in salt water when compared to fresh water (Al-Omran and Preston 1987). BEHP may also form complexes with fulvic acid, potentially increasing its mobility in aquatic environments (Johnson et al. 1977).

In aquatic environments, biodegradation is the primary route of degradation. BEHP is biodegraded in aerobic conditions; however, under anaerobic conditions, biodegradation is limited (O'Connor et al. 1989; Tabek et al. 1981; O'Grady et al. 1985). A half-life of approximately one month, due to microbial biodegradation has been reported for BEHP in river water (Wams 1987). BEHP does not undergo significant hydrolysis or photolysis in aquatic environments (Callahan et al. 1979). A hydrolysis half-life of 2,000 years has been estimated (Callahan et al. 1979); and in water a photolysis half-life of 143 days has been reported (Wolfe et al. 1980). BEHP does not significantly volatilize from water, with an half-life of 15 years reported (Callahan et al. 1979).

3.0 FATE IN ECOLOGICAL RECEPTORS

Aquatic receptors may be exposed through ingestion of contaminated food or water, dermal exposure, or in the case of fish, by direct contact of the gills with the surrounding water. Based on its low water solubility and high soil partition coefficient (ATSDR 1993), dietary uptake is the most significant route of exposure anticipated for BEHP.

Based on its high log Kow value, BEHP is expected to accumulate in aquatic species (Barrows et al.1980; Mayer 1977). Invertebrates will bioconcentrate BEHP from surface water and from sediment. The level of bioconcentration is receptor-specific, because some invertebrates can metabolize BEHP, while some have limited capability (Sanders et al. 1973). Under continuous exposure conditions, fish will bioconcentrate BEHP to levels moderately higher than the concentration in surface water (Mehrle and Mayer 1976). BEHP has a short half-life in fish, indicating that it is quickly eliminated (Park et al. 1990). Fish eliminate BEHP by metabolizing it to polar byproducts, which are quickly excreted (Melancon and Lech 1977; Menzie 1980). Therefore, food chain accumulation and biomagnification of BEHP in aquatic food webs is not significant (Callahan et al. 1979; Johnson et al. 1977; Wofford et al. 1981).

BEHP is absorbed by mammals following oral (Astill 1989; Rhodes et al. 1986) or dermal exposure (Melnick et al. 1987), with oral exposure being the route with the greatest absorption efficiency in laboratory animals. In laboratory animals, small amounts of BEHP have been shown to be absorbed following dermal exposure (Melnick et al. 1987). Following oral exposure, it has been reported that a portion of the BEHP is hydrolyzed in the small intestine to 2-ethylhexanol and mono(ethylhexyl)phthalate which is subsequently absorbed (Albro, et al. 1982). Following absorption, BEHP is distributed primarily to the liver and kidney, and in some species, to the testes (Rhodes et al. 1986).

In mammals, BEHP is metabolized by tissue esterases that hydrolyze one of the ester bonds resulting in the formation of mono(2-ethylhexyl)phthalate and 2-ethylhexanol. Small amounts of mono(2-ethylhexyl)phthalate may be further hydrolyzed to form phthalic acid; however, the majority undergoes aliphatic side chain oxidation followed by alpha- or beta-oxidation. These oxidized products may then be conjugated with glucuronic acid and excreted (Albro 1986). Metabolites of BEHP are excreted in both the urine and the feces (Astill 1989; Short et al. 1987; Ikeda et al. 1980).

BEHP may evaporate from the leaves of plants. In one study, using a closed terrestrial simulation chamber, BEHP was applied to the leaves of *Sinapis alba*. Evaporation rates from the leaves were <0.8 ng/cm^2-hr for a time interval of 0–1 days and <0.5 ng/cm^2-hr for a time interval of 8–15 days (Loekke and Bro-Rasumussen 1981). Uptake of BEHP by plants has also been reported (Overcash et al. 1986).

No data were available on the fate of BEHP in birds.

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CADMIUM

1.0 SUMMARY

Cadmium exists in the elemental (0+) state or the 2+ valance state in nature. Exposure routes for aquatic organisms include ingestion and gill uptake. Freshwater biota are the most sensitive organisms to cadmium exposure, with toxicity inversely proportional to water hardness. Cadmium bioaccumulates in both aquatic and terrestrial animals, with higher bioconcentration in aquatic organisms. Exposure routes for ecological mammalian species include ingestion and inhalation. Cadmium interferes with the absorption and distribution of other metals and causes renal toxicity in vertebrates.

The following is a profile of the fate of cadmium in soil, surface water and sediment, and the fate after uptake by biological receptors. Section 2 discusses the environmental fate and transport in soil, surface water and sediment. Section 3 discusses the fate in ecological receptors.

2.0 FATE IN SOIL, SURFACE WATER AND SEDIMENT

Cadmium has a low vapor pressure and is released from soil to air by entrainment with soil particles (EPA 1980; OHM/TADS 1997). Cadmium compounds in soil are stable and are not subject to degradation (ATSDR 1993). Cadmium compounds can be transformed by precipitation, dissolution, complexation, and ion exchange (McComish and Ong 1988).

Cadmium compounds in aquatic environments are not affected by photolysis, volatilization, or biological methylation (Callahan et al. 1979). Precipitation and sorption to mineral surfaces and organic materials are important removal processes for cadmium compounds (ATSDR 1993). Concentrations of cadmium are generally higher in sediments than in overlying water (Callahan et al. 1979).

3.0 ECOLOGICAL RECEPTORS

Cadmium bioconcentrates in aquatic organisms, primarily in the liver and kidney (EPA 1985). Cadmium accumulated from water is slowly excreted, while cadmium accumulated from food is eliminated more rapidly (EPA 1985). Metal-binding, proteinaceous, metallothionens appear to protect vertebrates from deleterious effects of high metal body burdens (Eisler 1985).

Exposure routes in ecological mammalian species include ingestion and inhalation, while dermal absorption is negligible (Goodman and Gilman 1985). Absorption and retention of cadmium decreases with prolonged exposure. Cadmium absorption through ingestion is inversely proportional to intake of other metals, especially iron and calcium (Friberg 1979). Cadmium accumulates primarily in the liver and kidneys (IARC 1973). Cadmium crosses the placental barrier (Venugopal 1978). Cadmium does not undergo direct metabolic conversion, but the ionic (+2 valence) form binds to proteins and other molecules (Nordberg et al. 1985). Absorbed cadmium is excreted very slowly, with urinary and fecal excretion being approximately equal (Kjellstrom and Nordberg 1978).

Freshwater aquatic species are most sensitive to the toxic effects of cadmium, followed by marine organisms, birds, and mammals.

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CHROMIUM

1.0 SUMMARY

Chromium exists primarily in the Cr3+ and Cr6+ valence forms in environmental and biological media. It exists in soil primarily in the form of insoluble oxides with very limited mobility. In the aquatic phase, chromium may be in the soluble state or attached to clay-like or organic suspended solids.

Exposure routes for aquatic organisms include ingestion, gill uptake, and dermal absorption. Bioaccumulation occurs in aquatic receptors; biomagnification does not occur in aquatic food chains. Exposure routes for ecological mammalian species include ingestion, inhalation, and dermal absorption. Chromium is not truly metabolized, but undergoes various changes in valence states and binding with ligands and reducing agents in vivo. Elimination of chromium is slow.

The following is a profile of the fate of chromium in soil, surface water and sediment, and the fate after uptake by biological receptors. Section 2 discusses the environmental fate and transport in soil, surface water and sediment. Section 3 discusses the fate in ecological receptors.

2.0 FATE IN SOIL, SURFACE WATER, AND SEDIMENT

In soil, chromium 3+ is readily hydrolyzed and precipitated as chromium hydroxide. It exists in soil primarily as insoluble oxide with very limited mobility (EPA 1984a, b).

In water, chromium 6+ occurs in the soluble state or as suspended solids adsorbed onto clay-like materials, organics, or iron oxides. Cr6+ persists in water for long periods of time, but is eventually reduced to chromium 3+ by organic matter or other reducing agents in water (Cary 1982).

3.0 ECOLOGICAL RECEPTORS

Exposure routes for aquatic organisms include ingestion, gill uptake, and dermal absorption. Chromium bioconcentrates in aquatic organisms (ATSDR 1993; OHM/TADS 1997; EPA 1985; EPA 1984a). The biomagnification and toxicity of chromium 3+ is low relative to chromium 6+ because of its low membrane permeability and noncorrosivity. Chromium is not significantly biomagnified in aquatic food chains.

In vertebrates, chromium 3+ is an essential nutrient needed to produce glucose tolerance factor (GTF), which is required for regulation of glucose levels (ATSDR 1993). Exposure routes for ecological mammalian species include ingestion, inhalation, and dermal absorption. Chromium is poorly absorbed from the gastrointestinal tract after oral exposure, but fasting increases the absorption (Chen et al. 1973). Absorbed chromium is distributed to various organs including the liver and spleen (Maruyama 1982 as cited in ATSDR 1993; Witmer et al. 1989, 1991, as cited in ATSDR 1993).

Following inhalation exposure, chromium is distributed to the lung, kidney, spleen, and erythrocytes (Weber 1983; Baetjer et al. 1959). Following dermal exposure, chromium is readily absorbed and is distributed to the blood, spleen, bone marrow, lymph glands, urine, and kidneys. Chromium is not truly metabolized, but undergoes various changes in valence states and binding with ligands and reducing agents in vivo. Elimination of chromium is slow (Langard et al. 1978).

A large degree of accumulation by aquatic and terrestrial plants and animals in the lower trophic levels has been documented, however, the mechanism of this accumulation remains unknown.

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COPPER

1.0 SUMMARY

Copper binds to soils and sediment. Copper is not biodegraded or transformed. Exposure routes for aquatic organisms include ingestion, gill uptake, and dermal absorption. In aquatic organisms, exposures to copper are associated with developmental abnormalities. Copper bioconcentrates in aquatic organisms, however, biomagnification does not occur. Exposure routes for ecological mammalian species include ingestion, inhalation, and dermal absorption. Copper is associated with adverse hematological, hepatic, developmental, immunological, and renal effects in mammals. Copper does not bioaccumulate in mammals.

The following is a profile of the fate of copper in soil, surface water and sediment; and the fate after uptake by ecological receptors. Section 2 discusses the environmental fate and transport in soil, surface water and sediment. Section 3 discusses the fate in ecological receptors.

2.0 FATE IN SOIL, SURFACE WATER AND SEDIMENT

Copper occurs naturally in many animals and plants and is an essential micronutrient. Copper may exist in two oxidation states: +1 or +2. Copper (+1) is unstable and, in aerated water over the pH range of most natural waters (6 to 8), oxidizes to the +2 state. In the aquatic environment, the fate of copper is determined by the formation of complexes, especially with humic substances, and sorption to hydrous metal oxides, clays, and organic materials. The amount of copper able to remain in solution is directly dependent on water chemistry, especially pH and temperature, and the concentration of other chemical species (Callahan et al. 1979; Tyler and McBride 1982; Fuhrer 1986).

The majority of copper released to surface waters settles out or adsorbs to sediments (Harrison and Bishop 1984). Copper is affected by photolysis (Moffett and Zika 1987). Some copper complexes undergo metabolism however, biotransformation of copper is low (Callahan 1979).

3.0 ECOLOGICAL RECEPTORS

Copper bioconcentrates in aquatic organisms. Copper does not biomagnify in aquatic food chains (Heit and Klusek 1985; Perwack et al. 1980).

Copper is absorbed by mammals following ingestion, inhalation, and dermal exposure (Batsura 1969; Van Campen and Mitchell 1965; Crampton et al. 1965). Once absorbed, copper is distributed to the liver (Marceau et al. 1970). Copper is not metabolized. Copper exerts its toxic effects by binding to DNA (Sideris et al. 1988) or by generating free radicals (EPA 1985). Copper does not bioaccumulate in mammals and is excreted primarily in the bile (Bush et al. 1955).

