Appendix I

Analytical Results Reported on a Dry Weight Basis

Table I-1. Analytical Results for EDC/VCM Sludge Samples - Reported on Dry Weight Basis

Chemical	CAS No.		OG-04		OG-06		OC-02		GL-01	Average Concentration	Maximum Concentration
Volatile Organics - Method 8260A µg/kg											
Acetone	67641		3,340	<	26	<	145		1,390	1,225.2	3,340
Allyl chloride	107051		13	J	9.2	<	38*	<	48*	11.1	13
Bromoform	75252	<	4	<	6.5*	<	38*	<	48	ND	ND
Methyl ethyl ketone	78933		200	<	6.5	<	38	<	48	73.2	200
Carbon disulfide	75150	<	4	<	6.5	<	38		131	44.9	131
Chloroform	67663	J	4.2	J	9.2	<	38		2,160	552.8	2,160
Dibromochloromethane	124481	<	4	<	13	<	38	<	48	ND	ND
1,2-Dichloroethane	107062		15	J	7.1	<	38		2,050	527.4	2,050
2-Hexanone	591786	J	4.2	<	6.5*	<	38*	<	48*	4.2	4.2
Methylene chloride	75092	<	8.5	<	13	<	73		166	65.1	166
Tetrachloroethene	127184	<	4	<	6.5	<	38	J	70	29.6	70
Trichloroethene	79016	J	4.7	<	6.5*	<	38*	<	48*	4.7	4.7
Vinyl acetate	108054	J	8		19	<	38*	<	48*	13.6	19
Vinyl chloride	75014	<	8.5	<	13	<	73*	J	58	26.5	58
TCLP Volatile Organics - Methods 1311 and 8260A µg/L											
Acetone	67641	B	670	B	330	B	23	B	91	278.5	670
Bromoform	75252	<	2.5	<	2.5	<	2.5	<	2.5	ND	ND
Methyl ethyl ketone	78933		28	<	2.5	<	2.5		6.8	10.0	28
Carbon disulfide	75150	<	2.5	<	2.5	<	2.5		7.2	3.7	7.2
Chloroform	67663	<	2.5	<	2.5	<	2.5		32	9.9	32
1,2-Dichloroethane	107062	<	2.5	J	2.6	J	4.8		36	11.5	36
cis-1,3-Dichloropropene	10061015	J	3.8	<	2.5	<	2.5	<	2.5	2.8	3.8
4-Methyl-2-pentanone	108101	<	2.5	<	2.5	JB	3.6	JB	3.7	3.1	3.7
Methylene chloride	75092		44		23	JB	7.8	JB	9.5	21.1	44

Table I-1. Analytical Results for EDC/VCM Sludge Samples - Reported on Dry Weight Basis

Chemical	CAS No.		OG-04		OG-06		OC-02		GL-01	Average Concentration	Maximum Concentration
Semivolatile Organics - Method 8270B µg/kg											
Benzoic acid	65850	J	320	<	1700*	<	1890*	<	25100*	320.0	320
Bis(2-chloroethyl)ether	111444	<	550		2,100	<	960	<	12700*	1,203.3	2,100
Bis(2-ethylhexyl)phthalate	117817	J	230		4,900	J	1,200	J	22,800	7,282.5	22,800
Hexachlorobenzene	118741	J	180	<	850*	<	960*	<	12700*	180.0	180
TCLP Semivolatile Organics - Methods 1311 and 8270B µg/L											
Benzoic acid	65850		108	<	10		40		38	49.0	108
Bis(2-chloroethyl)ether	111444	<	5		12	<	5	<	5	6.8	12
4-Methylphenol	106445	<	5	<	5	<	5		42	14.3	42
Total Metals - Methods 6010, 7471 mg/kg											
Aluminum	7429905		486		549		1,700		114,000	29,183.8	114,000
Arsenic	7440382		9.7		18.6	<	1.5		102	33.0	102
Barium	7440393	<	16.7		112		285		263	169.2	285
Cadmium	7440439	<	0.4		1.65	<	0.7	<	1.0	0.9	1.65
Calcium	7440702		357,000		34,600		50,300		16,900	114,700	357,000
Chromium	7440473		20.4		184		72.7		1,110	346.8	1,110
Cobalt	7440484	<	4.2		27.3	<	7.3	<	9.7	12.1	27.3
Copper	7440508		91.0		370		375		15,800	4,159	15,800
Iron	7439896		11,600		415,000		117,000		32,400	144,000	415,000
Lead	7439921		2.7		34.1		5.5		13.9	14.1	34.1
Magnesium	7439954	<	420		7,170		11,700		4,170	5,865.0	11,700
Manganese	7439965		222		1,740		942		288	798.0	1,740
Molybdenum	7439987	<	1.7	<	2.6	<	2.9		10.8	4.5	10.8
Nickel	7440020		52.6		210		99.1		463	206.2	463
Potassium	7440097	<	420	<	660	<	730	<	970	ND	ND
Sodium	7440235		4,570		7,430		27,500		8,340	11,960.0	27,500
Vanadium	7440622		24.4		23.9	<	7.3	<	9.7	16.3	24
Zinc	7440666		92.8		1,810		259		575	684.2	1,810

Table I-1. Analytical Results for EDC/VCM Sludge Samples - Reported on Dry Weight Basis

Chemical	CAS No.		OG-04		OG-06		OC-02		GL-01	Average Concentration	Maximum Concentration
TCLP Metals - Methods 1311, 6010, and 7470 mg/L											
Calcium	7440702		848		588		413		204	513.3	848
Cobalt	7440484	<	0.03		0.07	<	0.03	<	0.03	0.0	0.07
Copper	7440508		0.43	<	0.13	<	0.13		22.3	5.7	22.3
Magnesium	7439954		3.2		136		154		21.5	78.7	154
Manganese	7439965		1.7		12.9		0.81		2.0	4.4	12.9
Molybdenum	7439987	<	0.10		0.22	<	0.1	<	0.1	0.1	0.22
Nickel	7440020		0.34		0.67	<	0.1		1.3	0.6	1.3
Potassium	7440097		9.3		5.2		4.1		3.6	5.6	9.3
Zinc	7440666	<	1.0		4.0	<	1.0	<	1.0	1.8	4.0
Dioxins/Furans - Method 1613 ng/kg											
2,3,7,8-TCDF	51207319		1.9	<	8.0		23.0		560	148.2	560
Total TCDF	55722275		47.0		580		130		10,000	2,689.3	10,000
2,3,7,8-TCDD	1746016	<	0.45	<	1.6	<	1.0		150	38.3	150
Total TCDD	41903575		2.0	<	1.6		2.0		1,600	401.4	1,600
1,2,3,7,8-PeCDF	57117416		14.0		55.0		80.0	<	2.5	37.9	80.0
2,3,4,7,8-PeCDF	57117314		18.0		59.0		36.0		490	150.8	490
Total PeCDF	30402154		240		1,400		240		1,400	820.0	1,400
1,2,3,7,8-PeCDD	40321764	<	2.3	<	7.5	<	2.5	<	154	ND	ND
Total PeCDD	36088229		17.0	<	7.5	<	2.5		180	51.8	180
1,2,3,4,7,8-HxCDF	67562394		180		280		190		5,500	1,537.5	5,500
1,2,3,6,7,8-HxCDF	57117449		140	<	21.0		40.0	<	1150*	67.0	140
2,3,4,6,7,8-HxCDF	60851345		120		86.0		21.0		2,500	681.8	2,500
1,2,3,7,8,9-HxCDF	72918219		65.0	<	105*		45.0	<	550*	55.0	65
Total HxCDF	55684941		1,200		3,600		400		32,000	9,300.0	32,000
1,2,3,4,7,8-HxCDD	39227286		14.0	<	7.5	<	2.5	<	80*	8.0	14.0
1,2,3,6,7,8-HxCDD	57653857		13.0	<	7.5	<	2.5		320	85.8	320
1,2,3,7,8,9-HxCDD	19408743		9.4	<	7.5	<	2.5		240	64.9	240
Total HxCDD	34465468		71.0	<	7.5	<	2.5		1,200	320.3	1,200

Table I-1. Analytical Results for EDC/VCM Sludge Samples - Reported on Dry Weight Basis

Chemical	CAS No.		OG-04		OG-06		OC-02		GL-01	Average Concentration	Maximum Concentration
Dioxins/Furans - (continued)											
1,2,3,4,6,7,8-HpCDF	67562394		3,500		120		110		80,000	20,932.5	80,000
1,2,3,4,7,8,9-HpCDF	55673897		690		130		71.0		52,000	13,222.8	52,000
Total HpCDF	38998753		5,700		5,700		320		150,000	40,430.0	150,000
1,2,3,4,6,7,8-HpCDD	35822469		390		38.0		9.3		3,000	859.3	3,000
Total HpCDD	37871004		390		38.0		20.0		4,400	1,212.0	4,400
OCDF	39001020		18,000		1,700		180		820,000	209,970.0	820,000
OCDD	3268879		3,700		780		120		25,000	7,400.0	25,000
TCLP Dioxins/Furans - Methods 1311, 1613 ng/L											
Total TCDF	55722275		0.015	<	0.006	<	0.005		0.049	0.0	0.049
Total HxCDF	55684941	<	0.027	<	0.031	<	0.026		0.070	0.0	0.070
1,2,3,4,6,7,8-HpCDF	67562394		0.083	<	0.031	<	0.026		1.10	0.3	1.10
1,2,3,4,7,8,9-HpCDF	55673897	<	0.027	<	0.031	<	0.026		0.40	0.1	0.400
Total HpCDF	38998753		0.083	<	0.031	<	0.026		2.20	0.6	2.20
OCDF	39001020		0.50	<	0.06	<	0.05		99.0	24.9	99.0
OCDD	3268879	<	0.055	<	0.06	<	0.05		0.20	0.1	0.200
General Chemistry mg/kg											
TOC	NA		NA		NA		10,800		262,000	136,400	262,000
Oil & Grease	NA		NA		NA		1,980		3,760	2,870	3,760

* Non-Detect values greater than the highest detected concentration have been excluded from the calculations.
< Non-Detect values are reported as 1/2 the method detection limit.
All concentrations are reported on a dry-weight basis.

Table I-2 Analytical Results for Methyl Chloride Sludge Samples - Reported on a Dry Weight Basis

Chemical	CAS No.	DC-01
Volatile Organics - Method 8260A µg/kg		
Acetone	67641	4,100
Methylene chloride	75092	22,400
TCLP Volatile Organics - Methods 1311 and 8260A µg/L		
Acetone	67641	150
Carbon disulfide	75150	5.8
Methylene chloride	75092	J 9.1
Semivolatile Organics - Method 8270B µg/kg		
None detected	-	< 1,020
TCLP Semivolatile Organics - Methods 1311 and 8270B µg/L		
Benzoic acid	65850	J 13
Total Metals - Methods 6010, 7471 mg/kg		
Aluminum	7429905	3,600
Arsenic	7440382	3.54
Calcium	7440702	144,000
Chromium	7440473	13.0
Copper	7440508	1,200
Iron	7439896	10,600
Lead	7439921	13.0
Magnesium	7439954	43,500
Manganese	7439965	203
Nickel	7440020	17.0
Zinc	7440666	1,070

Table I-2 Analytical Results for Methyl Chloride Sludge Samples - Reported on a Dry Weight Basis

Chemical	CAS No.	DC-01
TCLP Metals - Methods 1311, 6010, and 7470 mg/L		
Aluminum	7429905	2.4
Calcium	7440702	1,470
Copper	7440508	5.3
Magnesium	7439954	81
Manganese	7439965	4.1
Zinc	7440666	11
Dioxins/Furans - Method 1613 ng/kg		
1,2,3,4,6,7,8-HpCDF	67562394	5.8
Total HpCDF	38998753	5.8
1,2,3,4,6,7,8-HpCDD	35822469	13.0
Total HpCDD	37871004	24.0
OCDF	39001020	18.0
OCDD	3268879	82.0
TCLP Dioxins/Furans - Methods 1311, 1613 ng/L		
None detected	-	< 0.006
General Chemistry mg/kg		
TOC	NA	78,500
Oil & grease	NA	122,000

< = Not detected. Value is the detection limit.
J = Estimated value is below the quantitation limit.
NA = Not applicable.
All concentrations are reported on a dry-weight basis

Appendix J

Screening Ecological Assessment of Chlorinated Aliphatics Waste Management Scenarios

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Screening Ecological Assessment of Chlorinated Aliphatics Waste Management Scenarios

This analysis seeks to investigate whether adverse effects may occur in ecological receptors inhabiting areas surrounding waste management units disposing of wastewater treatment sludges generated by the chlorinated aliphatics production processes. Sludges that were evaluated in this analysis included those generated by the manufacture of ethylene dichloride/vinyl chloride monomer (EDC/VCM) via the balanced process and those generated by the manufacture of methyl chloride. The fate and transport of chemicals from both landfills and a land treatment unit were the focus of this analysis. The same sites and constituents assessed in the human health analysis were used for the ecological analysis. This assessment does not meet the requirements of a formal ecological risk assessment as determined by the Environmental Protection Agency (U.S. EPA, 1998). Rather, this analysis is intended to provide a screening-level approach designed to identify the potential for adverse ecological effects. Very simply stated, a screening-level analysis compares, the modeled media concentrations to protective media concentrations using a ratio. When the ratio, or hazard quotient (HQ), exceeds 1 there is a potential for adverse effects, and if the result is less than 1, adverse effects are not expected for a particular ecological receptor. The screening nature of the analysis calls to attention a few important caveats in interpreting the results:

1. Because the screening methodology is based on the exceedance of a target hazard quotient of 1, the outcome of the screen is binary: HQ $>$ 1 or HQ $\leq$ 1. Although large exceedances suggest a greater potential for ecological damage, an HQ of 50 at one site is not necessarily five times worse than an HQ of 10 at another site.

2. The potential for adverse ecological effects (as indicated by an HQ exceedance) should not be confused with the ecological significance of those effects. The magnitude of exceedance is suggestive of the potential for adverse ecological effects; however, these screening results do not demonstrate actual ecological effects, nor do they indicate whether those effects will have significant implications for ecosystems and their components.

3. Ecological receptors selected for the screening methodology were chosen to represent relatively common populations and communities of wildlife that could potentially inhabit areas surrounding the facilities. Regionally unique species occurring in coastal areas of the southeastern United States (e.g., Florida Manatee) and other species listed as threatened and endangered were not evaluated in the analysis.

4. Although this analysis did not explicitly consider threatened or endangered species, the chemical stressor concentration limits (CSCLs) are protective media

Screening Ecological Assessment of Chlorinated Aliphatics Waste Management Scenarios

This analysis seeks to investigate whether adverse effects may occur in ecological receptors inhabiting areas surrounding waste management units disposing of sludge generated by the chlorinated aliphatics production processes. Sludges that were evaluated in this analysis included those generated by the manufacture of ethylene dichloride/vinyl chloride monomer (EDC/VCM) via the balanced process. The fate and transport of chemicals from both landfills and a land treatment unit were the focus of this analysis. The same sites and constituents assessed in the human health analysis were used for the ecological analysis. This assessment does not meet the requirements of a formal ecological risk assessment as determined by the Environmental Protection Agency (U.S. EPA, 1998). Rather, this analysis is intended to provide a screening-level approach designed to identify the potential for adverse ecological effects. Very simply stated, a screening-level analysis compares, the modeled media concentrations to protective media concentrations using a ratio. When the ratio, or hazard quotient (HQ), exceeds 1 there is a potential for adverse effects, and if the result is less than 1, adverse effects are not expected for a particular ecological receptor. The screening nature of the analysis calls to attention a few important caveats in interpreting the results:

1. Because the screening methodology is based on the exceedance of a target hazard quotient of 1, the outcome of the screen is binary: HQ > 1 or HQ ≤ 1. Although large exceedances suggest a greater potential for ecological damage, an HQ of 50 at one site is not necessarily five times worse than an HQ of 10 at another site.

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4. Although this analysis did not explicitly consider threatened or endangered species, the chemical stressor concentration limits (CSCLs) are protective media concentrations based on Agency-wide standards (e.g., Ambient Water Quality Criteria) and no observed adverse effects levels. The conservative nature of these CSCLs implies some degree of protection for species already considered to be under stress.

For this analysis, a screening-level methodology was applied that is designed to evaluate the potential for adverse ecological effects for selected receptors in generalized terrestrial and freshwater aquatic systems. This methodology has been applied and/or modified in other risk analyses conducted by OSW and was considered to provide an appropriate level of resolution given the management goals for this analysis. The data and methods chosen support the development of protective media concentrations in soil, sediment, and surface water based on conservative assumptions regarding exposure pathways and dietary preferences for selected ecological receptors. The SERA focused on a limited set of constituents of concern that were modeled for the human health risk analysis and included the following steps: (1) develop chemical stressor concentration limits, (2) compare CSCLs to exposure concentrations and calculate hazard quotients, (3) characterize key uncertainties and their impact on hazard quotients, and (4) determine the relevance of the SERA to potential ecological risks from chlorinated aliphatic facilities.

Identification of Chemical and Exposure Pathways of Concern

Chemicals of Concern

A complete list of the chemicals under consideration in this analysis is provided in Table 1 of Attachment 1. The same constituents of concern used in the human health risk analysis were adopted for the ecological analysis. The constituents evaluated can be categorized into the generalized chemical classes of volatile and semivolatile organics, metals, and dioxin/furan congeners. As the chemical classifications indicate, the individual groups of compounds tend to behave in a similar way. Although the chemical properties of a constituent influence the mobility and the potential for adverse effects, incorporating these variables into the risk estimates is beyond the scope of a screening-level analysis; however, the variability introduced by chemical behavior is considered an issue of uncertainty in interpreting the results of the assessment. A brief review of the predicted environmental behavior of these compounds is provided.

Volatile and Semivolatile Organic Compounds (VOCs)

Once released into the environment, VOCs volatilize into the atmosphere from soil and surface water where they react with free radicals and are broken down. The half-life of VOCs, ranges from hours to days. However, VOCs redeposited onto soils can leach into groundwater and persist for an extended period of time. Once percolated into groundwater, the mobility and degradation of VOCs are dependent on physical and chemical conditions (e.g., moisture content, soil aeration, organic carbon content). For example, VOCs minimally bind to organic carbon, making them moderately to highly mobile in ground water. In addition, the aeration of the soils determines the rate and probability of biodegradation. In most cases, the predominant mobility of VOCs is from soil and surface water to the atmosphere.

Metals

Metals considered in this analysis have unique speciation issues mediated by chemical conditions in surrounding media (e.g., pH, redox potential), which influence not only the ionic form of the metal present but also the complexes and compounds likely to be formed. As an example, the chemical-specific speciation of lead, one of the chemicals considered in this analysis, is provided in Table 1. Under typical environmental conditions, a large fraction of a total metal concentration is found in a form that is not bioavailable to organisms. Evidence suggests that dissolved concentrations of metals are more bioavailable and toxic to organisms and may reflect more relevant exposure scenarios. However, the vast majority of free ionic metals released into the environment are rapidly sorbed, precipitated, or complexed into relatively nontoxic forms. Both dissolved and total concentrations of metals were evaluated in this analysis where data were available.

Dioxin and Furan Congeners

Dioxin and furan congeners are persistent, bioaccumulative, and hydrophobic compounds. Because congeners adsorb to organic matter, the movement of sediments, particulates, and soil erosion mimics the mobility and fate of dioxin. For example, in surface water, dioxins and furans are primarily associated with suspended organic matter, which eventually settles into sediments. The primary sink for dioxin and furan congeners, as one would expect, is the sediment, but accumulation of congeners also occurs in biota tissues. Dioxin is highly bioaccumulative and biomagnifies in food webs. Typically, dioxin congeners are stored in the fat tissues of organisms and are minimally metabolized over time. During times of fat mobilization in organisms, dioxin can severely impact particularly sensitive receptors, such as vertebrates.

Table 1. Characterization of Environmental Behavior of Lead in Ecosystems

Descriptor	Lead
Speciated forms	Pb^0 (elemental) Pb^{2+} (ionic) Alkylated Pb
Unique behaviors	# Speciation dependent on adsorption, precipitation, and complexation # Can be methylated or ethylated to form organic chemical species.
Behavior in soil	# Primarily sorbed to organic matter # Minimally transported to surface and groundwater # Forms insoluble organocomplexes
Behavior in sediment	# Sediments act as a sink for Pb # Anaerobic conditions produce relatively volatile organo-tetramethyl Pb through biological alkylation
Behavior in surface water	# Speciation of Pb controlled by balance between complexed and dissolved organic matter and suspended solids

Ecological Exposure Pathways of Concern

The ecological pathways of concern for the analysis include the movement of the constituents from the landfills and land treatment units to media to which ecological receptors would be exposed. The screening analysis modeled concentrations of constituents in soil, sediment, surface water, and plant tissues. Media concentrations for chemicals in soil, sediment, and plant tissue were generated as total concentrations while both total and dissolved chemical concentrations were generated for surface water. Movement of chemicals off-site was primarily modeled through pathways of ground water, atmospheric transport, and erosion/runoff to water bodies. A detailed discussion of the modeling process, including the fate and transport algorithms applied, is provided in Appendices D and E of the background document. It should be noted that these modeling techniques do not reflect the complex speciation dynamics of many metals. The model is designed to partition cationic metals between suspended particulates and the “dissolved” phase, but it does not distinguish between free ionic metals and other “dissolved” forms of metals (e.g., complexes) that are less toxic. The implication of applying this model is that the total exposure concentrations estimated for sediment and surface water tend to be conservative.

The mobility of constituents into ecological systems and the resultant partitioning into soil, surface water, and sediment has the potential to result in exposures to multiple receptors. Biota inhabiting freshwater systems may be exposed through direct contact (e.g., fish and aquatic invertebrates and the benthic community) or ingestion (e.g., piscivorous mammals) of contaminated prey (e.g., fish) or media (e.g., sediment). Likewise, in terrestrial systems, biota foraging in habitats that are contaminated may be exposed to constituents from both food chain pathways, direct contact, and potentially inhalation of volatilized organics. In this screening analysis, only the direct contact and ingestion pathways were evaluated. Inhalation, as an exposure pathway for mammals and birds, was not evaluated because (1) measurement endpoints for inhalation exposures seldom include reproductive effects, (2) inhalation rates and uptake efficiency have not been well characterized for many wildlife species, and (3) models are currently not available to characterize the variability in spatial and temporal factors that influence inhalation exposures (e.g., foraging range, borrowing animals exposed to subsurface air).

Selection of Ecosystems and Receptors

Selection of Generalized Ecosystems

Generalized freshwater and terrestrial ecosystems were used to evaluate the potential for ecological risk. Generalized representative ecosystems are a simplification of true ecosystems, but they capture the basic elements characteristic of most freshwater and terrestrial ecosystems. Generalized freshwater ecosystems include a variety of waterbodies such as lakes and rivers. Variables that will influence the wildlife communities able to inhabit the waterbodies include water flow rate, bed sediment composition, periodicity of flood events, and the presence of aquatic vegetation. Since these variables were not explicitly used to characterize freshwater ecosystems, a level of uncertainty is introduced into the assignment of appropriate food webs to waterbodies. Generalized terrestrial ecosystems are soil-based ecosystems such as forests and grasslands. The composition of receptors within a terrestrial ecosystem is highly dependent on the physical structures (i.e., geology, soil composition, and vegetation) of the habitat. Since the variability in vegetation cover and soil types was not considered in this analysis, a level of uncertainty was introduced into assigning food webs that are appropriate to most generalized terrestrial habitats.

Although using generalized ecosystems is appropriate for a screening level analysis, there are uncertainties and limitations with applying this method. Since the location of chlorinated aliphatic facilities are somewhat regionally-bounded (i.e., centered around the Gulf Coast of Texas and Louisiana), the generalized ecosystem approach lacks resolution to evaluate the potential impacts to specific ecosystems surrounding facilities. These areas are characterized by unique habitat mosaics of tidal marshes, wetlands, and estuaries. Wetlands may be of particular concern given (1) the proximity of facilities to the coast, (2) the generally flat relief of the coastal counties in Texas and Louisiana, and (3) the relatively high water table characteristic of the area. Because these unique habitats were not evaluated through this screening analysis, a level of uncertainty about the potential for impacts to other more sensitive ecosystems is important to note.

Selection of Representative Receptors

Given that this was a screening assessment, a suite of receptor taxa[1] were selected that represented key trophic levels present in most generalized ecosystems. The receptor taxa included representative species of mammals and birds (Table 2) as well as generalized communities (e.g., soil invertebrates). It is important to note that the representative species and generalized communities selected for this analysis should not be given the status of indicator species. Indicator species imply that receptors occupy a level of significance to total ecosystem structure or function. The receptors were selected not because of their intrinsic value to the generalized ecosystem; rather they were selected because (1) there was life history data available to characterize potential exposures, and (2) these species in combination fulfill the needed trophic elements for the food web. The rationale for the selection of receptor taxa is detailed below.

- **Mammals**–Mammals include upper-trophic-level predators (e.g., red fox), lower-trophic-level consumers such as ruminants (e.g., deer), and insectivores (e.g., shrew, bat). Representative species cover a variety of body sizes, habitats, and dietary preferences and are those for which life history data are available. Mammals were further categorized into those that forage primarily in freshwater ecosystems (i.e., piscivorous mammals) and those that tend to forage in terrestrial ecosystems.

[1] Receptor taxa are the eight generalized trophic compartments used to construct freshwater and terrestrial food webs: mammals, birds, amphibians, plants, soil invertebrates, freshwater community, algae and aquatic plants, benthic community.

Table 2. Representative Receptors of Mammals and Birds In Generalized Freshwater and Terrestrial Ecosystems

Terrestrial Ecosystems		Freshwater Ecosystems	
Mammals	**Birds**	**Mammals**	**Birds**
Short-tailed shrew Deer mouse Meadow vole Eastern cottontail Red fox Raccoon White-tailed deer	Red-tailed hawk American kestrel Northern bobwhite American robin American woodcock	Mink River otter	Bald eagle Osprey Great blue heron Mallard Lesser scaup Kingfisher Spotted sandpiper Herring gull

Birds–Birds also include upper-trophic-level predators (e.g., bald eagle) and lower-trophic-level consumers that eat small vertebrates, earthworms, large insects, or vegetation (e.g., American robin). As with mammals, representative species encompass a variety of body sizes, habitats, and dietary preferences for which data are available. Birds were further categorized into those that forage primarily in freshwater ecosystems and those that tend to forage in terrestrial ecosystems.

Amphibians–Amphibians are currently under significant stress worldwide. Moreover, these organisms appear to be highly sensitive to a number of chemicals during the developmental stages of their life cycle (e.g., trace metals). They are essential parts of a number of food webs (particularly wetlands areas) and are likely to provide a fairly sensitive indicator for chemical stressors relevant to higher levels of biological organization. Representative amphibian species are not considered individually in this analysis, rather amphibians are considered to be a community-type receptor.

Plants–As primary producers, vascular plants are crucial components of virtually any type of terrestrial ecosystem. Representative species for plant communities are problematic for this application due to the general paucity of toxicity data on plants not grown as food crops. Species of plants used to represent this community within terrestrial ecosystems are frequently limited to forage grasses and food crops.

Soil Invertebrates–Invertebrate species (e.g., earthworms, insects) and microflora are crucial to the structure and function of a soil community (i.e., the community performs all of the essential functions such as mineralization, decomposition, etc). Organisms living in or on the soil are exposed through direct contact with contaminated soil and through the ingestion of contaminated soil and other soil biota such as centipedes (i.e., indirect food web exposure). This taxon is assessed as a generalized soil invertebrate community.

- # **Freshwater Community–**Fish and aquatic invertebrates are important organisms in the aquatic ecosystem. Both are subject to continuous exposure to contaminated water through gill exchange and may be highly exposed to bioaccumulative chemicals through the food chain. They occupy niches as both predator and prey, and the aquatic invertebrates include a diverse community of organisms (e.g., arthropods, molluscs, annelids). The extensive database on aquatic invertebrates suggests that arthropods are among the most sensitive aquatic species.

- # **Algae and Aquatic Plants–**Vascular aquatic plants and algae typical of freshwater aquatic ecosystems help oxygenate the water and are important food sources. Algal species primarily include green, blue-green, and diatoms; data on vascular plants are generally found only for duckweed (e.g., *Lemma minor*, *Spriodela polyrhize*).

- # **Benthic Community–**The benthic community is composed of a variety of organisms that are indigenous to most freshwater ecosystems, including organisms that break down decaying materials (e.g., detritivores) and others that filter organic materials from the water (e.g., filter feeders). Because these organisms spend most (if not all) of their lives in the sediment, they are exposed through direct contact and ingestion of contaminated sediments.

Selection of Assessment Endpoints

The selection of the assessment endpoints for each receptor taxa was critical to the development of the benchmarks and CSCLs. The selection of assessment endpoints, defined as "explicit expressions of the actual environmental value that is to be protected" (U.S. EPA, 1998) serves as a critical link between the ecological risk assessment (ERA) and the management goal. The assessment endpoints must be ecologically relevant to the ecosystem(s) they represent and must reflect attributes in receptors that are susceptible to the stressors of concern. The receptor taxa groups and assessment endpoints identified for this analysis are summarized in Table 3.

In developing assessment endpoints, a population- and community-inference approach was taken to predict the risks to ecological receptors. In the case of mammals and birds, studies identifying reproductive and developmental effects to surrogate laboratory species were extrapolated to representative wildlife species. Toxicity endpoints that can reasonably be assumed to influence the potential of a population to sustain themselves (e.g., developmental and reproductive) were used to infer a level of protection to populations. In the case of community receptors, protective levels for members of the community were used to extrapolate protective levels to preserve the functional and structural systems of the community. These endpoints do not reflect *true* population- and community-level benchmarks and CSCLs because they do not consider emigration, immigration, or predator-prey interactions between species. Benchmarks and CSCLs developed for this analysis reflect an individual-level of protection, but we infer a level of protection to populations and communities because of the toxicity endpoints (e.g., reproductive) used to develop the benchmarks and CSCLs.

Table 3. Assessment Endpoints for the Ecological Receptors of Concern

Ecological Significance	Assessment Endpoint	Representative Receptors	Characteristic(s)	Measure of Effect
# Multiple trophic levels represented # Socially valued (e.g., endangered species) # Top recipients of bioaccumulative chemicals # Represent species with large foraging ranges # Represent species with longer life spans	viable mammalian wildlife populations	e.g., deer mouse, meadow vole, red fox	reproductive and developmental success	chronic or subchronic NOAEL(s) or LOAEL(s) for developmental and reproductive effects
	viable avian wildlife populations	e.g., red-tailed hawk, northern bobwhite	reproductive and developmental success	chronic or subchronic NOAEL(s) or LOAEL(s) for developmental and reproductive effects
# Species represent unique habitat niches (e.g., partially aquatic and terrestrial) # Many species are particularly sensitive to exposure	protection of amphibian and reptile populations ("herps") against acute effects	e.g., frog, newt, snake, turtle	lethality and percent deformity	acute LC_{50}s for developmental effects resulting from early life stage exposures
# Represents base food web in terrestrial systems # Habitat vital to decomposers and soil aerators # Proper soil community function related to nutrient cycling	sustainable soil community structure and function	e.g., nematodes, soils mites, springtails, annelids, arthropods	growth, survival, and reproductive success	95% of species below no effects concentration at 50th percentile confidence interval
# Primary producers of energy in ecosystems # Act as food base for herbivores # Able to sequester some contaminants # Can act as vectors to bioaccumulation # Constitute a large fraction of the earth's biomass	maintain terrestrial primary producers (plant community)	e.g., soy beans, alfalfa, rye grass	growth, yield, germination	10th percentile from LOEC data distribution
# Highly exposed receptors from constant contact with contaminated media # Act as vectors to transfer contaminants to terrestrial species	sustainable aquatic community structure and function	e.g., fish (salmonids), aquatic invertebrates (daphnids)	growth, survival, reproductive success	National Ambient Water Quality Criteria (NAWQC) for aquatic life (95% species protection)
# Provide habitat for reproductive lifestages (e.g., eggs, larval forms) # Habitat for key invertebrate species # Act to process nutrients and decompose organic matter	sustainable benthic community structure and function	e.g., protozoa, flat worms, ostracods	growth, survival, reproductive success	10th percentile from LOEC data distribution
# Primary producers of energy in the aquatic system. # Base food source in the aquatic system # Can act to sequester contaminants from the water column # Act as substrate for other organisms in the water column (e.g., periphyton)	maintain primary aquatic producers (algal and plant community)	e.g., algae and vascular aquatic plants	growth, mortality, biomass, root length	EC_{20} for algae; lowest LOEC for aquatic plants

Development of Protective Chemical Stressor Concentration Limits (CSCLs)

In the simplest sense, developing chemical stressor concentration limits (CSCLs) was conducted by evaluating the available ecotoxicity data in an effort to estimate media concentrations that would be protective of ecological receptors. Although protective media concentrations were the final metric required to calculate hazard quotients for risk estimates, the derivation method of CSCLs differed across some receptor taxa.

- For mammals and birds, the derivation of the CSCL differed from the methods used to calculate other receptor CSCLs. Because the ecotoxicity data for mammals and birds are reported in units of ingested dose (mg/kg-d), deriving a protective media concentration (i.e., mg/L or mg/kg soil) for these receptors required making some assumptions about dietary preferences of the wildlife species and chemical uptake into prey items. Using these assumptions, CSCLs were generated for mammals and birds when sufficient data were available to characterize food web transfer of constituents.

- CSCLs developed for other receptors were derived from ecotoxicity data reflecting direct contact exposures. Some of these CSCLs were adopted from ecotoxicity databases, EPA, other government agencies, and private research laboratories.

This section outlines the specific methodologies used in developing the individual CSCLs for receptors of concern. Some of the key sources reviewed to develop direct contact CSCLs are provided in Table 4. The discussion first presents the methodology applied to develop mammalian and avian CSCLs followed by discussions of methods for each of the other receptor taxa.

