APPENDIX B

ESTIMATING MEDIA CONCENTRATION EQUATIONS AND VARIABLE VALUES

Screening Level Ecological Risk Assessment Protocol

August 1999

APPENDIX B

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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 f(f)-(c0.s)-22(o)2(((c0.s)-46(()-20(u)-19nlit)-24li)-2(e)22(s)-12(s)-12())]TJı˝/F4 irl)

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 = (-yw [.72 0 Tm)033 ak426-23.5i033 416-1.1[.72 0 ye20(nit3i 6.521700 11.04 144.21 534.45 Tm -0.0

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 bottomre F31s9 11. -6.56(F31s9 111 Tf -6.5217 -2.3913 TD -0.005
E

= i 1 dv r c Tfh 1 c Tfac)
=rae anupa pec F31(a)-34(t)-26(ion31s9 1(c)-12F4 1 /t)-26yir)
= i 1 nai 1 c Tfem31s8fuoi 1 tl4 1 Tf)
=.56(F(c)-12on(c)-12Tf -6o)1(t)-26(r)-36(a)-34(t)-26(iondup)-21(e)10((t)-26(o)1(dir)-36(e)10(c)-12.56(Fd(e
=.56(F(c)-12on(c)-12Tf -6o)1(t)-26(r)-36(a)-34(t)-26(iondup)-21(e)10((t)-26(o)1((r)-36oo.56(Fup)-21pb)-21(
=.56(F(c)-12on(c)-12Tf -6o)1(t)-26(r)-36(a)-34(t)-26(iondup)-21(e)10((t)-26(o)1((a)-34(l)-4(r)-36-))-14t9 -26(COeDea t(i-21ssuTf)52(34
COeDea t(i-21ssuTf)52())]TJ /F4 1 Tf -9.7826 6.72 0 0 6.72 87.5 0 0QS= Ocf
= nv119f(r)-71siaac79(a)-59n.56(79(31s9 59(a)-59.56(79F4 79-c)-59F4)]TJ /22 1 Tf 6.72 0 0 6.72

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 *i*th 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 c

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).

For Calculating *Cs* in Dry Land Soils

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

For Calculating *Cs* in Wetland Soils

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	

TSOIL EQUATIONS)

TAm5g2 B-1-1

TSOIL CONCENTRATION DUE TO DEPOSITION

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

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	µg-s/g-m^3	

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*

TABLE B-1-1

SOIL CONCENTRATION DUE TO DEPOSITION (SOIL EQUATIONS)

(Page 9 of 9)

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. (2rN(2rNSeposition 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. (2rN(2rNSeposition 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			

TABLE B-1-2

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*). *Draft Guidance for*

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	$g\text{-}kg/cm^2\text{-}m^2$	

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 watershedTvarious watersheds. Therefore, those defau curately represent site-spelt values may not acific

TABLE B-1-3

COPC LOSS CONSTANT DUE TO SOIL EROSION
(SOIL EQUATIONS)

TABLE B-1-3

COPC LOSS CONSTANT DUE TO SOIL EROSION
(SOIL EQUATIONS)

TABLE B-1-3

COPC LOSS CONSTANT DUE TO SOIL EROSION (SOIL EQUATIONS)

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 o14.236881SOILo16(e I)56(n)12(c)35(.)1s(mms(fw79b-uOILo1r(y thd by ( )]T3 -1.

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.

TABLE B-1-4

COPC LOSS CONSTANT DUE TO RUNOFF (SOIL EQUATIONS)

(Page 1 of 5)

TABLE B-1-4

COPC LOSS CONSTANT DUE TO RUNOFF (SOIL EQUATIONS)

(Page 2 of 5)

Variable	Description	Units	Value

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)

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

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 19 0), as summarized in U.S. EPA (1990). A range of 0. 3 to 1. 4 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 (19). The value of 1.5 g/cm^3 also represents Trb(FtheNPaRSVable is HansentsGrb(yFSoiNPaVNLUPVRNOGrh(MrOTOr(NrOOOPLTPVRNOWTVPLOUr(F3GrRrH(FHoffmaN

TABLE B-1-5

COPC LOSS CONSTANT DUE TO LEACHING (SOIL EQUATIONS)

(Page 6 of 6)

- A default value of 0.2 mL/cm^3 for soil volumetric water content, θ_{sw}.
- A range (2 to 2 0,000 mL/g) of Kd_s values for inorganic COPCs; the original source of these values is not identified.

U.S. Bureau of the Census. 19 7. *Statistical Abstract of the United States:* 19 7. 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. 19 5. *Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants in Surface and Groundwater*. Part I (Revised 19 5). Environmental Research Laboratory. Athens, Georgia. EPA/600/6- 5/002a. 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 (19 4) and U.S. Bureau of the Census (19 7) 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

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: 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 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

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*

TABLE B-1-6

COPC LOSS CONSTANT DUE TO VOLATILIZATION (SOIL EQUATIONS)

(Page 6 of 6)

- 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 thi

TABLE B-2-1

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

(Page 1 of 4)

[redacted]

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,

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}			

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

TABLE B-2-2

DEPOSITION TO WATER BODY (SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 3 of 3)

REFERENCES AND DISCUSSION

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

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.

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 abouTc 0.e30.013. TD 1-5.52 0 310.05 t-pu 0. the

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

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

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

TABLE B-2-6

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

(Page 1 of 6)

TABLE B-2-6

TABLE B-2-6

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

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)

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

Xe

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

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			

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*

TABLE B-2-7

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 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:

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 variousb

TABLE B-2-9

TOTAL WATER BODY CONCENTRATION
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 1 of 4)

$$C_{wtot} = \frac{L_T}{Vf_x \cdot f_{wc} + k_{wt} \cdot A_{W} \cdot (\quad)}$$

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)

TABLE B-2-10

TABLE B-2-10

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

TABLE B-2-10

FRACTION IN WATER COLUMN AND BENTHIC SEDIMENT

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)

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

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}			

TABLE B-2-12

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

(Page 4 of 4)

REFERENCES AND DISCUSSION

TABLE B-2-13

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

Page (1 of 4)

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:

TABLE B-2-13

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

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*

TABLE B-2-14

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

(Page 1 of 5)

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

$$K_L = (C_d{}^{0.5} \cdot W) \cdot \left(\frac{\rho_a}{\rho_w}\right)^{0.5} \cdot d$$

TABLE B-2-14

LIQUID-PHASE TRANSFER COEFFICIENT

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,

TABLE B-2-14

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

(Page 4 of 5)

Variable	Description	Units	Value

TABLE B-2-14

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

TABLE B-2-15

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

(Page 1 of 4)

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

$$K_G \ = \ (C_d^{\ 0.5} \ \cdot \ W) \ \cdot \left(\qquad \right)$$

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

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^{-31}We WaNR (793a) as its source us

TABLE B-2-16

BENTHIC BURIAL RATE CONSTANT
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 1 of 5)

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	

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: Limit73 755]able:

TABLE B-2-16

BENTHIC BURIAL RATE CONSTANT
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 4 of 5)

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}

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	Unit0(a)52	-5.52B11(e-22(a))11(31nC5-5.5m[(v)28Fim)25(e)7(rc)8428TJ 48(Hg

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

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.*

TABLE B-2-18

DISSOLVED PHASE WATER CONCENTRATION
(SURFACE WATER AND SEDIMENT EQUATIONS)

(Page 1 of 3)

TABLE B-2-18

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)

$$C_{sed} = f_{bs} \cdot C_{wtot} \cdot$$

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

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.