Copper is known to inhibit photosynthesis and plant growth. Because copper is an essential micronutrient for plant nutrition, most adverse effects result from copper deficiency (Adriano 1986).

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CROTONALDEHYDE

1.0 SUMMARY

Crotonaldehyde is a highly volatile, water-soluble, low molecular weight, organic compound. Volatilization is the major fate process for crotonaldehyde in surface water and surface soil. Crotonaldehyde does not bioconcentrate in aquatic organisms and does not accumulate in wildlife. Therefore, food chain transfer is insignificant.

The following summarizes information about the fate of crotonaldehyde in soil, surface water, and sediment; and the fate after uptake by ecological receptors. Section 2 discusses the environmental fate and transport in soil, water and sediment. Section 3 discusses the fate in ecological receptors.

2.0 FATE IN SOIL, SURFACE WATER, AND SEDIMENT

Crotonaldehyde has a low K_{oc} value, therefore it will not strongly adsorb to soils (Irwin 1988 as cited in ATSDR 1990), and may dissolve in soil water. Crotonaldehyde has a short half-life (Lyman 1982) and it will quickly volatilize from surface soils.

Crotonaldehyde is completely miscible in water and does not dissolve in oils. However, based on its volatilization half-life of about 1 to 2 days (Bowmer et al. 1974; Thomas 1982), crotonaldehyde is expected to quickly volatilize from surface water. The adsorption of crotonaldehyde to suspended solids and sediment is not expected to be significant because of its low K_{oc} value (Lyman 1982).

Aerobic biodegradation may degrade crotonaldehyde at low concentrations in natural water (Bowmer and Higgins 1976; Callahan et al. 1979; Tabak et al. 1981). In addition, data suggest that persistence of crotonaldehyde in aerobic aquatic environments for moderate to long periods of time will not occur (Jacobson and Smith 1990 as cited in ATSDR 1990).

3.0 FATE IN ECOLOGICAL RECEPTORS

Based on its short volatilization half life and low bioconcentration factor (Bysshe 1982; Hansch and Leo 1985), crotonaldehyde will not concentrate in aquatic organisms.

Little information was available on the fate of crontonaldehyde in mammals. Because crotonaldehyde has a low soil adsorption coefficient and strongly volatilizes, inhalation is the primary exposure route for mammals. Studies have indicated that inhaled crotonaldehyde is quickly absorbed by the upper and lower respiratory tracts (Egle 1972). Studies also suggest that absorbed crotonaledhyde is quickly metabolized (Alarcon 1976; Kaye 1973; Patel et al. 1980).

No information was available on the fate of crotonaldehyde in birds or plants.

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CUMENE (ISOPROPYLBENZENE)

1.0 SUMMARY

1-methylethylbenzene is also called cumene. Cumene and its superoxidized form, cumene hydroperoxide, are moderately volatile organic compounds. Cumene released to soil and surface water will rapidly dissipate through biodegradation and volatilization. Routes of exposure for cumene and cumene hydroperoxide include inhalation, ingestion, and dermal exposure. However, due to its high potential to volatilize, inhalation is the major exposure route for wildlife receptors. Bioconcentration of cumene is not likely in aquatic organisms. No information was available regarding the environmental fate of cumene hydroperoxide in air, water, or soil. However, degradation in soil and water is expected to be very rapid based on the high reactivity of cumene hydroperoxide with multivalent metal ions and free radicals.

The following is a profile of the fate of cumene and cumene hydroperoxide in soil, surface water and sediment; and the fate after uptake by ecological receptors. Section 2 discusses the environmental fate and transport in soil, surface water and sediment. Section 3 discusses the fate in ecological receptors.

2.0 FATE IN SOIL, SURFACE WATER, AND SEDIMENT

The primary removal process for cumene in soil is expected to be through biodegradation in surface soil, and volatilization (HSDB 1997). Based on its log K_{oc} value (Lyman 1982), cumene that does not volatilize is expected to strongly adsorb to soil.

The environmental fate of cumene hydroperoxide in soil is unknown. However, based on its high reactivity with multivalent metal ions and free radicals, degradation in soil is expected to be very rapid (HSDB 1997).

In surface water, cumene is expected to have a relatively short half-life. The primary removal processes for cumene when released in water are volatilization and biodegradation (GEMS 1986; HSDB 1997). Based on different water characteristics, volatilization half-lives ranging from a few hours to a few days have been estimated (GEMS 1986). Cumene is amenable to biodegradation (Price et al. 1974; Kappeler and Wuhrmann 1978), and biodegrades in 10 to 30 days (Walker and Colwell 1975; Price et al. 1974).

The environmental fate of cumene hydroperoxide in water is unknown. However, based on its high reactivity with multivalent metal ions and free radicals, degradation in water is expected to be very rapid (HSDB 1997).

3.0 FATE IN ECOLOGICAL RECEPTORS

Cumene is reported to have relatively low bioconcentration in fish (ITC/EPA 1984; Geiger 1986;).

In wildlife, cumene and cumene hydroperoxide enter the body primarily via inhalation and dermal absorption (Lefaux 1968; HSDB 1997). Cumene is readily absorbed in mammalian systems and oxidized (Clayton and Clayton 1982). In the event that cumene is ingested, it is readily metabolized and excreted (Robinson et al. 1955). Long-term exposure by mammals results in cumene distribution to many tissues and organs (Gorban et al. 1978).

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DDE

1.0 SUMMARY

Dichlorodiphenyldichloroethane (DDE) is a high molecular weight, chlorinated pesticide. It is also a congener of dichlorodiphenyltrichloroethane (DDT), a full-spectrum pesticide. DDE is stable, accumulates in soil and sediment, and concentrates in fatty tissue. DDE has a low water solubility, and is adsorbed strongly in soils and sediments. Soil and benthic organisms accumulate DDE from soil and sediment. Wildlife will accumulate DDE in fatty tissue. Following chronic exposure by wildlife to DDE, an equilibrium between absorption and excretion may occur; however, concentrations will continue to increase because accumulation is related to fat content, which increases with age.

The following summarizes the fate of DDE in surface soil, surface water, and sediment; and the fate after uptake by ecological receptors. Section 2 discusses the environmental fate and transport in soil, water, and sediment. Section 3 discusses the fate in ecological receptors.

2.0 FATE IN SOIL, SURFACE WATER, AND SEDIMENT

DDE absorbs strongly to soil and is only slightly soluble in water. Under normal environmental conditions, DDE does not hydrolyze or biodegrade. In soils with low organic content, evaporation from the surface of soil may be significant (HSDB 1997).

DDE is bioavailable to plants and soil invertebrates despite being highly bound to soil. DDT has been found to accumulate in grain, maize, and rice plants with the majority located in the roots. Mobilization of soil-bound DDT by earthworms to more bioavailable forms has also been reported (Verma and Pillai 1991).

DDE is very persistent in the aquatic environment, has a very low water solubility, and is highly soluble in lipids. Compounds with these characteristics tend to partition to the organic carbon fraction of sediments and lipid fraction of biota (EPA 1986). DDE absorbs very strongly to sediment, and bioconcentrates in aquatic organisms (HSDB 1997). In aquatic environments, the small fraction of dissolved DDE may be photolyzed.

3.0 FATE IN ECOLOGICAL RECEPTORS

In general, DDE will bioconcentrate in lower-trophic-level organisms and will accumulate in food chains. Fish and other aquatic organisms readily take up pesticides, including DDE. Pesticides are taken up by organisms through the gills, by direct contact with the contaminant in the water, or by ingestion of contaminated food, sediment, or water. The lipophilic nature and extremely long half life of DDE result in bioaccumulation when it is present in ambient water. DDE will bioconcentrate in freshwater and marine plankton, insects, mollusks and other invertebrates, and fish (Oliver and Niimi 1985). When these organisms are consumed by other receptors, DDE is transferred up food chains. Following absorption, either through the gills or by ingestion, pesticides appear in the blood and may be distributed to tissues of all soft organs (Nimmo 1985).

DDE is accumulated to high concentrations in fatty tissues of carnivorous receptors. Elimination and absorption of DDE may occur simultaneously once an equilibrium is reached. This equilibrium may be disturbed by high concentrations of DDE, but termination of exposure usually results in elimination of the stored substance. This elimination occurs in two phases—an initial rapid phase followed by a much slower gradual loss (Nimmo 1985).

DDE can be introduced into mammals through oral, dermal, and inhalation exposure. Inhalation absorption is considered minor because the large particle size of DDE precludes entry to the deeper spaces of the lung; DDE is deposited in the upper respiratory tract and, through mucociliary action, is eventually swallowed and absorbed in the gastrointestinal tract. Gastrointestinal absorption following oral exposure has been shown in experimental animals (Hayes 1982). Dermal absorption is limited and the toxic effects are less than those seen following oral exposure. The highest concentration of DDE and metabolites has been found in adipose tissue, followed by reproductive organs, liver, kidneys, and brain (EPA 1980).

The metabolism of DDE in animals is similar to that in humans. DDE metabolism and elimination occurs very slowly. The primary route of elimination is in the urine (Gold and Brunk 1982, 1983, 1984); however, DDE may also be eliminated through the feces, semen, or breast milk. When exposure ceases, DDE is slowly eliminated from the body (Murphy 1986). The biological half-life of DDE is 8 years (NAS 1977).

Bioaccumulation has been reported in one Alaskan study of two raptor species—the Rough-legged hawk and the Peregrine falcon. Higher tissue residues were reported in the peregrine falcon than in the rough-legged hawk. It was believed that these differences may have been due to the different feeding habits of the birds (Matsumura 1985).

No information was available on the fate of DDE taken up by plants.

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DICHLOROFLUOROMETHANE

1.0 SUMMARY

Dichlorofluoromethane (DCFM) is a highly volatile hydrocarbon. It has a high vapor pressure and low soil adsorption coefficient; therefore, volatilization is the main fate process for DCFM released to surface soil and surface water. For terrestrial animals, inhalation is the main exposure route and ingestion is a minor exposure route. DCFM is not expected to bioconcentrate in fish; however, it can accumulate in tissues of mammals. DCFM is not expected to move up food chains.

The following information summarizes the fate of dichlorofluoromethane in soil, surface water and sediment; and the fate after uptake by ecological receptors. Section 2 discusses the environmental fate and transport in soil, water and sediment. Section 3 discusses the fate in ecological receptors.

2.0 FATE IN SOIL, SURFACE WATER, AND SEDIMENT

If released to soil, DCFM, an inert gas at room temperature, is expected to volatilize into the air due to its low soil adsorption coefficient (K_{oc}) value (Lyman et al. 1982). Because it does not have a strong affinity for organic carbon, it may dissolve in soil pore water, thus becoming bioavailable. Photooxidation, hydrolysis, and biodegradation are not likely to be significant removal processes for DCFM in soil due to its high volatility and minimal reactivity (HSDB 1997).

Based on its high water solubility and low soil adsorption coefficient, DCFM does not adsorb strongly to suspended solids or sediment. Based on a reported half-life of less than 1 day, DCFM is expected to rapidly volatilize from water (Lyman et al. 1982). The hydrolysis of DCFM is reported to be very low (<0.01 g/l of water-yr) (Du Pont de Nemours Co. 1980).

3.0 FATE IN ECOLOGICAL RECEPTORS

DCFM is not expected to bioconcentrate in aquatic organisms, based on its low log K_{ow} value (Hansch and Leo 1985) and low estimated BCF value (Lyman et al. 1982).

Information was not available on the fate of DCFM in mammals, birds, or plants.

