NOTE: The initial version of the TRIM Ecological Toxicity Database, developed for use with TRIM.Risk$_{Eco}$, includes a preliminary collection of ecological receptor toxicity values compiled by OAQPS for a subset of the Clean Air Act Hazardous Air Pollutants. This initial version of the database has been derived from a compilation of numerous ecotoxicological reviews for several different EPA projects. The contents of the database are drawn from generally available, peer-reviewed information. These projects involved the review and selection or development of toxicity metrics for a variety of chemicals using the approaches described in section 3 and 4. EPA has not, however, reviewed or adopted this initial database with regard to any particular programmatic needs. **Users should review and modify this file to meet their application needs, making changes and additions, as needed, prior to use.**

Background Documentation- TRIM Ecological Toxicity Database (September 2005 version)

The Ecological Toxicity Database (referred to simply as the ecotox database) developed for TRIM provides toxicological information read by the TRIM.RISK$_{Eco}$ GUI that allows the user to choose the toxicity values will be used by the TRIM.RISK$_{Eco}$ module in estimating potential ecological risks associated with the release of hazardous air pollutants (HAPs). The database currently contains reported toxicological values (e.g., LC_{50}) and environmental quality criteria for 32 HAPS covering 65 ecological receptors (including individual species as well as "receptor groups" such as the soil community). These data have been classified according to the endpoint(s) reported in the study (e.g,. NOAEL, LOAEL) and toxicological effect(s) (e.g., mortality, fecundity). Table 1 lists the five types of exposure measures for which Toxicity Metrics (TMs) are included in the database. TMs included studies for acute as well as chronic exposure durations.

Table 1. Exposure Measures Associated With Toxicity Metrics

Code	Parameter Description	Units
D	Applied dose of chemical due to ingestion of contaminated media, plants, and prey **(ie. oral intakes)**	mg/kg-d wet wt
TW	Environmental criteria based on **total water concentration**	mg/L
DW	Environmental criteria based on **dissolved water concentration**	mg/L
SED	Environmental criteria based on **sediment concentration**	ug/g wet or dry wt
SOIL	Environmental criteria based on dry weight **soil concentration**	ug/g dry wt

Although the database is structured to accept TMs for air concentration criteria and body burden (also referred to as tissue residue), no data on these exposure measures are included in this version of the database. Attachment A presents the database schema and detailed description of each of the data tables.

1.0 Ecological Receptors in the Database

The database contains a wide variety of receptors common across much of the contiguous United States; however, we anticipate that additional receptors will be added (e.g., specific species of fish) to support TRIM usage either through: (1) expansion of the existing receptor list as part of the TRIM database development or (2) inclusion of new receptors and associated data from the user community (i.e., users may add receptors that are endemic to their particular location and interests). The rationales used to select ecological receptors included in the database are summarized below.

The ecological receptors covered in the ecotox database are widely applicable to a variety of sites across the coterminous United States and represent major taxa and trophic levels. In addition, functional niche was considered to ensure that the full spectrum of feeding guilds and exposure pathways was represented (e.g., insectivores, herbivores). Data availability was naturally an important consideration in selecting receptors to optimize data collection efforts. Therefore, the majority of receptors added to the database included species for which wildlife exposure factors were readily available. The main sources for ecological exposure factor data were the *Wildlife Exposure Factors Handbook* (U.S. EPA, 1993b), *Methods and Tools for Estimation of the Exposure of Terrestrial Wildlife to Contaminants* (Sample et al., 1997), and the U.S. Army Corps of Engineers' *Species Profile Series* (various dates and authors). Table 2 lists the major ecological receptor groups in the ecotox database along with available TMs.

Table 2. Receptor groups in the ecotox database and available TMs

Receptor Group*	Dose (oral intake)	Soil	Water (dissolved)	Water (total)	Sediment
Mammal	X				
Bird	X				
Terrestrial Plant		X			

Earthworm		X			
Soil community		X			
Amphibian				X	
Fish			X	X	
Aquatic Plant				X	
Water column invertebrate				X	
Aquatic community			X	X	
Sediment community					X

*Although reptiles were considered, no suitable toxicological data were identified..

2.0 Database

The discussion of the methods used in developing the TMs included in the database is organized around the specific exposure measures listed in Table 1.

