DATA COLLECTION FOR THE HAZARDOUS WASTE IDENTIFICATION RULE

SECTION 14.0 ECOLOGICAL BENCHMARKS

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Table of Contents

Section **Page**

Figures iv

Tables iv

14.0 Ecological Benchmarks 14-1
14.1 Parameters 14-1
14.2 Data Sources 14-1
14.2.1 Review Existing Synopses 14-2
14.2.2 Search Toxicological Databases 14-3
14.2.3 Conduct Online Literature Search 14-4
14.3 Methodology 14-5
14.3.1 Benchmark/CSCL Database 14-5
14.3.1.1 Database Compilation 14-5
14.3.1.2 Database Processing 14-22
14.3.1.3 Assumptions and Uncertainties 14-22
14.4 Quality Assurance/Quality Control 14-30
14.4.1 Technical QA/QC 14-30
14.4.2 Data Entry QA/QC 14-30
14.4.3 Data Formatting QA/QC 14-30
14.5 References 14-30

Appendix 14A-1 14-39
Appendix 14A-2 14-45
Appendix 14A-3 14-49
Appendix 14A-4 14-56
Appendix 14A-5 14-59
Appendix 14A-6 14-65
Appendix 14A-7 14-70
Appendix 14A-8 14-77
Appendix 14A-9 14-83
Appendix 14A-10 14-90

Figure

Number		Page
14-1	Simplified trophic structure of a generalized soil community	14-20

Tables

Number		Page
14-1	Parameters Included in the Benchmark/CSCL Database	14-2
14-2	Status of Literature Review Process for Chemicals of Concern	14-3
14-3	Key Sources of Information Consulted in the Development of Benchmarks and CSCLs	14-6
14-4	Primary Literature Used in Mammalian and Avian Benchmark Derivation	14-9
14-5	Conversion Factors for Dissolved Metal	14-15
14-6	Receptor Benchmarks and CSCLs Based on No-Effects Data	14-26
14A-1	Mammalian Benchmark Studies	14-39
14A-2	Avian Benchmark Studies	14-47
14A-3	Freshwater Community CSLs Based on Total Water Concentrations	14-52
14A-4	Freshwater Community CSCLs Based on Total Dissolved Water Concentrations	14-59
14A-5	Aquatic Plants and Algae CSCLs	14-62
14A-6	Amphibian CSCLs	14-68
14A-7	Benthic Community CSCLs	14-73
14A-8	Terrestrial Plant CSCLs	14-81
14A-9	Soil Community CSCLs	14-87
14A-10	Scaled Benchmark Doses for Ecological Receptors	14-94

14.0 Ecological Benchmarks

The ecological risk module was created to generate risk estimates for receptor taxa of concern. The risk quotient method was used to identify the potential for adverse effects to terrestrial and freshwater receptors. The risk quotient compares, by ratio, the modeled media concentrations to an estimated protective level for receptors of concern in the respective exposure media (i.e., water, soil, sediment, prey items). When the ratio exceeds 1, there is a potential for adverse effects to that receptor; when the ratio is less than 1, minimal risk to the receptor is indicated. The specific methods used to calculate the protective level (i.e., benchmarks and chemical stressor concentration limits [CSCLs]) varied with the receptor taxa.[1] Protective CSCLs were derived (in ppm) for specific communities and populations in direct contact with contaminated media (i.e., terrestrial plants, soil biota, sediment biota, fish/aquatic invertebrates, herpetofauna). Protective benchmark doses (mg/kg/d) were developed for mammals and birds based on exposure through the food web by ingestion of contaminated prey items. A complete review of how modeled media exposure concentrations were generated is provided in the documentation of the ecological exposure module. This section describes in detail how the benchmarks and CSCLs used in the risk quotient were derived.

14.1 Parameters

The key database developed in support of the ecological risk module was the benchmark/CSCL database. The parameters used to calculate ecological risk in the module are listed in Table 14-1. As the table indicates, all the parameters generated in the benchmark/CSCL database are chemical-specific properties.

14.2 Data Sources

In developing the chemical-specific benchmark/CSCL database, the major source of ecotoxicity data was the primary literature. Secondary sources of data included documents and databases developed by the U.S. Environmental Protection Agency, other government agencies (e.g., the National Oceanographic and Atmospheric Administration [NOAA]), and other research facilities (e.g., Oak Ridge National Laboratories [ORNL]). Given that changes were made to the priority constituent list after initial literature searches were completed, secondary review sources were the only references reviewed for some of the chemicals. The status of the

[1] For this analysis, CSCLs refer to constituent concentrations (e.g., mg/kg soil) in environmental media that are presumed to cause de minimis effects on ecological receptors. Benchmarks, in mg/kg/d, provide protective ingestion doses that are estimated to cause de minimis effects to mammalian and avian receptors.

Table 14-1. Parameters Included in the Benchmark/CSCL Database

Parameter Description	Parameter Code
Ecological benchmark for representative receptors that receive ingested doses	ChemEBRec
CSCL for water based on total concentrations	ChemCSCLWaterTotRec
CSCL for water based on dissolved concentrations	ChemCSCLWaterDissRec
CSCL for sediment	ChemCSCLSedimentRec
CSCL for soil	ChemCSCLSoilRec

literature searches for each constituent is presented in Table 14-2. Secondary review sources helped identify the most current literature available for benchmark and CSCL development; unfortunately, sufficient time was not available to complete more thorough literature searches for many of the constituents.

To provide a context for how data searches were initiated to develop the benchmark/CSCL database, the general steps taken in primary literature searches are outlined here. The key steps to the literature review process consisted of (1) reviewing existing synopses, (2) searching toxicological databases, and (3) conducting comprehensive online literature searches (see text box). A more detailed description of each step is provided in subsequent sections. This framework is not meant to be all-inclusive; rather, it provides key approaches and examples of data sources that have been shown to be highly productive in characterizing ecotoxicological effects.

Steps in Identifying Ecotoxicological Data

Step 1: Review Existing Synopses

- Develop understanding of behavior of constituents and generally recognized adverse effects.
- Summarize available data and identify primary studies for further analysis.
- Delineate key parameters that would mitigate (or enhance) the toxicity of constituents.

Step 2: Search Toxicological Databases

- Compile quantitative data on effects.
- Fill data gaps identified from review of synopses.
- Identify critical endpoints for benchmark development.

Step 3: Conduct Online Literature Search

- Focus on critical endpoints and fill in data gaps.
- Identify recent studies and data not available in synopses or toxicological databases.
- Provide supporting information for benchmark development.

14.2.1 Review Existing Synopses

In this step, major reviews of ecotoxicological effects are investigated. This step ensures that no obvious sources of

Table 14-2. Status of Literature Review Process for Chemicals of Concern

Primary Literature Review Completed	Secondary Source Review Completed
Methoxychlor	Benzene
Pentachlorophenol (PCP)	Toluene (methyl benzene)
2,3,7,8-Tetrachlorodibenzo-*p*-dioxin	Ethylene dibromide
Arsenic	(1,2-dibromoethane)
Mercury	Thiram
Lead	Methylene chloride (dichloromethane)
Silver	1,1,1-Trichloroethane
Zinc	Vinyl chloride (chloroethylene)
Cadmium	Trichloroethylene
Beryllium	Chlorobenzene
Bis-(2-ethylhexyl) phthalate	Hexachloro-1,3-butadiene
Benzo[a]pyrene	2,4-Dichlorophenoxyacetic acid (2,4-D)
Antimony	Phenol
Thallium	Methyl ethyl ketone
Chromium	Methyl methacrylate
Barium	Dibenz[a,h]anthracene
Nickel	Carbon disulfide
Selenium	Acetonitrile
Vanadium	Pyridine
Chromium, total	Nitrobenzene
Chromium III	Aniline
Chromium VI	Tetrachloroethylene
	Chloroform (trichloromethane)
	Acrylonitrile (2-propenenitrile)

effects data are missed and provides a road map for what information might be available. Documents such as U.S. Fish and Wildlife Service (FWS) synoptic reviews, EPA water quality criteria documents, and Agency for Toxic Substances and Disease Registry (ATSDR) toxicological profiles provide a broad overview of the fate and toxicological effects of constituents. These reviews provide a necessary foundation to delineate environmental characteristics that mitigate (or enhance) toxicity. Further, these reviews offer a first look at whether the available data suggest that the constituent is likely to be of ecological concern.

14.2.2 Search Toxicological Databases

Two distinct steps were made in searching toxicological databases. First, databases related to animal health effects, commonly used in conjunction with human health risk assessments, were searched to identify effects data for mammals and birds. Second, ecologically related databases were searched to evaluate the toxicity data available for other receptors (e.g., terrestrial plants, algae, fish/aquatic invertebrates). Expanded descriptions of these steps and databases follow:

Step 1—The Hazardous Substance Database (HSDB) and the Registry of Toxic Effects of Chemical Substances (RTECS) were reviewed for toxicological information of constituents on animals. These databases were selected because (1) they included a wide variety of toxicity data, (2) they were readily available, and (3) they provided a rapid (if incomplete) picture of the chemical toxicology. Results from searching these databases also were useful in identifying primary references for the development of stressor-response profiles and benchmarks for mammals and birds. These databases are limited, however, because toxicological data are presented only for mammals (including humans) and birds and because narrative text is generally insufficient to interpret the study data. Nevertheless, these data were enormously important in defining the range of effect levels and critical endpoints (e.g., teratogenicity) necessary for the stressor-response profile.

Step 2—EPA's ECOTOX database has become an essential reference for benchmark development because (1) it is the largest database of ecological effects data currently available, (2) it includes primary literature citations, and (3) it is readily available.

Three databases were available within ECOTOX covering different groups of ecological receptors: (1) TERRETOX for terrestrial wildlife and soil biota, (2) PHYTOTOX for effects on terrestrial plant species, and (3) the Aquatic Information Retrieval (AQUIRE) system for effects on aquatic biota (fish, invertebrates, and aquatic plants). The drawback to using ECOTOX is that its databases are only updated periodically. AQUIRE is updated annually. TERRETOX and PHYTOTOX offer a thorough search of data up to 1991; however, updates from 1991 to the present only partially represent the primary literature. The ecological effects information culled from ECOTOX was used to identify data gaps and to refine the bibliographic and keyword search for specific receptors in the next step. If sufficient data were not identified in ECOTOX (e.g., toxicity is only characterized for a few species), a more broad-based strategy was adopted for the online literature search.

14.2.3 Conduct Online Literature Search

Commercial online databases such as Dissertation Abstracts include extensive bibliographic databases that can provide additional information not found in ECOTOX or other similar databases. The general strategy for searching online bibliographic databases is summarized in Steps 1and 2 as follows:

Step 1—The bibliographic database search began with Toxline®/Medline® because they are relatively low-cost databases that specialize in toxicological citations. Research Triangle Institute (RTI) has used these databases frequently with a high degree of success.

Step 2—Based on the results of the primary search in Toxline®/Medline®, it was sometimes necessary to reconsider the search strategy and submit a new search or to search more

costly databases (e.g., royalty databases). Depending on the data gaps for specific ecological receptors (e.g., no data on birds), a more appropriate database was searched. For example, if we needed data on avian effects, we would select a database such as Biological Abstracts rather than a database limited to aquatic effects (i.e., Water Resources). For data-poor constituents, more general environmental databases such as Environline® or Pollution Abstracts were searched.

Following primary literature searches, appropriate studies were identified for benchmark and CSCL derivation. A summary of the key documents and databases consulted to develop benchmarks and CSCLs is provided in Table 14-3. The actual primary references that were specifically identified to derive benchmark doses for mammals and birds are provided in Table 14-4. For constituents added after primary literature searches were completed, only Steps 1 and 2 were completed (see text box). For these chemicals, the searches were limited to the effects data outlined in the sources presented in Table 14-3. The benchmarks and CSCLs for the newer constituents should be considered **preliminary** until further primary literature reviews are conducted.

14.3 Methodology

14.3.1 Benchmark/CSCL Database

14.3.1.1 <u>Database Compilation</u>. The methods used to derive each of the benchmarks and CSCLs were different across receptor taxa. Because of these differences, the methods used to develop benchmarks and CSCLs are reviewed separately for each receptor taxon. The discussion of the methods used in developing the benchmark/CSCL database is organized around the specific module parameters listed in Table 14-1. Because parameters are media-specific, some parameters cover more than one receptor category. For instance, total water CSCLs are generated for herpetofauna, the freshwater community, and algae/aquatic plants. In these cases, receptor-specific methods are discussed as subsections.

14.3.1.1.1 *Ecological Benchmarks for Representative Receptors (ChemEBRec)*. Ecological benchmarks (EBs), derived in units of dose (mg/kg/d), were developed for representative taxa of mammals and birds. The EBs were appropriate for upper-trophic-level consumers because the primary exposure route occurs through ingestion of contaminated prey items. Because the degree of exposure to mammals and birds is dependent on the foraging range, uptake rates, and percentage of the diet that is contaminated, in constructing the Hazardous Waste Identification Rule (HWIR) ecological exposure modeling system, these life history factors were used to develop an estimated dose for representative mammals and birds exposed to constituents. The risk estimate was derived by comparing exposure doses to the benchmark dose to assess whether the benchmark dose had been exceeded. An exceedance indicates the potential for adverse effects.

The overall approach used to establish these benchmarks is similar to the methods applied to derive reference doses (RfDs) for humans, as described in the Integrated Risk Information System (IRIS) (U.S. EPA, 1993c). The method adopted for HWIR uses a hierarchy for the selection of ecotoxicity data and extrapolates from a test species to the species of interest (in this

Table 14-3. Key Sources of Information Consulted in the Development of Benchmarks and CSCLs

Source	Contents
Mammals and Birds	
U.S. EPA (Environmental Protection Agency). 1995b. *Great Lakes Water Quality Initiative Criteria Documents for the Protection of Wildlife.* Office of Water.	This document provides wildlife criteria in surface water for exposures to DDT, 2,3,7,8-(TCDD), mercury, and polychlorinated biphenyls (PCBs).
Sample, B.E., D.M. Opresko, and G.W. Suter, II. 1996. *Toxicological Benchmarks for Wildlife: 1996 Revision.*	This compendium reference reviews ecotoxicity data derived from the primary literature of various constituents to species of mammals and birds.
U.S. EPA (Environmental Protection Agency). 1999a. *Ecotoxicological Database System.* Office of Research and Development, U.S. Environmental Protection Agency.	The terrestrial animal toxicity database (TERRETOX) contains more than 33,000 toxicity tests on terrestrial wildlife for more than 1,200 chemicals and 253 species.
U.S. FWS (Fish and Wildlife Service). Various years. *Contaminant Hazard Reviews*. U.S. Department of the Interior (e.g., Eisler, 1989).	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. 1997. *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision*.	This document provides ecotoxicity effects data for terrestrial plants exposed in soil and solution media. Approximately 45 constituents have proposed soil criteria.
U.S. EPA (Environmental Protection Agency). 1999a. *Ecotoxicological Database System.* Office of Research and Development, U.S. Environmental Protection Agency.	The terrestrial plant toxicity (PHYTOTOX) database contains more than 49,000 toxicity tests on terrestrial plants for more than 1,600 organic and inorganic chemicals and 900 species.
Freshwater Community	
U.S. EPA (Environmental Protection Agency). 1999a. *Ecotoxicological Database System.* Office of Research and Development, U.S. Environmental Protection Agency.	The aquatic biota toxicity database (AQUIRE) contains more than 145,000 toxicity tests for more than 5,900 organic and inorganic chemicals and 2,900 aquatic species.
U.S. EPA (Environmental Protection Agency). Various years. *Ambient Water Quality Criteria*. Office of Water, Washington, DC. (Example U.S. EPA, 1989).	These chemical-specific documents provide the ecotoxicity data and derivation methodologies used to develop the National Ambient Water Quality Criteria (NAWQC).

(continued)

Table 14-3. (continued)

Source	Contents
Freshwater Community (continued)	
U.S. EPA (Environmental Protection Agency). 1995a. *Great Lakes Water Quality Initiative Criteria Documents for the Protection of Aquatic Life in Ambient Water*. Office of Water. U.S. EPA (Environmental Protection Agency). 1996a. *1995 Updates. Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water*. EPA 820B96-001. Office of Water, Washington, DC.	For a limited number of constituents, the Great Lakes Water Quality Initiative (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 Potential Contaminants of Concern for Effects on Aquatic Biota*: *1996 Revision*.	This compendium reference provides acute and chronic water quality criteria for freshwater species, including algae.
Algae and Aquatic Plants	
Suter II, G.W. and C. Tsao. 1996. *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota*: *1996 Revision*.	This compendium reference provides acute and chronic water quality criteria for freshwater species, including algae.
U.S. EPA (Environmental Protection Agency). 1999a. *Ecotoxicology Database System*. Environmental Research Laboratory, Office of Research and Development.	The AQUIRE database contains more than 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. 1997. *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 (Environmental Protection Agency). 1993a. *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 (sediment quality criteria [SQC]) for nonionic hydrophobic organic chemicals using final chronic values (FCVs) and secondary chronic values (SCVs) developed for surface water. The criteria are estimated based on the assumption that the partitioning of the constituent between sediment organic carbon and pore water is at equilibrium.

(continued)

Table 14-3. (continued)

Source	Contents
Sediment Community (continued)	
Long, E.R., and L.G. 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.	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. Suter, II, and R.N. Hull. 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.
Long, E.R., D.D. MacDonald, S.L. Smith, and F.D. Calder. 1995. Incidence of adverse biological effects with ranges of chemical concentrations in marine and estuarine sediments. *Environmental Management* 19(1):81-97.	This paper contains an updated version of the NOAA approach (Long and Morgan, 1991) in which additional data were added to the data set. The range of sediment concentrations that may result in adverse impacts to benthic-dwelling invertebrates are indicated.
MacDonald, D.D. 1994. *Approach to the Assessment of Sediment Quality in Florida Coastal Waters*. Vol. 1. Florida Department of Environmental Protection (FDEP), Tallahassee, FL.	This approach applies statistical derivation methods to determine sediment criteria using NOAA data. The resulting criteria are more conservative than NOAA values.
Herpetofauna	
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 (Environmental Protection Agency). 1996b. *Amphibian Toxicity Data for Water Quality Criteria Chemicals*. EPA/600/R-96/124. National Health and 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 of NAWQC under the data requirement for species in phylum Chordata.
Devillers, J., and J.M. Exbrayat (eds). 1992. *Ecotoxicity of Chemicals to Amphibians*. Philadelphia, PA: Gordon and Breach Science.	This text provides test study summarizes for amphibians reporting endpoints related to reproduction and survival.

Table 14-4. Primary Literature Used in Mammalian and Avian Benchmark Derivation[a]

Constituent	Mammalian Reference	Avian Reference
Antimony	Rossi et al., 1987	ID
Arsenic	Byron et al., 1967	Stanley et al., 1994
Barium	ID	Johnson et al., 1960
Benzene	Sample et al., 1996	ID
Benzo(a)pyrene	MacKenzie and Angevine, 1981	ID
Bis(2-ethylhexyl) phthalate	Shiota and Nishimura, 1982	ID
Cadmium	Sutou et al., 1980	White and Finley, 1978
Chloroform	Sample et al., 1996	ID
Chromium III (insoluble salts)	Sample et al., 1996	ID
Chromium VI	Zahid et al., 1990	ID
Lead	Krasovskii et al., 1979	Edens and Garlich, 1983
Mercury	Wobeser et al., 1976a, 1976b	Heinz, 1974, 1975, 1979
Methyl ethyl ketone	Sample et al., 1996	ID
Nickel	Ambrose et al., 1976	Sample et al., 1996
Pentachlorophenol	Welsh et al., 1987	Prescott et al., 1982
Selenium	Rosenfeld and Beath, 1954	Heinz and Hoffman, 1987
TCDD, 2,3,7,8-	Murray et al., 1979	Nosek et al., 1992
Thallium	Sample et al., 1996	ID
Toluene	Sample et al., 1996	ID
Trichloroethylene	Sample et al., 1996	ID
Trichloroethane, 1,1,1-	Sample et al., 1996	ID
Vanadium	Domingo et al., 1986	Romoser et al., 1961
Vinyl chloride	Sample et al., 1996	ID
Zinc	Schlicker and Cox, 1968	Sample et al., 1996

ID=Insufficient data identified for benchmark derivation.
[a]Chemicals not listed had insufficient data to develop mammalian or avian benchmarks.

case, wildlife). There are fundamental differences between the goals of noncancer risk assessments for humans and ecological receptors. For example, risk assessments conducted for humans seek to protect the individual, while ecological risk assessments seek to protect populations or communities of important species (U.S. EPA, 1992a). Consequently, benchmark studies for mammals and birds were selected using a few key guidelines. These guidelines represent the minimum requirements for a study to be of sufficient rigor for benchmark derivation.