Mammals and Birds

The overall approach for developing CSCLs for mammals and birds can be summarized in four step s: (1) identify an appropriate benchmark study, (2) scale benchmark value, (3) identify uptake factors, and (4) calculate CSCL.

Step 1: Identify Appropriate Benchmark Study

The methods for establishing ecotoxicological benchmarks for mammals and birds are similar to the methods used to establish reference doses for humans as described in

Table 4. Key Sources of Information Used to Develop Chemical Stressor Concentration Limits (CSCLs)

Source	Contents
Mammals and Birds	
U.S. EPA, 1995b. Great Lakes Water Quality Initiative Criteria Documents for the Protection of Wildlife. Office of Water.	Provides wildlife criteria in surface water for exposures to DDT, 2,3,7,8- TCDD, mercury, and PCBs
Sample, B.E., Opresko, D.M. and Suter II, G.W. 1996. Toxicological Benchmarks for Wildlife: 1996 Revision.	Compendia reference developed from primary literature review of toxicity of various constituents to species of mammals and birds.
TERRETOX Database. Office of Research and Development. Environmental Protection Agency.	This database contains over 33,000 toxicity tests on terrestrial wildlife for more the 1,200 chemicals and 253 species.
ATSDR (Agency for Toxic Substances and Disease Registry). *Toxicological Profiles.* U.S. Department of Health and Human Services, Public Health Service.	These chemical-specific documents identify effects to mammalian receptors for derivation of human health benchmarks.
U.S. FWS (Fish and Wildlife Service). Hazard Profiles	These profiles review chemical-specific toxicity to various ecological receptors. These compendia also expand discussions to assess issues of bioaccumulation and biochemical effects.
Plant Community	
Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten. 1997b. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision.	This document provides effects data for terrestrial plants exposed in soil and solution mediums. Approximately 45 constituents have proposed soil criteria.
PHYTOTOX Database. Office of Research and Development. Environmental Protection Agency.	This database contains over 49,000 toxicity tests on terrestrial plants for more the 1,600 organic and inorganic chemicals and 900 species.
Freshwater Community	
AQUIRE (AQUatic toxicity Information REtrieval) Database. 1997. Environmental Research Laboratory, Office of Research and Development, U.S. EPA, Duluth, MN	This database contains over 145,000 toxicity tests for more than 5,900 organic and inorganic chemicals and 2,900 aquatic species.
U.S. EPA. *Ambient Water Quality Criteria.* U.S. EPA, Washington, DC.	These chemical-specific documents provide the ecotoxicity data and derivation methodologies used to develop the National Ambient Water Quality Criteria (NAWQC).
U.S. EPA. 1995a. Great Lakes Water Quality initiative Criteria Documents for the Protection of Aquatic Life in Ambient Water. Office of Water. (U.S. EPA, 1996a Update)	For a limited number of constituents, the GLWQI has proposed surface water criteria for aquatic biota using analogous methods as implemented in the derivation of the NAWQC.
Suter II, G.W. and C. Tsao. 1996. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Aquatic Biota: 1996 Revision	This compendia reference provides acute and chronic water quality criteria for freshwater species including algae.

(continued)

Table 4. (continued)

Source	Contents
Algae and Aquatic Plants	
Suter II, G.W. and C. Tsao. 1996. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Aquatic Biota: 1996 Revision	This compendia reference provides acute and chronic water quality criteria for freshwater species including algae.
AQUIRE (AQUatic toxicity Information REtrieval) Database. 1997. Environmental Research Laboratory, Office of Research and Development, U.S. EPA, Duluth, MN	This database contains over 145,000 toxicity tests for more than 5,900 organic and inorganic chemicals and 2,900 aquatic species.
Soil Community	
Efroymson, R.A., M.E. Will, and G.W. Suter II. 1997a. Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision. Oak Ridge National Laboratory.	This document provides effects data for soil biota (i.e., microbial processes and earthworms). Approximately 35 constituents have proposed soil criteria, and some field studies are included.
CCME (Canadian Council of Ministers of the Environment), 1997. Recommended Canadian Soil Quality Guidelines.	The criteria developed by the CCME are concentrations above which effects are likely to be observed.
Sediment Community	
U.S. EPA. 1993b. *Technical Basis for Deriving Sediment Quality Criteria for Nonionic Organic Contaminants for the Protection of Benthic Organisms by Using Equilibrium Partitioning*.	This document supplies toxicological criteria for nonionic hydrophobic organic chemicals using FCVs (final chronic values) and SCVs (secondary chronic values) developed for surface water (Sediment Quality Criteria, SQC). The criteria are estimated based on the assumption that the partitioning of the constituent between sediment organic carbon and pore water is at equilibrium.
Long and Morgan. 1991. *The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program*. National Oceanic and Atmospheric Administration (NOAA) Technical Memorandum. Update: (Long et al., 1995)	Field measured sediment concentrations are correlated with impacts to sediment biota in estuarine environments. Measures of abundance, mortality, and species composition are the primary toxicity endpoints.
Jones, D.S., G.W. Sutter III, and R.N. Hall. 1997. *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1997 Revision.* Oak Ridge National Laboratory.	This document proposes sediment criteria for both organic and inorganic constituents using both field and estimation methodologies.
MacDonald, D.D. 1994. Approach to the Assessment of Sediment Quality in Florida Coastal Waters. Florida Department of Environmental Protection (FDEP), Tallahassee.	This approach applies statistical derivation methods to determine sediment criteria using NOAA data. The resulting criteria are more conservative than NOAA values.
Amphibians	
Power, T., K.L. Clark, A. Harfenist, and D.B. Peakall. 1989. *A Review and Evaluation of the Amphibian Toxicological Literature*. Technical Report Series No. 61, Canadian Wildlife Service.	This reference was developed by Environment Canada to review the ecotoxicity literature so that risks to amphibian populations could be evaluated.
U.S. EPA. 1996b. *Amphibian Toxicity Data for Water Quality Criteria Chemicals*. EPA/600/R-96/124. National Health Environmental Effects Research Laboratory, Corvallis, OR.	This reference was developed by EPA to evaluate the primary literature available on amphibians in an effort to include more amphibian data into the development NAWQC under the data requirement for species in phylum Chordata.

Integrated Risk Information System (IRIS) (U.S. EPA, 1997). Each method uses a hierarchy for the selection of toxicity data and extrapolates from a test species to the species of interest. However, there are fundamental differences in the goals of noncancer risk assessments for humans and ecological receptors. Risk assessments of humans seek to protect the individual, while risk assessments of ecological receptors typically seek to protect populations or communities of important species (U.S. EPA, 1992). Consequently, appropriate benchmark studies for mammals and birds were identified using some points of evaluation which are bulleted below. The chemical-specific studies selected based on these data criteria are presented in Tables 5 and 6.

- **Toxicity Endpoints:** Because population viability in mammals and birds was selected as the assessment endpoint, the benchmarks were developed from no effects endpoints of reproductive/developmental success or, if unavailable, other effects that could conceivably impair population dynamics. Toxicity endpoints indicating doses corresponding to no observed adverse effects levels (NOAELs) or low observed adverse effects levels (LOAELs) were preferred.

- **Methods:** No specific test methodologies were required in studies; however, appropriate standard laboratory practices such as control dose groups needed to be documented in the paper for the study to be acceptable for CSCL derivation.

- **Receptor Requirements:** Laboratory surrogate species should be species that easily extrapolate to wildlife receptors. Typically, studies exposing rats and mice were used as benchmark studies for mammals, and chickens or quail represent typical surrogate species for birds. Toxicity studies conducted on wildlife species likely to occur in an ecological setting were chosen if available (e.g., mallards or mink).

- **Durations:** Study were selected that exposed surrogate species over chronic or subchronic durations extending (1) over a large percentage of the test species' lifetime, (2) over multiple generations, or (3) over a particularly sensitive lifestage of a species.

- **Exposure Routes:** Studies indicating oral exposures (e.g., dietary, gavage) were used if available. Mammals and birds in the field are typically more highly exposed through ingestion of contaminated prey than through inhalation or direct contact.

For many constituents, sufficient data were not available or the identified data did not meet the data standard requirements for CSCL development outlined above. In these cases, risk was not evaluated for these constituents. Given that literature searches were abbreviated by constraints of time, a more in-depth literature review would likely fill some of the outstanding data gaps.

Table 5. Studies Used to Develop Dose Benchmarks for Mammals (ID = insufficient data available)

CAS Number	Chemical Name	NOAEL (mg/kg-day)	Test Species Body Weight (kg)	Test Species	Sex	Reference
67-64-1	Acetone	ID	ID	ID	ID	ID
107-05-1	Allyl chloride	ID	ID	ID	ID	ID
7429-90-5	Aluminum	1.9e+00	3.0e-02	Mouse	Female	Sample et al., 1996
7440-38-2	Arsenic	4.6e+00	4.4e-01	Rat	Both	Byron et al., 1967
7440-39-3	Barium	ID	ID	ID	ID	ID
65-85-0	Benzoic acid	ID	ID	ID	ID	ID
111-44-4	Bis (2-chloroethyl) ether	ID	ID	ID	ID	ID
117-81-7	Bis(2-ethylhexyl) phthalate	7.0e+01	3.0e-02	Mice	Female	Shiota and Nishimura, 1982
7440-43-9	Cadmium	1.0e+00	4.6e-01	Rat	Both	Sutou et al., 1980
75-15-0	Carbon disulfide	ID	ID	ID	ID	ID
67-66-3	Chloroform	1.5e+01	3.5e-01	Rat	Both	Sample et al., 1996
7440-47-3	Chromium	ID	ID	ID	ID	ID
16065-83-1	Chromium III (insoluble salts)	2.7e+03	3.5e-01	Rat	Both	Sample et al., 1996
18540-29-9	Chromium VI	3.3e+00	2.3e-02	Mouse	Male	Zahid et al., 1990
7440-48-4	Cobalt	ID	ID	ID	ID	ID
7440-50-8	Copper	6.2e+00	7.5e-01	Mink	Female	Aulerich et al., 1982
107-06-2	Dichloroethane, 1,2-	5.0e+01	3.5e-02	Mouse	Female	Sample et al., 1996
118-74-1	Hexachlorobenzene	1.5e+00	4.6e-01	Sprague-Dawley Rat	Female	Grant, 1977
7439-92-1	Lead	5.0e-03	4.7e-01	Rat	Male	Krasovskii et al., 1979
7439-96-5	Manganese	8.8e+01	3.5e-01	Rat	Female	Sample et al., 1996
78-93-3	Methyl ethyl ketone	1.8e+03	3.5e-01	Rat	Female	Sample et al., 1996
75-09-2	Methylene chloride	ID	ID	ID	ID	ID
7439-98-7	Molybdenum	9.0e-01	1.1e-01	Rat	Female	Fungwe et al., 1990
7440-02-0	Nickel	5.4e+01	1.5e-01	Rat	Both	Ambrose et al., 1976
1746-01-6	TCDD 2,3,7,8- (TEQ)	1.0e-06	3.5e-01	Sprague-Dawley Rat	Both	Murray et al., 1979
127-18-4	Tetrachloroethylene	ID	ID	ID	ID	ID
79-01-6	Trichloroethylene	7.0e-01	3.0e-02	Mouse	Both	Sample et al., 1996
7440-62-2	Vanadium	5.0e-01	3.4e-01	Rat	Female	Domingo et al., 1986

(continued)

Table 5. (continued)

CAS Number	Chemical Name	NOAEL (mg/kg-day)	Test Species Body Weight (kg)	Test Species	Sex	Reference
108-05-4	Vinyl acetate	ID	ID	ID	ID	ID
75-01-4	Vinyl chloride	1.7e-01	3.5e-01	rat	Both	Sample et al., 1996
7440-66-6	Zinc	2.0e+02	1.7e-01	Rat	Female	Schlicker and Cox, 1968

Table 6. Studies Used to Develop Dose Benchmarks for Birds (ID = insufficient data available)

CAS Number	Chemical Name	NOAEL (mg/kg-day)	Test Species Body Weight (kg)	Test Species	Sex	Reference
67-64-1	Acetone	ID	ID	ID	ID	ID
107-05-1	Allyl chloride	ID	ID	ID	ID	ID
7429-90-5	Aluminum	1.1e+02	1.6e-01	Ringed dove	Both	Sample et al., 1996
7440-38-2	Arsenic	5.7e-03	1.0e+00	Mallard	Female	Stanley et al., 1994
7440-39-3	Barium	2.1e+01	1.2e-01	Chicken	Female	Johnson et al., 1960
65-85-0	Benzoic Acid	ID	ID	ID	ID	ID
111-44-4	Bis (2-chloroethyl) ether	ID	ID	ID	ID	ID
117-81-7	Bis(2-ethylhexyl) phthalate	1.1e+00	1.6e-01	Ringed Dove	Both	Sample et al., 1996
7440-43-9	Cadmium	1.4e+00	1.2e+00	Mallard	Both	White and Finley, 1978
75-15-0	Carbon disulfide	ID	ID	ID	ID	ID
67-66-3	Chloroform	ID	ID	ID	ID	ID
7440-47-3	Chromium	ID	ID	ID	ID	ID
16065-83-1	Chromium III (insoluble salts)	1.0e+00	1.3e+00	Duck	Both	Sample et al., 1996
18540-29-9	Chromium VI	ID	ID	ID	ID	ID
7440-48-4	Cobalt	ID	ID	ID	ID	ID
7440-50-8	Copper	4.7e+01	5.3e-01	Chick	Both	Sample et al., 1996
107-06-2	Dichloroethane, 1,2-	1.7e+01	1.6e+00	Chicken	Female	Sample et al., 1996
118-74-1	Hexachlorobenzene	6.0e-01	1.3e-01	Japanese Quail	Female	Vos et al., 1971
7439-92-1	Lead	2.1e-02	1.5e-01	Quail	Female	Eden and Garlich, 1983

(continued)

Table 6. (continued)

CAS Number	Chemical Name	NOAEL (mg/kg-day)	Test Species Body Weight (kg)	Test Species	Sex	Reference
7439-96-5	Manganese	ID	ID	ID	ID	ID
78-93-3	Methyl ethyl ketone	ID	ID	ID	ID	ID
75-09-2	Methylene chloride	ID	ID	ID	ID	ID
7439-98-7	Molybdenum	3.5e+00	1.4e-01	Chicken	Both	Sample et al., 1996
7440-02-0	Nickel	7.7e+01	7.8e-01	Mallard	Both	Sample et al., 1996
1746-01-6	TCDD 2,3,7,8- (TEQ)	1.4e-05	9.0e-01	Pheasant	Female	Nosek et al., 1992
127-18-4	Tetrachloroethylene	ID	ID	ID	ID	ID
79-01-6	Trichloroethylene	ID	ID	ID	ID	ID
7440-62-2	Vanadium	1.5e+00	4.9e-01	Chicken	Male	Romoser et al., 1961
108-05-4	Vinyl acetate	ID	ID	ID	ID	ID
75-01-4	Vinyl chloride	ID	ID	ID	ID	ID
7440-66-6	Zinc	1.1e+01	1.9e+00	Hen	Female	Sample et al., 1996

Step 2: Scale Benchmark

The benchmark studies selected for mammals under laboratory exposure conditions can be extrapolated to other mammalian species by the cross-species scaling equation (Sample et al., 1996) (Equation 1). This is the default methodology EPA proposed for carcinogenicity assessments and reportable quantity documents for adjusting animal data to an equivalent human dose (57 FR 24152).

For avian species, new research suggests that the cross-species scaling equation used mammals is not appropriate (Mineau et al., 1996). Mineau et al. (1996) used a database that characterized acute toxicity of pesticides to avian receptors of various body weights. The results of the regression analysis revealed that applying mammalian scaling equations may not predict sufficiently protective doses for avian species. Mineau et al. (1996) suggested that a scaling factor of 1 provides a better dose estimate for birds. This recommendation was applied for avian receptors in this assessment (Equation 2).

For mammals,

$$Benchmark_w = NOAEL_t \, x \left(\frac{bw_t}{bw_w} \right)^{1/4} \tag{1}$$

For birds,

$$Benchmark_w = NOAEL_t \, x \left(\frac{bw_t}{bw_w} \right)^0 \qquad (2)$$

where

$Benchmark_w$	=	scaled benchmark for wildlife species (mg/kg-d) (Table 7)
$NOAEL_t$	=	no-observed-adverse-effects level for test species (mg/kg-d) (Tables 5 and 6)
bw_t	=	body weight of test species (kg) (Tables 5 and 6)
bw_w	=	body weight of representative wildlife species (kg) (Table 8 and 9) (corresponding to the sex of the test species).

Table 6 presents the results of the scaled benchmark equations for mammals. Avian benchmarks are equal to the NOAELs which are reported in Table 6. Tables 7.1 and 7.2 present body weights of wildlife species used in calculating the scaled benchmarks for mammals. The body weights of test species are provided in Tables 5 and 6.

Table 7. Scaled Benchmarks for Representative Mammals in Freshwater and Terrestrial Ecosystems (mg/kg-day)

CAS Number	Chemical Name	Mink	River Otter	Short-tailed Shrew	Deer Mouse	Meadow Vole	Eastern Cottontail	Red Fox	Raccoon	White-tailed Deer
67-64-1	Acetone	ID	ID	ID	ID	ID	ID	ID	ID	ID
107-05-1	Allyl chloride	ID	ID	ID	ID	ID	ID	ID	ID	ID
7429-90-5	Aluminum	8.8e-01	4.9e-01	2.2e+00	2.2e+00	1.8e+00	7.6e-01	5.7e-01	5.5e-01	2.7e-01
7440-38-2	Arsenic	3.7e+00	2.2e+00	1.0e+01	1.0e+01	8.8e+00	3.6e+00	2.6e+00	2.4e+00	1.2e+00
7440-39-3	Barium	ID	ID	ID	ID	ID	ID	ID	ID	ID
65-85-0	Benzoic acid	ID	ID	ID	ID	ID	ID	ID	ID	ID
111-44-4	Bis (2-chloroethyl) ether	ID	ID	ID	ID	ID	ID	ID	ID	ID
117-81-7	Bis(2-ethylhexyl) phthalate	3.2e+01	1.8e+01	8.1e+01	7.9e+01	6.6e+01	2.8e+01	2.1e+01	2.0e+01	9.9e+00
7440-43-9	Cadmium	8.2e-01	4.9e-01	2.3e+00	2.2e+00	1.9e+00	7.8e-01	5.6e-01	5.4e-01	2.7e-01
75-15-0	Carbon disulfide	ID	ID	ID	ID	ID	ID	ID	ID	ID
67-66-3	Chloroform	1.1e+01	6.9e+00	3.2e+01	3.1e+01	2.7e+01	1.1e+01	7.9e+00	7.5e+00	3.8e+00
7440-47-3	Chromium	ID	ID	ID	ID	ID	ID	ID	ID	ID
16065-83-1	Chromium III (insoluble salts)	2.1e+03	1.3e+03	5.8e+03	5.7e+03	4.9e+03	2.0e+03	1.4e+03	1.4e+03	6.9e+02
18540-29-9	Chromium VI	1.2e+00	7.5e-01	3.5e+00	3.4e+00	2.9e+00	1.2e+00	8.6e-01	8.1e-01	4.0e-01
7440-48-4	Cobalt	ID	ID	ID	ID	ID	ID	ID	ID	ID
7440-50-8	Copper	6.3e+00	3.5e+00	1.6e+01	1.6e+01	1.3e+01	5.5e+00	4.1e+00	3.9e+00	2.0e+00
107-06-2	Dichloroethane, 1,2-	2.4e+01	1.3e+01	6.0e+01	5.9e+01	4.9e+01	2.1e+01	1.5e+01	1.5e+01	7.3e+00
118-74-1	Hexachlorobenzene	1.3e+00	7.3e-01	3.3e+00	3.3e+00	2.7e+00	1.1e+00	8.5e-01	8.2e-01	4.1e-01
7439-92-1	Lead	3.9e-03	2.4e-03	1.1e-02	1.1e-02	9.1e-03	4.0e-03	2.8e-03	2.6e-03	1.3e-03
7439-96-5	Manganese	7.4e+01	4.1e+01	1.9e+02	1.8e+02	1.5e+02	6.4e+01	4.8e+01	4.6e+01	2.3e+01
78-93-3	Methyl ethyl ketone	1.5e+03	8.3e+02	3.8e+03	3.7e+03	3.1e+03	1.3e+03	9.6e+02	9.2e+02	4.6e+02

(continued)

Table 7. (continued)

CAS Number	Chemical Name	Mink	River Otter	Short-tailed Shrew	Deer Mouse	Meadow Vole	Eastern Cottontail	Red Fox	Raccoon	White-tailed Deer
75-09-2	Methylene chloride	ID	ID	ID	ID	ID	ID	ID	ID	ID
7439-98-7	Molybdenum	5.6e-01	3.1e-01	1.4e+00	1.4e+00	1.2e+00	4.9e-01	3.6e-01	3.5e-01	0.174141
7440-02-0	Nickel	3.3e+01	2.0e+01	9.2e+01	8.9e+01	7.8e+01	3.2e+01	2.3e+01	2.2e+01	10.93085
1746-01-6	TCDD 2,3,7,8- (TEQ)	7.7e-07	4.6e-07	2.1e-06	2.1e-06	1.8e-06	7.3e-07	5.3e-07	5.0e-07	2.5e-07
127-18-4	Tetrachloroethylene	ID	ID	ID	ID	ID	ID	ID	ID	ID
79-01-6	Trichloroethylene	2.9e-01	1.7e-01	8.1e-01	7.8e-01	6.8e-01	2.8e-01	2.0e-01	1.9e-01	0.095945
7440-62-2	Vanadium	4.2e-01	2.3e-01	1.1e+00	1.0e+00	8.6e-01	3.6e-01	2.7e-01	2.6e-01	1.3e-01
108-05-4	Vinyl acetate	ID	ID	ID	ID	ID	ID	ID	ID	ID
75-01-4	Vinyl chloride	1.3e-01	7.8e-02	3.6e-01	3.5e-01	3.1e-01	1.2e-01	9.0e-02	8.5e-02	4.3e-02
7440-66-6	Zinc	1.4e+02	7.9e+01	3.6e+02	3.5e+02	2.9e+02	1.2e+02	9.1e+01	8.8e+01	4.4e+01

Note: Avian benchmarks were scaled using a factor of 1, therefore, they are equivalent to the NOAEL for all representative receptors.

Table 8. Life History Parameters for Representative Terrestrial Receptors

	Representative Species	Body Weight (kg)	Soil Intake: % of diet	Soil Intake: kg/d	Food Intake (kg/d)	Dietary Consumption (% volume)
Mammals	**Short-tailed shrew**					13% plants 31% earthworms 39% invertebrates
	female	0.017	1	9.4E-05	0.0094	
	male	0.017	1	9.5E-05	0.0095	
	both	0.017	1	9.2E-05	0.0092	
	Deer mouse					44% plants 43% invertebrates
	female	0.019	2	7.1E-05	0.0035	
	male	0.020	2	8.8E-05	0.0044	
	both	0.019	2	7.4E-05	0.0037	
	Meadow vole					98% plants 2% invertebrates
	female	0.039	2.4	3.0E-04	0.013	
	male	0.043	2.4	3.3E-04	0.014	
	both	0.033	2.4	2.6E-04	0.011	
	Eastern cottontail					100% plants
	female	1.22	6.3	6.4E-03	0.10	
	male	1.13	6.3	6.0E-03	0.10	
	both	1.22	6.3	6.4E-03	0.10	
	Red fox					4% plants 96% vertebrates
	female	4.04	2.8	8.1E-03	0.29	
	male	5.04	2.8	1.0E-02	0.36	
	both	4.54	2.8	1.2E-02	0.43	
	Raccoon					29% plants 52% invertebrates 10% vertebrates
	female	4.71	9.4	2.3E-02	0.25	
	male	6.22	9.4	2.9E-02	0.31	
	both	5.62	9.4	2.7E-02	0.28	
	White-tailed deer					100% plants
	female	76.00	2	4.1E-02	2.04	
	male	110.00	2	5.3E-02	2.67	
	both	85.00	2	4.4E-02	2.21	
Birds	**Red-tailed hawk**					100% vertebrates
	female	1.20	1	1.3E-03	0.13	
	male	1.06	1	1.1E-03	0.11	
	both	1.13	1	1.1E-03	0.11	
	American kestrel					49% invertebrates 51% vertebrates
	female	0.13	1	3.7E-04	0.037	
	male	0.11	1	3.4E-04	0.034	
	both	0.12	1	3.6E-04	0.036	
	Northern bobwhite					87% plants 13% invertebrates
	female	0.17	9.3	1.2E-03	0.013	
	male	0.16	9.3	1.2E-03	0.013	
	both	0.17	9.3	1.3E-03	0.014	
	American robin					11% plants 89% invertebrates
	female	0.082	1	9.9E-04	0.10	
	male	0.082	1	9.9E-04	0.10	
	both	0.081	1	9.8E-04	0.10	
	American woodcock					(summer diet) 68% earthworms 11% plants 20% invertebrates
	female	0.20	10.4	1.6E-02	0.16	
	male	0.15	10.4	1.2E-02	0.12	
	both	0.17	10.4	1.3E-02	0.13	

Note: Unless otherwise indicated, all values are taken from U.S. EPA (1993a).

Table 9. Life History Parameters for Representative Piscivorous Species in the Freshwater Ecosystem

	Representative Species	Body Weight (kg)	Water Intake (L/d)	Food Intake (kg/d)	Dietary Consumption (% volume)
Mammals	**Mink**				
	female	0.70	0.05	0.11	100% fish (trophic level 3)
	male	1.34	0.13	0.21	
	both	1.02	0.081	0.16	
	River otter				
	female	7.32	0.60	1.18	100% fish (0.5 trophic level 3) (0.5 trophic level 4)
	male	8.67	0.69	1.35	
	both	7.99	0.65	1.26	
Birds	**Bald eagle**				
	female	4.50	0.16	0.54	100% fish (trophic level 4)
	male	3.00	0.11	0.36	
	both	3.75	0.14	0.45	
	Osprey				
	female	1.77	0.09	0.37	100% fish (trophic level 3)
	male	1.43	0.08	0.30	
	both	1.63	0.08	0.34	
	Great blue heron				
	female	2.20	0.10	0.40	100% fish (trophic level 4)
	male	2.58	0.12	0.46	
	both	2.34	0.11	0.42	
	Mallard				
	female	1.11	0.06	0.31	100% aquatic invertebrates (trophic level 2)
	male	1.24	0.07	0.33	
	both	1.16	0.07	0.32	
	Lesser scaup				
	female	0.73	0.05	0.24	100% aquatic invertebrates (trophic level 2)
	male	0.86	0.05	0.26	
	both	0.75	0.05	0.24	
	Kingfisher				
	female	0.15	0.02	0.07	100% fish (trophic level 3)
	male	0.15	0.02	0.07	
	both	0.15	0.02	0.07	
	Spotted sandpiper				
	female	0.05	0.01	0.03	100% aquatic invertebrates (trophic level 2)
	male	0.04	0.01	0.03	
	both	0.04	0.01	0.03	
	Herring gull				
	female	0.98	0.06	0.19	100% fish (trophic level 3)
	male	1.21	0.07	0.24	
	both	1.09	0.06	0.21	

Note: Unless otherwise indicated, all values are taken from U.S. EPA (1993a).

Step 3: Identify Uptake Factors

Movement of contaminants through the food web is the primary vector of exposure for mammals and birds. To derive a CSCL, estimates of chemical accumulation in the tissues of prey items are required. Uptake factors (e.g., bioaccumulation factors) of various prey items were the metrics used estimate exposures. The prey items for which uptake factors were required included fish and aquatic invertebrates for the freshwater ecosystem and terrestrial plants, soil invertebrates (e.g., earthworms), and small vertebrates for the terrestrial ecosystem. Uptake factors were either derived from measured exposures to prey items or calculated through empirical relationships based on chemical properties (e.g., log K_{ow}). Measured uptake factors were identified in the primary literature, EPA databases (e.g., AQUIRE), and other compendia and review sources (e.g., Oak Ridge National Laboratories). Estimated uptake factors for fish were calculated for organic constituents using Equation 3 (Lyman et al., 1982).

$$\log\ BCF = 0.76\ [\log\ (K_{ow})] - 0.23 \tag{3}$$

where

BCF = Estimated bioconcentration factor for fish
Kow = Chemical-specific octanol-water partition coefficient

The results of data collection efforts and calculated uptake factors are presented in Table 10 for the freshwater ecosystem and Table 11 for the terrestrial ecosystem. In many cases, data were not sufficient to quantify uptake into all prey items. In these instances, a default value of 1 was applied. For most prey items, the default is a conservative estimate of uptake which was appropriate for this screening assessment.

Step 4: Derive CSCL from Benchmark Doses

The CSCL concentrations were derived for freshwater and terrestrial receptor taxa using the same approach. Applying the data gathered in the previous steps, Equation 4 was used to generated CSCLs. The final CSCL concentrations generated from this methodology are presented in Table 12 for mammals and Table 13 for birds.

$$CSCL_w = \frac{Scaled\ benchmark_w \times bw_w}{I_w + I_f \sum (F_j \times BAF \times AB_j)} \tag{4}$$

where

$CSCL_w$ = protective CSCL for mammals and birds (Tables 12 and 13)
- # freshwater receptor units are in mg/L
- # terrestrial receptor units are in mg/kg soil

Scaled $benchmark_w$	=	benchmark dose for wildlife species (mg/kg-d) (Table 7)
bw_w	=	body weight of wildlife species (kg) (Tables 8 and 9)
I_w	=	intake rate of water (L/d) (Table 9) parameter dropped for terrestrial receptors
I_f	=	intake rate of food (kg/d) (Tables 8 and 9)
F_j	=	dietary fraction of prey species j (unitless) (Tables 8 and 9)
BAF	=	bioaccumulation factor in prey species (Tables 10 and 11)
AB_j	=	fraction absorbed in gut of predator (assumed to be 1)

Table 10. Bioaccumulation Factors for Prey Items of Representative Receptors in Generalized Freshwater Ecosystems

CAS Number	Chemical Name	Trophic Level 3 Fish	Source	Trophic Level 4 Fish	Source	Aquatic Invertebrates	Source
67-64-1	Acetone	3.9e-01	Sample et al., 1996	3.9e-01	Sample et al., 1996	**1.0e+00**	Default
107-05-1	Allyl chloride	7.4e+00	Sample et al., 1996	7.4e+00	Sample et al., 1996	**1.0e+00**	Default
7429-90-5	Aluminum	2.3e+02	Sample et al., 1996	2.3e+02	Sample et al., 1996	**1.0e+00**	Default
7440-38-2	Arsenic	3.5e+00	Stephan, 1993	3.5e+00	Stephan, 1993	**1.0e+00**	Default
7440-39-3	Barium	**1.0e+00**	Default	**1.0e+00**	Default	**1.0e+00**	Default
65-85-0	Benzoic acid	1.5e+01	Sample et al., 1996	1.5e+01	Sample et al., 1996	**1.0e+00**	Default
111-44-4	Bis(2-chloroethyl) ether	4.8e+00	Sample et al., 1996	4.8e+00	Sample et al., 1996	**1.0e+00**	Default
117-81-7	Bis(2-ethylhexyl) phthalate	3.6e+00	Sample et al., 1996	1.5e+01	Sample et al., 1996	3.3e-01	Sample et al., 1996
7440-43-9	Cadmium	2.7e+02	Barrows et al., 1980	2.7e+02	Barrows et al., 1980	**1.0e+00**	Default
75-15-0	Carbon disulfide	2.0e+01	Sample et al., 1996	2.0e+01	Sample et al., 1996	**1.0e+00**	Default
67-66-3	Chloroform	1.1e+02	Sample et al., 1996	1.1e+02	Sample et al., 1996	**1.0e+00**	Default
7440-47-3	Chromium	1.0e+00	Stephan, 1993	1.0e+00	Stephan, 1993	**1.0e+00**	Default
16065-83-1	Chromium III (insoluble salts)	1.0e+00	Stephan, 1993	1.0e+00	Stephan, 1993	**1.0e+00**	Default
18540-29-9	Chromium VI	3.0e+00	Sample et al., 1996	3.0e+00	Sample et al., 1996	**1.0e+00**	Default
7440-48-4	Cobalt	**1.0e+00**	Default	**1.0e+00**	Default	**1.0e+00**	Default
7440-50-8	Copper	2.9e+02	Sample et al., 1996	2.9e+02	Sample et al., 1996	**1.0e+00**	Default
107-06-2	Dichloroethane, 1,2-	7.7e+00	Sample et al., 1996	7.7e+00	Sample et al., 1996	**1.0e+00**	Default
118-74-1	Hexachlorobenzene	1.7e+05	Sample et al., 1996	2.5e+05	Sample et al., 1996	**1.0e+00**	Default

(continued)

Table 10. (continued)

CAS Number	Chemical Name	Trophic Level 3 Fish	Source	Trophic Level 4 Fish	Source	Aquatic Invertebrates	Source
7439-92-1	Lead	4.6e+01	Stephan, 1993	4.6e+01	Stephan, 1993	**1.0e+00**	Default
7439-96-5	Manganese	**1.0e+00**	Default	**1.0e+00**	Default	**1.0e+00**	Default
78-93-3	Methyl ethyl ketone	9.6e-01	Sample et al., 1996	9.6e-01	Sample et al., 1996	**1.0e+00**	Default
75-09-2	Methylene chloride	5.3e+00	Sample et al., 1996	5.3e+00	Sample et al., 1996	**1.0e+00**	Default
7439-98-7	Molybdenum	9.6e-01	AQUIRE, 1998; Eisler, 1989	9.6e-01	AQUIRE, 1998; Eisler, 1989	**1.0e+00**	Default
7440-02-0	Nickel	8.0e-01	Stephan, 1993	8.0e-01	Stephan, 1993	**1.0e+00**	Default
1746-01-6	TCDD 2,3,7,8- (TEQ)	1.7e+05	U.S. EPA, 1995b	2.6e+05	U.S. EPA, 1995b	**1.0e+00**	Default
127-18-4	Tetrachloroethylene	3.4e+00	Sample et al., 1996	3.4e+00	Sample et al., 1996	**1.0e+00**	Default
79-01-6	Trichloroethylene	4.6e+01	Sample et al., 1996	4.6e+01	Sample et al., 1996	7.1e+01	Sample et al., 1996
7440-62-2	Vanadium	8.2e+00	Holdway et al., 1983	8.2e+00	Holdway et al., 1983	**1.0e+00**	Default
108-05-4	Vinyl acetate	2.1e+00	Sample et al., 1996	2.1e+00	Sample et al., 1996	**1.0e+00**	Default
75-01-4	Vinyl chloride	8.1e+00	Sample et al., 1996	8.1e+00	Sample et al., 1996	**1.0e+00**	Default
7440-66-6	Zinc	4.4e+00	Murphy et al., 1978	4.4e+00	Murphy et al., 1978	**1.0e+00**	Default

Note: Bold numbers are default values and the shaded cells are measured values. All other numbers were calculated using Lyman et al. (1982) using the following relationship: log BCF = 0.76*log(Kow)-0.23.