Dose (D) Toxicity Metrics (for Mammals and Birds)

Toxicity Reference Values (TRVs)

Toxicity Reference Values (TRVs) were developed to be a receptor-class specific estimate of a no-observed adverse effect level (dose) for the respective contaminant for chronic exposure. TRV-Low values represent the lowest credible no adverse effect level and TRV-High values represent the mid-point of a variety of adverse effects levels and therefore not necessarily a lowest adverse effect level (LOAEL). Because TRVs were identified to be protective of all mammalian and bird species in a given location, an allometric adjustment was not made (i.e., the TRVs were not extrapolated to a species-specific dose as described below for mammals). Therefore, these TRV values have generic receptors, such as “mammals” or “birds”, in the database. The database mainly used TRVs developed by the U.S. EPA Region 9 Biological Technical Assistance Group (BTAG) (BTAG, 2002), however, for lead and cadmium the database used TRVs developed for U.S. EPA ecological soil screening levels (U.S. EPA, 2005, ECO-SSL)

Other Toxicity Metrics

Toxicity values, in units of dose or oral intake (mg/kg-d), were developed for representative taxa of mammals and birds. The hierarchy for selection of ecotoxicity data

emphasizes reproductive and developmental endpoints as well as other chronic endpoints relevant to population sustainability; however, studies on other endpoints such as cancer were not excluded if they were identified in a major secondary source.

For mammals, study data from a test species were extrapolated to values for various species of mammals once an appropriate study value was selected; the value was scaled to species-specific values to account for differences in interspecies sensitivity. This method used an allometric scaling equation based on body weight to extrapolate test species doses to wildlife species doses. A scaling factor of 3/4 was used (Equation 1). This is the default methodology that EPA uses for human carcinogenicity assessments to adjust oral route animal data to equivalent human values, and is widely used in ecological risk assessment to scale across species of different sizes.

Equation 1: $D_w = D_t \times (bw_t / bw_w)^{1/4}$

where

D_w	=	scaled dose for wildlife species w (mg/kg-d)
D_t	=	study dose for test species t (mg/kg-d)
bw_t	=	body weight of the test species (kg)
bw_w	=	body weight of wildlife species (kg).

Body weights for wildlife species 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 in other compilations (e.g., U.S. Army profiles) as well as in primary literature sources. Note that the allometric scaling equation can be used for different effects levels (no effects versus low effects) for a variety of chronic endpoints.

Toxicity values for birds have not been scaled to other species. This will be considered in next steps for this database.

Total Surface Water Concentration Toxicity Metrics (TW)

The criteria developed for surface water for total chemical concentrations include the following receptor taxa: aquatic community, aquatic plants, fish, water column invertebrates, and herpetofauna.[1] The methods used to derive TMs are reviewed here for each receptor group.

1 Herpetofauna includes species of amphibians and reptiles.

Ambient Water Quality Criteria

Ambient water quality criteria intended to protect the freshwater community (e.g., including fish, aquatic invertebrates, etc.) have been developed by the EPA Office of Water. These criteria include those that satisfy the full data requirements as well as those developed using abbreviated methods (requiring fewer data points). With the exception of a few selected chemicals such as DDT, these criteria are not intended to protect species of mammals and birds that may forage in freshwater ecosystems. When available, the National Ambient Water Quality Criteria (NAWQC) were selected for the database. There are both acute and chronic NAWQC. Another term for the acute criterion is Criterion Maximum Concentration (CMC), and another term for the chronic criterion is Continuous Concentration Criterion (CCC).

The development of aquatic water quality criteria requires the compilation of appropriate acute and chronic ecotoxicity data reporting effects to survival, growth, and reproduction in aquatic biota for specific taxa in the freshwater community. For chemicals for which neither a CCC nor a FCV was available, a Secondary Chronic Value (SCV) was calculated using Tier II methods developed through the Great Lakes Water Quality Initiative (GLWQI [Stephan et al., 1985; Suter and Tsao, 1996]).

Other Toxicity Metrics

The database also includes chronic screening values (CSVs) as well as a number of alternative toxicity data for short-term exposures such as acute screening values (ASVs), and the secondary acute values (SAVs) from Suter and Tsao (1996). The variety of values in this section is due to the initial data gathering effort. However, the Agency hopes to further clarify the usefulness of these values and eliminate any redundancy in future development of the database. Until these next steps can be completed, the toxicity section for aquatic communities is still considered preliminary.

In addition, LOEL values presented in CCME (2003) were also included in the database. These values were entered as chronic duration values pertinent to growth and reproduction.

Aquatic Plants

For algae and aquatic plants, toxicological data 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 HAPs, studies were available for algae but not for aquatic vascular plants. Because of the lack of data on this receptor group and the differences between vascular aquatic plants and algae sensitivity,

the lowest value of those identified was typically selected. The database has EC_{50} (median effective concentration) values and, in instances where only a 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. It is noted here that chronic ambient water quality criteria (i.e., CCCs), described above, are derived in consideration of available plant data.

Amphibians

Though amphibians are a significant ecological receptor, ecotoxicity data characterizing the dose-response relationship for chemicals of concern is limited and none was found that could be reported as protective of all the amphibian community.