- *Measurement Endpoints*—Studies containing measurement endpoints reported as either a no-observed-adverse-effect level (NOAEL) or a lowest-observed-adverse-effect level (LOAEL) in units of daily dose were preferred. From these results, the geometric mean between the NOAEL and the LOAEL (i.e., maximum acceptable toxicant concentration [MATC]) was calculated. The MATC was the preferred benchmark for representative mammalian and avian species.

- *Toxicity Endpoints*—Because population viability in mammals and birds was selected as the assessment endpoint, the benchmarks were developed from toxicity endpoints of reproductive or developmental success or, if unavailable, other effects that could conceivably impair population dynamics.

- *Methods*—No specific test methodologies were required in studies used for benchmark derivation. Standard laboratory practices (e.g., control dose groups), however, were required. Field data may not be appropriate to develop a daily dose exposure.

- *Receptor Requirements*—Ecotoxicity data for wildlife species were preferred (e.g., mallards or mink); however, because of the paucity of studies exposing wildlife species, rats and mice were typically the surrogate species exposed in benchmark studies.

- *Durations*—Studies were selected that reflected chronic or subchronic exposure durations extending over a large percentage of the test species' lifetime, over multiple generations, or over a particularly sensitive life stage of a species.

- *Exposure Routes*—Studies indicating oral exposure (e.g., dietary, gavage) were preferred to studies using other exposure routes (e.g., intraperitoneal injection). Mammals and birds in the field are typically more highly exposed through ingestion of contaminated prey than through inhalation or direct contact, although there are exceptions (e.g., burrowing animals).

- *Dosing Scheme*—Dose-response curves characterized by at least three data points were selected over studies exposing animals to one dose level. This helped identify both a NOAEL and a LOAEL for MATC calculations.

In addition to the primary literature, several review sources of ecotoxicity data were identified containing study data of sufficient quality to meet data requirements (Table 14-3). Several benchmark studies, however, were selected from Sample et al. (1996), a compendium of study values reporting NOAELs and LOAELS for chronic and subchronic durations measuring reproductive and developmental endpoints.

Mammalian and avian benchmarks represent population-inference benchmarks. By developing benchmarks from NOAELs and LOAELs in mammals and birds, benchmarks were estimated to provide protection from ingested doses that may inhibit the reproductive capacities of these populations. The ability of the population to sustain itself (within normal biological variation) was inferred from individual effects such as fecundity. This inference, however, has yet to be validated from field or microcosm studies on exposed populations. Without validation, it is likely that some benchmarks are overprotective and others are underprotective of wildlife populations. Although this method does not confirm protection of populations, by protecting individuals from adverse effects to reproductive and developmental endpoints, some level of protection is provided to populations.

Once the benchmark study was identified, a scaled benchmark was calculated for representative receptors of mammals. This method used an allometric scaling equation based on body weight to extrapolate test species doses to estimate wildlife species doses. For mammals, a scaling factor of 3/4 was used (Equation 14-1). This is the default methodology EPA proposes for carcinogenicity assessments and reportable quantity documents for adjusting animal data to an equivalent human dose (U.S. EPA, 1992b). For birds, recent research suggests that the cross-species scaling equation used for mammals is not appropriate for avian species (Mineau et al., 1996). Using a database that characterized acute toxicity of pesticides to avian receptors of various body weights, Mineau et al. (1996) concluded that applying mammalian scaling equations may not sufficiently predict protective doses for avian species. Benchmarks scaled for small-bodied avian species using the mammalian equation generated scaled doses that were not protective enough for small birds. Mineau et al. (1996) suggested a scaling factor of 1 provided a better dose estimate for birds. Therefore, a scaling factor of 1 was applied for avian receptors (Equation 14-2).

$$EB_w = MATC_t \, x \left(\frac{bw_t}{bw_w} \right)^{1/4} \tag{14-1}$$

$$EB_w = MATC_t \, x \left(\frac{bw_t}{bw_w} \right)^{0} \tag{14-2}$$

where

EB_w = scaled ecological benchmark for species w (mg/kg/d)

$MATC_t$ = maximum acceptable toxicant concentration (mg/kg/d)
bw_t = body weight of the surrogate test species (kg)
bw_w = body weight of the representative wildlife species (kg).

Body weights for ecological receptors were identified from two primary sources: the *Wildlife Exposure Factors Handbook* (U.S. EPA, 1993b) and Sample et al. (1997). Body weights for wildlife species not covered in these sources were identified through primary literature sources. (See the exposure factors database documentation section for an expanded discussion of receptor body weights). Applying these decision criteria and methods resulted in the selection of benchmark studies and derivation of benchmark doses presented in Appendix 14A, Tables 14A-1 and 14A-2, for mammals and birds, respectively. The final scaled benchmarks for representative species are presented in Appendix 14A, Table 14A-10.

14.3.1.1.2 *Total Surface Water CSCLs (ChemCSCLWaterTotRec*). The CSCLs developed for surface water based on total concentrations of the constituent covered the following receptor taxa: freshwater community (i.e., fish and aquatic invertebrates), algae/aquatic plants, and herpetofauna.[2] The methods used to derive CSCLs are reviewed here for each receptor taxon. The CSCL developed for the freshwater community was derived to reflect both total and dissolved water concentrations (see Section 14.3.1.1.3 for a discussion of the methods used to derive dissolved CSCLs). The resulting CSCLs developed for these taxa are presented in Appendix 14A in Table 14A-3 (total freshwater community), Table 14A-5 (algae and aquatic plants), and Table 14A-6 (amphibians).

Freshwater Community

The freshwater community CSCL was developed to protect species of fish and aquatic invertebrates. The CSCL does not extend to protect species of mammals and birds that may forage in freshwater ecosystems. The methods adopted to develop freshwater community CSCLs are consistent with those supported across EPA offices. The CSCLs were derived using methodologies founded through the development of the National Ambient Water Quality Criteria (NAWQC). These methods require the compilation of appropriate acute and chronic

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), and
- A family in any order of insect or any phylum not already presented.

[2]Herpetofauna includes species of amphibians and reptiles. Insufficient ecotoxicity data were identified to derive CSCLs for reptiles. Therefore, continued discussions only review amphibians.

ecotoxicity data reporting effects to survival, growth, and reproduction in aquatic biota for specific members of the freshwater community. The NAWQC method uses a list of ecotoxicity data requirements for eight taxonomic families that represent typical freshwater species (see accompanying text box). Whether a final chronic value (FCV) or a secondary chronic value (SCV) is calculated depends on how well the eight taxonomic families are represented by the data.

For populations of the freshwater community (e.g., fish, aquatic invertebrates), the FCV developed for the NAWQC or the criterion continuous concentration (CCC) developed for the Great Lakes Water Quality Initiative (GLWQI) was the preferred CSCL to use for this analysis (U.S. EPA, 1995a, 1996a). If neither a CCC nor an FCV was available, an SCV was calculated using Tier II methods developed through the GLWQI (Stephan et al., 1985; Suter and Tsao, 1996).

A brief overview of the derivation methodology is provided here; however, 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).

- *FCV and CCC*—An FCV and a CCC are 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) that meets the eight species 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 2, and (4) dividing the result of the Step 3 value by the ACR.

- *SCV*—An SCV is calculated using analogous methods as those applied in calculating the FCV. The Tier II methods, however, (1) require chronic data on at least one of the eight species 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 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.

Algae and Aquatic Plants

For algae and aquatic plants, toxicological benchmarks were identified in the open literature or from data compiled 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-effects concentrations were identified for algae. The criteria for algae and aquatic plants were based on a lowest-observed-effect concentration (LOEC) for vascular aquatic plants or 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. In instances where only a median effective carcentration (EC_{50}) was identified to characterize effects to algae growth and survival, a safety factor of 5 was applied to generate an estimated low effects concentration.

Amphibians

Amphibians appear to be highly sensitive to a number of toxicants during the developmental stages of their life cycle (e.g., trace metals). Amphibians are essential parts of a number of food webs (particularly wetlands) and are likely to provide a fairly sensitive indicator for chemical stressors relevant to higher levels of biological organization. Though amphibians are a significant ecological receptor, ecotoxicity data characterizing the chronic dose-response relationship for chemicals of concern are limited. After a review of several compendia presenting amphibian ecotoxicity data (e.g., Devillers and Exbrayat, 1992; Power et al., 1989; U.S. EPA, 1996b) as well as primary literature sources, no suitable subchronic or chronic studies were identified that reported effects to reproductive or developmental endpoints in 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 water concentration resulting in 50 percent mortality) amphibian ecotoxicity data. A few general guidelines were followed in selecting analogous acute studies for developing the CSCL:

- Test duration was usually less than 15 d.
- Toxicity endpoints included mortality (LC_{50})
- Exposure occurred during early life stages (i.e., embryo, larvae, and tadpole).

Because the criteria are based on acute data (i.e., lethality), the severity of the potential adverse effects that this criteria indicates is significant. Incorporating the amphibian data into the NAWQC within the data requirement categories is currently under consideration. Because 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 CSCL is unclear.

14.3.1.1.3 ***Dissolved Surface Water CSCLs (ChemCSCLWaterDissRec*).** Conversion factors were available for several of the metal constituents to convert total metal concentrations in the water column to total dissolved concentrations (U.S. EPA, 1999b). 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).

Methods are currently only available to develop dissolved CSCLs for metals in the freshwater community. Dissolved CSCLs were derived from total water CSCLs using a conversion factor. The conversion factors applicable to chronic criterion in freshwater are presented in Table 14-5. 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. Dissolved CSCLs were derived by multiplying the total CSCL by the conversion factor (Equation 14-3).

$$Metal\ \ CSCL_{dissolved} = (Metal\ \ CSCL_{total})\ x\ (Conversion\ \ Factor) \qquad (14\text{-}3)$$

where

Metal CSCL $_{total}$ = either an FCV or an SCV in freshwater
Conversion Factor = the fraction of dissolved metal.

The final CSCLs generated for the freshwater community based on the total dissolved constituent concentrations are provided in Table 14A-4 of Appendix 14A.

Table 14-5. Conversion Factors for Dissolved Metal[a]

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

aConversion factor for chronic CSCLs in freshwater.
[b] Dependent on the water hardness (assumed to be 100 mg $CaCO_3$/L for this analysis).

14.3.1.1.4 *Sediment CSCL (ChemCSCLSedimentRec*). Two methods were applied in developing the CSCL for the benthic community (e.g., worms, amphipods). The first and preferred method used measured sediment concentrations that resulted in minimal effects to the composition and abundance of the sediment community. The sediment criteria were derived from the upper limit of the range of sediment contaminant concentrations dominated by no-

effects data to survival, species diversity, and abundance endpoints. Measurements to derive the CSCLs were taken at the national scale and reflected a variety of sediment types and benthic community species. The second CSCL derivation method used the equilibrium partitioning (EqP) relationship between sediments and surface waters to predict a protective concentration for the benthic community. This method was used only for nonionic organic constituents. For the benthic community, the approach used to establish CSCLs was based on a complete assessment of several sources proposing protective sediment CSCLs (Table 14-3). A discussion of each method (i.e., measured and estimated CSCLs) is provided. The resulting benthic CSCLs are presented in Appendix 14A, Table 14A-7.

Measured Sediment CSCLs

The premier sources of measured sediment CSCLs are the National Oceanic and Atmospheric Administration (NOAA) and the Florida Department of Environmental Protection (FDEP) sediment documents. 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 (NS&T) Program. Data collected by NOAA include measured sediment concentrations and the corresponding measures of toxicity in resident 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 (ER-L) and a median effects concentration (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 were 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 statistically derived 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 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; if not, ER-L values were used. The FDEP criteria were chosen above the NOAA criteria for the following reasons:

- The same database was used for both the NOAA criteria and the FDEP criteria development.

- In most cases, the FDEP criteria were more conservative than the NOAA criteria because a larger portion of the low-effects data was used in benchmark development.

- The marine TELs developed by the FDEP were found to be analogous to TELs observed in freshwater organisms (Smith et al., 1996).

Estimated Sediment CSCLs

When measured effects data were not available for organic constituents using the TEL or ER-L approach, the value was derived using the EqP approach to estimate the sediment CSCL (U.S. EPA, 1993a). The surface water FCV or SCV was used to generate a sediment CSCL using the partitioning relationships among surface water, pore water, and organic carbon in sediment. This method assumes that the equilibrium partitioning between the sediment and the water column is a function of the organic carbon. Equations 14-4 and 14-5 were used to calculate the sediment CSCL depending on whether an FCV or an SCV was available. In calculating sediment CSCL for nonionic chemicals, the fraction organic carbon (f_{oc}) was assumed to be 1 percent total organic carbon and K_{oc}s (organic carbon partitioning coefficients) were adopted as reported in Jones et al. (1997). However, because sediment CSCLs were derived for organic constituents based on site-specific f_{oc}, the CSCLs in Table 14A-7 were recalculated within the HWIR modeling framework on a site-specific basis.

$$Sediment\ \ CSCL = f_{oc}\ x\ K_{oc}\ x\ FCV \tag{14-4}$$

$$Sediment\ \ CSCL = f_{oc}\ x\ K_{oc}\ x\ SCV \tag{14-5}$$

14.3.1.1.5 *Soil CSCLs (ChemCSCLSoilRec*). Soil CSCLs were derived for the terrestrial plant community and the soil community. Each of the specific methods, including the rationale and the derivation methods, is outlined in the following sections. The results of the soil CSCL development are presented in Table 14A-8 (terrestrial plant community) and Table 14A-9 (soil community) of Appendix 14A.

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, Will, Suter, and Wooten, 1997). The measurement endpoints were generally limited to growth and yield parameters for the following reasons:

- They are the most common class of responses reported in phytotoxicity studies and, therefore, allow for criterion calculations for a large number of constituents.

- 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, Will, Suter, and Wooten (1997), 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 lowest LOEC was used. If there were more than 10 values, the 10th percentile LOEC was used.

Soil Community

Two methods were used in deriving soil community CSCLs: a community-based CSCL and an earthworm/microbial CSCL.

Community-Based CSCL—The first, and preferred, method was based on a community-level approach similar to that applied in deriving the NAWQC. This method developed a CSCL based on NOECs to reproductive and development endpoints in a number of key functional taxa in the soil community. The CSCL was designed to protect the structure and function of the soil community and its critical role in the overall nutrient processing that occurs in the terrestrial food web. A detailed discussion of the decision criteria and calculations used to develop a community-based CSCL are provided in the following section "Methodology to Develop Community-Based CSCLs." Review of the primary literature only supplied sufficient data to develop a community-based soil CSCL for the constituents of lead and cadmium.

Two key uncertainties were noted in the development of community-based CSCLs. First, the ecotoxicity data used in the method are based on NOECs. The CSCLs developed using the earthworm/microbial method for the soil community were based on low-effects levels. Because these CSCLs are based on no-effects soil concentrations, some added conservatism was generated in the soil community CSCLs for lead and cadmium. Second, the species taxa groups designed to represent key compartments in the soil community did not include microbes. This introduces some uncertainty in the soil CSCL because microflora make up approximately 80 to 90 percent of the biomass in soil and microflora are responsible for the majority of the biological activity in soil (e.g., N mineralization).

Earthworm and Microbial CSCLs—The second method used to derive soil CSCLs required the identification of LOECs for earthworms and microbial endpoints. However, because a single species alone cannot predict the potential toxicological impacts to the soil community, the community-based method was preferred over using an earthworm or microbial CSCL.

Earthworms have been recognized to play important roles in promoting soil fertility, releasing nutrients, and providing aeration and aggregation of soil, as well as being an important food source for higher trophic level organisms. In addition, their constant contact with soil media and permeable epidermis makes them more susceptible to contaminant exposures. Likewise, microbial communities play a key functional role in soil fertility, decomposition processes, and nutrient cycling, providing nutrients in available forms to plants. Microbial CSCLs were only used when they indicated a significantly higher sensitivity to a particular constituent than the corresponding earthworm toxicity data. This was the case only for nickel and zinc.

The earthworm and microbial CSCLs were developed using the ER-L approach, which was also applied to develop terrestrial plant CSCLs. When more than 10 studies were identified reporting LOECs, then the 10th percentile of the values was derived as the CSCL. When less than 10 values were identified, however, the lowest LOEC was selected as the CSCL. When

sufficient LOEC data were identified, this method was used to develop soil CSCLs for all constituents except lead and cadmium.

Methodology to Develop Community-Based CSCLs–The process of developing community-based soil CSCLs 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 these steps is 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. Figure14-1 illustrates the generalized soil community that is reflected in these metrics.

Five metrics were used to select representative soil species, as follows:

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. The top two horizons, however, tend to receive higher exposures to persistent and relatively immobile contaminants (such as some metals).

3. *Abundance*–the number of individuals present in a typical habitat. Caution must be implemented in using this criterion because abundant species are not always the 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 (Reiche, 1977).

4. *Energy metabolism*–the 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 useful tools in assessing ecological significance.

5. *Function in community*–feeding preferences of different organisms largely define their role in the trophic structure (see Figure 14-1), 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):

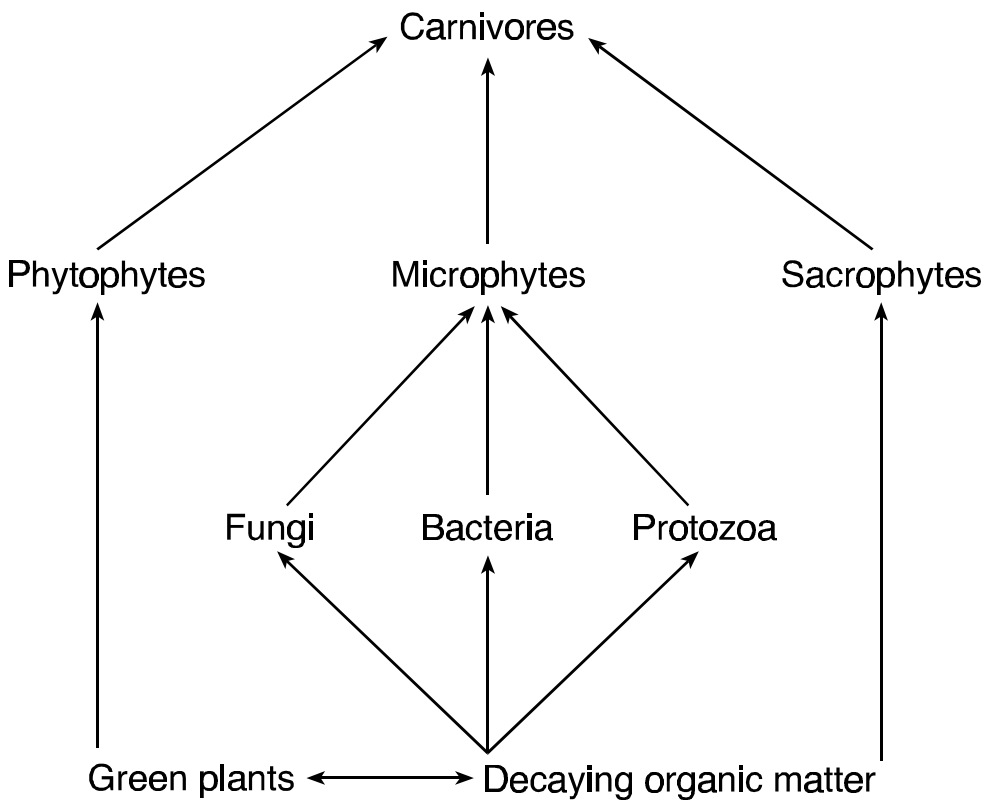

Figure 14-1. Simplified trophic structure of a generalized soil community.

