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Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota:
1996 Revision

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Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision

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PREFACE

The purpose of this report is to present and analyze alternate toxicological benchmarks for screening chemicals for aquatic ecological effects. This work was performed under Work Breakdown Structure 1.4.12.2.3.04.05.04 (Activity Data Sheet 8304, "Technical Integration—Risk Assessment"). Publication of this document meets a milestone for the Environmental Restoration (ER) Risk Assessment Program. Since the prior edition of this report (Suter and Mabrey 1994), both the U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response and EPA Region IV have developed sets of screening benchmarks for water. This report includes those values and updates the other benchmarks that were presented in the last edition.

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TABLES

ACRONYMS

ACRs	acute chronic ratios
ARARs	applicable or relevant and appropriate requirements
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CV	Chronic Value
EC50	median effective concentration
EPA	U.S. Environmental Protection Agency
ETs	Ecotox Thresholds
FACR	Final Acute-Chronic Ratio
FAV	Final Acute Value
FCV	final chronic value
GLWQI	Great Lakes Water Quality Initiative
GMAV	genus mean acute value
LC50	median lethal concentration
LOEC	Lowest Observed Effect Co
MATC	Maximum Acceptable Toxicant Concentration
NAWQC	National Ambient Water Quality Criteria
NOEC	No Observed Effect Concentration
OSWER	Office of Solid Waste and Emergency Response
RI	Remedial Investigation
SACR	secondary acute chronic ratio
SAV	Secondary Acute Values
SCV	Secondary Chronic Value
SS	sensitive species
SVs	screening values

EXECUTIVE SUMMARY

One of the initial stages in ecological risk assessment of hazardous waste sites is the screening of contaminants to determine which, if any, of them are worthy of further consideration; this process is termed contaminant screening. Screening is performed by comparing concentrations in ambient media to benchmark concentrations that are either indicative of a high likelihood of significant effects (upper screening benchmarks) or of a very low likelihood of significant effects (lower screening benchmarks). Exceedance of an upper screening benchmark indicates that the chemical in question is clearly of concern and remedial actions are likely to be needed. Exceedance of a lower screening benchmark indicates that a contaminant is of concern unless other information indicates that the data are unreliable or the comparison is inappropriate. Chemicals with concentrations below the lower benchmark are not of concern if the ambient data are judged to be adequate.

This report presents potential screening benchmarks for protection of aquatic life from contaminants in water. Because there is no guidance for screening benchmarks, a set of alternative benchmarks is presented herein. The alternative benchmarks are based on different conceptual approaches to estimating concentrations causing significant effects. For the upper screening benchmark, there are the acute National Ambient Water Quality Criteria (NAWQC) and the Secondary Acute Values (SAV). The SAV concentrations are values estimated with 80% confidence not to exceed the unknown acute NAWQC for those chemicals with no NAWQC. The alternative chronic benchmarks are the chronic NAWQC, the Secondary Chronic Value (SCV), the lowest chronic values for fish and daphnids, the lowest EC20 for fish and daphnids from chronic toxicity tests, the estimated EC20 for a sensitive species, and the concentration estimated to cause a 20% reduction in the recruit abundance of largemouth bass. It is recommended that ambient chemical concentrations be compared to all of these benchmarks. If NAWQC are exceeded, the chemicals must be contaminants of concern because the NAWQC are applicable or relevant and appropriate requirements (ARARs). If NAWQC are not exceeded, but other benchmarks are, contaminants should be selected on the basis of the number of benchmarks exceeded and the conservatism of the particular benchmark values, as discussed in the text.

To the extent that toxicity data are available, this report presents the alternative benchmarks for chemicals that have been detected on the Oak Ridge Reservation. It also presents the data used to calculate the benchmarks and the sources of the data. It compares the benchmarks and discusses their relative conservatism and utility.

This report supersedes a prior aquatic benchmarks report (Suter and Mabrey 1994). It adds two new types of benchmarks. It also updates the benchmark values where appropriate, adds some new benchmark values, replaces secondary sources with primary sources, and provides more complete documentation of the sources and derivation of all values.

1. INTRODUCTION

An important early step in the assessment of ecological risks posed by a contaminated site is the screening of contaminants. In many cases, concentrations in water will be reported for more than 100 chemicals, most of which will be reported as undetected at some defined limit of detection. The assessor must decide which of the detected chemicals constitute an ecological hazard and which of the undetected chemicals may pose a hazard at concentrations below the reported detection limits. This screening is done by comparing the reported concentrations to toxicological benchmarks. If concentrations of a chemical exceed its benchmark for a particular medium, then it is worthy of further measurement and assessment. If not, it can be ignored (assuming that the analytical data are adequate).

In practice, a series of benchmarks of differing conservatism may be used. Exceedance of an upper screening benchmark would suggest a severe hazard and a need for urgent action. Nonexceedance of all lower screening benchmarks would suggest no hazard. Exceedance of an increasing number of benchmarks would constitute increasing evidence of the need for measurement and assessment. In addition to providing a better indication of the magnitude of the hazard, the use of multiple benchmarks provides information about the nature of the hazard which can be used in development of the conceptual model and in planning the Remedial Investigation (RI). For example, is the chemical at concentrations that are toxic to only daphnids, to daphnids and fish, to fish and aquatic plants, etc.? Are they at concentrations that have been demonstrated to be toxic or do they exceed only benchmarks that include conservative factors?

The purpose of this report is to present and analyze alternate toxicological benchmarks for screening chemicals for aquatic ecological effects. Since the prior edition of this report (Suter and Mabrey 1994), both the U.S. Environmental Protection Agency (EPA) Office of Solid Waste and Emergency Response (OSWER) and EPA Region IV have developed sets of screening benchmarks for water. This report includes those values and updates the other benchmarks that were presented in the last edition.

This compilation is limited to chemicals that have been detected on the Oak Ridge Reservation and to benchmarks derived from studies of toxic effects on fresh water organisms. The list of chemicals detected on the Oak Ridge Reservation includes 45 metals and 105 industrial chemicals. Only four pesticides occur on the list, and those are persistent and wide-spread (chlordane, DDT, heptachlor, and lindane).

2. METHODS FOR DERIVING BENCHMARKS

2.1 TYPES OF BENCHMARKS

The simplest screening benchmarks are toxicity test endpoints. A test endpoint is a statistically derived numeric summary of the results of a toxicity test. Test endpoints can be calculated in two ways. First, a level of effect can be estimated by fitting a function such as the probit or logit to the concentration-response data to derive a concentration-response model. Then by inverse regression, a concentration can be estimated that causes a particular level of effect such as the median lethal concentration (LC50). Second, hypothesis testing statistics can be used to determine whether each of the tested concentrations caused an effect that was statistically significantly different from the controls. The lowest concentration causing such an effect is termed the Lowest Observed Effect Concentration

(LOEC); the highest concentration for which there were no such effects is termed the No Observed Effect Concentration (NOEC). The geometric mean of the LOEC and NOEC is te rmed the Chronic Value (CV) and was formerly termed the Maximum Acceptable Toxicant Concentration (MATC).

Toxicity tests are conventionally divided into acute and chronic tests. Standard acute aquati c toxicity tests are 48 or 96 hours in duration and use juvenile or adult organisms; the test endpoints are the median lethal concentration (LC50) or median effective concentration (EC50) for death or som e equivalent effect (e.g., immobilization). Standard chronic tests include all or most of the lifecycle of the test organisms, and they include observations of growth, deformities, and reproductive success as well as lethality. The standard endpoint for chronic tests is the CV.

Another important distinction is between response-specific and integrative endpoints. Conventionally, NOECs and LOECs are calculated for each response parameter, and the results for the most statistically sensitive parameter are reported. Because effects on populations and ecosystems are a result of the integrated effects of the toxicant on all life stages, it is more sensible to integrate th e responses in the test when calculating the test endpoint. Integrative endpoints may be simple arithmetic combinations of effects such as the proportional mortality across all tested life stages or populatio n parameters derived from simple models such as the intrinsic rate of natural increase, *r*.

Benchmarks may be combinations of multiple test en dpoints. An example is the chronic NAWQC, which are derived from at least eight LC50s and three CVs.

Finally, benchmarks may be derived by using mathematical models to simulate an assessmen t endpoint, a specific environmental characteristic that is valued and is at risk due to the contamination or disturbance that is being assessed (Suter 1989). For example, in this study we present concentrations estimated to correspond to a 20% reduction in recruit abundance for largemouth bass (*Micropterus salmoides*) because production of fish, particularly game fish, is an assessment endpoint for Oak Ridge Reservation ecological risk assessments (Suter et al. 1992).

Conventional aquatic benchmarks, which are based o n regulatory criteria or standard test endpoints used to derive criteria, are listed in Table 1. Unconventional aquatic benchmarks, which are based on levels of effects on integrative endpoints, are listed in Table 2.

2.2 WATER QUALITY CRITERIA

The National Ambient Water Quality Criteria (NAWQC) are appl icable or relevant and appropriate requirements (ARARs); therefore, they provide the basis for the screening benchmarks for contaminants in water. The acute NAWQC are calculated by the EPA as half the Final Acute Value (FAV), which is the fifth percentile of the distribution of 48- to 96-hour LC50 values or equivalent median effectiv e concentration (EC50) values for each criterion chemical (Stephan et al. 1985). The acute NAWQC are intended to correspond to concentrations that would cause less than 50% mortality in 5% of expose d populations in a brief exposure. They may be used as a reasonable upper screening benchmark because waste site assessments are concerned with sublethal effects and largely with continuous exposures, rather than the lethal effects and episodic exposures to which the acute NAWQC are applied. The chroni c NAWQC are the FAVs divided by the Final Acute- Chronic Ratio (FACR), which is the geometric mean of quotients of at least three LC50/CV

Table 1. Summary of conventional benchmarks for priority contaminants in fresh water (all values in micrograms per liter)

Chemical	NAWQ Criteria		Tier II Values		Lowest Chronic Value for:				
	Acute	Chronic	Secondary Acute Value	Secondary Chronic Value	Fish	Daphnids	Non-Daphnid Invertebrates	Aquatic Plants	All Organisms
Aluminum	750	87			3,288	1,900		460	460
Ammonia	pH and temperature dependent				1.7	630		2,400	1.7
Antimony			180[f]	30[f]	1,600	5,400		610	610
Arsenic III	360	190			2,962	914.1		2,320	914.1
Arsenic V			66	3.1	892	*450		48	48
Barium			110	4.0					
Beryllium			35	0.66	*57	5.3		100,000	5.3
Boron			30	1.6		8,830			8,830
Cadmium	3.9+	1.1+			1.7	0.15		2	0.15
Calcium						116,000			116,000
Chromium III	1,700+	210+			68.63	<44		397	<44
Chromium VI	16	11			73.18	6.132		2	2
Cobalt			1500	23	290	5.1			5.1
Copper	18+	12+			3.8	0.23	6.066	1	0.23
Cyanide	22	5.2			7.8		18.33	30	7.8
Iron		1,000			1,300	158			158
Lead	82+	3.2+			18.88	12.26	25.46	500	12.26
Lithium			260	14					
Magnesium						82,000			82,000
Manganese			2,300	120	1780	<1,100			<1,100
Mercury, inorganic or total	2.4			1.30[f]	<0.23	0.96		5	<0.23
Mercury, methyl			0.099	0.0028	0.52	<0.04		0.8-40	<0.04
Molybdenum			16,000	370		880			880

Table 1. (continued)

Chemical	NAWQ Criteria		Tier II Values		Lowest Chronic Value for:				
	Acute	Chronic	Secondary Acute Value	Secondary Chronic Value	Fish	Daphnids	Non-Daphnid Invertebrates	Aquatic Plants	All Organisms
Nickel	1,400+	160+			<35	<5	128.4	5	<5
Potassium						53,000			53,000
Selenium	20	5			88.32	91.65		100	88.32
Silver	4.1+			0.36	0.12	2.6		30	0.12
Sodium						680,000			680,000
Strontium			15,000	1,500		42,000			42,000
Thallium			110	12	57	130		100	57
Tin			2,700	73		350			350
Uranium			46	2.6	*142				*142
Vanadium			280	20	80	1,900			80
Zinc	120+	110+			36.41	46.73	>5,243	30	30
Zirconium			310	17	*548				*548
Organics									
Acenaphthene	80*	23*			74	*6,646	227	520	74
Acetone			28,000	1,500	*507,640	1,560			*507,640
Anthracene			13	0.73	*0.09	<2.1			*0.09
Benzene			2,300	130		>98,000		525,000	525,000
Benzidene			70	3.9	*134				*134
Benzo(a)anthracene			0.49	0.027		*0.65			*0.65
Benzo(a)pyrene			0.24	0.014		*0.30			*0.30
Benzoic acid			740	42	*12,976				*12,976
Benzyl alcohol			150	8.6	*589				*589
BHC (lindane)	2	0.08			14.6	14.5	3.3	500	3.3

Table 1. (continued)

Chemical	NAWQ Criteria		Tier II Values		Lowest Chronic Value for:				
	Acute	Chronic	Secondary Acute Value	Secondary Chronic Value	Fish	Daphnids	Non-Daphnid Invertebrates	Aquatic Plants	All Organisms
BHC (other)			39	2.2		*95			*95
Biphenyl				14[f]					
Bis(2-ethylhexyl)phthalate			27	3.0		912			912
4-Bromophenyl phenyl ether				1.5[f]					
Butylbenzyl phthalate				19[f]					
2-Butanone			240,000	14,000	*282,170	*1,394,927			*282,170
Carbon disulfide			17	0.92	*9,538	*244			*244
Carbon tetrachloride			180	9.8	1,970	*5,580			1,970
Chlordane	2.4	0.17[a]			1.6	16	1.09		1.09
Chlorobenzene			1,100	64	*1,203	*15,042		224,000	*1203
Chloroform			490	28	1,240	*4,483			1,240
DDD p,p'			0.19	0.011	*1.69				*1.69
DDT	1.1			0.013[a,c]	0.73[c]	*0.016		0.3	0.3
Decane			880	49		*7,874			*7,874
Di-n-butyl phthalate			190	35	717[e]	697			697
Diazinon			0.17[a]	0.043[a]					
Dibenzofuran			66	3.7		*1,003			*1,003
1,2-Dichlorobenzene			260[f]	14[f]					
1,3-Dichlorobenzene			630[f]	71[f]					
1,4-Dichlorobenzene			18[f]	15[f]					
1,1-Dichloroethane			830	47	*14,680				*14,680
1,2-Dichloroethane			8,800	910	41,364	15,200			15,200
1,1-Dichloroethene			450	25	>2,800	*4,720		>798,000	>2,800

Table 1. (continued)

Chemical	NAWQ Criteria Acute	NAWQ Criteria Chronic	Tier II Values Secondary Acute Value	Tier II Values Secondary Chronic Value	Lowest Chronic Value for: Fish	Daphnids	Non-Daphnid Invertebrates	Aquatic Plants	All Organisms
1,2-Dichloroethene			1,100	590	*9,538				*9,538
1,3-Dichloropropene			0.99	0.055	244	*805		4,950	244
Dieldrin	0.18[e]	0.062[e]							
Diethyl phthalate			1,800	210				85,600	85,600
Di-n-octyl phthalate					3,822	708			708
Endosulfan, all isomers				0.051[f]					
Endrin	0.095[e]	0.061[e]							
Ethyl benzene			130	7.3	>440	*12,922		>438,000	>440
Fluoranthene	33.6[e]	6.16[e]			30	15		54400	15
Fluorene			70[f]	3.9[f]					
Heptachlor			0.129[f,g]	0.0069[f,g]	1.26	*3.18		26.7	1.26
Hexachloroethane			210[f]	12[f]					
Hexane			10	0.58	*65,712				*65,712
2-Hexanone			1,800	99	*32,783				*32,783
Methoxychlor				0.019[f]					
1-Methylnaphthalene			37	2.1	*526				*526
4-Methyl-2-pentanone			2,200	170	77,400				77,400
2-Methylphenol			230	13	*489	*1,316			*489
Methylene chloride			26,000	2,200	108,000	*42,667			*42,667
Naphthalene			190	12	620	*1,163		33,000	620
4-Nitrophenol			1,200	300	*481	7,100		4190	*481
N-Nitrosodiphenylamine			3,800	210	*332	*1,042			*332
2-Octanone			150	8.3					

Table 1. (continued)

Chemical	NAWQ Criteria: Acute	NAWQ Criteria: Chronic	Tier II Values: Secondary Acute Value	Tier II Values: Secondary Chronic Value	Lowest Chronic Value for: Fish	Lowest Chronic Value for: Daphnids	Lowest Chronic Value for: Non-Daphnid Invertebrates	Lowest Chronic Value for: Aquatic Plants	Lowest Chronic Value for: All Organisms
PCBs total	2.0			0.14[h]	0.2	2.1	0.8	0.144	0.1
Aroclor® 1221			5.0	0.28	*60				*60
Aroclor® 1232			10	0.58	*124			--	*124
Aroclor® 1242			1.2	0.053	9.00		4.9	300	4.9
Aroclor® 1248			1.4	0.081				—	
Aroclor® 1254			0.60	0.033		2.9		0.1	0.1
Aroclor® 1260			1,700	94	<1.3			—	2.3
Pentachlorobenzene			8.4[f]	0.47[f]					
1-Pentanol			2,000	110	*30,493				*30,493
Phenanthrene	30[e]	6.3[e]				200			200
Phenol	3,600[f]	110[f]			<200	*2,005		20,000	<200
2-Propanol			130	7.5	*590				*590
1,1,2,2 Tetrachloroethane			2,100	610	2,400	9,900		136,000	2,400
Tetrachloroethene			830	98	840	750		>816,000	750
Tetrachloromethane			4,400[f]	240[f]					
Toluene			120	9.8	*1,269	*25,229		245,000	*1,269
Tribromomethane			2,300[f]	320[f]					
1,2,4-Trichlorobenzene			700[f]	110[f]					
1,1,1-Trichloroethane			200	11	*3,493			>669,000	*3,433
1,1,2-Trichloroethane			5,200	1,200	9,400	18,400			9,400
Trichloroethene			440	47	11,100	*7,257			*7,257
Vinyl acetate			280	16	*810				*810
Xylene			230	13	*62,308				*62,308
m-Xylene			32[f]	1.8[f]					

Table 1. (continued)

Notes:

+ Hardness dependent criterion normalized to 100 mg L

* Numbers preceded by * are estimates. Methods of estimation are described in the text.