TABLE B-3-1

PLANT CONCENTRATION DUE TO DIRECT DEPOSITION
(TERRESTRIAL PLANT EQUATIONS)

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Description

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

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

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

TABLE B-3-1

PLANT CONCENTRATION DUE TO DIRECT DEPOSITION (TERRESTRIAL PLANT EQUATIONS)

TABLE B-3-1

PLANT CONCENTRATION DUE TO DIRECT DEPOSITION
(TERRESTRIAL PLANT EQUATIONS)

(Page 4 of 10)

TABLE B-3-1

PLANT CONCENTRATION DUE TO DIRECT DEPOSITION
(TERRESTRIAL PLANT EQUATIONS)

(Page 5 of 10)

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 plantValue is on e-specific. U.S. EPA OSW13 commends the useN4.-theseNdefault v8120s in the absenceN4.of edible pon e-specific informast o. U.S. EPA (199re , U.S. EPA (1994be , and NCSTRHNR (1997)13 commended treastng f plantTp 60 days)1and the aver.08 laniodof edible pbetween successivetgraztng (30 days)1is used (that1is,79(days). f plantTp)Tj /2551.96o ore f of plant exposur 0 527o ore f is calculated as follows:f plantTpLECT 4346re fTof plant5exp pconverst oNfactonf pla.4176.08 pu0.7lessEo of 6c Eo of 9 re2o ore f0.12f plant5exposur-22.6603-ECT 4346re fU.S. EPA OSW13 commends ustng the v812014.-0.12. This default v8120 is based on the aver.08 rounded v		

TABLE B-3-1

PLANT CONCENTRATION DUE TO DIRECT DEPOSITION
(TERRESTRIAL PLANT EQUATIONS)

Variable	Description	Units	Value

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 2sEe n92sEe." 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

TABLE B-3-1

PLANT CONCENTRATION DUE TO DIRECT DEPOSITION (TERRESTRIAL PLANT EQUATIONS)

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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 2 of 5)

Variable	Description	Units	Value
Q	COPC-specific emission rate	g/s	**Varies (site-specific)** and site-specific (see Chapters 2 and 3). Uncertainties associated with this variable are
$_v$	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 $_T$ value for background plus local sources, rather than an $_T$ 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 $_v$.
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-pls vaF- sited-wiTf]TJı˝/Jı˝/F3 tjı˝7(sit17.5894l)-10		0 TDıitspsd wı˝08158˝0 5.52 -5.52 A0 307.17 335)

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

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.

TABLE B-3-3

PLANT CONCENTRATION DUE TO ROOT UPTAKE
(TERRESTRIAL PLANT EQUATIONS)

(Page 2 of 3)

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*

APPENDIX C

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

Screening Level Ecological Risk Assessment Protocol

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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 (

With the exception of the air-to-plant biotransfer factors (

C-1.4 WATER-TO-ALGAE BIOCONCENTRATION FACTORS

Experimental data for both marine and freshwater algal species were reviewed. As necessary, available

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.

<u>Inorganics</u> 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).

<u>Organics</u> 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.

<u>Inorganics</u> 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.

- 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*

McCrady, J.K., S.P. Maggard. 1993. "Uptake and Photodegradation of 2,3,7,8-Tetrachlorodibenzo-p-dioxin Sorbed to Grass Foliage." *Environmental Science and Technology*. 27:343-350.

Pietz, R.I., J.R. Peterson, J.E. Prater, and D.R. Zenz. 1984. "Metal Concentrations in Earthworms From

Screening Level Ecological Risk Assessment

MEDIA-TO-RECEPTOR *BCF* VALUES

Screening Level Ecological Risk Assessment Protocol

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TABLE C-1

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

(Page 1 of 14)

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			

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)

TABLE C-1

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

(Page 4 of 14)

18Reported Values[a]	References	Experimental Parameters	Species

TABLE C-1

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

(Page 5 of 14)

19Reported Values[a]	References	Experimental Parameters	Species

TABLE C-1

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

(Page 6 of 14)

20Reported Values[a]	References	Experimental Parameters	Species

TABLE C-1

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

21Reported Values			

TABLE C-1

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

(Page 9 of 14)

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,			

TABLE C-1

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

TABLE C-1

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

(Page 11 of 14)

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)

(Page 12 of 14)

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)

(Page 13 of 14)

TABLE C-1

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

(Page 14 of 14)

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).

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

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 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)

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Reported Values	References	Experimental Parameters	Species

TABLE C-2

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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Reported Values	References	Experimental Parameters	Species

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)

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TABLE C-3

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

(Page 3 of 18)

Reported Values[a]	Reference	Experimental Parameters	Species

[illegible]

Penaeus duorarum 6,088 Newsted and Giesy (1987) 24-hour exposure duration Daphnia magna

[illegible]ure of 1 or 5 µg/L in a closed seawater system.

TABLE C-3

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

(Page 5 of 18)

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*

TABLE C-3

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

(Page 6 of 18)

Reported Values[a]	Reference	Experimental Parameters	Species

TABLE C-3

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

(Page 7 of 18)

Reported Values[a]		Reference	Experimental Parameters	Species
11 7	10 17			

TABLE C-3

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

(Page 8 of 18)

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:			

TABLE C-3

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

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[redacted]LE C-3

WAT[redacted]ATE BIOCONCENTRATION FACTORS
[redacted](mg dissolved COPC / L water)

[redacted]10 of 18)

Reported Values[a]	[redacted]	Experimental Parameters	Species
	[redacted]		
	[redacted]		
	[redacted]		
	[redacted]		
	[redacted]		
	[redacted]		
	[redacted]		

TABLE C-3

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

(Page 11 of 18)

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 50 45 219 131	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

TABLE C-3

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

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TABLE C-3

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

(Page 13 of 18)

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 v ff 1 x 10	

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
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 calculatedted	

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)

(Page 17 of 18)

Reported Values[a]	Reference	Experimental Parameters	Species

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
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:

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

(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):

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

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: $f_{fd} = 1 / [1 + ((DOC \times K_{ow}) / 10) + (POC \times K_{ow})]$
DOC = Dissolved organic carbon, kilograms of organic carbon / li4Pbedafı˝0 9.12 -9.12 0 475.17 188.97 T6718i where: (P)15((n)12(c)3502 Tcı˝(ow)Tjı˝/F4 1
)]

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).	