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DICHLOROETHENE, 1,1-

1.0 SUMMARY

1,1-dichloroethene is a hydrophillic, low molecular weight, chlorinated hydrocarbon. It has a short half-life in the environment, thus acute exposures by ecological receptors are the main concern. Evaporation and biodegradation are major fate processes for 1,1-dichloroethene in soil, surface water, and sediment. It will also adsorb to detritus in soils and sediments. Ingestion and respiratory uptake are the significant direct exposure routes for ecological receptors exposed to 1,1-dichloroethene. Metabolic intermediates are responsible for the toxicity of 1,1-dichloroethene to upper trophic level receptors. Indirect (food chain) exposure through ingestion of contaminated food is minor because it is readily biotransformed and excreted. Hence, the biomagnification potential is very low.

The following is a profile of the fate of 1,1-dichloroethene in soil, surface water and sediment; and the fate after uptake by ecological receptors. Section 2 discusses the environmental fate and transport in soil, water and sediment. Section 3 discusses the fate in ecological receptors.

2.0 FATE IN SOIL, SURFACE WATER AND SEDIMENT

If released onto the soil surface, the majority of 1,1-dichloroethene will quickly evaporate. Depending on the hydrogeology of a site, some may leach into ground water. Based on its high water solubility and small K_{oc} value, 1,1-dichloroethene may migrate through soils by adsorbing to dissolved organic carbon (EPA 1982). Studies have also documented that 1,1-dichloroethene will biodegrade in soils (HSDB 1997). A bioaccumulation factor for 1,1-dichloroethene in soil was not reported. However, based on its volatility and polarity, 1,1-dichloroethene is not expected to significantly bioaccumulate in soil (Callahan et al. 1979).

Evaporation is the major fate of 1,1-dichloroethene in surface water, with a short half-life of 1-6 days. Only a small quantity of 1,1-dichloroethene will be lost by adsorption onto the sediment (HSDB 1997). 1,1-dichloroethene also quickly biodegrades in aqueous environments. Degradation studies showed that 45–78% was lost in 7 days, when incubated with a wastewater inoculum. A large amount was also lost due to volatilization (Patterson and Kodukala 1981). In anaerobic environments, 1,1-dichloroethene degrades (through reductive dechlorination) to vinyl chloride. Anaerobic degredation is slower that aerobic degradation. Approximately 50-80% of 1,1-dichloroethene underwent degradation in 6 months in a simulated groundwater environment (Barrio-Lage et al. 1986; Hallen et al. 1986). Photo-oxidation and hydrolysis are not expected to be significant removal processes for 1,1-dichloroethene (Callahan et al. 1979; Mabey et al. 1981; Cline and Delfino 1987). A bioaccumulation factor for 1,1-dichloroethene in water and sediment was not reported. However, based on its volatility and polarity, 1,1-dichloroethene is not expected to significantly bioaccumulate in water or sediment (Callahan et al. 1979).

3.0 FATE IN ECOLOGICAL RECEPTORS

Aquatic receptors may be directly exposed to dissolved 1,1-dichloroethene through gill respiration or through ingestion of suspended particles. Because 1,1-dichloroethene generally is not persistent in surface water, exposures are expected to be of short duration. 1,1-dichloroethene is not expected to bioconcentrate in fish or aquatic invertebrates, based on its low log K_{ow} value (Tute 1971; HSDB 1997). Due to limited bioconcentration, 1,1-dichloroethene is not expected to biomagnifiy in terrestrial or aquatic food chains (Barrio-Lage et al. 1986; Wilson et al. 1986).

1,1-dichloroethene is readily absorbed following inhalation (Dallas et al. 1983; McKenna et al. 1978a) or oral exposure, and is rapidly distributed in the body. Following inhalation exposure to 1,1-dichloroethene, uptake is dependent upon the duration of the exposure and the dose. Until equilibrium is reached, as exposure concentration increases, the percentage of 1,1-dichloroethene uptake decreases. Studies show that 2 minutes after inhalation exposure, substantial amounts of 1,1-dichloroethene were found in the venous blood of rats. Concentrations of 150 ppm or less of 1,1-dichloroethene showed a linear cumulative uptake. However, at 300 ppm steady state was not achieved, indicating saturation at high concentrations (Dallas et al. 1983).

Following oral administration of 1,1-dichloroethene in corn oil, rapid and almost complete absorption from the gastrointestinal tract of rats and mice was observed (Jones and Hathway 1978a; Putcha et al. 1986). Recovery of radio-labeled 1,1-dichloroethene was 43.55, 53.88, and 42.11%, 72 hours following oral administrations of 0.5, 5.0, and 50 mg/kg, respectively, to rats (Reichert et al. 1979). Also, 14.9-22.6% 1,1 dichloroethene was recovered in expired air, 42.11-53.88% in urine, 7.65-15.74% in feces, 2.77-5.57% in the carcass, and 5.91-9.8% in the cage rinse (Reichert et al. 1979).

1,1-dichloroethene is distributed mainly to the liver and kidneys following inhalation or oral exposure. In rodents, the highest levels of 1,1-dichloroethene are found in the liver and kidneys. Rats that were fasted and exposed to 1,1-dichloroethene showed significantly greater tissue burden than nonfasted rats (McKenna et al. 1978b; Jones and Hathway 1978b).

1,1-dichloroethene does not appear to be stored or accumulated in tissues, but is metabolized by the hepatic microsomal cytochrome P-450 system. This reaction produces reactive intermediates responsible for the toxicity of 1,1-dichloroethene. These reactive intermediates are detoxified through hydroxylation or conjugation with GSH, which is the primary biotransformation pathway in the rat. Excretion of unmetabolized 1,1-dichloroethene is through exhaled air, and metabolites are excreted via urine and exhaled air (Fielder et al. 1985; ATSDR 1994).

Avian receptors may be directly exposed to 1,1-dichloroethene through the ingestion of surface water and soil. Absorption studies specific to avian species were not identified in the literature.

Data on the fate of 1,1-dichloroethene in plant receptors were not identified in the literature. However, based on the low probability of significant bioaccumulation, uptake by plant receptors is expected to be minimal.

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DINITROTOLUENES

1.0 SUMMARY

2,4-dinitrotoluene and 2,6-dinitrotoluene are semi-volatile, nitrogen-substituted, organic compounds. They are moderately persistent in soil and have short half-lives in aqueous environments due to high rates of photolysis. Evidence also indicates that they are biodegraded in soil, surface waters and sediment. For wildlife, all routes of exposure are significant. Dinitrotoluenes are not expected to bioconcentrate in aquatic organisms and bioaccumulation is not expected in animal tissues. The major target organs following exposure to 2,4-dinitrotoluene are the liver and kidney. 2,6-dinitrotoluene is distributed to various organs following uptake. Evidence indicates that upper-trophic-level receptors rapidly metabolize 2,4-dinitrotoluene to innocuous by-products that are readily excreted. 2-6-dinitrotoluene is metabolized to a highly electrophilic ion that is capable of reacting with DNA and other biological nucleophiles.

The following summarizes the fate of 2,4-dinitrotoluene and 2,6-dinitrotoluene in soil, surface water and sediment; and the fate after uptake by ecological receptors. Section 2 discusses the environmental fate and transport in soil, water and sediment. Section 3 discusses the fate in ecological receptors.

2.0 FATE IN SOIL, SURFACE WATER, AND SEDIMENT

2,4-dinitrotoluene is expected to be slightly mobile in soil, based on its estimated K_{oc} value (Lyman et al 1982; Kenaga 1980). Information on the biodegradation of 2,4-dinitrotoluene in soil was not located; however, biodegradation is thought to occur in both aerobic and anaerobic zones of soil, based on aqueous biodegradation experiments (HSDB 1997).

2,6-dinitrotoluene readily biodegrades when released into the soil. Half-lives of 73 and 92 days were reported, when tested in two soils, with degradation rates of 0.5 to 0.7 mg/kg/day reported (Loehr 1989). Based on the calculated K_{oc} value (Lyman et al. 1982) and the estimated log K_{ow} value (GEMS 1984), 2,6-dinitrotoluene is expected to be slightly mobile in soil (Kenaga 1980).

Volatilization of dinitrotoluenes from surface soil is expected to be negligible due to very low vapor pressures of these compounds (Banerjee et al. 1990). Hydrolysis is not a significant removal process for nitroaromatic hydrocarbons (Lyman et al. 1982).

2,4-dinitrotoluene and 2,6-dinitrotoluene have a slight tendency to sorb to sediments, suspended solids, and biota, based on measured log K_{ow} values (GEMS 1984). In surface water, photolysis is the primary removal process for 2,4-dinitrotoluene and 2,6-dinitrotoluene. Reported half-lives range from a few minutes to a few hours (Spanggord et al. 1980; Zepp et al. 1984). Hydrolysis is not a removal process for nitroaromatics (Lyman et al. 1982).

Dinitrotoluenes do not readily volatilize in surface water. Volatilization half-lives of 2-4 dinitrotoluene from distilled water were 248 and 133 hours, which correspond to the volatilization rate constants of 0.0028 and 0.0052/hour (Smith et al. 1981). Davis et al. (1981), reported a 0.3 percent loss of 2,6-dinitrotoluene in a model waste stabilization pond. Empirical evidence indicates that dinitrotoluenes are expected to biodegrade in surface waters (Uchimura and Kido 1987; Umeda et al. 1985; Kondo et al. 1988; Tabak et al. 1981).

3.0 FATE IN ECOLOGICAL RECEPTORS

Aquatic organisms take up 2,4-dinitrotoluene, however, it does not bioconcentrate because it is readily eliminated. Measured BCF values for dinitrotoluenes are low indicating that bioconcentration does not occur in aquatic organisms (Deneer et al. 1987; EPA 1980).

Evidence indicates that once it is ingested by wildlife, 2,4-dinitrotoluene is rapidly absorbed into the bloodstream (Rickert et al. 1983). 2,4-dinitrotoluene is quickly distributed, with the highest concentrations in the liver and kidney (Rickert and Long 1981). The metabolism of 2,4-dinitrotoluene occurs in the liver and the intestine (via intestinal microflora), and it is quickly eliminated through the urine and feces (Lee et al. 1978; Long and Rickert 1982; Rickert and Long 1981; Schut et al. 1983). Based on the low log P value for 2,4-dinitrotoluene, bioaccumulation in animal tissues is not expected (Callahan et al. 1979; Mabey et al. 1981).

Dinitrotoluenes are expected to be readily taken up by plants, based on structural analogies with 1,3-dinitrobenzene and p-nitrotoluene (McFarlane et al. 1987; Nolt 1988).

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DI(N)OCTYLPHTHALATE

1.0 SUMMARY

Di(n)octylphthalate (DOP) is a high-molecular-weight, semi-volatile compound. It has a low water solubility and low vapor pressure, therefore it adsorbs strongly to the soil and sediment. Biodegradation is possible under aerobic conditions, but is slow under anaerobic conditions. DOP also undergoes hydrolysis in water. DOP may be absorbed following oral (dietary), inhalation, or dermal exposures, however dietary exposure is the most significant route of exposure. DOP may accumulate to increasing concentrations in algae, aquatic invertebrates, and fish, and accumulate to low levels in terrestrial wildlife. However, higher-trophic-level receptors will quickly metabolize it, therefore it does not biomagnify in food chains.

The following is a profile of the fate of DOP in soil, surface water and sediment; and the fate after uptake by ecological receptors. Section 2 discusses the environmental fate and transport in soil, water and sediment. Section 3 discusses the fate in ecological receptors.

2.0 FATE IN SOIL, SURFACE WATER AND SEDIMENT

DOP has a very high K_{oc} value; therefore, it should adsorb strongly and remain immobile in soil (Wolf et al. 1980). Degradation in soil is slow, especially under anaerobic conditions (HSDB 1997).