Table 11. Bioaccumulation Factors for Prey Items of Representative Receptors in Generalized Terrestrial Ecosystems

CAS Number	Chemical Name	Invertebrates (including earthworms)	Source	Plants	Source	Vertebrates	Source
67-64-1	Acetone	**1.0e+00**	Default	**1.0e+00**	Default	**1.0e+00**	Default
107-05-1	Allyl chloride	**1.0e+00**	Default	**1.0e+00**	Default	**1.0e+00**	Default
7429-90-5	Aluminum	**1.0e+00**	Default	**1.0e+00**	Default	**1.0e+00**	Default
7440-38-2	Arsenic	5.2e-01	Sample et al., 1998b	1.2e+00	Sample et al., 1997	1.5e-02	Sample et al., 1998a
7440-39-3	Barium	**1.0e+00**	Default	**1.0e+00**	Default	1.1e-01	Sample et al., 1998a
65-85-0	Benzoic Acid	**1.0e+00**	Default	**1.0e+00**	Default	**1.0e+00**	Default
111-44-4	Bis(2-chloroethyl) ether	**1.0e+00**	Default	**1.0e+00**	Default	**1.0e+00**	Default
117-81-7	Bis(2-ethylhexyl) phthalate	**1.0e+00**	Default	**1.0e+00**	Default	**1.0e+00**	Default
7440-43-9	Cadmium	4.1e+01	Sample et al., 1998b	4.6e+00	Sample et al., 1997	4.0e+00	Sample et al., 1998a
75-15-0	Carbon disulfide	**1.0e+00**	Default	**1.0e+00**	Default	**1.0e+00**	Default
67-66-3	Chloroform	**1.0e+00**	Default	**1.0e+00**	Default	**1.0e+00**	Default
7440-47-3	Chromium	3.2e+00	Sample et al., 1998b	**1.0e+00**	Default	3.3e-01	Sample et al., 1998a
16065-83-1	Chromium III (insoluble salts)	3.2e+00	Sample et al., 1998b	**1.0e+00**	Default	3.3e-01	Sample et al., 1998a
18540-29-9	Chromium VI	3.2e+00	Sample et al., 1998b	**1.0e+00**	Default	3.3e-01	Sample et al., 1998a
7440-48-4	Cobalt	**1.0e+00**	Default	**1.0e+00**	Default	1.0e-01	Sample et al., 1998a
7440-50-8	Copper	1.5e+00	Sample et al., 1998b	1.5e+00	U.S. EPA, 1992	**1.0e+00**	Default
107-06-2	Dichloroethane, 1,2-	**1.0e+00**	Default	**1.0e+00**	Default	**1.0e+00**	Default
118-74-1	Hexachlorobenzene	**1.0e+00**	Default	**1.0e+00**	Default	**1.0e+00**	Default

(continued)

Table 11. (continued)

CAS Number	Chemical Name	Invertebrates (including earthworms)	Source	Plants	Source	Vertebrates	Source
7439-92-1	Lead	1.5e+00	Sample et al., 1998b	6.2e-01	Sample et al., 1997	2.9e-01	Sample et al., 1998a
7439-96-5	Manganese	**1.0e+00**	Default	**1.0e+00**	Default	**1.0e+00**	Default
78-93-3	Methyl ethyl ketone	**1.0e+00**	Default	**1.0e+00**	Default	**1.0e+00**	Default
75-09-2	Methylene chloride	**1.0e+00**	Default	**1.0e+00**	Default	**1.0e+00**	Default
7439-98-7	Molybdenum	**1.0e+00**	Default	**1.0e+00**	Default	**1.0e+00**	Default
7440-02-0	Nickel	4.7e+00	Sample et al., 1998b	1.7e+00	Sample et al., 1997	5.9e-01	Sample et al., 1998a
1746-01-6	TCDD 2,3,7,8- (TEQ)	3.4e+00	Sample et al., 1996	**1.0e+00**	Default	7.2e+00	Sample et al.,, 1996
127-18-4	Tetrachloroethylene	**1.0e+00**	Default	**1.0e+00**	Default	**1.0e+00**	Default
79-01-6	Trichloroethylene	**1.0e+00**	Default	**1.0e+00**	Default	**1.0e+00**	Default
7440-62-2	Vanadium	**1.0e+00**	Default	**1.0e+00**	Default	**1.0e+00**	Default
108-05-4	Vinyl acetate	**1.0e+00**	Default	**1.0e+00**	Default	**1.0e+00**	Default
75-01-4	Vinyl chloride	**1.0e+00**	Default	**1.0e+00**	Default	**1.0e+00**	Default
7440-66-6	Zinc	1.3e+01	Sample et al., 1998b	2.8e+00	U.S. EPA, 1992	2.7e+00	Sample et al., 1998a

Note: Bold numbers are default values and the shaded cells are measured values. All other numbers were calculated using Lyman et al. (1982) using the following relationship: log BCF = 0.76*log(Kow)-0.23.

Table 12. Calculated CSCLs for Representative Mammalian Receptors in Freshwater (mg/L) and Terrestrial Ecosystems (mg/kg soil)

CAS Number	Chemical Name	Freshwater		Terrestrial						
		Mink	River Otter	Short-tailed Shrew	Deer Mouse	Meadow Vole	Eastern Cottontail	Red Fox	Raccoon	White-tailed Deer
67-64-1	Acetone	ID	ID	ID	ID	ID	ID	ID	ID	ID
107-05-1	Allyl chloride	ID	ID	ID	ID	ID	ID	ID	ID	ID
7429-90-5	Aluminum	2.4e-02	1.3e-02	5.0e+00	1.3e+01	5.4e+00	9.3e+00	6.0e+00	1.2e+01	1.0e+01
7440-38-2	Arsenic	6.0e+00	3.6e+00	3.7e+01	6.9e+01	2.2e+01	3.6e+01	4.9e+01	7.9e+01	4.0e+01
7440-39-3	Barium	ID	ID	ID	ID	ID	ID	ID	ID	ID
65-85-0	Benzoic Acid	ID	ID	ID	ID	ID	ID	ID	ID	ID
111-44-4	Bis (2-chloroethyl) ether	ID	ID	ID	ID	ID	ID	ID	ID	ID
117-81-7	Bis(2-ethylhexyl) phthalate	5.0e+01	1.1e+01	1.8e+02	4.7e+02	2.0e+02	3.4e+02	2.2e+02	4.4e+02	3.8e+02
7440-43-9	Cadmium	2.0e-02	1.2e-02	1.4e-01	5.8e-01	1.1e+00	2.1e+00	1.5e-01	4.7e-01	2.3e+00
75-15-0	Carbon disulfide	ID	ID	ID	ID	ID	ID	ID	ID	ID
67-66-3	Chloroform	6.6e-01	3.9e-01	7.1e+01	1.8e+02	8.1e+01	1.3e+02	8.3e+01	1.7e+02	1.5e+02
7440-47-3	Chromium	ID	ID	ID	ID	ID	ID	ID	ID	ID
16065-83-1	Chromium III (insoluble salts)	8.9e+03	5.2e+03	4.5e+03	1.6e+04	1.4e+04	2.4e+04	4.9e+03	1.4e+04	2.7e+04
18540-29-9	Chromium VI	2.2e+00	1.4e+00	2.8e+00	9.7e+00	8.3e+00	1.5e+01	2.9e+00	8.2e+00	1.5e+01
7440-48-4	Cobalt	ID	ID	ID	ID	ID	ID	ID	ID	ID
7440-50-8	Copper	1.4e-01	7.6e-02	2.4e+01	6.1e+01	2.6e+01	4.5e+01	2.9e+01	6.0e+01	5.0e+01
107-06-2	Dichloroethane, 1,2-	1.8e+01	1.0e+01	1.3e+02	3.5e+02	1.5e+02	2.5e+02	1.6e+02	3.2e+02	2.8e+02

(continued)

Table 12. (continued)

CAS Number	Chemical Name	Freshwater		Terrestrial						
		Mink	River Otter	Short-tailed Shrew	Deer Mouse	Meadow Vole	Eastern Cottontail	Red Fox	Raccoon	White-tailed Deer
118-74-1	Hexachlorobenzene	4.9e-05	2.2e-05	7.4e+00	1.9e+01	8.1e+00	1.4e+01	8.9e+00	1.8e+01	1.6e+01
7439-92-1	Lead	5.3e-04	3.3e-04	1.9e-02	6.2e-02	4.3e-02	7.9e-02	2.0e-02	5.3e-02	7.9e-02
7439-96-5	Manganese	3.1e+02	1.7e+02	4.2e+02	1.1e+03	4.6e+02	7.9e+02	5.0e+02	1.0e+03	8.8e+02
78-93-3	Methyl ethyl ketone	6.5e+03	3.6e+03	8.4e+03	2.2e+04	9.2e+03	1.6e+04	1.0e+04	2.0e+04	1.8e+04
75-09-2	Methylene chloride	ID	ID	ID	ID	ID	ID	ID	ID	ID
7439-98-7	Molybdenum	2.4e+00	1.3e+00	3.2e+00	8.2e+00	3.5e+00	6.0e+00	3.8e+00	7.7e+00	6.7e+00
7440-02-0	Nickel	1.6e+02	9.5e+01	4.8e+01	1.7e+02	1.3e+02	2.3e+02	5.2e+01	1.4e+02	2.5e+02
1746-01-6	TCDD 2,3,7,8- (TEQ)	2.8e-11	1.3e-11	1.6e-06	7.2e-06	7.9e-05	8.9e-06	1.7e-06	4.0e-06	9.7e-06
127-18-4	Tetrachloroethylene	ID	ID	ID	ID	ID	ID	ID	ID	ID
79-01-6	Trichloroethylene	4.0e-02	2.4e-02	1.8e+00	4.6e+00	2.1e+00	3.4e+00	2.1e+00	4.2e+00	3.7e+00
7440-62-2	Vanadium	3.0e-01	1.7e-01	2.4e+00	6.1e+00	2.6e+00	4.4e+00	2.8e+00	5.7e+00	5.0e+00
108-05-4	Vinyl acetate	ID	ID	ID	ID	ID	ID	ID	ID	ID
75-01-4	Vinyl chloride	9.6e-02	5.7e-02	8.1e-01	2.1e+00	9.2e-01	1.5e+00	9.5e-01	1.9e+00	1.7e+00
7440-66-6	Zinc	1.8e+02	1.0e+02	7.0e+01	2.6e+02	2.9e+02	5.4e+02	7.6e+01	2.2e+02	6.0e+02

Table 13. Calculated CSCLs for Representative Avian Receptors in Freshwater and Terrestrial Ecosystems (mg/L water and mg/kg soil)

CAS Number	Chemical Name	Bald Eagle	Osprey	Great Blue Heron	Mallard	Lesser Scaup	Kingfisher	Spotted Sandpiper	Herring Gull
67-64-1	Acetone77	ID	ID	ID	ID	ID	ID	ID	ID
107-05-1	Allyl chloride	ID	ID	ID	ID	ID	ID	ID	ID
7429-90-5	Aluminum	4.0e+00	2.3e+00	2.6e+00	3.3e+02	2.8e+02	1.0e+00	1.2e+02	2.5e+00
7440-38-2	Arsenic	1.3e-02	7.4e-03	8.5e-03	1.7e-02	1.5e-02	3.2e-03	6.1e-03	7.9e-03
7440-39-3	Barium	1.3e+02	8.1e+01	9.3e+01	6.3e+01	5.4e+01	3.4e+01	2.2e+01	8.5e+01
65-85-0	Benzoic acid	ID	ID	ID	ID	ID	ID	ID	ID
111-44-4	Bis (2-chloroethyl) ether	ID	ID	ID	ID	ID	ID	ID	ID
117-81-7	Bis(2-ethylhexyl) phthalate	5.8e-01	1.4e+00	3.9e-01	7.3e+00	6.4e+00	6.0e-01	2.3e+00	1.5e+00
7440-43-9	Cadmium	4.4e-02	2.5e-02	2.9e-02	4.2e+00	3.6e+00	1.1e-02	1.5e+00	2.7e-02
75-15-0	Carbon disulfide	ID	ID	ID	ID	ID	ID	ID	ID
67-66-3	Chloroform	ID	ID	ID	ID	ID	ID	ID	ID
7440-47-3	Chromium	ID	ID	ID	ID	ID	ID	ID	ID
16065-83-1	Chromium III (insoluble salts)	6.4e+00	3.9e+00	4.4e+00	3.0e+00	2.6e+00	1.6e+00	1.1e+00	4.0e+00
18540-29-9	Chromium VI	ID	ID	ID	ID	ID	ID	ID	ID
7440-48-4	Cobalt	ID	ID	ID	ID	ID	ID	ID	ID
7440-50-8	Copper	1.3e+00	7.8e-01	9.0e-01	1.4e+02	1.2e+02	3.4e-01	5.0e+01	8.4e-01
107-06-2	Dichloroethane, 1,2-	1.8e+01	1.0e+01	1.2e+01	5.1e+01	4.4e+01	4.5e+00	1.8e+01	1.1e+01
118-74-1	Hexachlorobenzene	2.0e-05	1.7e-05	1.4e-05	1.8e+00	1.6e+00	7.3e-06	6.4e-01	1.8e-05

(continued)

Table 13. (continued)

CAS Number	Chemical Name	Bald Eagle	Osprey	Great Blue Heron	Mallard	Lesser Scaup	Kingfisher	Spotted Sandpiper	Herring Gull
7439-92-1	Lead	3.8e-03	2.2e-03	2.5e-03	6.3e-02	5.4e-02	9.6e-04	2.2e-02	2.4e-03
7439-96-5	Manganese	ID	ID	ID	ID	ID	ID	ID	ID
78-93-3	Methyl ethyl ketone	ID	ID	ID	ID	ID	ID	ID	ID
75-09-2	Methylene chloride	ID	ID	ID	ID	ID	ID	ID	ID
7439-98-7	Molybdenum	2.3e+01	1.4e+01	1.6e+01	1.1e+01	9.1e+00	6.0e+00	3.8e+00	1.5e+01
7440-02-0	Nickel	5.8e+02	3.6e+02	4.1e+02	2.3e+02	2.0e+02	1.5e+02	8.2e+01	3.7e+02
1746-01-6	TCDD 2,3,7,8- (TEQ)	4.4e-10	3.9e-10	3.0e-10	2.3e-04	2.1e-04	1.7e-10	6.0e-05	4.2e-10
127-18-4	Tetrachloroethylene	ID	ID	ID	ID	ID	ID	ID	ID
79-01-6	Trichloroethylene	ID	ID	ID	ID	ID	ID	ID	ID
7440-62-2	Vanadium	1.5e+00	8.5e-01	9.8e-01	4.5e+00	3.9e+00	3.7e-01	1.6e+00	9.1e-01
108-05-4	Vinyl acetate	ID	ID	ID	ID	ID	ID	ID	ID
75-01-4	Vinyl chloride	ID	ID	ID	ID	ID	ID	ID	ID
7440-66-6	Zinc	1.9e+01	1.1e+01	1.3e+01	3.3e+01	2.8e+01	4.9e+00	1.2e+01	1.2e+01

Table 13. Calculated CSCLs for Representative Avian Receptors in Freshwater and Terrestrial Ecosystems (mg/L water and mg/kg soil)

CAS Number	Chemical Name	Red-tailed Hawk	American Kestrel	Northern Bobwhite	American Robin	American Woodcock
67-64-1	Acetone	ID	ID	ID	ID	ID
107-05-1	Allyl chloride	ID	ID	ID	ID	ID
7429-90-5	Aluminum	1.1e+03	3.6e+02	1.4e+03	8.9e+01	1.4e+02
7440-38-2	Arsenic	3.9e+00	7.2e-02	6.4e-02	7.8e-03	1.3e-02
7440-39-3	Barium	2.0e+03	1.3e+02	2.6e+02	1.7e+01	2.8e+01
65-85-0	Benzoic acid	ID	ID	ID	ID	ID
111-44-4	Bis (2-chloroethyl) ether	ID	ID	ID	ID	ID
117-81-7	Bis(2-ethylhexyl) phthalate	1.1e+01	3.6e+00	1.4e+01	8.9e-01	1.4e+00
7440-43-9	Cadmium	3.6e+00	2.1e-01	1.9e+00	3.1e-02	5.0e-02
75-15-0	Carbon disulfide	ID	ID	ID	ID	ID
67-66-3	Chloroform	ID	ID	ID	ID	ID
7440-47-3	Chromium	ID	ID	ID	ID	ID
16065-83-1	Chromium III (insoluble salts)	3.1e+01	1.9e+00	9.6e+00	2.7e-01	4.4e-01
18540-29-9	Chromium VI	ID	ID	ID	ID	ID
7440-48-4	Cobalt	ID	ID	ID	ID	ID
7440-50-8	Copper	4.8e+02	1.2e+02	3.9e+02	2.5e+01	4.1e+01
107-06-2	Dichloroethane, 1,2-	1.8e+02	5.7e+01	2.1e+02	1.4e+01	2.3e+01
118-74-1	Hexachlorobenzene	6.2e+00	2.0e+00	7.4e+00	4.9e-01	7.9e-01
7439-92-1	Lead	7.5e-01	7.9e-02	3.5e-01	1.2e-02	2.0e-02
7439-96-5	Manganese	ID	ID	ID	ID	ID
78-93-3	Methyl ethyl ketone	ID	ID	ID	ID	ID
75-09-2	Methylene chloride	ID	ID	ID	ID	ID
7439-98-7	Molybdenum	3.6e+01	1.2e+01	4.4e+01	2.9e+00	4.6e+00
7440-02-0	Nickel	1.4e+03	9.8e+01	4.6e+02	1.4e+01	2.3e+01
1746-01-6	TCDD 2,3,7,8- (TEQ)	2.0e-05	8.7e-06	3.9e-04	3.7e-06	6.0e-06
127-18-4	Tetrachloroethylene	ID	ID	ID	ID	ID
79-01-6	Trichloroethylene	ID	ID	ID	ID	ID
7440-62-2	Vanadium	1.5e+01	4.9e+00	1.9e+01	1.2e+00	2.0e+00
108-05-4	Vinyl acetate	ID	ID	ID	ID	ID
75-01-4	Vinyl chloride	ID	ID	ID	ID	ID
7440-66-6	Zinc	4.2e+01	4.7e+00	3.3e+01	7.5e-01	1.2e+00

Note: ID - Insufficient Data.

Community Receptor Taxa

Various methods were applied in developing CSCLs for receptor taxa other than birds and mammals assessed in this analysis. The remaining CSCL derivation methods are detailed individually in the following section. The final community CSCLs are presented in Table 14.

Freshwater Community

The CSCLs developed for the freshwater community were derived to reflect both total water and dissolved water concentrations of the constituent. Dissolved concentrations of chemicals are primarily an issue of concern when assessing the potential risk associated with metals. There is strong evidence that dissolved concentrations reflect the more bioavailable portion of constituent in the water column. When available, the EPA supports the use of dissolved concentrations over total concentrations.

Total Surface Water Concentrations

For populations of the freshwater community (e.g., fish, aquatic invertebrates), the final chronic value (FCV) developed for NAWQC or the continuous chronic criterion (CCC) developed for the Great Lakes Water Quality Initiative (GLWQI) were the preferred metrics to use for this analysis (U.S. EPA, 1995a, 1996a). If an FCV was unavailable or could not be calculated from available data, a secondary chronic value (SCV) was estimated using Tier II methods developed through the Great Lakes Initiative (Stephan et al., 1985; Suter and Tsao, 1996; RTI, 1995a, 1995b).

Surface water CSCLs were derived from ecotoxicity data reporting effects to survival, growth, and reproduction in aquatic biota. The NAWQC methods utilize a list of data requirements that consist of eight taxonomic families that represent typical freshwater species (see text box). Depending on how well the eight taxonomic families are represented by the toxicity data influences whether an FCV or SCV can be calculated. A brief overview of the derivation methodology is provided; however, it is important to note that this description is a simplification of the actual methods and does not address many of the nuances of study selection and data interpretation. For a complete review of calculation methods, refer to Stephan et al. (1985).

Data Requirements for FCV Calculation

- The family Salmonidae in the class *Osteichthyes*
- One other family (preferably a commercially or recreationally important warmwater species) in the class Osteichthyes (e.g., bluegill, channel catfish)
- A third family in the phylum *Chordata* (e.g., fish, amphibian)
- A planktonic crustacean (e.g., a cladoceran, copepod)
- A benthic crustacean (e.g., ostracod, isopod, amphipod)
- An insect (e.g., mayfly, dragonfly, damselfly, stonefly, midge)
- A family in a phylum other than Arthropoda or Chordata (e.g., *Rotifera, Annelida, Mollusca*)
- A family in any order of insect or any phylum not already presented

Table 14. Community CSCLs for Freshwater and Terrestrial Receptors

		Sediment (mg/kg)	Surface Water (mg/L)				Soil (mg/kg soil)	
CAS Number	Chemical Name	Benthic Community	Freshwater Community (total)	Freshwater Community (dissolved)	Algae	Amphibians	Plants	Soil Community
67-64-1	Acetone	8.7e-03	1.5e+00	ID	ID	ID	ID	ID
107-05-1	Allyl Chloride	ID	ID	ID	ID	ID	ID	ID
7429-90-5	Aluminum	ID	8.7e-02	ID	4.6e-01	5.0e-01	5.0e+01	ID
7440-38-2	Arsenic	7.2e+00	1.5e-01	1.5e-01	4.8e-02	4.3e+00	1.0e+01	6.0e+01
7440-39-3	Barium	ID	4.0e-03	ID	ID	ID	5.0e+02	ID
65-85-0	Benzoic Acid	ID	4.2e-02	ID	ID	ID	ID	ID
111-44-4	Bis(2-chlorethyl) ether	ID	1.0e+03	ID	ID	ID	ID	ID
117-81-7	Bis(2-ethylhexyl) phthalate	1.8e-01	3.0e-03	ID	ID	ID	ID	ID
7440-43-9	Cadmium	6.8e-01	2.5e-03	2.3e-03	2.0e-03	1.9e+00	4.0e+00	1.0e+00
75-15-0	Carbon disulfide	8.5e-04	9.2e-04	ID	ID	ID	ID	ID
67-66-3	Chloroform	2.2e-02	2.8e-02	ID	ID	1.5e+01	ID	ID
7440-47-3	Chromium	5.2e+01	ID	ID	ID	8.8e+00	ID	6.4e+01
16065-83-1	Chromium III	ID	8.6e-02	7.4e-02	4.0e-01	ID	ID	6.4e+01
18540-29-9	Chromium VI	ID	1.1e-02	1.1e-02	2.0e-03	ID	ID	4.0e-01
7440-48-4	Cobalt	ID	2.3e-02	ID	ID	5.0e-02	2.0e+01	ID
7440-50-8	Copper	1.9e+01	1.2e-02	8.9e-03	ID	1.1e+00	1.0e+02	2.1e+01

(continued)

Table 14. (continued)

CAS Number	Chemical Name	Sediment (mg/kg)	Surface Water (mg/L)				Soil (mg/kg soil)	
		Benthic Community	Freshwater Community (total)	Freshwater Community (dissolved)	Algae	Amphibians	Plants	Soil Community
107-06-2	Dichloroethane, 1,2-	2.5e-01	9.1e-01	ID	ID	3.3e+00	ID	ID
118-74-1	Hexachlorobenzene	7.7e+01	3.7e-03	ID	ID	ID	ID	ID
7439-92-1	Lead	3.0e+01	2.5e-03	2.0e-03	5.0e-01	2.1e+00	5.0e+01	2.8e+01
7439-96-5	Manganese	8.2e+02	1.2e-01	ID	ID	6.7e+00	5.0e+02	ID
78-93-3	Methyl ethyl ketone	ID	ID	ID	ID	ID	ID	ID
75-09-2	Methylene chloride	3.7e-01	2.2e+00	ID	ID	ID	ID	ID
7439-98-7	Molybdenum	ID	3.7e-01	ID	ID	ID	2.0e+00	ID
7440-02-0	Nickel	1.6e+01	5.2e-02	5.2e-02	5.0e-03	2.2e+00	3.0e+01	9.0e+01
1746-01-6	TCDD 2,3,7,8- (TEQ)	2.0e-04	1.2e-09	ID	ID	ID	ID	ID
127-18-4	Tetrachloroethylene	4.1e-01	9.8e-02	ID	8.2e+02	ID	1.7e+02	1.8e+01
79-01-6	Trichloroethylene	2.2e-01	4.7e-02	ID	ID	8.9e+01	1.4e+01	7.9e+01
7440-62-2	Vanadium	ID	2.0e-02	ID	ID	ID	8.0e+01	2.1e+02
108-05-4	Vinyl Acetate	8.4e-04	1.6e-02	ID	ID	ID	ID	ID
75-01-4	Vinyl chloride	ID	ID	ID	ID	ID	ID	ID
7440-66-6	Zinc	1.2e+02	1.2e-01	1.2e-01	3.0e-02	6.5e+00	5.0e+01	1.0e+02

ID = Insufficient Data.

An FCV is calculated in one of two ways. If acceptable chronic toxicity data are available on at least one species representing each of the eight different data requirements, the FCV is essentially the concentration corresponding to a cumulative probability of 0.05 for the appropriate species. If the chronic toxicity data do not meet the eight family requirements, the FCV is calculated by: (1) calculating a final acute value (FAV) which does meet the eight requirements, (2) estimating an acute to chronic ratio (ACR) as the ratio of at least three comparable (e.g., same species) acute and chronic toxicity studies, (3) dividing the FAV by two, and (4) dividing the result of step 3 value by the ACR.

An SCV is calculated using analogous methods as those applied in calculating the FCV. However, the Tier II methods (1) require chronic data on only one of the eight family requirements, (2) use a secondary acute value (SAV) in place of the FAV, and (3) are derived based on a statistical analysis of NAWQC data conducted by Host et al. (1991). Host et al (1991) developed adjustment factors (AFs) depending on the number of taxonomic families that are represented in the database. The Tier II methodology was designed to generate SCVs that are below FCVs (for a complete data set) with a 95 percent confidence limit.

Dissolved Surface Water Concentrations

Methods are currently available to develop dissolved CSCLs for metals only. Dissolved CSCLs were derived from total water CSCLs using a conversion factor. The conversion factors applicable to chronic criteria in freshwater water are presented in Table 15 (63 FR 68354). The conversion factors were developed by EPA using a series of filtration experiments that measured the difference between filtered and unfiltered concentrations of metals in surface waters. Evidence suggests that dissolved concentrations of constituents (metals in particular) are more bioavailable and toxic to organisms and may reflect more relevant exposure scenarios. Although the total concentrations supplied by the NAWQC and GLWQI are still deemed scientifically defensible by EPA, the agency recommends the use of dissolved metal concentrations when they are available (Prothro, 1993). Dissolved CSCLs are derived by multiplying the total CSCL by the conversion factor (Equation 5).

$$Metal\ CSCL_{dissolved} = (Metal\ CSCL_{total})\ x\ (Conversion\ Factor) \tag{5}$$

where Metal CSCL $_{total}$ is either an FCV or an SCV in freshwater and the Conversion Factor is the fraction of dissolved metal (Table 15).

Algae and Aquatic Plants

For algae and aquatic plants, available toxicological benchmarks were identified in the open literature or from data compilations presented in *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision* (Suter and Tsao, 1996). For most contaminants, studies were not available for aquatic vascular plants, but lowest

Table 15. Conversion Factors for Dissolved Metals [1]

Constituent	Conversion Factor
Arsenic	1.00
Cadmium [2]	1.1017-[(ln hardness)(0.04184)]
Chromium III	0.860
Chromium VI	0.960
Lead [2]	1.4620-[(ln hardness) (0.14571)]
Mercury	0.850
Zinc	0.986

[1] Conversion factor for chronic CSCLs in freshwater systems
[2] Depends on the water hardness (typical range from 50 to 100 mg $CaCO_3$/L)

effects concentrations were identified for algae for a limited number of constituents. The criteria for algae and aquatic plants were based on (1) a lowest observed effects concentration (LOEC) for vascular aquatic plants or (2) an effective concentration (EC_{xx}) for a species of freshwater algae, frequently a species of green algae (e.g., *Selenastrum capricornutum*). Because of the lack of data in this receptor group and the differences between vascular aquatic plants and algae sensitivity, usually the lowest value of those identified was used.

Amphibians

Though amphibians are a significant ecological receptor, ecotoxicity data characterizing the chronic dose-response relationship are limited. After a review of several compendia presenting amphibian ecotoxicity data (e.g., U.S. EPA, 1996b; Power et al., 1989) as well as primary literature sources, no suitable subchronic or chronic studies were identified that studied the reproductive or developmental effects of constituents on amphibian species. Therefore, a CSCL based on chronic endpoints and exposure durations was not derived. Instead, the CSCL was developed from a geometric mean of acute (i.e., [LC_{50}] lethal concentration 50% values) amphibian ecotoxicity data. A few general guidelines were followed in selecting appropriate acute studies for developing the benchmark.

- Test duration was less than 8 days.
- Toxicity endpoints included percent deformity and survival.
- Exposure occurred during early lifestages (i.e., embryo, larva, and tadpole).

Since these CSCLs are based on acute data (i.e., lethality), the severity of the potential adverse effects that this criterion indicates should be noted. Incorporating the amphibian data into the NAWQC within the data requirement categories is currently under consideration. Since amphibian species are more likely to breed in standing waters such as wetlands, ponds, or temporary puddles, the appropriateness of combining protection of amphibian receptors with the freshwater community criteria is unclear.

Benthic Community

Two methods were applied to developing CSCLs for the sediment community. The first and preferred derivation method used measured sediments concentrations that resulted in minimal effects to the composition and abundance of the sediment community. Measurements were taken at the national scale and tended to reflect a variety of sediment types and benthic community species. Because sediments can act to mediate or amplify the toxicity of constituents, measured field effects were seen as a better predictor of toxicity. The second derivation method used the equilibrium partitioning relationship between sediments and surface waters to predict a protective concentration for the benthic community using the chronic NAWQC. A discussion of each method is provided below.

Measured Sediment CSCLs

The premier sources of measured sediment toxicity data are the National Oceanic and Atmospheric Administration (NOAA) and the Florida Department of Environmental Protection (FDEP) (See Table 4). NOAA annually collects and analyzes sediment samples from sites located in coastal marine and estuarine environments throughout the United States as part of the National Status and Trends Program (NSTP). Data measured in the NOAA studies include measures of toxicity of *in situ* species such as amphipods, arthropods, and bivalves on a variety of community-based endpoints (e.g., abundance, mortality, species composition, and species richness). These data are used by NOAA to estimate the 10th percentile effects concentration effects range-low (ER-L) and a median effects concentration effects range-median (ER-M) for adverse effects in the sediment community. These values are not NOAA standards; rather, they are used to rank sites based on the potential for adverse ecological effects. In contrast, the FDEP sediment criteria are developed from the ER-L and ER-M data to approximate a probable effects level (PEL) (estimated from ER-M data) and a threshold effects level (TEL) (estimated from ER-L data). PELs and TELs correspond to the upper limit of contaminated sediment concentrations that demonstrate probable effects and no effects to the benthic community, respectively. Generally, FDEP values are more conservative than NOAA values. Even though these criteria were developed specifically for a marine community, researchers have demonstrated that marine TELs have good correlation with no-effects levels found for freshwater systems (Smith et al., 1996). In order of preference, TELs were adopted as CSCLs if available, and if not, ER-L were used. The FDEP criteria were chosen above the NOAA criteria for the following reasons; (1) the same database was used for both the NOAA criteria and the FDEP criteria development; (2) in most cases, the FDEP criteria was more conservative than the NOAA criteria because a larger portion of the low effects data was used in benchmark development; and (3) the marine TEL developed by the FDEP were found to be analogous to TELs observed in freshwater organisms (Smith et al., 1996).

Predicted Sediment CSCLs

When measured effects data were not available for organic constituents using the TEL or ER-L approaches, then the sediment quality criteria (SQC) method was used (U.S. EPA, 1993b). In this method, the previously derived FCV or SCV in surface water were used to generated a sediment CSCL. This method assumes that the equilibrium-partitioning between the sediment and water column is a function of the organic carbon fraction in sediment. Equation 6 and 7 were used to calculate the SQC, depending on whether and FCV or an SCV water quality CSCL was available. In the determination of the SQC sediment CSCL for nonionic chemicals, the f_{oc} was assumed to be 1% total organic carbon (Jones et al., 1997). The K_{oc} is chemical specific and is presented in Appendix C of chemical/physical properties.

$$Sediment\ Quality\ Criteria\ (SQC) = f_{oc}\ x\ K_{oc}\ x\ FCV \quad (6)$$

$$Sediment\ Quality\ Criteria\ (SQC) = f_{oc}\ x\ K_{oc}\ x\ SCV \quad (7)$$

Terrestrial Plants

For the terrestrial plant community, toxicological benchmarks were identified from a summary document prepared at the Oak Ridge National Laboratory (ORNL): *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants: 1997 Revision* (Efroymson et al., 1997a). The measurement endpoints were generally limited to growth and yield parameters because: (1) they are the most common class of response reported in phytotoxicity studies and, therefore, allow for criterion calculations for a large number of constituents; and (2) they are ecologically significant responses both in terms of plant populations and, by extension, the ability of producers to support higher trophic levels. As presented in Efroymson et al. (1997a), criteria for phytotoxicity were selected by rank ordering the LOEC values and then approximating the 10th percentile. If there were 10 or fewer values for a chemical, the LOEC was used. If there were more than 10 values, the 10th percentile LOEC was used. Such LOECs applied to toxicity endpoints measuring plant growth, yield reduction, or other effects are reasonably assumed to impair the ability of a plant population to sustain itself.