[a] The chronic NAWQC for chlordane (0.0043 μg L) and mercury (0.012 μg L), are based on the final residue values. FCVs are used as benchmarks to protect aquatic life.

[b] The chronic NAWQC for DDT (0.001 μg L), total PCBs (0.014 μg L), and heptachlor (0.0038 μg l) are is based on the final residue values; for benchmarks to protect aquatic life, we use SCVs.

[c] The CV for DDT in Jarvinen et al. 1977 of 0.9 μg l is the arithmetic mean of the NOEC and LOEC. We used the geometric mean which is 0.73.

[d] For fish di-n-butyl phthalate lowest CV, the geometric mean of the measured concentrations for the NOEC and LOEC rather than the nominal concentrations used by the authors (McCarthy and Whitmore 1985) was used herein.

[e] These numbers are Final Acute Values and Final Chronic Values calculated by the EPA for use in the derivation of sediment quality criteria (EPA 1993b).

[f] Values calculated for OSWER (1996).

[g] Values calculated by the Great Lakes Water Quality Initiative (EPA 1993d).

[h] SAV was calculated by the Great Lakes Water Quality Initiative because some data used to derive FAV were questionable (EPA 1992)

[i] These values are draft FAV and FCV values (EPA 1988b).

Table 2. Summary of alternative benchmarks for priority contaminants in fresh water based on levels of chronic effects (all values in micrograms per liter)

Chemical	Lowest Test EC_{20} for:		Sensitive Species Test EC_{20}	Population EC_{20}
	Fish	Daphnids		
Aluminum	4,700	540	75	
Antimony	2,310	1,900		79
Arsenic III	2,130	633	55	1,995
Arsenic V	1,500	>932		185
Barium				
Beryllium	*148	3.8		21
Boron		7,000		
Cadmium	1.8	0.75	0.013*	4.3
Calcium				
Chromium III	89		8.44	126
Chromium VI	51	0.5	0.266	316
Cobalt	810	<4.4		3.98
Copper	5	0.205	0.26	8.6
Cyanide	5.3		1.17	11
Fluorine	*5,336	3,706		1,080
Iron		16		
Lead	22		0.35	71
Magnesium				
Manganese	1,270	<1,100		112
Mercury, inorganic	0.87	0.87	0.18	0.32
Mercury, methyl	<0.03	0.87		0.28
Molybdenum		360		
Nickel	62	45	11*	215
Potassium				
Selenium	40	25	2.60	
Silver	0.20	<0.56	0.14*	0.32
Sodium				
Strontium				
Thallium	81	64		67

Table 2. (continued)

Chemical	Lowest Test EC_{20} for:		Sensitive Species Test EC_{20}	Population EC_{20}
	Fish	Daphnids		
Tin				
Uranium	*455			27
Vanadium	41	430		32
Zinc	47		21	80
Zirconium	*2,396			251
Organics				
Acenaphthene	<197			
Acetone	*161,867			23,714
Anthracene	*0.35	>8.2		
Benzene	21			229
Benzidene	*158			68
Benzo(a)anthracene				
Benzo(a)pyrene	>2.99			
Benzoic acid	*7,409			1,259
Benzyl alcohol	*550			375
BHC (lindane)	<1.1	11	0.11	
BHC (other)				
Bis(2-ethylhexyl)phthalate	>54	<3		50
2-Butanone	*98,772			17,783
Carbon disulfide	*5719			1,000
Carbon tetrachloride	65			224
Chlordane	<0.25	12.1	0.50	0.71
Chlorobenzene	1,002			165
Chloroethane				
Chloroform	8,400			562
DDD p,p'	*3.99			0.61
DDT	0.35		0.008	
Decane				

Table 2. (continued)

Chemical	Lowest Test EC_{20} for: Fish	Lowest Test EC_{20} for: Daphnids	Sensitive Species Test EC_{20}	Population EC_{20}
Di-n-butyl phthalate	270	500		251
Dibenzofuran				
1,1-Dichloroethane	*8,219			1,585
1,2-Dichloroethane	29,000	<11,000		1,259
1,1-Dichloroethene				447
1,2-Dichloroethenes	*5,719			
1,3-Dichloropropene	*350			40
Diethyl phthalate				1,000
Di-n-octyl phthalate	<100	310		1,995
Ethyl benzene				398
Fluoranthene				32
Heptachlor	0.86		0.004	0.1
Hexane	*28,995			
2-Hexanone	*16,155			1,259
1-Methylnaphthalene	*500			31.62
4-Methyl-2-pentanone				1,585
2-Methylphenol	*470			74
Methylene chloride	410			1,259
Naphthalene	450	>600		1,000
4-Nitrophenols	*464	5,000		60
N-Nitrosodiphenylamine	*339			40
3-Octanone	*3571			
PCBs total	0.4	1.2		0.63
Aroclor® 1221	*80			10
Aroclor® 1232	*148			16
Aroclor® 1242	<2.9			1.58
Aroclor® 1248	0.4	2.5		1.26
Aroclor® 1254	0.52	1.2		0.63
Aroclor® 1260	2.1			316
1-Pentanol	*15,200			3,548

Table 2. (continued)

Chemical	Lowest Test EC_{20} for:		Sensitive Species Test EC_{20}	Population EC_{20}
	Fish	Daphnids		
Phenanthrene		110		
Phenol	<230			4,467
2-Propanol	*35,381			3,162
1,1,2,2-Tetrachloroethane	1,400	<420		1,585
Tetrachloroethene	500	510		50
Toluene	<26			200
1,1,1-Trichloroethane	*2,457	1,300		251
1,1,2-Trichloroethane	14,800	13,000		15,849
Trichloroethene	5758			232
Vinyl acetate	*718			108
Xylene	2680			

Notes:
* Numbers preceded by * are estimates. Methods of estimation are described in the text.
* Study LC50's were used rather than species mean LC50s so water hardness would correspond to EC20 values.

ratios from tests of different families of aquatic organisms (Stephan et al. 1985). It is intended to prevent significant toxic effects in chronic exposures and is used in this assessment as one possible lower screening benchmark. The NAWQC are listed in Table 1.

NAWQC for several metals are functions of water hardness; the criteria are lower for lower hardness levels. The criteria for 100 mg/L hardness as reported by the EPA are presented in this report. That hardness is near the lower end of the range of hardness values reported for the Oak Ridge Reservation, so it is moderately conservative. For sites with different water hardnesses, site-specific criteria should be calculated. The formulas for hardness correction are listed in the discussions of individual chemicals.

Many readers will note that the EPA's compilations of NAWQC contain values for many chemicals that have no NAWQC listed herein (EPA 1986b); the EPA lists lowest CVs for those chemicals for which there is not enough data to calculate a criterion but for which there is at least one CV. Lowest CVs are treated as a separate category of benchmarks in this compilation.

Some chronic NAWQC are based on protection of humans or other piscivorous organisms rather than protection of aquatic organisms. Those criteria are not included herein because screening for risks to wildlife or humans is performed by other methods. However, if sufficient data were available to calculate a final chronic value (FCV) for those chemicals, then the FCV are presented in place of the chronic NAWQC in Table 1, and its derivation is noted.

For particular chemicals, the lower screening benchmark could be lower than the chronic NAWQC for any one of the following reasons. First, the chronic NAWQC are based on a threshold for statistical significance rather than biological significance. In some chronic tests, because of highly variable results, the statistical threshold corresponds to greater than 50% effect on a response parameter (Stephan and Rogers 1985, Suter et al. 1987). Second, not all important responses are included in the subchronic toxicity tests that are used to calculate many chronic NAWQC. In particular, effects on fecundity, which is the most sensitive response parameter on average in fish toxicity tests (Suter et al. 1987), are often not included. Third, the chronic NAWQC are based on the most statistically sensitive of the measured response parameters in each chronic or subchronic test. Therefore, cumulative effects over the lifecycle of fish and invertebrates are not considered. Fourth, the NAWQC are set at a level that protects "most species most of the time." Finally, many of the NAWQC have not been revised since 1980 so they do not incorporate recent data that are included in the calculation of other benchmarks. These concerns are supported by the recent finding that nickel concentrations (on the Oak Ridge Reservation) that are below chronic NAWQC are nonetheless toxic to daphnids (Kszos et al. 1992).

2.3 TIER II VALUES

If NAWQC were not available for a chemical, the Tier II method described in the EPA's *Proposed Water Quality Guidance for the Great Lakes System* was applied (EPA 1993a). Tier II values were developed so that aquatic benchmarks could be established with fewer data than are required for the NAWQC. The Tier II values are concentrations that would be expected to be higher than NAWQC in no more than 20% of cases. Tier II values calculated by the EPA are listed in Table 1, and the sources are cited. Other Tier II values are derived as described in the following text.

The Tier II values equivalent to the FAV and FCV are the Secondary Acute Values (SAVs) and Secondary Chronic Values (SCVs), respectively. The sources of data for the Tier II values are listed in Appendix A, and the procedure and factors used to calculate the SACs and SCVs are in Appendix B. The methods described herein differ from EPA's (1993a) in one respect. The Great Lakes SAVs require an LC50 for a daphnid, but that requirement would severely restrict the number of benchmarks that could be calculated. The EPA has provided factors for calculating SAVs when no daphnid LC50s are available, and these factors are used herein (Stephan 1991).

Some of the SAVs and SCVs presented in this report differ from those presented in the prior edition (Suter and Mabrey 1994) for three reasons. First, in the previous report we included all data that occurred in EPA water quality criteria documents. However, much of the data included in criteria documents issued prior to 1985 are no longer considered acceptable by the EPA. Second, some data from the EPA's AQUIRE data set were used by Suter and Mabrey (1994) that appeared to be acceptable based on the information provided in the data base and the EPA's rating of the data. It has become clear that much of that data would not be acceptable to the EPA for calculating criteria. Therefore, we obtained all original publications and independently reviewed them against the criteria in Stephan et al. (1985). Those criteria are summarized in Appendix B. Finally, some new data have been found and incorporated.

Only high quality standard data are used in this document if such values are available for a chemical. That is, if even one test that meets the criteria in Stephan et al (1985) was found, all nonconforming tests were excluded. However, when no such values are available, nonstandard or lower quality test results which were judged by the authors to be reliable were used. Values derived using data that did not meet the Stephan et al. (1985) criteria are noted.

2.4 LOWEST CHRONIC VALUES

The lowest chronic values for fish and invertebrates reported in the literature are potential lower benchmarks. Chronic values are used to calculate the chronic NAWQC, but the lowest chronic value may be lower than the chronic NAWQC. Because of the short generation time of algae and the relative lack of standard chronic tests for aquatic plants, EPA guidelines are followed in using any algal test of at least 96-hour duration and any biologically meaningful response for the plant values.

2.5 ESTIMATED LOWEST CHRONIC VALUES

Estimated lowest chronic values for fish and invertebrates are another set of potential lower benchmarks. Estimated chronic values were extrapolated from 96-hour LC50s using equations from Suter et al. (1987) and Suter (1993). The equations are as follows where LC50 equals the lowest species mean 96-hour LC50 for fish and 48-hour EC50 for daphnids, and CV equals the estimated chronic value for that taxon. The 95% prediction interval at the mean is log CV ± the PI value (95% prediction intervals contain 95% of observations versus 95% confidence intervals which contain the mean with 95% confidence).

Fish CV for a metallic contaminant: (1)

$$\log CV = 0.73 \log LC50 - 0.70$$
$$PI = 1.2$$

Fish CV for a nonmetallic contaminant: (2)

$$\log CV = 1.07 \log LC50 - 1.51$$
$$PI = 1.5$$

Daphnid CV for a metallic contaminant: (3)

$$\log CV = 0.96 \log LC50 - 1.08$$
$$PI = 1.56$$

Daphnid CV for a nonmetallic contaminant: (4)

$$\log CV = 1.11 \log LC50 - 1.30$$
$$PI = 1.35$$

2.6 TEST EC20s

Another potential lower benchmark is the test EC20 for fish, which is defined as the highest tested concentration causing less than 20% reduction in (1) the weight of young fish per initial female fish in a lifecycle or partial life-cycle test or (2) the weight of young per egg in an early life-stage test. A similar potential lower benchmark is the test EC20 for daphnids, which is 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. (Daphnids include members of the genera *Daphnia*, *Ceriodaphnia*, and *Simocephalus*.) These benchmarks are intended to be indices of population production. They are equivalent to chronic values in that they are simply a summary of the results of chronic toxicity tests, and in most cases the same test supplied the lowest chronic value and the lowest test EC20. However, the test EC20s are based on a level of biological effect rather than a level of statistical significance, and they integrate all of the stages of the toxicity test rather than treating each response independently. The 20% figure was chosen as approximately the mean level of effect on individual response parameters observed at CVs and as a minimum detectable difference in population characteristics in the field (Suter et al. 1987, 1992). These values are listed in Table 2.

2.7 ESTIMATED TEST EC20s

The estimated test EC20 is another potential benchmark. The estimated values were extrapolated from 96-hour LC50 values using equations from Suter (1992). The equation for the lowest fish test EC20 is as follows where LC50 equals the lowest species mean 96-hour LC50 for fish, and the EC25 for weight of juveniles per egg is used as an estimate of the test EC20 value. (The difference between 20% and 25% effect is trivial given the uncertainties in these estimates and the steepness of the concentration-response curves.) The log-scaled 95% prediction interval at the mean is log EC25 ± the PI value:

$$\log EC25 = 0.90 \log LC50 - 0.86 \qquad (5)$$
$$PI = 1.6$$

These values are listed in Table 2 for those chemicals that have no empirical test EC20.

2.8 SENSITIVE SPECIES TEST EC20s

The sixth potential benchmark is the EC20, adjusted to approximate the fifth percentile of the species sensitivity distribution. It is calculated in the same way as the chronic NAWQC except that the test EC20s are used in place of CVs, and salt water species were not included. The FAV for each of the criterion chemicals was divided by the geometric mean of ratios of LC50s to EC20s. These benchmarks are referred to as sensitive species (SS) test EC20s, and are listed in Table 2.

2.9 POPULATION EC25s

The last potential benchmark is an estimate of the continuous concentration that would cause a 20% reduction in the recruit abundance of largemouth bass. The method used was described by Barnthouse et al. (1990) and is briefly summarized herein. The recruit abundance estimates are generated by a matrix model of a reservoir largemouth bass population (Bartell 1990). The fecundity, hatching success, larval survival, and post-larval survival of the model population are each decremented by a value generated from statistical extrapolation models. For each life stage for which a concentration-response relationship could be calculated, that relationship was adjusted for the relative sensitivity of the test species and the bass. For those life stages with no concentration-response relationship, the relationship was estimated using life stage to life stage extrapolation models, and the taxonomic adjustment was made. However, if the authors of the study reported that life stage was unaffected, the decrement for that life stage was set to zero. If no chronic test data were available, extrapolations from LC50s to chronic responses of each life stage were performed. Uncertainties in all of these extrapolations were propagated through the models to generate estimates of uncertainty. For each chemical, each available freshwater fish chronic test was used to parameterize a model run. If no chronic test data were available, each available freshwater fish LC50 was used to parameterize a model run. The results are presented in Appendix C. The geometric mean of all population EC25 estimates for each chemical is reported in Table 2.

2.10 ECOTOX THRESHOLDS

The EPA's OSWER has published Ecotox Thresholds (ETs) which are intended to be used for screening contaminants at Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites (OSWER 1996); these values are available for 20 metals and 47 organics in fresh water and for 10 metals and 7 organics in marine waters. The fresh water values are presented in Table 3. Their derivation is briefly explained in the following text.