With the data available, LC_{50} values (lethal concentration for 50% of the test population), EC_{50} values (effects concentration for 50% of the test population), and chronic values (CV) were developed for specific amphibian receptors. This was done by estimating a geometric mean of acute or chronic amphibian toxicity data across the same receptor species. The units for these values are mg/L. A few general guidelines were followed in selecting analogous acute studies for developing criteria:

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

Water column invertebrates and fish

A variety of toxicity values were entered in the database for fish. Most of them correspond to values obtained from Suter and Tsao (1996), which provides SCVs (secondary chronic values) and LCVs (lowest chronic values), along with SAVs (secondary acute values) and EC_{20} (effects concentrations for 20% of the test population).

Toxicological data specific to water column invertebrates are widely available in the open scientific literature; however, the sheer volume of data on *daphnids* would have been prohibitively resource-intensive to enter and QC in the database, and few studies were available that could be used to infer effects at the population level. This latter point is of particular importance; the ecological significance (e.g., long-term impact on the aquatic ecosystem) of potential risks to aquatic invertebrates is difficult to determine given the currently available data. Only the value for chlordane presented in Suter and Tsao (1996) has been entered into the current database (this is an acute toxicity value (EC_{20}) for daphnids). This benchmark was defined as the highest tested concentration causing less than 20% reduction in the product of growth, fecundity, and survivorship in a chronic test with a daphnid species and it is intended to be an index of population production.

Dissolved Surface Water Concentration Toxicity Metrics (DW)

The National Recommended Water Quality Criteria (U.S.EPA, 2004) presents dissolved surface water criteria for metals. These values were entered in the TRIM ecotox database as presented by U.S.EPA (2004). U.S.EPA (2004) calculated the water quality criteria by using the conversion factors that are presented in Table 3 and by assuming a value of 100 mg/L $CaCO_3$ for water hardness. 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 criteria were derived by multiplying the total water criterion (TW) by the conversion factor (Equation 2):

Equation 2: Metal DW = (Metal TW) x (Conversion~Factor)

where

Metal DW = either a CCC (continuous concentration criterion) or a CMC (criterion maximun concentration)
Conversion Factor = the fraction of dissolved metal

Table 3. Conversion factors for dissolved metals

Constituent	Conversion Factor for CCC	Conversion Factor for CMC
Cadmium	1.101672-[(ln hardness)(0.041838)]	1.136672-[(ln hardness)(0.041838)]
Lead	1.46203-[(ln hardness)(0.145712)]	1.46203-[(ln hardness)(0.145712)]
Mercury	0.85	0.85

Note: U.S. EPA (2004) calculated the water quality criteria assuming a value for water hardness of 100 mg/L $CaCO_3$, and this calculation was carried into the Ecological Effects Database

Sediment Concentration Toxicity Metrics (SED)

Two methods were used in developing quality criteria for the benthic community (e.g., worms, amphipods). The first and preferred method used measured sediment concentrations that

resulted in *de minimis* effects on 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 on survival, species diversity, and abundance endpoints. Measurements to derive the criteria were taken at the national scale and reflected a variety of sediment types and benthic community species. The second 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.

Measured Sediment Criteria

One of the sources of sediment criteria based on measured data is the Florida Department of Environmental Protection (FDEP) sediment documents. 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 indicated probable effects and no effects to the benthic community, respectively. Even though these criteria were developed for a marine community, researchers have indicated that marine TELs may have good correlation with no-effects levels found for freshwater systems (Smith et al., 1996). Many of the TEL values in the database were extracted from CCME (2003) and entered according to guidelines established for previous U.S.EPA projects such Sludge Screening 2003. These guidelines specified their use as chronic values affecting growth and reproduction.

Using the methods applied by the FDEP, the National Biological Service produced a set of Threshold Effect Concentration (TEC) benchmarks for the EPA Great Lakes National Program Office that are reported in Jones et al. (1997). These values were calculated using laboratory data on the toxicity of contaminants associated with up to 62 sediment samples collected predominantly from freshwater sites.

A small number of subchronic sediment values were also gathered from primary literature; these subchronic values include endpoints such as EC_{20} and SAVs. It should be noted that sediment criteria are typically reported in dry weight.

Estimated Sediment Criteria

When measured effects data were not available for organic constituents in the literature, sediment value were derived using the EqP approach (U.S. EPA, 1993a). Surface water criteria (e.g., Ambient Water Quality Criteria or Secondary Chronic Values) were used to generate a

sediment criterion 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 organic carbon; Equation 3 was used to calculate the sediment TMs for nonionic chemicals.

Equation 3: $SED = f_{oc} \times K_{oc} \times TW$

where

f_{oc} - fraction organic carbon was assumed to be 1 percent total organic carbon

K_{oc}s - (organic carbon partitioning coefficients) were estimated following Di Toro's equation (1985), $\log_{10}(K_{oc})=0.00028+0.983 \log_{10}(K_{ow})$.