Soil Community

For the soil community, CSCLs were developed using methods similar to those used in deriving the NAWQC. In brief, the CSCL values for soil fauna were estimated to protect 95 percent of the species found in a typical soil community, including earthworms, insects, and various other soil fauna. Microflora were not included in the soil community primarily because of the difficulty in assigning ecological significance to effects levels for soil microorganisms (e.g., at what effect level is microbial inhibition significant to soil communities). This introduces some uncertainty in the soil criteria because: (1) microflora make up approximately 80 to 90 percent of the biomass in soil and (2) microflora are responsible for the majority of the biological activity in soil (e.g., N mineralization). When data were insufficient for CSCL development using the community approach, criteria studies identifying effects to earthworms and other soil biota proposed by ORNL (Efroymson et al., 1997b) or criteria developed by the Canadian Council of Ministers of the Environment (CCME, 1997) were used as *preliminary* CSCLs for the soil community.

In developing the soil community CSCL, eight taxa of soil fauna were identified to capture the key structural (e.g., trophic elements) and functional (e.g., decomposers) components of the soil ecosystem. The methodology presumes that protecting 95 percent of the soil species with a 50th percentile level of confidence ensures long-term sustainability of a functioning soil community. The toxicity data on soil fauna were compiled from several major compendia and supplemented with additional studies identified in the open literature. Ecotoxicity data used in CSCL derivation were limited to soil studies (versus aqueous studies) on measurement endpoints believed to be relevant to population survival (e.g., growth, reproduction). Although the process of developing criteria for the generalized soil community is iterative in nature, the approach may be divided into three basic components: (1) selection of representative soil species, (2) collection of toxicological data on soil species, and (3) calculation of a CSCL for the soil community. Each of the three steps are detailed in the following sections.

Selection of Representative Soil Species

Two important assumptions were made in developing the approach to select representative soil species. First, species using resources in a similar way (e.g., similar diet) should receive similar exposures (i.e., guild theory). Second, taxonomically related soil invertebrates tend to have similar toxicological sensitivity to chemicals (Neuhauser et al., 1986). Soil communities are made up of numerous groups of species performing one or more functions for the community. Thus, the set of "representative" species was designed to reflect the breadth and variety of taxonomic and structural/functional groups. Five metrics were identified to serve as a practical guide in the selection of appropriate soil species. Figure 1 illustrates the generalized soil community that is reflected in these metrics.

Five metrics were used to select representative soil species:

1. *Organism size*–classified into three groups: microfauna (<0.15 mm; e.g., Protozoa, Nematoda), mesofauna (0.16 to 10 mm; e.g., Enchytraeidae, Acari), and macrofauna (>10 mm; i.e., larger invertebrates). This convenient, albeit somewhat arbitrary, classification was useful in considering the interactions between soil species and their habitat.

2. *Distribution in soil horizon*–divided into three layers: deep mineral, shallow organic, and soil litter. Exposures to soil contaminants are presumed to occur for organisms at any horizon. However, the top two horizons tend to receive higher exposures to persistent and relatively immobile contaminants (such as some metals).

3. *Abundance*–number of individuals present in a typical habitat. Caution must be implemented in using this criteria because abundance species are not always the

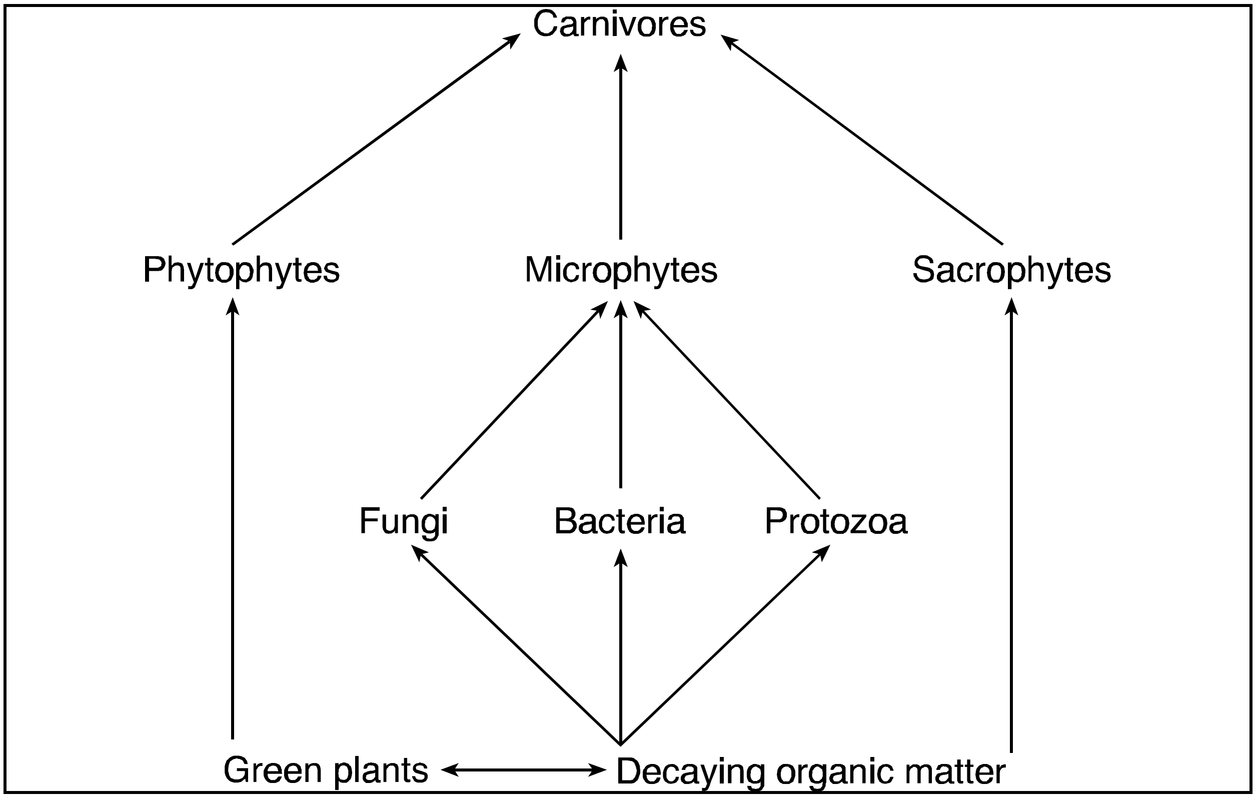

Figure 1. Simplified Trophic Structure of a Generalized Soil Community.

most ecologically significant. For example, nematodes and annelids both contribute equally to the flux of CO_2, yet nematodes outnumber annelids more than 100 to 1 (Reichle, 1977).

4. *Energy metabolism*–relative importance of a species to the overall community can be based on the contribution of energy that species provides (Curry, 1994). Increasingly, energy budgets are being viewed as a useful tool in assessing ecological significance.

5. *Function in community*–feeding preferences of different organisms largely define their role in the trophic structure (see Figure 1), shaping the dynamics of the soil community. The selection of species should adequately represent different functional roles within the trophic structure. To ensure a balanced representation of a generalized soil community, organisms were classified into four functional categories (Brown, 1978):

Microphytic–organisms that feed on fungal spores, hyphae, lichens, and bacteria (e.g., ants, fungus gnats, nematodes, and protozoa)

- # Saprophytic–organisms that feed on dead or decaying organic matter (e.g., earthworms, acari, and collembola)

- # Phytophagous–organisms that feed on living plant material including plant stems, leaves, roots, or woody parts (e.g., mollusks, symphylids, termites, insect larvae)

- # Carnivorous–organisms that are true predators (e.g., carabids, mites, spiders).

Collection of Toxicological Data on Soil Species

Guidelines were established to collect data on LOECs for representative species in the soil community. The toxicological data included studies on a variety of relevant physiological and process-based endpoints (e.g., cocoon production, maintenance of reproductive processes). Assumed routes of exposure were direct contact and ingestion. Toxicological representation of each of the following species groups was the goal of data collection efforts.

Group 1–one species from the phylum Nematoda. Nematodes are the most abundant organisms in the soil and provide the third largest amount of biomass. In addition, they represent the only microfauna evaluated.

Group 2–one species of soil mite (Acarina) from one of the following suborders: Cryptostigmata, Prostigmata, Mesostigmata, or Metastigmata. Soil mites are important as decomposers, predators, and plant eaters. Mites provide the largest amount of CO_2 flux among these groups.

Group 3–one insect from the order Collembola. Springtails were selected because they are saprophytic and the second most abundant invertebrates in the soil. Their high abundance also results in moderately high biomass.

Groups 4 & 5–two annelids from the orders Plesiopora or Opisthopora (families Enchytraeidea and Lumbricidae preferred). The oligochaeta represent some of the largest soil organisms and, as subterranean animals, are important saprophytic feeders. Members of Opisthopora are the largest contributors to soil fauna biomass.

Groups 6 & 7–two additional species of arthropods selected from one of the following taxonomic groups: Diptera, Coleoptara, Isopoda, Chilopoda, and Diplopoda. Arthropods play a variety of critical roles in the soil community and rank high in terms of all five metrics.

Group 8–a species of mollusc from the order Stylommatophora. Although the majority of molluscs are marine organisms, they represent surface decomposers in the trophic structure that are not duplicated by the other organisms in the representative set.

Calculation of Criteria for the Soil Community

The statistical approach adopted consisted of two steps: (1) fitting the LOEC data on representative species of soil biota to a lognormal distribution, and (2) extrapolating to a criterion based on the mean and standard deviation of the toxicity data set. The key assumptions were that: (1) LOEC data are distributed lognormally, (2) the selection of LOEC data (rather than no observed effects concentration, NOEC data) is appropriate for this methodology, and (3) the 95 percent level of protection is ecologically significant. The approach to calculating benchmarks for the soil community was based on efforts by Dutch scientists (the RIVM methodology) to develop hazardous concentrations (HCs) at specified levels of protection (primarily 95 percent) at both a 95th percentile and a 50th percentile level of confidence (Sloof, 1992). For the soil fauna benchmarks, the 50th percentile level of confidence was selected because the 95th percentile appeared to be overly conservative for a no-effects approach. Equation 8 was used to calculate soil community CSCLs.

$$HC_{5\%} = [x_m - k_l \, s_m] \tag{8}$$

where

$HC_{5\%}$ = soil concentration protecting 95 percent of the soil species

x_m = sample mean of the log LOEC data

k_l = extrapolation constant for calculating the one-sided leftmost confidence limit for a 95 percent protection level

s_m = sample standard deviation of the log LOEC data.

It is important to note that only one value for k_l is calculated for the 50th and 95th percentile confidence limits, respectively, for each sample size (*m*). Consequently, it is assumed that: (1) there is just one extrapolation constant with the required confidence property for each species sample size, and (2) extrapolation factors may be determined through Monte Carlo simulation by generating random sample averages and deviations for the **standard** logistic distribution and adjusting for a specified confidence level (i.e., 50th or 95th).

Calculation of Results

As appropriate for a screening analysis, the hazard quotient (HQ) method was adopted to estimate ecological risks. The HQs were calculated using Equation 8. The CSCLs generated in section 4.0, and the media concentrations generated through the fate and transport modeling were used to derive the HQ.

$$\text{Hazard Quotient (HQ)} = \frac{\text{Modeled Media Concentration}}{\text{Chemical Stressor Concentration Limit (CSCL)}} \quad (8)$$

The modeled media concentrations for both high-end and central tendency management scenarios are presented in Tables 2.1 to 2.6 of Attachment 1. The corresponding HQ determinations are presented in Tables 3.1 to 3.6 of Attachment 1.

All CSCLs were examined closely to select the most appropriate criterion for each media (i.e., soil, surface water, and sediment) to use in risk determinations. This process was somewhat simple for the sediment community because only one CSCL was developed for this receptor category. However, for surface water and soil, CSCLs were generated for a number receptor taxa (within the constraints of ecotoxicity data gaps). For soil, CSCLs (mg/kg soil) were developed for mammals, birds, terrestrial plants, and the soil community. For surface water, CSCLs (mg/L) for mammals, birds, aquatic plants, amphibians, and the freshwater community were developed. A few general steps were taken to select a media-specific CSCL for calculating the HQs.

1. Soil CSCLs were compared to background concentration averages and ranges reported for the conterminous United States. Several of the derived terrestrial criteria fell below background concentrations measured in soils. Values falling below background concentrations were not considered appropriate as screening values (with the exception of aluminum, see Section 5.1.1.2).

2. From the remaining criteria in each media type (i.e., soil and surface water), the lowest CSCL was selected for hazard quotient determinations. This step allowed a screening to identify sensitive receptors indicating risk under the management scenarios. The lowest CSCLs selected for initial HQ calculations are presented in Table 16. In cases where data were insufficient to develop a CSCL, no risk determination could be calculated. However, a lack of data should not be construed as a lack of risk.

3. For combinations of constituents and receptor taxa that indicate risk in the initial screen, hazard quotients were also generated for other sensitive species. To do this, the CSCLs within each media type were ranked from lowest to highest (i.e., most sensitive receptors to least sensitive receptors). Hazard quotients were calculated from the list of ranked CSCLs using the modeled media concentrations until a hazard quotient less than one was generated. Although the hazard quotients from this secondary screen are not included in this analysis, all receptors indicating exceedances are summarized in Table 17.

A slight modification was used to estimate HQs for dioxin. In the case of dioxin and furan congeners a toxicity equivalency quotient (TEQ) approach was applied. Modeled media concentrations of dioxin and furan congeners were converted to equivalents of 2,3,7,8-TCDD using toxicity equivalency factors (TEFs) (Table 4 of Attachment 1). In this calculation, the dioxin or furan modeled media concentrations are multiplied by the corresponding congener TEF[2]. The sum of these equivalents was the 2,3,7,8-TCDD toxicity equivalent concentration (TEC). The TEC concentration and the 2,3,7,8-TCDD CSCL were used to generate the hazard quotient for dioxin. This approach was very conservative because all dioxin congeners were presumed to bioaccumulate to the same degree in prey items. However, research has indicated that dioxin and furan congeners bioaccumulate to different degrees (U.S. EPA, 1993).

<u>Results Overview</u>

The combinations of management scenarios, receptors, and constituents that indicated risk in the analysis are summarized in Table 17. The following general trends were seen in the results.

- The potential for adverse effects was indicated for the constituents, aluminum, arsenic, barium, copper, lead, nickel, zinc, and dioxin/furan congeners for at least one but usually several receptors evaluated in this analysis. None of the volatile or semi-volatile compounds evaluated in this analysis were identified as a potential risk in waste.

[2] The same TEFs were used for mammals and birds. There are reported differences in dioxin toxicity to mammalian and avian receptor taxa. Avian-specific TEFs are being developed by the World Health Organization, but they have not yet been finalized. Applying mammalian TEFs to generate HQs for birds creates some uncertainty in the analysis.

Table 16. Lowest Chemical Stressor Concentration Limit (CSCL) Derived for Soil, Sediment, Surface Water, and Plant Tissue

		Media Types								Plant Types	
		Sediment (mg/kg)		Surface water (mg/L)				Soil (mg/kg)		Plant (mg/kg DW)	
CAS Number	Chemical Names		Receptor	Total	Receptor	Dissolved	Receptor		Receptor		Receptor
67-64-1	Acetone	8.7e-03	BC	1.5e+00	FWT	ID		ID		ID	
107-05-1	Allyl chloride	ID		ID		ID		ID		ID	
7429-90-5	Aluminum	ID		1.3e-02	River Otter	ID		5.0e+00	Short-tailed Shrew	5.5e+00	Meadow Vole
7440-38-2	Arsenic	7.2e+00	BC	3.2e-03	Kingfisher	1.5e-01	FWD	1.0e+01	Plant Community[1]	8.1e-02	Northern Bobwhite
7440-39-3	Barium	ID		4.0e-03	FWT	ID		1.7e+01	American Robin	3.0e+02	Northern Bobwhite
65-85-0	Benzoic acid	ID		4.2e-02	FWT	ID		ID		ID	
111-44-4	Bis (2-chloroethyl) ether	ID		ID		ID		ID		ID	
117-81-7	Bis(2-ethylhexyl) phthalate	1.8e-01	BC	3.0e-03	FWT	ID		8.9e-01	American Robin	1.6e+01	Northern Bobwhite
7440-43-9	Cadmium	6.8e-01	BC	2.0e-03	Algae	2.3e-03	FWD	3.1e-02	American Robin	5.9e+00	Meadow Vole
75-15-0	Carbon disulfide	8.5e-04	BC	9.2e-04	FWT	ID		ID		ID	
67-66-3	Chloroform	2.2e-02	BC	2.8e-02	FWT	ID		7.1e+01	Short-tailed Shrew	8.3e+01	Meadow Vole
7440-47-3	Chromium	5.2e+01	BC	8.8e+00	Amphibians	ID		6.4e+01	Soil Community	ID	
16065-83-1	Chromium III (insoluble salts)	ID		8.6e-02	FWT	7.4e-02	FWD	2.7e-01	American Robin	1.4e+01	Northern Bobwhite
18540-29-9	Chromium VI	ID		2.0e-03	Algae	1.1e-02	FWD	4.0e-01	Soil Community	8.9e+00	Meadow Vole
7440-48-4	Cobalt	ID		2.3e-02	FWT	ID		2.0e+01	Plant Community	ID	
7440-50-8	Copper	1.9e+01	BC	1.2e-02	FWT	8.9e-03	FWD	2.1e+01	Soil Community	4.0e+01	Meadow Vole
107-06-2	Dichloroethane, 1,2-	2.5e-01	BC	9.1e-01	FWT	ID		1.4e+01	American Robin	1.5e+02	Meadow Vole
118-74-1	Hexachlorobenzene	7.7e+01	BC	7.3e-06	Kingfisher	ID		4.9e-01	American Robin	8.3e+00	Meadow Vole
7439-92-1	Lead	3.0e+01	BC	3.3e-04	River Otter	2.0e-03	FWD	2.8e+01	Soil Community[1]	2.8e-02	Meadow Vole

(continued)

Table 16. (continued)

CAS Number	Chemical Names	Media Types								Plant Types	
		Sediment (mg/kg)		Surface water (mg/L)				Soil (mg/kg)		Plant (mg/kg DW)	
			Receptor	Total	Receptor	Dissolved	Receptor		Receptor		Receptor
7439-96-5	Manganese	8.2e+02	BC	1.2e-01	FWT	ID		4.2e+02	Short-tailed Shrew	4.7e+02	Meadow Vole
78-93-3	Methyl ethyl ketone	ID		3.6e+03	River Otter	ID		8.4e+03	Short-tailed Shrew	9.4e+03	Meadow Vole
75-09-2	Methylene chloride	3.7e-01	BC	2.2e+00	FWT	ID		ID		ID	
7439-98-7	Molybdenum	ID		3.7e-01	FWT	ID		2.0e+00	Plant Community	3.6e+00	Meadow Vole
7440-02-0	Nickel	1.6e+01	BC	5.0e-03	Algae	5.2e-02	FWD	1.4e+01	American Robin	2.4e+02	Meadow Vole
1746-01-6	TCDD 2,3,7,8- (TEQ)	ID		1.3e-11	River Otter	ID		1.6e-06	Short-tailed Shrew	5.5e-06	Meadow Vole
127-18-4	Tetrachloroethylene	4.1e-01	BC	9.8e-02	FWT	ID		1.8e+01	Soil Community	ID	
79-01-6	Trichloroethylene	2.2e-01	BC	2.4e-02	River Otter	ID		1.8e+00	Short-tailed Shrew	2.1e+00	Meadow Vole
7440-62-2	Vanadium	ID		2.0e-02	FWT	ID		1.2e+00	American Robin	2.6e+00	Meadow Vole
108-05-4	Vinyl acetate	8.4e-04	BC	1.6e-02	FWT	ID		ID		ID	
75-01-4	Vinyl chloride	ID		5.7e-02	River Otter	ID		8.1e-01	Short-tailed Shrew	9.4e-01	Meadow Vole
7440-66-6	Zinc	1.2e+02	BC	3.0e-02	Algae	1.2e-01	FWD	7.5e-01	American Robin	1.6e+02	Northern Bobwhite

Note: Benthic Community (BC), Freshwater Community - Total (FWT), Freshwater Community - Dissolved (FWD)

[1] Although there were other soil CSCLs less than the selected value, this value was the lowest value that exceeded mean soil background concentrations for the Eastern United States.

Table 17. Summary of Receptors Indicating the Potential for Adverse Effects Under High-End and Central Tendency Waste Management Scenarios

Constituents	High-End Waste Management Scenario		Central Tendency Waste Management Scenario	
	Freshwater Receptors	Terrestrial Receptors	Freshwater Receptor	Terrestrial Receptors
Aluminum	Mink River Otter Osprey Kingfisher Freshwater Community (Total) Algae and Aquatic Plants Amphibians	Short-tailed Shrew Deer Mouse Eastern Cottontail Red Fox Raccoon White-tailed Deer Red-tailed Hawk American Kestrel Northern Bobwhite American Robin American Woodcock Meadow Vole Terrestrial Plants	Mink River Otter Freshwater Community (Total) Algae and Aquatic Plants Amphibians	Short-tailed Shrew Deer Mouse Eastern Cottontail Red Fox Raccoon White-tailed Deer American Robin American Woodcock Meadow Vole Soil Community Terrestrial Plants
Arsenic	Kingfisher	No Exceedance	No Exceedance	No Exceedance
Barium	Great Blue Heron Kingfisher Osprey Spotted Sandpiper Herring Gull Freshwater Community (Total)	No Exceedance	Kingfisher Freshwater Community (Total)	No Exceedance
Copper	Freshwater Community (Total) Freshwater Community (Dissolved) Mink River Otter Kingfisher	Soil Community	Freshwater Community (Total) Freshwater Community (Dissolved) River Otter	No Exceedance

(continued)

Table 17. (continued)

Constituents	High-End Waste Management Scenario		Central Tendency Waste Management Scenario	
	Freshwater Receptors	Terrestrial Receptors	Freshwater Receptor	Terrestrial Receptors
Lead	River Otter Mink Kingfisher	No Exceedance	River Otter	No Exceedance
Nickel	Algae/Aquatic Plants	No Exceedance	Algae/Aquatic Plants	No Exceedance
2,3,7,8-TCDD (TEQ)	River Otter Mink Bald Eagle Osprey Great Blue Heron Kingfisher Herring Gull Freshwater Community (Total)	Short-tailed Shrew Deer Mouse Eastern Cottontail (soil) Eastern Cottontail (plant) Red Fox Raccoon White-tailed Deer (soil) White-tailed Deer (plant) Red-tailed Hawk American Kestrel American Robin American Woodcock Meadow Vole (plant)	River Otter Mink Bald Eagle Osprey Great Blue Heron Kingfisher Herring Gull Freshwater Community (Total)	Short-tailed Shrew Red Fox
Zinc	Algae	American Robin American Woodcock	No Exceedance	American Robin American Woodcock

- # In comparing the results of high-end and central tendency, the only constituent that indicated risk under the high-end but not under central tendency management scenario was arsenic. For all other constituents, if risk was indicated under high-end management scenarios, it was also indicated for central tendency scenarios.

- # Exceedances were indicated only in surface water, soils, and plant tissue. Risk was not indicated in sediment media for any of the constituents.

- # For the waste management scenarios of EDC/VCM and methyl chloride landfills, risk is not anticipated under either high-end and central tendency waste management scenarios for the receptors that were evaluated in this analysis. However, the potential risk to ecological receptors was indicated for the EDC/VCM land treatment unit for both high-end and central tendency management scenarios.

- # Ranking the chemicals from highest to lowest in terms of total number of receptors with HQs greater than 1 results in the following sequence: dioxin/furan congeners, aluminum, barium, copper, lead, zinc, arsenic, and nickel.

The ecological significance of these results must be assessed within the confines of the screening level assessment. A significant level of uncertainty is associated with the interpretation of these screening level results for two primary reasons: (1) the representative mammal and bird species used in the analysis do not necessarily represent region-specific wildlife, nor were threatened or endangered species assessed; and (2) risk was assess for generalized terrestrial and freshwater ecosystems without consideration of biotic and abiotic characteristics of the Gulf Coast region. In particular, coastal wetland ecosystems and wildlife species were not assessed. Because of the large number of receptors and chemicals for which exceedance was indicated; the pertinent findings are presented in a bullet format on a chemical-specific basis, for freshwater and terrestrial ecosystems, respectively. Only those compounds for which HQs exceeded 1 are discussed. These compounds include seven metals and one dioxin congener, but no organics. The discussions for each chemical include the risk estimation and risk description and are outlined as follows:

Risk Estimation

Receptors Indicating Risk. For clarity, this section summarizes the contents of Table 17 presenting the receptor/management scenarios that exceed the target HQ of 1.

Magnitude of Potential Risk. This section discusses the general nature and magnitude of the risk exceedances by presenting (1) the trophic levels of receptor taxa that exceed HQs of 1 and (2) the relative magnitude of HQ exceedances (e.g., less than 10, greater than 100).

Risk Description

Potential for Adverse Effects. This section provides the link between the results showing exceedance and the types of adverse effects that could potentially occur. The assessment endpoints selected for each receptor taxa (Table 3) are reviewed in the context of the risk results.

Ecological Significance. The ecological significance of the results in the context of the potential effects and the limitations of a screening level analysis are discussed. Although limited extrapolation can be made about the extent and significance of the impacts, this section provides a context for the interpretation of the HQs.

Aluminum

Potential risks for aluminum were modeled in land treatment units but not in landfills. Sufficient data were available to assess only total surface water and soil.

<u>Freshwater Ecosystem.</u>

Risk Estimation

Receptors Indicating Risk.

- Exceedances were indicated for aluminum at multiple trophic levels under both high-end and central tendency management scenarios in both freshwater and terrestrial ecosystems.

- Under high-end management scenarios, HQs exceeded for all receptor taxa evaluated: mammals (mink, river otter), birds (osprey, kingfisher), the freshwater community (fish and aquatic invertebrates), algae/aquatic plants, and amphibians.

- Under the central tendency management scenarios, HQs exceeded 1 for the same receptors with the exception of the avian species which fell below the target HQ of 1.

- Insufficient ecotoxicity data were available to evaluate the potential risks to the benthic community.

Magnitude of Potential Risk

- In freshwater ecosystems, the highest HQs exceeded 100 under high-end management scenarios; the corresponding central tendency HQ approximated 50.

Exceedances were indicated in five of the six receptor taxa (mammals, birds, freshwater community, amphibians, algae/aquatic plants, and the benthic community) for the freshwater ecosystem.

Risk Description

Potential for Adverse Effects

Assessing the impacts in terms of the assessment endpoints, the following potential impacts may occur where exceedances are indicated.

Representative mammalian and avian receptors could potentially encounter decreased reproductive capacity.

Adverse impacts to the growth and reproductive success of fish and aquatic invertebrates could potentially occur.

Growth and maintenance of algae and aquatic plants may potentially be inhibited. Potential impacts to amphibian populations are also suggested by the results. The HQ of approximately 5 for amphibians is based on acute effects; therefore, the exceedance indicates the potential for lethal effects to amphibians.

Ecological Significance

Given that most of the freshwater trophic levels are impacted in some way from aluminum exposure, the results suggest a high level of concern for the freshwater ecosystems that may receive waste from LTU management practices.

Primary producers (i.e., algae) in addition to primary and secondary consumers could potentially be adversely impacted at varying levels of severity. These results suggest that in addition to the potential risks that exists for individual receptors, the potential for indirect food web shifts may occur from loss or decline in certain food chain components. The significance of indirect effects is beyond the screening nature of this analysis, but these shifts have the potential to cause impacts to the ecosystem.

Because the sites being considered in this analysis have a high probability to contain wetlands (i.e., amphibian habitat) and the benchmark for amphibians, based on lethal acute effects, is indicating exceedance, this population is likely to experience significant impacts if exposed to concentrations predicted in the high-end or central tendency management scenarios.

Aluminum toxicity is highly influenced by surface water pH, and this parameter can act to mediate or magnify the potential for adverse effects. Benchmarks were generated within typical pH ranges for the freshwater community, but aluminum chemistry and equilibria are complex, and small changes in pH can significantly

alter bioavailable waterbody concentrations of aluminum. Also note that wetlands and other aquatic habitats at the sites in question may be tidally influenced and therefore contain brackish water. Without completing a site-based assessment, the impact of pH and other chemical equilibria cannot be accounted for.

Terrestrial Ecosystem.

Risk Estimation

Receptors Indicating Risk

These results indicate the potential for adverse effects to most of the trophic levels considered in the terrestrial ecosystem.

Under high-end management scenarios, HQs exceeded 1 for mammals (short-tailed shrew, meadow vole, deer mouse, eastern cottontail, red fox, raccoon, white-tailed deer), birds (red-tailed hawk, American Kestrel, Northern bobwhite, American robin, American woodcock), the soil community (e.g., earthworms), and terrestrial plants.

Under central tendency management scenarios, risk was indicated for the same receptors with the exception of a few avian receptors (red-tailed hawk, American kestrel, and Northern bobwhite) that fell below the target HQ of 1.

Insufficient ecotoxicity data were available to evaluate the potential risks to the soil community.

Exceedances were not indicated for the plant tissue exposure pathway in herbivores.

Magnitude of Potential Risk

In terrestrial ecosystems, the highest HQs estimated for high-end management scenarios exceeded 100 for land treatment units; the corresponding central tendency HQ approximated 75.

Out of the four receptor taxa in the generalized terrestrial habitat (mammals, birds, soil invertebrates, and plants) food web, three indicated exceedances of the target HQ of 1 for both high-end and central tendency (mammals, birds, and plants).

Risk Description

Potential for Adverse Effects

These results suggest that there is a high potential for adverse effects to be exhibited in the taxa that were consider in this analysis. Interpreting these results in the context of the assessment endpoints, the following potential effects are suggested:

- Reproductive fitness may not be maintained in representative mammalian and avian receptors.

- Adverse impacts to the growth and yield of terrestrial plants is suggested.

Ecological Significance

There is high uncertainty with the terrestrial ecosystem aluminum results. Key uncertainties include:

- All of the soil CSCLs developed for aluminum fell below mean background concentrations for the eastern United States (i.e., 33,000 mg/kg soil).

- Not all the aluminum in soil is in a form that can be taken up by ecological receptors, and soil pH plays a significant role in the fraction of aluminum that is bioavailable.

- In this analysis, HQs were calculated using (1) total soil aluminum predicted through the fate and transport modeling and (2) CSCLs generated from ecotoxicity data that expose receptors to a more bioavailable form of aluminum. These differences introduce uncertainty in the comparison of these values to generate a reliable HQ.

- A better predictor of the bioavailable portion of aluminum in soil is the concentration of soluble aluminum. A better risk estimate could becalculated using modeled groundwater concentrations (before applying dilution attenuation factors [DAFs]) and pore-water soil CSCLs. Such a comparison was not within the scope and schedule of thisanalysis. **The use of total aluminum concentrations in this analysis generates low confidence in the results.**

- **In the context of these uncertainties**, the results indicate that there may be significant effects to terrestrial receptors considered in this analysis. The HQ results indicate that both primary producers and primary and secondary consumers may be impacted by aluminum exposure. The cumulative effects at each trophic level have the potential to cause adverse effects in the terrestrial food web as a whole.

- # The potential significance of a decrease in plant growth is unclear, but these potential adverse effects may influence the prey base for the terrestrial food web.

Arsenic

Potential risk for arsenic was modeled in land treatment units but not in landfills. Sufficient data were available to assess all media.

Freshwater Ecosystem

Risk Estimation

Receptors Indicating Risk

- # The results generated for arsenic in high-end management scenarios suggest the potential for adverse effects to the kingfisher in the freshwater ecosystem. Exceedances were eliminated for the kingfisher under central tendency management scenarios.

- # Risk was not indicated for other representative avian or mammalian receptors or for other community receptors (amphibians, the benthic community, the freshwater community, or algae/aquatic plants).

Magnitude of Potential Risk

- # The HQ estimated for high-end management exposures for surface water was less than 10 for the kingfisher.

- # The results suggest that only the kingfisher has the potential to be adversely impacted by arsenic exposures in surface water.

Risk Description

Potential for Adverse Effects

- # The CSCL developed for avian receptors was estimated to be protective of the reproductive potential of the species based on endpoints such as egg hatching success, clutch size, egg shell thinning, and developmental abnormalities. The HQ exceedance suggests that these endpoints may be adversely affected by exposure to arsenic compounds during at the high-end management scenarios.

Ecological Significance

- # Risk results for arsenic generated exceedance for only one representative receptor under high-end management scenarios while central tendency management scenarios did not indicated risk. Considering the limited extent of exceedances across the freshwater ecosystem, arsenic contributes minimally to the overall risk.

Considering that conservative benchmark studies (i.e., the lowest NOAEL dose) and bioaccumulation factors were applied to calculate protective surface water concentrations, using a fish uptake value closer to the median or a geometric mean of NOAEL doses may generate a an HQ below 1.

Terrestrial Ecosystem.

Risk results indicate no potential effects from arsenic exposure to terrestrial receptors considered in this analysis.