Following release into aquatic environments, DOP adsorbs strongly to sediments and particulate material suspended in the water column (HSDB 1997). DOP has a moderate half-life in aquatic environments; losses are due to both volatilization and microbial degradation. Slow degradation is possible in aerobic conditions; however, DOP is resistant to anaerobic degradation (HSDB 1997). Approximately 50% degradation was observed within 5 days in a model terrestrial-aquatic ecosystem, with the monoester and phthalic acids the primary degradation products (Sanborn et al. 1975). DOP may bioconcentrate in aquatic organisms (Sanborn et al. 1975).

3.0 FATE IN ECOLOGICAL RECEPTORS

Sanborn et al. (1975) evaluated the bioconcentration and trophic transfer of DOP in model aquatic ecosystems containing phytoplankton, zooplankton, snails, insects, and fish. Evidence showed that the algae and invertebrates bioconcentrated DOP. Fish accumulated DOP to low levels, indicating that these receptors readily eliminate DOP.

DOP may be absorbed following oral, inhalation or dermal exposures (EPA 1980a); however, due to low volatility of DOP, inhalation is not a significant route of exposure (Meditext 1997). Following absorption, DOP is rapidly distributed with the highest amounts concentrated in the liver, kidney and bile (EPA 1980b). DOP is rapidly metabolized to water-soluble derivatives (Gosselin et al. 1984) prior to and after absorption (EPA 1980b). These metabolites are then excreted through the urine and the bile (Ikeda et al. 1978).

No information was available on the fate of DOP in birds or plants.

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DIOXANE, 1,4-

1.0 SUMMARY

1,4-dioxane is a highly water-soluble, moderately volatile organic compound. In soil, surface water, and sediment environments, 1,4-dioxane is not persistent because it is volatile and because it has a low affinity for adsorption to organic carbon. It has a low potential to bioconcentrate in aquatic receptors. Wildlife can be exposed to 1,4-dioxane through ingestion, inhalation, and dermal contact. It does not bioaccumulate in food chains.

The following is a profile of the fate of 1,4-dioxane in soil, surface water and sediment; and the fate after uptake by ecological receptors. Section 2 discusses the environmental fate and transport in soil, water and sediment. Section 3 discusses the fate in ecological receptors.

2.0 FATE IN SOIL, SURFACE WATER AND SEDIMENT

Based on an estimated log K_{oc} value (Lyman et al. 1982), 1,4-dioxane is expected to have a low affinity for organic carbon in soil, thus having a high potential to leach out of surface soils (HSDB 1997). This reduces the exposure potential for vegetation (through root uptake) and soil invertebrates. In addition, because of its moderate vapor pressure, volatilization is expected to be a significant fate process in soil (Verschueren 1983). Based on the volatility of 1,4-dioxane, biaccumulation is not considered to be a significant fate process in soil.

1,4-dioxane is infinitely soluble in water (Lange 1967). However, because 1,4-dioxane has a moderate vapor pressure at 25°C, volatilazation from water is a significant removal process (Verschueren 1983; HSDB 1997). 1,4-dioxane is not expected to adsorb to suspended sediments or detritus due to the estimated K_{oc} value (HSDB 1997). Based on its high volatility in water and low absorption to sediments, bioaccumulation is not expected to be a significant fate process for 1,4-dioxane in water and sediment.

3.0 FATE IN ECOLOGICAL RECEPTORS

Because it is highly soluble in water, aquatic receptors can take up 1,4-dioxane through direct exposure, however, it is not expected to bioconcentrate based on its low K_{ow} value (Hansch and Leo 1985).

Information suggests that 1,4-dioxane has a low potential to be biodegraded in aerobic aquatic environments. Biodegradation experiments with activated sludge showed a negligible biochemical oxygen demand for 1,4-dioxane, therefore, classifying 1,4-dioxane as relatively undegradable (Mills 1954; Alexander 1973; Heukelekian and Rand 1955; Fincher and Payne 1962; Lyman et al. 1982; Kawasaki 1980).

No information was available on the fate of 1,4-dioxane after uptake by aquatic receptors. However, its low bioconcentration factor suggests that 1,4-dioxane is readily eliminated after uptake (Hansch 1985).

The metabolism of 1,4-dioxane in rats has been studied, and information indicates that at high daily doses, 1,4-dioxane can induce its own metabolism. There is an apparent threshold of toxic effects of 1,4-dioxane that coincides with saturation of the metabolic pathway for its detoxification (Young et al. 1978). 1,4-dioxane is highly toxic via all routes of exposure (OHM/TADS 1997), and is readily absorbed through intact skin (Gosselin 1984). Once 1,4-dioxane enters the body, it is distributed throughout the tissues, including the liver, kidney, spleen, lung, colon, and skeletal muscle (Woo et al. 1977). The excretion of 1,4-dioxane is primarily through the urine, in which approximately 85% of excreted material is in the form of beta-hydroxyethoxyacetic acid, a metabolic byproduct. The remaining material is excreted as unchanged dioxane (Braun & Young 1977).

Information was not available on the fate of 1,4-dioxane in birds or plants.

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DIBENZO-*p*-DIOXINS

1.0 SUMMARY

Dibenzo-p-dioxins (dioxins) are a group of high molecular weight chlorinated compounds that are highly soluble in fatty tissues. The congener tetrachlorodibenzodioxin (TCDD) is commonly used as a surrogate for estimating the fate of dioxins in the environment and in ecological receptors. Dioxins have low water solubilities and adsorb strongly to organic carbon in sediment and soil. Dioxins bioaccumulate in aquatic organisms and wildlife, and biomagnify in food chains because of their affinity for lipids. Biomagnification of TCDD appears to be significant between fish and fish-eating birds, but not between fish and their food (other fish).

The following is a profile of the fate of dioxins in soil, surface water, and sediment; and the fate after uptake by ecological receptors. Section 2 discusses the environmental fate and transport in soil, water, and sediment. Section 3 discusses the fate in ecological receptors.

2.0 FATE IN SOIL, SURFACE WATER, AND SEDIMENT

TCDD adsorbs strongly to soils (HSDB 1997). TCDD in soil may be susceptible to photodegradation. Volatilization from soil surfaces during warm months may be a major mechanism by which TCDD is removed from soil. Various biological screening studies have demonstrated that TCDD is generally resistant to biodegradation. The half-life of TCDD in surface soil varies from less than 1 year to 3 years. Half-lives in deeper soils may be as long as 12 years (EPA 1993).

TCDD is very persistent in the aquatic environment, has a very low aqueous solubility, and is highly soluble in lipids. Aquatic sediments are an important reservoir for dioxins, and may be the ultimate environmental sink for all global releases of TCDD (HSDB 1997). TCDD may be removed from water through either photolysis or volatilization. The photolysis half-life at surface level has been estimated to range from 21 hours in summer to 118 hours in winter (HSDB 1997). These rates increase significantly with increasing water depths. Therefore, many bottom sediments may not be susceptible to significant photodegradation. The volatilization half-life from the water column of an environmental pond has been estimated to be 46 days, and may be as high as 50 years if adjusted for the effects of sediment adsorption.

Various biological screening studies have demonstrated that TCDD is generally resistant to biodegradation. The persistent half-life of TCDD in lakes has been estimated to be in excess of 1.5 years (HSDB 1997).

3.0 FATE IN ECOLOGICAL RECEPTORS

Ecological exposures to TCDD can occur via ingestion of contaminated soils, water, and sediment, dermal exposure to soil and water, and to a much lesser extent via inhalation of airborne vapors and particulates. It should be noted that, unlike toxicokinetic and toxicodynamic studies where exposures are closely controlled, environmental exposure to dioxin occurs as a complex mixture of congeners, including TCDD. It is generally understood that persistent, lipophilic compounds accumulate in fish in proportion to the lipid content and age of each animal (Gutenmann et al. 1992). Also, it has been demonstrated that the influence of biotransformation on bioaccumulation increases as a function of the K_{ow} of the compound (de Wolf et al. 1992). The dependence of metabolic rate on TCDD dose and length of exposure is not well understood, but time-course studies of P-450 induction in rainbow trout by β-napthoflavone demonstrate that different toxicity responses can occur over time depending on the frequency and duration of exposure (Zhang et al. 1990).

Dioxins readily bioconcentrate in aquatic organisms (Branson et al. 1985; Mehrle et al. 1988; Cook et al. 1991; and Schmieder et al. 1992). Evidence indicates that dioxins will distribute in fish tissues in proportion to the total lipid content of the tissues (Cook et al 1993). Dioxins are metabolized and eliminated very slowly from fish (Kleeman et al. 1986a,b; Opperhuizen and Sijm 1990; Kuehl et al. 1987).

Several studies in a wide range of mammalian and aquatic species indicate that TCDD is metabolized to more polar metabolites (Ramsey et al. 1979; Poiger and Schlatter 1979; Olson et al. 1980; Olson 1986; Poiger et al. 1982; Sijm et al. 1990; Kleeman et al. 1986a,b, 1988; Gasiewicz et al. 1983; Ramsey et al. 1982). The metabolism of TCDD and related compounds is required for urinary and biliary elimination and plays an important role in regulating the rate of excretion of these compounds.

Dioxins are transferred through food chains, biomagnifying in upper-trophic-level receptors, especially birds. Biomagnification of TCDD appears to be significant between fish and fish-eating birds but not between fish and their food (Carey et al. 1990). The lack of apparent biomagnification between fish and their prey is probably due to the influence of biotransformation of TCDD by the fish. Limited data for the base of the Lake Ontario lake trout food chain indicates little or no biomagnification between zooplankton and forage fish (Whittle et al. 1992). BMFs based on fish consuming invertebrate species probably are close to 1.0 because of the TCDD biotransformation by forage fish.

Oral absorption of dioxin related compounds in laboratory animals has been reported to be contingent on species, test compound, administered dose, and vehicle. Typical oral absorption values range from 50 to 90 percent (EPA 1994). Because TCDD in the environment is likely to be adsorbed strongly to soil, the oral bioavailability of TCDD varies significantly from laboratory values. Studies have shown that oral bioavailability of TCDD in soil is lower by as much as 50 percent as compared to oral bioavailability of TCDD administered in corn oil over a 500-fold dose range (EPA 1994). Moreover, oral bioavailability of TCDD may be significantly lower in different soil types, with values as low as 0.5 percent bioavailability reported (Umbreit et al. 1986 a,b).

Dermal absorption of TCDD has been studied extensively in laboratory animals. Dermal absorption has been demonstrated to depend on applied dose, with lower relative absorption (percentage of administered dose) decreasing at higher doses (Brewster et al. 1989). Dermal absorption rates in laboratory rats ranged from 17 to 40 percent of administered dose (Brewster et al. 1989). Percent bioavailability of TCDD following dermal absorption is significantly lower than bioavailability following oral absorption by as much as 60 percent (Poiger and Schlatter 1980). As with oral absorption of TCDD in soil, percent bioavailability following dermal exposure to TCDD in soil was significantly lower than percent bioavailability following an equivalent oral dose (approximately 1 percent of an administered dose) (Shu et al. 1988).

Transpulmonary absorption of TCDD has been studied in laboratory animals following intratracheal instillation of the compound in various vehicles (Nessel et al. 1990, 1992). Systemic effects characteristic of TCDD exposures, including hepatic microsomal cytochrome p-450 induction, were observed after inhalation exposures, indicating that transpulmonary absorption does occur and that inhalation may be an important route of TCDD exposure. Transpulmonary bioavailability was estimated at approximately 92 percent of administered dose, very similar to that observed after oral exposures (Diliberto et al. 1992). It should be noted that in an environmental setting, inhalation exposures to TCDD in fly ash, dust and soil particulates may be associated with very different absorption and bioavailability patterns.