In general, chronic NAWQC values are preferred as aqueous ETs. However, as with the benchmarks in Table 1, criteria that are based on fish consumption rather than aquatic toxic effects (DDT, heptachlor, and toxaphene) are not used. Tier II values are presented in their place. For diazinon, the FCV calculated by the Great Lakes Water Quality Initiative (GLWQI) was used as a criterion value (EPA 1992).

OSWER recommends the use of dissolved concentrations of metals. Therefore, the method described in Prothro (1993) is used to correct for dissolved phase concentrations, which causes some of the metals criteria values used as ETs to differ slightly from the criteria listed in Table 1 or in the Region IV values.

SCVs are used when NAWQCs are not available. Four of these SCVs are from the GLWQI (EPA 1992), 34 are from the prior edition of this document (Suter and Mabrey 1994), and 18 were calculated by OSWER (1996). Three chemicals with OSWER-derived SCVs (endosulfan, methoxyclor, and malathion) had NAWQCs, but the criteria were judged to be old and unreliable. Tier II values were not derived if no daphnia acute values were available.

2.11 REGION IV SCREENING VALUES

EPA Region IV has published acute and chronic ecological screening values (SVs) for fresh surface water (Waste Management Division 1995); they are presented in Table 3. The acute SVs consist of acute NAWQCs or, for chemicals with no acute NAWQC, of lowest acute LC50 or EC50 values divided by 10. The chronic SVs consist of chronic NAWQCs or, for chemicals with no chronic NAWQC, of lowest CVs divided by 10. If there were no CVs, the acute SV is divided by 10 to obtain the chronic SV. These divisions by 10 serve the same purpose as the models used to calculate Tier II values, but without the scientific or statistical basis and without using the full available data set. For some chemicals, the SVs are based on effects on fish eaters or irrigated plants rather than aquatic life. Region IV acknowledges that other values have greater ecological relevance (Waste Management Division 1995). As explained previously, there are separate benchmarks to address effects on plants and wildlife and an entirely separate set of risk assessment methods to protect humans who eat fish. Finally, the hardness dependent criteria are adjusted to 50 mg/L which is unrealistically low for the Oak Ridge Reservation and most other sites.

2.12 BACKGROUND CONCENTRATIONS

Background water concentrations should be used as a check for these benchmarks. That is, because some of these benchmarks are quite conservative and because the measured concentrations in ambient water may include forms that are not bioavailable, benchmark concentrations may be lower than background water concentrations. If the background concentrations are valid and represent an uncontaminated state and if exposed site does not contain forms of the chemicals that are more bioavailable or toxic than the forms at background sites, then screening benchmarks lower than th e background concentration should not be used.

Table 3. Summary of OSWER threshold values for aquatic life (EPA 1996) and Region IV screening values for freshwater surface water (Region IV 1995) (All values are μg/L)

Chemical	OSWER Values		Region IV Values[3]	
	NAWQC or FCV[1]	Tier II[2]	Acute Screening Values	Chronic Screening Values
		Metals		
Aluminum			750	87
Antimony			1300 (2s)	160 (2s)
Arsenic III	190		360	190
Arsenic V		8.1 *		
Barium		3.9 *		
Beryllium		5.1 *	16 (6s)	053 (1s)
Boron			--	750[4]
Cadmium	1.0 h		1.79 h	0.66 h
Chromium III	180 h		984.32 h	117.32 h
Chromium VI	10		16	11
Cobalt		3.0 *		
Copper	11 h		9.22 h	6.54 h
Iron	1000		--	1000
Lead	2.5 h		33.78	1.32
Manganese		80 *		
Mercury			2.40	0.0123
Mercury, inorganic	1.3			
Mercury, methyl		0.003 *		
Molybdenum		240 *		
Nickel	160 h		789.00 h	87.71 h
Selenium	5.0		20.00	5.00
Silver			1.23 h	0.012 (1s)
Thallium			140.00(3s)	4.00 (2s)

Table 3. (continued)

Chemical	OSWER Values		Region IV Values[3]	
	NAWQC or FCV[1]	Tier II[2]	Acute Screening Values	Chronic Screening Values
Vanadium		19 *		
Zinc	100 h		65.04 h	58.91 h
Organic Compounds				
Acenaphthene	23 S		170 (2s)	17
Acrolein			6.8 (3s)	2.1 (1s)
Acrylonitrile			755 (4s)	75.5
Aldrin			3	0.3
Benzene		46 *	530 (7s)	53
Benzidine			250 (4s)	25
Benzo(a)pyrene		0.014 *		
a-BHC			--	500*
b-BHC			--	5000*
g-BHC (Lindane)	0.08		2	0.08
Biphenyl		14 #		
Bis(2-chloroethyl) ether			23800 (1s)	2380
Bis(2-ethylhexyl)phthalate		32 *	1110 (2s)	<0.3 (2s)
Bromoform			2930 (2s)	293
4-Bromophenylphenyl ether		1.5 #		
4- Bromophenylphenyl phthalate			36 (2s)	12.2 (1s)
Butylbenzyl phthalate		19 #	330 (4s)	22 (2s)
Carbon tetrachloride			3520 (3s)	352
Chlordane			2.4	0.0043[5]
Chlorobenzene		130 *	1950 (5s)	195
2-Chloroethylvinyl ether			35400 (1s)	3540
Chloroform			2890 (3s)	289
2-Chlorophenol			438 (5s)	43.8
Chloropyrifos			0.083	0.041

Table 3. (continued)

Chemical	OSWER Values		Region IV Values[3]	
	NAWQC or FCV[1]	Tier II[2]	Acute Screening Values	Chronic Screening Values
4,4'-DDT		0.013 +	1.1	0.001
4,4'-DDE			105 (1s)	10.5
4,4'-DDD			0.064 (8s)	0.0064
Demeton			--	0.1
Diazinon	0.043 F			
Dibenzofuran		20 *		
1,2-Dichlorobenzene		14 #	158 (4s)	15.8 (3s)
1,3-Dichlorobenzene		71 #	502 (3s)	50.2
1,4-Dichlorobenzene		15 #	112 (5s)	11.2
1,1-Dichloroethane		47 *		
1,2-Dichloroethane			11800 (3s)	2000 (1s)
1,1-Dichloroethylene			3030 (3s)	303
2,4-Dichlorophenol			202 (3s)	36.5 (1s)
1,2-Dichloropropane			5250 (3s)	525
Dichloropropylene (cis and trans)			606 (2s)	24.4 (1s)
Dieldrin	0.062 S		2.5	0.0019[4]
Diethyl phthalate		220 *	5210 (2s)	521
2,4-Dimethylphenol			212 (3s)	21.2
Dimethyl phthalate			3300 (2s)	330
Di-n-butyl phthalate		33 *	94 (6s)	9.4
2,4-Dinitrophenol			62 (3s)	6.2
2,4-Dinitrotoluene			3100 (2s)	310
Dioxin (2,3,7,8-TCDD)			0.1	0.00001[5]
1,2-Diphenylhydrazine			27 (2s)	2.7
Endosulfan, mixed isomers		0.051 #		
Endosulfan, alpha		0.051 #	0.22	0.056
Endosulfan, beta		0.051 #	0.22	0.056

Table 3. (continued)

Chemical	OSWER Values		Region IV Values[3]	
	NAWQC or FCV[1]	Tier II[2]	Acute Screening Values	Chronic Screening Values
Endrin	0.061 S		0.18	0.0023[5]
Ethylbenzene		290 *	4530 (5s)	453
Fluoranthene	8.1 S		398 (2s)	39.8
Fluorene		3.9 #		
Guthion			--	0.01
Heptachlor		0.0069 +	0.52	0.0038[5]
Heptachlor epoxide			0.52	0.0038[5]
Hexachlorobutadiene			9 (5s)	0.93 (1s)
Hexachlorocyclopentadiene			0.7 (4s)	0.07
Hexachloroethane		12 #	98 (5s)	9.8
Isophorone			11700 (2s)	1170
Lindane (see g-BHC)				
Malathion		0.097	--	0.01
Methoxychlor		0.019 #	--	0.03
Methyl bromide			1100 (1s)	110
Methyl chloride			55000 (1s)	5500
3-Methyl-4-chlorophenol (p-Chloro-m-cresol)			3 (1s)	0.3
2-Methyl-4, 6-dinitrophenol (4,6- Dinitro-o-cresol)			23 (4s)	2.3
Methylene chloride			19300 (3s)	1930
Mirex			--	0.001
Naphthalene		24 *	230 (4s)	62 (1s)
Nitrobenzene			2700 (2s)	270
2-Nitrophenol			--	3500
4-Nitrophenol			828 (3s)	82.8
n-Nitrosodiphenylamine			585 (2s)	58.5
Parathion			0.065	0.013

Table 3. (continued)

Chemical	OSWER Values		Region IV Values[3]	
	NAWQC or FCV[1]	Tier II[2]	Acute Screening Values	Chronic Screening Values
PCB (total polychlorinated biphenyls)		0.19 •		
PCB-1242			0.2 (7s)	0.014
PCB-1254			0.2 (7s)	0.014
PCB-1221			0.2 (7s)	0.014
PCB-1232			0.2 (7s)	0.014
PCB-1248			0.2 (7s)	0.014
PCB-1260			0.2 (7s)	0.014
PCB-1016			0.2 (7s)	0.014
Pentachlorobenzene		0.47 #	250	50
Pentachlorophenol	13 pH		20 pH	13 pH
Phenol			1020 (16s)	256 (1s)
Polynuclear aromatic hydrocarbons				
Phenanthrene	6.3 S			
1,2,4,5-Tetrachlorobenzene			250	50
1,1,2,2-Tetrachloroethane		420 •	932 (3s)	240 (1s)
Tetrachloroethylene		120 •	528 (5s)	84 (1s)
Tetrachloromethane		240 #		
Toluene		130 *	1750 (5s)	175
Toxaphene		0.011 #	0.73	0.00025
1,2-Trans-Dichloroethylene,			13500 (1s)	1350
Tribromomethane		320 #		
Tributyltin			--	0.026
1,2,4-Trichlorobenzene		110 #	150 (4s)	44.9 (1s)
1,1,1-Trichloroethane		62 *	5280 (2s)	528
1,1,2-Trichloroethane			3600 (3s)	940 (1s)
Trichloroethylene		350 *		

Table 3. (continued)

Chemical	OSWER Values		Region IV Values[3]	
	NAWQC or FCV[1]	Tier II[2]	Acute Screening Values	Chronic Screening Values
2,4,6-Trichlorophenol			32 (3s)	3.2
m-Xylene		1.8 #		
Other				
Chloride			860,000	230,000
Chlorine (total residual - TRC)			19	11
Cyanide	5.2		22	5.2
pH				-2.5
Oil and Grease			--	0.01 (Low LC_{50})
Sulfide (S_2-, HS-)			--	2

Notes:

[1] EPA derived NAWQC or final chronic values (FCVs).
[2] Values calculated using the GLWQI Tier II methodology.
[3] Based on EPA Region IV Water Management Division, Water Quality Standards Unit's Screening List. Those followed by (*ns*) are derived by Region IV using safety factors.
[4] For long-term irrigation of sensitive crops (minimum standard).
[5] Based on the marketability of fish. The use of other values which may have greater ecological significance may be considered.
• Lowest plant value reported.
(*ns*) = number of species
h = hardness-dependent ambient water quality criterion (100 mg/L as $CaCO_3$ used for OSWER thresholds and 50 mg/L for Region IV values).
pH = pH-dependent ambient water quality criterion (7.8 pH used for OSWER thresholds and 6.0 for Region IV values).
S = FCV derived for EPA Sediment Quality Criteria documents.
F = FCV calculated using GLWQI Tier 1 methodology.
t = value is for total of all chemical forms.
* = value as calculated in Suter and Mabrey (1994).
\+ = Value with EPA support documents.
\# = value calculated by OSWER.

3. CHEMICAL-SPECIFIC INFORMATION

This section describes the sources of information and procedures that are specific to individual elements. Except where noted, the sources of data for estimating chronic values and test EC20s for fish are the same. All data used to calculate Tier II values and estimated chronic values and EC20s are presented in Appendix A.

3.1 INORGANICS

Aluminum. There are NAWQC for aluminum. The toxicity of aluminum has been shown to vary widely with water hardness and pH (Ingersoll et al., 1990a 1990b; Woodward et al., 1989; Sadler and Lynam, 1988; and Cleveland et al. 1986; and others). The benchmarks were calculated using only tests in circumneutral water. Lowest chronic and test EC20 values for fish are from 28-day embryo-larval tests with *Pimephales promelas*. Kimball (n.d.) presented a CV of 5800 µg/L, however, after further analysis of Kimball's data, the EPA (1988a) offered another value of 3288 µg/L as the CV for aluminum. Lowest chronic and test EC20 values for daphnids are from McCauley et al. (1986). The EPA (1988a) gives a 4-day test EC50 for *Selenastrum capricornutum* which is used as the plant chronic value.

Ammonia. The test EC20 value for fish is from an embryo-larval test with fathead minnows (Thurston et al. 1986). The chronic value for fish is from an early life stage test with pink salmon, *Oncorhynchus gorbuscha* (Rice and Bailey 1980). The chronic value for daphnids is from EPA (1985a). Chronic values were determined using *Daphnia magna* in life-cycle tests. EPA (1985a) provided the chronic value for aquatic plants, in which *Chlorella vulgaris* experienced growth inhibition (EC50). The NAWQC for ammonia are functions of temperature (T) and pH. The acute NAWQC for ammonia is 0.52/FT/FPH/2, and the chronic NAWQC for ammonia is 0.80/FT/FPH/Ratio, where:

$$FT = 10^{0.03(20-TCAP)}; \quad TCAP \le T \le 30$$
$$ 10^{0.03(20-T)}; \quad 0 \le T \le TCAP$$

$$FPH = 1; \quad 8 < pH \le 9$$
$$ \frac{1 + 10^{7.4-pH}}{1.25}; \quad 6.5 \le pH \le 8$$

$$Ratio = 16; \quad 7.7 \le pH \le 9$$
$$ = (24)\frac{10^{7.7-pH}}{1 + 10^{7.4-pH}}; \quad 6.5 \le pH \le 7.7$$

TCAP = 20° C for acute criteria and 15° C for chronic criteria when Salmonids or other sensitive cold water species are present
= 25° C for acute criteria and 20° C for chronic criteria when Salmonids and other sensitive coldwater species are absent

These criteria are presented in greater detail in EPA (1985a and 1986b).

Antimony. Chronic and test EC20 values for antimony are from Kimball (n.d.). The chronic tests of *Pimephales promelas* were embryo-larval, and 28-day life-cycle tests were used for *Daphnia magna*. The EPA (1978) gives a 4-day EC50 for chlorophyll A inhibition in *Selenastrum capricornutum* which is used as the plant value. The SAV and SCV listed in this report are draft FAV and FCV values (EPA 1988b).

Arsenic III. NAWQC are listed for arsenic III. The lowest chronic values for fish and daphnids are given by Call et al. (1983) and Lima et al. (1984). Early life stage tests were used on *Pimephales promelas* and life-cycle tests were used on *Daphnia magna*. Cowell (1965) provides the lowest chronic value for the algae *Spirogyra*, *Cladophora*, and *Zygnema* which is a concentration that produced a

100% kill in 2 weeks. The test EC20 value is derived from Lima et al. (1984) for fish and from Call et al. (1983) and Lima et al. (1984) for daphnids.

Arsenic V. The chronic and test EC20 values for fish are from an early life stage test with *Pimephales promelas* (DeFoe 1982), and the test EC20 for daphnids is from Spehar et al. (1980). The estimated chronic value for daphnids was calculated with a *Daphnia magna* LC50 from EPA (1985b) using Equation (3). Vocke (1980) provides the plant value from a 14-day EC50 test with *Scenedesmus obliquus*. The SAV and SCV listed in this report are lower than the acute and chronic LOEL values listed in the Water Quality Criteria Summary (EPA 1986b).

Barium. The chronic value for daphnids is from a 21-day test on *Daphnia magna* by Biesinger and Christensen (1972) which resulted in 16% reproductive impairment.

Beryllium. The chronic and test EC20 values for *Daphnia magna* are from a life-cycle test in Kimball (n.d.). Karlander and Krauss (1972) provide the plant value for *Chlorella vannieli*, a 10 to 20% reduction in autotrophic growth rates. The estimated chronic and test EC20 values for fish were derived using data for *Pimephales promelas* from EPA (1980f) in Equations (1) and (5). The derived SAV and SCV listed in this report are lower than the lowest CV listed in the Water Quality Criteria Summary (EPA 1986b) and the acute and chronic LOEL values listed in the Water Quality Criteria Summary (EPA 1986b).