TABLE C-4

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

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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

TABLE C-4

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

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*

TABLE C-4

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

TABLE C-4

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

(Page 8 of 12)

Reported Values[a]	Reference	Experimental Parameters	Species

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 (19562.05 580.65 l 562.05 7c35/ 0.21-d3wo5 l 5ex(he,)--.001 Tc 0.012 Tw [(R)10(e)-2TJ 4.73ns dw [(R)10(e)-2TJ 4.73nse0(u)1(e:)42(782)]T		

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

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:

$$Conversion\ factor = \frac{1.0\ g\ algae\ total\ weight}{1.0\ g\ algae\ total\ weight - 0.675\ g\ algae\ wet\ weight}$$

[redacted]

[redacted]

TABLE C-5

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

(Page 1 of 19)

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)

(Page 3 of 19)

Reported Values	Reference	Experimental Parameters	Species

TABLE C-5

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

(Page 4 of 19)

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)

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

TABLE C-5

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

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)

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

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
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 15,250 21,140 12,600 13,330	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)

(Page 11 of 19)

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			
			Morone saxatilis

TABLE C-5

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

(Page 14 of 19)

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, Ca37(12 Tw [(C)10(3(S0 -1.2105 TD)04)uber05 Tr05 T(u)4n)0(,9-6(hD 8f 454.29 53 13(295)]TJ l-i [(R)10(e)-2(c)24(o)	

TABLE C-5

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

(Page 15 of 19)

Reported Values	Reference	Experimental Parameters	Species

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:			

TABLE C-5

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

(Page 18 of 19)

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

TABLE C-6

SEDIMENT-TO-BENTHIC INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg COPC / kg dry sediment)

(Page 1 of 11)

The BCF e BCF was calculated using the TCDD BCF and a congener-speccific bioacc.S. EPA4 -95b) as fo

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
un(The BCF was calculated using the TCDD BCF and a conEate ener-specific BEF- sU.S. EPA3 395b) alcfollows: and =19,596 x)2676 =un(The BCF was calculated using the TCDD BCF and a conEate			

TABLE C-6

SEDIMENT-TO-BENTHIC INVERTEBRATE BIOCONCENTRATION FACTORS (mg COPC / kg wet tissue) / (mg COPC / kg dry sediment)

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:			

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

TABLE C-6

SEDIMENT-TO-BENTHIC INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg COPC / kg dry sediment)

(Page 6 of 11)

Reported Values[a]	Reference	Experimental Parameters	Species

TABLE C-6

SEDIMENT-TO-BENTHIC INVERTEBRATE BIOCONCENTRATION FACTORS

[redacted]

- 1.146 (Southworth, Beauchamp, and Schmieder 1978), where log K = 7.540 (Karickoff and Long 1995)**Inorganics**

TABLE C-6

SEDIMENT-TO-BENTHIC INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg COPC / kg dry sediment)

(Page 8 of 11)

TABLE C-6

SEDIMENT-TO-BENTHIC INVERTEBRATE BIOCONCENTRATION FACTORS
(mg COPC / kg wet tissue) / (mg COPC / kg dry sediment)

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 0.22	0.13 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 0.36 0.16 0.73	0.31 0.36 0.06 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 0.08 0.04	0.04 0.08 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 11 of 11)

Notes:

$$Conversion\ factor = \frac{1.0\ g\ invertebrate\ total\ weight}{1.0\ g\ invertebrate\ total\ weight - 0.833\ g\ invertebrate\ wet\ weight}$$

TABLE C-7

AIR-TO-PLANT BIOTRANSFER FACTORS
(µg COPC / g dry plant) / (µg COPC / g air)

(Page 2 of 3)

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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Screening Level Ecological Risk Assessment

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APPENDIX D

BIOCONCENTRATION FACTORS (*BCF*s)
FOR WILDLIFE MEASUREMENT RECEPTORS

Screening Level Ecological Risk Assessment Protocol

August 1999

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 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

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TABLE D-1

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TABLE D-1

BIOCONCENTRATION FACTORS FOR PLANTS TO WILDLIFE MEASUREMENT RECEPTORS

(Page 2 of 3)

Compound	Measurement Receptor													
	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$_{TP-OM}$	

TABLE D-1

BIOCONCENTRATION FACTORS FOR PLANTS TO WILDLIFE MEASUREMENT RECEPTORS

(Page 3 of 3)

Table D-2

Bioconcentration Factors for Water to Wildlife Measurement Receptors

(Page 1 of 6)

	Measurement Receptors										
Compound	**American Kestrel (BCF_{W-CB})**	**American Robin (BCF_{W-OB})**									

Table D-2

Bioconcentration Factors for Water to Wildlife Measurement Receptors

(Page 2 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})

Table D-2

Bioconcentration Factors for Water to Wildlife Measurement Receptors

(Page 3 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(	B C	F			

Table D-2

Bioconcentration Factors for Water to Wildlife Measurement Receptors

(Page 5 of 6)

Table D-2

Bioconcentration Factors for Water to Wildlife Measurement Receptors

(Page 6 of 6)

Compound	Measurement Receptors										
	Muskrat (BCF_{W-OM})	Northern Bobwhite (BCF_{W-OB})	Northern Harrier (BCF_{W-CM})	Red Fox (BCF_{W-CM})	Red-tailed Hawk (BCF_{W-HM})	Salt-marsh Harvest Mouse (BCF_{W-HM})	Short-tailed ShrewD 0.026 5 ())Tj 11 Tc [(B)-11B rec(h)22(rewD)Tj 0 4.8 -4.92 0 166.17(r)-13(te11 Tc				

L
M
M
N
S
S
Thallium 3.93e-03 NA NA 3.45e-0
Z

TABLE D-3

BIOCONCENTRATION FACTORS FOR SOIL/SEDIMENT TO WILDLIFE MEASUREMENT RECEPTORS

(Page 2 of 6)

TABLE D-3

BIOCONCENTRATION FACTORS FOR SOIL/SEDIMENT TO WILDLIFE MEASUREMENT RECEPTORS

(Page 3 of 6)

Compound	Measurement Receptors										
	American Kestrel ($\text{BCF}_{\text{S-CB}}$)	American Robin ($\text{BCF}_{\text{S-OB}}$)	Canvas Back ($\text{BCF}_{\text{S-HB}}$)	Deer Mouse ($\text{BCF}_{\text{S-HM}}$)	Least Shrew ($\text{BCF}_{\text{S-OM}}$)	Long-tailed Weasel ($\text{BCF}_{\text{S-OM}}$)	Mallard Duck ($\text{BCF}_{\text{S-OB}}$)	Marsh Rice Rat ($\text{BCF}_{\text{S-OM}}$)	Marsh Wren ($\text{BCF}_{\text{S-OB}}$)	Mink ($\text{BCF}_{\text{S-CM}}$)	Mourning Dove ($\text{BCF}_{\text{S-OM}}$)
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 5 of 6)

Compound	Measurement Receptors										
	Muskrat (BCF)	Northern Bobwhite (BCF									

APPENDIX E

TOXICITY REFERENCE VALUES

Screening Level Ecological Risk Assessment

Screening Level Ecological Risk Assessment

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

$$DD = \frac{C \cdot IR}{BW} \qquad \text{Equation E-2}$$

U.S. EPA. 1996b. "Ecotox Thresholds." *ECO Update*. EPA 540/F-95/038. Office of Emergency and Remedial Response. January.