The $\log_{10}(K_{ow})$(octanol-water partition coefficients) obtained from EPIWIN (v3.10) and NLM (2002) as specified in tbl_Chemicals (See Attachment A)

EPA's OSWER has published Ecotox Thresholds (ETs) intended to be used for screening contaminants at CERCLA sites. Sediment quality criteria (SQC) values, which are derived from the AWQC (Ambient Water Quality Criteria) using the equilibrium partitioning methodology described above, are the basis for the ETs. The ETs correspond to the lower limit of the 95% confidence interval and are normalized to 1% total organic carbon. The database includes both the SQC ET values and SQB (Sediment Quality Benchmark) values which are calculated in the same manner as the SQC values except that a Tier II Secondary Chronic Value is used. Sediment criteria developed using the equilibrium partitioning method are in wet weight.

Soil Concentration Toxicity Metrics (SOIL)

Terrestrial Plants

For the terrestrial plant community, most of the TMs were identified from a summary document prepared at the Oak Ridge National Laboratory (ORNL): *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants: 1997 Revision* (Efroymson et al., 1997a). The measurement endpoints were generally limited to growth and yield parameters because they are common effects observed in phytotoxicity studies and they are ecologically significant responses in terms of plant populations. As presented in Efroymson et al., criteria for phytotoxicity were selected by rank ordering the LOEC values and then approximating the 10^{th} percentile, which was then considered the ER-L value. If there were 10 or fewer values for a chemical, the lowest LOEC was used. If there were more than 10 values, the ER-L value was used.

The threshold effects concentration (TEC) values from CCME (2003) were also included in the database. These are considered chronic duration values pertinent to growth, reproduction

and mortality.

Ecological Soil Screening Levels (SSL) for cadmium and lead were also entered into the database. These values are presented in U.S.EPA (2005) and were derived as the geometric mean of the maximum acceptable toxicant concentration (MATC) values for different species and test conditions that were presented in selected studies.

Earthworms

For earthworms, most of the TMs were identified from a summary document prepared at the Oak Ridge National Laboratory (ORNL): Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision (Efroymson et al., 1997b). ER-L values were also used for earthworms by identifying the LOECs and applying the same method as for finding terrestrial plant ER-L values (see above). Also similar to terrestrial plants, if more than 10 studies were identified reporting LOECs, the ER-L was used, however, when less than 10 values were identified, the lowest LOEC was selected as the soil criterion.

SSLs (USEPA 2005) and TEC values (CCME 2003) were also entered into the database. These values are derived in a similar way as the one for terrestrial plants described above.

Soil Community

Toxicity data on microbial function, C-CSCLs (Efroymson et al., 1997b), and TEC values were included in the database. The TECs were entered for use as chronic values affecting growth, reproduction, and mortality.

A methodology for deriving soil community criteria is based on a statistical approach for environmental quality criteria published by Dutch researchers. This methodology was presented at a national conference (SRA, 1996) and has been reviewed by the EPA Science Advisory Board as part of the 3MRA review. The resultant soil community criteria are 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.

This statistical approach consists 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 (Aldenberg & Slob, 1993; Sloof, 1992; Denneman & VanStraalen, 1991). For the soil community criteria, the 50^{th} percentile level of confidence was selected because the 95^{th} percentile appeared to be overly conservative for a no-effects approach based on comparisons with background concentrations. Equation 4 illustrates this approach to calculating soil community criteria.

Equation 4: $SOIL = [x_m - k_l s_m]$

where SOIL = soil concentration protecting 95 percent of the soil species at a 50^{th} percentile confidence limit
- 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 50^{th} and 95^{th} 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., 50^{th} or 95^{th}).

5.0 Summary of TMs Availability

Data were compiled as described in the previous sections for 32 hazardous air pollutants (HAPs). These data have been collected in different years from 1995 through 2005, with an emphasis on secondary sources of data in 2005. Table 4 presents the overall data availability for each combination of chemical/exposure measures/receptor group. Suitable data were not identified for Benzo(e)pyrene and Benzo(j)fluoranthene from the sources of information that were reviewed.

Table 4. Toxicity Metrics Availability in the TRIM Ecotox Database

CAS	Chemical_Name	Oral Dose		Soil			Water					Sediment
		Bird	Mammal	Soil Community	Soil Invertebrates	Terrestrial Plant	Aquatic Community	Aquatic Invertebrate	Aquatic Plant	Fish	Amphibian	Sediment Community
208-96-8	Acenaphthylene											X
83-29-9	Acenapthene					X	X			X		X
120-12-7	Anthracene						X					X
56-55-3	Benzo(a)anthracene			X	X	X	X					X
50-32-8	Benzo(a)Pyrene		X	X	X	X	X	X		X		X
205-99-2	Benzo(b)fluoranthene			X	X	X						
192-97-2	Benzo(e)pyrene											
191-24-2	Benzo(g,h,i)perylene											X
205-82-3	Benzo(j)fluoranthene											
207-08-9	Benzo(k)fluoranthene			X	X	X						
7440-43-9	Cadmium	X	X	X	X	X	X		X		X	X
57-74-9	Chlordane	X	X				X	X		X		X
218-01-9	Chrysene											X