Tissue distribution studies in laboratory rats and mice indicate that TCDD is distributed preferentially to adipose tissue and liver (EPA 1994). TCDD is distributed to other organs as well, but to a lesser extent. Also, tissue distribution of TCDD has been demonstrated to be time and dose-dependent, with increasing levels of TCDD distributing to adipose and liver associated with higher doses and increased latency period from time of dosage (EPA 1994).

Plants will take up TCDD through root uptake from soil and through foliar uptake from air (EPA 1994). No other information was available on the fate of dioxins after uptake by plants.

No information was available on the fate of dioxins in birds.

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DIBENZOFURANS

1.0 SUMMARY

Polychlorinated dibenzofurans (PCDF) are a class of hydrophobic chlorinated compounds that adsorb strongly to soils and sediments. Like dioxins, PCDFs are persistent in the environment, bioconcentrate in aquatic organisms, and biomagnify in some food chains. Because PCDFs are associated with organic material in abiotic media, direct contact by soil and sediment receptors, and ingestion by bottom-feeding fish and upper trophic level wildlife, are the most important exposure routes.

Since PCDFs are structurally similar to, and behave in the environment like dioxins, fate of PCDFs is inferred from information about dioxins. Most of the description on the fate of PCDFs is based on the behavior of tetrachlorodibenzofuran (TCDF), one of the most toxic PCDF congeners. The following is a profile of the fate of polychlorinated dibenzofurans (PCDFs) in soil, water, and sediment; and the fate after uptake by ecological receptors. Section 2 discusses the environmental fate and transport in soil, surface water, and sediment. Section 3 discusses the fate in ecological receptors.

2.0 FATE IN SOIL, SURFACE WATER, AND SEDIMENT

TCDF adsorbs strongly to soils. Based upon its high K_{oc} value, TCDF is expected to sorb very strongly in soil and not be susceptible to leaching under most soil conditions. No data are available regarding the biological degradation of TCDF in soil (HSDB 1997).

TCDF in the water column can be expected to partition strongly to sediment and suspended particulate matter. Volatilization from the water column can be important, however the significance of this fate process is limited by strong sorption to sediments (HSDB 1997). Bioconcentration in aquatic organisms may be significant. Aquatic hydrolysis is not expected to be important. Data on biodegradation of TCDF are unavailable (HSDB 1997).

3.0 FATE IN ECOLOGICAL RECEPTORS

Based on high Kow values, PCDFs are expected to accumulate in aquatic receptors (Gutenmann et al. 1992).

Based on its similar structure to dioxins, PCDFs are expected to accumulate to high concentrations in aquatic and semi-aquatic mammals and in fish-eating birds.

Information was not available on the disposition of PCDFs in plants.

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HEXACHLOROBENZENE

1.0 SUMMARY

Hexachlorobenzene (HCB) is a persistent chemical that adsorbs strongly to soil and sediment. It is relatively stable in the environment and is resistant to hydrolysis, photolysis, and oxidation, with relatively no metabolism by microorganisms. Due to its high affinity for organic carbon, HCB will accumulate in sediments. Soil invertebrates and benthic invertebrates will take up HCB directly from these media. For higher-trophic-level receptors, indirect (food chain) exposure is anticipated to be the most significant pathway because HCB is resistant to metabolism and is very soluble in fat. The major toxic effect that has been observed across all species tested is porphyria.

The following is a profile of the fate of HCB in soil, surface water and sediment; and the fate after uptake by ecological receptors. Section 2 discusses the environmental fate and transport in soil, water and sediment. Section 3 discusses the fate in ecological receptors.

2.0 FATE IN SOIL, SURFACE WATER, AND SEDIMENT

Due to a long half-live in soil and its strong affinity for organic carbon, HCB released to soil is likely to remain there for extended periods of time (Beck and Hansen 1974). Minimal biodegradation occurs, depending on the organic carbon content of the soil. Some evaporation from surface soil to air may occur, again depending on the organic carbon content of the soil (Gile and Gillett 1979).

Once released to water, HCB will either evaporate rapidly or adsorb to sediments, with very little dissolved in water (HSDB 1997; Kelly et al. 1991). Limited degradation of HCB is expected, since it appears to be stable to hydrolysis, photolysis, and oxidation (Callahan et al. 1979). Since HCB adsorbs strongly to sediments, it may build up in bottom sediments.

3.0 FATE IN ECOLOGICAL RECEPTORS

Aquatic organisms may be exposed to HCB through ingestion of contaminated water, soil, sediment, or food. Empirical information indicates that HCB bioconcentrates in fish and invertebrates (Giam et al.

1980; Konemann and Vanleeuwen 1980; Veith et al. 1979; Oliver and Niimi 1983; Parrish et al. 1978; Kosian et al. 1978; Neely et al. 1974; Zitko and Hutzinger 1976; Laseter et al. 1976).

HCB can be transferred through aquatic food chains. Knezovich and Harrison (1988) reported that chironomid larvae, a common food item of young fish and other aquatic receptors, rapidly bioaccumulate HCB and other chlorobenzenes from contaminated sediments, achieving steady state within 48 hours. Information was not available about metabolism of HCB by fish.

Ingestion of contaminated media and food is the main route of mammalian exposure to HCB (HSDB 1997; ATSDR 1994; Edwards et al. 1991). Following ingestion, HCB is readily absorbed and is distributed through the lymphatic system to all tissues. It accumulates in fatty tissues and persists for many years since it is highly lipophilic and is very slowly metabolized (Weisenberg 1986; Mathews 1986).

HCB is slowly metabolized by the hepatic cytochrome P-450 system, conjugated with glutathione, or reductively dechlorinated (ATSDR 1994). The metabolites of HCB in laboratory animals include pentachlorophenol, pentachlorobenzene, tetrachlorobenzene, traces of trichlorophenol, a number of sulfur containing compounds, and some unidentified compounds (Mehendale et al. 1975; Renner and Schuster 1977, 1978; Renner et al. 1978; Edwards et al. 1991).

Plants take up relatively minimal amounts of HCB from soils (EPA 1985; Carey et al. 1979). Information was not available on the fate of HCB in birds.

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HEXACHLOROBUTADIENE

1.0 SUMMARY

Hexachlorobutadiene (HCBD) is a moderately volatile, high molecular weight, chlorinated compound. In surface soil and sediment, it will adsorb to organic carbon. It is moderately soluble in water. In surface water, it will adsorb to suspended material; however, it has a tendency to volatilize. In aerobic environments, in will biodegrade. Exposure routes for aquatic organisms include ingestion, gill uptake, and dermal contact. HCBD bioconcentrates in aquatic life. For mammalian and avian wildlife, HCBD can be taken up through oral, inhalation, and dermal exposure routes. HCBD is not expected to bioaccumulate to high levels in upper-trophic-level receptors. HCBD metabolites cause adverse effects.

The following is a profile of the fate of HCBD in soil, surface water and sediment; and the fate after uptake by ecological receptors. Section 2 discusses the environmental fate and transport in soil, water and sediment. Section 3 discusses the fate in ecological receptors.

2.0 FATE IN SOIL, SURFACE WATER, AND SEDIMENT

HCBD has a high soil partition coefficient, and would, therefore, be expected to adsorb to soils with a high organic content (Montgomery and Welkom 1990); however, in sandy soils with a low organic content, HCBD is more mobile and will be found in soil pore water (Piet and Zoeteman 1980). HCBD also has a moderate potential to evaporate from surface soils, unless it is bound to organic carbon (Pearson and McConnel 1975). HCBD is expected to biodegrade in aerobic soils (Tabak et al. 1981), but not in anaerobic environments (Johnson and Young 1983).

Following release into water, HCBD will either quickly volatilize or adsorb to sediments and suspended material (Montgomery and Welkom 1990). HCBD will accumulate concentrations in sediments (Elder et al. 1981; EPA 1976; Oliver and Charlton 1984). Biodegradation is a significant removal process for HCBD in aerobic environments (Tabak et al. 1981). However, under anaerobic conditions biodegradation does not occur (Johnson and Young 1983).

3.0 FATE IN ECOLOGICAL RECEPTORS

HCBD dissolved in surface water is expected to bioconcentrate in aquatic organisms, including algae, benthic macroinvertebrates (such as worms and bivalves), detritivore (crayfish), and plantivorous fish (EPA 1976, Oliver and Niimi 1983). HCBD also accumulates in carnivorous fish (EPA 1976). In fish, HCBD will distribute to fatty tissue, especially the liver (Pearson and McConnell 1975 as cited in ATSDR 1994).

Mammals may be exposed to HCBD through (1) ingestion of soil and exposed sediment while foraging for food, grooming, and soil covering plant matter, (2) ingestion of drinking water, and (3) indirect ingestion of contaminated plant and animal matter. Based on HCBD's affinity for soil and sediment, and its potential to be bioconcentrated, it is anticipated that indirect exposure will be the most significant exposure route for mammals. Once ingested, HCBD is readily absorbed in the gastrointestinal tract (Reichert et al. 1985). Following absorption, HCBD is distributed primarily to the kidney, liver, adipose tissue, and brain (Dekant et al. 1988; Nash et al. 1984; Reichert et al. 1985).

HCBD does not appear to be metabolized by the hepatic mixed function oxidase system; however, it does undergo conjugation with glutathione in the liver (Garle and Fry 1989). Metabolic derivatives of these conjugates are believed to be responsible for the renal damage associated with exposure to HCBD (Dekant et al. 1991; Koob and Dekant 1992).

In gravid birds, low levels of HCBD will be transferred to eggs (Dow Chemical Co. 1972).

Information was not available on the fate of HCBD in plants.

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HEXACHLOROCYCLOPENTADIENE

1.0 SUMMARY

Hexachlorocyclopentadiene (HCCP) is a semi-volatile, chlorinated compound. If HCCP is released as an emission product, it has been shown to exist mostly in the vapor phase, with photolysis resulting in rapid degradation. HCCP in soil will adsorb to soil particles. Degradation of HCCP may also occur in the environment by chemical hydrolysis and biodegradation by soil biota. Depending on the route of exposure, HCCP may distribute mainly to the lungs, kidneys, and liver. HCCP could potentially bioaccumulate in some aquatic organisms depending upon the species. The respiratory system is the major site of toxicity following inhalation exposure, while, depending on the species, the kidney or the liver are the major sites of toxicity following oral exposure.

The following is a profile of the fate of HCCP in soil, surface water and sediment, and the fate after uptake by ecological receptors. Section 2 discusses the environmental fate and transport in soil, water and sediment. Section 3 discusses the fate in ecological receptors.

2.0 FATE IN SOIL, SURFACE WATER, AND SEDIMENT

HCCP deposited to soil is expected to adsorb strongly to organic carbon in the soil (HSDB 1997). Volatilization from soil surfaces is expected to be minor. In moist soil, hydrolysis and biodegradation under aerobic and anaerobic conditions may occur (HSDB 1997). HCCP on the surface of soil may be subject to photolysis.

HCCP present in surface water will degrade primarily by photolysis and chemical hydrolysis. The half-life of HCCP from photodegradation is very short ; Wolfe et al.(1982) reported a half-life of less than 15 minutes in the top of the water column. In unlit or deep, turbid water, the degradation of HCCP occurs by chemical hydrolysis. Hydrolytic half-lives for HCCP range from several hours to 2-3 weeks, depending on the temperature of the water (Chou et al. 1981; Zepp and Wolfe 1987). HCCP has the potential to adsorb to suspended solids in surface water and sediments; however, this adsorption does not affect the rate of hydrolysis (Wolfe et al. 1982).

Volatilization from water is also expected to be a significant removal mechanism; however, adsorption to suspended solids and sediments may interfere with this process. (EPA 1987).