Barium

Potential risks for barium was modeled for land treatment units but not for landfills. Sufficient data were available to assess total surface water, soil, and plants.

Freshwater Ecosystem.

Risk Estimation

Receptors Indicating Risk

The risk results for barium suggested the potential for adverse effects to freshwater receptors in multiple trophic compartments.

Risks to freshwater receptors were indicated under both high-end and central tendency management scenarios.

Under high-end management scenarios, HQs exceeded 1 for birds (great blue heron, kingfisher, osprey, spotted sandpiper, herring gull) and the freshwater community (e.g., fish and aquatic invertebrates).

Under central tendency management scenarios, risk was indicated for the same receptor taxa (birds and the freshwater community); however, fewer representative avian species (i.e., only kingfisher) indicated HQs greater than 1.

Insufficient ecotoxicity data were available to evaluate the potential risks to amphibians, algae/aquatic plants, the benthic community, and representative mammalian receptors.

Magnitude of Potential Risk

- # The highest HQs estimated for high-end and central tendency management scenarios were both less than 10.

- # The HQ results indicate the potential for adverse effects in two receptor taxa assessed in this analysis (birds and the freshwater community). However, data limitations did not allow the evaluation of representative mammalian receptors that characteristically forage in freshwater ecosystems.

Risk Description

Potential for Adverse Effects

- # The context of the assessment endpoints, the results suggest that the reproductive fitness of avian receptors may be impacted from barium exposure through consumption of contaminated prey items.

- # The freshwater community may potentially exhibit adverse effects to growth and/or reproduction under both waste management scenarios.

Ecological Significance

- # The risk results suggest a potential for adverse effects to avian receptors that forage in the freshwater ecosystems. The resulting effects could potentially reduce populations of avian receptors through lowered reproductive capacity.

- # In the freshwater community, populations of fish or other aquatic invertebrates could have decreased reproductive capacity which in turn would alter the internal food web structure of the freshwater community.

- # Because these two receptor taxa are somewhat dependent on one another, it is difficult to assign the ecological significance to the potential cumulative impacts to the freshwater ecosystem. Birds associated with the freshwater ecosystem are typically piscivores and depend on fish as a major part of their diet. Considering the interdependence of these two groups, an adverse effect to one compartment could indirectly impact the other. The significance of indirect impacts is unclear and beyond the scope of this assessment; however, the potential significance of these interactions should not be over looked.

- # The inability to evaluate piscivorous mammals because of data limitations contributes to the uncertainty in these results.

<u>Terrestrial Ecosystem</u>.

In the terrestrial ecosystem, risk was not indicated under either management scenario for the receptors considered in this analysis; however, insufficient ecotoxicity data were available to evaluate the potential risks to the soil community.

Copper

Freshwater Ecosystem.

Risk Estimation

Receptors Indicating Risk

The risk results for copper suggested the potential for adverse effects to freshwater receptors in multiple trophic compartments. Risks to freshwater receptors were indicated for both high-end and central tendency management scenarios.

Under high-end management scenarios, HQs exceeded 1 for mammals (mink, river otter), birds (kingfisher) and the freshwater community (e.g., fish and aquatic invertebrates).

Under central tendency management scenarios, risk was only indicated for mammals (river otter) and the freshwater community.

Both the total and dissolved freshwater community CSCLs were exceeded for the high-end scenario, while only the total CSCL was exceeded for the central tendency scenario.

Risk was not indicated for amphibians or the benthic community; however, insufficient data were available to evaluate algae and aquatic plants.

Magnitude of Potential Risk

The highest surface water HQs estimated for high-end management scenarios ranged from approximately 30 to 40 for total and dissolved CSCLs, respectively. The highest HQ generated for the central tendency management scenarios for surface water was approximately equal to 10.

These results indicate the potential for adverse effects to three of the six receptor taxa assessed in this analysis.

Risk Description

Potential for Adverse Effects

Interpreting these results in the context of the assessment endpoints, the exceedances suggest that the reproductive fitness of mammalian and avian receptors may be impacted from copper exposure through consumption of contaminated prey items.

Under the high-end exposure scenarios, potential risk is indicated to both mammals and birds; whereas, under central tendency exposures, only mammals are likely to be impacted.

The results also indicate that growth and fecundity in the freshwater community may also be impacted at both high-end and central tendency waste management scenarios.

Ecological Significance

Considering that three out of the six receptor taxa in the freshwater ecosystem indicated HQ exceedances in the high-end management scenario and two out of six taxa indicated HQ exceedances in the central tendency management scenario, it is likely that the freshwater ecosystem may be impacted by exposure to copper.

The potential decrease in reproductive success of mammals and birds may translate into population declines for representative receptors indicating exceedance.

Considering the interactions between these different receptors indicating exceedance within the aquatic food web, an adverse effect in one compartment could result in food web shifts resulting in altered dynamics between receptors. These potential indirect effects introduce uncertainty into interpreting the ecological significance of HQ exceedances.

<u>Terrestrial Ecosystem</u>.

Risk Estimation

Receptors Indicating Risk

The results generated for the terrestrial ecosystem indicate HQs exceeding the target HQ of 1 for the soil community using the high-end waste management scenario. However, the exceedance drops below 1 under central tendency management scenarios.

Magnitude of Potential Risk

The soil community HQ generated under the high-end management scenario approximates 1.

- # The HQ exceeds 1 for only one receptor taxa in the terrestrial ecosystem. Risk was not indicated for representative mammals, birds, or the terrestrial plant community.

Risk Description

Potential for Adverse Effects

- # The HQ exceedance indicated for the soil community suggests that the community structure and function could potentially be impacted by exposure to copper.

Ecological Significance

- # Given the functional redundancy in soil communities and the relatively low HQ generated for this community receptor, the potential for adverse effects is minimal. Soil community structure and function is important to terrestrial ecosystems, but it is likely that these low concentrations will not generate adverse effects in the soil community structure and function. Since average background concentrations of copper range from 1 to 700 mg copper/kg soil (average 13 mg copper/kg), it is likely that the soil community would be able to tolerate the exposures modeled under high-end management scenarios (23 mg copper/kg soil) even though they minimally exceed the soil CSCL (21 mg copper/kg soil).

Lead

Freshwater Ecosystem.

Risk Estimation

Receptors Indicating Risk

- # Exceedances were only indicated in freshwater ecosystems for upper trophic level consumers (i.e., mammals and birds).

- # Under high-end waste management scenarios, modeled surface water concentrations exceeded the protective CSCL for representative mammals (river otter, mink) and birds (kingfisher).

- # Under central tendency waste management practices, only the freshwater river otter exceeded the target HQ of 1.

- # Other freshwater receptors did not indicate exceedance (e.g. freshwater community, benthic community, algae/aquatic plants, and amphibians).

Magnitude of Potential Risk

- # HQs generated for lead under both high-end and central tendency management scenarios were less than 10 for all receptors.

- # HQs exceeding 1 were indicated in two of the six freshwater receptor taxa assessed in this analysis.

Risk Description

Potential for Adverse Effects

- # The CSCL used in calculating HQ exceedances for mammals and birds were based on reproductive and developmental endpoints. Exceedances for the representative receptors indicate the potential for inhibited reproductive potential to those receptors.

Ecological Significance

- # The exceedance indicates the potential for a reduction in populations of some representative receptors that forage in the freshwater ecosystem. Quantifying impacts that may result from a loss of population is beyond the scope of this assessment and would require true population level modeling to determine the potential impacts to these species.

- # Since the river otter, mink, and kingfisher are associated with aquatic habitats and feed on trophic level 3 and 4 fish, the absence of these predators may disturb the dynamics of the freshwater fish community.

<u>Terrestrial Ecosystem</u>.

No exceedances were indicated for the terrestrial receptors considered in this analysis.

Nickel

<u>Freshwater Ecosystem</u>.

Risk Estimation

Receptors Indicating Risk

- # Under both high-end and central tendency management scenarios, algae and aquatic plants were the only receptors indicating exceedance.

- # Other freshwater receptors (amphibians, representative mammals and birds, freshwater community, and benthic community) did not indicate HQ exceedances.

Magnitude of Potential Risk

- # The HQs generated under the high-end and central tendency management scenarios were both less than 10.

- # The HQ exceeded 1 for one of the six receptor taxa under both management scenarios.

Risk Description

Potential for Adverse Effects

- # The assessment endpoints for algae and aquatic plants were derived to protect the growth, survival, and biomass of primary producers in the freshwater ecosystem. Consequently, the exceedance generated in these results indicates the potential for a reduction in algal growth in aquatic systems.

Ecological Significance

- # Since algae are the primary producers in the aquatic ecosystem, their decreased growth has the potential to cause impacts throughout the freshwater food chain. In particular it could potentially result in resource pressure to those organisms dependent on algae and aquatic plants in their diet. In addition, a decline in more sensitive algal populations may shift the composition of the algae community, which has the potential to cause shift in the herbivores that depend on this food source.

- # There is low confidence in the CSCL generated for algae and aquatic plants because it is based on so few studies. More confidence is attributed to the CSCL generated for the freshwater community which does not indicate exceedance.

- # Because (1) the HQs are relatively low and (2) this receptor taxa is robust, the potential impacts from nickel exposure to the freshwater ecosystem are expected to be minimal.

<u>Terrestrial Ecosystem</u>.

No exceedances were indicated for the terrestrial receptors considered in this analysis.

Dioxin and Furan Congeners (2,3,7,8-TCDD TEQs)

Freshwater Ecosystem.

Risk Estimation

Receptors Indicating Risk

- # Exceedances were indicated for dioxin and furan congeners at multiple trophic levels under both high-end and central tendency management scenarios in the freshwater ecosystem.

- # Under high-end and central tendency management scenarios, HQs exceeded 1 for mammals (mink, river otter), birds (osprey, kingfisher, bald eagle, great blue heron, herring gull), and the freshwater community (e.g., fish and aquatic invertebrates).

- # Insufficient ecotoxicity data were available to evaluate the potential risk to amphibians and algae/aquatic plants.

Magnitude of Potential Risk.

- # In freshwater ecosystems, the highest HQ estimated for high-end management exposures for surface water exceeded 1000, and the analogous central tendency HQ exceeded 100.

- # Exceedances were indicated for three of the six receptor taxa in the freshwater ecosystem.

Risk Description

Potential for Adverse Effects

- # The risk indicated by HQ exceedances suggests that representative mammalian and avian species as well as the freshwater community (i.e., fish and aquatic invertebrates) may be at risk from dioxin and furan exposures. Reproductive fitness may not be maintained in the representative mammalian and avian receptors considered in this analysis, and adverse impacts to the growth and reproductive capacity of fish and aquatic invertebrates could potentially occur.

Ecological Significance

- # Research has indicated that vertebrate species are more sensitive to dioxin exposure. In instances where data were available on vertebrates, potential risk was indicated; thus, suggesting that these HQ exceedances are significant.

- # The relative magnitude of exceedances also raises some concern. The HQs for dioxin were far higher than those generated for other constituent/receptor combinations. The high relative exceedances indicates a higher **potential** for adverse effects, not necessarily greater impacts.

These results call to attention the risk of dioxin and furan congeners to vertebrate wildlife species. A more in-depth analysis, beyond a screening level, seems appropriate for this constituent.

Terrestrial Ecosystem.

Risk Estimation

Receptors Indicating Risk

Under high-end management scenarios, HQs exceed 1for mammals (short-tailed shrew, meadow vole, deer mouse, eastern cottontail, red fox, raccoon, white-tailed deer) and birds (red-tailed hawk, American kestrel, Northern bobwhite, American robin, American woodcock).

Under central tendency management scenarios, all of the HQs generated for avian receptors fell below the target HQ of 1. Only the short-tailed shrew and red fox indicated the potential for adverse effects in the terrestrial ecosystem.

The herbivorous pathway indicates risk for the eastern cottontail, meadow vole, and the white-tailed deer under the high-end management scenario. Under central tendency management scenarios risk fell below the target HQ of 1 for these representative herbivorous species. Dioxin and furan congeners were the only constituents evaluated that indicated risk for the plant tissue pathway.

Insufficient ecotoxicity data were available to evaluate risk to the soil community and terrestrial plants exposed to dioxin and furan congeners.

Magnitude of Potential Risk

In terrestrial ecosystems, the highest HQ estimated for high-end management exposures were less than 100, and the analogous central tendency HQs were less than 10.

The relative risk from the plant tissue pathway was less than 10 for high-end and fell below the target HQ of 1 for central tendency management scenarios.

Of the four receptor taxa in the terrestrial food web, two showed exceedance under high-end exposure scenarios (mammals and birds) and only one indicated exceedance under central tendency exposure scenarios (mammals).

Risk Description

Potential for Adverse Effects

- # These results suggest that there is a high potential for adverse effects to be exhibited in the taxa that were considered in this analysis. Interpreting these results into the context of the assessment endpoints, reproductive fitness may not be maintained in the representative terrestrial mammalian and avian receptors indicating risk in this analysis.

- # Risk was reduced significantly under central tendency management scenarios. Where 11 representative species indicated exceedance for high-end, only two representative receptors indicated exceedance under central tendency exposure scenarios.

Ecological Significance

- # The number of mammalian and avian representative receptors that indicated exceedance under high-end exposure scenarios indicates that the impact to mammalian and avian populations has the potential to be significant.

- # The potential decrease in reproductive success of mammals and birds may translate into population declines for representative receptors indicating exceedance. Understanding that vertebrate species are more sensitive to dioxin exposure and HQs range from 10 to 100 for high-end exposure scenarios leads to the a high potential risk to primary and secondary consumers in the terrestrial environment.

- # Even though data were not available to evaluate terrestrial plants and the soil community, these receptor are usually not sensitive to dioxin exposures (U.S. EPA, 1993c).

- # The reduction in risk that was suggested from high-end to central tendency exposure scenarios indicates that the risk was eliminated for avian receptors and minimized for mammalian receptors using central tendency exposure scenarios.

Zinc

<u>Freshwater Ecosystem</u>.

Risk Estimation

Receptors Indicating Risk

- # Algae and aquatic plants exceeded the target HQ of 1 under high-end management scenarios and fell below the target HQ of 1 under central tendency management scenarios.

- # Other receptors evaluated in the freshwater ecosystems, such as the benthic community, representative mammals and birds, the freshwater community, and amphibians, did not indicate risk.

Magnitude of Potential Risk

- # The HQs derived for zinc were less than 10 for algae and aquatic plants, and only one of the six receptor taxa indicated risk in the freshwater ecosystem.

Risk Description

Potential for Adverse Effects

- # The assessment endpoints for algae and aquatic plants were derived to protect the growth, survival, and biomass of primary producers in the freshwater ecosystem. Consequently, the exceedance generated in these results indicates the potential for a reduction in algal growth in aquatic systems.

Ecological Significance

- # Since algae are the primary producers in the aquatic ecosystem, their decreased growth has the potential to impacts throughout the freshwater ecosystem. Impacts would include resource pressure to those organisms dependent on algae and aquatic plants as a part of their diet. A loss in more sensitive populations of algae may shift the composition of the algal community, which has the potential to cause shift in the herbivores that depend on this food source.

- # There is low confidence in the CSCL generated for algae and aquatic plants because it is based on so few studies (i.e., usually based on the lowest chronic value identified in the literature). The next-to-lowest CSCL for the freshwater community has greater confidence and does not indicate exceedance.

- # Because (1) the HQs are relatively low and (2) this receptor taxa is relatively robust, the impacts to the freshwater ecosystem are expected to be minimal.

<u>Terrestrial Ecosystem</u>.

Risk Estimation

Receptors Indicating Risk

- # Under both high-end and central tendency management scenarios, risk was indicated for two avian receptors: the American robin and the American woodcock.

- # Risk was not indicated for other terrestrial receptors assessed in this analysis when data were available for CSCL development.

Magnitude of Potential Risk

- # The HQs derived for these avian receptors were less than 10 in both the high-end and central tendency risk estimates.

- # Only one receptor taxa in the terrestrial ecosystem suggested the potential for adverse effects.

Risk Description

Potential for Adverse Effects

- # The assessment endpoints selected for CSCL derivation suggest that there is a potential for reproductive inhibition in the American robin and American woodcock exposed to zinc.

Ecological Significance

- # The potential decrease in reproductive success of representative receptors may translate into population declines the American robin and American woodcock.

- # It is unclear how changes in the populations in these avian species may influence the terrestrial ecosystem dynamics. However, it is likely that only a few terrestrial avian species may be impacted by zinc exposure since only a few of the representative receptors indicated risk. Small to medium-sized birds are prey items for raptors and medium-to-large sized mammals, such as the fox or mink. Therefore, there may also be potential for impacts to other receptor taxa.

Conclusions

These generalized significant findings summarize the results of this analysis.

- # The freshwater ecosystem generally indicates higher risk than the terrestrial ecosystem. Metal constituents and dioxin and furan congeners generated exceedances, while no exceedances resulted for organic constituents.

- # The greatest extent of HQ exceedances were indicated for aluminum and 2,3,7,8-TCDD. There is such high uncertainty associated with the comparisons made for aluminum creating low confidence in these risk estimates. In contrast, the exceedances indicated for 2,3,7,8-TCDD are based on more robust data, and they occur in receptors across both freshwater and terrestrial ecosystems that are known to be sensitive to dioxin exposure.

- Moderate risk was indicated for barium, copper, and lead predominantly in freshwater ecosystems. The risk associated with terrestrial ecosystems were minor for these constituents.

- Compared to other findings in this analysis, minimal risk was generated for zinc, nickel, and arsenic.

- As expected, the central tendency management scenarios, decreased the relative potential for adverse effects compared to the high-end management scenarios.

Key Uncertainties

This section discusses the uncertainty specific to this analysis. Uncertainty associated with methods developed outside of this analysis, such as development of the NAWQC, is not included in this discussion. In addition, the generally accepted assumptions that are made in developing CSCLs in the field of risk assessment are also not covered (e.g., lab to field extrapolation, LOAEL to NOAEL extrapolation). Rather, the *key assumptions and uncertainties* specific to this screening level analysis are reviewed. The key issues can be summarized into the following general categories: exposure uncertainty and data uncertainty.

Exposure Uncertainty

Exposure Routes

Ingestion was considered the most significant exposure route for ecological receptors in this analysis. Although inhalation and dermal exposures were not considered, they may be important exposure routes for some constituents. Inhalation as an exposure route was not considered for birds and mammals for several reasons. First, measurement endpoints for inhalation exposures seldom include reproductive effects or other effects likely to be associated with population impacts. Second, wildlife may spend varying amounts of time within different locations in the habitat (e.g., ground level and tree canopy). As a result, air concentrations would need to be modeled so that both the spatial and temporal characteristics of an animal's behavior are represented. Third, air models capable of estimating inhalation exposures relevant to the unique exposure routes of wildlife inhabiting forest interiors are only in the preliminary stages of development. For instance, the inhalation of subsurface air may be an important route of exposure for ground-dwelling animals such as the short-tailed shrew. At least one study has demonstrated that the risk from inhalation of subsurface air (for volatile chemicals) is several orders of magnitude higher than the risk from soil ingestion (Carlsen, 1996). Considering that this analysis includes volatile organics such as vinyl chloride and trichloroethylene, the lack of assessment of this exposure route produces some uncertainty in the analysis.

The direct contact route of exposure was also not included for birds and mammals. Although some exposure scenarios may be associated with dermal exposures (e.g., ground-dwelling animals), toxicological data to evaluate this route of exposure are insufficient. For example, little information is available on the absorption coefficient for chemicals across fur or feathers.

Volatilization of VOCs

In the fate and transport modeling effort, loss of chemical through volatilization was accounted for in the final media concentrations. However, the issue remained unsolved in some of the toxicity data used to derive CSCL concentrations. In cases where this loss was not accounted for, the CSCL may not be conservative enough. Comparison of the modeled concentrations which did account for this loss and CSCLs that did not creates a disconnect between the comparison. Considering that none of the VOCs or semi-VOCs indicated risk (i.e., usually several orders of magnitude below 1) this may be an insignificant point; however, it does generate some uncertainty in the risks estimates.

Metabolism of VOCs

The exposures assumed for representative species of mammals and birds did not account for the metabolism of compounds in prey items. Many of the VOCs considered in this analysis can be metabolized in the livers of prey items (e.g., fish, small mammals), but this loss was not account for in the development of CSCLs. The food web exposures simulated through calculations estimated the uptake of compounds into the fish and transfer to higher piscivorous mammals without accounting for the probable metabolism of these compounds (e.g., phthalates). The BAFs used in the case of fish were estimated through previously developed linear functions based on the constituent K_{ow}. The complexity of metabolism kinetics is beyond the scope of this assessment; however, not accounting for this loss generates a somewhat conservative CSCL.

Application of Uptake Default Values

In the aquatic and terrestrial food web, data were not available to characterize the uptake into all prey items. When estimated or measured uptake values were not identified in prey, a default value of 1 was applied. In some cases this value is not conservative enough, while in other cases it is too conservative. Commonly, the best estimate of uptake into prey items is a measured value from either field or laboratory data. When this is not available, an estimated uptake value using equations based on the K_{ow} was applied in the case of fish. Applying default values generates some uncertainty in the results. As more data become available, these values should be replaced with a more accurate measured BCFs.

Soil Invertebrate Bioaccumulation Factors

The soil invertebrate BAFs applied in the terrestrial ecosystem were made up of BAFs identified for both earthworm species and other invertebrates inhabiting the soil. There is support suggesting that earthworms and other invertebrates accumulate compounds at much different rates and degrees. Earthworms, because of their intimate contact with soil and their highly permeable skin, receive much higher exposure that other soil invertebrates. The lack of data characterizing these prey items individually led to combining these prey items into the same category. This creates some uncertainty because it may produce much higher exposures to some species for which earthworms make up a relatively small part of their diet compared to other soil invertebrates.

Extrapolation Using Allometric Scaling

For mammals and birds, differences in interspecies uncertainty were indirectly addressed through the use of the species-scaling equations. The method has not been applied to wildlife by EPA, but this method is used by EPA in carcinogenicity assessments when extrapolating from rats to humans. Wildlife toxicologists commonly scale dose to body weight without incorporating the exponential factor. There is continued disagreement among experts whether the application of scaling factors is appropriate in ecological risk assessment since this method may not account for physiological/biochemical differences in species sensitivity. Differences in sensitivity that are contrary to estimates produced by the scaling equation have been demonstrated for several chemicals (e.g., dioxin). Applying this method to species demonstrating different sensitivities across chemical classes introduces some uncertainty in the analysis.

Data Uncertainty

Confidence Ranks

As the data are presented in the analysis, it appears that all benchmarks and CSCLs represent equal levels of confidence, but this not the case. Rather, some benchmarks and CSCLs are supported by large data sets that characterize the toxicity of the constituent in great detail while other benchmarks or CSCLs may be based on only one or two data points. The confidence of a benchmark or CSCL is dependent on both the data quantity and data quality. A confidence rank can be assigned by evaluating each benchmark or CSCL based on a set of data standards. The standards vary with receptor taxa because of the variability in derivation methods. Because confidence is not explicitly included in the development of the CSCLs, there is some uncertainty in how the HQs generated from these CSCLs should be interpreted.

Depth of Literature Surveys

A complete and exhaustive literature search has been completed for almost half of the constituents considered in this analysis. The other constituents have only been reviewed at a more superficial level. The characterization of toxicity for some constituents was cursory given time constraints. Rather than conducting primary literature searches for constituents, review compendia (Table 4) were utilized to propose *preliminary* benchmarks and CSCLs for risk estimation. The limited literature review generates some uncertainty in the preliminary benchmarks and CSCLs.

Receptor Selection

The selection of the suite of receptors was intended to confer a protection to the entire ecosystem by representing key structural and functional components (e.g., producers, grazer guilds, predators). However, in establishing measurement endpoints for these assessment endpoints, a number of uncertainties and issues of concern were identified concerning the development of toxicological benchmarks. The approach used to select ecological receptors is based on the premise that, if key components of the ecosystem are protected, then protection will be conferred to the ecosystem. Although this approach is reasonable, given the nature of the analysis (i.e., generic) and the availability of data, protection of measurable endpoints may not adequately protect all ecologically significant receptors. For example, reptiles have high ecological significance in certain food webs. Snakes keep rodent and insect populations in check and serve as prey for many of the representative species; however, reptiles could not be evaluated because of a lack of life history and ecotoxicity data to characterize exposures. Thus, the selection of ecological receptors was ultimately driven by what could be assessed rather than what should be assessed.

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Attachments

Tables Supporting Ecological Risk Analysis for Chlorinated Aliphatics

Table 1. Constituents used for Exposure Analysis

Volatile and Semivolatile Organic Compounds		Metals		Dioxin and Furan Congeners	
Chemical Name	CAS Number	Chemical Name	CAS Number	Chemical Name	CAS Number
Acetone	67-64-1	Aluminum	7429-90-5	HpCDD, 1,2,3,4,6,7,8,-	99999-99-9
Allyl chloride	107-05-1	Arsenic	7440-38-2	HpCDF,1,2,3,4,6,7,8-	67562-39-4
Benzoic acid	65-85-0	Barium	7440-39-3	HpCDF,1,2,3,4,7,8,9-	55673-89-7
Bis(2-chloroethyl) ether	111-44-4	Cadmium	7440-43-9	HxCDD, 1,2,3,4,7,8-	39227-28-6
Bis(2-ethylhexyl) phthalate	117-81-7	Chromium	7440-47-3	HxCDD, 1,2,3,6,7,8-	57653-85-7
Carbon disulfide	75-15-0	Chromium III (insoluble salts)	16065-83-1	HxCDD, 1,2,3,7,8,9-	19408-74-3
Chloroform	67-66-3	Chromium VI	18540-29-9	HxCDF, 1,2,3,4,7,8-	70648-26-9
Dichloroethane, 1,2-	107-06-2	Cobalt	7440-48-4	HxCDF, 1,2,3,6,7,8-	57117-44-9
Hexachlorobenzene	118-74-1	Copper	7440-50-8	HxCDF, 1,2,3,7,8,9-	72918-21-9
Methyl ethyl ketone	78-93-3	Lead	7439-92-1	HxCDF, 2,3,4,6,7,8-	60851-34-5
Methylene chloride	75-09-2	Manganese	7439-96-5	OCDD, 1,2,3,4,5,7,8,9-	3268-87-9
Tetrachloroethylene	127-18-4	Molybdenum	7439-98-7	OCDF, 1,2,3,4,6,7,8,9-	39001-02-0
Trichloroethylene	79-01-6	Nickel	7440-02-0	PeCDD, 1,2,3,7,8-	40321-76-4
Vinyl acetate	108-05-4	Vanadium	7440-62-2	PeCDF, 1,2,3,7,8-	57117-41-6
Vinyl chloride	75-01-4	Zinc	7440-66-6	PeCDF, 2,3,4,7,8-	57117-31-4
				TCDD 2,3,7,8-	1746-01-6
				TCDF, 2,3,7,8-	51207-31-9

Table 2.1. Modeled Concentrations for Constituents in Soil, Sediment, Surface Water, and Plant Tissue Using High-End Management/Use Scenarios for EDC/VCM Landfills

CAS Number	Chemical Name	Sediment (mg/kg)	Total Surface Water (mg/L)	Dissolved Surface Water (mg/L)	Soil (mg/kg)	Plant (ug/g)
67-64-1	Acetone	1.4e-09	8.9e-08	8.9e-08	2.1e-11	3.6e-09
107-05-1	Allyl chloride	1.4e-10	1.9e-10	1.9e-10	4.8e-14	6.5e-12
7429-90-5	Aluminum	NA	NA	NA	NA	NA
7440-38-2	Arsenic	NA	NA	NA	NA	NA
7440-39-3	Barium	NA	NA	NA	NA	NA
65-85-0	Benzoic acid	1.1e-10	5.7e-11	5.7e-11	5.5e-11	5.0e-09
111-44-4	Bis(2-chlorethyl) ether	7.7e-10	1.8e-09	1.8e-09	3.2e-11	3.2e-09
117-81-7	Bis(2-ethylhexyl) phthalate	3.5e-09	5.3e-13	8.2e-15	2.4e-11	1.0e-05
7440-43-9	Cadmium	NA	NA	NA	NA	NA
75-15-0	Carbon disulfide	2.0e-09	7.6e-10	7.6e-10	2.6e-13	3.6e-11
67-66-3	Chloroform	2.1e-08	9.9e-09	9.9e-09	1.8e-11	2.4e-09
7440-47-3	Chromium	NA	NA	NA	NA	NA
16065-83-1	Chromium III (insoluble salts)	NA	NA	NA	NA	NA
18540-29-9	Chromium VI	NA	NA	NA	NA	NA
7440-48-4	Cobalt	NA	NA	NA	NA	NA
7440-50-8	Copper	NA	NA	NA	NA	NA
107-06-2	Dichloroethane, 1,2-	9.5e-09	1.2e-08	1.2e-08	2.0e-11	2.6e-09
118-74-1	Hexachlorobenzene	2.1e-08	4.4e-12	1.2e-12	8.9e-11	4.0e-10
7439-92-1	Lead	NA	NA	NA	NA	NA
7439-96-5	Manganese	NA	NA	NA	NA	NA
78-93-3	Methyl ethyl ketone	1.4e-10	2.6e-09	2.6e-09	2.0e-12	2.3e-10
75-09-2	Methylene chloride	6.4e-10	1.4e-09	1.4e-09	9.1e-13	1.1e-10
7439-98-7	Molybdenum	NA	NA	NA	NA	NA
7440-02-0	Nickel	NA	NA	NA	NA	NA
1746-01-6	TCDD-2,3,7,8	ID	9.2e-16	ID	1.0e-11	6.6e-11
127-18-4	Tetrachloroethylene	3.6e-09	3.1e-10	3.1e-10	9.3e-13	1.1e-10
79-01-6	Trichloroethylene	4.4e-10	3.4e-11	3.4e-11	1.9e-13	2.4e-11
7440-62-2	Vanadium	NA	NA	NA	NA	NA
108-05-4	Vinyl acetate	6.6e-11	4.5e-10	4.5e-10	2.4e-13	2.7e-11
75-01-4	Vinyl chloride	3.3e-10	3.9e-10	3.9e-10	5.3e-14	6.8e-12
7440-66-6	Zinc	NA	NA	NA	NA	NA

Note: Concentrations are based on dry weight waste concentration.
NA = Not a modeled pathway for metals in landfills. ID = Insufficient Data.

Table 2.2. Modeled Concentrations for Constituents in Soil, Sediment, Surface Water, and Plant Tissue Using High-End Management/Use Scenarios for EDC/VCM Land Treatment Unit

CAS Number	Chemical Name	Sediment (mg/kg)	Total Surface Water (mg/L)	Dissolved Surface Water (mg/L)	Soil (mg/kg)	Plant (mg/kg)
67-64-1	Acetone	1.9e-05	6.7e-04	6.7e-04	4.3e-09	8.9e-06
107-05-1	Allyl chloride	2.4e-07	1.9e-07	1.9e-07	3.1e-12	3.5e-08
7429-90-5	Aluminum	3.2e+03	2.4e+00	2.1e+00	1.4e+03	NA
7440-38-2	Arsenic	6.8e-01	3.5e-03	3.4e-03	7.8e-01	6.3e-02
7440-39-3	Barium	6.0e-01	1.0e-02	9.9e-03	1.1e+00	1.6e-01
65-85-0	Benzoic acid	5.9e-05	1.8e-05	1.8e-05	2.1e-06	1.5e-05
111-44-4	Bis(2-chlorethyl) ether	1.2e-04	1.6e-04	1.6e-04	1.6e-07	5.3e-06
117-81-7	Bis(2-ethylhexyl) phthalate	3.2e-02	4.8e-06	4.4e-08	4.2e-04	6.5e-03
7440-43-9	Cadmium	2.3e-04	3.5e-05	3.5e-05	2.1e-04	2.7e-05
75-15-0	Carbon disulfide	1.5e-06	3.3e-07	3.3e-07	2.1e-11	1.5e-07
67-66-3	Chloroform	2.8e-05	7.6e-06	7.6e-06	2.3e-09	2.5e-06
7440-47-3	Chromium	2.4e+01	3.0e-02	2.8e-02	1.3e+01	2.3e-01
16065-83-1	Chromium III (insoluble salts)	NM	NM	NM	NM	NM
18540-29-9	Chromium VI	NM	NM	NM	NM	NM
7440-48-4	Cobalt	4.3e-02	9.6e-04	9.6e-04	8.2e-02	2.4e-03
7440-50-8	Copper	1.2e+01	3.5e-01	3.4e-01	2.3e+01	7.4e-01
107-06-2	Dichloroethane, 1,2-	2.9e-05	2.1e-05	2.1e-05	2.9e-09	2.3e-06
118-74-1	Hexachlorobenzene	1.9e-03	3.6e-07	6.6e-08	3.6e-05	5.7e-06
7439-92-1	Lead	1.1e+00	1.3e-03	1.2e-03	5.9e-01	3.9e-03
7439-96-5	Manganese	4.5e+00	6.9e-02	6.9e-02	8.1e+00	1.9e+00
78-93-3	Methyl ethyl ketone	3.2e-06	3.5e-05	3.5e-05	7.8e-10	5.4e-07
75-09-2	Methylene chloride	1.3e-06	1.7e-06	1.6e-06	6.3e-11	1.9e-07
7439-98-7	Molybdenum	3.9e-03	2.0e-04	2.0e-04	6.5e-03	3.9e-03
7440-02-0	Nickel	2.3e+00	1.5e-02	1.5e-02	3.0e+00	4.0e-01
1746-01-6	TCDD, 2,3,7,8- (TEQ)	ID	6.0e-08	ID	4.1e-05	1.4e-05
127-18-4	Tetrachloroethylene	1.3e-06	6.3e-08	6.3e-08	1.0e-10	7.9e-08
79-01-6	Trichloroethylene	2.0e-07	9.2e-09	9.2e-09	3.0e-11	1.3e-08
7440-62-2	Vanadium	1.3e+00	1.4e-03	1.3e-03	6.7e-01	1.0e-02
108-05-4	Vinyl acetate	1.9e-07	7.4e-07	7.4e-07	1.5e-11	3.1e-08
75-01-4	Vinyl chloride	4.2e-07	3.0e-07	3.0e-07	3.1e-12	6.5e-08
7440-66-6	Zinc	2.4e+00	6.1e-02	6.1e-02	4.6e+00	4.1e-01

Note: Concentrations are based on wet weight waste concentrations.
NM = Not Modeled.
ID = Insufficient Data.