CAS	Chemical_Name	Oral Dose		Soil			Water					Sediment
		Bird	Mammal	Soil Community	Soil Invertebrates	Terrestrial Plant	Aquatic Community	Aquatic Invertebrate	Aquatic Plant	Fish	Amphibian	Sediment Community
4/4/3547	DDE	X								X		X
53-70-3	Dibenz(a,h)anthracene			X	X	X						X
132-64-9	Dibenzofurans						X					X
HG_CMPDS	Divalent mercury	X	X	X	X	X						X
HG_TOTAL	Total mercury	X	X	X			X					X
7439-97-6	Elemental mercury						X					
206-44-0	Fluoranthene						X					X
86-73-7	Fluorene						X					X
76-44-8	Heptachlor		X				X		X	X	X	X
118-74-1	Hexachlorobenzene	X	X	X	X	X				X		X
193-39-5	Indeno(1,2,3-c,d)pyrene			X	X	X						X
7439-92-1	Lead	X	X	X	X	X	X		X	X	X	X
72-43-5	Methoxychlor		X				X			X		X
22967-92-6	MethylMercury	X	X				X	X	X	X	X	
85-01-8	Phenanthrene			X	X	X	X					X
1336-36-3	Polychlorinated biphenyls (Aroclors)	X	X	X	X	X	X	X	X	X		X

CAS	Chemical_Name	Oral Dose		Soil			Water					Sediment
		Bird	Mammal	Soil Community	Soil Invertebrates	Terrestrial Plant	Aquatic Community	Aquatic Invertebrate	Aquatic Plant	Fish	Amphibian	Sediment Community
1290-00-0	Pyrene			X	X	X	X					X
1746-01-6	Tetrachlorodibenzo-p-dioxin, 2,3,7,8-	X	X							X		X
8001-35-2	Toxaphene (chlorinated camphene)	X	X				X				X	X
1582-09-8	Trifluralin						X		X	X	X	X

References

Aldenberg T. and W. Slob. 1993. Confidence limits for hazardous concentrations based on logistically distributed NOEC toxicity data. *Ecotoxicology and Environmental Safety*, 25:48-61.

BTAG (U.S. EPA Region 9 Biological Technical Assistance Group). 2002. *Currently Recommended BTAG Mammalian and Avian Toxicity Reference Values (TRVs)*. Website at http://www.dtsc.ca.gov/ScienceTechnology/eco.html#EcoNOTE5

California OEHHA (Office of Environmental Health Hazard Assessment). 2003. *Cal/Ecotox Database*. Website at http://www.oehha.org/cal_ecotox/default.htm

CCME (Canadian Council of Ministries of the Environment). 2003. Update. *Canadian Environmental Quality Guidelines*. Science Policy and Environmental Quality Branch, Ecosystem Science Directorate, Environment Canada, Ottawa, Ontario. Website at http://www.ec.gc.ca/ceqg-rcqe/English/ceqg/default.cfm

Denneman, C. A. J., and N. M. van Straalen. 1991. The toxicity of lead and copper in reproduction tests using the oribatid mite *Platynothrus peltifer*. *Pedobiologia,* 35:305-311.

Devillers, J., and J.M. Exbrayat (eds). 1992. *Ecotoxicity of Chemicals to Amphibians*. Gordon and Breach Science, Philadelphia, PA.

Di Toro, D.M, 1985. *A Particle Interaction Model of Reversible Organic Chemical Sorption*. Chemosphere 14(10), 1503-38.

Efroymson, R.A., M.E. Will, G.W. Suter, and A.C. Wooten. 1997a. *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision.* ES/ER/TM-85/R3. Oak Ridge National Laboratory, Oak Ridge, TN.

Efroymson, R.A., M.E. Will, and G.W. Suter. 1997b. *Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision.* ES/ER/TM-126/R2. Oak Ridge National Laboratory, Oak Ridge, TN.

Eisler, R. 1989. *Pentachlorophenol Hazards to Fish, Wildlife, and Invertebrates. A Synoptic Review.* Biological Report 85(1.17). U.S. Fish and Wildlife Service, U.S. Department of the Interior, Washington, DC.

EPIWIN (v3.10). Available on-line at http://www.epa.gov/opptintr/exposure/docs/episuite.htm

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.* ES/ER/TM-95/R4. Oak Ridge National Laboratory, Oak Ridge, TN.

MacDonald, D.D. 1994. *Approach to the Assessment of Sediment Quality in Florida Coastal Waters. Volume 1: Development and Evaluation of Sediment Quality Assessment Guidelines*. Report prepared for Florida Department of Environmental Protection, Tallahassee, FL.