- 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, and insect larvae)

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

Collection of Toxicological Data on Soil Species—Guidelines were established to collect data on NOECs 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 and 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 and 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 mollusk from the order Stylommatophora. Although the majority of mollusks 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 CSCL for the Soil Community—The statistical approach adopted consisted of two steps: (1) fitting the NOEC 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. Key assumptions were that NOEC data are distributed lognormally and the 95 percent level of protection is ecologically significant. The approach to calculating CSCLs 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 (Aldenberg & Slob, 1993; Sloof, 1992; VanStraalen & Denneman, 1989). For the soil community CSCL, the 50th percentile level of confidence was selected because the 95th percentile appeared to be overly conservative for a no-effects approach. Equation 14-6 was used to calculate soil community CSCLs.

$$HC_{5\%} = [x_m - k_l \; s_m] \tag{14-6}$$

where

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

x_m = sample mean of the log NOEC 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 NOEC data.

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 there is just one extrapolation constant with the required confidence property for each species sample size and 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).

14.3.1.2 <u>Database Processing</u>. Minimal manual processing of the benchmark/CSCL database was conducted. Most of the CSCL and benchmark values generated were manually entered into the data table. The parameters for the benchmark/CSCL database were one-dimensional chemical properties that were dimensioned on the variable Num Receptor in the ecological risk module.

Processing of the benchmark/CSCL database was conducted for the scaling of mammalian and avian benchmarks and the derivation of module-generated, site-based CSCLs (e.g., hardness dependent upon water quality criteria). Data processing was conducted on the mammalian benchmarks, which were scaled by body weight to extrapolate from surrogate laboratory species to representative wildlife species (see Section 14.3.1). In addition, some of the criteria were generated on a site-specific basis using parameters of water hardness (mg $CaCO_3$/L) and f_{oc} in sediment. In cases where CSCLs were developed on a site-specific basis, CSCLs reported in the database may not reflect the value used in calculate hazard quotient (HQ) calculations.

14.3.1.3 <u>Assumptions and Uncertainties</u>. In this section, the key assumptions and uncertainties associated with the application and development of the ecological benchmark and CSCL database are reviewed. The discussion of assumptions and uncertainties is constructed around three key issues: (1) the relationship between assessment endpoints and measures of effect, (2) the quality of the ecotoxicological data, and (3) the extrapolation methods used to derive receptor-specific benchmarks and CSCLs from the ecotoxicity data.

14.3.1.3.1 Relationship Between Assessment Endpoints and Measures of Effect. In developing ecological benchmarks and CSCLs for the HWIR analysis, it is crucial to establish the relationship between the assessment endpoints (i.e., the ecological values to be protected) and the measures of effect (i.e., the ecotoxicity data used to support benchmarks and CSCLs). Because the HWIR assessment is predictive, there is no mechanism to verify that assessment endpoints are, in fact, protected by the measures of effect selected to support benchmark/CSCL development. Consequently, there is uncertainty in applying the benchmarks/CSCLs to evaluate risks to the assessment endpoints chosen for HWIR. These uncertainties are discussed below along with key assumptions that are implicit in developing benchmarks and CSCLs (e.g., 95 percent protection level for aquatic biota).

Mammals and Birds

- *Assessment Endpoint*: *maintain viable mammalian and avian wildlife populations.* The attribute to be protected was the reproductive and developmental success of representative species.

- *Measure of Effect*: *a de minimis threshold for developmental and reproductive toxicity in mammalian and avian wildlife species.* The threshold was calculated as the geometric mean of the NOAEL and LOAEL, frequently referred to as the maximum acceptable toxicant concentration (MATC). Implicit in this calculation is the assumption that the toxicological sensitivity is lognormal.

An important source of uncertainty is the benchmark calculation of the MATC. Based on numerous discussions among the technical staff at OSW, this threshold value was determined to be appropriate given the assessment endpoints for a national assessment. The rationale for this determination is based on two assertions: (1) the MATC is above a no effects level and, therefore, is associated with some finite level of risk (i.e., the regulations would not be based on no effects), and (2) the MATC is conservative in that it does not allow for the level of effect associated with a low effects level (often estimated at roughly 20 percent of the population). In making the assumption that a threshold for effects on individual organisms can be used to predict the potential risks to populations, we accept considerable uncertainty regarding the “true” effects on wildlife populations that can only be addressed through simulations with population-level models. These models are designed to address various elements of population dynamics, such as predator prey interactions, carrying capacity of the habitat, immigration and emigration, and initial population size (to name but a few attributes of population-level models). Nevertheless, because the MATC is assumed to be below the level of effect distinguishable from natural population variability, it is assumed that the benchmark provides a reasonably conservative level of protection to wildlife populations.

A second important source of uncertainty is in the selection of study endpoints, in essence, how well an MATC based on reproductive/developmental effects translates into maintenance of wildlife populations. Although the selection of reproductive and developmental effects is consistent with current EPA guidance on ecological risk assessment, it is not possible to demonstrate with certainty that these are the critical endpoints of concern. For example,

neurological effects that impact behavior may occur at a threshold value below the MATC. Depending upon the nature and severity of the effect (e.g., inability to avoid predators), a constituent may affect enough organisms that relatively few reach reproductive maturity. As a result, the overall impacts on the wildlife population may be greater than those inferred from endpoints on reproductive fitness and developmental effects. The implications for receptors with relatively large home ranges (e.g., wolves) are difficult to interpret. For these receptors, the study area may impact only a single reproducing pair of animals and the endpoint of interest may be crucial in determining: (1) whether adverse effects occur and (2) what the ecological significance of those effects might be.

CSCLs for the Freshwater and Soil Communities

- *Assessment Endpoint: maintain sustainable community structure and function*. The attributes to be protected were growth, survival, and reproductive success of species that represent key functional roles in the community.

- *Measure of Effect: concentration in soil or surface water, respectively, based on ecotoxicity studies on endpoints that include lethality, fecundity, growth, and survival*. The CSCLs for the freshwater and soil communities were typically derived at a 95 percent protection level using both no effects and low effects data, as appropriate. When available, the Ambient Water Quality Criteria for chronic effects were chosen as the freshwater CSCLs.

The CSCLs derived for the soil and freshwater organisms are intended to ensure protection of critical structures and functions of the respective communities. However, the CSCLs are not **true** community-level measures of effect in that they do not consider the complex interactions among community members. Consequently, there is uncertainty inherent in inferring risk estimates for the community from a statistical interpretation of data on individual organisms.

In addition, there has been some criticism of the method used to develop the community-based soil CSCL because it does not incorporate microbial populations as a taxa category. There is some question about the endpoint and level of effect that would result in an ecologically significant no- or low-adverse effects to microorganisms (e.g., LOEC, EC_{25}, or EC_{50} for nitrification). There is no doubt that microbial communities are critical to the continued functioning of soil communities, and work is ongoing to consider how to appropriately include this receptor group in the species requirements. Their absence in the current method generates some uncertainty that the measure of effect provides protection to this key receptor.

Ecotoxicity data on earthworms were used to derive CSCLs for the soil community if no other suitable data were identified (i.e., if the data set were limited exclusively to earthworms). However, earthworms represent only one element of a healthy soil community and there is large uncertainty in applying these data to evaluate risks to the entire community. Earthworms play an important role in the soil community (e.g., soil fertility, nutrient release, aeration, food source for predators) and, because ecotoxicity data are relatively abundant, are valuable as indicator species.

Benthic Community

- *Assessment Endpoint*: *maintain sustainable community structure and function*. The attributes of the benthic community to be protected included the growth, survival, and reproductive success of benthic biota.

- *Measure of Effect*: *concentration in sediment based on ecotoxicity studies on endpoints that include lethality, fecundity, growth, and survival*. The CSCLs for the sediment community were typically derived at a 95 percent protection level using both no effects and low effects data, as appropriate. As with the freshwater CSCLs, the Ambient Water Quality Criteria for chronic effects were used to support the sediment CSCLs. In addition, field data on the toxicity of metals to sediment communities in saltwater were also used to develop sediment CSCLs and include a number of "true" community-level effects (e.g., abundance of sediment biota).

The CSCLs for metals were derived from field studies conducted in marine ecosystems. These data were based on effects to marine biota and reflect the surface water chemistry and equilibria characteristic of marine systems. It is implicitly assumed that: (1) the relative sensitivity of species in saltwater sediments is similar to those in freshwater sediments, and (2) the behavior of metals (e.g., bioavailability) in the marine environment is not significantly different from the freshwater environment. However, comparisons made between freshwater and marine CSCLs developed using analogous methods indicate that there is not a significant difference between the effects seen across these systems at low exposure levels (Smith et al., 1996). The methods used to collect field data do not fully support a definitive cause-effect relationship because they do not account for other stressors that may impact the sediment community (i.e., temperature, predation). The CSCLs for non-ionizing organic constituents were developed based on EPA guidelines for sediment community criteria.

Terrestrial Plant Community

- *Assessment Endpoint*: *maintain structure and function of terrestrial plant community*. The attributes to be protected included growth and survival of terrestrial plants.

- *Measure of Effect*: *soil concentrations related to growth, yield, seedling emergence germination endpoints*. The low effects data on phytotoxicity were rank ordered and the plant CSCL was estimated as the 10th percentile value.

The endpoints for plants were limited to low effects concentrations for growth and yield parameters such as seed germination, seedling emergence, and vegetative vigor. It is unclear, however, if the selected measure of effect actually represents a biologically significant effect to populations of wild plants since terrestrial plant communities are quite robust and can shift to more tolerant plant species, and still maintain an adequate prey base for herbivores. There is added uncertainty because most of the ecotoxicity data identified were based on studies using agricultural varieties of plants. Further, other effects, such as RNA synthesis or respiration, may be more sensitive indicators of potentially significant risks to plants. Substantial uncertainty will

be associated with evaluating risks to the plant community until studies are available to determine: (1) the most sensitive, biologically significant endpoint for plants (e.g., seed germination, early growth), and (2) the effects level at which the effect should be considered significant in terms of plant population growth and survival.

Algae/Aquatic Plants

- **#** *Assessment Endpoint*: *maintain primary producers in freshwater systems, including both algal and vascular aquatic plant communities*. The attribute to be protected for this taxa was the growth and biomass.

- **#** *Measure of Effect*: *surface water concentrations related to gross measures of "health" (e.g., biomass) for the algal community and a variety of endpoints for aquatic plants (e.g., number of fronds, root number, plant number, root length).* For algae, the EC_{20} was selected as an adequate threshold for adverse effects and, because of the paucity of data, the lowest LOEC for endpoints of interest was chosen for vascular aquatic plants.

Algae and aquatic plants not only provide a food source for aquatic biota, but also provide needed structure and habitat for many aquatic species. Because the assessment endpoint includes the functional contribution of primary aquatic producers to aquatic ecosystems, there is uncertainty in applying low effects concentrations to this receptor group to protect its value to the ecosystem as a whole. Nevertheless, the design of the HWIR analysis goes well beyond screening and, therefore, use of no effects data was considered inappropriate.

Data availability on algae far exceeded the data identified for vascular aquatic plants. As a result, the CSCL for aquatic producers generally reflects ecotoxicity studies on algae. Because little is known about the relative sensitivity between algae and aquatic plants, representing this receptor group with algal data introduces additional uncertainty in the risk estimates for freshwater systems. There are significant differences in uptake, transport, and biochemical processes between algae and aquatic plants and, therefore, uncertainty in determining how well the measures of effect act to maintain communities of primary producers in aquatic systems.

Herpetofauna

- **#** *Assessment Endpoint*: *maintain viable amphibian and reptile populations ("herps").* The attribute to be protected was the survival and developmental success of these receptors.

- **#** *Measure of Effect*: The measure of effect selected to meet the assessment endpoint was the acute LC_{50}s for lethality and survival and developmental effects resulting from early lifestage exposures.

As indicated by the assessment endpoint, this surface water CSCL was designed to protect both reptile and amphibian species. One uncertainty identified in data collection efforts

was the lack of reptilian ecotoxicity data. There is significant uncertainty that the data identified to derive the measure of effect will, in fact, provide protection to reptiles. This data gap limits the overall characterization of risk of this receptor taxa.

There is additional uncertainty that the measure of effect used for herpetofauna adequately represents a level of protection suitable to the assessment. The CSCL represents a relatively severe effect that includes lethality to 50 percent of the population; this level of effect far exceeds other CSCLs developed for the HWIR analysis and should be considered as non-conservative. Therefore, there is substantial uncertainty in applying this measure of effect given the goal of maintaining viable herp populations. Acute data were used to develop this CSCL because so few chronic data were available. There potentially could be dramatic impacts to other more sensitive endpoints such as reproduction at these surface water CSCLs and, moreover, herpetofauna appear to be under considerable stress from other, as yet unidentified, factors.

The CSCLs for herpetofauna cannot be categorized as protective given nature and magnitude of potential effects. Additional analysis of the risk results for this receptor group may be warranted for exit criteria associated with herp HQs close to the target value of 1. The uncertainty associated with the protection of this species needs special attention when the risk results are interpreted.

14.3.1.3.2 Data Quality Issues. In addition to uncertainties associated with the application of benchmarks/CSCLs, there are uncertainties inherent in the development of benchmarks/CSCLs (e.g., extrapolating from dose-response data; interspecies scaling of benchmarks). The quality and quantity of data used to develop the benchmarks and CSCLs varies greatly across the receptor groups. Thus, there are uncertainties inherent in deriving benchmarks and CSCLs using such a wide range of ecotoxicological data. The key data quality issues are reviewed here.

No-Effects Concentrations Used When Low-Effects Data Were Unavailable

For some of the receptor taxa, only a no-effects concentration was identified through literature searches. In cases where no-effects data were available but sufficient low-effects data were not, the no-effects level was used. As a result, some benchmarks are more conservative than others. This was the case for the soil community CSCLs calculated for lead and cadmium.

Statistically Based Soil Community CSCLs

The community-based soil CSCL was developed to assess the potential effects to multiple trophic elements and various key taxa. This method was applied only for a limited number of metals in the analysis; however, there are several unresolved issues in the application of this method.

- A variety of endpoints were aggregated to derive a geometric mean for the NOEC data for each of the eight representative soil species data requirements. The geometric mean of multiple values representing several measurement endpoints

has statistical meaning but not well-defined biological significance. The loss of the true stressor-response relationship in this approach makes interpreting the ecological significance of CSCL exceedances difficult.

- The issue of bioavailability is particularly important in assessing the impacts to the soil community, particularly for metals that exist in multiple ionic forms in the environment. The toxicity and mobility of a metal can be highly influenced by the local environmental chemistry of the soil matrix. Characterizing the bioavailability of metals in different environmental conditions is crucial in establishing CSCLs that are useful across different soil matrices. Bioavailability was not accounted for in this methodology.

- Although soil invertebrates may be classified according to ecological function (e.g., trophic level, feeding habits), few studies were identified that supported the assumption that taxonomically related soil invertebrates have toxicologically similar responses to chemical stressors (e.g., Neuhauser et al., 1986). In addition, many species of soil invertebrates were excluded that occur only in specialized microenvironments such as dung piles, carrion, and rotting wood (i.e., niche organisms). As a result, species were selected to represent a range of trophic levels and functions in the community (rather than selecting the "most sensitive" species). This community-based approach assumes that, if key components in the soil community are protected, community structure and function will not be adversely affected. However, this approach has not been validated in field or mesocosm studies. The development of a more generalized soil comunity reduced the resolution of the potential impacts to this community.

Statistical versus Biological Endpoints

There is some uncertainty associated with using the MATC as a benchmark because it is derived from **statistically relevant** endpoints rather than **biologically relevant** endpoints. Because the NOAELs and LOAELs are generated using hypothesis-testing statistics, the quantification of these effects levels depends on the size, design, and variability of an experiment (e.g., range-finding test or definitive test). Because the MATC is a geometric mean of two statistically derived toxicity endpoints, uncertainty is generated by establishing this value as a “protective” benchmark. In some cases, low-effects and no-effects concentrations derived using hypothesis testing result in chronic benchmarks for aquatic organisms (e.g., MATCs) that result in greater than 50 percent mortality (Stephan et al., 1985). For example, the MATC has been shown to correspond to fairly high levels of effect. Data from 176 tests on 93 chemicals with 18 species indicated that average reductions in reproductive endpoints at the MATC were 20 percent for parental survival, 42 percent for fecundity, and 35 percent for an integrative weight/egg parameter (Suter et al., 1987). The uncertainty associated with the biological relevance and conservatism of these doses needs to be considered in the characterization of the risk results.

Research and Analysis of Data Supporting Benchmarks and CSCLs

A complete and exhaustive primary literature search has been completed for almost half of the constituents considered in this analysis. For other constituents, secondary sources have been consulted to identify appropriate benchmarks and CSCLs. The different levels of data review and analysis were the result of changes made to the list of constituents after primary literature searches were completed. Rather than conducting primary literature searches for the newly added constituents, compendia were used to identify preliminary benchmarks and CSCLs to support the risk estimates. The limited literature review given to these chemicals, listed in Table 14-2, magnifies the uncertainties in developing benchmarks and CSCLs.

14.3.1.3.3 Extrapolation

Uncertainty Factors Applied

Additional uncertainty was introduced into the analysis through developing the measures of effect by applying uncertainty factors to convert LOAELs for mammalian and avian benchmarks to NOAELs. When only LOAELs were available, the LOAEL was divided by 10 to estimate the NOAEL. This is not an uncommon procedure when only a low-effects concentration is available; however, EPA has recently assessed the accuracy of uncertainty factors and reported that, in many cases, the difference can be less than 10. Applying a factor of 10 may create added conservatism in the MATCs generated for mammals and birds (Abt Associates, Inc., 1995). For algae and aquatic plants, a similar uncertainty factor of 5 was applied to convert EC_{50} data to estimate a low-effects concentration.

Allometric Scaling

For mammals, differences in interspecies uncertainty were indirectly addressed through the use of the species-scaling equation. 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 because this method may not account for physiological/biochemical differences in species sensitivity. Applying this method to species demonstrating different sensitivities across chemical classes introduces some uncertainty in the analysis. Allometric scaling was not applied to avian receptors because a recent study indicated that scaling benchmark doses for birds may not be protective of small-bodied avian receptors (Mineau et al., 1996).

Laboratory-to-Field Extrapolation

The toxicological benchmarks for ecological receptors were developed assuming that effects that are observed in laboratory test species are applicable to wildlife species under similar field conditions. As a result, there were no laboratory-to-field extrapolation factors applied to account for the additional stress that may be encountered under field conditions (e.g., cold or drought). Van Straalen and Denneman (1989) and Stephan et al. (1985) examined arguments

both for and against a laboratory-to-field extrapolation factor and concluded that laboratory-to-field extrapolation factors were not necessary; i.e., criteria derived with laboratory data should protect soil fauna in the field. However, other authors have suggested that laboratory species tend to be more homogeneous and have narrower tolerance distributions than their field counterparts, and that the distribution of the target population of species is likely to have a different shape and scale relative to the laboratory species (Smith and Cairns, 1993; Suter et al., 1983). As a result, the distribution of the endpoint will be narrower for the laboratory species. In addition, Smith and Cairns (1993) point out that local adaptation to conditions may make an individual species more or less tolerant to a chemical stressor.