Boron. The EC20 value for daphnids was based on a 21-day test on *Daphnia magna* by Gerisch (1984). A 21-day test of *Daphnia magna* by Lewis and Valentine (1981) provided the lowest daphnid chronic value.

Cadmium. The NAWQC for cadmium are functions of water hardness. The equations for these are $e^{(0.7852[\ln(\text{hardness})]-3.490)}$ for the chronic value and $e^{(1.128[\ln(\text{hardness})]-3.828)}$ for the acute value (EPA 1986b). The lowest chronic value for fish is from Sauter et al. (1976) and Chapman et al. (n.d.) for daphnids. Early life stage tests were performed on brook trout, and life-cycle tests were performed on *Daphnia magna*. The test EC20 value is from Carlson et al. (1982) for fish and Elnabarawy et al. (1986) for daphnids. The value for aquatic plants is from Conway (1977). A relatively low cadmium concentration reduced the population growth rate of *Asterionella formosa* by an order of magnitude.

Calcium. The chronic value for daphnids is a concentration causing a 16% reduction in reproduction of *Daphnia magna* exposed to $CaCl_2 \cdot 2H_2O$ (Biesinger and Christensen 1972). Because the highly conservative secondary values were below commonly occurring ambient concentrations of this macronutrient, they were judged to be inappropriate and are not presented.

Chromium III. The NAWQC for chromium III are functions of water hardness. The equations are $e^{(0.8190[\ln(\text{hardness})]+1.561)}$ for the chronic value and $e^{(0.8190[\ln(\text{hardness})]+3.688)}$ for the acute value. The lowest chronic value for fish is from an early life stage test by Stevens and Chapman (1984) on rainbow trout. Chapman et al. (n.d.) provide a chronic value from a life-cycle test of *Daphnia magna*. The plant value for chromium III is from a 4-day chronic test in which there was a 50% inhibition of growth of *Selenastrum capricornutum* (EPA 1985c). Stevens and Chapman (1984) also provided data for the test EC20 value for fish.

Chromium VI. There are NAWQC for chromium VI. The chronic and test EC20 values for fish are from Sauter et al. (1976). An early life stage test produced the chronic value for rainbow trout. For daphnids, a life-cycle chronic test was run by Mount (1982) on *Daphnia magna*, and the test EC20 is from Elnabarawy et al. (1986). *Microcystis aeruginosa*, used for the aquatic plant value, showed incipient inhibition in tests reported by the EPA (1985c).

Cobalt. The chronic and test EC20 values for cobalt are from Kimball (n.d.). *Daphnia magna* were used in 28-day life-cycle tests, and *Pimephales promelas* were used in embryo-larval tests.

Copper. The NAWQC for copper are functions of water hardness. The equations are $e^{(0.8545[\ln(\text{hardness})]-1.465)}$ for the chronic value and $e^{(0.9422[\ln(\text{hardness})]-1.464)}$ for the acute value. The chronic and test EC20 values for fish are from an early life stage test with brook trout by Sauter et al. (1976). The daphnid chronic value is from Chapman (n.d.). The test EC20 value for daphnids is derived from Dave (1984a). A 21-day test LC50 on *Daphnia magna* provided the chronic value for daphnids. Arthur and Leonard (1970) provided a chronic value through 6-week tests on the amphipod, *Gammarus pseudolimnaeus*. Steeman-Nielsen and Wium-Anderson (1970) provide a plant value based on a lag in growth of the alga, *Chlorella pyrenoidosa*.

Cyanide. There are NAWQC for cyanide. The chronic and test EC20 values for fish were both from a brook trout life-cycle test by Koenst et al. (1977). Oseid and Smith (1979) provide full life-cycle test on *Gammarus pseudolimnaeus*, an amphipod. The alga, *Scenedesmus quadricauda*, showed incipient inhibition in chronic tests by the EPA (1985c).

Iron. The NAWQC for iron is based on a field study at a site receiving acid mine drainage and is not consistent with the current method for deriving criteria. The lowest chronic value for daphnids (158 µg/L) is a threshold for reproductive effects from a 21-day test of $FeCl_3$ with *Daphnia magna* (Dave 1984c). It is considerably lower than the 4380 µg/L concentration causing 16% reproductive decrement in another test of $FeCl_3$ with *D. magna* (Biesinger and Christensen 1972). Dave (1984c) argued that his result was more applicable to a situation in which "an acidic iron-containing waste water is discharged into a lake or a river" where it is neutralized, but Biesinger and Christensen's (1972) result "is probably more close to the steady-state situation in natural freshwater without any point source of iron." The lowest chronic value for fish is a concentration that caused 100% larval mortality in an embryo-larval test with rainbow trout exposed to dissolved iron salts (Amelung 1981).

Lead. The NAWQC for lead are functions of water hardness. The equations are $e^{(1.273[\ln(\text{hardness})]-4.705)}$ for the chronic value and $e^{(1.273[\ln(\text{hardness})]-1.460)}$ for the acute value. The lowest chronic value for fish was provided by an early life stage test on rainbow trout by Davies et al. (1976). *Daphnia magna* were used in 21-day tests to determine lowest chronic toxicity by Chapman et al. (manuscript). Borgmann et al. (1978) provided a chronic value for a life-cycle test on *Lymnaea palustris*, a snail. *Chlorella vulgaris*, *Scenedesmus quadricauda*, and *Selenastrum capricornutum* experienced 53%, 35%, and 52% growth inhibition, respectively, at the plant chronic value (EPA 1985f). The test EC20 value for fish is from Sauter et al. (1976). The acute-EC20 ratio from which the SS test EC20 was calculated had to be obtained using a species mean acute value for *Salmo gairdneri* (EPA 1985f) since no acute value was reported by Sauter et al. (1976).

Magnesium. The chronic value for daphnids is a concentration causing a 16% reduction in reproduction of *Daphnia magna* exposed to $MgCl_2 \cdot 6H_2O$ (Biesinger and Christensen 1972). Because the highly conservative secondary values were below commonly occurring ambient concentrations of this nutrient element, they were judged to be inappropriate and are not presented.

Manganese. All chronic and test EC20 values for manganese are from Kimball (n.d.). The fish chronic value is from a 28-day early life-stage test with *Pimephales promelas*.

Mercury, inorganic, or total. Mercury has NAWQC. However, the chronic criterion for mercury is based on the final residue value derived from a methyl mercury bioconcentration factor. To protect aquatic life, the secondary values were derived from the EPA's (1985f) final acute and chronic values.

The chronic and test EC20 values for fish are from Call et al. (1983), and those for daphnids are from Biesinger et al. (1982). The chronic tests for fish were run on *Pimephales promelas* throughout their embryo-larval stage. *Daphnia magna* were used in flow through life-cycle tests. The plant value is for incipient inhibition of *Microcystis aeruginosa* in an 8-day test (EPA 1985f). The acute-EC20 ratio used to calculate the SS test EC_{20} value had to be derived using a species mean acute value (EPA 1985g) since no acute value was reported in Biesinger et al. (1982).

Mercury, methyl. The chronic and test EC20 values for fish are from McKim et al. (1976). Brook trout were used in three generation life-cycle tests. The test EC20 value for daphnids is from Biesinger et al. (1982). The alga, *Chlorella vulgaris*, was used in 15-day EC50 (growth) tests by Rai et al. (1981) to determine chronic toxicity values for aquatic plants.

Molybdenum. The chronic and test EC20 values for daphnids are from Kimball (n.d.). *Daphnia magna* were used in a 28-day life-cycle test to determine the chronic value.

Nickel. The NAWQC for nickel are functions of water hardness. The equation for these are $e^{(0.846[\ln(\mathrm{hardness})]+1.1645)}$ for the chronic value and $e^{(0.8460[\ln(\mathrm{hardness})]+3.3612)}$ for the acute value. However, nickel concentrations of 10 µg/L in Oak Ridge Reservation stream water (considerably below the chronic NAWQC for nickel but similar to the lowest of the alternate benchmarks) reduced 7-day *Ceriodaphnia dubia* survivorship to 60% (Kszos et al. 1992). The chronic and test EC20 values for fish are from Nebeker et al. (1985). The chronic value for fish was determined through an early life stage test on rainbow trout. For daphnids, the chronic value was from Lazareva (1985) and the test EC20 was from Münzinger (1990). *Daphnia magna* were used in a life-cycle test to determine the chronic value. The caddisfly, *Clistoronia magnifica*, was used in life-cycle tests by Nebeker et al. (1984) to determine the chronic value. The plant chronic toxicity values were provided by the EPA (1986a) for *Microcystis aeruginosa*, which showed incipient inhibition.

Potassium. The chronic value for daphnids is a concentration causing a 16% reduction in reproduction of *Daphnia magna* exposed to KCl (Biesinger and Christensen 1972). Because the highly conservative secondary values were below commonly occurring ambient concentrations of this macronutrient, they were judged to be inappropriate and are not presented.

Selenium. NAWQC are listed for selenium. The chronic and test EC20 values for fish are from Goettl and Davies (1976). Their tests were during the early life stage of rainbow trout. The chronic value for daphnids is from Kimball (n.d.), and the test EC20 is from Johnston (1987). These tests were run for 28 days on *Daphnia magna*. The green alga, *Scenedesmus obliquus*, exhibited reduced growth in the 14-day chronic toxicity tests (Vocke et al. 1980). The acute-EC20 ratio used in calculation of the SS EC20 value had to be derived using a species mean acute value for *Daphnia magna* (EPA 1987a) because no acute value was reported by Johnston.

Silver. The acute NAWQC for silver, which is a function of water hardness, is given by the equation $e^{(1.72[\ln(\mathrm{hardness})]-6.52)}$. The SCV was estimated from the FAV and acute-chronic ratios for three species. Although questions about two of these ratios prompted the EPA to refrain from calculating a final chronic value, we judged them to be better than the default value. The lowest chronic value for fish is based on an early life stage test on rainbow trout by Davies et al. (1978). The lowest chronic value for daphnids and the test EC20 for fish are from Nebeker et al. (1983). The daphnid CV is from a test with *Daphnia magna*. The test EC20 for daphnids is from Elnabarawy et al. (1986). The plant value is for growth inhibition in *Chlorella vulgaris* (EPA 1980y).

Sodium. The chronic value for daphnids is a concentration causing a 16% reduction in reproduction of *Daphnia magna* exposed to NaCl (Biesinger and Christensen 1972). Because the highly conservative secondary values were below commonly occurring ambient concentrations of this micronutrient, they were judged to be inappropriate and are not presented.

Strontium. The chronic value for daphnids is from 21-day tests on *Daphnia magna* by Biesinger and Christensen (1972) which resulted in 16% reproductive impairment.

Thallium. Chronic and test EC20 values are from Kimball (n.d.). Embryo-larval tests were run on *Pimephales promelas*, and 28-day chronic tests were run on *Daphnia magna*. The aquatic plant value is a 4-day EC50 which reduced the cell numbers of the alga, *Selenastrum capricornutum* (EPA 1978).

Tin. The chronic value is from Biesinger and Christensen (1972). It caused 16% reproductive impairment in *Daphnia magna* in 21 days.

Uranium. The chronic value for fish is an estimate based on a fathead minnow LC50 from Cushman et al. (1977) used in Equation (1). The test EC20 is an estimate based on the same data; however, Equation (5) was used.

Vanadium. The lowest chronic and test EC20 values for fish are from Holdway and Sprague (1979) and for daphnids from Kimball (n.d.).

Zinc. The NAWQC for zinc are functions of water hardness. The equations are $e^{(0.8473[\ln(hardness)]+0.7614)}$ for the chronic value and $e^{(0.8473[\ln(hardness)]+0.8604)}$ for the acute value. The chronic and test EC20 values for fish are from Spehar (1976), and the chronic value for daphnids is from Chapman et al. (n.d.). Life-cycle tests were run on *Jordanella floridae* and *Daphnia magna*. Nebeker et al. (1984) provided chronic values from life-cycle tests on the caddisfly, *Clistoronia magnifica*. Bartlett et al. (1974) ran 7-day tests on *Selenastrum capricornutum*. These aquatic plants showed incipient inhibition of growth.

Zirconium. The chronic and test EC20 values for fish are estimates based on an LC50 for *Pimephales promelas* from Cushman et al. (1977). These values were calculated using Equations (1) and (5).

3.2 ORGANICS

Acenaphthene. Although the full data requirements are not met for acenaphthene, the EPA has presented final acute and chronic values for derivation of sediment quality criteria which are presented in the criteria columns (EPA 1993b). The fish chronic value is from an early life-stage test with *Pimephales promelas*, and the non-daphnid chronic value is from a life-cycle test with a midge *Paratanytarsus sp.* (EPA 1993b). The plant value is from EPA (1978). *Selenastrum capricornutum* were used in 96-hour EC50 (50% reduction in cell numbers).

Acetone. The test EC20 value for fish is an estimate based on an LC50 for rainbow trout. The chronic value for Daphnia magna is a 28-day life-cycle test from LeBlanc and Surprenant (1983).

Anthracene. The chronic value for daphnids (*Daphnia magna*) was estimated using an EC50 from Holst and Giesy (1989). The chronic and test EC20 values for fish are an estimate based on an LC50 for bluegill from Oris and Giesy (1985). Calculations were performed using Equations (2), (4), and (5).

Benzene. The lowest chronic value for daphnids is given by EPA (1978). *Daphnia magna* were used in life-cycle tests. The lowest chronic value for aquatic plants is given by Kauss and Hutchinson (1975), which was a 48-hour test EC50 on *Chlorella vulgaris*. The chronic value for fish is an estimate based on data for the rainbow trout from EPA (1980d) and Equation (2). The test EC20 value for fish is derived from Black and Birge (1982). The reader should note that Black and Birge conducted a series of screening tests for a large number of chemicals on several freshwater organisms. Larval fish survival was recorded to only 4 days post-hatch, and LOECs and NOECs were not determined. These tests, then, did not generate standard chronic values and are not equivalent to the other chronic tests cited in this report. The test EC20 values based on tests by Black and Birge may be high relative to those from conventional chronic tests.

Benzidene. The chronic and EC20 value for fish are an estimate based on data for red shiner from EPA (1980c). Calculations were performed using Equations (2) and (5).

Benzo(a)anthracene. The chronic value for daphnids is an estimate based on data for *Daphnia magna* from Trucco et al. (1983) used in Equation (4).

Benzo(a)pyrene. The test EC20 for fish is derived from Hannah et al. (1982). The chronic value for daphnids is an estimate based on data for *Daphnia magna* from Trucco et al. (1985) used in Equation (4).

Benzoic Acid. The chronic value for fish is an estimate based on data for the mosquitofish from AQUIRE used in Equation (2). The estimated test EC20 for fish is based on the same data, but Equation (5) was used.

Benzyl Alcohol. The chronic and test EC20 values for fish are estimates based on data for bluegill from Dawson et al. (1977). The calculations were performed using Equations (2) and (5).

BHC (lindane). There are NAWQC for lindane. The chronic values for daphnids, fish, and non-daphnid invertebrates are all from Macek et al. (1976a). The test EC20 values for daphnids and fish are also from Macek et al. (1976a). The chronic values were derived from life-cycle tests run on *Pimephales promelas*, *Daphnia magna*, and the midge *Chironimus tentans*. The chronic value for aquatic plants is from Krishnakumari (1977); *Scenedesmus acutus* exhibited 20% growth inhibition in 5 days. The acute-EC20 ratio from which the SS EC20 was calculated was derived using a species mean acute value for *Salvelinus fontinalis* (EPA 1980s) since no acute data were reported by Macek et al. (1976a).

BHC (other). The chronic value for daphnids was estimated using a *Daphnia magna* EC50 from AQUIRE in Equation (4).

Bis(2-ethylhexyl)phthalate. The chronic and test EC20 values for fish are from a rainbow trout early life-stage test (Mehrle and Mayer 1976). A much lower value was reported in the previous edition of this report, but the results of that study are now believed to be incorrect (Knowles et al. 1987). The new value is supported by a CV of 912 µg/L from Adams and Heidolph (1985). That study is used in the derivation of the SCV because, unlike the Knowles et al. (1987) study, it has an accompanying acute value (48-hr EC50). No test EC20 for daphnids was calculated because insufficient detail was presented by Adams and Heidolph (1985) and Knowles et al. (1987).

2-Butanone. The chronic values for fish and daphnids are estimates based on data from Veith et al. (1983) and Randall and Knopp (1980), respectively. Equation (4) was applied to the data for *Daphnia magna*, and Equation (2) was applied to the data for *Pimephales promelas*. The test EC20 value for fish is also an estimate using Equation (5) and an LC50 from Veith et al. (1983).

Carbon disulfide. The chronic and test EC20 values for fish are estimates based on data for mosquitofish from AQUIRE using equations (2) and (5). The chronic value for daphnids is an estimate for *Daphnia magna* using data from Van Leeuwen (1985) in Equation (4).