Table 2.3. Modeled Concentrations for Constituents in Soil, Sediment, Surface Water, and Plant Tissue Using High-End Management/Use Scenarios for Methyl Chloride Landfill

CAS Number	Chemical Name	Sediment (mg/kg)	Total Surface Water (mg/L)	Dissolved Surface Water (mg/L)	Soil (mg/kg)	Plant (mg/kg)
67-64-1	Acetone	2.3e-10	6.2e-09	6.2e-09	1.5e-11	1.8e-09
7429-90-5	Aluminum	NA	NA	NA	NA	NA
7440-38-2	Arsenic	NA	NA	NA	NA	NA
7440-47-3	Chromium VI	NA	NA	NA	NA	NA
7440-50-8	Copper	NA	NA	NA	NA	NA
7439-92-1	Lead	NA	NA	NA	NA	NA
7439-96-5	Manganese	NA	NA	NA	NA	NA
75-09-2	Methylene chloride	4.2e-08	3.9e-08	3.9e-08	2.6e-10	1.7e-08
7440-02-0	Nickel	NA	NA	NA	NA	NA
1746-01-6	TCDD, 2,3,7,8- (TEQ)	ID	1.9e-19	ID	5.5e-15	2.4e-13
7440-66-6	Zinc	NA	NA	NA	NA	NA

Note: NA = Not a modeled pathway for metals in landfills.
Concentrations are based on dry weight waste concentrations.
Only the above constitutes were modeled for this landfill.

Table 2.4. Modeled Concentrations for Constituents in Soil, Sediment, Surface Water, and Plant Tissue Using Central Tendency Management/Use Scenarios for EDC/VCM Landfills

CAS Number	Chemical Name	Sediment (mg/kg)	Total Surface Water (mg/L)	Dissolved Surface Water (mg/L)	Soil (mg/kg)	Plant (ug/g)
67-64-1	Acetone	1.4e-10	8.5e-09	8.5e-09	1.7e-12	2.8e-10
107-05-1	Allyl chloride	1.4e-11	1.8e-11	1.8e-11	3.8e-15	5.0e-13
7429-90-5	Aluminum	NA	NA	NA	NA	NA
7440-38-2	Arsenic	NA	NA	NA	NA	NA
7440-39-3	Barium	NA	NA	NA	NA	NA
65-85-0	Benzoic acid	1.0e-11	5.5e-12	5.5e-12	4.4e-12	3.8e-10
111-44-4	Bis(2-chlorethyl)ether	7.4e-11	1.7e-10	1.7e-10	2.6e-12	2.4e-10
117-81-7	Bis(2-ethylhexyl)phthalate	3.3e-10	5.1e-14	7.9e-16	1.9e-12	7.8e-07
7440-43-9	Cadmium	NA	NA	NA	NA	NA
75-15-0	Carbon disulfide	1.9e-10	7.3e-11	7.3e-11	2.1e-14	2.7e-12
67-66-3	Chloroform	1.6e-09	7.6e-10	7.6e-10	1.2e-12	1.6e-10
7440-47-3	Chromium	NA	NA	NA	NA	NA
16065-83-1	Chromium III (insoluble salts)	NA	NA	NA	NA	NA
18540-29-9	Chromium VI	NA	NA	NA	NA	NA
7440-48-4	Cobalt	NA	NA	NA	NA	NA
7440-50-8	Copper	NA	NA	NA	NA	NA
107-06-2	Dichloroethane, 1,2-	7.3e-10	9.4e-10	9.4e-10	1.4e-12	1.7e-10
118-74-1	Hexachlorobenzene	2.0e-09	4.2e-13	1.2e-13	7.1e-12	3.0e-11
7439-92-1	Lead	NA	NA	NA	NA	NA
7439-96-5	Manganese	NA	NA	NA	NA	NA
78-93-3	Methyl ethyl ketone	1.3e-11	2.4e-10	2.5e-10	1.6e-13	1.8e-11
75-09-2	Methylene chloride	6.1e-11	1.3e-10	1.3e-10	7.2e-14	8.5e-12
7439-98-7	Molybdenum	NA	NA	NA	NA	NA
7440-02-0	Nickel	NA	NA	NA	NA	NA
1746-01-6	TCDD-2,3,7,8 (TEQ)	ID	9.1e-18	ID	1.1e-13	5.9e-13
127-18-4	Tetrachloroethylene	3.5e-10	3.0e-11	3.0e-11	7.3e-14	8.4e-12
79-01-6	Trichloroethylene	4.2e-11	3.2e-12	3.2e-12	1.5e-14	1.8e-12
7440-62-2	Vanadium	NA	NA	NA	NA	NA
108-05-4	Vinyl acetate	6.3e-12	4.3e-11	4.3e-11	1.9e-14	2.1e-12
75-01-4	Vinyl chloride	3.2e-11	3.8e-11	3.8e-11	4.2e-15	5.2e-13
7440-66-6	Zinc	NA	NA	NA	NA	NA

Note: NA = Not a modeled pathway for metals in landfills.
ID = Insufficient Data.
Concentrations are based on dry weight waste concentration.

Table 2.5 Modeled Concentrations for Constituents in Soil, Sediment, Surface Water, and Plant Tissue Using Central Tendency Management/Use Scenarios for EDC/VCM Land Treatment Unit

CAS Number	Chemical Name	Sediment (mg/kg)	Total Surface Water (mg/L)	Dissolved Surface Water (mg/L)	Soil (mg/kg)	Plant (mg/kg)
67-64-1	Acetone	5.7e-06	2.0e-04	2.0e-04	1.2e-09	9.6e-07
107-05-1	Allyl chloride	1.7e-07	1.3e-07	1.3e-07	1.9e-12	8.7e-09
7429-90-5	Aluminum	8.3e+02	6.2e-01	5.5e-01	3.6e+02	NA
7440-38-2	Arsenic	2.6e-01	1.3e-03	1.3e-03	3.0e-01	2.0e-02
7440-39-3	Barium	3.3e-01	5.6e-03	5.5e-03	6.1e-01	7.5e-02
65-85-0	Benzoic acid	5.8e-05	1.8e-05	1.8e-05	1.8e-06	7.9e-06
111-44-4	Bis(2-chlorethyl) ether	7.4e-05	9.9e-05	9.9e-05	8.2e-08	1.4e-06
117-81-7	Bis(2-ethylhexyl) phthalate	1.0e-02	1.5e-06	1.4e-08	1.6e-04	1.0e-03
7440-43-9	Cadmium	1.2e-04	1.8e-05	1.8e-05	1.1e-04	9.9e-06
75-15-0	Carbon disulfide	5.5e-07	1.2e-07	1.2e-07	6.3e-12	2.0e-08
67-66-3	Chloroform	7.2e-06	1.9e-06	1.9e-06	4.8e-10	2.2e-07
7440-47-3	Chromium	8.2e+00	1.0e-02	9.6e-03	4.4e+00	5.6e-02
16065-83-1	Chromium III (insoluble salts)	NM	NM	NM	NM	NM
18540-29-9	Chromium VI	NM	NM	NM	NM	NM
7440-48-4	Cobalt	1.8e-02	4.0e-04	4.0e-04	3.4e-02	6.5e-04
7440-50-8	Copper	3.3e+00	9.3e-02	9.3e-02	6.1e+00	1.3e-01
107-06-2	Dichloroethane, 1,2-	7.4e-06	5.6e-06	5.5e-06	6.2e-10	2.1e-07
118-74-1	Hexachlorobenzene	1.6e-03	2.9e-07	5.4e-08	3.4e-05	2.4e-06
7439-92-1	Lead	4.3e-01	5.1e-04	4.8e-04	2.3e-01	5.2e-04
7439-96-5	Manganese	2.0e+00	3.1e-02	3.1e-02	3.6e+00	7.5e-01
78-93-3	Methyl ethyl ketone	9.7e-07	1.1e-05	1.1e-05	2.1e-10	6.0e-08
75-09-2	Methylene chloride	6.0e-07	7.4e-07	7.4e-07	2.4e-11	3.0e-08
7439-98-7	Molybdenum	2.0e-03	1.0e-04	1.0e-04	3.4e-03	1.8e-03
7440-02-0	Nickel	1.2e+00	8.4e-03	8.3e-03	1.7e+00	1.9e-01
1746-01-6	TCDD, 2,3,7,8- (TEQ)	ID	5.2e-09	ID	3.5e-06	4.8e-07
127-18-4	Tetrachloroethylene	6.0e-07	3.0e-08	3.0e-08	4.2e-11	1.4e-08
79-01-6	Trichloroethylene	1.8e-07	8.2e-09	8.2e-09	2.3e-11	4.1e-09
7440-62-2	Vanadium	6.4e-01	6.9e-04	6.4e-04	3.2e-01	3.2e-03
108-05-4	Vinyl acetate	1.6e-07	6.3e-07	6.3e-07	1.1e-11	9.0e-09
75-01-4	Vinyl chloride	2.3e-07	1.6e-07	1.6e-07	1.4e-12	1.3e-08
7440-66-6	Zinc	8.7e-01	2.2e-02	2.2e-02	1.6e+00	1.2e-01

Note: Concentrations are based on wet weight waste concentrations.
NM = Not Modeled.
ID = Insufficient Data.

Table 2.6. Modeled Concentrations for Constituents in Soil, Sediment, Surface Water, and Plant Tissue Using Central Tendency Management/Use Scenarios for Methyl chloride Landfill

CAS Number	Chemical Name	Sediment (mg/kg)	Total Surface Water (mg/L)	Dissolved Surface Water (mg/L)	Soil (mg/kg)	Plant (mg/kg)
67-64-1	Acetone	1.5e-10	4.0e-09	4.0e-09	1.6e-12	1.9e-10
7429-90-5	Aluminum	NA	NA	NA	NA	NA
7440-38-2	Arsenic	NA	NA	NA	NA	NA
7440-47-3	Chromium VI	NA	NA	NA	NA	NA
7440-50-8	Copper	NA	NA	NA	NA	NA
7439-92-1	Lead	NA	NA	NA	NA	NA
7439-96-5	Manganese	NA	NA	NA	NA	NA
75-09-2	Methylene chloride	2.7e-08	2.5e-08	2.5e-08	2.9e-11	1.8e-09
7440-02-0	Nickel	NA	NA	NA	NA	NA
1746-01-6	TCDD, 2,3,7,8- (TEQ)	ID	1.1e-19	ID	8.3e-16	2.6e-14
7440-66-6	Zinc	NA	NA	NA	NA	NA

Note: NA = Not a modeled pathway for metals in landfills.
Concentrations are based on dry weight waste concentrations.
Only the above constitutes were modeled for this landfill.

Table 3.1. Hazard Quotient (HQs) Calculated for Constituents in Soil, Sediment, Surface Water, and Plant Tissue Using High-End Management/Use Scenarios for EDC/VCM Landfills

CAS Number	Chemical Name	Sediments	Total Surface Water	Dissolved Surface Water	Soil	Plant
67-64-1	Acetone	1.7e-07	5.9e-08	ID	ID	ID
107-05-1	Allyl chloride	ID	ID	ID	ID	ID
7429-90-5	Aluminum	NA	NA	NA	NA	NA
7440-38-2	Arsenic	NA	NA	NA	NA	NA
7440-39-3	Barium	NA	NA	NA	NA	NA
65-85-0	Benzoic acid	ID	1.4e-09	ID	ID	ID
111-44-4	Bis(2-chlorethyl) ether	ID	ID	ID	ID	ID
117-81-7	Bis(2-ethylhexyl) phthalate	1.9e-08	1.8e-10	ID	2.7e-11	6.5e-07
7440-43-9	Cadmium	NA	NA	NA	NA	NA
75-15-0	Carbon disulfide	2.3e-06	8.3e-07	ID	ID	ID
67-66-3	Chloroform	9.7e-07	3.5e-07	ID	2.6e-13	2.9e-11
7440-47-3	Chromium	NA	NA	NA	NA	NA
16065-83-1	Chromium III (insoluble salts)	NA	NA	NA	NA	NA
18540-29-9	Chromium VI	NA	NA	NA	NA	NA
7440-48-4	Cobalt	NA	NA	NA	NA	NA
7440-50-8	Copper	NA	NA	NA	NA	NA
107-06-2	Dichloroethane, 1,2-	3.8e-08	1.3e-08	ID	1.4e-12	1.7e-11
118-74-1	Hexachlorobenzene	2.8e-10	6.0e-07	ID	1.8e-10	4.8e-11
7439-92-1	Lead	NA	NA	NA	NA	NA
7439-96-5	Manganese	NA	NA	NA	NA	NA
78-93-3	Methyl ethyl ketone	ID	7.2e-13	ID	2.4e-16	2.5e-14
75-09-2	Methylene chloride	1.7e-09	6.1e-10	ID	ID	ID
7439-98-7	Molybdenum	NA	NA	NA	NA	NA
7440-02-0	Nickel	NA	NA	NA	NA	NA
1746-01-6	TCDD-2,3,7,8	ID	6.9e-05	ID	6.1e-06	1.2e-05
127-18-4	Tetrachloroethylene	8.9e-09	3.2e-09	ID	5.2e-14	ID
79-01-6	Trichloroethylene	2.0e-09	1.4e-09	ID	1.0e-13	1.1e-11
7440-62-2	Vanadium	NA	NA	NA	NA	NA
108-05-4	Vinyl acetate	7.8e-08	2.8e-08	ID	ID	ID
75-01-4	Vinyl chloride	ID	6.9e-09	ID	6.5e-14	7.3e-12
7440-66-6	Zinc	NA	NA	NA	NA	NA

Note: NA = Not a modeled pathway for metals in landfills.
ID = Insufficient Data

Table 3.2. Hazard Quotient (HQs) Calculated for Constituents in Soil, Sediment, Surface Water, and Plant Tissue Using High-End Management/Use Scenarios for EDC/VCM Land Treatment Unit

CAS Number	Chemical Name	Sediment	Total Surface Water	Dissolved Surface Water	Soil	Plant
67-64-1	Acetone	2.1e-03	4.5e-04	ID	ID	ID
107-05-1	Allyl chloride	ID	ID	ID	ID	ID
7429-90-5	Aluminum	ID	1.8e+02	ID	2.8e+02	ID
7440-38-2	Arsenic	9.5e-02	1.1e+00	2.3e-02	7.8e-02	7.7e-01
7440-39-3	Barium	ID	2.5e+00	ID	6.4e-02	5.2e-04
65-85-0	Benzoic acid	ID	4.3e-04	ID	ID	ID
111-44-4	Bis(2-chlorethyl)ether	ID	ID	ID	ID	ID
117-81-7	Bis(2-ethylhexyl)phthalate	1.7e-01	1.6e-03	ID	4.8e-04	4.1e-04
7440-43-9	Cadmium	3.3e-04	1.7e-02	1.5e-02	6.8e-03	4.6e-06
75-15-0	Carbon disulfide	1.7e-03	3.6e-04	ID	ID	ID
67-66-3	Chloroform	1.3e-03	2.7e-04	ID	3.3e-11	3.0e-08
7440-47-3	Chromium VI	4.5e-01	3.4e-03	ID	2.0e-01	ID
16065-83-1	Chromium III (insoluble salts)	NM	NM	NM	NM	NM
18540-29-9	Chromium VI	NM	NM	NM	NM	NM
7440-48-4	Cobalt	ID	4.2e-02	ID	4.1e-03	ID
7440-50-8	Copper	6.3e-01	2.9e+01	3.9e+01	1.1e+00	1.9e-02
107-06-2	Dichloroethane, 1,2-	1.1e-04	2.3e-05	ID	2.1e-10	1.6e-08
118-74-1	Hexachlorobenzene	2.5e-05	4.9e-02	ID	7.4e-05	6.9e-07
7439-92-1	Lead	3.7e-02	4.0e+00	6.2e-01	2.1e-02	1.4e-01
7439-96-5	Manganese	5.5e-03	5.8e-01	ID	1.9e-02	4.1e-03
78-93-3	Methyl ethyl ketone	ID	9.8e-09	ID	9.3e-14	5.8e-11
75-09-2	Methylene chloride	3.6e-06	7.5e-07	ID	ID	ID
7439-98-7	Molybdenum	ID	5.3e-04	ID	3.3e-03	1.1e-03
7440-02-0	Nickel	1.4e-01	3.0e+00	2.9e-01	2.1e-01	1.7e-03
1746-01-6	TCDD, 2,3,7,8- (TEQ)	ID	4.5e+03	ID	2.5e+01	2.6e+00
127-18-4	Tetrachloroethylene	3.1e-06	6.4e-07	ID	5.8e-12	ID
79-01-6	Trichloroethylene	9.2e-07	3.9e-07	ID	1.7e-11	6.0e-09
7440-62-2	Vanadium	ID	7.1e-02	ID	5.5e-01	3.8e-03
108-05-4	Vinyl acetate	2.2e-04	4.7e-05	ID	ID	ID
75-01-4	Vinyl chloride	ID	5.2e-06	ID	3.9e-12	7.0e-08

Note: NM = Not Modeled for the LTU.
ID = Insufficient Data.
Highlighted boxes represent hazard quotients greater than 1.

Table 3.3. Hazard Quotient (HQs) Calculated for Constituents in Soil, Sediment, Surface Water, and Plant Tissue Using High-End Management/Use Scenarios for Methyl chloride Landfill

CAS Number	Chemical Name	Sediment	Total Surface Water	Dissolved Surface Water	Soil	Plant
67-64-1	Acetone	2.6e-08	4.1e-09	ID	ID	ID
7429-90-5	Aluminum	NA	NA	NA	NA	NA
7440-38-2	Arsenic	NA	NA	NA	NA	NA
7440-47-3	Chromium VI	NA	NA	NA	NA	NA
7440-50-8	Copper	NA	NA	NA	NA	NA
7439-92-1	Lead	NA	NA	NA	NA	NA
7439-96-5	Manganese	NA	NA	NA	NA	NA
75-09-2	Methylene chloride	1.1e-07	1.8e-08	ID	ID	ID
7440-02-0	Nickel	NA	NA	NA	NA	NA
1746-01-6	TCDD, 2,3,7,8- (TEQ)	ID	1.4e-08	ID	3.4e-09	4.4e-08
7440-66-6	Zinc	NA	NA	NA	NA	NA

Note: NA = Not a modeled pathway for metals in landfills.
ID = Insufficient Data.
Only the above constitutes were modeled for this landfill.

Table 3.4. Hazard Quotient (HQs) Calculated for Constituents in Soil, Sediment, Surface Water, and Plant Tissue Using Central Tendency Management/Use Scenarios for EDC/VCM Landfills

CAS Number	Chemical Name	Sediment	Total Surface Water	Dissolved Surface Water	Soil	Plant
67-64-1	Acetone	1.6e-08	5.7e-09	ID	ID	ID
107-05-1	Allyl chloride	ID	ID	ID	ID	ID
7429-90-5	Aluminum	NA	NA	NA	NA	NA
7440-38-2	Arsenic	NA	NA	NA	NA	NA
7440-39-3	Barium	NA	NA	NA	NA	NA
65-85-0	Benzoic acid	ID	1.3e-10	ID	ID	ID
111-44-4	Bis(2-chlorethyl) ether	ID	ID	ID	ID	ID
117-81-7	Bis(2-ethylhexyl) phthalate	1.8e-09	1.7e-11	ID	2.2e-12	5.0e-08
7440-43-9	Cadmium	NA	NA	NA	NA	NA
75-15-0	Carbon disulfide	2.2e-07	8.0e-08	ID	ID	ID
67-66-3	Chloroform	7.5e-08	2.7e-08	ID	1.7e-14	1.9e-12
7440-47-3	Chromium	NA	NA	NA	NA	NA
16065-83-1	Chromium III (insoluble salts)	NA	NA	NA	NA	NA
18540-29-9	Chromium VI	NA	NA	NA	NA	NA
7440-48-4	Cobalt	NA	NA	NA	NA	NA
7440-50-8	Copper	NA	NA	NA	NA	NA
107-06-2	Dichloroethane, 1,2-	2.9e-09	1.0e-09	ID	9.7e-14	1.1e-12
118-74-1	Hexachlorobenzene	2.7e-11	5.8e-08	ID	1.5e-11	3.7e-12
7439-92-1	Lead	NA	NA	NA	NA	NA
7439-96-5	Manganese	NA	NA	NA	NA	NA
78-93-3	Methyl ethyl ketone	ID	6.9e-14	ID	1.9e-17	1.9e-15
75-09-2	Methylene chloride	1.7e-10	5.9e-11	ID	ID	ID
7439-98-7	Molybdenum	NA	NA	NA	NA	NA
7440-02-0	Nickel	NA	NA	NA	NA	NA
1746-01-6	TCDD-2,3,7,8 (TEQ)	ID	6.8e-07	ID	6.9e-08	1.1e-07
127-18-4	Tetrachloroethylene	8.5e-10	3.0e-10	ID	4.1e-15	ID
79-01-6	Trichloroethylene	1.9e-10	1.4e-10	ID	8.2e-15	8.6e-13
7440-62-2	Vanadium	NA	NA	NA	NA	NA
108-05-4	Vinyl acetate	7.5e-09	2.7e-09	ID	ID	ID
75-01-4	Vinyl chloride	ID	6.6e-10	ID	5.2e-15	5.5e-13
7440-66-6	Zinc	NA	NA	NA	NA	NA

Note: NA = Not a modeled pathway for metals in landfills.
ID = Insufficient Data

Table 3.5. Hazard Quotient (HQs) Calculated for Constituents in Soil, Sediment, Surface Water, and Plant Tissue Using Central Tendency Management/Use Scenarios for Land Treatment Unit

CAS Number	Chemical Name	Sediment	Total Surface Water	Dissolved Surface Water	Soil	Plant
67-64-1	Acetone	6.5e-04	1.4e-04	ID	ID	ID
107-05-1	Allyl Chloride	ID	ID	ID	ID	ID
7429-90-5	Aluminum	ID	4.6e+01	ID	7.4e+01	ID
7440-38-2	Arsenic	3.6e-02	4.1e-01	8.6e-03	3.0e-02	2.5e-01
7440-39-3	Barium	ID	1.4e+00	ID	3.6e-02	2.5e-04
65-85-0	Benzoic Acid	ID	4.3e-04	ID	ID	ID
111-44-4	Bis (2-chloroethyl) ether	ID	ID	ID	ID	ID
117-81-7	Bis(2-ethylhexyl) phthalate	5.6e-02	5.1e-04	ID	1.8e-04	6.4e-05
7440-43-9	Cadmium	1.7e-04	9.1e-03	7.9e-03	3.5e-03	1.7e-06
75-15-0	Carbon disulfide	6.5e-04	1.4e-04	ID	ID	ID
67-66-3	Chloroform	3.3e-04	6.9e-05	ID	6.8e-12	2.7e-09
7440-47-3	Chromium	1.6e-01	1.2e-03	ID	6.9e-02	ID
16065-83-1	Chromium III (insoluble salts)	NM	NM	NM	NM	NM
18540-29-9	Chromium VI	NM	NM	NM	NM	NM
7440-48-4	Cobalt	ID	1.8e-02	ID	1.7e-03	ID
7440-50-8	Copper	1.7e-01	7.8e+00	1.0e+01	2.9e-01	3.3e-03
107-06-2	Dichloroethane, 1,2-	3.0e-05	6.1e-06	ID	4.5e-11	1.4e-09
118-74-1	Hexachlorobenzene	2.1e-05	4.0e-02	ID	6.9e-05	2.9e-07
7439-92-1	Lead	1.4e-02	1.5e+00	2.4e-01	8.1e-03	1.9e-02
7439-96-5	Manganese	2.5e-03	2.6e-01	ID	8.7e-03	1.6e-03
78-93-3	Methyl ethyl ketone	ID	3.0e-09	ID	2.5e-14	6.4e-12
75-09-2	Methylene chloride	1.6e-06	3.4e-07	ID	ID	ID
7439-98-7	Molybdenum	ID	2.7e-04	ID	1.7e-03	5.0e-04
7440-02-0	Nickel	7.8e-02	1.7e+00	1.6e-01	1.2e-01	8.0e-04
1746-01-6	TCDD 2,3,7,8- (TEQ)	ID	3.9e+02	ID	2.2e+00	8.7e-02
127-18-4	Tetrachloroethylene	1.5e-06	3.0e-07	ID	2.3e-12	ID
79-01-6	Trichloroethylene	8.2e-07	3.4e-07	ID	1.3e-11	2.0e-09
7440-62-2	Vanadium	ID	3.4e-02	ID	2.7e-01	1.2e-03
108-05-4	Vinyl Acetate	1.9e-04	3.9e-05	ID	ID	ID
75-01-4	Vinyl chloride	ID	2.9e-06	ID	1.8e-12	1.3e-08
7440-66-6	Zinc	7.0e-03	7.3e-01	1.8e-01	2.2e+00	7.7e-04

Note: NM = Not Modeled for the LTU.
ID = Insufficient Data.
Highlighted boxes represent hazard quotients greater than 1.

Table 3.6. Hazard Quotient (HQs) Calculated for Constituents in Soil, Sediment, Surface Water, and Plant Tissue Using Central Tendency Management/Use Scenarios for Methyl chloride Landfill

CAS Number	Chemical Name	Sediment	Total Surface Water	Dissolved Surface Water	Soil	Plant
67-64-1	Acetone	1.7e-08	2.7e-09	ID	ID	ID
7429-90-5	Aluminum	NA	NA	NA	NA	NA
7440-38-2	Arsenic	NA	NA	NA	NA	NA
7440-47-3	Chromium VI	NA	NA	NA	NA	NA
7440-50-8	Copper	NA	NA	NA	NA	NA
7439-92-1	Lead	NA	NA	NA	NA	NA
7439-96-5	Manganese	NA	NA	NA	NA	NA
75-09-2	Methylene chloride	7.3e-08	1.1e-08	ID	ID	ID
7440-02-0	Nickel	NA	NA	NA	NA	NA
1746-01-6	TCDD, 2,3,7,8- (TEQ)	ID	8.4e-09	ID	5.1e-10	4.7e-09
7440-66-6	Zinc	NA	NA	NA	NA	NA

Note: NA = Not a modeled pathway for metals in landfills.
ID = Insufficient Data.
Only the above constitutes were modeled for this landfill.

Table 4. Toxicity Equivalency Factors (TEFs) for Dioxin and Furan Congeners

Congener	TEF
1,2, 3, 4, 6, 7,8- Heptachlorodibenzodioxin	0.01
1, 2, 3, 4, 6, 7, 8-Heptachlorodibenzofuran	0.01
1, 2, 3, 4, 7, 8, 9-Heptachlorodibenzofuran	0.01
1, 2, 3, 4, 7, 8-Hexachlorodibenzodioxin	0.1
1, 2, 3, 6, 7, 8-Hexachlorodibenzodioxin	0.1
1, 2, 3, 7, 8, 9-Hexachlorodibenzodioxin	0.1
1, 2, 3, 7, 8, 9-Hexachlorodibenzofuran	0.1
2, 3, 4, 6, 7, 8-Hexachlorodibenzofuran	0.1
1, 2, 3, 6, 7, 8-Hexachlorodibenzofuran	0.1
1,2, 3, 4, 7, 8-Hexachlorodibenzofuran	0.1
Octochlorodibenzodioxin	0.001
Octochlorodibenzofuran	0.001
1, 2, 3, 7, 8-Pentachlorodibenzodioxin	0.5
1, 2, 3, 7, 8-Pentachlorodibenzofuran	0.05
2, 3, 4, 7, 8-Pentachlorodibenzofuran	0.5
2, 3, 7, 8-Tetrachlorodibenzodioxin	1
2, 3, 7, 8-Tetrachlorodibenzofuran	0.1

Appendix K

Deterministic and Probabilistic Input Data

Table K-1. List of Input Parameters for the Deterministic Analysis

Parameter	Units	High End	Central Tendency	Used in:					Reference
				Partitioning	CHEMDAT8	ISC	EPACMTP	Indirect Exp.	
EDC/VCM Wastewater Treatment Sludge Managed in an Off-site Landfill									
Waste Parameters									
Annual waste (sludge) quantity	Mtons/yr	1,804	542.2	✓					U.S. EPA, 1999 (TBD)
Waste concentration	mg/kg		Chemical-specific	✓					U.S. EPA, 1999 (TBD)
Leachate concentration (TCLP)	mg/L		Chemical-specific				✓		U.S. EPA, 1999 (TBD)
Bulk density	g/cm^3		1.07	✓					U.S. EPA, 1991b[1]
Fraction of organic carbon	unitless		0.1364 (DW) 0.0358 (WW)	✓					U.S. EPA, 1999 (TBD)
Landfill Parameters									
Site location (based on Met data)		Baton Rouge	Houston	✓		✓	✓	✓	See Section 2
Station location for air modeling data Surface data Upper air data		 Baton Rouge Lake Charles	 Houston Lake Charles			✓			Professional judgement
Area	m^2	420,888 (For groundwater modeling only)	60,705	✓		✓	✓	✓	DPRA, 1993
Depth	m		11	✓					Crumley, 1997 (50th percentile)

Table K-1. List of Input Parameters for the Deterministic Analysis (continued)

Parameter	Units	High End	Central Tendency	Used in:					Reference
				Partitioning	CHEMDAT8	ISC	EPACMTP	Indirect Exp.	
Apparent depth of waste	m		6.25				✓		The apparent depth of waste is calculated from the waste volume (90th percentile), the bulk density, and the landfill depth (10th percentile).
Active life	yrs		30	✓					DPRA, 1993
Inactive period (following closure)	yrs		40	✓					Assumption
Area of active face	m^2		2,024	✓		✓			Calculated based on area of the landfill and the number of cells (Total area of landfill/Number of cells)
Number of cells			30	✓					Assumed one active cell per year of operation.
Water-filled soil porosity	unitless		0.12	✓					U.S. EPA, 1994b; The HELP Model, pg.33
Total soil porosity	unitless		0.671	✓					U.S. EPA, 1994b; The HELP Model, pg.30, "Table 4. Default Soil, Waste, and Geosynthetic Characteristics"
Air porosity	unitless		0.55	✓					Calculated (Air Porosity = Total soil porosity - Water filled soil porosity)
Layers	unitless		11	✓					Assumption
Daily additions/layer	unitless		31	✓					Assumption

Table K-1. List of Input Parameters for the Deterministic Analysis (continued)

Parameter	Units	High End	Central Tendency	Used in: Partitioning	CHEMDAT8	ISC	EPACMTP	Indirect Exp.	Reference
Avg. exposed time	days		32	✓					Assumption
Area of daily addition	m^2		66	✓					Assumption
Length of time daily waste is uncovered	hrs		12	✓					Assumption
Thickness of daily cover	m		0.15	✓					40 CFR 258.21, 1994
Type of daily cover			Soil	✓					Assumption
Type of cap			Soil	✓					Assumption
Thickness of cap	m		0.6	✓					40 CFR 258.60, 1994 (18 inches of earthen material to minimize infiltration, 6 inches of earthen material to minimize erosion.
Operating Days per Year	d/yr		350	✓					Assumption
Source duration	yr		Constituent-specific value				✓		Leaching continues until all constituent mass is depleted; U.S. EPA, 1997a
Location Specific Parameters									
Surface and Subsurface Soil Parameters (Unsaturated zone)									
Soil texture		Silt loam	Loam						Miller and White, 1998
Average soil pH	unitless	5.6	7.1				✓		EPA Hydrogeologic Database for Industrial Subtitle D facilities
Residual water content	unitless	0.067	0.078				✓		Carsel and Parish, 1988

Table K-1. List of Input Parameters for the Deterministic Analysis (continued)

Parameter	Units	High End	Central Tendency	Used in: Partitioning	CHEMDAT8	ISC	EPACMTP	Indirect Exp.	Reference
Soil bulk density	g/cm^3	1.46	1.51				✓	✓	Calculated from saturated volumetric water content
Fraction of organic carbon for soil	unitless	0.012	0.0067					✓	Schwarz and Alexander, 1995
USLE Rainfall factor for receptor location	1/yr	520	414					✓	USDA, 1978
USLE erodibility factor for receptor location	tons/acre	0.43	0.35					✓	Schwarz and Alexander, 1995
USLE length/slope factor for receptor location	unitless	0.402	0.152					✓	USDA, 1978
USLE cover factor for receptor location	unitless		0.12					✓	USDA, 1978
USLE erosion control practice factor for receptor location	unitless		1					✓	USDA, 1978
Soil saturated volumetric water content	unitless	0.45	0.43				✓	✓	Carsel and Parish, 1988
Saturated hydraulic conductivity	cm/hr	0.45	1.04				✓	✓	Carsel and Parish, 1988
Soil specific exponent representing water retention	unitless	5.3	5.39					✓	Clapp and Hornberger, 1978
Hydraulic parameter, α	1/cm	0.02	0.036				✓		Carsel and Parish, 1988
Hydraulic parameter, β	unitless	1.41	1.56				✓		Carsel and Parish, 1988
Unsaturated zone thickness (depth to water table)	m	13	8				✓		Guthrie, 1998b
Percent organic matter	unitless	2.045	1.163				✓		Schwarz and Alexander, 1995
Saturated Zone Parameters									
Porosity	unitless		0.24				✓		U.S. EPA, 1997a

Table K-1. List of Input Parameters for the Deterministic Analysis (continued)