14.4 Quality Assurance/Quality Control

14.4.1 Technical QA/QC

Each value in the benchmark/CSCL database has undergone some level of technical QA. Constituents that were included in the proposed HWIR have undergone extensive review and have been periodically updated to reflect new findings. Additional constituents included after the primary literature review was completed have been technically reviewed for appropriateness. Technical QA efforts went into reviewing the decision criteria used in benchmark and CSCL development to ensure that the implementation of the methods produced appropriate values.

14.4.2 Data Entry QA/QC

Data entry was performed primarily by hard-copy data entry. Data were checked by different ecological staff members by reviewing data input from the original and secondary sources. Identified errors were reviewed and corrected. The calculations used in allometric scaling were manually checked for confirmation that equations in the spreadsheet were coded properly.

14.4.3 Data Formatting QA/QC

Manual QA/QC checks were conducted to identify errors that may have occurred during data formatting efforts. Approximately 10 percent of the values were checked to ensure formatting for the modeling system did not change or shift values.

14.5 References

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Table 14A-1. Mammalian Benchmark Studies

CAS Number	Constituent Name	Benchmark Dose (mg/kg-d)	Test Species	Endpoint/ Duration	Notes	Source
Organics						
75-05-8	Acetonitrile	ID	---	---	No studies evaluating reproductive endpoints were identified.	---
107-13-1	Acrylonitrile	ID	---	---	No studies evaluating reproductive endpoints were identified.	---
62-53-3	Aniline	ID	---	---	No studies evaluating reproductive endpoints were identified.	---
71-43-2	Benzene	83.4	Mouse	Reproduction/ 6 to 12 d of gestation	Benchmark dose was the MATC calculated from a NOAEL of 26.36 mg/kg-d and a LOAEL of 263.6 mg/kg-d.	Sample et al., 1996
75-15-0	Carbon disulfide	ID	---	---	No studies evaluating reproductive endpoints were identified.	---
108-90-7	Chlorobenzene	ID	---	---	No studies evaluating reproductive endpoints were identified.	---
67-66-3	Chloroform	24.8	Rat	Reproduction/ 13 weeks sub-chronic	Benchmark dose was the MATC calculated from a NOAEL of 15 mg/kg-d and a LOAEL of 41 mg/kg-d.	Sample et al., 1996
94-75-7	2,4-Dichlorophenoxyacetic acid (2,4-D)	ID	---	---	No studies evaluating reproductive endpoints were identified.	---
106-93-4	Ethylene dibromide	ID	---	---	No studies evaluating reproductive endpoints were identified.	---

(continued)

Table 14A-1. (continued)

CAS Number	Constituent Name	Benchmark Dose (mg/kg-d)	Test Species	Endpoint/ Duration	Notes	Source
87-68-3	Hexachloro-1,3-butadiene	ID	---	---	No studies evaluating reproductive endpoints were identified.	---
72-43-5	Methoxychlor	141	Rat	Reproduction/ 6 to 15 d gestation	Benchmark dose was the MATC calculated from a NOAEL of 100 mg/kg-d and a LOAEL of 200 mg/kg-d.	Khera et al., 1978
78-93-3	Methyl ethyl ketone	2,845	Rat	Reproduction/ 2 generations	Benchmark dose was the MATC calculated from a NOAEL of 1,771 mg/kg-d and a LOAEL of 4,571 mg/kg-d.	Sample et al., 1996
80-62-6	Methyl methacrylate	ID	---	---	No studies evaluating reproductive endpoints were identified.	---
75-09-2	Methylene chloride	ID	---	---	No studies evaluating reproductive endpoints were identified.	---
98-95-3	Nitrobenzene	ID	---	---	No studies evaluating reproductive endpoints were identified.	---
108-95-2	Phenol	ID	---	---	No studies evaluating reproductive endpoints were identified.	---
110-86-1	Pyridine	ID	---	---	No studies evaluating reproductive endpoints were identified.	---
127-18-4	Tetrachloroethylene	ID	---	---	No studies evaluating reproductive endpoints were identified.	---

(continued)

Table 14A-1. (continued)

CAS Number	Constituent Name	Benchmark Dose (mg/kg-d)	Test Species	Endpoint/ Duration	Notes	Source
137-26-8	Thiram	ID	---	---	No studies evaluating reproductive endpoints were identified.	---
108-88-3	Toluene	82.2	Mouse	Reproduction/ 6 to 12 d of gestation	Benchmark dose was the MATC calculated from a NOAEL of 26 mg/kg-d and a LOAEL of 260 mg/kg-d.	Sample et al., 1996
71-55-6	1,1,1-Trichloroethane	1,000	Mouse	Reproduction/ 2 generations	Benchmark dose was the NOAEL of 1,000 mg/kg-d. No LOAEL was identified.	Sample et al., 1996
79-01-6	Trichloroethylene	2.2	Mouse	Hepatic toxicity/6 weeks	Benchmark dose was the MATC calculated from a NOAEL of 0.7 mg/kg-d and a LOAEL of 7 mg/kg-d.	Sample et al., 1996
75-01-4	Vinyl chloride	0.54	Rat	Longevity/144 weeks	Benchmark dose was the MATC calculated from a NOAEL of 0.17 mg/kg-d and a LOAEL of 1.7 mg/kg-d.	Sample et al., 1996
Metals						
7440-36-0	Antimony	0.45	Rat	Reproduction/ 60 d	Benchmark dose was the MATC calculated from a NOAEL of 0.143 mg/kg-d LOAEL of 1.431 mg/kg-d.	Rossi et al., 1987
7440-38-2	Arsenic	6.54	Rat	Growth and development/ 2 yr	Benchmark dose was the MATC calculated from a NOAEL of 4.6 mg/kg-d and a LOAEL of 9.3 mg/kg-d.	Byron et al., 1967

(continued)

Table 14A-1. (continued)

CAS Number	Constituent Name	Benchmark Dose (mg/kg-d)	Test Species	Endpoint/ Duration	Notes	Source
7440-39-3	Barium	ID	---	---	No studies evaluating reproductive endpoints were identified.	---
7440-41-7	Beryllium	ID	---	---	No studies evaluating reproductive endpoints were identified.	---
7440-43-9	Cadmium	3.16	Rat	Reproduction/ 6 weeks through gestation	Benchmark dose was the MATC calculated from a NOAEL of 1 mg/kg-d and a LOAEL of 10 mg/kg-d.	Sutou et al., 1980
7440-47-3	Chromium	ID	---	---	No studies evaluating reproductive endpoints were identified.	---
16065-83-1	Chromium III (insoluble salts)	2737	Rat	Reproduction/ 2 yr	Benchmark dose was the NOAEL of 2,737 mg/kg-d. No LOAEL was identified.	Sample et al., 1996
18540-29-9	Chromium VI	10.4	Mouse	Growth/1 yr	Benchmark dose was the MATC calculated from a NOAEL of 3.3 mg/kg-d and a LOAEL of 33 mg/kg-d.	Zahid et al., 1990
7439-92-1	Lead	0.016	Rat	Reproduction	Benchmark dose was the MATC calculated from a NOAEL of 0.005 mg/kg-d and a LOAEL of 0.05 mg/kg-d.	Krasovskii et al., 1979
7440-02-0	Nickel	75.7	Rat	Reproduction/ 3 yrs	Benchmark dose was the MATC calculated from a NOAEL of 53.5 mg/kg-d and a LOAEL of 107 mg/kg-d.	Ambrose et al., 1976

(continued)

Table 14A-1. (continued)

CAS Number	Constituent Name	Benchmark Dose (mg/kg-d)	Test Species	Endpoint/ Duration	Notes	Source
7782-49-2	Selenium	0.26	Rat	Reproduction/ 78 d	Benchmark dose was the MATC calculated from a NOAEL of 0.20 mg/kg-d and a LOAEL of 0.34 mg/kg-d.	Rosenfeld and Beath, 1954
7440-22-4	Silver	ID	---	---	No studies evaluating reproductive endpoints were identified.	---
7446-18-6	Thallium	0.023	Rat	Reproduction./ 60 d	Benchmark dose was the MATC calculated from a NOAEL of 0.0074 mg/kg-d and a LOAEL of 0.074 mg/kg-d.	Sample et al., 1996
7440-62-2	Vanadium	1.6	Rat	Reproduction/ 60 d	Benchmark dose was the MATC calculated from a NOAEL of 0.5 mg/kg-d and a LOAEL of 5 mg/kg-d.	Domingo et al., 1986
7440-66-6	Zinc	290	Rat	Reproduction/ 1 to 16 d of gestation	Benchmark dose was the MATC calculated from a NOAEL of 200 mg/kg-d and a LOAEL of 410 mg/kg-d.	Schlicker and Cox, 1968
Special						
117-81-7	Bis(2-ethylhexyl) phthalate	115	Mouse	Reproduction/ through gestation	Benchmark dose was the MATC calculated from a NOAEL of 70 mg/kg-d and a LOAEL of 190 mg/kg-d.	Shiota and Nishimura, 1982
50-32-8	Benzo(a)pyrene	3.2	Mouse	Reproduction/ 7 to 16 d of gestation	Benchmark dose was the MATC calculated from a NOAEL of 1 mg/kg-d and a LOAEL of 10 mg/kg-d.	MacKenzie and Angevine, 1981
53-70-3	Dibenz(a,h)anthracene	ID	---	---	No studies evaluating reproductive endpoints were identified.	---

(continued)

Table 14A-1. (continued)

CAS Number	Constituent Name	Benchmark Dose (mg/kg-d)	Test Species	Endpoint/ Duration	Notes	Source
87-86-5	Pentachlorophenol	7.2	Rat	Reproduction/ 181 d	Benchmark dose was the MATC calculated from a NOAEL of 4 mg/kg-d and a LOAEL of 13 mg/kg-d.	Welsh et al., 1987
Mercury and Dioxin						
7439-97-6m	Methyl mercury	0.099	Mink	Reproduction/	Benchmark dose was the MATC calculated from a NOAEL of 0.055 mg/kg-d and a LOAEL of 0.18 mg/kg-d.	U.S. EPA, 1997
7439-97-6e	Mercury (elemental)	ID	---	---	No studies evaluating reproductive endpoints were identified.	---
7439-97-6	Mercury (divalent)	1	Mink	Reproduction/ 6 months	Benchmark dose was the NOAEL of 1 mg/kg-d. No LOAEL was identified.	Sample et al., 1996
1746-01-6	2,3,7,8-Tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD)	0.0000032	Rat	Reproduction/ 3 generations	Benchmark dose was the MATC calculated from a NOAEL of 0.000001 mg/kg-d and a LOAEL of 0.00001 mg/kg-d.	Murray et al., 1979

ID = Insufficient data.
LOAEL = Lowest-observed-adverse-effects level.
--- = Not applicable because insufficient data were identified.
MATC = Maximum acceptable toxicant concentration.
NOAEL = No-observed-adverse-effects level.

Table 14A-2. Avian Benchmark Studies

CAS Number	Constituent Name	Benchmark Dose (mg/kg-d)	Test Species	Endpoint/ Duration	Notes	Source
Organics						
All	Organics	ID	---	---	No studies evaluating reproductive endpoints were identified.	---
Metals						
7440-36-0	Antimony	ID	---	---	No studies evaluating reproductive endpoints were identified.	---
7440-38-2	Arsenic	0.011	Mallard	Reproduction/ 128 d	Benchmark dose was the MATC calculated from a NOAEL of 0.0057 mg/kg-d and a LOAEL of 0.023 mg/kg-d.	Stanley et al., 1994
7440-39-3	Barium	30	Chicken	Reproduction/ 3 weeks	Benchmark dose was the MATC calculated from a NOAEL of 21 mg/kg-d and a LOAEL of 42 mg/kg-d.	Johnson et al., 1960
7440-41-7	Beryllium	ID	---	---	No studies evaluating reproductive endpoints were identified.	---
7440-43-9	Cadmium	4.4	Mallard	Reproduction/ 90 d	Benchmark dose was the MATC calculated from a NOAEL of 1.4 mg/kg-d and a LOAEL of 14 mg/kg-d.	White and Finley, 1978
7440-47-3	Chromium	ID	---	---	No studies evaluating reproductive endpoints were identified.	---

(continued)

Table 14A-2. (continued)

CAS Number	Constituent Name	Benchmark Dose (mg/kg-d)	Test Species	Endpoint/ Duration	Notes	Source
16065-83-1	Chromium III (insoluble salts)	2.2	Duck	Reproduction/ 10 months	Benchmark dose was the MATC calculated from a NOAEL of 1 mg/kg-d and a LOAEL of 5 mg/kg-d.	Sample et al., 1996
18540-29-9	Chromium VI	ID	---	---	No studies evaluating reproductive endpoints were identified.	---
7439-92-1	Lead	0.066	Quail	Reproduction/ 4 weeks	Benchmark dose was the MATC calculated from a NOAEL of 0.021 mg/kg-d and a LOAEL of 0.21 mg/kg-d.	Edens and Garlich, 1983
7440-02-0	Nickel	91	Mallard	Growth and behavior/ 90 d	Benchmark dose was the MATC calculated from a NOAEL of 77.4 mg/kg-d and a LOAEL of 07 mg/kg-d.	Sample et al., 1996
7782-49-2	Selenium	0.71	Mallard	Reproduction/ 4 weeks	Benchmark dose was the MATC calculated from a NOAEL of 0.05 mg/kg-d and a LOAEL of 1.0 mg/kg-d.	Heinz and Hoffman,1987
7440-22-4	Silver	ID	---	---	No studies evaluating reproductive endpoints were identified.	---
7446-18-6	Thallium	ID	---	---	No studies evaluating reproductive endpoints were identified.	—

(continued)

Table 14A-2. (continued)

CAS Number	Constituent Name	Benchmark Dose (mg/kg-d)	Test Species	Endpoint/ Duration	Notes	Source
7440-62-2	Vanadium	1.8	Chicken	Growth at sensitive life stage/30 d	Benchmark dose was the MATC calculated from a NOAEL of 1.5 mg/kg-d and a LOAEL of 2.2 mg/kg-d.	Romoser et al., 1961
7440-66-6	Zinc	32	Hen	Reproduction/ 44 weeks	Benchmark dose was the MATC calculated from a NOAEL of 11 mg/kg-d and a LOAEL of 94 mg/kg-d.	Sample et al. 1996
Special						
117-81-7	Bis(2-ethylhexyl) phthalate	1.1	Ringed dove	Reproduction/ 90 d	Benchmark dose was the NOAEL of 1.1 mg/kg-d. No LOAEL values were identified.	Sample et al., 1996
50-32-8	Benzo(a)pyrene	ID	---	---	No studies evaluating reproductive endpoints were identified.	---
53-70-3	Dibenz(a,h)anthracene	ID	---	---	No studies evaluating reproductive endpoints were identified.	---
87-86-5	Pentachlorophenol	62	Chicks	Growth at sensitive life stage/8 weeks	Benchmark dose was the MATC calculated from a NOAEL of 44 mg/kg-d and a LOAEL of 88 mg/kg-d.	Prescott et al., 1982

(continued)

Table 14A-2. (continued)

CAS Number	Constituent Name	Benchmark Dose (mg/kg-d)	Test Species	Endpoint/ Duration	Notes	Source
Mercury and Dioxin						
7439-97-6m	Methyl mercury	0.025	Mallard	Reproduction/ 3 generations	Benchmark dose was the MATC calculated from a NOAEL of 0.0078 mg/kg-d and a LOAEL of 0.078 mg/kg-d.	Heinz 1974, 1975, 1979; U.S. EPA, 1997
7439-97-6e	Mercury (elemental)	ID	---	---	No studies evaluating reproductive endpoints were identified.	---
7439-97-6	Mercury (divalent)	0.64	Japanese quail	Reproduction/ 1 yr	Benchmark dose was the MATC calculated from a NOAEL of 0.45 mg/kg-d and a LOAEL of 0.9 mg/kg-d.	Sample et al., 1996
1746-01-6	2,3,7,8-Tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD)	0.0000443	Pheasant	Reproduction/ 10 weeks	Benchmark dose was the MATC calculated from a NOAEL of 0.000014 mg/kg-d and a LOAEL of 0.00014 mg/kg-d.	Nosek et al., 1992

ID = Insufficient data.
LOAEL = Lowest-observed-adverse-effects level.
MATC = Maximum acceptable toxicant concentration.
NOAEL = No-observed-adverse-effects level.
--- = Not applicable because insufficient data were identified.

Table 14A-3. Freshwater Community CSLs Based on Total Water Concentrations

CAS Number	Constituent Name	CSCL (Total) (mg/L)	Method	Notes	Source
Organics					
75-05-8	Acetonitrile	ID	---	Insufficient ecotoxicity data were available to develop a water quality criteria.	---
107-13-1	Acrylonitrile	ID	---	Insufficient ecotoxicity data were available to develop a water quality criteria.	---
62-53-3	Aniline	ID	---	Insufficient ecotoxicity data were available to develop a water quality criteria.	---
71-43-2	Benzene	0.13	SCV	Value was calculated using the Tier II methodology from 29 data points representing 6 of the 8 species requirements.	Stephan et al., 1985; Suter and Tsao, 1996
75-15-0	Carbon disulfide	0.00092	SCV	Value was calculated using the Tier II methodology from one data point representing two of the eight species requirements.	Stephan et al., 1985; Suter and Tsao, 1996
108-90-7	Chlorobenzene	0.064	SCV	Value was calculated using the Tier II methodology from 12 data points representing 4 of the 8 species requirements.	Stephan et al., 1985; Suter and Tsao, 1996
67-66-3	Chloroform	0.028	SCV	Value was calculated using the Tier II methodology from 15 data points representing 3 of the 8 species requirements.	Stephan et al., 1985; Suter and Tsao, 1996
94-75-7	2,4-Dichlorophenoxyacetic acid (2,4-D)	ID	---	Insufficient ecotoxicity data were available to develop a water quality criteria.	---

(continued)

Table 14A-3. (continued)

CAS Number	Constituent Name	CSCL (Total) (mg/L)	Method	Notes	Source
106-93-4	Ethylene dibromide	ID	---	Insufficient ecotoxicity data were available to develop a water quality criteria.	---
87-68-3	Hexachloro-1,3-butadiene	ID	---	Insufficient ecotoxicity data were available to develop a water quality criteria.	---
72-43-5	Methoxychlor	0.000019	SCV	Value was adopted from OSWER calculated using the Tier II methodology.	Suter and Tsao, 1996
78-93-3	Methyl ethyl ketone	ID	---	Insufficient ecotoxicity data were available to develop a water quality criteria.	---
80-62-6	Methyl methacrylate	ID	---	Insufficient ecotoxicity data were available to develop a water quality criteria.	---
75-09-2	Methylene chloride	2.2	SCV	Value was calculated using the Tier II methodology from five data points representing three of the eight species requirements.	Stephan et al., 1985; Suter and Tsao, 1996
98-95-3	Nitrobenzene	ID	---	Insufficient ecotoxicity data were available to develop a water quality criteria.	---
108-95-2	Phenol	0.11	FCV	Value was calculated as the chronic NAWQC meeting all of the data and species requirements.	U.S. EPA, 1999
110-86-1	Pyridine	ID	---	Insufficient ecotoxicity data were available to develop a water quality criteria.	---
127-18-4	Tetrachloroethylene	0.098	SCV	Value was calculated using the Tier II methodology from nine data points representing four of the eight species requirements.	Stephan et al., 1985; Suter and Tsao, 1996

(continued)

Table 14A-3. (continued)