Carbon tetrachloride. The chronic value for fish is a rainbow trout embryo-larval LC50 (Black and Birge 1982); therefore, it may be too high. However, it is lower than values presented by Kimball et al. (n.d.) and EPA (1980h) for fathead minnows. The same test was used to derive the test EC20 for fish (see the comments on benzene). The chronic value for daphnids is from a 7-day reproduction test with *Daphnia magna* (Kimball et al. n.d.). None of the subchronic tests could be used in the calculation of the SCV.

Chlordane. The chronic NAWQC for chlordane is based on the final residue value. For a criterion to protect aquatic life rather than its use, the FCV is reported. The lowest chronic and test EC20 values are derived from *Daphnia magna*, bluegill, and *Chironomus tentans* life-cycle tests (Cardwell et al. 1977).

Chlorobenzene. The chronic values for fish and daphnids are estimates based on data for bluegill and *Daphnia magna* from EPA (1980j). The values were calculated using Equations (2) and (4). The plant value is a 96-hour EC50 for cell number with *Selenastrum capricornutum* (EPA 1980j).

Chloroform. The test EC20 value for fish is from Black and Birge (1982). (Refer to the section on benzene). The chronic value is a 27-day LC50 for rainbow trout (embryo-larval) from EPA (1980l). The EPA (1986b) gives this value as a lowest observed effect value in lieu of a NAWQC. The chronic value for daphnids is an estimate based on data for *Daphnia magna* from EPA (1980l) and calculated from Equation (4).

DDD. The chronic and EC20 values for fish are estimates based on data for largemouth bass from Mayer and Ellersieck (1986) and are calculated using Equations (2) and (5).

DDT. The acute NAWQC for DDT is used. The chronic NAWQC, however, is not used because it is based on the final residue value. To protect aquatic life, an SCV is presented. The test EC20 value for fish is derived from Jarvinen et al. (1977). The fish chronic value is from a *Pimephales promelas* life-cycle test (EPA 1980m). The chronic value for daphnids is an estimate based on data for *Daphnia pulex* from EPA (1980m) and calculated with Equation (4). The aquatic plant chronic value is from Sodergreen (1968). *Chlorella vulgaris* was affected in growth and morphology.

Decane. The chronic value for daphnids is an estimate based on data for *Daphnia magna* from LeBlanc (1980) used in Equation (4).

Di-n-butyl phthalate. All chronic and test EC20 values are from McCarthy and Whitmore (1985). The chronic value for daphnids is based on the geometric means of the observed concentration of fresh solutions and aged solutions. *Daphnia magna* were used in life-cycle tests, and *Pimephales promelas* were used in early life stage tests.

Dibenzofuran. The chronic value for daphnids is an estimate based on data for *Daphnia magna* from LeBlanc (1980) and used in Equation (4).

1,1-Dichloroethane. The chronic and test EC20 values for fish are estimates based on an LC50 for guppy from Koneman (1981) and calculated using Equations (2) and (5).

1,2-Dichloroethane. The chronic value for fish is from Ahmad et al. (1984). Early life stage tests were conducted on *Pimephales promelas*. The test EC20 value for fish is from Benoit et al. (1982). The chronic and test EC20 values for daphnids are from *Daphnia magna* 28-day life-cycle tests (Richter et al. 1983).

1,1-Dichloroethene. The chronic values for fish and aquatic plants are from EPA (1978). *Pimephales promelas* were used in embryo-larval tests. The alga, *Selenastrum capricornutum*, was used in a 96-hour EC50 where it exhibited loss of chlorophyll A and cell numbers. The chronic value for daphnids is an estimate based on data for *Daphnia magna* from EPA (1980n) used in Equation (4).

1,2-Dichloroethene. The chronic and test EC20 values for fish are estimates based on data for bluegill from EPA (1980n). These values were derived using Equations (2) and (5).

1,3-Dichloropropene. The test EC20 for fish was estimated using an LC50 for bluegill from EPA (1980o) in Equation (5). The chronic values for fish and aquatic plants are from EPA (1978). *Pimephales promelas* were used in an embryo-larval test, and *Selenastrum capricornutum* were used in a 96-hour EC50. The alga showed chlorophyll A and cell loss. The chronic value for daphnids was estimated using an EC50 for *Daphnia magna* from EPA (1980o) in Equation (4).

Diethyl phthalate. The plant value is a 96-hour EC50 for *Selenastrum capricornutum* (EPA 1978).

Di-n-octyl phthalate. All chronic and test EC20 values are from McCarthy and Whitmore (1985). Chronic values were based on *Pimephales promelas* in early life stage tests and *Daphnia magna* in life-cycle tests. There are no Tier II values for di-n-octyl phthalate because LC50s were not available.

Ethyl benzene. The chronic value for aquatic plants is from EPA (1978). *Selenastrum capricornutum* displayed chlorophyll A inhibition in 96-hour EC50. The chronic value for daphnids was estimated using an EC50 for *Daphnia magna* from EPA (1980p) in Equation (4).

Fluoranthene. Although the full data requirements are not met for fluoranthene, the EPA (1993c) has derived an FAV and FCV as a part of the derivation of sediment quality criteria which are presented in Table 1. The fish CV is from an early life-stage test with *Pimephales promelas*, and the daphnid CV is from a life-cycle test with *Daphnia magna* EPA (1993c).

Heptachlor. The acute NAWQC for heptachlor is used. Because the chronic NAWQC is based on the final residue value, an SCV is reported herein. The chronic and test EC20 values for fish are from Macek et al. (1976b). *Pimephales promelas* were used in life-cycle tests to determine the chronic value for fish. The SS test EC20 value was calculated using an acute-EC20 ratio that was derived from a species mean acute value for *Pimephales promelas* (EPA 1980r) because no acute data are available from Macek et al. (1976b). The chronic value for aquatic plants is from EPA (1980r). Growth inhibition was exhibited by *Selenastrum capricornutum* in 96-hour EC50. The chronic value for daphnids is an estimate based on data for *Daphnia pulex* from EPA (1980r) using Equation (4).

Hexane. The chronic value and test EC20 value for fish are estimates based on LC50s for golden orfe from AQUIRE and calculated using Equations (2) and (5).

2-Hexanone. The chronic value and test EC20 value are estimates based on an LC50 for *Pimephales promelas* from Geiger et al. (1986) and calculated using Equations (2) and (5).

1-Methylnaphthalene. The chronic and test EC20 values for fish are estimates based on data for *Pimephales promelas* from Mattson (1976). The values were calculated with Equations (2) and (5).

4-Methyl-2-pentanone. The chronic value for fish is from Call et al. (1985). *Pimephales promelas* embryos, larva, and juveniles were exposed for 31 to 33 days.

2-Methylphenol. The chronic value for daphnids is an estimate based on data for *Daphnia magna* from Adema (1978) and Canton and Adema (1978). The value was calculated using Equation (4). The chronic and test EC20 values for fish were estimated using an LC50 for rainbow trout from DeGraeve et al. (1980) in Equations (2) and (5).

Methylene chloride. The chronic value for fish is from Dill et al. (1987). *Pimephales promelas* were used in 32-day embryo-larval tests. The chronic value for daphnids is an estimate based on data for *Daphnia magna* from LeBlanc (1980) used in Equation (4). The test EC20 value for fish is from Black and Birge (1982). (Refer to the section on benzene concerning data from this source.)

Naphthalene. The chronic and test EC20 values for fish are from DeGraeve et al. (1982), and the test EC20 value for daphnids is from Geiger and Buikema (1982). *Pimphales promelas* were used in embryo-larval tests to determine chronic toxicity. The chronic value for aquatic plants is from EPA (1980t). The alga, *Chlorella vulgaris*, exhibited inhibited cell numbers in 48-hour EC50. The chronic value for daphnids is an estimate based on data for *Daphnia magna* from EPA (1980t) used in Equation (4).

4-Nitrophenol. The chronic and test EC20 values for daphnids are from Francis et al. (1986). The chronic and test EC20 values for fish are estimates based on data for bluegill from Buccafusco et al. (1981) and used with Equations (2) and (5). The EPA (1978) is the source for the chronic value for aquatic plants. *Selenastrum capricornutum* exhibited chlorophyll A reduction in 96-hour EC50.

N-nitrosodiphenylamine. The source for the estimated fish and daphnid chronic values are Buccafusco et al. (1981) and LeBlanc (1980), respectively. Equation (2) was used to calculate the estimated fish (bluegill) value, and Equation (4) was used for the estimated daphnid (*Daphnia magna*) value. The test EC20 value for fish is also an estimate. Buccafusco et al. (1981) provided the LC50 for bluegill used with Equation (5) to estimate the EC20.

PCBs: Total. There are NAWQC for PCBs, but the chronic criterion is based on the final residue value. Since that value is intended to protect the use of aquatic life, an SCV is calculated to protect the aquatic life itself. The fish lowest chronic value and test EC20 are from a full life-cycle test of fathead minnows by DeFoe (1978). The lowest chronic value and test EC20 for daphnids are from a 2-week continuous flow test with *Daphnia magna* (Nebeker and Puglisi 1974). The lowest chronic value for non-daphnid invertebrates is from a 3-week LC50 for *Tanytarsus dissimilis* by Nedeker and Puglisi (1974). The lowest plant value is for reduction in carbon fixation by *Scenedesmus quadricaudata* in a 24-hour test (Laird 1973).

PCBs: Aroclor® 1221. The chronic and test EC20 fish values are estimates based on data for cutthroat trout by Stalling and Mayer (1972). Equations (2) and (5) were used to determine the EC20 value for fish. The chronic value for aquatic plants is a 48-hour LC50 for *Euglena gracilis* (Ewald et al. 1976).

PCBs: Aroclor® 1232. The chronic and test EC20 fish values are estimates based on data for cutthroat trout by Stalling and Mayer (1972) and AQUIRE. The geometric mean was derived from these two values and then placed into Equations (2) and (5).

PCBs: Aroclor® 1242. The chronic and test EC20 values for fish are from Nebeker et al. (1974). *Pimephales promelas* were used in full life-cycle tests. The chronic values for non-daphnid invertebrates are from Nebeker and Puglisi (1974). *Gammarus pseudolimnaeus* were exposed to PCBs for 2 months in a continuous-flow system. The chronic value for aquatic plants is a 24-hour test in which *Scenedesmus obtusiusculus* showed growth inhibition (Larsson and Tillberg 1975).

PCBs: Aroclor® 1248. The chronic and test EC20 values for fish are from DeFoe et al. (1978), and the chronic and test EC20 values for daphnids are from Nebeker and Puglisi (1974). The chronic values for fish were full life-cycle tests carried out on *Pimephales promelas*. The chronic value for daphnids was determined through 3-week exposures that created a 16% reproductive impairment in *Daphnia magna*. The chronic value for a non-daphnid invertebrate is from Nebeker and Puglisi (1974). *Gammarus pseudolimnaeus* was exposed for 2 months.

PCBs: Aroclor® 1254. The chronic value for fish is from a brook trout life-cycle test (Mauck et al. 1978), and the test EC20 value is from a fathead minnow life-cycle test (Nebeker et al. 1974). The chronic and test EC20 values for daphnids are from Nebeker and Puglisi (1974). *Daphnia magna* were exposed for 2 weeks in a continuous-flow environment. The lowest chronic value for nondaphnid invertebrates is from a 3-week LC50 for *Tanytarsis dissimilis* by Nedeker and Puglisi (1974). The lowest plant value is for reduction in carbon fixation by *Scenedesmus quadricaudata* in a 24-hour test (Laird 1973).

PCBs: Aroclor® 1260. The chronic and test EC20 values for fish are from DeFoe et al. (1978). The chronic value is ambiguous because significant effects occurred at the lowest concentration tested in a 30-day fathead minnow larval test at the lowest concentrations tested (1.3 µg/L) but not in a 240-day lifecycle at the highest concentration tested (2.1 µg/L).

1-Pentanol. The chronic and test EC20 values for fish are estimates based on data for rainbow trout from AQUIRE and calculated using Equations (2) and (5).

Phenanthrene. The chronic and test EC20 values for daphnids are from Geiger and Buikema (1982). The chronic value was determined using *Daphnia pulex* in full life-cycle tests.

Phenol. The chronic and test EC20 values for fish are from fathead minnow embryo-larval tests (DeGraeve et al. 1980). The chronic value for daphnids is an estimate based on data for *Daphnia longispina* from EPA (1980v) and calculated using Equation (4). The chronic value for aquatic plants is from Reynolds (1975). *Selenastrum capricornutum* exhibited 60% reduction in cell numbers and 12% growth inhibition.

2-Propanol. The chronic and test EC20 values for fish are estimates based on data for *Pimephales promelas* from AQUIRE and Veith et al. (1983). The geometric mean of these LC50s was used in Equations (2) and (4).

1,1,2,2-Tetrachloroethane. The chronic and test EC20 values for fish are from Ahmad et al. (1984), and the values for daphnids are from Richter et al. (1983). The chronic values for fish were derived from embryo-larval tests on *Pimephales promelas*. The chronic values for daphnids were derived from 28-day tests run on *Daphnia magna*. The chronic value for aquatic plants is from EPA (1978). *Selenastrum capricornutum* exhibited chlorophyll A inhibition in 96-hour EC50.

Tetrachloroethene. The chronic value for fish is an embryo-larval test on fathead minnows (EPA 1980aa). The test EC20 value for fish is from Ahmad et al. (1984). The chronic and test EC20 values for daphnids are from Richter et al. (1983). These were 28-day tests on *Daphnia magna*. The plant value is from EPA (1978). *Selenastrum capricornutum* decreased in cell number and chlorophyll A during the 96-hour EC50.

Toluene. The chronic value is an estimate based on data for *Daphnia magna* from EPA (1980cc) and calculated using Equation (4). The chronic value from *Pimephales promelas* is from Devlin et al. (1982). The test EC20 value for fish is from Black and Birge (1982). (Refer to the section on benzene.) *Chlorella vulgaris* was used in 10-day tests by Kauss and Hutchinson (1975) to determine the chronic value for aquatic plants.

1,1,1-Trichloroethane. The chronic value and test EC20 value for daphnids are from Thompson and Carmichael (1989). *Daphnia magna* were used in 17-day chronic tests. The chronic value and test EC20 for fish were estimated based on data for *Pimephales promelas* from Alexander et al. (1978) and calculated using Equation (2). The chronic value for aquatic plants is from EPA (1978). *Selenastrum capricornutum* decreased in chlorophyll A and cell numbers in the 96-hour EC50.

1,1,2-Trichloroethane. The chronic value and test EC20 values for fish are from Ahmad et al. (1984) and the chronic and test EC20 values for daphnids are from Richter et al. (1983). The chronic value for fish is based on 32-day embryo-larval tests on *Pimephales promelas*, while the chronic value for daphnids is based on 28-day tests on *Daphnia magna*.

Trichloroethene. The chronic and test EC20 values for fish are from Smith et al. (1991). *Jordanella floridae*, the flagfish, was used in 28-day embryo-larval tests. The chronic value for daphnids is an estimate based on data for *Daphnia pulex* from EPA (1980dd) and calculated using Equation (4).

Vinyl acetate. The chronic and test EC20 values for fish are estimates based on an LC50 for *Pimephales promelas* from AQUIRE calculated using Equations (2) and (5).

Xylene. The chronic value for fish is an estimate based on an LC50 for common carp from AQUIRE and calculated using Equation (2). The test EC20 value for fish is from Black and Birge (1982). (Refer to the section on benzene.)

4. APPLICATION OF BENCHMARKS

Use of these aquatic screening benchmarks requires that the assessor choose which benchmarks to employ and which water concentrations to apply them to. The choice of benchmarks depends on the interpretation of the benchmarks, their regulatory standing, and their degree of conservatism.

Each of the alternative benchmarks has a different interpretation. Exceedances of NAWQC create a regulatory imperative for action under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) because they are ARARS. Exceedance of a Tier II value implies a greater than 20% chance that the NAWQC, if their value were known, would be exceeded. Exceedance of a CV indicates that the field concentration is greater than a concentration dividing statistically insignificant from significant effects in a chronic toxicity test. Exceedance of a test EC20 indicates that biologically significant effects levels were exceeded in a chronic toxicity test. Exceedance of the SS test EC20 indicates that a biologically significant effect level may be exceeded in a sensitive species. Exceedance of a population EC20 indicates that a significant reduction in a largemouth bass population could occur. Therefore, exceedance of either the acute or chronic NAWQC indicates a need for action. Exceedance of an SCV implies a low risk. Exceedance of any of the other benchmarks indicates a risk of real effects that should lead to additional data collection and assessment. However, these inferences all depend on comparison of the benchmarks to appropriate water concentrations.

Contaminant screening is not a regulatory process, but managers at some sites prefer to use only values that have regulatory standing. The NAWQC are clearly regulatory values in that they are ARARS and have been adopted by Tennessee and most other states as water quality standards. Lowest chronic values (the last column in Table 1) have been presented by the EPA in place of NAWQC (EPA 1986b), but they are not criteria. They merely indicate that the EPA believes toxic effects may occur at that concentration. The Tier II values (SAV and SCV) are proposed by the EPA as values that could be used for regulatory enforcement in the Great Lakes (EPA 1993a). They are more conceptually consistent with the NAWQC than lowest chronic values and may come to have the same standing as NAWQC, but currently they are only proposed by the EPA.