3.0 FATE IN ECOLOGICAL RECEPTORS

HCCP is expected to be moderately bioconcentrated by algae, invertebrates, and fish. (Lu et al. 1975; Spehar et al. 1979; Veith et al. 1979; Podowski and Khan 1984; Freitag et al. 1982) (Geyer et al. 1981). HCCP taken up by freshwater fish (goldfish) is readily distributed, stored, and metabolized (Podowski et al. 1991). In fish, HCCP is excreted in the bile. The biological half-life of HCCP in the goldfish was approximately 9 days (Podowski and Khan 1984).

Inhalation is the main exposure route for HCCP toxicity in mammals. HCCP is less absorbed following ingestion (Lawrence and Dorough 1981). Following ingestion, HCCP will move primarily to the liver and the kidney (Lawrence and Dorough 1981), which appear to be the main sites of toxicity (Abdo et al. 1984; Southern Research Inst 1981).

Limited information was available regarding the metabolism of HCCP. Some degradation may occur in the gut following oral administration (Dorough and Ranieri 1984; Mehendale 1977).

Information was not available on the fate of HCCP in birds or plants.

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HEXACHLOROPHENE

1.0 SUMMARY

Hexachlorophene is a persistent organic chemical that is highly soluble in lipids and adsorbs strongly to soil and sediment In surface soils and the euphotic (light-penetrating) zone of surface waters, hexachlorophene is degraded by photolysis. Hexachlorophene may be bioconcentrated by aquatic and soil organisms. In upper-trophic-level receptors, hexachlorophene may be absorbed following oral or dermal exposure and is distributed throughout all body tissues. Due to its high lipid solubility, hexachlorophene has the potential to be transferred significantly in food chains. In mammals, the nervous system is the major site of toxicity for hexachlorophene; however, reproductive and developmental effects have also been reported. Exposure to hexachlorophene may result in decreased egg production in birds.

The following is a profile of the fate of hexachlorophene in soil, surface water, and sediment; and the fate after uptake by ecological receptors. Section 2 discusses the environmental fate and transport in soil, water, and sediment. Section 3 discusses the fate in ecological receptors.

2.0 FATE IN SOIL, SURFACE WATER, AND SEDIMENT

Hexachlorophene adsorbs strongly to soil and once bound does not tend to leach from soil or mobilize in soil. Hexachlorophene does not undergo significant hydrolysis or evaporation from the soil; however, slow photodegradation may occur if exposed to light above 290 nm (Kotzias et al. 1982).

Hexachlorophene does not undergo hydrolysis, evaporation or volatilization in water; however, slow photodegradation may occur. Hexachlorophene adsorbs strongly to sediments and has been identified in the humic acid portion of sediment. The half-life of hexachlorophene in water is expected to be greater than 50 years with a half-life of 290 days reported in sediment. Hexachlorophene has been reported to bioconcentrate in aquatic organisms (Kotzias et al. 1982; Hansch and Leo 1985; Lyman et al. 1982).

3.0 FATE IN ECOLOGICAL RECEPTORS

Based on its high octanol-water partition coefficient, hexachlorophene is expected to bioconcentrate in aquatic life living in the water column and in the sediment. Bioconcentration has been measured in mosquito fish and snail (Hansch and Leo 1985; Lyman et al. 1982).

Hexachlorophene is absorbed rapidly following oral exposure (Hatch 1982). Hexachlorophene may also be absorbed following dermal exposure with blood levels peaking approximately 6 to 10 hours post-application (Meditext 1997). Hexachlorophene is highly lipid-soluble. After entering the bloodstream, it distributes into adipose tissue and tissue with a high lipid content including the central nervous system. Hexachlorophene binds preferentially to myelin (Meditext 1997). Transplacental transfer of hexachlorophene has also been reported (Hatch 1982). Target organs include the nervous system, the gastrointestinal system, and skin (Meditext 1997).

Hexachlorophene has been reported to have low volatility from plant leaves (Goetchius et al. 1986). Additional data regarding the potential effects of hexachlorophene on plants were not located. Information was not available on the fate of hexachlorophene in exposed birds.

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HYDRAZINE

1.0 SUMMARY

Hydrazine is a reactive, nitrogen-containing compound. It is readily biodegraded after release to soil and surface water. Volatilization may also be a significant removal process. Hydrazine is readily absorbed following inhalation, ingestion, and dermal absorption. Mammals rapidly break down and excrete hydrazine.

The following is a profile of the fate of hydrazine in soil, surface water and sediment; and the fate after uptake by ecological receptors. Section 2 discusses the environmental fate and transport in soil, surface water, and sediment. Section 3 discusses the fate in ecological receptors.

2.0 FATE IN SOIL, SURFACE WATER, AND SEDIMENT

Studies show that hydrazine is expected to biodegrade in soils high in organic carbon, and to adsorb to soils high in clay content (Braun and Zirrolli 1983; Sun et al. 1992). For dry surface soil, volatilization may be a significant process (HSDB 1997).

Hydrazine is expected to have a relatively short half-life of 8.3 days in pond water (Braun and Zirrolli 1983). Hydrazine has been reported to react with dissolved oxygen at a rate inversely proportional to its concentration (Slonim and Gisclard 1976); its degradation rate increases with increasing temperature, dissolved oxygen, and the presence of microorganisms (Sun et al. 1992).

3.0 FATE IN ECOLOGICAL RECEPTORS

Hydrazine is absorbed rapidly from the lungs, gastrointestinal tract, and through skin (ACGIH 1991). Hydrazine is reported to be neurotoxic, hepatotoxic and nephrotoxic in rodents (Lambelt and Shank 1988). Hydrazine is rapidly metabolized in the liver and eliminated (Jenner and Timbrell 1995).

Information was not available on the fate of hydrazine in exposed birds, aquatic life, or plants.

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MERCURY

1.0 SUMMARY

Mercury is a highly toxic compound with no known natural biological function. Mercury exists in three valence states: mercuric (Hg2+), mercurous (Hg1+), and elemental (Hg0+) mercury. It is present in the environment in inorganic and organic forms. Inorganic mercury compounds are less toxic than organomercury compounds, however, the inorganic forms are readily converted to organic forms by bacteria commonly present in the environment. The organomercury compound of greatest concern is methylmercury.

Mercury sorbs strongly to soil and sediment. Elemental mercury is highly volatile. In aquatic organisms, mercury is primarily absorbed through the gills. In aquatic and terrestrial receptors, some forms of mercury, especially organomercury compounds, bioaccumulate significantly and biomagnify in the food chain. In all receptors, the target organs are the kidney and central nervous system. However, mercury causes numerous other effects including teratogenicity and mutagenicity.

The following is a profile of the fate of mercury in soil, surface water and sediment, and the fate after uptake by biological receptors. Section 2 discusses the environmental fate and transport in soil, surface water and sediment. Section 3 discusses the fate in ecological receptors.

2.0 FATE IN SOIL, SURFACE WATER, AND SEDIMENT

In soil, mercury exists in the mercuric (Hg2+) and mercurous (Hg1+) states. Mercury adsorbs to soil or is converted to volatile forms (Krabbenhoft and Babiarz 1992; Callahan et al. 1979). Mercury can migrate by volatilization from aquatic and terrestrial sources through the reduction of metallic mercury to complex species and by the deposition in reducing sediments. Atmospheric transport is a major environmental distribution pathway.

Mercury 2+ is the predominant form of mercury in surface waters (ATSDR 1993). Nonvolatile mercury in surface water binds to organic matter and sediment particles (Lee and Iverfeldt 1991).

Sorption to suspended and bed sediments is one of the most important processes determining the fate of mercury in aquatic systems; sorption onto organic materials is the strongest for mercury 2+. As a result, mercury is generally complexed to organic compounds and is not readily leached from either organic-rich or mineral-rich soils (Rosenblatt et al 1975). Most mercury compounds can be remobilized in aquatic systems by microbial conversion to methyl and dimethyl forms. Conditions reported to enhance microbial conversion include large amounts of available mercury, large numbers of bacteria, absence of strong complexing agents, near neutral pH, high temperatures, and moderately aerobic conditions.

3.0 ECOLOGICAL RECEPTORS

Sorption at the gill surface is the major pathway of mercury entry in aquatic organisms (EPA 1984). In aquatic organisms, bioaccumulation is rapid and elimination is slow. Biomagnification occurs in the aquatic food chain (NRCC 1979). Absorbed mercury is distributed to the blood and ultimately the internal organs. Mercury which is not absorbed is eliminated rapidly in the feces (Eisler 1987). The biological half-life of mercury in fish is approximately 2 to 3 years (EPA 1985). In general, mercury accumulation is enhanced by elevated water temperatures, reduced water hardness or salinity, reduced water pH, increased age of the organism, reduced organic matter content of the medium, and the presence of zinc, cadmium, or selenium in solution.

Mercury is readily absorbed by terrestrial species following oral and inhalation exposure. Elemental and organomercury compounds are readily transferred across the placenta and blood-brain barrier. Mercury is bioaccumulated primarily in the kidney (Rothstein and Hayes 1964; Nielsen and Andersen 1991), and mercury is biomagnified in mammals (Eisler 1987). Retention of mercury in mammals is longer for organomercury compounds (especially methylmercury) than for inorganic forms. Mercury elimination occurs via the urine, feces, expired air, and breast milk (Clarkson 1989; Yoshida et al. 1992).

All mercury compounds interfere with metabolism in organisms, causing inhibition or inactivation of proteins containing thiol ligands and ultimately leading to miotic disturbances (Das et al 1982; Elhassani 1983). Mercury also binds strongly with sulfhydryl groups. Phenyl and methyl mercury compounds are among the strongest known inhibitors of cell division (Birge et al 1979). In mammals, methyl mercury irreversibly destroys the neurons of the central nervous system.

Information was not available on the fate of mercury in birds.

Mercury in soils is generally not available for uptake by plants due to the high binding capacity to clays and other charged particles (Beauford et al 1977). However, mercury levels in plant tissues increase as soil levels increase with 95% of the accumulation and retention in the root system (Beauford et al 1977; Cocking et al 1991). Mercury is reported to inhibit protein synthesis in plant leaves and may affect water-adsorbing and transporting mechanisms in plants (Adriano 1986).

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METHANOL

1.0 SUMMARY

Methanol is a highly water soluble hydrocarbon. It does not adsorb to organic carbon. The primary removal process for methanol in soil and water is biodegradation. Aquatic, soil, and sediment communities can be exposed to methanol through direct contact. Upper-trophic-level receptors may be directly exposed through ingestion, inhalation, or dermal exposure. Methanol does not bioconcentrate or move through food chains.

The following is a profile of the fate of methanol in soil, surface water, and sediment; and the fate after uptake by ecological receptors. Section 2 discusses the environmental fate and transport in soil, surface water, and sediment. Section 3 discusses the fate in ecological receptors.

2.0 FATE IN SOIL, SURFACE WATER, AND SEDIMENT

Based on biological screening studies, including soil microcosm studies, methanol undergoes biodegradation if released to the soil. Methanol is expected to be highly mobile in soil, based on its miscibility in water and low log K_{ow} value. Evaporation from dry surfaces is also expected to occur, based on the high vapor pressure of methanol (Weber et al. 1981; Hansch and Leo 1985; HSDB 1997).

Methanol is completely soluble in water. Methanol is significantly biodegradable in water, based on screening studies (HSDB 1997). Volatilization is expected to be a significant removal process (Lyman 1982). Aquatic hydrolysis, oxidation, photolysis, adsorption to sediment, and bioconcentration are not considered significant removal processes for methanol (HSDB 1997).

3.0 FATE IN ECOLOGICAL RECEPTORS

Methanol uptake across gill epithelia is the most significant exposure route. However, based on its low bioconcentration factor for fish, methanol does not bioconcentrate (Freitag et al. 1985; Bysshe 1982) (Hansch and Leo 1985).