U.S. EPA. 1999. *National Recommended Water Quality Criteria-Correction.* EPA 822-Z-99-001. Office of Water. April.

Washington State Department of Ecology. 1991. *Sediment Management Standards*. Washington Administrative Code 173-204.

Washington State Department of Ecology. 1994. *Creation and Analysis of Freshwater Sediment Quality Values in Washington State*. Publication No. 97-32-a. July.

TABLES O

TABLE E-1

FRESHWATER TOXICITY REFERENCE VALUES

(Page 2 of 8)

TABLE E-1

FRESHWATER TOXICITY REFERENCE VALUES

(Page 4 of 8)

	Toxicity Value				
Compound			Uncertainty Factor[b]	TRV[c]	R47 T0.05 (c)3 Tc 0.01 Tw [(R47 i)-9(cigren)6TJ anR4c

TABLE E-1

FRESHWATER TOXICITY REFERENCE VALUES

(Page 6 of 8)

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

TABLE E-1

FRESHWATER TOXICITY REFERENCE VALUES

(Page 7 of 8)

REFERENCES

Bringmann, V.G. and R. Kühn. 1982. "Results of Toxic Action of Water Pollutants on *Daphnia magna* Straus Tested by an Improved Standardized Procedure." *Z. Wasser Abwasser Forsch*. 15.

TABLE E-2

MARINE/ESTUARINE SURFACE WATER TOXICITY REFERENCE VALU E-2

TABLE E-2

MARINE/ESTUARINE SURFACE WATER TOXICITY REFERENCE VALUES

(Page 2 of 8)

	Toxicity Value		Uncertaint		
Compound					

TABLE E-2

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			

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]	5.0d temperature onA(i)-11liug63(P (Ti)-10 -8(I exaI exa S)110(509(V-10(36(.)-0TJ -47.27.8TD 0 applicable	

TABLE E-2

MARINE/ESTUARINE SURFACE WATER TOXICITY REFERENCE VALUES

(Page 5 of 8)

Compound	Toxicity Value		Uncertainty Factor[b]	Toxicity Reference	

TABLE E-2

MARINE/ESTUARINE SURFACE WATER TOXICITY REFERENCE VALUES

(Page 6 of 8)

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.

TABLE E-2

MARINE/ESTUARINE SURFACE WATER TOXICITY REFERENCE VALUES

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REFERENCES

TABLE E-2

MARINE/ESTUARINE SURFACE WATER TOXICITY REFERENCE VALUES

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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 applicab(H)12(M)-t	M M M M M	M M M M M M	M M M M M M M M M M M M M M M MD Meight (HMW) PAH Not ap

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]

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FRESHWATER SEDIMENT TOXICITY REFERENCE VALUES

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TABLE E-3

FRESHWATER SEDIMENT TOXICITY REFERENCE VALUES

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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).

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-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).
Inde(t)]TJ 7(t)]8(p)11(p)11(lic)2BWr Florida DER (MacDonald 1993).				

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)				

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 sedi7.93 edit(e) 4(a)-(p)ri(a)8(ri6177

470 TRV was calculated using OC-based marine sedi7

TABLE E-4

MARINE/ESTUARINE SEDIMENT TOXICITY REFERENCE VALUES

(Page 4 of 8)

Compound	Marine/Estuarine Surface Water			

TABLE E-4

MARINE/ESTUARINE SEDIMENT TOXICITY REFERENCE VALUES

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Compound	Marine/Estuarine Surface Water TRV[a]	K_{oc} Value[b]	Bed	

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.

TABLE E-4

MARINE/ESTUARINE SEDIMENT TOXICITY REFERENCE VALUES

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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.

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Washington State Department of Ecology. 1991. *Sediment Management Standards*. Washington Administrative Code 173-204.

TABLE E-5

TERRESTRIAL PLANT TOXICITY REFERENCE VALUES

(Page 1 of 15)

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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TABLE E-5

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]		
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)

TABLE E-5

TERRESTRIAL PLANT TOXICITY REFERENCE VALUES

(Page 5 of 15)

Compound	Basis for TRV				TRV [c]	Reference and Notes [d]
	Duration and Endpoint [a]	Test Organism	Concentration	Uncertainty Factor [b]		
Cy0.88 2 re f e f 391.89 717.93 20.88 -0.72 re f 391.89 719.85 20.88 -033.3-7 20.88 -88 -033.M,j4itl						

TABLE E-5

TERRESTRIAL PLANT TOXICITY REFERENCE VALUES

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TABLE E-5

TERRESTRIAL PLANT TOXICITY REFERENCE VALUES

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REFERENCES

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.

Benzo(a)pyrene

Sims R.C. and Overcash M.R. 1983. “Fate of Polynuclear Aromatic Compounds (PNAs) in Soil-Plant Systems.” *Residue Reviews*. Volume 88.

Benzo(k)fluoranthene

Sims R.C. and Overcash M.R. 1983. “Fate of Polynuclear Aromatic Compounds (PNAs) in Soil-Plant Systems.” *Residue Reviews*. Volume 88.

Aroclor 1254

Weber, J.B., and E. Mrozek, Jr. 1979. "Polychlorinated Biphenyls: Phytotoxicity, Absorption, and Translocation by Plants, and Inactivation by Activated Carbon." *Bulletin of Environmental Contamination and Toxicology*. Volume 23. Pages 412-417. As cited in Will and Suter II (1995b).

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Hexachlorocyclopentadiene

Hulzebos, E.M., D.M.M. Adema, E.M. Dirven-van Breeman, L. Henzen, W.A. van Dis, H.A. Herbold, J.A. Hoekstra, R. Baerselman, and C.A.M. van Gestel. 1993. "Phototoxicity Studies with *Latuca sativa* in soil and soil nutrient solution." *Environmental Toxicology and Chemistry*. Volume 12. Pages 1079-1094.

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Aluminum

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TERRESTRIAL PLANT TOXICITY REFERENCE VALUES

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Arsenic

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Rehab, F. I., and A. Wallace. 1978. “Excess Trace Metal Effects on Cotton: 5. Nickel and Cadmium in Solution Culture.” *Communities in Soil Science and Plant Analysis*. Volume 9(8). Pages 771-778.

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TERRESTRIAL PLANT TOXICITY REFERENCE VALUES

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TERRESTRIAL PLANT TOXICITY REFERENCE VALUES

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Thallium

TABLE E-5

TERRESTRIAL PLANT TOXICITY REFERENCE VALUES

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TABLE E-6

SOIL INVERTEBRATE TOXICITY REFERENCE VALUES

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	TRV					
Compound	**Duration and Endpoint [a]**	**Test Species**	**Concentration**	**Uncertainty Factor [b]**	**TRV [c]**	**Reference and Notes [d]**
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 to1*0.01 Tw c14(n)0(s

TABLE E-6

SOIL INVERTEBRATE TOXICITY REFERENCE VALUES

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	TRV					
Compound	Duration and Endpoint [a]	Test Species	Concentration	Uncertainty Factor [b]	TRV [c]	Reference and Notes [d]

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SOIL INVERTEBRATE TOXICITY REFERENCE VALUES

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Compound	TRV				TRV [c]	Reference and Notes [d]
	Duration and Endpoint [a]	Test Species	Concentration	Uncertainty Factor [b]		

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

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SOIL INVERTEBRATE TOXICITY REFERENCE VALUES

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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

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.