Parameter	Units	High End	Central Tendency	Used in: Partitioning	Used in: CHEMDAT8	Used in: ISC	Used in: EPACMTP	Used in: Indirect Exp.	Reference
Soil bulk density	g/cm^3	1.46	1.51				✓		Calculated from saturated volumetric water content
Saturated zone thickness (Aquifer thickness)	m		9.14				✓		API Database, U.S. EPA, 1997a and 1997b
Hydraulic conductivity (K_x)	m/yr		1580				✓		API Database, U.S. EPA, 1997a and 1997b
Hydraulic gradient	unitless		0.005				✓		API Database, U.S. EPA, 1997a and 1997b
Longitudinal dispersivity (α_L)	m	HE(x)=5.29 HE(y)=8.29	8.29				✓		U.S. EPA, 1997a and Gelhar et al., 1992
Transverse dispersivity (α_T)	m	HE(x)=0.66 HE(y)=1.04	1.04				✓		Derived from α_L (U.S. EPA, 1997a)
Veritical dispersivity (α_V)	m	HE(x)=0.03 HE(y)=0.05	0.05				✓		Derived from α_T (U.S. EPA, 1997a)
Seepage velocity (pore velocity)	m/yr		32.92				✓		Derived from conductivity and gradient
Groundwater temperature	°C		22.5				✓		U.S. EPA, 1997a and 1997b, based on location
Aquifer pH	unitless		7.1				✓		EPA's STORET database for HWIR analysis; U.S. EPA, 1997a
Fraction organic carbon	unitless	0.012	0.0067				✓		Schwarz and Alexander, 1995

Table K-1. List of Input Parameters for the Deterministic Analysis (continued)

Parameter	Units	High End	Central Tendency	Used in: Partitioning	CHEMDAT8	ISC	EPACMTP	Indirect Exp.	Reference
Meteorological Parameters									
Annual average precipitation rate	cm/yr	146.1	119.1	✓		✓		✓	NOAA, 1992
Annual average irrigation rate	cm/yr		0	✓				✓	Assumption
Annual average runoff rate	cm/yr	24	14	✓				✓	Geraghty et al., 1973
Average annual evapotranspiration rate	cm/yr	74	66	✓				✓	Calculated (Evapotranspiration = Precipitation - (Precipitation/3) - Runoff)
Infiltration rate used in Jury solution[2]	cm/yr	49	40	✓					Calculated (Precipation + Irrigation - Evapotranspiration - Runoff)
Infiltration rate used in EPACMTP[2]	cm/yr	59	5.5				✓		HELP modeling for closest HWIR climate site (silty loam soil); U.S. EPA, 1997a and 1997b.
Recharge rate	m/yr	0.55	0.25				✓		Guthrie, 1998b
Ambient air temperature	°K	293	294			✓		✓	NOAA, 1992
Mean annual wind speed	m/s	4.1	4.1			✓		✓	NOAA, 1992
Methyl Chloride Wastewater Treatment Sludge Managed in an On-site Landfill									
Waste Parameters									
Annual waste (sludge) quantity	Mtons/yr		776	✓					U.S. EPA, 1999 (TBD)

Table K-1. List of Input Parameters for the Deterministic Analysis (continued)

Parameter	Units	High End	Central Tendency	Used in:					Reference
				Partitioning	CHEMDAT8	ISC	EPACMTP	Indirect Exp.	
Waste concentration	mg/kg		Chemical-specific	✓					U.S. EPA, 1999 (TBD)
Bulk density	g/cm^3		1.07	✓					U.S. EPA, 1991b[1]
Fraction of organic carbon	unitless		0.079	✓					U.S. EPA, 1999 (TBD)
Landfill Parameters									
Site location (based on Met data)			Louisville, KY	✓		✓		✓	Actual landfill location
Station location for air modeling data Surface data Upper air data			 Louisville, KY Dayton, OH			✓			Professional judgement
Area	m^2		83,610	✓				✓	Atwood, 1998 (Personal communication)
Depth	m		1.83	✓					Atwood, 1998 (Personal communication)
Active life	yrs		90	✓					Assumption
Inactive period (following closure)	yrs		40	✓					Assumption
Area of active face	m^2		929	✓		✓			Atwood, 1998 (Personal communication)
Number of cells			90	✓					Assumed one active cell per year of operation.
Water-filled soil porosity	unitless		0.12	✓					U.S. EPA, 1994b; (HELP Model, pg.33)

Table K-1. List of Input Parameters for the Deterministic Analysis (continued)

Parameter	Units	High End	Central Tendency	Used in: Partitioning	CHEMDAT8	ISC	EPACMTP	Indirect Exp.	Reference
Total soil porosity	unitless		0.671	✓					U.S. EPA, 1994b; (HELP Model, pg.30, "Table 4. Default Soil, Waste, and Geosynthetic Characteristics")
Air porosity	unitless		0.55	✓					Calculated (Total soil porosity - Water filled soil porosity)
Layers			7	✓					Assumption
Daily Additions/Layer			50	✓					Assumption
Average Exposed Time	days		52	✓					Calculated (Avg. Exposed Time = 365 days per year/7 Layers)
Depth of Daily Addition	m		0.26	✓					Assumption
Area of Daily Addition	m^2		18.58	✓					Assumption
Length of uncovered time for the first day	hrs		24	✓					Assumption
Thickness of daily cover	m		0	✓					Assumption
Type of daily cover			Soil	✓					Assumption
Type of cap			Soil	✓					Assumption
Thickness of cap	m		0.3	✓					Assumption
Operating Days per Year	d/yr		350	✓					Assumption

Table K-1. List of Input Parameters for the Deterministic Analysis (continued)

Parameter	Units	High End	Central Tendency	Used in: Partitioning	Used in: CHEMDAT8	Used in: ISC	Used in: EPACMTP	Used in: Indirect Exp.	Reference
Location Specific Parameters									
Surface and Subsurface Soil Parameters									
Soil texture			Silt loam						Miller and White, 1998
Average soil pH	unitless		6.0				✓		Schwarz and Alexander, 1995
Residual water content	unitless		0.089				✓		Carsel and Parish, 1988
Soil bulk density	g/cm^3		1.46	✓				✓	Calculated from saturated volumetric water content
Fraction of organic carbon	unitless		0.016					✓	Schwarz and Alexander, 1995
USLE rainfall factor for receptor location	1/yr		193					✓	USDA, 1978
USLE erodibility factor for receptor location	tons/acre		0.33					✓	Schwarz and Alexander, 1995
USLE length/slope factor for receptor location	unitless		1.69					✓	USDA, 1978
USLE cover factor for receptor location	unitless		0.12					✓	USDA, 1978
USLE erosion control practice factor for receptor location	unitless		1					✓	USDA, 1978
Soil saturated volumetric water content	unitless		0.45					✓	Carsel and Parish, 1988
Saturated hydraulic conductivity	cm/hr		0.45					✓	Carsel and Parish, 1988
Soil specific exponent representing water retention	unitless		5.3					✓	Clapp and Hornberger, 1978

Table K-1. List of Input Parameters for the Deterministic Analysis (continued)

Parameter	Units	High End	Central Tendency	Used in: Partitioning	CHEMDAT8	ISC	EPACMTP	Indirect Exp.	Reference
Meteorological Parameters									
Annual average precipitation rate	cm/yr		112	✓		✓		✓	NOAA, 1992
Annual average irrigation rate	cm/yr		0	✓				✓	Assumption
Annual average runoff rate	cm/yr		21	✓				✓	Geraghty et al., 1973
Average annual evapotranspiration rate	cm/yr		53	✓				✓	Calculated (Evapotranspiration = Precipitation - (Precipitation/3) - Runoff)
Infiltration rate	cm/yr		37	✓					Calculated (Precipitation + Irrigation - Evapotranspiration - Runoff)
Ambient air temperature	°K		287				✓	✓	NOAA, 1992
Mean annual wind speed	m/s		4.1				✓	✓	NOAA, 1992
EDC/VCM Waste Managed in a Land Treatment Unit									
Waste Parameters									
Annual waste (sludge) quantity	Mtons/yr		624.2	✓					U.S. EPA, 1999 (TBD)
Waste concentration	mg/kg		Chemical-specific	✓					U.S. EPA, 1999 (TBD)
Fraction of organic carbon	unitless		0.0358	✓				✓	U.S. EPA, 1999 (TBD) (Wet weight)

Table K-1. List of Input Parameters for the Deterministic Analysis (continued)

Parameter	Units	High End	Central Tendency	Used in: Partitioning	CHEMDAT8	ISC	EPACMTP	Indirect Exp.	Reference
LTU Parameters									
Site location (based on Met data)			Baton Rouge	✓		✓	✓	✓	Actual land treatment unit location
Station location for air modeling data Surface data Upper air data			 Baton Rouge Lake Charles			✓			Professional judgement
Area	m^2		687,990	✓		✓		✓	U.S. EPA, 1999 (TBD)
Active life	yrs		40	✓					Assumption
Inactive period (following closure)	yrs		40	✓					Assumption
Tilling depth	m		0.2	✓					U.S. EPA, 1990 (Indirect Exposure Document)
Bulk Density at the LTU	g/cm^3		1.52	✓					Carsel and Parish, 1988
Source duration	yr		80				✓		Assumption
Location Specific Parameters									
Surface and Subsurface Soil Parameters (Unsaturated Zone)									
Soil texture			Silt loam						Miller and White, 1998
Average soil pH	unitless		6.8				✓		Schwarz and Alexander, 1995
Residual water content	unitless		0.067				✓		Carsel and Parish, 1988
Soil bulk density	g/cm^3		1.5				✓	✓	Carsel and Parish, 1988
Water-filled soil porosity	unitless		0.07	✓					Carsel and Parish, 1988

Table K-1. List of Input Parameters for the Deterministic Analysis (continued)

Parameter	Units	High End	Central Tendency	Used in: Partitioning	CHEMDAT8	ISC	EPACMTP	Indirect Exp.	Reference
Total soil porosity	unitless		0.38	✓					Carsel and Parish, 1988
Air porosity	unitless		0.31	✓					Calculated
Fraction of organic carbon for receptor location	unitless		0.012					✓	Calculated using Schwarz and Alexander, 1995
USLE rainfall factor	1/yr		520					✓	USDA, 1978
USLE erodibility factor	tons/acre		0.37					✓	Schwarz and Alexander, 1995
USLE length/slope factor	unitless		0.402					✓	USDA, 1978
USLE cover factor	unitless		1					✓	USDA, 1978
USLE erosion control practice factor	unitless		1					✓	USDA, 1978
Soil saturated volumetric water content	unitless		0.45 0.41				✓	 ✓	Carsel and Parish, 1988
Saturated hydraulic conductivity	cm/hr		0.45 0.29				✓	 ✓	Carsel and Parish, 1988
Soil specific exponent representing water retention	unitless		5.3					✓	Clapp and Hornberger, 1978
Hydraulic parameter, α	1/cm		0.02				✓		Carsel and Parish, 1988
Hydraulic parameter, β	unitless		1.41				✓		Carsel and Parish, 1988
Unsaturated zone thickness (Depth to water table)	m		13				✓		Guthrie, 1998a
Percent organic matter	unitless		2.045				✓		Schwarz and Alexander, 1995

Table K-1. List of Input Parameters for the Deterministic Analysis (continued)

Parameter	Units	High End	Central Tendency	Used in: Partitioning	CHEMDAT8	ISC	EPACMTP	Indirect Exp.	Reference
Saturated Zone Parameters									
Porosity	unitless		0.24				✓		U.S. EPA, 1997a
Soil bulk density	g/cm^3		1.46				✓		Calculated from saturated volumetric water content
Saturated zone thickness (Aquifer thickness)	m		9.14				✓		API Database, U.S. EPA, 1997a and 1997b
Hydraulic conductivity (K_x)	m/yr		1580				✓		API Database, U.S. EPA, 1997a and 1997b
Hydraulic gradient	unitless		0.005				✓		API Database, U.S. EPA, 1997a and 1997b
Longitudinal dispersivity (α_L)	m	HE(x)=8.01 HE(y)=10.2	10.2				✓		U.S. EPA, 1997a and Gelhar et al., 1992
Transverse dispersivity (α_T)	m	HE(x)=1.00 HE(y)=1.28	1.28				✓		Derived from α_L (U.S. EPA, 1997a)
Veritical dispersivity (α_V)	m	HE(x)=0.05 HE(y)=0.06	0.06				✓		Derived from α_T (U.S. EPA, 1997a)
Seepage velocity (pore velocity)	m/yr		32.92				✓		Derived from conductivity and gradient
Groundwater temperature	°C		22.5				✓		U.S. EPA, 1997a and 1997b, based on location
Aquifer pH	unitless		7.1				✓		EPA's STORET database for HWIR analysis; U.S. EPA, 1997a

Table K-1. List of Input Parameters for the Deterministic Analysis (continued)

Parameter	Units	High End	Central Tendency	Used in: Partitioning	CHEMDAT8	ISC	EPACMTP	Indirect Exp.	Reference
Fraction organic carbon	unitless		0.012				✓		Schwarz and Alexander, 1995
Meteorological Parameters									
Annual average precipitation rate	cm/yr		146	✓		✓		✓	NOAA, 1992
Annual average irrigation rate	cm/yr		0	✓				✓	Assumption
Annual average runoff rate	cm/yr		24	✓				✓	Geraghty et al., 1973
Average annual evapotranspiration rate	cm/yr		74[3]	✓				✓	Calculated (Evapotranspiration = Precipitation - (Precipitation/3) - Runoff)
Infiltration rate and Recharge rate	cm/yr		59	✓			✓		HELP modeling data for closest HWIR climate site (silty loam soil); U.S. EPA, 1997a and 1997b.
Ambient air temperature	°K		293			✓		✓	NOAA, 1992
Mean annual wind speed	m/s		4.1			✓		✓	NOAA, 1992
Wasterwaters Managed in Aerated Tanks									
Waste Parameters									
Annual wastewater quantity	Mtons/yr	9.63E+05	3.22E+05		✓				U.S. EPA, 1999 (TBD)
Waste concentration	mg/kg		Chemical-specific	✓					U.S. EPA, 1999 (TBD)

Table K-1. List of Input Parameters for the Deterministic Analysis (continued)

Parameter	Units	High End	Central Tendency	Used in:					Reference
				Partitioning	CHEMDAT8	ISC	EPACMTP	Indirect Exp.	
Total organic concentration (TOC) in influent (mg/L)	mg/L		498.17		✓				Applied average total organic concentration measured during sampling
Tank Parameters									
Site location (based on Met data)		Baltimore, MD & Baton Rouge, LA	Memphis,TN	✓	✓	✓	✓	✓	See Section 2
Station location for air modeling data Surface data		Baltimore, MD Baton Rouge, LA	Memphis, TN			✓			Professional judgement
Station location for air modeling data Upper air data		Sterling, VA Lake Charles,LA	Little Rock, AR			✓			Professional judgement
Wastewater depth	m		4.6		✓				Assumption
Surface Area	m^2	1147	384		✓				Calculated based on waste generation and retention time of 2 days (provided by EPA)
Flow	m^3/yr	9.63E+05	3.22E+05		✓				Generation rates converted to volumetric flow using an assumed wastewater density of 1 g/cm^3 (equal to water)

Table K-1. List of Input Parameters for the Deterministic Analysis (continued)

Parameter	Units	High End	Central Tendency	Used in: Partitioning	CHEMDAT8	ISC	EPACMTP	Indirect Exp.	Reference
Active Biomass or mixed liquor volatile suspended solids	g/L		2		✓				Default value used in development of chemical-specific biodegradation rates used in CHEMDAT8 (Research Triangle Institute, 1988)
Biomass solid (or TSS) concentration in influent	g/L		0.349		✓				Applied average total suspended solids (TSS) concentration measured during sampling.
Total biorate	mg/g bio-hr		19		✓				Default value recommended in CHEMDAT8. Sensitivity analysis indicates that this parameter has very minimal impact on emission estimates.
Fraction agitated	unitless		0.75		✓				HI - Aeration rate assumed for situations where agitation is used for biological treatment. Engineering judgement.
Submerged air flow	m^3/s		0		✓				Set equal to 0; assumed mechanical surface mixing only.
Number of Aerators	unitless	2	1		✓				Engineering judgement

Table K-1. List of Input Parameters for the Deterministic Analysis (continued)

Parameter	Units	High End	Central Tendency	Used in: Partitioning	CHEMDAT8	ISC	EPACMTP	Indirect Exp.	Reference
Oxygen transfer rate	lb O_2/h-hp		3		✓				Typical value applied to U.S. EPA, 1991a. Model shown to be insensitive to this parameter/
Total power	hp	115	80		✓				Range of 80-150 hp per million gallons of tank would be expected for HI aeration power. Based on information from Metcalf and Eddy, 1979.
Power efficiency	unitless		0.83		✓				U.S. EPA, 1991a. Typical range 0.80 to 0.85.
Impeller diameter	unitless		61		✓				U.S. EPA, 1991a and 1994a. Input used for all aerated units.
Impeller speed	rad/s		126		✓				CHEMDAT8 default value (U.S. EPA, 1994a) for aerated unit. Sensitivity analysis indicates that this parameter has very little impact on emission estimates.
Surface and Subsurface Soil Parameters									
Soil texture Memphis Baltimore and Baton Rouge		 Silt loam	 Silt loam						Miller and White, 1998

Table K-1. List of Input Parameters for the Deterministic Analysis (continued)

Parameter	Units	High End	Central Tendency	Used in: Partitioning	CHEMDAT8	ISC	EPACMTP	Indirect Exp.	Reference
Soil bulk density Memphis Baltimore Baton Rouge	g/cm^3	 1.5 1.5	 1.5					✓	Calculated based on mass/volume relationship: Bulk density = particle density * (1-Soil saturated volumetric water content). Soil saturated volumetric water content is 0.45 for all sites (Carsel and Parish, 1988). Particle density = 2.65g/cc.
Fraction of organic carbon for receptor location Memphis Baltimore Baton Rouge	unitless	 0.019 0.012	 0.0084					✓	Calculated using Schwarz and Alexander, 1995
USLE Rainfall factor Memphis Baltimore Baton Rouge	1/yr	 200 520	 300					✓	USDA, 1978
USLE erodibility factor Memphis Baltimore Baton Rouge	tons/acre	 0.31 0.43	 0.48					✓	Schwarz and Alexander, 1995
USLE length/slope factor Memphis Baltimore Baton Rouge	unitless	 0.40 0.40	 5.7					✓	USDA, 1978
USLE cover factor	unitless		0.12					✓	USDA, 1978

Table K-1. List of Input Parameters for the Deterministic Analysis (continued)

Parameter	Units	High End	Central Tendency	Used in: Partitioning	CHEMDAT8	ISC	EPACMTP	Indirect Exp.	Reference
USLE erosion control practice factor	unitless		1					✓	USDA, 1978
Soil saturated volumetric water content Memphis Baltimore and Baton Rouge	unitless	 0.45	 0.45					✓	Carsel and Parish, 1988
Saturated hydraulic conductivity Memphis Baltimore and Baton Rouge	cm/hr	 0.45	0.45					✓	Carsel and Parish, 1988
Soil specific exponent representing water retention Memphis Baltimore and Baton Rouge	unitless	 5.3	 5.3					✓	Clapp and Hornberger, 1978
Meteorological Parameters									
Annual average precipitation rate Memphis Baltimore Baton Rouge	cm/yr	 105 146	 139	✓		✓		✓	NOAA, 1992
Annual average irrigation rate	cm/yr		0	✓				✓	Assumption
Annual average runoff rate Memphis Baltimore Baton Rouge	cm/yr	 19 24	 24	✓				✓	Geraghty et al., 1973

Table K-1. List of Input Parameters for the Deterministic Analysis (continued)

Parameter	Units	High End	Central Tendency	Used in: Partitioning	CHEMDAT8	ISC	EPACMTP	Indirect Exp.	Reference
Average annual evapotranspiration rate	cm/yr			✓				✓	Calculated (Evapotranspiration = Precipitation - (Precipitation/3) - Runoff)
Memphis			69						
Baltimore		51							
Baton Rouge		74							
Ambient air temperature	°K					✓		✓	NOAA, 1992
Memphis			291						
Baltimore		286							
Baton Rouge		293							
Mean annual wind speed	m/s					✓		✓	NOAA, 1992
Memphis			3.6						
Baltimore		4.6							
Baton Rouge		4.1							
Constants used in Fate and Transport Modeling									
Dry Deposition Velocity	cm/s	0.2						✓	Koester and Hites, 1992
Enrichment Ratio	unitless	Organics = 3 Metals = 1						✓	U.S. EPA, 1993
Viscosity of air	g/cm-s	1.81E-04						✓	Weast, 1979 (CRC)
Density of air	g/cm^3	1.20E-03						✓	U.S. EPA, 1997e
Ideal gas constant	atm-m^3/mol-°K	8.21E-05						✓	U.S. EPA, 1997e

Table K-1. List of Input Parameters for the Deterministic Analysis (continued)

Parameter	Units	High End	Central Tendency	Used in: Partitioning	CHEMDAT8	ISC	EPACMTP	Indirect Exp.	Reference
Food Chain Parameters									
Plant Parameters									
Crop yield - Fruits	kg DW/m^2		0.25					✓	Womack, 1997; Table 2
Crop yield - Exposed vegetables	kg DW/m^2		3					✓	Derived using Womack, 1997[4]
Crop yield - Forage	kg DW/m^2		0.24					✓	U.S. EPA, 1995[5] (pg 6-280)
Interception fraction - Fruits	unitless		0.053					✓	Womack, 1997; Table 3
Interception fraction - Exposed vegetables	unitless		0.3					✓	U.S. EPA, 1997d
Interception fraction - Forage	unitless		0.5					✓	U.S. EPA, 1997d
Plant surface loss coefficient	1/yr		18					✓	U.S. EPA, 1997e; pg. 250 (PGD)
Length of exposure to deposition - Fruits & Exposed vegetables	yr		0.16					✓	U.S. EPA, 1997d
Length of exposure to deposition - Forage	yr		0.12					✓	U.S. EPA, 1997e; pg. 140 (PGD)
Empirical correction factor for plant uptake - Fruits and Exposed vegetables	unitless		0.01					✓	U.S. EPA, 1997e; pg. 142-145 (PGD)
Empirical correction factor for plant uptake - Root vegetables	unitless		0.01					✓	U.S. EPA, 1997e; pg. 142-145 (PGD)
Empirical correction factor for plant uptake - Forage	unitless		1.0					✓	U.S. EPA, 1997e; pg. 142-145 (PGD)

Table K-1. List of Input Parameters for the Deterministic Analysis (continued)

Parameter	Units	High End	Central Tendency	Used in: Partitioning	Used in: CHEMDAT8	Used in: ISC	Used in: EPACMTP	Used in: Indirect Exp.	Reference
Terrestrial Parameters									
Consumption rate of forage - Beef - Dairy	kg DW/day		 8.8 13.2					✓	Rice, 1994
Consumption rate of silage - Beef - Dairy	kg DW/day		 2.5 4.1					✓	Rice, 1994
Consumption rate of grain - Beef - Dairy	kg/day		 0.47 3					✓	Rice, 1994
Consumption rate of soil - Beef - Dairy	kg/day		 0.5 0.4					✓	Rice, 1994
Fraction contaminated - Forage, silage, and grain (For beef and dairy)	unitless		1					✓	U.S. EPA, 1997e; pg. 126 (PGD)
Surface Water / Fish Parameters									
Area of waterbody	m^2		4.6E+04					✓	Calculated (length * width)
Width of waterbody	m		5.5						Van der Leeden et al., 1990
Length of waterbody	m		8,500						Van der Leeden et al., 1990
Total waterbody depth	m		0.18						Van der Leeden et al., 1990
Waterbody flow	m^3/yr		1.3E+07					✓	Van der Leeden et al., 1990

Table K-1. List of Input Parameters for the Deterministic Analysis (continued)

Parameter	Units	High End	Central Tendency	Used in: Partitioning	CHEMDAT8	ISC	EPACMTP	Indirect Exp.	Reference
Velocity	m/s		0.5					✓	Van der Leeden et al., 1990
Flow independent mixing volume	m3		8.3E+03					✓	Calculated (length * width * depth) as suggested in U.S. EPA, 1993
Depth of bed sediment	m		0.03					✓	U.S. EPA, 1993
Depth of water column	m		0.15					✓	Calculated (Total waterbody depth - bed sediment depth)
Total suspended solids	mg/L		80					✓	U.S. EPA, 1993
Gas phase transfer coefficient for flowing stream	m/yr		36,500					✓	U.S. EPA, 1993
Waterbody temperature	°K		298					✓	U.S. EPA, 1993
Bed sediment porosity	L water/L		0.6					✓	U.S. EPA, 1993
Bed sediment concentration	kg sediment/L		1.0					✓	U.S. EPA, 1993
Suspended sediment multiplier	unitless		7.5					✓	U.S. EPA, 1993
Bottom sediment multiplier	unitless		4					✓	U.S. EPA, 1993
Lipid content of fish	unitless		0.05					✓	58 FR 20802, April 16, 1993
Receptor Specific Data									
Residence									
Distance from source to residential plot	m	75	300			✓		✓	55 FR 25454, June 21, 1990

Table K-1. List of Input Parameters for the Deterministic Analysis (continued)

Parameter	Units	High End	Central Tendency	Used in: Partitioning	Used in: CHEMDAT8	Used in: ISC	Used in: EPACMTP	Used in: Indirect Exp.	Reference
Area	m^2		5,100					✓	No data available, U.S. EPA, 1995 data used.
Soil mixing depth of residential plot – untilled	cm		2.5					✓	U.S. EPA, 1990
Shower duration	min		10					✓	U.S. EPA, 1997c (Table 15-20)
Time in bathroom (includes shower duration, time spent in shower stall after showering, and time spent in bathroom after leaving shower stall)	min		40					✓	U.S. EPA, 1997c (Table 15-20, 15-23, and 15-114)
Shower rate	L/min		5.5					✓	Calculated
Shower/bath water use	gcd (gallons per capita per day)		15					✓	U.S. EPA, 1997c (Table 17-14)
Bathroom water use	gcd		35.5					✓	U.S. EPA, 1997c (Table 17-14)
House water use	gcd		17.5					✓	U.S. EPA, 1997c (Table 17-14)
Volume of shower stall	m^3		2					✓	McKone, 1987
Volume of bathroom	m^3		10					✓	McKone, 1987
Volume of house	m^3		369					✓	U.S. EPA, 1997c; Table 17-31
Volumetric gas exchange rate between shower and bathroom	L/min		100					✓	RTI Derived value

Table K-1. List of Input Parameters for the Deterministic Analysis (continued)

Parameter	Units	High End	Central Tendency	Used in: Partitioning	CHEMDAT8	ISC	EPACMTP	Indirect Exp.	Reference
Volumetric gas exchange rate between bathroom and house	L/min		300					✓	RTI Derived value
Volumetric gas exchange rate between house and atmosphere	air changes per hour		0.45					✓	U.S. EPA, 1997c; Table 17-31
Fraction emitted, bathroom	unitless		0.50					✓	Calculated
Fraction emitted, house water	unitless		0.66					✓	Calculated
Time toilet emits	min/d		40					✓	U.S. EPA, 1997c; Tables 15-20, 15-23, and 15-114
Time house water emits	h/d		15.7					✓	U.S. EPA, 1997c (based on cumulative time spent indoors at a residence, Table 15-131, minus time spent in bathroom (see above))
Water droplet diameter	cm		0.098						RTI Derived value
Nozzle velocity	cm/s		400						RTI Derived value
Nozzle height	m		1.8						RTI Derived value
Home Garden									
Distance from source to garden	m	75	300			✓		✓	55 FR 25454, June 21, 1990
Area	m^2		5,100					✓	No data available, U.S. EPA, 1995 data used.

Table K-1. List of Input Parameters for the Deterministic Analysis (continued)

Parameter	Units	High End	Central Tendency	Used in: Partitioning	CHEMDAT8	ISC	EPACMTP	Indirect Exp.	Reference
Soil depth of home garden from which leaching removal occurs – tilled	cm		15					✓	U.S. EPA 1990 (Indirect Exposure Document suggests a range of 10-20 cm for tilled mixing depth)
Waterbody									
Distance from source to waterbody	m	102	300 430 (LTU only)			✓		✓	102m and 430m from DPRA, 1993. 300m based on distance to receptor.
Agricultural Field									
Distance from source to field	m	75	300			✓		✓	55 FR 25454, June 21, 1990
Area	m^2		2,000,000					✓	U.S. Department of Commerce, 1992
Soil mixing depth for ag. field - tilled	cm		15					✓	U.S. EPA 1990 (Indirect Exposure Document suggests a range of 10-20 cm for tilled mixing depth)
Groundwater/Well									
Distance to receptor well (x-well)	m	102	430				✓		DPRA, 1993
Distance from centerline of plume (y-well)	m	0	Half way to plume boundary				✓		CT: Half way to plume boundary. HE: On plume centerline
Depth of receptor well (z-well)	m		4.57				✓		Calculated

Table K-1. List of Input Parameters for the Deterministic Analysis (continued)

Parameter	Units	High End	Central Tendency	Used in: Partitioning	CHEMDAT8	ISC	EPACMTP	Indirect Exp.	Reference
Averaging time for groundwater concentration	yr	30	9				✓		Corresponds to the exposure duration in the risk calculation.

USLE = Universal Soil Loss Equation
HWIR = Hazardous Waste Identification Rule
1 Calculated using raw data that is no longer available.
2 See Section 2 for discussion on the different iniltration rates used.. See Appendix D.1 for discussion on infiltration rates used in partitioning model, see Appendix H for discussion on infiltration rates used in groundwater modeling.
3 The partitioning model used 102 cm/yr instead of 74cm/yr. The 102 cm/yr is calculated from the precipitation rate (0.7 * 146 cm/yr)
4 The crop yield calculated in the memo is for fruits and aboveground vegetables combined. In order to calculate the crop yield for exposed vegetables only, the unweighted crop yields given in Table 2 were multiplied by a weight factor (based on intake) for leafy vegetables (0.133), fruiting vegetables (0.280), and legumes (0.587).
5 The crop yield for forage is calculated from the crop yields for pasture grass and hay. The weight factor is based on the fraction of a year cattle could be pastured.

Table K-2. Exposure Parameters for the Deterministic Analysis

Parameter	Units	High End	Central Tendency	Reference
All Receptors				
Averaging time for carcinogens	yrs		70	Standard Assumption
Exposure frequency	days/yr		350	U.S. EPA, 1992 (Dermal Document)
Body weight for adults	kg		70	U.S. EPA, 1997c; Calculated using Tables 7-4 & 7-5
Skin surface area for adults	cm^2		20,000	U.S. EPA, 1997c; Table 6-16
Adult Resident				
Exposure duration	yrs	30	9	U.S. EPA, 1997c; pg 15-17
Drinking water ingestion rate	L/day		1.4	U.S. EPA, 1997c; Table 3-30
Fraction of drinking water from a contaminated source	unitless		1	Assumption
Soil ingestion rate	kg/day		5.0E-05	U.S. EPA, 1997c; Table 4-23
Fraction of soil from contaminated source	unitless		1	Assumption
Inhalation rate	m^3/hr	0.98	0.67	Myers, 1998; Table 5-2
Child of Resident				
Exposure Duration	yrs	15.3	7.3	U.S. EPA, 1997c; Table 15-168
Drinking water ingestion rate	L/kg/day		0.02	U.S. EPA, 1997c; Tables 3-7 and 3-30
Fraction of drinking water from a contaminated source			1	Assumption

Table K-2. Exposure Parameters for the Deterministic Analysis (continued)

Parameter	Units	High End	Central Tendency	Reference
Soil ingestion rate	kg/kg/day	8.1E-6	2.7E-06	U.S. EPA, 1997c; Table 4-23
Fraction of soil from contaminated source	unitless		1	Assumption
Inhalation rate	m^3/kg/day	0.55	0.32	Myers, 1998; Table 5-2
Gardener (in addition to Adult Resident)				
Exposed vegetable ingestion rate	kg DW/day	0.0192	0.0047	U.S. EPA, 1997c; Table 13-63, HH who garden
Fraction of exposed vegetables from contaminated source	unitless		0.233	U.S. EPA, 1997c; Table 13-71, HH who garden
Root Vegetable Ingestion Rate	kg DW/day[1] kg WW/day	0.024 0.17	0.0058 0.40	U.S. EPA, 1997c; Table 13-65, HH who garden
Fraction of root vegetables from contaminated source	unitless		0.106	U.S. EPA, 1997c; p. 13-65, Table 13-71, HH who garden
Fruit Ingestion Rate	kg DW/day	0.031	0.0079	U.S. EPA, 1997c; Table 13-61, HH who garden
Fraction of fruit from a contaminated source	unitless		0.116	U.S. EPA, 1997c; Table 13-71, HH who garden
Fisher (in addition to Adult Resident)				
Fish Ingestion Rate	g/day	25	8	U.S. EPA, 1997c; pg 10-26, Recreational Freshwater Angler
Fraction of fish from a contaminated source	unitless		0.325	U.S. EPA, 1997c; Table 13-71, HH who fish
Farmer				
Exposure Duration	yrs	48.3	10	U.S. EPA, 1997c; Table 15-164
Drinking water ingestion rate	L/day		1.4	U.S. EPA, 1997c; Table 3-30

Table K-2. Exposure Parameters for the Deterministic Analysis (continued)

Parameter	Units	High End	Central Tendency	Reference
Fraction of drinking water from a contaminated source	unitless		1	Assumption
Soil Ingestion Rate	kg/day		5.0E-05	U.S. EPA, 1997c; Table 4-23
Fraction of soil from a contaminated source	unitless		1	Assumption
Inhalation rate	m^3/hr	0.98	0.67	Myers, 1998; Table 5-2
Exposed vegetable ingestion rate	kg DW/day	0.032	0.0073	U.S. EPA, 1997c; Table 13-63, HH who farm
Fraction of exposed vegetables from contaminated source	unitless		0.42	U.S. EPA, 1997c; Table 13-71, HH who farm
Root Vegetable Ingestion Rate	kg DW/day[1] kg WW/day	0.027[2] 0.19	7.5E-03[2] 5.3E-02	U.S. EPA, 1997c; Table 13-65, HH who farm
Fraction of root vegetables from contaminated source	unitless		0.173	U.S. EPA, 1997c; Table 13-71, HH who farm
Fruit Ingestion Rate	kg DW/day	0.045	0.012	U.S. EPA, 1997c; Table 13-61, HH who farm
Fraction of fruit from a contaminated source	unitless		0.328	U.S. EPA, 1997c; Table 13-71, HH who farm
Beef ingestion rate	kg DW/day[3] kg WW/day	0.092 0.3234	0.028 0.098	U.S. EPA, 1997c; Table 13-36, HH who farm
Fraction of beef from a contaminated source	unitless		0.485	U.S. EPA, 1997c; Table 13-71, HH who farm
Dairy ingestion rate	kg DW/day[3] kg WW/day	0.50 2.1	0.17 0.73	U.S. EPA, 1997c; Table 13-28, HH who farm
Fraction of dairy from a contaminated source	unitless		0.254	U.S. EPA, 1997c; Table 13-71, HH who farm

Table K-2. Exposure Parameters for the Deterministic Analysis (continued)

Parameter	Units	High End	Central Tendency	Reference
Child of Farmer				
Exposure Duration	yrs	15.3	7.3	U.S. EPA, 1997c; Table 15-168
Drinking water ingestion rate	L/kg/day		0.02	U.S. EPA, 1997c; Tables 3-7 and 3-30
Fraction of drinking water from a contaminated source			1	Assumption
Soil ingestion rate	kg/kg/day	8.1E-6	2.7E-06	U.S. EPA, 1997c; Table 4-23
Fraction of soil from contaminated source	unitless		1	Assumption
Inhalation rate	m^3/kg/day	0.55	0.32	Myers, 1998; Table 5-2
Exposed vegetable ingestion rate	kg DW/kg/day	3.2E-04	7.6E-05	U.S. EPA, 1997c; Table 13-63
Fraction of exposed vegetables from contaminated source	unitless		0.42	U.S. EPA, 1997c; Table 13-71, HH who farm
Root Vegetable Ingestion Rate	kg DW/kg/day[1] kg WW/kg/day	7.1E-04 5.0E-3	8.2E-5 5.7E-4	U.S. EPA, 1997c; Table 13-65
Fraction of root vegetables from contaminated source	unitless		0.17	U.S. EPA, 1997c; Table 13-71, HH who farm
Fruit Ingestion Rate	kg DW/kg/day	9.1E-04	1.8E-4	U.S. EPA, 1997c; Table 13-61
Fraction of fruit from a contaminated source	unitless		0.33	U.S. EPA, 1997c; Table 13-71, HH who farm
Beef ingestion rate	kg DW/kg/day[3] kg WW/kg/day	1.7E-03 5.9E-03	4.6E-4 1.6E-3	U.S. EPA, 1997c; Tables 11-3 and 13-36
Fraction of beef from a contaminated source	unitless		0.49	U.S. EPA, 1997c; Table 13-71, HH who farm

Table K-2. Exposure Parameters for the Deterministic Analysis (continued)

Parameter	Units	High End	Central Tendency	Reference
Dairy ingestion rate	kg DW/kg/day[3] kg WW/kg/day	5.9E-03 2.4E-2	2.8E-3 1.2E-2	U.S. EPA, 1997c; Table 11-2
Fraction of dairy from a contaminated source	unitless		0.25	U.S. EPA, 1997c; Table 13-71 HH who farm

1 Root vegetable intake in whole weight (WW) for organics and dry weight (DW) for all other chemicals.
2 Root vegetable intake for metals was inadvertently calculated using the whole weight intake for the farmer scenario. The dry weight intake should be used for metals.
3 Beef and dairy intakes in dry weight (DW) for cadmium and (WW) for all other chemicals.