CAS Number	Constituent Name	CSCL (Total) (mg/L)	Method	Notes	Source
137-26-8	Thiram	ID	---	Insufficient ecotoxicity data were available to develop a water quality criteria.	---
108-88-3	Toluene	0.0098	SCV	Value was calculated using the Tier II methodology from seven data points representing two of the eight species requirements.	Stephan et al., 1985; Suter and Tsao, 1996
71-55-6	1,1,1-Trichloroethane	0.011	SCV	Value was calculated using the Tier II methodology from two data points representing two of the eight species requirements.	Stephan et al., 1985; Suter and Tsao, 1996
79-01-6	Trichloroethylene	0.047	SCV	Value was calculated using the Tier II methodology from five data points representing two of the eight species requirements.	Stephan et al., 1985; Suter and Tsao, 1996
75-01-4	Vinyl chloride	ID	---	Insufficient ecotoxicity data were available to develop a water quality criteria.	---
Metals					
7440-36-0	Antimony	0.03	Draft FCV	Value is a draft FCV and met all data requirements for calculating NAWQC.	U.S. EPA, 1988
7440-38-2	Arsenic	0.15	CCC	NAWQC value was updated through the GLWQI incorporating newly identified toxicity data for freshwater biota.	U.S. EPA, 1996a
7440-39-3	Barium	0.004	SCV	Value was calculated using the Tier II methodology from 12 data points representing 4 of the 8 species requirements.	Stephan et al., 1985; Suter and Tsao, 1996

(continued)

Table 14A-3. (continued)

CAS Number	Constituent Name	CSCL (Total) (mg/L)	Method	Notes	Source
7440-41-7	Beryllium	0.00066	SCV	Value was calculated using the Tier II methodology from 27 data points representing 6 of the 8 species requirements.	Stephan et al., 1985; Suter and Tsao, 1996
7440-43-9	Cadmium	0.0025	CCC	NAWQC value was updated through the GLWQI incorporating newly identified toxicity data for freshwater biota. This criteria is dependent on water hardness and was calculated using the following equation, assuming a water hardness of 100 mg $CaCO_3$/L: $CCC = e^{0.7852(\ln hardness) - 2.715}$	U.S. EPA, 1996a
7440-47-3	Chromium	ID	---	Insufficient ecotoxicity data were available to develop a water quality criteria.	---
16065-83-1	Chromium III (insoluble salts)	0.086	CCC	NAWQC value was updated through the GLWQI incorporating newly identified toxicity data for freshwater biota. This criteria is dependent on water hardness and was calculated using the following equation, assuming a water hardness of 100 mg $CaCO_3$/L: $CCC = e^{0.819(\ln hardness) + 0.6848}$	U.S. EPA, 1996a
18540-29-9	Chromium VI	0.011	CCC	NAWQC value was updated through the GLWQI incorporating newly identified toxicity data for freshwater biota.	U.S. EPA, 1996a
7439-92-1	Lead	0.0032	FCV	Value is an FCV and met all data requirements for calculating NAWQC.	U.S. EPA, 1985

(continued)

Table 14A-3. (continued)

CAS Number	Constituent Name	CSCL (Total) (mg/L)	Method	Notes	Source
7440-02-0	Nickel	0.052	CCC	NAWQC value was updated through the GLWQI incorporating newly identified toxicity data for freshwater biota. This criteria is dependent on water hardness and was calculated using the following equation, assuming a water hardness of 100 mg $CaCO_3$/L: $CCC = e^{0.846(\ln \text{hardness}) + 0.0584}$	U.S. EPA, 1996a
7782-49-2	Selenium	0.005	CCC	NAWQC value was updated through the GLWQI incorporating newly identified toxicity data for freshwater biota, including some field studies.	U.S. EPA, 1996a
7440-22-4	Silver	0.00036	SCV	Value derived from the NAWQC FAV for silver.	Suter and Tsao, 1996
7446-18-6	Thallium	0.012	SCV	Value was calculated using the Tier II methodology from 10 data points representing 3 of the 8 species requirements.	Stephan et al., 1985; Suter and Tsao, 1996
7440-62-2	Vanadium	0.02	SCV	Value was calculated using the Tier II methodology from 25 data points representing 4 of the 8 species requirements.	Stephan et al., 1985; Suter and Tsao, 1996
7440-66-6	Zinc	0.12	CCC	NAWQC value was updated through the GLWQI incorporating newly identified toxicity data for freshwater biota. This criteria is dependent on water hardness and was calculated using the following equation, assuming a water hardness of 100 mg $CaCO_3$/L: $CCC = e^{0.8473(\ln \text{hardness}) + 0.884}$	U.S. EPA, 1996a

(continued)

Table 14A-3. (continued)

CAS Number	Constituent Name	CSCL (Total) (mg/L)	Method	Notes	Source
Special					
117-81-7	Bis(2-ethylhexyl) phthalate	0.003	SCV	Value was calculated using the Tier II methodology from 15 data points representing 5 of the eight species requirements.	Stephan et al., 1985; Suter and Tsao, 1996
50-32-8	Benzo(a)pyrene	0.000014	SCV	Value was calculated using the Tier II methodology from one data point representing one of the eight species requirements.	Stephan et al., 1985; Suter and Tsao, 1996
53-70-3	Dibenz(a,h)anthracene	ID	---	Insufficient ecotoxicity data were available to develop a water quality criteria.	---
87-86-5	Pentachlorophenol	0.0055	CCC	NAWQC value was updated through the GLWQI incorporating newly identified toxicity data for freshwater biota. This criteria is dependent on pH and was calculated using the following equation, assuming a pH of 6.8: $CCC = e^{1.005(pH) - 5.134}\ 0.884$	U.S. EPA, 1996a
Mercury and Dioxin					
7439-97-6m	Methyl mercury	0.0000028	SCV	Value was calculated using the Tier II methodology from four data points representing one of the eight species requirements.	Stephan et al., 1985; Suter and Tsao, 1996
7439-97-6e	Mercury (elemental)	ID	---	Insufficient ecotoxicity data were available to develop a water quality criteria.	---

(continued)

Table 14A-3. (continued)

CAS Number	Constituent Name	CSCL (Total) (mg/L)	Method	Notes	Source
7439-97-6	Mercury (divalent)	0.00091	CCC	NAWQC value was updated through the GLWQI incorporating newly identified toxicity data for freshwater biota.	U.S. EPA, 1996a
1746-01-6	TCDD 2,3,7,8-	ID	---	Insufficient ecotoxicity data were available to develop a water quality criteria.	---

CSCL = Chemical stressor concentration limit.
CCC = Criterion continuous concentration.
FCV = Final chronic value.
GLWQI = Great lakeswater quality initiative.
ID = Insufficient data.
NAWQC = National ambient water quality criteria.
SCV = Secondary chronic value.
--- = Not applicable because insufficient data identified.

Table 14A-4. Freshwater Community CSCLs Based on Total Dissolved Water Concentrations

CAS Number	Constituent Name[1]	CSCL (Total)[2] (mg/L)	Conversion Factor[3]	CSCL (Dissolved) (mg/L)	Notes	Source
Metals						
7440-36-0	Antimony	0.03	ID	ID	Insufficient data were available to derive a dissolved surface water concentration.	U.S. EPA, 1988
7440-38-2	Arsenic	0.15	1.00	0.15	EPA's Office of Water supports the use of dissolved criteria over the total criteria because dissolved criteria reflect the bioavailable fraction of the metal.	U.S. EPA, 1996a;1999
7440-39-3	Barium	0.004	ID	ID	Insufficient data were available to derive a dissolved surface water concentration.	Stephan et al., 1985; Suter and Tsao, 1996
7440-41-7	Beryllium	0.00066	ID	ID	Insufficient data were available to derive a dissolved surface water concentration.	Stephan et al., 1985; Suter and Tsao, 1996
7440-43-9	Cadmium	0.0025	0.909	0.0023	Conversion factor was derived as a hardness, dependent criterion assuming 100 mg CaCO3/L using the following equation: CF =1.101672-[(ln hardness)(0.041838)]	U.S. EPA, 1996a; 1999
7440-47-3	Chromium	ID	ID	ID	Insufficient data were available to derive a dissolved surface water concentration.	---
16065-83-1	Chromium III (insoluble salts)	0.086	0.860	0.074	EPA's Office of Water supports the use of dissolved criteria over the total criteria because dissolved criteria reflect the bioavailable fraction of the metal.	U.S. EPA, 1996a, 1999

(continued)

Table 14A-4. (continued)

CAS Number	Constituent Name[1]	CSCL (Total)[2] (mg/L)	Conversion Factor[3]	CSCL (Dissolved) (mg/L)	Notes	Source
18540-29-9	Chromium VI	0.011	0.962	0.011	EPA's Office of Water supports the use of dissolved criteria over the total criteria because dissolved criteria reflect the bioavailable fraction of the metal.	U.S. EPA, 1996a, 1999
7439-92-1	Lead	0.0032	0.791	0.0025	Conversion factor was derived as a hardness-dependent criterion, assuming 100 mg CaCO3/L using the following equation: CF =1.46203-[(ln hardness)(0.145712)]	U.S. EPA, 1985, 1999
7440-02-0	Nickel	0.052	0.997	0.052	EPA's Office of Water supports the use of dissolved criteria over the total criteria because dissolved criteria reflect the bioavailable fraction of the metal.	U.S. EPA, 1996a, 1999
7782-49-2	Selenium	0.005	ID	ID	Insufficient data were available to derive a dissolved surface water concentration.	U.S. EPA, 1999
7440-22-4	Silver	0.00036	ID	ID	Insufficient data were available to derive a dissolved surface water concentration.	Suter and Tsao, 1996
7446-18-6	Thallium	0.012	ID	ID	Insufficient data were available to derive a dissolved surface water concentration.	Stephan et al., 1985; Suter and Tsao, 1996
7440-62-2	Vanadium	0.02	ID	ID	Insufficient data were available to derive a dissolved surface water concentration.	Stephan et al., 1985; Suter and Tsao, 1996

(continued)

Table 14A-4. (continued)

CAS Number	Constituent Name[1]	CSCL (Total)[2] (mg/L)	Conversion Factor[3]	CSCL (Dissolved) (mg/L)	Notes	Source
7440-66-6	Zinc	0.12	0.986	0.12	EPA's Office of Water supports the use of dissolved criteria over the total criteria because dissolved criteria reflect the bioavailable fraction of the metal.	U.S. EPA, 1996a, 1999

[1] Dissolved CSCLs are currently available to estimate concentrations of metals in surface waters; therefore, constituents categorized as special, organic constitutents, and mercury and dioxin compounds are not included in this table.
[2] Values were derived as indicated in Table 10.
[3] Conversion factors were developed to estimate the fraction of the total concentration that was dissolved in the water column. The conversion factors developed by EPA for converting freshwater chronic criteria were adopted.

ID = Insufficient data.
CSCL = Chemical stressor concentration limit.
— = Not applicable because insufficient data were indentified.

Table 14A-5. Aquatic Plants and Algae CSCLs

CAS Number	Constituent Name	CSCL (mg/L)	Methodology	Notes	Source
Organics					
75-05-8	Acetonitrile	ID	---	Insufficient data were available to develop an aquatic plant CSCL.	---
107-13-1	Acrylonitrile	ID	---	Insufficient data were available to develop an aquatic plant CSCL.	---
62-53-3	Aniline	ID	---	Insufficient data were available to develop an aquatic plant CSCL.	---
71-43-2	Benzene	530	Lowest chronic value EC_{50}	Based on a 48-h EC_{50} test by exposing *Chlorella vulgaris*.	Suter and Tsao, 1996
75-15-0	Carbon disulfide	ID	---	Insufficient data were available to develop an aquatic plant CSCL.	---
108-90-7	Chlorobenzene	220	Lowest chronic value EC_{50}	Based on a 96-h EC_{50} test for cell number, by exposing *Selenastrum capricornutum.*	Suter and Tsao, 1996
67-66-3	Chloroform	ID	---	Insufficient data were available to develop an aquatic plant CSCL.	---
94-75-7	2,4-Dichlorophenoxyacetic acid (2,4-D)	ID	---	Insufficient data were available to develop an aquatic plant CSCL.	---
106-93-4	Ethylene dibromide	ID	---	Insufficient data were available to develop an aquatic plant CSCL.	---
87-68-3	Hexachloro-1,3-butadiene	ID	---	Insufficient data were available to develop an aquatic plant CSCL.	—

(continued)

Table 14A-5. (continued)

CAS Number	Constituent Name	CSCL (mg/L)	Methodology	Notes	Source
72-43-5	Methoxychlor	ID	---	Insufficient data were available to develop an aquatic plant CSCL.	---
78-93-3	Methyl ethyl ketone	ID	---	Insufficient data were available to develop an aquatic plant CSCL.	---
80-62-6	Methyl methacrylate	ID	---	Insufficient data were available to develop an aquatic plant CSCL. SSC	---
75-09-2	Methylene chloride	ID	---	Insufficient data were available to develop an aquatic plant CSCL.	---
98-95-3	Nitrobenzene	ID	---	Insufficient data were available to develop an aquatic plant CSCL.	---
108-95-2	Phenol	20	Lowest chronic value EC_{50}	Based on a value that exhibited 60 percent reduction in cell numbers and 12percent growth inhibition by exposing *Selenastrum capricornutum.*	Suter and Tsao, 1996
110-86-1	Pyridine	ID	---	Insufficient data were available to develop an aquatic plant CSCL.	---
127-18-4	Tetrachloroethylene	ID	---	Insufficient data were available to develop an aquatic plant CSCL.	---
137-26-8	Thiram	ID	---	Insufficient data were available to develop an aquatic plant CSCL.	---
108-88-3	Toluene	250	Lowest chronic value EC_{50}	Based on an unspecified 10-d test by exposing *Chlorella vulgaris.*	Suter and Tsao, 1996

(continued)

Table 14A-5. (continued)

CAS Number	Constituent Name	CSCL (mg/L)	Methodology	Notes	Source
71-55-6	1,1,1-Trichloroethane	669	Lowest chronic value EC_{50}	Based on a value that exhibited 60 percent reduction in cell numbers and 12percent growth inhibition by exposing *Selenastrum capricornutum.*	Suter and Tsao, 1996
79-01-6	Trichloroethylene	ID	---	Insufficient data were available to develop an aquatic plant CSCL.	---
75-01-4	Vinyl chloride	ID	---	Insufficient data were available to develop an aquatic plant CSCL.	---
Metals					
7440-36-0	Antimony	0.61	Lowest chronic value EC_{50}	Based on a 4-d EC_{50} for chlorophyll A inhibition by exposing *Selenastrum capricornutum*.	Suter and Tsao, 1996
7440-38-2	Arsenic	0.048	Lowest chronic value EC_{50}	Based on a 14-d EC_{50} test by exposing *Scendesmus obliquus.*	Suter and Tsao, 1996
7440-39-3	Barium	ID	---	Insufficient data were available to develop an aquatic plant CSCL.	
7440-41-7	Beryllium	100	Lowest chronic value EC_{50}	Based on a 10 to 20percent reduction in autotrophic growth rates by exposing *Chlorella vannieli.*	Suter and Tsao, 1996
7440-43-9	Cadmium	0.002	Lowest chronic value EC_{50}	Based on the population growth rate by exposing *Asterionella formosa.*	Suter and Tsao, 1996
7440-47-3	Chromium	ID	---	Insufficient data were available to develop an aquatic plant CSCL.	

(continued)

Table 14A-5. (continued)

CAS Number	Constituent Name	CSCL (mg/L)	Methodology	Notes	Source
16065-83-1	Chromium III (insoluble salts)	0.4	Lowest chronic value EC_{50}	Based on a 4-d chronic test in which there was a 50percent inhibition of growth, by exposing *Selenastrum capricornutum*.	Suter and Tsao, 1996
18540-29-9	Chromium VI	0.002	Lowest chronic value EC_{50}	Based on a value that showed incipient inhibition of growth by exposing *Microcystis aeruginosa.*	Suter and Tsao, 1996
7439-92-1	Lead	0.5	Lowest chronic value EC_{50}	Based on value based on 53percent, 35percent, and 52percent growth inhibition by exposing *Chlorella vulgaris*, *Scenedesmus quadricauda*, and *Selenastrum capricornutum*.	Suter and Tsao, 1996
7440-02-0	Nickel	0.005	Lowest chronic value EC_{50}	Based on a value that showed incipient inhibition of growth by exposing *Microcystis aeruginosa.*	Suter and Tsao, 1996
7782-49-2	Selenium	0.1	Lowest chronic value EC_{50}	Based on 14-d chronic toxicity tests by exposing *Scenedesmus obliquus.*	Suter and Tsao, 1996
7440-22-4	Silver	0.03	Lowest chronic value EC_{50}	Based on growth inhibition by exposing *Chlorella vulgaris*.	Suter and Tsao, 1996
7446-18-6	Thallium	0.1	Lowest chronic value EC_{50}	Based on a 4-d EC_{50} which reduced the plant's cell numbers by exposing *Selenastrum capricornutum*.	Suter and Tsao, 1996
7440-62-2	Vanadium	ID	---	Insufficient data were available to develop an aquatic plant CSCL.	
7440-66-6	Zinc	0.03	Lowest chronic value EC_{50}	Based on 7-d tests that showed incipient inhibition of growth by exposing *Selenastrum capricornutum.*	Suter and Tsao, 1996

(continued)

Table 14A-5. (continued)

CAS Number	Constituent Name	CSCL (mg/L)	Methodology	Notes	Source
Special					
117-81-7	Bis(2-ethylhexyl) phthalate	ID	---	Insufficient data were available to develop an aquatic plant CSCL.	---
50-32-8	Benzo(a)pyrene	ID	---	Insufficient data were available to develop an aquatic plant CSCL.	---
53-70-3	Dibenz(a,h)anthracene	ID	---	Insufficient data were available to develop an aquatic plant CSCL.	---
87-86-5	Pentachlorophenol	ID	---	Insufficient data were available to develop an aquatic plant CSCL.	---
Mercury and Dioxin					
7439-97-6m	Methyl mercury	ID	---	Insufficient data were available to develop an aquatic plant CSCL.	---
7439-97-6e	Mercury (elemental)	ID	---	Insufficient data were available to develop an aquatic plant CSCL.	---
7439-97-6	Mercury (divalent)	0.005	Lowest chronic value EC_{50}	Based on an 8-d test that showed incipient inhibition of growth by exposing *Microcystis aeruginosa*.	Suter and Tsao, 1996
1746-01-6	TCDD 2,3,7,8-	ID	---	Insufficient data were available to develop an aquatic plant CSCL.	---

CSCL = Chemical stressor concentration limit.
EC_{50} = Effective concentration for 50% of the organisms.
ID = Insufficient data.
--- = Not applicable because insufficient data were identified.