Mineau, P., B.T. Collins, and A. Baril. 1996. On the use of scaling factors to improve interspecies extrapolation of acute toxicity in birds. *Regul. Toxicol. and Pharmacol.* 24:24-29.

NLM (National Library of Medicine). 2002. Toxicology Data Network (TOXNET) Hazardous Substances Data Bank (HSDB). Website at http://toxnet.nlm.nih.gov.

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, Environment Canada, Hull, Quebec.

Sample, B.E., M.S. Aplin, R.A. Efroymson, G.W. Suter, II, and C.J.E. Welsh. 1997. *Methods and Tools for Estimation of the Exposure of Terresrial Wildlife to Contaminants*. ORNL/TM 13391. Oak Ridge National Laboratory, Oak Ridge, TN.

Sample, B.E., D.M. Opresko, and G.W. Suter, II. 1996. *Toxicological Benchmarks for Wildlife: 1996 Revision*. ES/ER/TM-86/R3. Oak Ridge National Laboratory, Oak Ridge, TN.

Sloof, W. 1992. *Ecotoxicological Effect Assessment: Deriving Maximum Tolerable Concentrations (MTC) from Single Species Toxicity Data*. Guidance Document. Report No. 719102.018. National Institute of Public Health and Environmental Protection (RIVM), Hilversum, the Netherlands.

Smith, S.L., D.D. MacDonald, K.A. Keenleyside, C.G. Ingersoll, and L.J. Field. 1996. A preliminary evaluation of sediment quality assessment values for freshwater ecosystems. *J. Great Lakes Res*. 22(3):624-638.

Stephan, C.E., D.I. Mount, D.J. Hansen, J.H. Gentile, G.A. Chapman, and W.A. Brungs. 1985. *Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses.* PB85-227049. National Technical Information Service, Springfield, VA.

Suter, G.W. II, and C.L. Tsao. 1996. *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision*. ES/ER/TM-96/R2. Prepared for the U.S. Department of Energy, Washington, DC.

U.S.EPA (Environmental Protection Agency). 2005. *Ecological Soil Screening Levels*. Office of Solid Waste and Emergency Response, Washington, DC. March. Website at http://www.epa.gov/ecotox/ecossl/

U.S.EPA (Environmental Protection Agency). 2004. Update. *National Recommended Water Quality Criteria*. Office of Science and Technology, Office of Water. EPA-822-R-02-047. Website at http://www.epa.gov/waterscience/criteria/wqcriteria.html

U.S. EPA (Environmental Protection Agency), 2003a. Multimedia, Multipathway, and Multireceptor Risk Assessment (3MRA) Modeling System Volume II: Site-based, Regional, and National Data (SAB Review Draft). Offices of Solid Waste and Research and Development.

U.S. EPA (Environmental Protection Agency), 2003b. Technical Background Document for the Sewage Sludge Screening Analysis (Draft). Office of Water. September

U.S. EPA (Environmental Protection Agency). 2002. ECOTOX User Guide: ECOTOXicology Database System. Version 3.0. Available: http:/www.epa.gov/ecotox/

U.S. EPA (Environmental Protection Agency), 2001. Screening Ecological Risk Assessment Inputs and Calculations. Appendix R in the Risk Assessment Technical Background Document for the Paint and Coatings Hazardous Waste Listing Determination. Office of Solid Waste: Washington, DC.

U.S. EPA, 2001. Residual Risk Assessment for the Coke Ovens Source Category. Office of Air Quality Planning and Standards: Research Triangle Park, NC.

U.S. EPA (Environmental Protection Agency), 1999a. Ecotoxicological Profile for Ecological Receptors. Appendix J in Human Health and Ecological Risk Assessment Support to the Development of Technical Standards for Emission from Combustion Units Burning Hazardous Wastes, Background Document. Office of Solid Waste: Washington, DC.

U.S. EPA (Environmental Protection Agency), 1999b. Ranking of Hazardous Air Pollutants for Residual Risk Assessment (Draft). Office of Air Quality Planning and Standards: Research Triangle Park, NC.

U.S. EPA (Environmental Protection Agency), 1999c. Screening Ecological Assessment of Chlorinated Aliphatics Waste Management Scenarios. Appendix J in the Risk Assessment Technical Background Document for the Chlorinated Aliphatics Listing Determination. Office of Solid Waste: Washington, DC

U.S. EPA (Environmental Protection Agency), 1998. Ecotoxicological Profiles for Constituents of Concern. Appendix I in Non-groundwater Pathways, Human Health and Ecological Risk Analysis of Fossil Fuel Combustion Phase 2 (FFC2) (Draft Final Report). Office of Solid Waste: Washington, DC.