Polychlorinated dibenzo(p)dioxins

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Benzo(a)pyrene

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TABLE E-6

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Ma, W.-C. 1988. "Toxicity of Copper to Lumbricid Earthworms in Sandy Agricultural Soils Amended with Cu-enriched Organic Waste Materials." *Ecology Bulletin*. Volume 39. Pages 53-56.

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Streit, B. 1984. “Effects of High Copper Concentrations on Soil Invertebrates (Earthworms and Oribatid Mites): Experimental Results and a Model.” *Oecologia*. Volume 64. Pages 381-388.

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van Rhee, J.A. 1975. "Copper Contamination Effects on Earthworms by Disposal of Pig Waste in Pastures." *Progress in Soil Zoology*. Volume 1975. Pages 451-457.

Lead

Bengtsson, G., T. Gunnarsson, and S. Rundgren. 1986. “Effects of Metal Pollution on the Earthworm *Dendrobaena rubida* (Sav.) in Acidified Soils.”

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Methyl mercury

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TABLE E-7

MAMMAL TOXICITY REFERENCE VALUES

(Page 2 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]		
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)

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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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MAMMAL TOXICITY REFERENCE VALUES

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REFERENCES

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Beryllium

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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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BIRD TOXICITY REFERENCE VALUES

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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]		

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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

TABLE E-8

BIRD TOXICITY REFERENCE VALUES

(Page 7 of 13)

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.

Huds(e)-2(c)24osdosw5Tn. 4d103(n)3 4d10igos 4d10iT6u313(4d103(n)7 4d4)9(o)0(s)-1h¯D4s.

TABLE E-8

BIRD TOXICITY REFERENCE VALUES

(Page 8 of 13)

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.**

TABLE E-8

BIRD TOXICITY REFERENCE VALUES

(Page 9 of 13)

TABLE E-8

BIRD TOXICITY REFERENCE VALUES

(Page 11 of 13)

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 D TD()-9(f)-9(ect)8r2YJ /F3 1 a4s 1 Tf 19.7632 0 1.***

TABLE E-8

BIRD TOXICITY REFERENCE VALUES

(Page 12 of 13)

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.

TABLE E-8

APPENDIX F

EQUATIONS FOR COMPUTING COPC CONCENTRATIONS AND COPC DOSE INGESTED TERMS

Screening Level Ecological Risk Assessment Protocol

August 1999

Scree

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*

$$C_{TP} = (Pd \quad Pv \quad Pr)$$

TABLE F-1-1

COPC CONCENTRATIONS IN TERRESTRIAL PLANTS FOR TERRESTRIAL FOOD WEBS

(Page 2 of 2)

Variable	Description	Units	Value
Pd			

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

$$C_{HM} = (C_{TP} \cdot BCF_{TP-HM} \cdot P_{TP} \cdot F_{TP}) \quad (C_S \cdot BCF_{S-HM} \cdot P_S) \quad (C_{wctot} \cdot BCF_{W-HM} \cdot P_W)$$

TABLE F-1-2

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

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

C_{INV}

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.
$BCF_{S\text{-}INV}$	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 $BCF_{S\text{-}INV}$ 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 $BCF_{S\text{-}INV}$ is based on a limited number of test organism. The uncertainty associated with calculating concentrations using $BCF_{S\text{-}INV}$ 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

(Page 1 of 4)

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

$$C_{HB} = (C_{TP} \cdot BCF_{TP-HB} \cdot P_{TP} \cdot F_{TP}) + (C_S \cdot BCF_{S-HB} \cdot P_S) + (C_{wctot} \cdot BCF_{W-HB} \cdot P_W)$$

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-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-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 $F_{dietcs\ 2se}$

TABLE F-1-4

COPC CONCENTRATIONS IN HERBIVOROUS BIRDS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 3 of 4)

TABLE F-1-4

COPC CONCENTRATIONS IN HERBIVOROUS BIRDS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

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)

TABLE F-1-5

COPC CONCENTRATIONS IN OMNIVOROUS MAMMALS IN FOREST, TALLGRASS PRAIRIE, SHORTGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 3 of 9)

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

TABLE F-1-5

COPC CONCENTRATIONS IN OMNIVOROUS MAMMALS IN FOREST, TALLGRASS PRAIRIE, SHORTGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 4 of 9)

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} *inclu an eo site-speci*

TABLE F-1-5

COPC CONCENTRATIONS IN OMNIVOROUS MAMMALS IN FOREST, TALLGRASS PRAIRIE, SHORTGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

TABLE F-1-5

COPC CONCENTRATIONS IN OMNIVOROUS MAMMALS IN FOREST, TALLGRASS PRAIRIE, SHORTGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 6 of 9)

Variable	Description	Units	Value
P_{HB}	Proportion of herbivorous birds in diet that is contaminated	unitless	**0 to 1** **Default: 1.0**

TABLE F-1-5

COPC CONCENTRATIONS IN OMNIVOROUS MAMMALS IN FOREST, TALLGRASS PRAIRIE, SHORTGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 8 of 9)

Variable	Description	Units	Value

TABLE F-1-6

COPC CONCENTRATIONS IN OMNIVOROUS BIRDS

TABLE F-1-6

COPC CONCENTRATIONS IN OMNIVOROUS BIRDS IN FOREST, TALLGRASS PRAIRIE, SHORTGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 2 of 7)

Variable	Description	Units	Value
$\frac{FCM_{TL3}}{FCM_{TL2}}$	Food chain multiplier for trophic level 3 predator consuming trophic level 2 prey	unitless	

TABLE F-1-6

COPC CONCENTRATIONS IN OMNIVOROUS BIRDS

TABLE F-1-6

COPC CONCENTRATIONS IN OMNIVOROUS BIRDS

TABLE F-1-6

COPC CONCENTRATIONS IN OMNIVOROUS BIRDS IN FOREST, TALLGRASS PRAIRIE, SHORTGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

Variable	Description	Units	Value

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.
$BCF_{W\text{-}OB}$	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

TABLE F-1-6

COPC CONCENTRATIONS IN OMNIVOROUS BIRDS

TABLE F-1-7

COPC CONCENTRATIONS IN AQUATIC VEGETATION IN THE FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 1 of 2)

C

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-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-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-AV} is based on soil-to-plant bioconcentration studies. The uncertainty associated with calculating concentrations using BCF_{BS-AV} in site-specific organisms is unknown and may over- or under-estimate C_{AV}.