Table K-3. List of Input Parameters for Monte Carlo Analysis

(All parameters that were not varied in the Monte Carlo analysis used the central tendency value from the deterministic analysis)

Parameter	Units	Monte Carlo Variable	Variable Type	Minimum -or- Constant	Maximum	Used In: Partitioning	Used In: CHEMDAT8	Used In: ISC	Used In: EPACMTP	Used In: Indirect Exp.	Data Source and Remarks	Source for Minimum and Maximum Values (If different from the Data Source)
EDC/VCM Wastewater Treatment Sludge Managed in an Off-site Landfill												
Waste Parameters												
Annual waste quantity	Mtons/yr	yes	Industry-specific	95.5	1804	✓			✓		U.S EPA, 1999 (TBD)	
Contaminant concentration	mg/kg	yes	Industry-specific	chemical specific		✓			✓		U.S EPA, 1999 (TBD) (Used samples OG-04, OG-06, OC-02, and GL-01)	
Leachate concentration (TCLP)	mg/L	yes	Industry-specific	chemical specific					✓		U.S EPA, 1999 (TBD) (Used samples OG-04, OG-06, OC-02, and GL-01)	
Fraction organic carbon	unitless	yes	Industry-specific	0.0108	0.262	✓				✓	U.S EPA, 1999 (TBD)	
Landfill Parameters												
Area	m^2	yes	National	4.1E+03	9.4E+06	✓		✓	✓	✓	DPRA, 1993	
Recharge rate	m/yr	yes	Regional	0.028	1.08				✓		HELP model data for the closest HWIR climate site (silty loam soil)	

Table K-3. List of Input Parameters for Monte Carlo Analysis (continued)

(All parameters that were not varied in the Monte Carlo analysis used the central tendency value from the deterministic analysis)

Parameter	Units	Monte Carlo Variable	Variable Type	Minimum	Maximum	Used In:					Data Source and Remarks	Source for Minimum and Maximum Values (If different from the Data Source)
				-or- Constant		Partitioning	CHEMDAT8	ISC	EPACMTP	Indirect Exp.		
Infiltration rate	m/yr	yes	Regional	0.014	0.5893				✓		HELP model data for the closest HWIR climate site (silty loam soil); U.S. EPA, 1997a	
Source duration	years	yes	Derived	constituent-specific value					✓		Leaching continues until all of the constituent mass is depleted; U.S. EPA, 1997a	
Landfill Depth	m	yes	National	3.48E-04	5.97				✓		Crumley, 1997	
Unsaturated Zone Parameters												
Saturated conductivity of the soil	cm/hr	yes	Soil type-specific	1.54E-04	24.43				✓		Carsel and Parish, 1988	EPACMTP
Alpha (moisture retention)	1/cm	yes	Soil type-specific	1.42E-03	1.71E-01				✓		Carsel and Parish, 1988	EPACMTP
Beta (moisture retention)	unitless	yes	Soil type-specific	1.05	2.43				✓		Carsel and Parish, 1988	EPACMTP
Residual water content	unitless	yes	Soil type-specific	9.43E-03	1.11E-01				✓		Carsel and Parish, 1988	EPACMTP
Soil saturated volumetric water content	unitless	yes	Soil type-specific	0.41	0.45				✓		Carsel and Parish, 1988	EPACMTP

Table K-3. List of Input Parameters for Monte Carlo Analysis (continued)
(All parameters that were not varied in the Monte Carlo analysis used the central tendency value from the deterministic analysis)

Parameter	Units	Monte Carlo Variable	Variable Type	Minimum	Maximum	Used In:					Data Source and Remarks	Source for Minimum and Maximum Values (If different from the Data Source)
				-or- Constant		Partitioning	CHEMDAT8	ISC	EPACMTP	Indirect Exp.		
Unsaturated Zone Thickness (Depth to water table)	m	yes	Regional	0.31	610.0				✓		API Database U.S. EPA, 1997a and 1997b.	EPACMTP
Percent organic matter	unitless	yes	Soil type-specific	5.75E-03	2.24				✓		Carsel et al., 1988	EPACMTP
Bulk density	g/cm^3	yes	Soil type-specific	1.60	1.67				✓		Carsel et al., 1988	EPACMTP
Saturated Zone Parameters												
Particle diameter	cm	yes	Empirical Distribution	4.13E-04	0.208				✓		U.S. EPA, 1997a	EPACMTP
Porosity	unitless	no	Derived	0.05	0.42				✓		Derived from particle dismeter.; U.S. EPA, 1997a	EPACMTP
Bulk density	g/cm^3	no	Derived	1.16	1.8				✓		Derived from porosity; U.S. EPA, 1997a	EPACMTP
Saturated zone thickness (Aquifer thickness)	m	yes	Regional	0.31	914.0				✓		API Database (U.S. EPA, 1997a and 1997b)	EPACMTP
Hydraulic conductivity (K_x)	m/y	yes	Regional	3.15	8.2E+06				✓		API Database (U.S. EPA, 1997a and 1997b)	EPACMTP

Table K-3. List of Input Parameters for Monte Carlo Analysis (continued)
(All parameters that were not varied in the Monte Carlo analysis used the central tendency value from the deterministic analysis)

Parameter	Units	Monte Carlo Variable	Variable Type	Minimum	Maximum	Used In:					Data Source and Remarks	Source for Minimum and Maximum Values (If different from the Data Source)
				-or- Constant		Partitioning	CHEMDAT8	ISC	EPACMTP	Indirect Exp.		
Hydraulic gradient	unitless	yes	Regional	2.0E-06	0.65				✓		API Database (U.S. EPA, 1997a and 1997b)	EPACMTP
Longitudinal Dispersivity	m	yes	Empirical Distribution	0.1	324				✓		U.S. EPA, 1997a and Gelhar et al., 1992	EPACMTP
Transverse Dispersivity	m	yes	Derived	0.013	40.5				✓		Derived from α_L (U.S. EPA, 1997a)	EPACMTP
Vertical Dispersivity	m	yes	Derived	9.14E-04	2.03				✓		Derived from α_L (U.S. EPA, 1997a)	EPACMTP
Seepage Velocity (pore velocity)	m/yr	yes	Derived	0.102	9983				✓		Derived from conductivity and gradient	EPACMTP
Groundwater Temperature	°C	yes	Regional	22.5					✓		U.S. EPA, 1997a and 1997b, based on location	EPACMTP
Aquifer pH	unitless	yes	National	3.24	9.68				✓		EPA's STORET database for HWIR analysis; U.S. EPA, 1997a	EPACMTP
Fraction organic carbon	unitless	yes	Soil type-specific	1.62E-05	9.82E-03				✓		EPA's STORET database for HWIR analysis (U.S. EPA, 1997a)	EPACMTP

Table K-3. List of Input Parameters for Monte Carlo Analysis (continued)

(All parameters that were not varied in the Monte Carlo analysis used the central tendency value from the deterministic analysis)

Parameter	Units	Monte Carlo Variable	Variable Type	Minimum -or- Constant	Maximum	Used In: Partitioning	Used In: CHEMDAT8	Used In: ISC	Used In: EPACMTP	Used In: Indirect Exp.	Data Source and Remarks	Source for Minimum and Maximum Values (If different from the Data Source)
Receptor Well Parameters												
X-distance to well (X-well)	m	yes	National	2.55E-02	1.60E-03				✓		DPRA, 1993	EPACMTP
Y-distance to well (Y-well)	m	yes	National	2.63E-02	1605				✓		Uniform distr. within the areal extent of the plume at the given radial distance (U.S.EPA, 1997a).	EPACMTP
Receptor well depth (Z-well)	m	yes	Regional	7.25E-03	10.0				✓		Uniform distribution throughout aquifer thickness or throughout upper 10.0 m of aquifer thickness, whichever is less.	EPACMTP
EDC/VCM Waste Managed in a Land Treatment Unit												
Waste Parameters												
Contaminant concentration	mg/kg	yes	Industry-specific	chemical specific		✓					U.S EPA, 1999 (TBD) (Used samples OG-04, OG-06, OC-02, and GL-01)	
Fraction organic carbon	unitless	yes	Industry-specific	0.04	0.07	✓				✓	U.S EPA, 1999 (TBD)	
Land Treatment Unit Parameters												

Table K-3. List of Input Parameters for Monte Carlo Analysis (continued)
(All parameters that were not varied in the Monte Carlo analysis used the central tendency value from the deterministic analysis)

Parameter	Units	Monte Carlo Variable	Variable Type	Minimum	Maximum	Used In:					Data Source and Remarks	Source for Minimum and Maximum Values (If different from the Data Source)
				-or- Constant		Partitioning	CHEMDAT8	ISC	EPACMTP	Indirect Exp.		
Unsaturated Zone Parameters												
Saturated conductivity of the soil	cm/hr	yes	Soil type-specific	1.19E-04	2.73E+01				✓		Carsel and Parish, 1988	EPACMTP
Alpha (moisture retention)	1/cm	yes	Soil type-specific	1.36E-03	2.22E-01				✓		Carsel and Parish, 1988	EPACMTP
Beta (moisture retention)	unitless	yes	Soil type-specific	1.07	2.39				✓		Carsel and Parish, 1988	EPACMTP
Residual water content	unitless	yes	Soil type-specific	0.0218	0.115				✓		Carsel and Parish, 1988	EPACMTP
Soil saturated volumetric water content	unitless	yes	Soil type-specific	0.41	0.45				✓		Carsel and Parish, 1988	EPACMTP
Unsaturated Zone Thickness (Depth to water table)	m	yes	Regional	0.305	610.0				✓		API Database U.S. EPA, 1997a and 1997b.	EPACMTP
Percent organic matter	unitless	yes	Soil type-specific	6.97E-03	1.31				✓		Carsel et al., 1988	EPACMTP
Bulk density	g/cm^3	yes	Soil type-specific	1.60	1.67				✓		Carsel et al., 1988	EPACMTP
Saturated Zone Parameters												
Particle diameter	cm	yes	Empirical Distribution	4.02E-04	0.21				✓		U.S. EPA, 1997a	EPACMTP
Porosity	unitless	no	Derived	0.0501	0.416				✓		U.S. EPA, 1997a	EPACMTP

Table K-3. List of Input Parameters for Monte Carlo Analysis (continued)

(All parameters that were not varied in the Monte Carlo analysis used the central tendency value from the deterministic analysis)

Parameter	Units	Monte Carlo Variable	Variable Type	Minimum	Maximum	Used In:					Data Source and Remarks	Source for Minimum and Maximum Values (If different from the Data Source)
				-or- Constant		Partitioning	CHEMDAT8	ISC	EPACMTP	Indirect Exp.		
Bulk density	g/cm^3	no	Derived	1.16	1.8				✓		U.S. EPA, 1997a	EPACMTP
Saturated zone thickness (Aquifer thickness)	m	yes	Regional	0.305	914.0				✓		API Database (U.S. EPA, 1997a and 1997b)	EPACMTP
Hydraulic conductivity (K_x)	m/y	yes	Regional	3.15	4.25E+06				✓		API Database (U.S. EPA, 1997a and 1997b)	EPACMTP
Hydraulic gradient	unitless	yes	Regional	2.0E-06	2.2E-01				✓		API Database (U.S. EPA, 1997a and 1997b)	EPACMTP
Longitudinal Dispersivity	m	yes	Empirical Distribution	0.241	324				✓		U.S. EPA, 1997a and Gelhar et al., 1992	EPACMTP
Transverse Dispersivity	m	yes	Derived	0.0302	40.5				✓		Derived from α_L (U.S. EPA, 1997a)	EPACMTP
Vertical Dispersivity	m	yes	Derived	1.82E-03	2.03				✓		Derived from α_L (U.S. EPA, 1997a)	EPACMTP
Seepage Velocity (pore velocity)	m/yr	yes	Derived	0.108	1.08E+04				✓		Derived from conductivity and gradient	EPACMTP
Aquifer pH	unitless	yes	National	3.25	9.64				✓		EPA's STORET database for HWIR analysis (U.S. EPA, 1997a)	EPACMTP

Table K-3. List of Input Parameters for Monte Carlo Analysis (continued)

(All parameters that were not varied in the Monte Carlo analysis used the central tendency value from the deterministic analysis)

Parameter	Units	Monte Carlo Variable	Variable Type	Minimum	Maximum	Used In:					Data Source and Remarks	Source for Minimum and Maximum Values (If different from the Data Source)
				-or- Constant		Partitioning	CHEMDAT8	ISC	EPACMTP	Indirect Exp.		
Fraction organic carbon	unitless	yes	National	1.99E-05	7.97E-03				✓		EPA's STORET database (U.S. EPA, 1997a)	EPACMTP
Receptor Well Parameters												
X-distance to well (X-well)	m	yes	National	5.17E-02	1.61E+03				✓		DPRA, 1993	EPACMTP
Y-distance to well (Y-well)	m	yes	Uniform Distribution	0.147	1.41E+03				✓		Uniformly within the lateral extent of the plume at the given radial distance.	EPACMTP
Receptor well depth (Z-well)	m	yes	Uniform Distribution	3.49E-03	10.0				✓		Uniform distribution throughout aquifer thickness or throughout upper 10.0 m of aquifer thickness, whichever is less.	EPACMTP
Wastewaters Managed in Aerated Tanks												
Waste Parameters												
Annual wastewater quantity	Mtons/yr	yes	Industry-specific	98,000	962,950		✓				U.S EPA, 1999 (TBD)	

Table K-3. List of Input Parameters for Monte Carlo Analysis (continued)
(All parameters that were not varied in the Monte Carlo analysis used the central tendency value from the deterministic analysis)

Parameter	Units	Monte Carlo Variable	Variable Type	Minimum	Maximum	Used In:					Data Source and Remarks	Source for Minimum and Maximum Values (If different from the Data Source)
				-or- Constant		Partitioning	CHEMDAT8	ISC	EPACMTP	Indirect Exp.		
Contaminant concentration	mg/kg	yes	Industry-specific	chemical specific			✓		✓		U.S EPA, 1999 (TBD) (Used samples OG-01, OG-03, PL-01, PL-02, PL-03, and GL-02)	
Total organic carbon	unitless	yes	Industry-specific	19	1570		✓				U.S EPA, 1999 (TBD)	
Tank Parameters												
Surface Area	m^2	yes	Industry-specific	117	1147		✓				Calculated based on industry waste generation and retention time of 2 days (provided by EPA)	
Flow	m^3/yr	yes	Industry-specific	98,000	962,950		✓				Generation rates converted to volumetric flow using an assumed wastewater density of 1 g/cm^3 (equal to water)	
Biomass solid (or TSS) concentration in influent	g/L	no	Industry-specific	0	1.44		✓				U.S EPA, 1999 (TBD)	

Table K-3. List of Input Parameters for Monte Carlo Analysis (continued)
(All parameters that were not varied in the Monte Carlo analysis used the central tendency value from the deterministic analysis)

Parameter	Units	Monte Carlo Variable	Variable Type	Minimum	Maximum	Used In:					Data Source and Remarks	Source for Minimum and Maximum Values (If different from the Data Source)
				-or- Constant		Partitioning	CHEMDAT8	ISC	EPACMTP	Indirect Exp.		
Number of Aerators	unitless	yes	Discrete	1	4		✓				Based on total HP with randomization as follows: <30 HP, N_Aer = 1 or 2; >80 HP, N_Aer = HP/X rounded up to an integer; X = random number 60-100	
Total power	hp	yes	Normal	10	222		✓				Calculated based on tank volume. Assumed normal distribution with 90% of values in the range of 80-150 hp per million gallons of tank based on information from Metcalf and Eddy, 1979.	
Soil Parameters												
Bulk density	g/cm^3	yes	Site specific	1.46	1.70					✓	Carsel and Parish, 1988	
Fraction organic carbon for soil	unitless	yes	Site specific	0.0036	0.028					✓	Calculated from Schwarz and Alexander, 1995 data	
USLE Rainfall factor	1/yr	yes	Site-specific	57	550					✓	USDA, 1978	

Table K-3. List of Input Parameters for Monte Carlo Analysis (continued)
(All parameters that were not varied in the Monte Carlo analysis used the central tendency value from the deterministic analysis)

Parameter	Units	Monte Carlo Variable	Variable Type	Minimum	Maximum	Used In:					Data Source and Remarks	Source for Minimum and Maximum Values (If different from the Data Source)
				-or- Constant		Partitioning	CHEMDAT8	ISC	EPACMTP	Indirect Exp.		
USLE erodibility factor	tons/acre	yes	Site specific	0.27	0.48					✓	Schwarz and Alexander, 1995	
USLE length/slope factor	unitless	yes	Site specific	0	5.71					✓	USDA, 1978	
Soil saturated volumetric water content	unitless			0.36	0.45					✓	Carsel and Parish, 1988	
Saturated hydraulic conductivity	cm/hr			2.0E-02	3.0E+01					✓	Carsel and Parish, 1988	
Soil specific exponent representing water retention	unitless			4.05	11.4					✓	Clapp and Hornberger, 1978	
Meteorological Parameters												
Annual average precipitation rate	cm/yr	yes	Site specific	74.4	153.9			✓		✓	NOAA, 1992	
Annual average runoff rate	cm/yr	yes	Site specific	3	25.4					✓	Geraghty et al., 1973	
Average annual evapotranspiration rate	cm/yr	yes	Site specific	35.2	77.5					✓	Calculated (Evapotranspiration = Precipitation - (Precipitation/3) - Runoff)	
Ambient air temperature	K	yes	Site specific	281.5	293.7			✓		✓	NOAA, 1992	

Table K-3. List of Input Parameters for Monte Carlo Analysis (continued)

(All parameters that were not varied in the Monte Carlo analysis used the central tendency value from the deterministic analysis)

Parameter	Units	Monte Carlo Variable	Variable Type	Minimum	Maximum	Used In:					Data Source and Remarks	Source for Minimum and Maximum Values (If different from the Data Source)
				-or- Constant		Partitioning	CHEMDAT8	ISC	EPACMTP	Indirect Exp.		
Mean annual wind speed	m/s	yes	Site specific	3.6	6.2			✓		✓	NOAA, 1992	
Receptor Location Parameters												
Distance to receptor (residential plot, agricultural field, or home garden)	m	yes	Uniform	50	1000					✓	Professional judgement	

Table K-4. Exposure Parameters for the Monte Carlo Analysis
Lognormal Distribution

Parameter	Units	Mean	Standard Deviation	Source for Mean and Standard Deviation	Minimum Value	Maximum Value	Source for Minimum; Source for Maximum
Adult Resident							
Adult body weight	kg	71.2	13.3	RTI, 1999	24	205	EFH, Table 7-5 (Half the 5th percentile value for females, all races); EFH, Table 7-4 (Twice the 95th percentile for males, all races)
Inhalation rate	m^3/day	13.3	3.99	RTI, 1999	5	51	EFH, Table 5-6 (Half the average resting inhalation rate for women); Myers et al., 1998 (99th percentile weighted average for adults)
Home Gardener (In addition to the exposure factors for the adult resident)							
Fruit intake	g WW/kg/day	1.57	2.3	RTI, 1999	0	32.5	Professional Judgement; EFH Table 13-61 (100th percentile value for households who garden)
Fisher (In addition to the exposure factors for the adult resident)							
Fish intake	g/day	6.48	19.9	RTI, 1999	0	1500	Professional Judgement
Farmer							
Adult body weight	kg	71.2	13.3	RTI, 1999	24	205	EFH, Table 7-5 (Half the 5th percentile for females, all races); EFH Table 7-4 (Twice the 95th percentile value for males, all races)
Inhalation rate	m^3/day	13.3	3.99	RTI, 1999	5	51	EFH, Table 5-6 (Half the average resting inhalation rate for women); Myers et al., 1998 (99th percentile weighted average for adults)
Exposed vegetable intake	g WW/kg/day	2.38	3.5	RTI, 1999	0	13.3	Professional Judgement; 100th percentile value for households who farm, presented in EFH, Table 13-63
Exposed fruit intake	g WW/kg/day	2.36	3.33	RTI, 1999	0	15.7	Professional Judgement; 100th percentile value for households who farm, presented in EFH, Table 13-61
Root vegetable intake	g WW/kg/day	1.45	2.06	RTI, 1999	0	7.69	Professional Judgement; 100th percentile value for households who farm, presented in EFH, Table 13-65
Beef intake	g WW/kg/day	2.5	2.69	RTI, 1999	0	19.4	Professional Judgement; 100th percentile value for households who farm, presented in EFH, Table 13-36
Child of Resident (1-5 years)							
Exposure Duration	years	6.53	5.6	RTI, 1999	1	30	Professional Judgement; EPA decison
Body weight	kg	15.5	2.05	RTI, 1999	6.1	39	EFH, Table 7-7 (Half the 5th percentile for females, ages 1-5); EFH, Table 7-6 (Twice the 95th percentile for males, ages 1-5)

Table K-4. Exposure Parameters for the Monte Carlo Analysis
Lognormal Distribution

Parameter	Units	Mean	Standard Deviation	Source for Mean and Standard Deviation	Minimum Value	Maximum Value	Source for Minimum; Source for Maximum
Soil intake	mg/day	100	150	RTI, 1999	0	2300	Professional Judgement; EFH Table 4-10 (Upper bound)
Child of Resident (6-11 years)							
Body weight	kg	30.7	5.96	RTI, 1999	11.3	86.9	EFH, Table 7-7 (Half the 5th percentile female average for ages 6-11); EFH, Table 7-6 (Twice the 95th percentile male average for ages 6-11)
Child of Resident (12-19 years)							
Body weight	kg	58.2	10.2	RTI, 1999	20.9	165.8	EFH, Table 7-7 (Half the 5th percentile female average for ages 12-19); EFH, Table 7-6 (Twice the 95th percentile male average for ages 12-19)
Child of Farmer (1-5 years)							
Body weight	kg	15.5	2.05	RTI, 1999	6.1	39	EFH, Table 7-7 (Half the 5th percentile for females, ages 1-5); EFH, Table 7-6 (Twice the 95th percentile for males, ages 1-5)
Soil intake	mg/day	100	150	RTI, 1999	0	2300	Professional Judgement; EFH Table 4-10 (Upper bound)
Root vegetable intake	g WW/kg/day	2.31	6.05	RTI, 1999	0	7.49	Professional Judgement; EFH Table 13-63 (100th percentile value for 1-5 year olds)
Beef intake*	g WW/kg/day	3.88	4.71	RTI, 1999	0	13.3	Professional Judgement; EFH Table 13-61 (100th percentile value for 6-11 year olds)
Child of Farmer (6-11 years)							
Body weight	kg	30.7	5.96	RTI, 1999	11.3	86.9	EFH, Table 7-7 (Half the 5th percentile female average for ages 6-11); EFH, Table 7-6 (Twice the 95th percentile male average for ages 6-11)
Exposed vegetable intake	g WW/kg/day	1.64	3.95	RTI, 1999	0	13.3	Professional Judgement; EFH Table 13-63 (100th percentile value for 6-11 year olds)
Exposed fruit intake	g WW/kg/day	2.78	5.12	RTI, 1999	0	15.9	Professional Judgement; EFH Table 13-61 (100th percentile value for 6-11 year olds)
Beef intake	g WW/kg/day	3.88	4.71	RTI, 1999	0	13.3	Professional Judgement; EFH Table 13-61 (100th percentile value for 6-11 year olds)
Child of Farmer (12-19 years)							
Body weight	kg	58.2	10.2	RTI, 1999	20.9	165.8	EFH, Table 7-7 (Half the 5th percentile female average for ages 12-19); EFH, Table 7-6 (Twice the 95th percentile male average for ages 12-19)

Table K-4. Exposure Parameters for the Monte Carlo Analysis
Lognormal Distribution

Parameter	Units	Mean	Standard Deviation	Source for Mean and Standard Deviation	Minimum Value	Maximum Value	Source for Minimum; Source for Maximum
Exposed fruit intake	g WW/kg/day	1.54	2.44	RTI, 1999	0	5.9	Professional Judgement; EFH Table 13-61 (100th percentile value for 12-19 year olds)

EFH - U.S. EPA, 1997

All variable are based on national data.

*No data available for 1-5 year old intake of beef, data for 6-11 year old was used.

Table K-5. Exposure Parameters for the Monte Carlo Analysis
Gamma and Weibull Distributions

Parameter	Units	Distribution Type	Scale	Shape	Source for Scale and Shape	Minimum Value	Maximum Value	Source for Minimum; Source for Maximum
Adult Resident								
Exposure duration	years	Gamma	7.91	1.71	RTI, 1999	1	50	EPA Decision
Drinking water intake	mL/day	Gamma	356.85	3.88	RTI, 1999	0	8000	Professional Judgement; Twice the 99th percentile value for Adults (ages 20-64) presented in EFH, Table 3-6
Home Gardener (In addition to the exposure factors for the adult resident)								
Exposed vegetable intake	g WW/kg/day	Weibull	1.48	0.89	RTI, 1999	0	20.6	Professional Judgement; 100th percentile value for households who garden, presented in EFH, Table 13-63
Root vegetable intake	g WW/kg/day	Weibull	1.07	0.87	RTI, 1999	0	12.8	Professional Judgement; 100th percentile value for households who garden, presented in EFH, Table 13-65
Farmer								
Dairy intake	g WW/kg/day	Weibull	17.45	1.25	RTI, 1999	0	111	Professional Judgement; 100th percentile value for households who farm, presented in EFH, Table 13-28
Drinking water intake	mL/day	Gamma	356.85	3.88	RTI, 1999	0	8000	Professional Judgement; Twice the 99th percentile value for Adults (ages 20-64) presented in EFH, Table 3-6
Child of Resident (1-5 years)								
Drinking water intake	mL/day	Gamma	236.55	2.95	RTI, 1999	0	4000	Professional Judgement; Twice the 99th percentile value for 4-6 year olds, presented in EFH, Table 3-6
Child of Resident (6-11 years)								
Exposure duration	years	Gamma	3.23	2.6	RTI, 1999	1	30	Professional Judgement; EPA decison
Drinking water intake	mL/day	Gamma	235.09	3.35	RTI, 1999	0	4000	Professional Judgement; Twice the 99th percentile value for 7-10 year olds, presented in EFH, Table 3-6
Child of Resident (12-19 years)								
Exposure duration	years	Weibull	9.82	1.71	RTI, 1999	1	30	Professional Judgement; EPA decison
Drinking water intake	mL/day	Gamma	341.82	2.82	RTI, 1999	0	6000	Professional Judgement; Twice the 99th percentile value for 15-19 year olds, presented in EFH, Table 3-6
Child of Farmer (1-5 years)								
Drinking water intake	mL/day	Gamma	236.55	2.95	RTI, 1999	0	4000	Professional Judgement; Twice the 99th percentile value for 4-6 year olds, presented in EFH, Table 3-6
Exposed vegetable intake	g WW/kg/day	Gamma	2.62	0.97	RTI, 1999	0	10.3	Professional Judgement; 100th percentile weighted average for 1-2 years and 3-5 years, presented in EFH, Table 13-63
Exposed fruit intake	g WW/kg/day	Gamma	1.58	1.43	RTI, 1999	0	32.5	Professional Judgement; 100th percentile value for 3-5 year olds, presented in EFH, Table 13-61

Table K-5. Exposure Parameters for the Monte Carlo Analysis
Gamma and Weibull Distributions

Parameter	Units	Distribution Type	Scale	Shape	Source for Scale and Shape	Minimum Value	Maximum Value	Source for Minimum; Source for Maximum
Dairy intake	g WW/kg/day	Weibull	26.47	1.7	RTI, 1999	0	109	Professional Judgement; 100th percentile value for 1-2 years, presented in EFH, Table 11-2
Child of Farmer (6-11 years)								
Drinking water intake	mL/day	Gamma	235.09	3.35	RTI, 1999	0	4000	Professional Judgement; Twice the 99th percentile value for ages 7-10 years presented in EFH, Table 3-6
Root vegetable intake	g WW/kg/day	Weibull	1.06	0.68	RTI, 1999	0	7.47	Professional Judgement; 100th percentile value for 6-11 year olds, presented in EFH, Table 13-65
Dairy intake	g WW/kg/day	Weibull	14.82	1.56	RTI, 1999	0	62.6	Professional Judgement; 100th percentile value for 6-11 year olds, presented in EFH, Table 11-2
Child of Farmer (12-19 years)								
Drinking water intake	mL/day	Gamma	341.82	2.82	RTI, 1999	0	6000	Professional Judgement; Twice the 99th percentile value for 15-19 year olds presented in EFH, Table 3-6
Exposed vegetable intake	g WW/kg/day	Gamma	1.19	0.91	RTI, 1999	0	5.67	Professional Judgement; 100th percentile value for 12-19 year olds, presented in EFH, Table 13-63
Root vegetable intake	g WW/kg/day	Weibull	0.91	0.84	RTI, 1999	0	5.13	Professional Judgement; 100th percentile value for 12-19 year olds, presented in EFH, Table 13-65
Beef intake	g WW/kg/day	Gamma	0.71	2.47	RTI, 1999	0	4.28	Professional Judgement; 100th percentile value for 12-19 year olds, presented in EFH, Table 13-36
Dairy intake	g WW/kg/day	Weibull	6.52	1.14	RTI, 1999	0	53.5	Professional Judgement; 100th percentile value for 12-19 years, presented in EFH, Table 11-2

EFH - U.S. EPA, 1997

All variable are based on national data.

Location is equal to 0 for all parameters

Table K-6. Exposure Parameters for the Monte Carlo Analysis
Extreme Value Distribution

Parameter	Units	Distribution Type	25th	50th	75th	90th	95th	Source for Values	Minimum Value	Maximum Value	Source for Minimum; Source for Maximum
Farmer											
Exposure duration	years	Best fit to Extreme Value	2.4	10	26.7	48.3	58.4	EFH, Table 15-164	1	50	EPA Decision
Child of Farmer											
Exposure duration	years	Best fit to Extreme Value	2.4	10	26.7	48.3	58.4	EFH, Table 15-164	1	30	EPA Decision

EFH - U.S. EPA, 1997

Table K-7. Exposure Parameters for the Monte Carlo Analysis Constants

Parameter	Units	Value	Source
Soil intake for adults and all children over age 5	mg/day	50	EFH, pg 4-20 - 4-21

EFH - U.S. EPA, 1997

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