Mammals are exposed to methanol through ingestion, inhalation, and dermal contact. Methanol is reported to readily absorb from the gastrointestinal and respiratory tracts (Gosselin et al. 1984), and rapidly distribute within tissues (Clayton and Clayton 1982). Following absorption, methanol is widely distributed in body tissue. Small amounts are excreted in the urine and expired air; however, methanol is mostly oxidized to formaldehyde and formic acid (Goodman and Gillman 1985).

Information was not available on the fate of methanol in exposed birds or plants.

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NITROPROPANE, 2-

1.0 SUMMARY

2-nitropropane is a highly volatile, low molecular weight hydrocarbon. Generally, it does not adsorb to soil or sediment, and rapidly volatilizes from soil and surface water. Wildlife may be exposed to 2-nitropropane through ingestion or inhalation. Due to its high water solubility, 2-nitropropane does not bioconcentrate in fish, and does not bioaccumulate in wildlife. 2-nitropropane is rapidly metabolized and excreted by mammals.

The following summarizes information on the fate of 2-nitropropane in soil, surface water and sediment, and its fate after uptake by ecological receptors. Section 2 discusses the environmental fate and transport in soil, water and sediment. Section 3 discusses the fate in ecological receptors.

2.0 FATE IN SOIL, SURFACE WATER, AND SEDIMENT

2-nitropropane rapidly volatilizes from soil, and also has the potential to leach in moist soils. 2-nitropropane undergoes minimal degradation in soil (Freitag et al. 1988).

2-nitropropane is highly soluble in water (Baker and Bollmeier 1981). It is expected to have a short half-life in surface water because of its propensity for rapid volatilization, based on its high vapor pressure (Dougan et al. 1976). Adsorption of 2-nitropropane to suspended solids or sediment is not expected, based on its low K_{oc} value (Lyman 1982).

3.0 FATE IN ECOLOGICAL RECEPTORS

2-nitropropane does not bioconcentrate in aquatic organisms (Baker and Bollmeier 1981; Freitag et al. 1988). 2-nitropropane is readily absorbed by the gastrointestinal tract and the lungs, when inhaled. Accumulation of 2-nitropropane in tissues of mammals is low because it is rapidly metabolized and eliminated after uptake (Nolan et al. 1982). 2-nitropropane may be excreted unchanged in expired air or as nitrite and nitrate in the urine (Browning 1965).

No information was available on the fate of 2-nitropropane in birds or plants.

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POLYNUCLEAR AROMATIC HYDROCARBONS (PAHS)

1.0 SUMMARY

Polynuclear aromatic hydrocarbons (PAH) are a class of semi-volatile compounds that have a high affinity for soil and sediment particles. PAHs have low water solubility. Low molecular weight PAHs volatilize and photolyze from soil and surface water, and may be biodegraded as well. High molecular weight PAHs are resistant to volatilization, photolysis, and biodegradation. PAHs can be bioconcentrated to high concentrations by some aquatic organisms. However, many aquatic organisms can metabolize PAHs. The main PAH exposure route for upper-trophic-level receptors is ingestion. However, wildlife can readily metabolize PAHs and eliminate the by-products. Therefore, food chain transfer and biomagnification are anticipated to be minimal.

The following is a profile of the fate of PAHs in soil, surface water and sediment; and the fate after uptake by ecological receptors. The PAHs considered are benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene. Section 2 discusses the environmental fate and transport in soil, surface water and sediment. Section 3 discusses the fate in ecological receptors.

2.0 FATE IN SOIL, SURFACE WATER, AND SEDIMENT

PAHs strongly adsorb to the soil; therefore, leaching to groundwater and volatilization are slow insignificant processes in most instances (HSDB 1997). However, the persistence of PAHs in soil is dependent upon the number of condensed rings that a PAH contains. The major source of degradation of PAHs in soil is microbial metabolism (ATSDR 1995). Volatilization and photolysis were determined to be important processes for the degradation of PAHs containing less than four aromatic rings, when analyzed from four surface soils amended with PAHs in sewage sludge. However, PAHs containing four or more aromatic rings showed insignificant abiotic losses (Wild and Jones 1993).

Within aquatic systems, PAHs are found sorbed to particles suspended in the water column or particles which have settled to the bottom. This is due to the low solubility and high affinity PAHs have for organic carbon. Studies have estimated that two-thirds of PAHs found in aquatic systems are in particle form and only one-third are in dissolved form (Eisler 1987). Low molecular weight PAHs (2 to 3 rings) studied in estuaries show that the primary removal processes are volatilization and biodegradation, while high molecular weight PAHs (4 or more rings) volatilize and adsorb to suspended sediments (Thomas 1982; Southworth et al. 1978; Southworth 1979).

Photo-oxidation, chemical oxidation, and biodegradation by aquatic microorganisms are the primary degradation processes associated with PAHs in water (Neff 1979). The process of photo-oxidation varies widely among PAHs when considering the rate and extent of degradation. Benzo(a)pyrene is the most resistant to photo-oxidation, while benzo(a)anthracene is the most sensitive (Neff 1979). Microbial degradation of PAHs in water is very rapid under oxygenated conditions, but extremely slow under anoxic conditions (Neff 1979).

3.0 FATE IN ECOLOGICAL RECEPTORS

Sources of PAH accumulation in aquatic organisms include water, sediment, and food. Bioconcentration factors can range from low to very high, depending on the PAH and the receptor. Invertebrates and bottom-dwelling fish may accumulate PAHs through ingestion of sediment (Eisler 1987).

Studies indicate that fish are capable of metabolizing PAHs by the mixed function oxidase (MFO) system in the liver. The breakdown products are then eliminated through the urine and feces. Half-lives ranging from 2 to 9 days have been reported for the elimination of PAHs in fish (Niimi 1987). Chrysene has a near-surface half-life computed for sunlight at latitude 40°N of 4.4 hours (Zepp and Schlotzhauer 1979). Assimilation of PAHs from contaminated food is readily achieved by fish and crustaceans; however, this process is limited for mollusks and polychaete worms (Eisler 1987). It is also noted that aquatic organisms such as phytoplankton, certain zooplankton, mussels, scallops, and snails lack a metabolic detoxification enzyme system. Therefore, these organisms have potential for PAH accumulation (Malins 1977).

PAHs can be introduced into mammals through ingestion, inhalation, and dermal exposure. Because PAHs are highly lipid soluble and can cross epithelial membranes, they are readily absorbed from the gastrointestinal tract and lung (HSDB 1997). PAHs are absorbed through the mucous lining of bronchi when inhaled (Bevan and Ulman 1991) and taken up by the gastrointestinal tract in fat-soluble compounds when ingested. Passive diffusion is the process in which PAHs are distributed following percutaneous absorption (Ng et al. 1991). Once absorbed into the body, PAHs are distributed to the lymph fluid and then the blood stream. Following oral or inhalation exposure, PAHs are widely distributed in animal tissue (Bartosek et al. 1984; Withey et al. 1991; Yamazaki and Kakiuchi 1989).

PAHs have limited transfer across the placenta; therefore, PAH levels are generally lower in the fetus, when compared to maternal levels (Neubert and Tapken 1988; Withey et al. 1992). The major metabolism sites for PAHs are the liver and kidneys. Additional sites of metabolism include the adrenal glands, testes, thyroid, lungs, skin, sebaceous glands, and placenta (Meditext 1997). PAHs are primarily excreted through the urine and bile (Bevan and Weyand 1988; Grimmer et al. 1988; Petridou-Fischer et al. 1988; Weyand and Bevan 1986; Wolff et al. 1989).

PAHs may be taken up by terrestrial plants from the soil or air depending on the concentration, solubility, and molecular weight of the PAHs. Lower molecular weight PAHs are absorbed by plants more readily than higher molecular weight PAHs (USFWS 1987). Some plants are capable of producing benzo(b)fluoranthene (HSDB 1997). The partitioning of PAHs between vegetation and the atmosphere was found to be primarily dependent upon the atmospheric gas-phase PAH concentration and the ambient temperature, when studied throughout the growing season under natural conditions (Simonich and Hites 1994). Above-ground parts of vegetables have been found to contain more PAHs than underground parts, mainly attributable to airborne deposition and subsequent adsorption (USFWS 1987). Growth promoting effects were observed in higher plants, as well as cultures of lower plants, when benzo(a)anthracene, indeno(1,2,3-cd)pyrene, and benzo(b)fluoranthene were tested in a series of soil and hydrocultures (Graf and Nowak 1968).

Information was not available on the fate of PAHs in exposed birds.

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POLYCHLORINATED BIPHENYLS (PCBs)

1.0 SUMMARY

Polychlorinated biphenyls (PCB) are mixtures of different congeners of chlorobiphenyl. PCBs are a group of highly fat-soluble, semi-volatile compounds that readily bioaccumulate and biomagnify in ecological receptors, especially upper-trophic-level carnivores in aquatic food webs. In general, PCBs adsorb strongly to soil and sediment, and are soluble in fatty tissues. Volatilization and biodegradation of the lower chlorinated congeners also occur. The toxicological properties of individual PCBs are influenced primarily by: (1) lipophilicity, which is correlated with log K_{ow}, and (2) steric factors resulting from different patterns of chlorine substitution on the biphenyl molecule. In general, PCB isomers with high K_{ow} values and high numbers of substituted chlorines in adjacent positions constitute the greatest environmental concern. Biological responses to individual isomers or mixtures vary widely, even among closely related taxonomic species.

The following is a profile of the fate of PCBs in soil, surface water, and sediment; and the fate after uptake by ecological receptors. Section 2 discusses the environmental fate and transport in soil, surface water, and sediment. Section 3 discusses the fate in ecological receptors.

2.0 FATE IN SOIL, SURFACE WATER, AND SEDIMENT

The environmental fate of PCBs in soil depends on the degree of chlorination of the molecule. In general, adsorption and the persistence of PCBs increases with an increase in the degree of chlorination (EPA 1988). Mono-, di-, and trichlorinated biphenyls (Aroclors 1221 and 1232) biodegrade relatively rapidly. Tetrachlorinated biphenyls (Aroclors 1016 and 1242) biodegrade slowly, and higher chlorinated biphenyls (Aroclors 1248, 1254, and 1260) are resistant to biodegradation (HSDB 1997). Although biodegradation of higher chlorinated congeners may occur very slowly, no other degradation mechanisms have been shown to be significant in soil (HSDB 1997). Vapor loss of PCBs from soil surfaces appears to be an important mechanism with the rate of volatilization decreasing with increasing chlorination. Although the volatilization rate may be low, the total loss by volatilization over time may be significant because of persistence and stability of PCBs (Sklarew and Girvin 1987).

In water, adsorption to sediments and organic matter is a major fate process for PCBs (EPA 1988; Callahan et al. 1979). Volatilization of dissolved PCBs is an important aquatic process. Strong PCB adsorption to sediment significantly decreases the rate of volatilization, with higher chlorinated PCBs having longer half-lives than the lower chlorinated PCBs (EPA 1988).

3.0 FATE IN ECOLOGICAL RECEPTORS

Diet is a major route of PCB uptake in many aquatic species (Eisler 1986). However, some species accumulate PCBs from the water column to a much larger extent than the diet, even when comparing closely-related species. Based on its high log K_{ow} value, receptors are expected to bioconcentrate and bioaccumulate PCBs to tissue levels much greater than the concentrations in water and sediment (Eisler 1986). Due to their high lipophilicity, PCBs concentrate mostly in fatty tissues. For upper-trophic-level receptors, diet is the main exposure pathway for PCB exposure (Eisler 1986). In aquatic food webs, evidence indicates that PCBs biomagnify in upper trophic levels, but not in lower trophic levels (Shaw and Connell 1982).