TABLE F-1-8

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-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-AL} is based on a limited number of test organisms. The uncertainty associated with calculating concentrations using BCF_{W-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

$$C_{HM} = (C_{AV} \cdot BCF_{HM} \cdot P_{AV} \cdot F_{AV}) \quad (C_{AL} \cdot BCF_{HM} \cdot P_{AL} \cdot F_{AL}) \quad (C_{sed} \cdot BCF_{BS-HM} \cdot P_{BS}) \quad (C_{wctot} \cdot BCF_{W-HM} \cdot P_{W})$$

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)**

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**

TABLE F-1-9

COPC CONCENTRATIONS IN HERBIVOROUS MAMMALS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 3 of 5)

TABLE F-1-9

TABLE F-1-9

COPC CONCENTRATIONS IN HERBIVOROUS MAMMALS

TABLE F-1-10

COPC CONCENTRATIONS IN HERBIVOROUS BIRDS
IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 1 of 5)

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. Therefioamial1(d)1163.411 Tw [(anu)-9(o c)25(vv)37(a-TJ /)9(.163.(i)-91 Tw 100 p-9(c)2am)17e(

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	

TABLE F-1-10

COPC CONCENTRATIONS IN HERBIVOROUS BIRDS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 4 of 5)

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 (

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) $BCF_{BS\text{-}BI}$

$$C_{BI} = C_{sed} \cdot BCF_{BS-BI}$$

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

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-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-WI} values may not accurately represent site-specific conditions, therefore over-or under-estimating

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 appli a ltite-ti f

$$C_{HF} = C_{dw} \cdot BCF_f \cdot FCM_{TL2}$$

TABLE F-1-13

COPC CONCENTRATIONS IN HERBIVOROUS AND PLANKTIVOROUS 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 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.

TABLE F-1-13

COPC CONCENTRATIONS IN HERBIVOROUS AND PLANKTIVOROUS 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-1-14

COPC CONCENTRATIONS IN OMNIVOROUS MAMMALS

TABLE F-1-14

COPC CONCENTRATIONS IN OMNIVOROUS MAMMALS

TABLE F-1-14

COPC CONCENTRATIONS IN OMNIVOROUS MAMMALS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

TABLE F-1-14

COPC CONCENTRATIONS IN OMNIVOROUS MAMMALS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 6 of 10)

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

(Page 8 of 10)

Variable	Description	Units	Value
$BCF_{AV\text{-}OM}$	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. $BCF_{AV\text{-}OM}$ 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,

TABLE F-1-14

COPC CONCENTRATIONS IN OMNIVOROUS MAMMALS

TABLE F-1-15

COPC CONCENTRATIONS IN OMNIVOROUS BIRDS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 2 of 9)

TABLE F-1-15

COPC CONCENTRATIONS IN OMNIVOROUS BIRDS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 3 of 9)

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 6 of 9)

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

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 9 of 9)

REFERENCES AND DISCUSSIONS

U.S. EPA. 1995. *Great Lakes Water Quality Initiative Technical (ntRS/(P(a)10(/)-oce[((du0(/)-e[((tRS)-1o)n(tRS(0(/)-mTw iRS(B0(iiRS)-1oac1umTw (r (lRS)-1)-1(tRS)-1iRS(ctRS)-1o0(/)-s(/)-.ATNS*

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		

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	

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*

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 leTD -0.002w [(t)7(s003 (c)3iBcf4 01 T6 e)8(TD m1F(ly)64(re)8(p)u)11(s)5(in)11(g)37( ) 81(TD 0.011)]TJ 0 -1.(Nh7632 3.6316 TD 0.003 Tc [(V)14(a)3(ri)-8(es)]TJ /F2 1 Tf -22		

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

(Page 1 of 4)

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-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 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.

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

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 contaminat10(g)36(e6(r)1(-)2 p)10

TABLE F-2-1

COPC DOSE INGESTED TERMS IN HERBIVOROUS MAMMALS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

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)

$$D_{HB} = \left(\qquad \qquad \right)$$

TABLE F-2-2

COPC DOSE INGESTED TERMS IN HERBIVOROUS BIRDS IN FOREST, SHRUB/SCRUB, SHORTGRASS PRAIRIE, AND TALLGRASS PRAIRIE FOOD WEBS

(Page 2 of 5)

TABLE F-2-2

COPC DOSE INGESTED TERMS IN HERBIVOROUS BIRDS IN FOREST, SHRUB/SCRUB, SHORTGRASS PRAIRIE, AND TALLGRASS PRAIRIE FOOD WEBS

(Page 3 of 5)

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-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

TABLE F-2-2

TABLE F-2-2

COPC DOSE INGESTED TERMS IN HERBIVOROUS BIRDS IN FOREST, SHRUB/SCRUB, SHORTGRASS PRAIRIE, AND TALLGRASS PRAIRIE FOOD WEBS

(Page 5 of 5)

TABLE F-2-3

COPC DOSE INGESTED TERMS IN OMNIVOROUS 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}			

TABLE F-2-3

COPC DOSE INGESTED TERMS IN OMNIVOROUS MAMMALS

TABLE F-2-3

COPC DOSE INGESTED TERMS IN OMNIVOROUS MAMMALS IN FOREST, SHRUB/SCRUB, SHORTGRASS PRAIRIE, AND TALLGRASS PRAIRIE FOOD WEBS

(Page 4 of 8)

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) $BCF_{S\text{-}INV}$ values may not accurately represent site-specific soil conditions and therefore, may over- or under-

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)

TABLE F-2-3

COPC DOSE INGESTED TERMS IN OMNIVOROUS MAMMALS IN FOREST, SHRUB/SCRUB, SHORTGRASS PRAIRIE, AND TALLGRASS PRAIRIE FOOD WEBS

(Page 6 of 8)

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

TABLE F-2-3

COPC DOSE INGESTED TERMS IN OMNIVOROUS MAMMALS IN FOREST, SHRUB/SCRUB, SHORTGRASS PRAIRIE, AND TALLGRASS PRAIRIE 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

TABLE F-2-4

COPC DOSE INGESTED TERMS IN OMNIVOROUS BIRDS IN FOREST, SHRUB/SCRUB, TALLGRASS PRAIRIE, AND SHORTGRASS PRAIRIE FOOD WEBS

(Page 4 of 6)

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

TABLE F-2-4

COPC DOSE INGESTED TERMS IN OMNIVOROUS BIRDS IN FOREST, SHRUB/SCRUB, TALLGRASS PRAIRIE, AND SHORTGRASS PRAIRIE FOOD WEBS

(Page 6 of 6)

TABLE F-2-5

COPC DOSE INGESTED TERMS IN CARNIVOROUS MAMMALS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 1 of 8)

TABLE F-2-5

COPC DOSE INGESTED TERMS IN CARNIVOROUS MAMMALS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 2 of 8)

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:

TABLE F-2-5

COPC DOSE INGESTED TERMS IN CARNIVOROUS MAMMALS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 3 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 $BCF_{S\text{-}OB}$ 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}

TABLE F-2-5

COPC DOSE INGESTED TERMS IN CARNIVOROUS MAMMALS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 4 of 8)

Variable	Description	Units	Value
C_{OM}			

TABLE F-2-5

COPC DOSE INGESTED TERMS IN CARNIVOROUS MAMMALS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 5 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. (2) Variables BCF_{S-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 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

TABLE F-2-5

COPC DOSE INGESTED TERMS IN CARNIVOROUS MAMMALS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 6 of 8)

TABLE F-2-5

COPC DOSE INGESTED TERMS IN CARNIVOROUS MAMMALS 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. 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	L/kg BW-day	**Varies**

[redacted]

TABLE F-2-6

COPC DOSE INGESTED TERMS IN CARNIVOROUS BIRDS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 1 of 8)

TABLE F-2-6

COPC DOSE INGESTED TERMS IN CARNIVOROUS BIRDS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 3 of 8)

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

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-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 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.