OSWER's Ecotox Thresholds and Region IV's screening values (or values proposed by other regions) are alternative benchmark sets derived by the EPA. Both are based on NAWQC values; however, Region IV uses values adjusted to 50 ppm hardness which is unrealistically conservative for most sites, while OSWER adjusts to dissolved-phase concentrations which are not available for most screening assessments. In addition, Region IV uses NAWQCs based on fish marketability which is not relevant to protecting aquatic life. Therefore, the standard EPA Office of Water NAWQC values and FCVs in Table 1 will be more useful in most cases. When NAWQCs are not available, the ETs correspond to SCVs, but some of the SCVs have been superseded by values presented in Table 1 of this document. When NAWQCs are not available, the SVs are based on divisions of lowest toxic values by 10 or 100 which is equivalent to derivation of SAVs and SCVs but is not as scientifically defensible. Therefore, for the Oak Ridge Reservation and many other sites, the NAWQCs and Tier II values listed in Table 1 are generally preferable to either the ETs or SVs.

As discussed in the introduction, the chronic benchmarks are to be used as lower screening benchmarks. The acute NAWQC and SAVs are to be used as upper screening benchmarks. However, because of their conservatism, exceedance of the SAV cannot be taken to indicate that severe effects are likely to be occurring. If an SAV is exceeded, the assessor should examine the acute values used to generate the Tier II values (Appendix A) and judge whether in fact severe effects are likely.

All of these benchmarks are based on toxicity tests conducted in the laboratory. Therefore, they should be compared to water concentrations that are as equivalent as possible to concentrations in test water which is nearly all dissolved. The EPA Office of Water has decided that for metals the appropriate comparison is to concentrations in 0.1 to 0.45 µm filtered ambient water (HECD 1992, Prothro 1993). Acid soluble or even total recoverable concentrations, rather than dissolved concentrations, are often reported because they are required for human health risk assessments. In addition, Region IV and most other EPA regional offices require use of acid soluble concentrations in ecological risk assessments for the sake of conservatism. However, acid soluble concentrations of metals typically include 30 to 95% particle bound material (HECD 1992). Therefore, acid soluble concentrations should be used for aquatic ecological risk assessments to satisfy the regional regulators, but dissolved concentrations should also be used if possible for a realistic screening of the chemicals and to make realistic estimates of risk.

The NAWQC for hardness dependent metals are based on a hardness of 100 mg/L, which is appropriately conservative for ambient waters on the Oak Ridge Reservation. If these benchmarks are applied to a site with hard or soft water, the NAWQC for those metals should be recalculated as recommended by the EPA.

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Appendix A

DATA USED FOR TIER II CALCULATIONS

Table A.1. Data and calculated results for derivation of Tier II values (all values in µg/l). Requirements are listed in App. B.2; other terms are defined in the text

Compound	Genus/species	Requirement[a]	Endpoint	Concentration	GMAV[b]	A C Ratio[c]	Reference
			INORGANICS				
Arsenic V							
	Bosmina longirostris	4	EC50	850	850		Passino and Novak, 1984
	Daphnia pulex	4	LC50	3,600	3,600		Jurewicz and Buikema, 1980
	Gambusia affinis	2,3	LC50	49,000	49,000		Jurewicz and Buikema, 1980
	Morone saxatilis	2,3	LC50	40,500			Palawski et al., 1985
	Morone saxatilis	2,3	LC50	30,500	35,150		Palawski et al., 1985
	Oncorhynchus kisutch	1	LC50	43,600			Buhl and Hamilton, 1990
	Oncorhynchus kisutch	1	LC50	58,500			Buhl and Hamilton, 1990
	Oncorhynchus mykiss	1	LC50	28,000			Palawski et al., 1985
	Oncorhynchus mykiss	1	LC50	67,500	46,860		Buhl and Hamilton, 1990
	Pimephales promelas	2,3	LC50	42,000			Palawski et al., 1985
	Pimephales promelas	2,3	LC50	25,600	32,790		DeFoe, 1982
	Pimephales promelas		CV	892		28.7	DeFoe, 1982
	Thymallus arcticus	1	LC50	5,020			Buhl and Hamilton, 1990
	Thymallus arcticus	1	LC50	5,500	5,255		Buhl and Hamilton, 1990
	Tubifex tubifex	7,8	LC50	127,360	127,360		Fargasova, 1994

Tier II Parameters	Tier II Values
FAVF	12.9
SAV	65.89
SACR	20.95
SCV	3.1

[a] The eight acute data requirements.
[b] Genus Mean Acute Value.
[c] Acute Chronic Ratio.

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A-C Ratio	Reference
Barium	*Daphnia magna*	4	LC50	410,000	410,000		LeBlanc, 1980
	Daphnia magna		EC15	5,800		70.69[a]	Biesinger and Christensen, 1972
	Echinogammarus berilloni	5	LC50	122,000	122,000		Vincent et al., 1986
	Gammarus pulex	5	LC50	238,000	238,000		Vincent et al., 1986
	Potamopyrgus jenkinsi	7,8	LC50	1,700			Vareille Morel, 1990
	Potamopyrgus jenkinsi	7,8	LC50	930			Vareille Morel, 1990
	Potamopyrgus jenkinsi	7,8	LC50	1,800			Vareille Morel, 1990
	Potamopyrgus jenkinsi	7,8	LC50	1,400			Vareille Morel, 1990
	Potamopyrgus jenkinsi	7,8	LC50	1,100			Vareille Morel, 1990
	Potamopyrgus jenkinsi	7,8	LC50	440			Vareille Morel, 1990
	Potamopyrgus jenkinsi	7,8	LC50	330			Vareille Morel, 1990
	Potamopyrgus jenkinsi	7,8	LC50	1,300	976.6		Vareille Morel, 1990

Tier II Parameters	Tier II Values
FAVF	8.6
SAV	113.6
SACR	28.29
SCV	4.0

[a] In the absence of any experimental value, EC15 is used to calculate an A-C ratio.

Table A.1. (continued)

Compound	Genus/species	Requirement	Endpoint	Concentration	GMAV	A-C Ratio	Reference
Beryllium	*Asellus intermedius*	5	LC50	10,000	10,000		Ewell et al., 1986
	Dugesia tigrina	7,8	LC50	10,000	10,000		Ewell et al., 1986
	Gammarus fasciatus	5	LC50	700	700		Ewell et al., 1986
	Helisoma trivolvis	7,8	LC50	10,000	10,000		Ewell et al., 1986
	Lumbriculus variegatus	7,8	LC50	10,000	10,000		Ewell et al., 1986
	Pimephales promelas	2,3	LC50	10,000	10,000		Ewell et al., 1986
	Ambystoma maculatum	2,3	LC50	3,150			Slonim and Ray, 1975
	Ambystoma maculatum	2,3	LC50	18,200			Slonim and Ray, 1975
	Ambystoma maculatum	2,3	LC50	8,020			Slonim and Ray, 1975
	Ambystoma maculatum	2,3	LC50	8,320			Slonim and Ray, 1975
	Ambystoma opacum	2,3	LC50	3,150	4,977		Slonim and Ray, 1975
	Caenorhabditis elegans	7,8	LC50	140	140		Williams and Dusenbery, 1990
	Carassius auratus	2,3	LC50	55,900	55,900		Cardwell et al., 1976
	Daphnia magna	4	EC50	2,410			Kimball n.d.
	Daphnia magna	4	EC50	2,450	2,430		Kimball n.d.
	Daphnia magna		CV	5.267		451.4	Kimball n.d.
	Jordanella floridae	2,3	LC50	45,300			Cardwell et al., 1976
	Jordanella floridae	2,3	LC50	41,100			Cardwell et al., 1976
	Jordanella floridae	2,3	LC50	41,100	42,760		Cardwell et al., 1976
	Pimephales promelas	2,3	LC50	37,900			Cardwell et al., 1976
	Pimephales promelas	2,3	LC50	17,900			Kimball n.d.
	Pimephales promelas	2,3	LC50	17,500	22,810		Kimball n.d.
	Poecilia reticulata	2,3	LC50	1,330			Slonim and Slonim, 1973
	Poecilia reticulata	2,3	LC50	160			Slonim and Slonim, 1973
	Poecilia reticulata	2,3	LC50	190			Slonim and Slonim, 1973

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A:C Ratio	Reference
	Poecilia reticulata	2,3	LC50	1,330	343.2		Slooff and Slooff, 1973
	Tubifex tubifex	7,8	EC50	10,250	10,250		Khangarot, 1991

Tier II Parameters	Tier II Values
FAVF	4.0
SAV	35
SACR	52.88
SCV	0.66

Table A.1. (continued)

Compound	Genus/species	Requirement	Endpoint	Concentration	GMAV	A-C Ratio	Reference
Boron							
	Daphnia magna	4	LC50	133,000			Gersich, 1984
	Daphnia magna		CV	9,330			Gersich, 1984
	Daphnia magna	4	LC50	226,000	173,400		Lewis and Valentine, 1981
	Daphnia magna		CV	8,832		19.10[a]	Lewis and Valentine, 1981
	Ptychocheilus lucius	2,3	LC50	279			Hamilton, 1995
	Ptychocheilus lucius	2,3	LC50	>100			Hamilton, 1995
	Ptychocheilus lucius	2,3	LC50	527	383.4		Hamilton, 1995
	Xyrauchen texanus	2,3	LC50	>100			Hamilton, 1995
	Xyrauchen texanus	2,3	LC50	233			Hamilton, 1995
	Xyrauchen texanus	2,3	LC50	279	255.0		Hamilton, 1995
	Gila elegans	2,3	LC50	>100			Hamilton, 1995
	Gila elegans	2,3	LC50	280			Hamilton, 1995
	Gila elegans	2,3	LC50	552	393.1		Hamilton, 1995

Tier II Parameters	Tier II Values
FAVF	8.6
SAV	29.65
SACR	18.29
SCV	1.6

[a] The A-C Ratio for *D. magna* is the geometric mean of A-C Ratios from Gersich, 1987 and Lewis and Valentine, 1981.

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A-C Ratio	Reference
Cobalt[a]	*Asellus intermedius*	5	LC50	>100,000			Ewell et al., 1986
	Carassius auratus	2.3	LC50	66,800	66,800		Dirg, 1980
	Cyprinus carpio	2.3	LC50	82,700	82,700		Dirg, 1980
	Daphnia magna	4	EC50	6,830			Kimball, 1978
	Daphnia magna	4	EC50	5,150	5,931		Kimball, 1978
	Daphnia magna		CV	5.103		1,162	Kimball, 1978
	Dugesia tigrina	7.8	LC50	25,000	25,000		Ewell et al., 1986
	Gammarus fasciatus	5	LC50	>100,000			Ewell et al., 1986
	Helisoma trivolvis	7.8	LC50	>100,000			Ewell et al., 1986
	Lumbriculus variegatus	7.8	LC50	>100,000			Ewell et al., 1986
	Philodina acuticornis	7.8	EC50	59,000	59,000		Buikema et al., 1974
	Pimephales promelas	2.3	LC50	22,000			Ewell et al., 1986
	Pimephales promelas	2.3	LC50	3,750			Kimball, 1978
	Pimephales promelas	2.3	LC50	3,460	6,534		Kimball, 1978
	Pimephales promelas		CV	285.2		12.59	Kimball, 1978
	Rana hexadactyla	3	LC50	17,590	17,590		Khangarot et al., 1985
	Tubifex tubifex	7.8	EC50	139,320	139,320		Khangarot, 1991

Tier II Parameters	Tier II Values
FAVF	4.0
SAV	1,483
SACR	63.98
SCV	23

[a] All data are for cobalt II.

Table A.1. (continued)

Compound	Genus/species	Requirement	Endpoint	Concentration	GMAV	A:C Ratio	Reference
Lithium							
	Ptychocheilus lucius	2.3	LC50	28,000			Hamilton, 1995
	Ptychocheilus lucius	2.3	LC50	41,000	33,850		Hamilton, 1995
	Xyrauchen texanus	2.3	LC50	53,000			Hamilton, 1995
	Xyrauchen texanus	2.3	LC50	186,000	99,290		Hamilton, 1995
	Gila elegans	2.3	LC50	62,000			Hamilton, 1995
	Gila elegans	2.3	LC50	65,000	63,480		Hamilton, 1995
	Tubifex tubifex	7.8	EC50	9,340	9,340		Khangarot, 1991

Tier II Parameters	Tier II Values
FAVF	36.2
SAV	258.0
SACR	17.9
SCV	14

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A-C Ratio	Reference
Manganese[a]							
	Asellus aquaticus	5	EC50	333,000	333,000		Martin and Holdich, 1986
	Crangonyx pseudogracilis	5	EC50	694,000	694,000		Martin and Holdich, 1986
	Daphnia magna	4	EC50	19,500			Kimball n.d.
	Daphnia magna	4	EC50	19,200	19,350		Kimball n.d.
	Pimephales promelas	2,3	LC50	30,600			Kimball n.d.
	Pimephales promelas	2,3	LC50	36,900	33,600		Kimball n.d.
	Pimephales promelas		CV	1,775		18.93	Kimball n.d.

Tier II Parameters	Tier II Values
FAVF	8.6
SAV	2,250
SACR	18.24
SCV	120

[a] All data are for manganese II

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A-C Ratio	Reference
Mercury, methyl							
	Oncorhynchus mykiss	1	LC50	24	24		Lock and van Overbeeke, 1981
	Salvelinus fontinalis	1	LC50	65			McKim et al., 1976
	Salvelinus fontinalis	1	LC50	84	74		McKim et al., 1976
	Salvelinus fontinalis		CV	0.5193		142.3	McKim et al., 1976

Tier II Parameters	Tier II Values
FAVF	242
SAV	0.09917
SACR	35.72
SCV	0.0028

Table A.1. (continued)

Compound	Genus/species	Requirement	Endpoint	Concentration	GMAV	A:C Ratio	Reference
Molybdenum[a]							
	Daphnia magna	4	LC50	203,200			Kimball n.d.
	Daphnia magna	4	LC50	210,300	206,700		Kimball n.d.
	Daphnia magna		CV	877.8		235.5	Kimball n.d.
	Pimephales promelas	2.3	LC50	628,000	628,000		Kimball n.d.

Tier II Parameters	Tier II Values
FAVF	33.2
SAV	15,660
SACR	42.26
SCV	370

[a] All tests are for molybdenum VI

Table A.1. (continued)

Compound	Genus/species	Requirement	Endpoint	Concentration	GMAV	A:C Ratio	Reference
Strontium							
	Daphnia magna	4	LC50	125,000	125,000		Biesinger and Christensen, 1972
	Daphnia magna		EC16	42,000		2.98[a]	Biesinger and Christensen, 1972
	Tubifex tubifex	7,8	EC50	240,800	240,800		Khangarot, 1991
	Caenorhabditis elegans	7,8	LC50	465,000	465,000		Williams and Dusenbery, 1990

Tier II Parameters	Tier II Values
FAVF	16
SAV	14,530
SACR	9.85
SCV	1,500

[a] In the absence of any experimental chronic values, EC16 is used to calculate an A:C Ratio.

Table A.1. (continued)

Compound	Genus/species	Requirement	Endpoint	Concentration	GMAV	A-C Ratio	Reference
Thallium[a]							
	Daphnia magna	4	EC50	830			Kimball, n.d.
	Daphnia magna	4	LC50	930	905.0		Kimball, n.d.
	Daphnia magna		CV	134.5		6.724	Kimball, n.d.
	Cyprinodon variegatus		LC50	20,900[b]			EPA, 1978
	Cyprinodon variegatus		CV	6,010		3.478	EPA, 1978
	Lepomis macrochirus	2,3	LC50	120,000			Buccafusco et al., 1981
	Lepomis macrochirus	2,3	LC50	132,000	125,900		Dawson et al., 1977
	Pimephales promelas	2,3	LC50	1,810			Kimball, n.d.
	Pimephales promelas	2,3	LC50	1,780	1,795		Kimball, n.d.
	Pimephales promelas		CV	56.92		31.53	Kimball, n.d.

Tier II Parameters	Tier II Values
FAVF	8.6
SAV	105.2
SACR	9.034
SCV	12

[a] All data are for thallium I.

[b] Acute value of *C. variegatus*, a saltwater species, is used for SACR calculation only.

Table A.1. (continued)

Compound	Genus/species	Requirement	Endpoint	Concentration	GMAV	A:C Ratio	Reference
Tin[a]							
	Daphnia magna	4	LC50	55,000	55,000		Biesinger and Christensen, 1972
	Daphnia magna		EC16[b]	350		157.1	Biesinger and Christensen, 1972

Tier II Parameters	Tier II Values
FAVF	20.5
SAV	2,683
SACR	36.93
SCV	73

[a] All data are for tin II.
[b] In the absence of any experimental chronic values, EC16 is used to calculate an A:C Ratio.