Table 14A-6. Amphibian CSCLs

CAS Number	Constituent Name	CSCL (mg/L)	Methodology	Notes	Source
Organics					
75-05-8	Acetonitrile	ID	---	Insufficient data were available to develop an amphibian CSCL.	---
107-13-1	Acrylonitrile	ID	---	Insufficient data were available to develop an amphibian CSCL.	---
62-53-3	Aniline	370	Geomean of acute values	The geomean of LC_{50} values was based on 7 values ranging from 95 to 940 mg/L.	U.S. EPA, 1996b
71-43-2	Benzene	34	Geomean of acute values	The geomean of LC_{50} values was based on 4 values ranging from 3.7 to 370 mg/L.	U.S. EPA, 1996b
75-15-0	Carbon disulfide	ID	---	Insufficient data were available to develop an amphibian CSCL.	---
108-90-7	Chlorobenzene	ID	---	Insufficient data were available to develop an amphibian CSCL.	---
67-66-3	Chloroform	11	Geomean of acute values	The geomean of LC_{50} values was based on 7 values ranging from 2.7 to 68 mg/L.	U.S. EPA, 1996b
94-75-7	2,4-Dichlorophenoxyacetic acid (2,4-D)	ID	---	Insufficient data were available to develop an amphibian CSCL.	---
106-93-4	Ethylene dibromide	ID	---	Insufficient data were available to develop an amphibian CSCL.	---
87-68-3	Hexachloro-1,3-butadiene	ID	---	Insufficient data were available to develop an amphibian CSCL.	---

(continued)

Table 14A-6. (continued)

CAS Number	Constituent Name	CSCL (mg/L)	Methodology	Notes	Source
72-43-5	Methoxychlor	0.29	Geomean of acute values	The geomean of LC_{50} values was based on 4 values ranging from 0.10 to 0.33 mg/L.	U.S. EPA, 1996b
78-93-3	Methyl ethyl ketone	ID	---	Insufficient data were available to develop an amphibian CSCL.	---
80-62-6	Methyl methacrylate	ID	---	Insufficient data were available to develop an amphibian CSCL.	---
75-09-2	Methylene chloride	ID	---	Insufficient data were available to develop an amphibian CSCL.	---
98-95-3	Nitrobenzene	0.64	Geomean of acute values	The geomean of LC_{50} values was based on one value.	U.S. EPA, 1996b
108-95-2	Phenol	1.3	Geomean of acute values	The geomean of LC_{50} values was based on 9 values ranging from 0.04 to 51 mg/L.	U.S. EPA, 1996b
110-86-1	Pyridine	ID	---	Insufficient data were available to develop an amphibian CSCL.	---
127-18-4	Tetrachloroethylene	ID	---	Insufficient data were available to develop an amphibian CSCL.	---
137-26-8	Thiram	ID	---	Insufficient data were available to develop an amphibian CSCL.	---
108-88-3	Toluene	0.58	Geomean of acute values	The geomean of LC_{50} values was based on two values, 0.39 and 0.85 mg/L.	U.S. EPA, 1996b
71-55-6	1,1,-Trichloroethane	ID	---	Insufficient data were available to develop an amphibian CSCL.	---

(continued)

Table 14A-6. (continued)

CAS Number	Constituent Name	CSCL (mg/L)	Methodology	Notes	Source
79-01-6	Trichloroethylene	89	Geomean of acute values	The geomean of LC_{50} values was based on six values ranging from 34 to 443 mg/L.	U.S. EPA, 1996b
75-01-4	Vinyl chloride	ID	---	Insufficient data were available to develop an amphibian CSCL.	---
Metals					
7440-36-0	Antimony	0.3	Geomean of aacute values	The geomean of LC_{50} values was based on one value.	U.S. EPA, 1996b
7440-38-2	Arsenic	4.3	Geomean of acute values	The geomean of LC_{50} values was based on six values ranging from 0.040 to 71 mg/L.	U.S. EPA, 1996b
7440-39-3	Barium	ID	---	Insufficient data were available to develop an amphibian CSCL.	---
7440-41-7	Beryllium	11	Geomean of acute values	The geomean of LC_{50} values was based on 8 values ranging from 3.2 to 32 mg/L.	U.S. EPA, 1996b
7440-43-9	Cadmium	2.2	Geomean of acute values	The geomean of LC_{50} values was based on 28 values ranging from 0.04 to 20 mg/L.	Power et al., 1989; U.S. EPA, 1996b
7440-47-3	Chromium	12	Geomean of acute values	The geomean of LC_{50} values was based on 10 values ranging from 0.03 to 100 mg/L.	Power et al., 1989; U.S. EPA, 1996b
16065-83-1	Chromium III (insoluble salts)	ID	---	Insufficient data were available to develop an amphibian CSCL.	---
18540-29-9	Chromium VI	ID	---	Insufficient data were available to develop an amphibian CSCL.	---

(continued)

Table 14A-6. (continued)

CAS Number	Constituent Name	CSCL (mg/L)	Methodology	Notes	Source
7439-92-1	Lead	2.1	Geomean of acute values	The geomean of LC_{50} values was based on 6 values ranging from 0.04 to 105 mg/L.	U.S. EPA, 1996b
7440-02-0	Nickel	2.2	Geomean of acute values	The geomean of LC_{50} values was based on 11 values ranging from 0.05 to 53 mg/L.	Power et al., 1989; U.S. EPA, 1996b
7782-49-2	Selenium	1.8	Geomean of acute values	The geomean of LC_{50} values was based on 13 values ranging from 0.09 to 11 mg/L.	U.S. EPA, 1996b
7440-22-4	Silver	0.03	Geomean of acute values	The geomean of LC_{50} values was based on 7 values having ranging from 0.004 to 26 mg/L.	Power et al., 1989; U.S. EPA, 1996b
7446-18-6	Thallium	0.11	Geomean of acute values	The geomean of LC_{50} values was based on one value.	U.S. EPA, 1996b
7440-62-2	Vanadium	ID	---	Insufficient data were available to develop an amphibian CSCL.	---
7440-66-6	Zinc	10	Geomean of acute values	The geomean of LC_{50} values was based on 25 values ranging from 0.01 to 47 mg/L.	Power et al., 1989; U.S. EPA, 1996b
Special					
117-81-7	Bis(2-ethylhexyl) phthalate	ID	---	Insufficient data were available to develop an amphibian CSCL.	---
50-32-8	Benzo(a)pyrene	ID	---	Insufficient data were available to develop an amphibian CSCL.	---

(continued)

Table 14A-6. (continued)

CAS Number	Constituent Name	CSCL (mg/L)	Methodology	Notes	Source
53-70-3	Dibenz(a,h)anthracene	ID	---	Insufficient data were available to develop an amphibian CSCL.	---
87-86-5	Pentachlorophenol	0.070	Geomean of acute values	The geomean of LC_{50} values was based on 10 values ranging from 0.0003 to 0.35 mg/L.	Power et al., 1989; U.S. EPA, 1996b
Mercury and Dioxin					
7439-97-6m	Methyl mercury	0.06	Geomean of acute values	The geomean of LC_{50} values was based on 67 values ranging from 0.001 to 108 mg/L.	Power et al., 1989; U.S. EPA, 1996b
7439-97-6e	Mercury (elemental)	ID	---	Insufficient data were available to develop an amphibian CSCL.	---
7439-97-6	Mercury (divalent)	0.06	Geomean of acute values	The geomean of LC_{50} values was based on 2 values ranging from 0.056 to 0.060 mg/L.	---
1746-01-6	TCDD 2,3,7,8-	ID	---	Insufficient data were available to develop an amphibian CSCL.	---

CSCL = Chemical stressor concentration limit.
ID = Insufficient data.
LC_{50} = Lethal concentration for 50% of the organisms.
--- = Not applicable because insufficient data were identified.

Table 14A-7. Benthic Community CSCLs

CAS Number	Constituent	CSCL (mg/kg sediment DW)	Methodology	Notes	Source
Organics					
75-05-8	Acetonitrile	ID	---	No water quality criteria have been developed; therefore, the EqP approach could not be applied to estimate a benthic community CSCL.	---
107-13-1	Acrylonitrile	ID	---	No water quality criteria have been developed; therefore, the EqP approach could not be applied to estimate a benthic community CSCL.	---
62-53-3	Aniline	ID	---	No water quality criteria have been developed; therefore, the EqP approach could not be applied to estimate a benthic community CSCL.	---
71-43-2	Benzene	0.16	EqP	Based on the SCV of 0.13 mg/L calculated by Suter and Tsao (1996), assuming 1percent total organic carbon and log K_{oc} equal to 2.09.	Jones et al., 1997; U.S. EPA, 1993a
75-15-0	Carbon disulfide	0.00085	EqP	Based on the SCV of 0.00092 mg/L calculated by Suter and Tsao (1996), assuming 1 percent total organic carbon and log K_{oc} equal to 1.97.	Jones et al., 1997; U.S. EPA, 1993a
108-90-7	Chlorobenzene	0.41	EqP	Based on the SCV of 0.064 mg/L calculated by Suter and Tsao (1996), assuming 1 percent total organic carbon and log K_{oc} equal to 2.81.	Jones et al., 1997; U.S. EPA, 1993a
67-66-3	Chloroform	0.022	EqP	Based on the SCV of 0.028 mg/L calculated by Suter and Tsao (1996), assuming 1percent total organic carbon and log K_{oc} equal to 1.89.	Jones et al., 1997; U.S. EPA, 1993a

(continued)

Table 14A-7. (continued)

CAS Number	Constituent	CSCL (mg/kg sediment DW)	Methodology	Notes	Source
94-75-7	2,4-Dichlorophenoxyacetic acid (2,4-D)	ID	---	No water quality criteria have been developed; therefore, the EqP approach could not be applied to estimate a benthic community CSCL.	---
106-93-4	Ethylene dibromide	ID	---	No water quality criteria have been developed; therefore, the EqP approach could not be applied to estimate a benthic community CSCL.	
87-68-3	Hexachloro-1,3-butadiene	ID	---	No water quality criteria have been developed; therefore, the EqP approach could not be applied to estimate a benthic community CSCL.	---
72-43-5	Methoxychlor	0.019	EqP	Based on the SCV of 0.000019 mg/L calculated by Suter and Tsao (1996), assuming 1percent total organic carbon and log K_{oc} equal to 4.99.	Jones et al., 1997; U.S. EPA, 1993a
78-93-3	Methyl ethyl ketone	ID	---	No water quality criteria have been developed; therefore, the EqP approach could not be applied to estimate a benthic community CSCL.	---
80-62-6	Methyl methacrylate	ID	---	No water quality criteria have been developed; therefore, the EqP approach could not be applied to estimate a benthic community CSCL.	---
75-09-2	Methylene chloride	0.37	EqP	Based on the SCV of 2.2 mg/L calculated by Suter and Tsao (1996), assuming 1percent total organic carbon and log K_{oc} equal to 1.23.	Jones et al., 1997; U.S. EPA, 1993a
98-95-3	Nitrobenzene	ID	---	No water quality criteria have been developed; therefore, the EqP approach could not be applied to estimate a benthic community CSCL.	—

(continued)

Table 14A-7. (continued)

CAS Number	Constituent	CSCL (mg/kg sediment DW)	Methodology	Notes	Source
108-95-2	Phenol	0.031	EqP	Based on the FCV of 0.11 mg/L calculated by Suter and Tsao (1996), assuming 1 percent total organic carbon and log K_{oc} equal to 1.46.	Jones et al., 1997; U.S. EPA, 1993a
110-86-1	Pyridine	ID	---	No water quality criteria have been developed; therefore, the EqP approach could not be applied to estimate a benthic community CSCL.	---
127-18-4	Tetrachloroethylene	ID	---	No water quality criteria have been developed; therefore, the EqP approach could not be applied to estimate a benthic community CSCL.	---
137-26-8	Thiram	ID	---	No water quality criteria have been developed; therefore, the EqP approach could not be applied to estimate a benthic community CSCL.	---
108-88-3	Toluene	0.05	EqP	Based on the SCV of 0.0098 mg/L calculated by Suter and Tsao (1996), assuming 1 percent total organic carbon and log K_{oc} equal to 2.70.	Jones et al., 1997; U.S. EPA, 1993a
71-55-6	1,1,1-Trichloroethane	0.03	EqP	Based on the SCV of 0.011 mg/L calculated by Suter and Tsao (1996), assuming 1 percent total organic carbon and log K_{oc} equal to 2.44.	Jones et al., 1997; U.S. EPA, 1993a
79-01-6	Trichloroethylene	0.22	EqP	Based on the SCV of 0.047 mg/L calculated by Suter and Tsao (1996), assuming 1 percent total organic carbon and log K_{oc} equal to 2.66.	Jones et al., 1997; U.S. EPA, 1993a
75-01-4	Vinyl chloride	ID	---	No water quality criteria have been developed; therefore, the EqP approach could not be applied to estimate a benthic community CSCL.	—

(continued)

Table 14A-7. (continued)

CAS Number	Constituent	CSCL (mg/kg sediment DW)	Methodology	Notes	Source
Metals					
7440-36-0	Antimony	2	ER-L	Estimated from a distribution of 13 effects concentrations measured in field sediments. Endpoints were associated with decreased abundance and species diversity as well as shifts in community structure.	Long and Morgan, 1991
7440-38-2	Arsenic	7.2	TEL	Estimated from a distribution of 295 sediment concentrations associated with no- and low-effects concentrations to endpoints of lethality, abundance, diversity, and benthic community structure.	MacDonald, 1994
7440-39-3	Barium	ID	---	Insufficient data were available to develop a benthic community CSCL.	---
7440-41-7	Beryllium	ID	---	Insufficient data were available to develop a benthic community CSCL.	---
7440-43-9	Cadmium	0.68	TEL	Estimated from a distribution of 433 sediment concentrations associated with no- and low-effects concentrations to endpoints of lethality, abundance, diversity, and benthic community structure.	MacDonald, 1994
7440-47-3	Chromium	52	TEL	Estimated from a distribution of 354 sediment concentrations associated with no- and low-effects concentrations to endpoints of lethality, abundance, diversity, and benthic community structure.	MacDonald, 1994

(continued)

Table 14A-7. (continued)

CAS Number	Constituent	CSCL (mg/kg sediment DW)	Methodology	Notes	Source
16065-83-1	Chromium III	ID	---	Insufficient data were available to develop a benthic community CSCL.	---
18540-29-9	Chromium VI	ID	---	Insufficient data were available to develop a benthic community CSCL.	---
7439-92-1	Lead	30	TEL	Estimated from a distribution of 402 sediment concentrations associated with no- and low-effects concentrations to endpoints of lethality, abundance, diversity, and benthic community structure.	MacDonald, 1994
7440-02-0	Nickel	16	TEL	Estimated from a distribution of 355 sediment concentrations associated with no- and low-effects concentrations to endpoints of lethality, abundance, diversity, and benthic community structure.	MacDonald, 1994
7782-49-2	Selenium	ID	---	Insufficient data were available to develop a benthic community CSCL.	---
7440-22-4	Silver	0.73	TEL	Estimated from a distribution of 190 sediment concentrations associated with no- and low-effects concentrations to endpoints of lethality, abundance, diversity, and benthic community structure.	MacDonald, 1994
7446-18-6	Thallium	ID	---	Insufficient data were available to develop a benthic community CSCL.	---
7440-62-2	Vanadium	ID	---	Insufficient data were available to develop a benthic community CSCL.	---

(continued)

Table 14A-7. (continued)

CAS Number	Constituent	CSCL (mg/kg sediment DW)	Methodology	Notes	Source
7440-66-6	Zinc	120	TEL	Estimated from a distribution of 411 sediment concentrations associated with no- and low-effects concentrations to endpoints of lethality, abundance, diversity, and benthic community structure.	MacDonald, 1994
Special					
117-81-7	Bis(2-ethylhexyl) phthalate	0.18	TEL	Estimated from a distribution of 131 sediment concentrations associated with no- and low-effects concentrations to endpoints of lethality, abundance, diversity, and benthic community structure.	MacDonald, 1994
50-32-8	Benzo(a)pyrene	0.089	TEL	Estimated from a distribution of 259 sediment concentrations associated with no- and low-effects concentrations to endpoints of lethality, abundance, diversity, and benthic community structure.	MacDonald, 1994
53-70-3	Dibenz(a,h)anthracene	0.0062	TEL	Estimated from a distribution of 246 sediment concentrations associated with no- and low-effects concentrations to endpoints of lethality, abundance, diversity, and benthic community structure	MacDonald, 1994
87-86-5	Pentachlorophenol	ID	---	Insufficient data were available to develop a benthic community CSCL.	---
Mercury and Dioxin					
7439-97-6m	Methyl mercury	ID	---	Insufficient data were available to develop a benthic community CSCL.	

(continued)

Table 14A-7. (continued)

CAS Number	Constituent	CSCL (mg/kg sediment DW)	Methodology	Notes	Source
7439-97-6e	Mercury (elemental)	ID	---	Insufficient data were available to develop a benthic community CSCL.	---
7439-97-6	Mercury (divalent)	0.13	TEL	Estimated from a distribution of 331 sediment concentrations associated with no- and low-effects concentrations to endpoints of lethality, abundance, diversity, and benthic community structure.	MacDonald, 1994
1746-01-6	TCDD 2,3,7,8-	ID	---	Insufficient data were available to develop a benthic community CSCL.	---

ID = Insufficient data.
CSCL = Chemical stressor concentration limit.
FCV = Final chronic value.
SCV = Secondary chronic value.
ER-L = Effects range low- The value was the 10th percentile from the ranked distribution of sediment effects concentrations.
EqP = Equilibrium partitioning. The value is the product of the following calculation.
--- = Not applicable because insufficient data identified.
Benthic Community CSCL = Surface Well Water CSCL x This is calculation f_{oc}) x K_{oc}
TEL = Threshold effects level - The value calculated from the following equation, where EDS-L is the 15th[h] percentile of the effects data set and NEDS-M is the 50th percentile of the no-effects data set:

Table 14A-8. Terrestrial Plant CSCLs

CAS Number	Constituent	CSCL (mg/kg soil DW)	Methodology	Notes	Source
Organics					
75-05-8	Acetonitrile	ID	---	Insufficient data were available to develop a terrestrial plant CSCL.	---
107-13-1	Acrylonitrile	ID	---	Insufficient data were available to develop a terrestrial plant CSCL.	---
62-53-3	Aniline	ID	---	Insufficient data were available to develop a terrestrial plant CSCL.	---
71-43-2	Benzene	ID	---	Insufficient data were available to develop a terrestrial plant CSCL.	---
75-15-0	Carbon disulfide	ID	---	Insufficient data were available to develop a terrestrial plant CSCL.	---
108-90-7	Chlorobenzene	ID	---	Insufficient data were available to develop a terrestrial plant CSCL.	---
67-66-3	Chloroform	ID	---	Insufficient data were available to develop a terrestrial plant CSCL.	---
94-75-7	2,4-Dichlorophenoxyacetic acid (2,4-D)	ID	---	Insufficient data were available to develop a terrestrial plant CSCL.	---
106-93-4	Ethylene dibromide	ID	---	Insufficient data were available to develop a terrestrial plant CSCL.	---
87-68-3	Hexachloro-1,3-butadiene	ID	---	Insufficient data were available to develop a terrestrial plant CSCL.	—

(continued)

Table 14A-8. (continued)

CAS Number	Constituent	CSCL (mg/kg soil DW)	Methodology	Notes	Source
72-43-5	Methoxychlor	ID	---	Insufficient data were available to develop a terrestrial plant CSCL.	---
78-93-3	Methyl ethyl ketone	ID	---	Insufficient data were available to develop a terrestrial plant CSCL.	---
80-62-6	Methyl methacrylate	ID	---	Insufficient data were available to develop a terrestrial plant CSCL.	---
75-09-2	Methylene chloride	ID	---	Insufficient data were available to develop a terrestrial plant CSCL.	---
98-95-3	Nitrobenzene	ID	---	Insufficient data were available to develop a terrestrial plant CSCL.	---
108-95-2	Phenol	70	Lowest LOEC	Derived from the lowest of two toxicity values (range: 79 to 170 mg/kg soil) based on effects to plant weight.	Efroymson, Will, Suter, and Wooten, 1997
110-86-1	Pyridine	ID	---	Insufficient data were available to develop a terrestrial plant CSCL.	---
127-18-4	Tetrachloroethylene	ID	---	Insufficient data were available to develop a terrestrial plant CSCL.	---
137-26-8	Thiram	ID	---	Insufficient data were available to develop a terrestrial plant CSCL.	---
108-88-3	Toluene	ID	---	Insufficient data were available to develop a terrestrial plant CSCL.	---
71-55-6	1,1,1-Trichloroethane	ID	---	Insufficient data were available to develop a terrestrial plant CSCL.	—

(continued)

Table 14A-8. (continued)

CAS Number	Constituent	CSCL (mg/kg soil DW)	Methodology	Notes	Source
79-01-6	Trichloroethylene	ID	---	Insufficient data were available to develop a terrestrial plant CSCL.	---
75-01-4	Vinyl chloride	ID	---	Insufficient data were available to develop a terrestrial plant CSCL.	---
Metals					
7440-36-0	Antimony	5	Lowest LOEC	Value was the only LOEC identified based on phytotoxic effects.	Efroymson, Will, Suter and Wooten, 1997
7440-38-2	Arsenic	10	ER-L	Derived as the 10th percentile of 15 toxicity values (range: 2 to 1,000 mg/kg soil) based on effects to plant weight and yield.	Efroymson, Will, Suter and Wooten, 1997
7440-39-3	Barium	500	Lowest LOEC	Derived from the lowest of two toxicity values (range: 500 to 2,000 mg/kg soil) based on effects to plant weight.	Efroymson, Will, Suter and Wooten, 1997
7440-41-7	Beryllium	10	Lowest LOEC	Derived from the lowest of three toxicity values (range: 10 to 25 mg/kg soil) based on effects to plant weight and survival.	Efroymson, Will, Suter and Wooten, 1997
7440-43-9	Cadmium	4	ER-L	Derived as the10th percentile of 74 toxicity values (range: 1 to 300 mg/kg soil) based on effects to plant weight, yield, and germination success.	Efroymson, Will, Suter and Wooten, 1997
7440-47-3	Chromium	ID	---	Insufficient data were available to develop a terrestrial plant CSCL.	—