U.S. EPA (Environmental Protection Agency). 1996. *Amphibian Toxicity Data for Water Quality Criteria Chemicals*. EPA/600/R-96/124. National Health and Environmental Effects Research Laboratory, Corvallis, OR.

U.S. EPA (Environmental Protection Agency). 1995a. *Great Lakes Water Quality Initiative*

Criteria Documents for the Protection of Wildlife. Office of Water.

U.S. EPA (Environmental Protection Agency). 1995b. *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). 1993a. *Technical Basis for Deriving Sediment Quality Criteria for Nonionic Organic Contaminants for the Protection of Benthic Organisms by Using Equilibrium Partitioning*. EPA-822-R-93-011. Office of Water, Washington, DC.

U.S. EPA (Environmental Protection Agency). 1993b. *Wildlife Exposure Factors Handbook. Volumes I and II.* EPA/600/R-93/187. U.S. Environmental Protection Agency, Office of Health and Environmental Assessment and Office of Research and Development, Washington, DC. December

U.S. FWS (Fish and Wildlife Service). Various years. *Contaminant Hazard Reviews*. U.S. Department of the Interior. Website at http://www.pwrc.usgs.gov/infobase/eisler/reviews.cfm

Appendix 1 - Data Sources

In developing the database, both the primary literature and widely reviewed secondary sources of data were used. Secondary sources of data primarily included reports 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]).

The key steps involved in developing/selecting suitable TMs consisted of (1) reviewing existing synopses, (2) searching toxicological databases, and (3) conducting online literature searches and reviews. It should be noted that this strategy was intended to take full advantage of existing data sources to provide a cost-effective solution to address data gaps in the ecotox database. The approaches and examples of data sources have been shown to be highly productive in characterizing ecotoxicological effects for receptors included in the database. However, the search and review of primary literature was relatively limited, and it is anticipated that this database will continue to evolve through the user community, as more obscure sources of data and recent studies are identified. Each of these steps is described briefly below.

1. Review Existing Synopses

In this step, major reports (other than the project reports listed above) on ecotoxicological effects for specific chemicals were considered. This step ensured that no obvious sources of effects data were missed and provided a road map for what information might be available. The U.S. Fish and Wildlife Service (FWS) synoptic reviews, EPA water quality criteria documents, and Eco-SSL reports are excellent examples of these reports. These reviews also serve as the foundation to understand environmental characteristics that mitigate (or enhance) toxicity.

2. Search Toxicological Databases

- The Hazardous Substance Database (HSDB) and the Registry of Toxic Effects of Chemical Substances (RTECS) were reviewed for toxicological information for animals. These databases were selected because (1) they include a wide variety of toxicity data, (2) they are readily available, and (3) they provide a rapid (if incomplete) picture of the chemical toxicology. Results from searching these databases are also useful in identifying primary references for the development of TMs for mammals and birds.

- EPA's ECOTOX database has become an essential reference for TMs 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 are available within ECOTOX covering different groups of ecological receptors: (1) TERRETOX for terrestrial wildlife, soil biota, and terrestrial life stages of amphibians, (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) and early life stages of amphibians.

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 1 and 2 as follows:

- The bibliographic database search begins with Toxline®/Medline® because they are relatively low-cost databases that specialize in toxicological citations.
- Based on the results of the primary search, it is sometimes necessary to reconsider the search strategy and submit a new search or to search more costly literature databases (e.g., royalty databases). For data-poor constituents, more general environmental databases such as Environline® or Pollution Abstracts are searched.

Following primary literature searches, the appropriate studies were identified for review.

A summary of the key documents and databases consulted to develop TMs is provided in Table A-1 and organized according to the relevant receptor taxon.

Table A-1. Summary of key sources of information consulted in developing TMs

Source	Contents
Mammals and Birds	
U.S. EPA (Environmental Protection Agency). 1995a. *Great Lakes Water Quality Initiative Criteria Documents for the Protection of Wildlife.* Office of Water.	This document provides mammals and birds dose TMs for exposures to DDT, 2,3,7,8-(TCDD), mercury, and polychlorinated biphenyls (PCBs). Exposure results from the intake of drinking water or prey taken from surface water containing those contaminants.
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. It presents dose TMs.
U.S. Environmental Protection Agency. 2002. *ECOTOX User Guide: ECOTOXicology Database System.* Version 3.0.	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.	These profiles review chemical-specific toxicity to various ecological receptors. They also expand discussions to assess issues of bioaccumulation and biochemical effects.
U.S.EPA (Environmental Protection Agency). 2005. *Ecological Soil Screening Levels*. Office of Solid Waste and Emergency Response, Washington, DC. March.	Ecological Soil Screening Levels (Eco-SSLs) are concentrations of contaminants in soil that are protective of ecological receptors that commonly come into contact with soil or ingest biota that live in or on soil. TMs and subsequently Eco-SSLs are derived for birds and mammals.
BTAG (U.S. EPA Region 9 Biological Technical Assistance Group). 2002. *Currently Recommended BTAG Mammalian and Avian Toxicity Reference Values (TRVs)*.	This document presents currently recommended U.S. EPA Region 9 BTAG Mammalian and Avian Toxicity Reference Values (TRVs) derived from no/adverse effect levels.
California OEHHA (Office of Environmental Health Hazard Assessment). 2003. *Cal/Ecotox Database*.	It presents dose-response data for 20 different species of mammals and birds including mortality and reproductive effects.
Terrestrial Plants	