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A-C Ratio	Reference
Uranium							
	Salvelinus fontinalis	1	LC50	5,500			Parkhurst et al., 1984
	Salvelinus fontinalis	1	LC50	23,000	11,250		Parkhurst et al., 1984

Tier II Parameters	Tier II Values
FAVF	242
SAV	46.43
SACR	17.9
SCV	2.6

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A C Ratio	Reference
Vanadium[a]							
	Daphnia magna	4	EC50	1,580			Kimball, n.d.
	Daphnia magna	4	EC50	1,450			Kimball, n.d.
	Daphnia magna	4	EC50	3,800			Beusen & Neven, 1987
	Daphnia magna	4	EC50	2,900			Beusen & Neven, 1987
	Daphnia magna	4	EC50	3,900			Beusen & Neven, 1987
	Daphnia magna	4	EC50	3,600			Beusen & Neven, 1987
	Daphnia magna	4	EC50	3,300	2,746		Beusen & Neven, 1987
	Daphnia magna		CV	1900		2[b]	Beusen & Neven, 1987
	Gila elegans	2,3	LC50	8,400			Hamilton, 1995
	Gila elegans	2,3	LC50	4,000			Hamilton, 1995
	Gila elegans	2,3	LC50	3,000	4,727		Hamilton, 1995
	Jordanella floridae	2,3	LC50	11,200	11,200		Holdway and Sprague, 1979
	Jordanella floridae		CV	83.49		134.1	Holdway and Sprague, 1979
	Oncorhynchus tshawytscha	1	LC50	16,500	16,500		Hamilton and Buhl, 1990
	Pimephales promelas	2,3	LC50	1,830			Kimball, n.d.
	Pimephales promelas	2,3	LC50	1,900	1,850		Kimball, n.d.
	Pimephales promelas		CV	169.7		10.90	Kimball, n.d.
	Ptychocheilus lucius	2,3	LC50	7,800			Hamilton, 1995
	Ptychocheilus lucius	2,3	LC50	3,800			Hamilton, 1995
	Ptychocheilus lucius	2,3	LC50	4,300	5,032		Hamilton, 1995
	Salvelinus fontinalis	1	LC50	7,000			Ernst and Garside, 1987
	Salvelinus fontinalis	1	LC50	15,000	10,250		Ernst and Garside, 1987
	Xyrauchen texanus	2,3	LC50	5,300			Hamilton, 1995

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A:C Ratio	Reference
	Xyrauchen texanus	2,3	LC50	2,200			Hamilton, 1995
	Xyrauchen texanus	2,3	LC50	4,600	3,770		Hamilton, 1995

Tier II Parameters	Tier II Values
FAVF	6.5
SAV	284.6
SACR	14.29
SCV	20

[a] All data are for vanadium V.

[b] Since the experimental A:C Ratio is less than 2, the A:C Ratio of *D. magna* is set to 2 (Stephan et al., 1985).

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A-C Ratio	Reference
Zirconium							
	Oncorhynchus mykiss	1	LC50	20,000	20,000		Couture et al., 1989
	Tubifex tubifex	7,8	EC50	221,180	221,180		Khangarot, 1991

Tier II Parameters	Tier II Values
FAVF	64.8
SAV	303.6
SACR	17.9
SCV	17

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A-C Ratio	Reference
			ORGANICS				
Acetone	*Asellus intermedius*	5	LC50	>100,000	>100,000		Ewell et al., 1986
	Ceriodaphnia dubia	4	LC50	8,098,000	8,098,000		Cowgill and Milazzo, 1991
	Chironomus tentans	6	LC50	45,900,000	45,900,000		Ziegenfuss et al., 1986
	Corbicula manilensis	7,8	LC50	20,000,000	20,000,000		Chandler and Marking, 1979
	Daphnia magna	4	EC50	13,500,000	13,500,000		Randall and Knopp, 1980
	Daphnia magna	4	LC50	30,640[a]			LeBlanc and Surprenant, 1983
	Daphnia magna		CV	1,556		19.69	LeBlanc and Surprenant, 1983
	Dugesia tigrina	7,8	LC50	>100,000	>100,000		Ewell et al., 1986
	Gammarus fasciatus	5	LC50	>100,000	>100,000		Ewell et al., 1986
	Helisoma trivolvis	7,8	LC50	>100,000	>100,000		Ewell et al., 1986
	Lepomis macrochirus	2,3	LC50	8,300,000	8,300,000		Cairns and Scheier, 1968
	Lumbriculus variegatus	7,8	LC50	>100,000	>100,000		Ewell et al., 1986
	Oncorhynchus mykiss	1	LC50	5,540,000	5,540,000		Johnson and Finley, 1980
	Pimephales promelas	2,3	EC50	7,280,000			Brooke et al., 1984
	Pimephales promelas	2,3	EC50	8,120,000			Brooke et al., 1984
	Pimephales promelas	2,3	EC50	6,210,000	7,160,000		Brooke et al., 1984

Tier II Parameters	Tier II Values
FAVF	3.6
SAV	27,780
SACR	18.43
SCV	1500

[a] Since the acute test was part of the same study as the chronic test, the acute value was used to derive an ACR for *D. magna*. The LC50 value was not used as part of GMAV because EC50 for immobilization is available.

Table A.1. (continued)

Compound	Genus/species	Requirement	Endpoint	Concentration	GMAV	A-C Ratio	Reference
Anthracene							
	Daphnia magna	4	EC50	95			Munoz and Tarazona, 1993
	Daphnia pulex	4	EC50	754	267.6		Smith et al., 1988

Tier II Parameters	Tier II Values
FAVF	20.5
SAV	13.06
SACR	17.9
SCV	0.73

Table A.1. (continued)

Compound	Genus/species	Requirement	Endpoint	Concentration	GMAV	A-C Ratio	Reference
Benzene							
	Asellus aquaticus	5	LC50	254,000	254,000		Erben and Pisl, 1993
	Carassius auratus	2,3	LC50	34,420	34,420		Pickering and Henderson, 1966
	Chironomus thummi	6	LC50	100,000	100,000		Slooff, 1983
	Cottus cognatus	2,3	LC50	13,500	13,500		Moles et al., 1979
	Daphnia magna	4	LC50	200,000			LeBlanc, 1980
	Daphnia magna	4	LC50	400,000			Canton and Adema, 1978
	Daphnia magna	4	LC50	620,000			Canton and Adema, 1978
	Daphnia magna	4	LC50	412,000			Canton and Adema, 1978
	Daphnia magna	4	LC50	356,000			Canton and Adema, 1978
	Daphnia magna	4	LC50	412,000			Canton and Adema, 1978
	Daphnia magna	4	LC50	356,000	376,200		Canton and Adema, 1978
	Daphnia pulex	4	LC50	345,000			Canton and Adema, 1978
	Daphnia pulex	4	LC50	265,000	302,400		Canton and Adema, 1978
	Gasterosteus aculeatus	2,3	LC50	21,500	21,800		Moles et al., 1979
	Ictalurus punctatus	2,3	LC50	425,000	425,000		Johnson and Finley, 1980
	Lepomis macrochirus	2,3	LC50	22,490	22,490		Pickering and Henderson, 1966
	Oncorhynchus gorbuscha	1	LC50	4,630			Moles et al., 1979
	Oncorhynchus kisutch	1	LC50	12,350			Moles et al., 1979
	Oncorhynchus mykiss	2,3	LC50	5,300			DeGraeve et al., 1982
	Oncorhynchus mykiss	1	LC50	21,600			Hodson et al., 1984
	Oncorhynchus nerka	1	LC50	9,430			Moles et al., 1979
	Oncorhynchus tshawytscha	1	LC50	10,250	9,003		Moles et al., 1979
	Pimephales promelas	2,3	LC50	24,600			Geiger et al. 1990

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A-C Ratio	Reference
	Pimephales promelas	2,3	LC50	12,600	17,600		Geiger et al, 1990
	Poecilia reticulata	2,3	LC50	36,600			Pickering and Henderson, 1966
	Poecilia reticulata	2,3	LC50	23,600	32,350		Galassi et al., 1988
	Salvelinus malma	2,3	LC50	10,430			Moles et al., 1979
	Salvelinus malma	2,3	LC50	10,450	10,450		Moles et al., 1979
	Thymallus arcticus	2,3	LC50	12,890	12,890		Moles et al., 1979

Tier II Parameters	Tier II Values
FAVF	4.0
SAV	2,252
SACR	17.9
SCV	130

Table A.1. (continued)

Compound	Genus/species	Requirement	Endpoint	Concentration	GMAV	A:C Ratio	Reference
Benzidine							
	Daphnia magna	4	EC50	600	600		Kuhn et al., 1989
	Oncorhynchus mykiss	1	LC50	7,400	7,400[a]		EPA, 1980c
	Salmo trutta lacustris	1	LC50	4,350	4,350[a]		EPA, 1980c
	Notropis lutrensis	2,3	LC50	2,500	2,500[a]		EPA, 1980c

Tier II Parameters	Tier II Values
FAVF	8.6
SAV	69.77
SACR	17.9
SCV	3.9

[a] The EPA criteria document was cited because the data come from an EPA internal investigation, which was not available.

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A/C Ratio	Reference
Benzo(a)anthracene							
	Daphnia pulex	4	LC50 MOR	10[a]	10		Trucco et al., 1983

Tier II Parameters	Tier II Values
FAVF	20.5
SAV	0.4578
SACR	17.9
SCV	0.027

[a] The test was based on a non-standard, but conservative, exposure of 96 hours. The standard exposure is 48 hr for daphnids. The length of the Daphnid is 1.9-2.1 mm; the age of the Daphnid species is not available.

Table A.1. (continued)

Compound	Genus/species	Requirement	Endpoint	Concentration	GMAV	A-C Ratio	Reference
Benzo(a)pyrene							
	Daphnia pulex	4	LC50 SSOR	5*	5		Trucco et al., 1983

Tier II Parameters	Tier II Values
FAVF	20.5
SAV	0.2439
SACR	17.9
SCV	0.014

*The test was based on a non standard, but conservative, exposure of 96 hours. The standard exposure is 48 hr for daphnids.
The length of the Daphnid is 1.9-2.1 mm; the age of the Daphnid species is not available.

Table A.1. (continued)

Compound	Genus/species	Requirement	Endpoint	Concentration	GMAV	A-C Ratio	Reference
Benzoic acid							
	Gambusia affinis	2.3	LC50	180,000[a]	180,000		Wallen et al., 1957

Tier II Parameters	Tier II Values
FAVF	242
SAV	743.8
SACR	17.9
SCV	42

[a]Done in turbid water.

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A:C Ratio	Reference
Benzyl alcohol							
	Lepomis macrochirus	2,3	LC50	10,000	10,000		Dawson et al., 1977
	Pimephales promelas	2,3	LC50	460,000	460,000		Mattson et al., 1976

Tier II Parameters	Tier II Values
FAVF	64.8
SAV	154.3
SACR	17.9
SCV	8.6

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A:C Ratio	Reference
BHC (other than Lindane)							
	Daphnia magna	4	EC50	800	800		Carson et al., 1975

Tier II Parameters	Tier II Values
FAVF	20.5
SAV	39.02
SACR	17.9
SCV	2.2

Table A.1. (continued)

Compound	Genus/species	Requirement	Endpoint	Concentration	GMAV	A:C Ratio	Reference
Bis(2-ethylhexyl) phthalate							
	Chironomus plumosus	6	EC50	>18,000			Streufert et al., 1980
	Daphnia pulex	4	EC50	133	133		LeBlanc, 1980
	Daphnia magna	4	LC50	2,000*			Adams & Heidolph, 1985
	Daphnia magna		CV	912		2.193	Adams & Heidolph, 1985
	Gammarus pseudolimnaeus	4	LC50	>32,000			Sanders et al., 1973
	Gasterosteus aculeatus	2,3	LC50	>300			van den Dikkenberg et al., 1989
	Ictalurus punctatus	2,3	LC50	>100,000			Johnson and Finley, 1980
	Jordanella floridae	2,3	LC50	>320			Adema et al., 1981
	Lepomis macrochirus	2,3	LC50	>770,000			Buccafusco et al., 1981
	Lepomis macrochirus	2,3	LC50	>100,000			Johnson and Finley, 1980
	Oncorhynchus kisutch	1	LC50	>100,000			Johnson and Finley, 1980
	Oncorhynchus mykiss	1	LC50	>320			Adams et al., 1995
	Pimephales promelas	2,3	LC50	>670			Adams et al., 1995
	Pimephales promelas	2,3	LC50	>160			Adams et al., 1995
	Rana pipiens	3	LC50	4,440	4,440		Birge et al., 1978

Tier II Parameters	Tier II Values
FAVF	5.0
SAV	26.60
SACR	8.890
SCV	3.0

* This LC50 was used to calculate the A:C ratio, but not the GMAV because an EC50 was available.

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A C Ratio	Reference
2-Butanone							
	Daphnia magna	4	EC50	5,091,000	5,091,000		Randall and Knopp, 1980
	Pimephales promelas	2.3	LC50	3,200,000	3,200,000		Veith et al. 1983

Tier II Parameters	Tier II Values
FAVF	13.2
SAV	242,430
SACR	17.9
SCV	14,000

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A:C Ratio	Reference
Carbon disulfide*							
	Poecilia reticulata	2.3	LC50 MOR	4,000	4,000		Van Leeuwen et al., 1985

Tier II Parameters	Tier II Values
FAVF	242
SAV	16.53
SACR	17.9
SCV	0.92

*Although carbon disulfide is a volatile compound, static test was used because flow-through, measured tests are not available.

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A C Ratio	Reference
Carbon tetrachloride[a]	*Pimephales promelas*	2.3	LC50	41,400			Geiger et al., 1990
	Pimephales promelas	2.3	LC50	43,300			Kimball, n.d.
	Pimephales promelas	2.3	LC50	42,900	42,530		Kimball, n.d.

Tier II Parameters	Tier II Values
FAVF	242
SAV	175.7
SACR	17.9
SCV	9.8

[a] Because carbon tetrachloride is a volatile compound, only flow through, measured tests were used.

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A-C ratio	Reference
Chlorobenzene							
	Carassius auratus	2,3	LC50	51,620	51,620		Pickering and Henderson, 1966
	Ceriodaphnia dubia	4	LC50	7,900[a]			Cowgill et al., 1985
	Ceriodaphnia dubia	4	LC50	7,900[a]			Cowgill et al., 1985
	Ceriodaphnia dubia	4	LC50	11,400[a]	8,927		Cowgill et al., 1985
	Daphnia magna	4	LC50	86,000			LeBlanc, 1980
	Daphnia magna	4	LC50	13,000[a]			Cowgill et al., 1985
	Daphnia magna	4	LC50	10,700[a]			Cowgill et al., 1985
	Daphnia magna	4	LC50	15,400[a]	116,500		Cowgill et al., 1985
	Lepomis macrochirus	2,3	LC50	7,400	7,400		Bailey et al., 1985
	Oncorhynchus mykiss	1	LC50	7,460	7,460		Hodson et al., 1984
	Pimephales promelas	2,3	LC50	16,900	16,900		Geiger et al., 1990
	Poecilia reticulata	2,3	LC50	45,530	45,530		Pickering and Henderson, 1966

Tier II Parameters	Tier II Values
FAVF	6.5
SAV	1,138
SACR	17.9
SCV	64

[a] Author indicated both *D. magna* and *C. dubia/affinis* are less sensitive to chlorobenzene at 24°C than at 20°C; thus, tests with 20°C were used to established a conservative estimate of the effect of chlorobenzene.

Table A.1. (continued)

Compound	Genus/species	Requirement	Endpoint	Concentration	GMAV	A C Ratio	Reference
Chloroform[a]	*Ictalurus punctatus*	2,3	LC50	75,000	75,000		Anderson and Lusty, 1980
	Lepomis macrochirus	2,3	LC50	16,200			Anderson and Lusty, 1980
	Lepomis macrochirus	2,3	LC50	22,300			Anderson and Lusty, 1980
	Lepomis macrochirus	2,3	LC50	13,300			Anderson and Lusty, 1980
	Lepomis macrochirus	2,3	LC50	18,300			Anderson and Lusty, 1980
	Lepomis macrochirus	2,3	LC50	20,800	17,830		Anderson and Lusty, 1980
	Micropterus salmoides	2,3	LC50	55,800			Anderson and Lusty, 1980
	Micropterus salmoides	2,3	LC50	52,500			Anderson and Lusty, 1980
	Micropterus salmoides	2,3	LC50	45,400	51,040		Anderson and Lusty, 1980
	Oncorhynchus mykiss	1	LC50	18,200			Anderson and Lusty, 1980
	Oncorhynchus mykiss	1	LC50	18,400			Anderson and Lusty, 1980
	Oncorhynchus mykiss	1	LC50	22,100			Anderson and Lusty, 1980
	Oncorhynchus mykiss	1	LC50	15,100			Anderson and Lusty, 1980
	Oncorhynchus mykiss	1	LC50	17,100	18,040		Anderson and Lusty, 1980
	Pimephales promelas	2,3	EC50	70,700	70,700		Geiger et al., 1990

Tier II Parameters	Tier II Values
FAVF	36.2
SAV	493.9
SACR	17.9
SCV	28

[a] Because chloroform is a volatile compound, only flow through, measured tests were used.