Tr /GS1 gs EX 0.012(BLE F)31(-)14(2)7(-)14(6)]TJ -10.8261 -2.3913 TD -/GS15[(Tr /GS

Tr /gs EX(C)Tjr /g5.52 -5.

TABLE F-2-6

COPC DOSE INGESTED TERMS IN CARNIVOROUS BIRDS IN FOREST, SHORTGRASS PRAIRIE, TALLGRASS PRAIRIE, AND SHRUB/SCRUB FOOD WEBS

(Page 6 of 8)

Variable	Description	Units	Value
Cs	COPC concentration in soil	mg COPC /kg DW soil	**Varies** This variable is COPC 74u-5(C)w 72 -pe4lle 74u5(C)w 7(h)1ovla-21(l)pe4cPld ughTa-21abl(B)10(74u1(74u1.B)-12(s)]TJ /F

TABLE F-2-6

TABLE F-2-6

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)

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}			

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}	d		

TABLE F-2-7

COPC DOSE INGESTED TERMS IN HERBIVOROUS MAMMALS

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)

$$D_{HB} = \left(C_{AV} \cdot IR_{HB} \cdot P_{AV} \cdot F_{AV}\right) + \left(C_{AL} \cdot IR_{HB} \cdot P_{AL} \cdot F_{AL}\right) + \Big($$

TABLE F-2-8

COPC DOSE INGESTED TERMS IN HERBIVOROUS BIRDS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

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		

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 con34(o)5 19.0v9r 124.53 227.61 14.88 -0.14(C)25 124.53 2 i.53 2 b53 2 14.-9.12 00(I)-59.12 0 15282.93 752.97 0.72 -4r>Tf 63(di-47.9m(Va)-8(3(nt0 152872 578.72 752.97 0.8		

TABLE F-2-8

COPC DOSE INGESTED TERMS IN HERBIVOROUS BIRDS 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		

TABLE F-2-8

COPC DOSE INGESTED TERMS IN HERBIVOROUS BIRDS IN FRESHWATER/WETLAND, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 6 of 6)

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

(Page 1 of 10)

$$D_{OM} = \left(C_{HM} \cdot IR_{OM} \cdot P_{HM} \cdot F_{HM}\right) + \left(C_{HB} \cdot IR_{OM} \cdot P_{HB} \cdot F_{HB}\right) + \left(C_{BI} \cdot IR_{OM} \cdot P_{BI} \cdot F_{BI}\right) + \left(C_{WI} \cdot IR_{OM} \cdot P_{WI} \cdot F_{WI}\right)$$

$$+ \left(C_{AV} \cdot IR_{OM} \cdot P_{AV} \cdot F_{AV}\right) + \left(C_{AL} \cdot IR_{OM} \cdot P_{AL} \cdot F_{AL}\right) + \big($$

TABLE F-2-9

COPC DOSE INGESTED TERMS IN OMNIVOROUS MAMMALS IN FRESHWATER/WETLAND MARSH, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 2 of 10)

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 avail Tc 0.004 Tw (d)11.omd(2)1())-11pld EP64(e)8(d)7(o)3taf (o)37((e)8(s)37()8(ss)1U ()28(i)0(c8(d)11(.

TABLE F-2-9

COPC DOSE INGESTED TERMS IN OMNIVOROUS MAMMALS IN FRESHWATER/WETLAND MARSH, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 3 of 10)

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-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 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

(Page 4 of 10)

Variable	Description	Units	Value

TABLE F-2-9

COPC DOSE INGESTED TERMS IN OMNIVOROUS MAMMALS IN FRESHWATER/WETLAND MARSH, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 5 of 10)

Variable	Description	Units	Value
C_{WI}	Concentration of CO0.72LC in water invertebrates		

TABLE F-2-9

COPC DOSE INGESTED TERMS IN OMNIVOROUS MAMMALS IN FRESHWATER/WETLAND MARSH, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 6 of 10)

TABLE F-2-9

COPC DOSE INGESTED TERMS IN OMNIVOROUS MAMMALS IN FRESHWATER/WETLAND MARSH, BRACKISH/INTERMEDIATE MARSH, AND SALTMARSH FOOD WEBS

(Page 9 of 10)

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 with737 07.89 Tm4(t)-7(h)4(a)-1(bl)-c 0 Tw (C)

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

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TABLE F-2-10

COPC DOSE INGESTED TERMS IN OMNIVOROUS BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

TABLE F-2-10

COPC DOSE INGESTED TERMS IN OMNIVOROUS BIRDS
[redacted] BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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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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TABLE F-2-10

COPC DOSE INGESTED TERMS IN OMNIVOROUS BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

(Page 7 of 7)

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

(Page 1 of 10)

TABLE F-2-11

EQUATIONS FOR COMPUTING COPC DOSE INGESTED TERMS IN CARNIVOROUS MAMMALS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

(Page 3 of 10)

TABLE F-2-11

EQUATIONS FOR COMPUTING COPC DOSE INGESTED TERMS IN CARNIVOROUS MAMMALS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

(Page 4 of 10)

Variable	Description	Units	Value
C_{CF}			

TABLE F-2-11

EQUATIONS FOR COMPUTING COPC DOSE INGESTED TERMS IN CARNIVOROUS MAMMALS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

TABLE F-2-11

EQUATIONS FOR COMPUTING COPC DOSE INGESTED TERMS IN CARNIVOROUS MAMMALS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

(Page 6 of 10)

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*

TABLE F-2-11

EQUATIONS FOR COMPUTING COPC DOSE INGESTED TERMS IN CARNIVOROUS MAMMALS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

(Page 7 of 10)

Variable	Description	Units	Value
C_{HM}	Concentration of COPC in herbivorous mammals	mg COPC/kg FW tissue	**Varies (calculated - Table F-1-9)**

TABLE F-2-11

EQUATIONS FOR COMPUTING COPC DOSE INGESTED TERMS IN CARNIVOROUS MAMMALS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

(Page 8 of 10)

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

(Page 9 of 10)

Variable	Description	Units	Value

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

O[redacted]GESTED TERMS IN CARNIVOROUS BIRDS IN BRACKISH/INTERM SH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

(Page 1 of 11)

TABLE F-2-12

COPC DOSE INGESTED TERMS IN CARNIVOROUS BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

(Page 2 of 11)

Variable	Description	Units	Value

TABLE F-2-12

COPC DOSE INGESTED TERMS IN CARNIVOROUS BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

(Page 3 of 11)

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 pecies pecies p(8(c)/2F3 Tc n)34(ie)8(s2)-2(S)14(.)-2(E)17(P

TABLE F-2-12

COPC DOSE INGESTED TERMS IN CARNIVOROUS BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

(Page 5 of 11)

Variable	Description	Units	Value

TABLE F-2-12

COPC DOSE INGESTED TERMS IN CARNIVOROUS BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

(Page 6 of 11)

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

TABLE F-2-12

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.