Source	Contents
Efroymson, R.A., M.E. Will, G.W. Suter, II, and A.C. Wooten. 1997a. *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. Environmental Protection Agency. 2002. *ECOTOX User Guide: ECOTOXicology Database System*. Version 3.0.	The PHYTOTOX database is the ECOTOX terrestrial plant database that includes lethal and sublethal toxic effects data.
U.S.EPA (Environmental Protection Agency). 2005. *Ecological Soil Screening Levels.* Office of Solid Waste and Emergency Response, Washington, DC. March.	Ecological Soil Screening Levels (Eco-SSLs) are concentrations of contaminants in soil that are protective of ecological receptors that commonly come into contact with soil or ingest biota that live in or on soil. Eco-SSLs are derived for terrestrial plants.
Soil Community and Earthworms	
Efroymson, R.A., M.E. Will, and G.W. Suter, II. 1997b. *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 organisms and earthworms). Approximately 35 constituents have proposed soil criteria, and some field studies are included.
CCME (Canadian Council of Ministries of the Environment). 2003. Update. *Canadian Environmental Quality Guidelines*. Science Policy and Environmental Quality Branch, Ecosystem Science Directorate, Environment Canada, Ottawa, Ontario.	The soil criteria developed by the CCME are concentrations above which effects are likely to be observed.
U.S. Environmental Protection Agency. 2002. *ECOTOX User Guide: ECOTOXicology Database System.* Version 3.0.	The TERRETOX database was developed at WED-Corvallis in the early 1980s and is currently maintained at MED-Duluth. Initial funding for TERRETOX came from the U.S. EPA's Office of Toxic Substances. Data are available from the publication years 1969 through 2001.
U.S.EPA (Environmental Protection Agency). 2005. *Ecological Soil Screening Levels*. Office of Solid Waste and Emergency Response, Washington, DC. March.	Ecological Soil Screening Levels (Eco-SSLs) are concentrations of contaminants in soil that are protective of ecological receptors that commonly come into contact with soil or ingest biota that live in or on soil. Eco-SSLs are derived for soil invertebrates.

Amphibians	
Power, T., K.L. Clark, A. Harfenist, and D.B. Peakall. 1989. *A Review and Evaluation of the Amphibian Toxicological Literature.* Technical Report Series No. 61, Canadian Wildlife Service.	This reference was developed by Environment Canada to review the ecotoxicity literature so that risks to amphibian populations could be evaluated.
U.S. EPA (Environmental Protection Agency). 1996. *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 document provides test study data that considers reproduction and survival endpoints.
California OEHHA (Office of Environmental Health Hazard Assessment). 2003. *Cal/Ecotox Database*.	It presents dose-response data for nine different species of amphibians including mortality and reproductive effects.
Aquatic community and Fish	
U.S. Environmental Protection Agency. 2002. *ECOTOX User Guide: ECOTOXicology Database System.* Version 3.0.	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).
U.S. EPA (Environmental Protection Agency). 2004. Update. *National Recommended Water Quality Criteria*. Office of Science and Technology, Office of Water.	This document presents the 2004 National Ambient Water Quality Criteria.

U.S. EPA (Environmental Protection Agency). 1995b. *Great Lakes Water Quality Initiative Criteria Documents for the Protection of Aquatic Life in Ambient Water*. Office of Water.	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.
CCME (Canadian Council of Ministries of the Environment). 2003. Update. *Canadian Environmental Quality Guidelines*. Science Policy and Environmental Quality Branch, Ecosystem Science Directorate, Environment Canada, Ottawa, Ontario.	The water criteria developed by the CCME are concentrations above which effects are likely to be observed.
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. Environmental Protection Agency. 2002. *ECOTOX User Guide: ECOTOXicology Database System.* Version 3.0.	The AQUIRE database contains more than 145,000 toxicity tests for more than 5,900 organic and inorganic chemicals and 2,900 aquatic species.
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.

CCME (Canadian Council of Ministries of the Environment). 2003. Update. *Canadian Environmental Quality Guidelines*. Science Policy and Environmental Quality Branch, Ecosystem Science Directorate, Environment Canada, Ottawa, Ontario.	The sediment criteria developed by the CCME are concentrations above which effects are likely to be observed.
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.