Among mammals, aquatic predators (e.g., mink, otters, seals, etc.) have been found to accumulate PCBs to significant levels. Lower chlorinated PCBs are eliminated more rapidly from lipids than higher chlorinated PCBs. Placental transfer of PCBs occurs in mammals (Hidaka et al. 1983).

The primary biochemical effect of PCBs is to induce hepatic mixed function oxidase systems, increasing an organism’s capacity to biotransform or detoxify xenobiotic chemicals. PCBs also induce hepatic enzymes that metabolize naturally occurring steroidal hormones (Peakall 1975). These hepatic microsomal enzyme systems are most likely correlated with observed adverse reproductive effects (Tanabe 1988).

PCBs accumulate in bird tissues and eggs (Eisler 1986). Residues of PCBs in birds are affected by numerous biotic factors including fat content, tissue specificity, sex, and the developmental stage of an organism (Eisler 1986). Sexual differences in PCB bioaccumulation are pronounced due to the female’s ability to pass a significant portion of the PCB burden to eggs (Lemmetyinen and Rantamaki 1980).

Water snakes (*Nerodia spp.*) and turtles accumulate PCB levels similar to those of PCB residues in their prey. Aroclor 1260 accounted for most of the PCBs detected in water snakes (Sabourin et al. 1984;

Olafsson et al. 1983). These data suggest diet is an important route of PCB transfer in reptiles (McKim and Johnson 1983).

Organic matter and clay content of soil influences the bioavailability of PCBs to plants (Strek and Weber 1982). Uptake of PCBs from soils by plants has been documented, however, only very low amounts are typically accumulated (Iwata et al 1974, Iwata and Gunther 1976, Weber and Mrozek 1979). Effects of PCBs on plants include reduced growth and chlorophyll content, and negative effects on photosynthesis (Strek and Weber 1982).

Terrestrial and aquatic plants bioconcentrate PCBs (Sawhney and Hankin 1984). Aquatic plants also bioaccumulate PCBs from both the water column and sediments. Transfer of PCBs on microparticulate materials to phytoplankton is well documented, as is partitioning from aqueous solution into algal lipids (Rohrer et al. 1982).

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PENTACHLOROPHENOL

1.0 SUMMARY

Pentachlorophenol (PCP) has a strong affinity for soil, with sorption higher at lower pH and with increased organic content. Microorganisms readily metabolize PCP in soil, surface water, and sediment. Photolysis rapidly breaks down PCP in surface water. Ecological receptors will rapidly absorb PCP, but will also rapidly excrete it. Therefore, the potential for bioconcentration and bioaccumulation is only moderate. PCP biomagnification has not been observed.

The following is a profile of the fate of PCP in soil, surface water, and sediment, and the fate after uptake by ecological receptors. Section 2 discusses the environmental fate and transport in soil, water and sediment. Section 3 discusses the fate in ecological receptors.

2.0 FATE IN SOIL, SURFACE WATER, AND SEDIMENT

PCP adsorbs strongly to soil, with adsorption higher in acidic conditions (Callahan et al. 1979). The amount of PCP adsorbed to soil at a given pH also increases with increasing organic content of the soil (Chang and Choi 1974). The half-life of PCP in soil ranges from weeks to months (Ide et al. 1972; Murthy 1979; Rao and Davidson 1982). Photolysis and hydrolysis do not appear to be significant processes of degradation in soil (Ball 1987). In certain soil environments, PCP may volatilize; however, in general, mobility of PCP in soil is limited (Arsenault 1976).

Biodegradation is considered the major transformation mechanism for PCP in soil, with PCP metabolized rapidly by acclimated microorganisms (Kaufman 1978). The main degradation products of PCP in soil are 2,3,7,8-tetrachlorophenol and carbon dioxide (Knowlton and Huckins 1983).

The fate of PCP in water and sediment is heavily dependent upon the pH of the water. At lower pH, more of the PCP dissociates and is available for degradation (Weiss et al. 1982). PCP also adsorbs to sediment more readily under acidic conditions, and is more mobile under neutral or alkaline conditions (Kuwatsuka and Igarashi 1975).

In surface water, photolysis and biodegradation are the predominant transformation processes for PCP (ATSDR 1994). Photolysis occurs mainly at the water surface, with its impact decreasing with increasing depth (Callahan et al. 1979). The reported half-life for the photolysis of PCP is about 1 hour (Callahan et al. 1979). Biodegradation of PCP can occur under both aerobic and anaerobic conditions, with more rapid degradation under aerobic conditions (Pignatello et al. 1983). The greatest biodegradation of PCP was observed in the top 0.5 to 1 cm layer of sediment.

3.0 FATE IN ECOLOGICAL RECEPTORS

The aquatic toxicity of PCP depends on water pH; at low pH, PCP is more lipophilic, with a high potential for accumulation. At alkaline pH, PCP is more hydrophilic, with a decreased potential for bioconcentration (Eisler 1989). Fish and bivalves may moderately bioconcentrate PCP (Makela et al. 1991). Accumulation of PCP in fish is rapid, and occurs primarily by direct uptake from water rather than through the food chain or diet. In fish, PCP residues are found in the liver, gill, muscle, and hepatopancreas. PCP is readily metabolized in the liver and hepatopancreas. (Menzie 1978). Half-lives in tissues are less than 24 hours (Eisler 1989).

In mammals, PCP may be absorbed into the body through inhalation, diet or skin contact (Eisler 1989). The degree of accumulation is small, since PCP is efficiently and rapidly excreted. The highest residuals are found in the liver and kidneys, likely reflecting that these organs are the principal organs for metabolism and excretion (Gasiewicz 1991). Small amounts of PCP have been shown to cross the placenta (Shepard 1986).

Uptake into rice has been demonstrated in a 2-year study under flooded conditions. After a single application of radiolabeled PCP, 12.9% of the application was taken up by the plants within the first year, with the highest levels found in the roots (Eisler 1989).

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THALLIUM

1.0 SUMMARY

In the environment, thallium exists in either the monovalent (thallous) or trivalent (thallic) form. Thallium is chemically reactive with air and moisture, undergoing oxidation. Thallium is relatively insoluble in water, although thallium compounds exhibit a wide range of solubilities. Thallium adsorbs to soil and sediment and is not transformed or biodegraded. In aquatic organisms, thallium is absorbed primarily from ingestion and thereafter bioconcentrates in the organism. In mammals, thallium is absorbed primarily from ingestion and is distributed to several organs and tissues, with the highest levels reported in the kidneys. Thallium exposure in mammals causes cardiac, neurologic, reproductive and dermatological effects. Thallium is taken up by plants and inhibits chlorophyll formation and seed germination.

The following is a profile of the fate of thallium in soil, surface water and sediment; and the fate after uptake by ecological receptors. Section 2 discusses the environmental fate and transport in soil, surface water and sediment. Section 3 discusses the fate in ecological receptors.

2.0 FATE IN SOIL, SURFACE WATER, AND SEDIMENT

In soil, thallium exists in either the monovalent (thallous) or trivalent (thallic) form, with the monovalent form being more common and stable and, therefore, forming more numerous salts (Hampel 1968). Thallium is reactive with air and moisture, oxidizing slowly in air at 20°C and more rapidly with increasing temperatures (Standen 1967). Moisture increases the oxidation of thallium. Thallium adsorbs to soil and is not transformed or biodegraded (Callahan et al. 1979).

Elemental thallium is relatively insoluble in water (Windholz 1976). However, thallium compounds exhibit solubilities ranging from 220 mg/L to more than 700,000 mg/L (Standen 1967; Weast 1975).

Thallium adsorbs to sediments and micaceous clays (Callahan et al. 1979; Frantz and Carlson 1987). Data regarding the transformation or biodegradation of thallium in water were not located.

3.0 ECOLOGICAL RECEPTORS

The primary exposure route for aquatic organisms exposed to thallium is ingestion. Thallium bioconcentrates in aquatic organisms (Zitko and Carson 1975). Toxic effects have been observed in numerous aquatic organisms including daphnia, fat-head minnow, sheepshead minnow, saltwater shrimp, atlantic salmon, bluegill sunfish, and others (USEPA 1980).

Birds and mammals are exposed to thallium via ingestion of soil, water, and plant material (Lie et al. 1960). Following absorption, thallium is distributed to numerous organs including the skin, liver, and muscle, with the greatest amount found in the kidneys (Downs et al. 1960; Manzo et al. 1983). Thallium is excreted primarily in the urine, with some excretion in the feces (Lehman and Favari 1985). Thallium is distributed from the maternal circulation to the fetus (Gibson et al. 1967; Gibson and Becker 1970). Various effects and toxic responses have been reported. Tikhonova (1967) reported paralysis and pathological changes in the liver, kidneys, and stomach mucosa in rabbits chronically exposed to thallium. Formigli et al. (1986) reported testicular toxicity in rats exposed to thallium. Grunfeld et al. (1963) reported changes in the electrocardiographs of rabbits following oral exposure to thallium.

Some levels of thallium occurs naturally in plants (Seiler 1988). Thallium is taken up by the roots of higher plants (Cataldo and Wildung 1983). Thallium has been shown to inhibit chlorophyll formation and seed generation (OHM/TADS 1997).

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VINYL CHLORIDE

1.0 SUMMARY

Vinyl chloride is a low molecular weight organic compound that rapidly volatilizes after released to soil and surface water. Aquatic organisms may take up vinyl chloride, however it is rapidly depurated because it is highly water-soluble. Routes of exposure for wildlife include inhalation, ingestion, and dermal exposure. Bioaccumulation in terrestrial and aquatic organisms is not an important process in the environmental fate of vinyl chloride because of its high volatility and the rapid metabolism by higher-tropic-level receptors.

The following is a profile of the fate of vinyl chloride in soil, surface water and sediment, and the fate after uptake by ecological receptors. Section 2 discusses the environmental fate and transport in soil, surface water, and sediment. Section 3 discusses the fate in ecological receptors.

2.0 FATE IN SOIL, SURFACE WATER, AND SEDIMENT

Vinyl chloride in dry soil has a very short half-life (less than 1 day) (Jury et al. 1984). Vinyl chloride has a high vapor pressure, indicating rapid volatilization from dry soil surfaces (Riddick et al. 1986; Verschueren 1983). Vinyl chloride is also biodegraded and photolyzed in surface soil (ATSDR 1995; Nelson and Jewell 1993). Vinyl chloride does not adsorb to soil in significant amounts.

Vinyl chloride in surface water has a half-life of a few hours (Thomas 1982). An estimated half-life in fresh water for vinyl chloride of 2.5 hours was reported (Mabey et al. 1981). Vinyl chloride is slightly soluble (Cowfer and Magistro 1983). However, vinyl chloride released to surface water will quickly volatilize, negating other fate processes that might be significant based on physical and chemical parameters.

3.0 FATE IN ECOLOGICAL RECEPTORS

Vinyl chloride is not expected to significantly bioconcentrate in aquatic organisms because it has a very low log K_{ow} value. Bioconcentration and accumulation in aquatic carnivores is not expected because of the high volatility of vinyl chloride and the rapid metabolism of vinyl chloride by higher-tropic-level organisms (Freitag et al. 1985; Lu et al. 1977).

In mammals, vinyl chloride may be absorbed by the body via inhalation (Bolt et al. 1977; Krajewski et al. 1980; Withey 1976), ingestion (Feron et al. 1981; Watanabe et al. 1976; Withey 1976) and dermal contact (Hefner et al. 1975). It is rapidly absorbed and distributed throughout the tissues following uptake. Because of the rapid metabolism and excretion of vinyl chloride, storage within the body is limited.

Information was not available on the fate of vinyl chloride in birds or plants.

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