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

TABLE F-2-13

COPC DOSE INGESTED TERMS IN CARNIVOROUS SHORE BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

(Page 2 of 10)

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

(Page 4 of 10)

Variable	Description	Units	Value

TABLE F-2-13

COPC DOSE INGESTED TERMS IN CARNIVOROUS SHORE BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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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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 5,y1an(i)0(r6(t)-11a 0(e)7an(i)C, 0.01 Ts 10(d)(n)10(d)10 0.01io)36(n)1-

TABLE F-2-13

COPC DOSE INGESTED TERMS IN CARNIVOROUS SHORE BIRDS IN BRACKISH/INTERMEDIATE MARSH, SALTMARSH, AND FRESHWATER/WETLAND FOOD WEBS

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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APPENDIX G

STATE NATURAL HERITAGE PROGRAMS

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August 1999

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Alabama Natural Heritage Program Huntingdon College 1500 East Fairview Avenue Montgomery, AL 36106 334-834-4519 334-834-5439 (Fax) Department of Conservation & Natural Resources Game and Fish Divison Folsom Administration Building 64 N. Union Street, Room 421 Montgomery, AL 36130 334-242-3484 334-242-0098 (Fax)	Alaska Natural Heritage Program University of Alaska Anchorage 707 A Street Anchorage, AK 99501 907-257-2702 907-258-9139 (Fax)	Arizona Heritage Data Management System Arizona Game & Fish Department WM-H 2221 W. Greenway Road Phoenix, AZ 85023 602-789-3612 602-789-3928 (Fax)	Arkansas Natural Heritage Commission Suite 1500, Tower Building 323 Center Street Little Rock, AR 72201 501-324-9150 501-324-9618 (Fax)
California Natural Heritage Division Department of Fish & Game 1220 S Street Sacramento, CA 95814 916-322-2493 916-324-0475 (Fax)	Colorado State University 254 General Services Building Fort Collins, CO 80523 970-491-1309 970-491-3349 (Fax)	Connecticut Natural Diversity Database Natural Resources Center Department of Environmental Protection 79 Elm Street, Store Level Hartford, CT 06106-5127 860-424-3540 860-424-4058 (Fax)	Delaware Natural Heritage Program Division of Fish & Wildlife Department of Natural Resources & Environmental Control 4876 Hay Point Landing Road Smyrna, DA 19977 302-653-2880 302-653-3431 (Fax)
District of Columbia Natural Heritage Program 13025 Riley's Lock Road Poolesville, MD 20837 301-427-1354 301-427-1355 (Fax)	Florida Natural Areas Inventory 1018 Thomasville Road Suite 200-C Tallahassee, FL 32303 904-224-8207 904-681-9364 (Fax)	Georgia Natural Heritage Program Wildlife Resources Division Georgia Department of Natural Resources 2117 U.S. Highway 278 S.E. Social Circle, GA 30279 706-557-3032 or 770-918-6411 706-557-3033 or 706-557-3040 (Fax)	Hawaii Natural Heritage Program The Nature Conservancy of Hawaii 1116 Smith Street, Suite 201 Honolulu, HI 96817 808-537-4508 808-545-2019 (Fax)
Idaho Conservation Data Center Department of Fish & Game 600 South Walnut Street, Box 25 Boise, ID 83707-0025 208-334-3402 208-334-2114 (Fax)	Illinois Natural Heritage Division Department of Natural Resources Division of Natural Heritage 524 South Second Street Springfield, IL 62701-1787 217-785-8774 217-785-8277 (Fax)	Indiana Natural Heritage Data Center Division of Nature Preserves Department of Natural Resources 402 West Washington Street, Room W267 Indianapolis, IN 46204 317-232-4052 317-233-0133 (Fax)	Iowa Natural Areas Inventory Bureau of Preserves & Ecological Services Department of Natural Resources Wallace State Office Building Des Moines, IA 50319-0034 515-281-8524 (Fax)

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STATE NATURAL HERITAGE PROGRAMS

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Kansas Natural Heritage Inventory Kansas Biological Survey 2041 Constant Avenue Lawrence, KS 66047-2906 913-864-3453 913-864-5093 (Fax)	Kentucky Natural Heritage Program Kentucky State Nature Preserves Commission 801 Schenkel Lane Frankfort, KY 40601 502-573-2886 502-573-2355 (Fax)	Louisiana Natural Heritage Program Department of Wildlife & Fisheries P.O. Box 98000 Baton Rouge, LA 70898-9000 504-765-2821 504-765-2607 (Fax)	Maine Natural Areas Program Department of Conservation (FedEx/UPS: 159 Hospital Street) 93 State House Station Augusta, ME 04333-0093 207-287-8044 207-287-8040 (Fax)
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, MN1eaG 11 T* (517-30-974-6)T7-4964 (517-30-974-6

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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		

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TOXICOLOGICAL PROFILES

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TOXICOLOGICAL PROFILES

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TOXICOLOGICAL PROFILES

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).

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ACRYLONITRILE

1.0 SUMMARY

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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,

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

James B, Riha S. 1989. “Aluminum Leaching by Mineral Acids in Forest Soils: I. Nitric-sulfuric Acid Differences.” Soil Sci Soc Am J 53:259-264.

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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).

4.0 REFERENCES

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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

(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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(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 soilE WATil26(e)ynt26(e)ilnment wilth WATsoilEprticles (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

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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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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

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 [illegible]4; Geiger 1986;).

In wildlife, cumene and cumene hydroperoxide enter the [illegible] primarily [illegible] inhalation and [illegible] absorption (Lefaux 1968; HSDB 1997). Cumene is [illegible] absorbed in mammalian systems and oxidized (Clayton and Clayton 1982). In the event that cumene [illegible]gested, 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.

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).

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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

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}

[illegible] ural analogies with 3(D(c-Du25.952/(29.5

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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).

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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

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).

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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

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

EPA. 1993. *Interim report on data and methods for assessment of 2,3,7,8-tetrachlorodibenzo-p-dioxin*
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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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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

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

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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).

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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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

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

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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B y m a 1 0 (f) - 1 4 (a m) 6

No information was available on the fate of 2-nitropropane in birds or plants.

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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 (n(nv10(ny6(icT7)23(.)-10( )]TJ -23.1087 -1.7826 TDBA0(ny6(icT7 (c)1y6(ic4(s ()8a)-7[8(

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

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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,liuivable

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 stoma( )22(lm9)19(u)-20(s)22(l)2(s)-22(e)-33(ing)-35(,)-33(b)-20(s)-20(s)-3(t)-25(h)-22(i)22(lm2(r)-35(poni

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