(continued)

Table 14A-8. (continued)

CAS Number	Constituent	CSCL (mg/kg soil DW)	Methodology	Notes	Source
16065-83-1	Chromium III	ID	---	Insufficient data were available to develop a terrestrial plant CSCL.	---
18540-29-9	Chromium VI	1	Lowest LOEC	Derived from the lowest of seven toxicity values (range: 1.8 to 31 mg/kg soil) based on effects to plant weight.	Efroymson, Will, Suter and Wooten, 1997
7439-92-1	Lead	50	ER-L	Derived as the 10th percentile of 17 toxicity values (range: 50 to 5,000 mg/kg soil) based on effects to plant weight and transpiration.	Efroymson, Will, Suter, and Wooten, 1997
7440-02-0	Nickel	30	ER-L	Derived as the 10th percentile of 14 toxicity values (range: 25 to 290 mg/kg soil) based on effects to plant weight.	Efroymson, Will, Suter, and Wooten, 1997
7782-49-2	Selenium	1	ER-L	Derived as the 10th of 14 toxicity values (range: 1 to 4 mg/kg soil) based on effects to plant weight.	Efroymson, Will, Suter, and Wooten, 1997
7440-22-4	Silver	2	Lowest LOEC	Value was the only LOEC identified based on phytotoxic effects.	Efroymson, Will, Suter, and Wooten, 1997
7446-18-6	Thallium	1	Lowest LOEC	Value was the only LOEC identified based on phytotoxic effects.	Efroymson, Will, Suter, and Wooten, 1997
7440-62-2	Vanadium	2	Lowest LOEC	Derived from the lowest of two toxicity values (range: 2.5 to 50 mg/kg soil) based on phytotoxic effects.	Efroymson, Will, Suter, and Wooten, 1997
7440-66-6	Zinc	50	ER-L	Derived as the 10th percentile of 14 toxicity values (range: 25 to 400 mg/kg soil) based on effects to plant weight, growth, and yield.	Efroymson, Will, Suter, and Wooten, 1997

(continued)

Table 14A-8. (continued)

CAS Number	Constituent	CSCL (mg/kg soil DW)	Methodology	Notes	Source
Special					
117-81-7	Bis(2-ethylhexyl) phthalate	ID	---	Insufficient data were available to develop a terrestrial plant CSCL.	---
50-32-8	Benzo(a)pyrene	ID	---	Insufficient data were available to develop a terrestrial plant CSCL.	---
53-70-3	Dibenz(a,h)anthracene	ID	---	In sufficient data were available to develop a terrestrial plant CSCL.	---
87-86-5	Pentachlorophenol	3	Lowest LOEC	Derived from the lowest of four toxicity values (range: 8 to 20 mg/kg soil) based on effects to plant weight.	Efroymson, Will, Suter, and Wooten, 1997
Mercury and Dioxin					
7439-97-6m	Methyl mercury	ID	---	Insufficient data were available to develop a terrestrial plant CSCL.	
7439-97-6e	Mercury (elemental)	ID	---	Insufficient data were available to develop a terrestrial plant CSCL.	---
7439-97-6	Mercury (divalent)	0.3	Lowest LOEC	Derived from the lowest of two toxicity values (range: 0.3 to 64 mg/kg soil) based on effects to seedling height and phytotoxicity.	Efroymson, Will, Suter, and Wooten, 1997
1746-01-6	TCDD 2,3,7,8-	ID	---	Insufficient data were available to develop a terrestrial plant CSCL.	---

CSCL = Chemical stressor concentration limit.
ER-L = Effects range low—The value was the 10th percentile from the ranked distribution of soil effects concentrations.
ID = Insufficient data.
LOEC = Lowest observed effect concentration.
--- = Not applicable because insufficient data were identified.

Table 14A-9. Soil Community CSCLs

CAS Number	Constituent	CSCL (mg/kg soil DW)	Methodology	Notes	Source
Organics					
75-05-8	Acetonitrile	ID	---	Insufficient data were available to develop a soil community CSCL.	---
107-13-1	Acrylonitrile	ID	---	Insufficient data were available to develop a soil community CSCL.	---
62-53-3	Aniline	ID	---	Insufficient data were available to develop a soil community CSCL.	---
71-43-2	Benzene	ID	---	Insufficient data were available to develop a soil community CSCL.	---
75-15-0	Carbon disulfide	ID	---	Insufficient data were available to develop a soil community CSCL.	---
108-90-7	Chlorobenzene	40	Lowest LC_{50}	Value is based on the lowest of four values assessing lethality to populations of earthworms. The lowest LC_{50} of 240 was used, applying an uncertainty factor of 5.	Efroymson, Will, and Suter, 1997
67-66-3	Chloroform	ID	---	Insufficient data were available to develop a soil community CSCL.	---
94-75-7	2,4-Dichlorophenoxyacetic acid (2,4-D)	ID	---	Insufficient data were available to develop a soil community CSCL.	---
106-93-4	Ethylene dibromide	ID	---	Insufficient data were available to develop a soil community CSCL.	---

(continued)

Table 14A-9. (continued)

CAS Number	Constituent	CSCL (mg/kg soil DW)	Methodology	Notes	Source
87-68-3	Hexachloro-1,3-butadiene	ID	---	Insufficient data were available to develop a soil community CSCL.	---
72-43-5	Methoxychlor	ID	---	Insufficient data were available to develop a soil community CSCL.	---
78-93-3	Methyl ethyl ketone	ID	---	Insufficient data were available to develop a soil community CSCL.	---
80-62-6	Methyl methacrylate	ID	---	Insufficient data were available to develop a soil community CSCL.	---
75-09-2	Methylene chloride	ID	---	Insufficient data were available to develop a soil community CSCL.	---
98-95-3	Nitrobenzene	40	Lowest LC_{50}	Value is based on the lowest of four values assessing lethality to populations of earthworms. The lowest LC_{50} of 226 was used, applying an uncertainty factor of 5.	Efroymson, Will, and Suter, 1997
108-95-2	Phenol	30	Lowest LC_{50}	Value is based on the lowest of five values assessing lethality to populations of earthworms. The lowest LC_{50} of 188 was used, applying an uncertainty factor of 5.	Efroymson, Will, and Suter, 1997
110-86-1	Pyridine	ID	---	Insufficient data were available to develop a soil community CSCL.	---
127-18-4	Tetrachloroethylene	ID	---	Insufficient data were available to develop a soil community CSCL.	---

(continued)

Table 14A-9. (continued)

CAS Number	Constituent	CSCL (mg/kg soil DW)	Methodology	Notes	Source
137-26-8	Thiram	ID	---	Insufficient data were available to develop a soil community CSCL.	---
108-88-3	Toluene	ID	---	Insufficient data were available to develop a soil community CSCL.	---
71-55-6	1,1,1-Trichloroethane	ID	---	Insufficient data were available to develop a soil community CSCL.	---
79-01-6	Trichloroethylene	ID	---	Insufficient data were available to develop a soil community CSCL.	---
75-01-4	Vinyl chloride	ID	---	Insufficient data were available to develop a soil community CSCL.	---
Metals					
7440-36-0	Antimony	ID	---	Insufficient data were available to develop a soil community CSCL.	---
7440-38-2	Arsenic	60	Lowest LOEC	Value was the only LOEC identified based on reproductive endpoints in earthworms.	Efroymson, Will, and Suter, 1997
7440-39-3	Barium	ID	---	Insufficient data were available to develop a soil community CSCL.	---
7440-41-7	Beryllium	ID	---	Insufficient data were available to develop a soil community CSCL.	—

(continued)

Table 14A-9. (continued)

CAS Number	Constituent	CSCL (mg/kg soil DW)	Methodology	Notes	Source
7440-43-9	Cadmium	1	Community-based CSCL	Based on NOEC data for eight different taxonomic groups represented in the soil community. Concentrations ranged from 1 to 19 mg/kg soil based on toxicity endpoints of reproduction, growth, and development.	vanStraalen & Denneman, 1989; Aldenberg & Slob, 1993; Sloof, 1992; Haight et al., 1982; vanStraalen et al., 1989; van de Meent et al., 1990; Russell et al., 1981; Malecki et al., 1982
7440-47-3	Chromium	66	Geometric mean	The ecotoxicity data indicate that soil concentrations indicating effects to survival are below soil concentrations indicating reproductive effects in earthworms. A geometric mean of LOEC data from both reproductive and survival endpoints was used to remain consistent with the assessment endpoints of the analysis..	Efroymson, Will, and Suter, 1997
16065-83-1	Chromium III	66	Geometric mean	Hexavalent chromium is reduced to Cr^{3+} under normal soil pH and redox conditions (Katz and Salem, 1994); hence, a greater portion of chromium in the soil is found as Cr^{3+}; therefore, the same benchmark used for total chromium is appropriate for Cr^{3+}.	Efroymson, Will, and Suter, 1997
18540-29-9	Chromium VI	0.4	Lowest LOEC	Value was the only LOEC identified based on reproductive endpoints in earthworms.	---

(continued)

Table 14A-9. (continued)

CAS Number	Constituent	CSCL (mg/kg soil DW)	Methodology	Notes	Source
7439-92-1	Lead	28	Community-based CSCL	Based on NOEC data for six different taxonomic groups represented in the soil community. Concentrations ranged from 23 to 1,100 mg/kg soil based on toxicity endpoints of reproduction, growth, and litter breakdown.	vanStraalen & Denneman, 1989; Aldenberg & Slob, 1993; Sloof, 1992; Denneman & van Straalen, 1991; van de Meent et al., 1990; Bengtsson et al., 1986, Marigomez et al., 1986
7440-02-0	Nickel	90	ER-L	Derived as the 10th percentile of 56 toxicity values (range: 50 to 8,100 mg/kg soil) based on effects microbial growth and productivity endpoints. Microbial endpoints appeared more sensitive than earthworms.	Efroymson, Will, and Suter, 1997
7782-49-2	Selenium	70	Lowest LOEC	Value was the only LOEC identified based on reproductive endpoints in earthworms.	Efroymson, Will, and Suter, 1997
7440-22-4	Silver	ID	---	Insufficient data were available to develop a soil community CSCL.	---
7446-18-6	Thallium	ID	---	Insufficient data were available to develop a soil community CSCL.	---
7440-62-2	Vanadium	ID	---	Insufficient data were available to develop a soil community CSCL.	---
7440-66-6	Zinc	100	ER-L	Derived as the 10th percentile of 46 toxicity values (range: 50 to 9,700 mg/kg soil) based on effects microbial growth and productivity endpoints. Microbial endpoints appeared more sensitive than earthworms.	Efroymson, Will, and Suter, 1997

(continued)

Table 14A-9. (continued)

CAS Number	Constituent	CSCL (mg/kg soil DW)	Methodology	Notes	Source
Special					
117-81-7	Bis(2-ethylhexyl) phthalate	ID	---	Insufficient data were available to develop a soil community CSCL.	---
50-32-8	Benzo(a)pyrene	ID	---	Insufficient data were available to develop a soil community CSCL.	---
53-70-3	Dibenz(a,h)anthracene	ID	---	Insufficient data were available to develop a soil community CSCL.	---
87-86-5	Pentachlorophenol	6	ER-L	Derived as the 10th percentile of 21 toxicity values (range: 16 to 2,300 mg/kg soil) based on effects earthworm mortality and reproductive success.	Efroymson, Will, and Suter, 1997
Mercury and Dioxin					
7439-97-6m	Methyl mercury	ID	---	Insufficient data were available to develop a soil community CSCL.	
7439-97-6e	Mercury (elemental)	ID	---	Insufficient data were available to develop a soil community CSCL.	---
7439-97-6	Mercury (divalent)	0.1	Lowest LOEC	Derived from the lowest of two toxicity values (range: 0.5 to 12.5 mg/kg soil) based on effects to earthworm survival and reproduction.	Efroymson, Will, and Suter, 1997
1746-01-6	TCDD 2,3,7,8-	ID	---	Insufficient data were available to develop a soil community CSCL.	---

ID = Insufficient data.
LOEC = Lowest observed effects concentration.
CSCL = Chemical stressor concentration limit.
ER-L = Effects range low— The value was the 10th percentile from the ranked distribution of soil effects concentrations.
NOEC = No observed effects concentration.
--- = Not applicable because insufficient data were identified.

Table 14A-10. Scaled Benchmark Doses for Ecological Receptors

CAS Number	Chemical Name	Chemical Type	Alligator Snapping Turtle	American Kestrel	American Robin	American Woodcock	Bald Eagle	Beaver	Belted Kingfisher	Black Bear	Black-Tailed Jackrabbit	Bullfrog	Burrowing Owl
75-05-8	Acetonitrile	O	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
107-13-1	Acrylonitrile	O	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
62-53-3	Aniline	O	ID	ID	ID	ID	ID	ID	ID	ID	ID	370	ID
7440-36-0	Antimony	M	ID	ID	ID	ID	ID	0.15	ID	0.11	0.26	0.3	ID
7440-38-2	Arsenic	M	ID	0.011	0.011	0.011	0.011	2.5	0.011	1.6	4.3	4.3	0.011
7440-39-3	Barium	M	ID	30	30	30	30	ID	30	ID	ID	ID	30
71-43-2	Benzene	O	ID	ID	ID	ID	ID	17	ID	12	28	34	ID
50-32-8	Benzo(a)pyrene	S	ID	ID	ID	ID	ID	0.67	ID	0.41	1.1	ID	ID
7440-41-7	Beryllium	M	ID	ID	ID	ID	ID	ID	ID	ID	ID	11	ID
117-81-7	Bis(2-ethylhexyl) phthalate	S	ID	1.1	1.1	1.1	1.1	23	1.1	16	38	ID	1.1
7440-43-9	Cadmium	M	ID	4.4	4.4	4.4	4.4	1.2	4.4	0.77	2.1	1.9	4.4
75-15-0	Carbon disulfide	O	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
108-90-7	Chlorobenzene	O	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
67-66-3	Chloroform	O	ID	ID	ID	ID	ID	9.1	ID	5.7	15	15	ID
7440-47-3	Chromium	M	ID	ID	ID	ID	ID	ID	ID	ID	ID	8.8	ID
16065-83-1	Chromium III (insoluble salts)	M	ID	2.2	2.2	2.2	2.2	1,000	2.2	570	1,700	ID	2.2
18540-29-9	Chromium VI	M	ID	ID	ID	ID	ID	1.9	ID	1.2	3.3	ID	ID
53-70-3	Dibenz(a,h)anthracene	S	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
94-75-7	2,4-Dichlorophenoxyacetic acid (2,4-D)	O	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
106-93-4	Ethylene dibromide	O	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID

(continued)

Table 14A-10. (continued)

CAS Number	Chemical Name	Chemical Type	Alligator Snapping Turtle	American Kestrel	American Robin	American Woodcock	Bald Eagle	Beaver	Belted Kingfisher	Black Bear	Black-Tailed Jackrabbit	Bullfrog	Burrowing Owl
87-68-3	Hexachloro-1,3-butadiene	O	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
7439-92-1	Lead	M	ID	0.066	0.066	0.066	0.066	0.0062	0.066	0.0036	0.011	2.1	0.066
7439-97-6	Mercury (divalent)	Hg	ID	0.64	0.64	0.64	0.64	0.48	0.64	0.34	0.8	2.1	0.64
7439976e	Mercury (elemental)	Hg	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
72-43-5	Methoxychlor	O	ID	ID	ID	ID	ID	44	ID	31	74	0.19	ID
78-93-3	Methyl ethyl ketone	O	ID	ID	ID	ID	ID	1000	ID	650	1800	ID	ID
7439976m	Methyl mercury	Hg	ID	0.025	0.025	0.025	0.025	0.045	0.025	0.032	0.075	ID	0.025
80-62-6	Methyl methacrylate	O	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
75-09-2	Methylene chloride	O	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
7440-02-0	Nickel	M	ID	91	91	91	91	22	91	14	38	2.2	91
98-95-3	Nitrobenzene	O	ID	ID	ID	ID	ID	ID	ID	ID	ID	0.64	ID
87-86-5	Pentachlorophenol	O	ID	62	62	62	62	2.6	62	1.6	4.4	0.013	62
108-95-2	Phenol	O	ID	ID	ID	ID	ID	ID	ID	ID	ID	1.3	ID
110-86-1	Pyridine	O	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
7782-49-2	Selenium	M	ID	0.71	0.71	0.71	0.71	0.094	0.71	0.066	0.16	1.6	0.71
7440-22-4	Silver	M	ID	ID	ID	ID	ID	ID	ID	ID	ID	0.03	ID
1746-01-6	2,3,7,8-Tetrachlorodibenzo-*p*-dioxin	D	ID	4.4E-05	4.4E-05	4.4E-05	4.4E-05	6.5E-07	4.4E-05	4.0E-07	1.1E-06	ID	4.4E-05
127-18-4	Tetrachloroethylene	O	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
7446-18-6	Thallium	S	ID	ID	ID	ID	ID	0.0087	ID	0.005	0.015	0.11	ID
137-26-8	Thiram	O	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID

(continued)

Table 14A-10. (continued)

CAS Number	Chemical Name	Chemical Type	Alligator Snapping Turtle	American Kestrel	American Robin	American Woodcock	Bald Eagle	Beaver	Belted Kingfisher	Black Bear	Black-Tailed Jackrabbit	Bullfrog	Burrowing Owl
108-88-3	Toluene	O	ID	ID	ID	ID	ID	16	ID	10	27	0.58	ID
71-55-6	1,1,1-Trichloroethane	O	ID	ID	ID	ID	ID	210	ID	130	350	ID	ID
79-01-6	Trichloroethylene	O	ID	ID	ID	ID	ID	0.44	ID	0.27	0.74	89	ID
7440-62-2	Vanadium	M	ID	1.8	1.8	1.8	1.8	0.54	1.8	0.38	0.9	ID	1.8
75-01-4	Vinyl chloride	O	ID	ID	ID	ID	ID	0.2	ID	0.12	0.33	ID	ID
7440-66-6	Zinc	M	ID	32	32	32	32	88	32	62	150	6.5	32

Table 14A-10. (continued)

CAS Number	Chemical Name	Canada Goose	Cerulean Warbler	Cooper's Hawk	Coyote	Deer Mouse	Eastern Box Turtle	Eastern Cottontail	Eastern Newt	Flatwoods Salamander	Gopher Frog	Great Basin Pocket Mouse	Great Blue Heron
75-05-8	Acetonitrile	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
107-13-1	Acrylonitrile	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
62-53-3	Aniline	ID	ID	ID	ID	ID	ID	ID	370	370	370	ID	ID
7440-36-0	Antimony	ID	ID	ID	0.18	0.84	ID	0.3	0.3	0.3	0.3	0.89	ID
7440-38-2	Arsenic	0.011	0.011	0.011	2.8	14	ID	5.1	4.3	4.3	4.3	15	0.011
7440-39-3	Barium	30	30	30	ID	ID	ID	ID	ID	ID	ID	ID	30
71-43-2	Benzene	ID	ID	ID	19	91	ID	33	34	34	34	97	ID
50-32-8	Benzo(a)pyrene	ID	ID	ID	0.73	3.7	ID	1.3	ID	ID	ID	3.8	ID
7440-41-7	Beryllium	ID	ID	ID	ID	ID	ID	ID	11	11	11	ID	ID
117-81-7	Bis(2-ethylhexyl) phthalate	1.1	1.1	1.1	26	130	ID	46	ID	ID	ID	130	1.1
7440-43-9	Cadmium	4.4	4.4	4.4	1.4	7	ID	2.5	1.9	1.9	1.9	7.1	4.4
75-15-0	Carbon disulfide	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
108-90-7	Chlorobenzene	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
67-66-3	Chloroform	ID	ID	ID	10	51	ID	18	15	15	15	52	ID
7440-47-3	Chromium	ID	ID	ID	ID	ID	ID	ID	8.8	8.8	8.8	ID	ID
16065-83-1	Chromium III (insoluble salts)	2.2	2.2	2.2	1,100	5,600	ID	2,000	ID	ID	ID	5,700	2.2
18540-29-9	Chromium VI	ID	ID	ID	2.1	11	ID	3.9	ID	ID	ID	11	ID
53-70-3	Dibenz(a,h)anthracene	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
94-75-7	2,4-Dichlorophenoxyacetic acid (2,4-D)	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
106-93-4	Ethylene dibromide	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID

(continued)

Table 14A-10. (continued)

CAS Number	Chemical Name	Canada Goose	Cerulean Warbler	Cooper's Hawk	Coyote	Deer Mouse	Eastern Box Turtle	Eastern Cottontail	Eastern Newt	Flatwoods Salamander	Gopher Frog	Great Basin Pocket Mouse	Great Blue Heron
87-68-3	Hexachloro-1,3-butadiene	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
7439-92-1	Lead	0.066	0.066	0.066	0.0069	0.035	ID	0.013	2.1	2.1	2.1	0.035	0.066
7439-97-6	Mercury (divalent)	0.64	0.64	0.64	0.55	2.6	ID	0.95	2.1	2.1	2.1	2.8	0.64
7439976e	Mercury (elemental)	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
72-43-5	Methoxychlor	ID	ID	ID	51	240	ID	88	0.19	0.19	0.19	260	ID
78-93-3	Methyl ethyl ketone	ID	ID	ID	1100	5800	ID	2100	ID	ID	ID	6000	ID
7439976m	Methyl mercury	0.025	0.025	0.025	0.051	0.25	ID	0.089	ID	ID	ID	0.26	0.025
80-62-6	Methyl methacrylate	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
75-09-2	Methylene chloride	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
7440-02-0	Nickel	91	91	91	25	130	ID	45	2.2	2.2	2.2	130	91
98-95-3	Nitrobenzene	ID	ID	ID	ID	ID	ID	ID	0.64	0.64	0.64	ID	ID
87-86-5	Pentachlorophenol	62	62	62	2.9	15	ID	5.2	0.013	0.013	0.013	15	62
108-95-2	Phenol	ID	ID	ID	ID	ID	ID	ID	1.3	1.3	1.3	ID	ID
110-86-1	Pyridine	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
7782-49-2	Selenium	0.71	0.71	0.71	0.11	0.51	ID	0.19	1.6	1.6	1.6	0.55	0.71
7440-22-4	Silver	ID	ID	ID	ID	ID	ID	ID	0.03	0.03	0.03	ID	ID
1746-01-6	2,3,7,8-Tetrachlorodibenzo-*p*-dioxin	4.4E-05	4.4E-05	4.4E-05	7.1E-07	3.6E-06	ID	1.3E-06	ID	ID	ID	3.7E-06	4.4E-05
127-18-4	Tetrachloroethylene	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
7446-18-6	Thallium	ID	ID	ID	0.0095	0.049	ID	0.018	0.11	0.11	0.11	0.049	ID
137-26-8	Thiram	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
108-88-3	Toluene	ID	ID	ID	18	91	ID	33	0.58	0.58	0.58	94	ID

(continued)

Table 14A-10. (continued)

CAS Number	Chemical Name	Canada Goose	Cerulean Warbler	Cooper's Hawk	Coyote	Deer Mouse	Eastern Box Turtle	Eastern Cottontail	Eastern Newt	Flatwoods Salamander	Gopher Frog	Great Basin Pocket Mouse	Great Blue Heron
71-55-6	1,1,1-Trichloroethane	ID	ID	ID	230	1200	ID	410	ID	ID	ID	1200	ID
79-01-6	Trichloroethylene	ID	ID	ID	0.48	2.5	ID	0.88	89	89	89	2.5	ID
7440-62-2	Vanadium	1.8	1.8	1.8	0.61	2.9	ID	1.1	ID	ID	ID	3.1	1.8
75-01-4	Vinyl chloride	ID	ID	ID	0.22	1.1	ID	0.39	ID	ID	ID	1.1	ID
7440-66-6	Zinc	32	32	32	100	480	ID	180	6.5	6.5	6.5	510	32

Table 14A-10. (continued)

CAS Number	Chemical Name	Green Frog	Green Heron	Herring Gull	Kit Fox	Least Weasel	Lesser Scaup	Little Brown Bat	Loggerhead Shrike	Long-Tailed Weasel	Mallard Duck	Marsh Wren	Meadow Vole
75-05-8	Acetonitrile	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
107-13-1	Acrylonitrile	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
62-53-3	Aniline	370	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
7440-36-0	Antimony	0.3	ID	ID	0.27	0.73	ID	1.1	ID	0.55	ID	ID	0.73
7440-38-2	Arsenic	4.3	0.011	0.011	4.6	12	0.011	17	0.011	8.1	0.011	0.011	14
7440-39-3	Barium	ID	30	30	ID	ID	30	ID	30	ID	30	30	ID
71-43-2	Benzene	34	ID	ID	30	79	ID	120	ID	59	ID	ID	78
50-32-8	Benzo(a)pyrene	ID	ID	ID	1.2	3.1	ID	4.6	ID	2.1	ID	ID	3.7
7440-41-7	Beryllium	11	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
117-81-7	Bis(2-ethylhexyl) phthalate	ID	1.1	1.1	41	110	1.1	160	1.1	82	1.1	1.1	110
7440-43-9	Cadmium	1.9	4.4	4.4	2.2	5.8	4.4	8.5	4.4	4	4.4	4.4	6.9
75-15-0	Carbon disulfide	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
108-90-7	Chlorobenzene	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
67-66-3	Chloroform	15	ID	ID	16	42	ID	62	ID	29	ID	ID	50
7440-47-3	Chromium	8.8	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
16065-83-1	Chromium III (insoluble salts)	ID	2.2	2.2	1,800	4,600	2.2	7,500	2.2	3,000	2.2	2.2	4,600
18540-29-9	Chromium VI	ID	ID	ID	3.5	9	ID	13	ID	6.2	ID	ID	11
53-70-3	Dibenz(a,h)anthracene	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
94-75-7	2,4-Dichlorophenoxyacetic acid (2,4-D)	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
106-93-4	Ethylene dibromide	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID

(continued)

Table 14A-10. (continued)

CAS Number	Chemical Name	Green Frog	Green Heron	Herring Gull	Kit Fox	Least Weasel	Lesser Scaup	Little Brown Bat	Loggerhead Shrike	Long-Tailed Weasel	Mallard Duck	Marsh Wren	Meadow Vole
87-68-3	Hexachloro-1,3-butadiene	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
7439-92-1	Lead	2.1	0.066	0.066	0.011	0.028	0.066	0.046	0.066	0.018	0.066	0.066	0.029
7439-97-6	Mercury (divalent)	2.1	0.64	0.64	0.85	2.3	0.64	3.4	0.64	1.7	0.64	0.64	2.3
7439976e	Mercury (elemental)	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
72-43-5	Methoxychlor	0.19	ID	ID	79	210	ID	310	ID	160	ID	ID	210
78-93-3	Methyl ethyl ketone	ID	ID	ID	1,900	4,900	ID	7,100	ID	3,300	ID	ID	5,800
7439976m	Methyl mercury	ID	0.025	0.025	0.08	0.22	0.025	0.32	0.025	0.16	0.025	0.025	0.21
80-62-6	Methyl methacrylate	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
75-09-2	Methylene chloride	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
7440-02-0	Nickel	2.2	91	91	41	100	91	150	91	71	91	91	120
98-95-3	Nitrobenzene	0.64	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
87-86-5	Pentachlorophenol	0.013	62	62	4.7	12	62	18	62	8.3	62	62	14
108-95-2	Phenol	1.3	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
110-86-1	Pyridine	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
7782-49-2	Selenium	1.6	0.71	0.71	0.17	0.45	0.71	0.66	0.71	0.33	0.71	0.71	0.44
7440-22-4	Silver	0.03	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
1746-01-6	2,3,7,8-Tetrachlorodibenzo-*p*-dioxin	ID	4.4E-05	4.4E-05	1.2E-06	3.0E-06	4.4E-05	4.4E-06	4.4E-05	2.1E-06	4.4E-05	4.4E-05	3.6E-06
127-18-4	Tetrachloroethylene	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
7446-18-6	Thallium	0.11	ID	ID	0.015	0.039	ID	0.064	ID	0.026	ID	ID	0.04
137-26-8	Thiram	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID

(continued)

Table 14A-10. (continued)

CAS Number	Chemical Name	Green Frog	Green Heron	Herring Gull	Kit Fox	Least Weasel	Lesser Scaup	Little Brown Bat	Loggerhead Shrike	Long-Tailed Weasel	Mallard Duck	Marsh Wren	Meadow Vole
108-88-3	Toluene	0.58	ID	ID	30	76	ID	110	ID	52	ID	ID	90
71-55-6	1,1,1-Trichloroethane	ID	ID	ID	370	960	ID	1,400	ID	660	ID	ID	1,100
79-01-6	Trichloroethylene	89	ID	ID	0.8	2	ID	3	ID	1.4	ID	ID	2.4
7440-62-2	Vanadium	ID	1.8	1.8	0.96	2.6	1.8	3.8	1.8	1.9	1.8	1.8	2.5
75-01-4	Vinyl chloride	ID	ID	ID	0.36	0.92	ID	1.4	ID	0.63	ID	ID	1.1
7440-66-6	Zinc	6.5	32	32	160	420	32	620	32	310	32	32	420

Table 14A-10. (continued)

CAS Number	Chemical Name	Mink	Mule Deer	Muskrat	Northern Bobwhite	Northern Water Snake	Osprey	Painted Turtle	Pine Vole	Prairie Vole	Raccoon	Racer	Red Fox
75-05-8	Acetonitrile	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
107-13-1	Acrylonitrile	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
62-53-3	Aniline	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
7440-36-0	Antimony	0.35	0.12	0.34	ID	ID	ID	ID	0.8	0.75	0.21	ID	0.23
7440-38-2	Arsenic	5.3	1.8	5.5	0.011	ID	0.011	ID	13	12	3.4	ID	3.6
7440-39-3	Barium	ID	ID	ID	30	ID	30	ID	ID	ID	ID	ID	ID
71-43-2	Benzene	38	13	36	ID	ID	ID	ID	86	81	23	ID	24
50-32-8	Benzo(a)pyrene	1.4	0.47	1.4	ID	ID	ID	ID	3.5	3.1	0.9	ID	0.96
7440-41-7	Beryllium	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
117-81-7	Bis(2-ethylhexyl) phthalate	53	17	50	1.1	ID	1.1	ID	120	110	32	ID	34
7440-43-9	Cadmium	2.6	0.88	2.7	4.4	ID	4.4	ID	6.5	5.8	1.7	ID	1.8
75-15-0	Carbon disulfide	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
108-90-7	Chlorobenzene	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
67-66-3	Chloroform	19	6.5	20	ID	ID	ID	ID	48	42	12	ID	13
7440-47-3	Chromium	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
16065-83-1	Chromium III (insoluble salts)	2,000	680	2,200	2.2	ID	2.2	ID	5,300	5,000	1,300	ID	1,400
18540-29-9	Chromium VI	4.1	1.4	4.2	ID	ID	ID	ID	10	9	2.6	ID	2.8
53-70-3	Dibenz(a,h)anthracene	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
94-75-7	2,4-Dichlorophenoxyacetic acid (2,4-D)	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
106-93-4	Ethylene dibromide	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID

(continued)

Table 14A-10. (continued)

CAS Number	Chemical Name	Mink	Mule Deer	Muskrat	Northern Bobwhite	Northern Water Snake	Osprey	Painted Turtle	Pine Vole	Prairie Vole	Raccoon	Racer	Red Fox
87-68-3	Hexachloro-1,3-butadiene	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
7439-92-1	Lead	0.012	0.0042	0.013	0.066	ID	0.066	ID	0.033	0.031	0.0083	ID	0.0087
7439-97-6	Mercury (divalent)	1.1	0.36	1	0.64	ID	0.64	ID	2.5	2.3	0.66	ID	0.71
7439976e	Mercury (elemental)	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
72-43-5	Methoxychlor	100	34	97	ID	ID	ID	ID	230	220	61	ID	66
78-93-3	Methyl ethyl ketone	2,200	740	2,300	ID	ID	ID	ID	5,500	4,800	1,400	ID	1,500
7439976m	Methyl mercury	0.1	0.034	0.098	0.025	ID	0.025	ID	0.23	0.22	0.062	ID	0.066
80-62-6	Methyl methacrylate	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
75-09-2	Methylene chloride	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
7440-02-0	Nickel	47	16	49	91	ID	91	ID	120	100	30	ID	32
98-95-3	Nitrobenzene	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
87-86-5	Pentachlorophenol	5.5	1.9	5.7	62	ID	62	ID	14	12	3.5	ID	3.7
108-95-2	Phenol	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
110-86-1	Pyridine	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
7782-49-2	Selenium	0.22	0.071	0.21	0.71	ID	0.71	ID	0.49	0.46	0.13	ID	0.14
7440-22-4	Silver	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
1746-01-6	2,3,7,8-Tetrachlorodibenzo-*p*-dioxin	1.4E-06	4.6E-07	1.4E-06	4.4E-05	ID	4.4E-05	ID	3.4E-06	3.0E-06	8.8E-07	ID	9.3E-07
127-18-4	Tetrachloroethylene	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
7446-18-6	Thallium	0.017	0.0059	0.019	ID	ID	ID	ID	0.046	0.043	0.012	ID	0.012
137-26-8	Thiram	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID

(continued)

Table 14A-10. (continued)

CAS Number	Chemical Name	Mink	Mule Deer	Muskrat	Northern Bobwhite	Northern Water Snake	Osprey	Painted Turtle	Pine Vole	Prairie Vole	Raccoon	Racer	Red Fox
108-88-3	Toluene	34	12	35	ID	ID	ID	ID	86	76	22	ID	23
71-55-6	1,1,1-Trichloroethane	430	150	450	ID	ID	ID	ID	1,100	960	280	ID	300
79-01-6	Trichloroethylene	0.92	0.31	0.95	ID	ID	ID	ID	2.3	2	0.6	ID	0.63
7440-62-2	Vanadium	1.2	0.41	1.2	1.8	ID	1.8	ID	2.8	2.6	0.74	ID	0.8
75-01-4	Vinyl chloride	0.41	0.14	0.43	ID	ID	ID	ID	1	0.92	0.27	ID	0.28
7440-66-6	Zinc	200	67	190	32	ID	32	ID	460	430	120	ID	130

Table 14A-10. (continued)

CAS Number	Chemical Name	Red-Tailed Hawk	River Otter	Short-Tailed Shrew	Short-Tailed Weasel	Snapping Turtle	Southern Hognose Snake	Spotted Sandpiper	Tree Swallow	Western Meadowlark	White-Tailed Deer
75-05-8	Acetonitrile	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
107-13-1	Acrylonitrile	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
62-53-3	Aniline	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
7440-36-0	Antimony	ID	0.2	0.89	0.59	ID	ID	ID	ID	ID	0.12
7440-38-2	Arsenic	0.011	3.1	15	7.9	ID	ID	0.011	0.011	0.011	1.8
7440-39-3	Barium	30	ID	ID	ID	ID	ID	30	30	30	ID
71-43-2	Benzene	ID	21	96	63	ID	ID	ID	ID	ID	13
50-32-8	Benzo(a)pyrene	ID	0.81	4	2.1	ID	ID	ID	ID	ID	0.48
7440-41-7	Beryllium	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
117-81-7	Bis(2-ethylhexyl) phthalate	1.1	29	130	88	ID	ID	1.1	1.1	1.1	19
7440-43-9	Cadmium	4.4	1.5	7.4	3.9	ID	ID	4.4	4.4	4.4	0.9
75-15-0	Carbon disulfide	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
108-90-7	Chlorobenzene	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
67-66-3	Chloroform	ID	11	55	28	ID	ID	ID	ID	ID	6.6
7440-47-3	Chromium	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
16065-83-1	Chromium III (insoluble salts)	2.2	1200	5800	2800	ID	ID	2.2	2.2	2.2	680
18540-29-9	Chromium VI	ID	2.4	12	6.1	ID	ID	ID	ID	ID	1.4
53-70-3	Dibenz(a,h)anthracene	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
94-75-7	2,4-Dichlorophenoxyacetic acid (2,4-D)	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
106-93-4	Ethylene dibromide	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID

(continued)

Table 14A-10. (continued)

CAS Number	Chemical Name	Red-Tailed Hawk	River Otter	Short-Tailed Shrew	Short-Tailed Weasel	Snapping Turtle	Southern Hognose Snake	Spotted Sandpiper	Tree Swallow	Western Meadowlark	White-Tailed Deer
87-68-3	Hexachloro-1,3-butadiene	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
7439-92-1	Lead	0.066	0.0076	0.036	0.017	ID	ID	0.066	0.066	0.066	0.0042
7439-97-6	Mercury (divalent)	0.64	0.61	2.8	1.8	ID	ID	0.64	0.64	0.64	0.39
7439976e	Mercury (elemental)	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
72-43-5	Methoxychlor	ID	57	260	170	ID	ID	ID	ID	ID	36
78-93-3	Methyl ethyl ketone	ID	1,300	6,300	3,300	ID	ID	ID	ID	ID	760
7439976m	Methyl mercury	0.025	0.057	0.26	0.17	ID	ID	0.025	0.025	0.025	0.036
80-62-6	Methyl methacrylate	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
75-09-2	Methylene chloride	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
7440-02-0	Nickel	91	27	130	70	ID	ID	91	91	91	16
98-95-3	Nitrobenzene	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
87-86-5	Pentachlorophenol	62	3.2	16	8.2	ID	ID	62	62	62	1.9
108-95-2	Phenol	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
110-86-1	Pyridine	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
7782-49-2	Selenium	0.71	0.12	0.54	0.36	ID	ID	0.71	0.71	0.71	0.076
7440-22-4	Silver	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
1746-01-6	2,3,7,8-Tetrachlorodibenzo-*p*-dioxin	4.4E-05	7.9E-07	3.9E-06	2.0E-06	ID	ID	4.4E-05	4.4E-05	4.4E-05	4.7E-07
127-18-4	Tetrachloroethylene	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
7446-18-6	Thallium	ID	0.011	0.05	0.024	ID	ID	ID	ID	ID	0.0058
137-26-8	Thiram	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID

(continued)

Table 14A-10. (continued)

CAS Number	Chemical Name	Red-Tailed Hawk	River Otter	Short-Tailed Shrew	Short-Tailed Weasel	Snapping Turtle	Southern Hognose Snake	Spotted Sandpiper	Tree Swallow	Western Meadowlark	White-Tailed Deer
108-88-3	Toluene	ID	20	98	51	ID	ID	ID	ID	ID	12
71-55-6	1,1,1-Trichloroethane	ID	250	1,200	650	ID	ID	ID	ID	ID	150
79-01-6	Trichloroethylene	ID	0.54	2.6	1.4	ID	ID	ID	ID	ID	0.32
7440-62-2	Vanadium	1.8	0.69	3.1	2.1	ID	ID	1.8	1.8	1.8	0.44
75-01-4	Vinyl chloride	ID	0.24	1.2	0.62	ID	ID	ID	ID	ID	0.14
7440-66-6	Zinc	32	110	510	340	ID	ID	32	32	32	71

ID = Insufficient data.
O = Organic constituent.
M = Metal.
S = Special.
Hg = Mercury.