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A-C Ratio	Reference
p,p-DDD	*Asellus brevicaudus*	5	LC50	10			Sanders, 1972
	Asellus brevicaudus	5	LC50	16	12.65		Mayer and Ellersieck, 1986
	Bufo woodhousei	3	LC50	140	140		Sanders, 1970
	Cypridopsis vidua	5	EC50	45	45		Mayer and Ellersieck, 1986
	Daphnia pulex	4	EC50	3.2	3.2		Mayer and Ellersieck, 1986
	Gammarus fasciatus	5	LC50	0.6			Sanders, 1972
	Gammarus fasciatus	5	LC50	0.86			Sanders, 1972
	Gammarus lacustris	5	LC50	0.64	0.68		Sanders, 1969
	Ictalurus punctatus	2,3	LC50	1,500	15,000		Mayer and Ellersieck, 1986
	Ischnura verticalis	6	LC50	34	34		Mayer and Ellersieck, 1986
	Micropterus salmoides	2,3	LC50	42	42		Mayer and Ellersieck, 1986
	Oncorhynchus mykiss	1	LC50	70	72		Mayer and Ellersieck, 1986
	Palaemonetes kadiakensis	5	LC50	0.68			Sanders, 1972
	Palaemonetes kadiakensis	5	LC50	2.4	1.3		Mayer and Ellersieck, 1986
	Pimephales promelas	2,3	LC50	4,400	4,400		Mayer and Ellersieck, 1986
	Polycelis felina	7,8	LC50	740	740		Kouyoumjian and Uglow, 1974
	Pseudacris triseriata	3	LC50	400	400		Sanders, 1970
	Pteronarcys californica	6	LC50	380	380		Sanders and Cope, 1968
	Simocephalus serrulatus	4	EC50	4.5	4.5		Mayer and Ellersieck, 1986
	Stizostedion vitreum	2,3	LC50	14	14		Mayer and Ellersieck, 1986

Tier II Parameters	Tier II Values
FAVF	3.6
SAV	0.1889
SACR	17.9
SCV	0.011

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A-C Ratio	Reference
Decane[a]							
	Daphnia magna	4	LC50	18,000	18,000		LeBlanc, 1980

Tier II Parameters	Tier II Values
FAVF	20.5
SAV	878.0
SACR	17.9
SCV	49

[a] Although decane is a volatile compound, static test was used because flow through tests were not available.

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A-C ratio	Reference
Di n butyl phthalate							
	Chironomus plumosus	6	EC50	760	760		Streufert et al., 1980
	Daphnia magna	4	EC50	5200	5200		McCarthy and Whitmore, 1985
	Daphnia magna		CV	1004		5.179	McCarthy and Whitmore, 1985
	Gammarus pseudolimnaeus	5	LC50	2100	2100		Johnson and Finley, 1980
	Ictalurus punctatus	2,3	LC50	2900	2900		Johnson and Finley, 1980
	Lepomis macrochirus	2,3	LC50	1200			Buccafusco et al., 1981
	Lepomis macrochirus	2,3	LC50	700	916.5		Johnson and Finley, 1980
	Oncorhynchus mykiss	1	LC50	1600	1600		Adams et al., 1995
	Oncorhynchus mykiss		CV	137.8[a]		11.61	Rhodes et al., 1995
	Orconectes nais	5	LC50	10000	10000		Johnson and Finley, 1980
	Pimephales promelas	2,3	LC50	1100			Geiger et al., 1985
	Pimephales promelas	2,3	LC50	850			Geiger et al., 1985
	Pimephales promelas	2,3	LC50	2020[a]			McCarthy and Whitmore, 1985
	Pimephales promelas	2,3	LC50	920	1148		Adams et al., 1995
	Pimephales promelas		CV	745.3		2.699	McCarthy and Whitmore, 1985

Tier II Parameters	Tier II Values
FAVF	4.0
SAV	190.0
SACR	5.455
SCV	35

[a] Length of the test is 60 d post hatch (99 d exposure); the National Guidelines recommend 90 d post hatch for salmonids.

Table A.1. (continued)

[b] Authors note toxicity is hardness (44-272 ppm) and pH (6.5-9.0) independent; no further data are available.
[c] Derived from range finding test.
[d] ACR derived from acute test of larval fathead minnows is the only test available as part of the same study as the chronic test. The National Guidelines recommend using juvenile fish for deriving ACR.
[e] Because of an accident during the experiment, length of the test is 20 d post hatch; the National Guidelines recommend 28-32 d post hatch for fish other than salmonids. However, the authors note since a larger number of fish died at 1.0 mg/L, "no evidence that additional exposure time would have produced any meaningful result".

Table A.1. (continued)

Compound	Genus/species	Requirement	Endpoint	Concentration	GMAV	A C Ratio	Reference
Dibenzofuran							
	Daphnia magna	4	LC50	1,700	1,700		LeBlanc, 1980
	Pimephales promelas	2,3	EC50	780			Geiger et al., 1988
	Pimephales promelas	2,3	EC50	980	874.3		Geiger et al., 1988

Tier II Parameters	Tier II Values
FAVF	13.2
SAV	66.23
SACR	17.9
SCV	3.7

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A C Ratio	Reference
1,1 Dichloroethane[a]							
	Poecilia reticulata	2.3	LC50	202,000	202,000		Könemann, 1981

Tier II Parameters	Tier II Values
FAVF	242
SAV	834.7
SACR	17.9
SCV	47

[a] Although 1,1 dichloroethane is a volatile compound, static test was used because flow through test is not available.

Table A.1. (continued)

Compound	Genus/species	Requirement	Endpoint	Concentration	GMAV	A-C ratio	Reference
1,2 Dichloroethane[a]							
	Daphnia magna	4	EC50	160,000	160,000		Richter et al., 1983
	Pimephales promelas	2,3	LC50	116,000	116,000		Walbridge et al., 1983
	Pimephales promelas		CV	41,360		2.804	Benoit et al. 1985

Tier II Parameters	Tier II Values
FAVF	13.2
SAV	8,785
SACR	9.649
SCV	910

[a] Because 1,2 Dichloroethane is a volatile compound, only flow through, measured tests were used (static, measured tests for Daphnids).

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A-C Ratio	Reference
1,1 Dichloroethene[a]							
	Pimephales promelas	2.3	LC50 MOR	108,000	108,000		Dill et al., 1980

Tier II Parameters	Tier II Values
FAVF	242
SAV	446.3
SACR	17.9
SCV	25

[a] Although 1,1 dichloroethene is a volatile compound, static test is used because flow-through, measured tests are not available.

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A:C Ratio	Reference
1,2 Dichloroethene[a]							
	Lepomis macrochirus	2,3	LC50	140,000	140,000		Buccafusco, 1981
	Daphnia magna	4	LC50	220,000	220,000		LeBlanc, 1980

Tier II Parameters	Tier II Values
FAVF	13.2
SAV	10,610
SACR	17.9
SCV	590

[a] Although 1,2 dichloroethene is a volatile compound, static tests were used because flow through, measured tests are not available.

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A-C Ratio	Reference
1,3 Dichloropropene[a]							
	Pimephales promelas	2.3	EC50	239	239		Geiger et al., 1990

Tier II Parameters	Tier II Values
FAVF	242
SAV	0.5376
SACR	17.9
SCV	0.055

a Because 1,3 dichloropropene is a volatile compound, only flow through measured test was used.

Table A.1. (continued)

Compound	Genus/species	Requirement	Endpoint	Concentration	GMAV	A-C Ratio	Reference
Diethyl phthalate							
	Daphnia magna	4	EC50	86,000	86,000		Adams et al., 1995
	Daphnia magna		CV	33,410		2.239	Rhodes et al., 1995
	Lepomis macrochirus	2,3	LC50	16,700	16,700		Adams et al., 1995
	Pimephales promelas	2,3	LC50	31,800			Geiger et al., 1985
	Pimephales promelas	2,3	LC50	17,000	23,250		Adams et al., 1995
	Oncorhynchus mykiss	1	LC50	12,000	12,000		Adams et al., 1995

Tier II Parameters	Tier II Values
FAVF	6.5
SAV	1,845
SACR	8.952
SCV	210

Table A.1. (continued)

Compound	Genus/species	Requirement	Endpoint	Concentration	GMAV	A-C Ratio	Reference
Ethylbenzene[a]							
	Pimephales promelas	2,3	EC50	8,450	8,450		Geiger et al., 1990
	Poecilia reticulata	2,3	LC50	9,600	9,600		Galassi et al., 1988

Tier II Parameters	Tier II Values
FAVF	64.8
SAV	130.4
SACR	17.9
SCV	7.3

[a] Because ethylbenzene is a volatile compound, only flow-through, measured tests were used.

Table A.1. (continued)

Compound	Genus/species	Requirement	Endpoint	Concentration	GMAV	A:C Ratio	Reference
Hexane							
	Pimephales promelas	23	EC50	2,500	2,500		Geiger et al., 1990

Tier II Parameters	Tier II Values
FAVF	242
SAV	10.33
SACR	17.9
SCV	0.53

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A C Ratio	Reference
2 Hexanone							
	Pimephales promelas	2,3	LC50	428,000	428,000		Geiger et al., 1986

Tier II Parameters	Tier II Values
FAVF	242
SAV	1,769
SACR	17.9
SCV	99

Table A.1. (continued)

Compound	Genus/species	Requirement	Endpoint	Concentration	GMAV	A-C Ratio	Reference
1-Methylnaphthalene							
	Pimephales promelas	2,3	EC50	9,000	9,000		Mattson et al., 1976

Tier II Parameters	Tier II Values
FAVF	242
SAV	37.19
SACR	17.9
SCV	2.1

Table A.1. (continued)

Compound	Genus/species	Requirement	Endpoint	Concentration	GMAV	A-C Ratio	Reference
4-Methyl-2-pentanone							
	Pimephales promelas	2,3	LC50	540,000			Brooke et al., 1984
	Pimephales promelas	2,3	LC50	505,000	522,200		Veith et al., 1983a
	Pimephales promelas		CV	77,360		6.750	Call et al., 1985

Tier II Parameters	Tier II Values
FAVF	242
SAV	2,158
SACR	12.93
SCV	170

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A-C Ratio	Reference
2-Methylphenol							
	Carassius auratus	2,3	LC50 MOR	23,250	23,250		Pickering and Henderson, 1966
	Lepomis macrochirus	2,3	LC50 MOR	20,780	20,780		Pickering and Henderson, 1966
	Oncorhynchus mykiss	1	LC50 MOR	8,400	8,400		DeGraeve et al., 1980
	Pimephales promelas	2,3	LC50	14,000			Geiger et al., 1990
	Pimephales promelas	2,3	LC50	18,200	15,960		DeGraeve et al., 1980
	Poecilia reticulata	2,3	LC50	18,850	18,850		Pickering and Henderson, 1966

Tier II Parameters	Tier II Values
FAVF	36.2
SAV	232.0
SACR	17.9
SCV	13

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A-C Ratio	Reference
Methylene chloride							
	Daphnia magna	4	LC50 MOR	220,000	220,000		LeBlanc, 1980
	Lepomis macrochirus	2,3	LC50 MOR	220,000	220,000		Bucciafusco et al., 1981
	Pimephales promelas	2,3	EC50	330,000	330,000		Geiger, 1986
	Pimephales promelas		LC50 MOR	502,000[a]			Dill et al., 1987
	Pimephales promelas		CV	108,540		4.625	Dill et al., 1987

Tier II Parameters	Tier II Values
FAVF	8.6
SAV	25,550
SACR	11.40
SCV	2,200

[a] The LC50 value is used to calculate the ACR because it is part of the same study as the chronic test; but it is not used to determine the GMAV of *Pimephales* sp. because an EC50 is available.

Table A.1. (continued)

Compound	Genus/species	Requirement	Endpoint	Concentration	GMAV	A-C ratio	Reference
Napthalene							
	Daphnia magna	4	EC50	2,194			Munoz and Tarazona, 1993
	Daphnia pulex	4	EC50	4,663	3,199		Smith et al., 1988
	Oncorhynchus mykiss	1	LC50	1,600	1,600		DeGraeve et al., 1982
	Pimephales promelas	2,3	LC50	6,140			Geiger et al., 1985
	Pimephales promelas	2,3	LC50	7,900	6,965		DeGraeve et al., 1982
	Pimephales promelas		CV	619		12.77	DeGraeve et al., 1982

Tier II Parameters	Tier II Values
FAVF	8.6
SAV	186.0
SACR	15.96
SCV	12

Table A.1. (continued)

Compound	Group/Species	Requirement	Endpoint	Concentration	GMAV	A-C Ratio	Reference
4-Nitrophenol							
	Daphnia magna	4	EC50	7,650			Keen and Ballard, 1985
	Daphnia magna	4	EC50	4,700	6,008		Kuhn et al., 1989
	Daphnia magna		CV	7,071		2[a]	Kuhn et al., 1989
	Gammarus pseudolimnaeus	5	LC50	6,550	6,550		Howe et al., 1994
	Ictalurus punctatus	2,3	LC50	15,000	15,000		Holcombe et al., 1984
	Lepomis macrochirus	2,3	LC50	8,300	8,300		Buccafusco et al., 1981
	Oncorhynchus mykiss	1	LC50	7,900	7,900		Hodson et al., 1984
	Oncorhynchus mykiss		CV	989.1		7.987	Hodson et al., 1991
	Pimephales promelas	2,3	LC50	59,000			Phipps et al., 1981
	Pimephales promelas	2,3	LC50	62,000			Phipps et al., 1981
	Pimephales promelas	2,3	LC50	41,000			Holcombe et al., 1984
	Pimephales promelas	2,3	LC50	37,300			Geiger et al., 1985
	Pimephales promelas	2,3	LC50	41,000			Geiger et al., 1985
	Pimephales promelas	2,3	LC50	53,600	48,760		Geiger et al., 1985

Tier II Parameters	Tier II Values
FAVF	5.0
SAV	1,202
SACR	3.997
SCV	300

[a] Since the experimental A-C Ratio was less than 2, the A-C Ratio of *D. magna* is set to 2 (Stephan et al. 1985).

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A-C Ratio	Reference
N-Nitrosodiphenylamine							
	Daphnia magna	4	LC50	7,800	7,800		LeBlanc, 1980

Tier II Parameters	Tier II Values
FAVF	20.5
SAV	380.5
SACR	17.9
SCV	21.3

Table A.1. (continued)

Compound	Genus/species	Requirement	Endpoint	Concentration	GMAV	A:C Ratio	Reference
2-Octanone[a]							
	Pimephales promelas	2,3	EC50	36,000	36,000		Brooke, 1984

Tier II Parameters	Tier II Values
FAVF	242
SAV	145.8
SACR	17.9
SCV	8.3

[a]Because 3-Octanone tests do not have standardized exposure, 2-Octanone tests, which have the standard exposure, were used

Table A.1. (continued)

Compound	Genus/species	Requirement	Endpoint	Concentration	GMAV	A:C Ratio	Reference
PCBs: total							
	Pimephales promelas					9.443	Nebeker et al., 1974

Tier I Parameters	Tier I Values	
FAV	2.0	EPA, 1980a

Tier II Parameters	Tier II Values
SACR	14.64
SCV	0.14

Table A.1. (continued)

Compound	Genus/species	Requirement	Endpoint	Concentration	GMAV	A:C Ratio	Reference
PCBs: Aroclor® 1221							
	Oncorhynchus clarki	1	LC50	1,200			Mayer et al., 1977

Tier II Parameters	Tier II Values
FAVF	242
SAV	4.959
SACR	17.9
SCV	0.28

Table A.1. (continued)

Compound	Genus/species	Requirement	Endpoint	Concentration	GMAV	A C Ratio	Reference
PCBs: Aroclor® 1232							
	Oncorhynchus clarki	1	LC50	2,500			Johnson and Finley, 1980

Tier II Parameters	Tier II Values
FAVF	242
SAV	10.33
SACR	17.9
SCV	0.58

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A-C Ratio	Reference
PCBs: Aroclor® 1242							
	Gammarus pseudolimnaeus	5	LC50	72			Nebeker and Puglisi, 1974
	Gammarus pseudolimnaeus	5	LC50	74	72.99		Nebeker and Puglisi, 1974
	Ictalurus punctatus	2,3	LC50	>100			Johnson and Finley, 1980
	Ischnura verticalis	7,8	LC50	400	400		Mayer et al., 1977
	Oncorhynchus clarki	1	LC50	5,400	5,400		Mayer et al., 1977
	Perca flavescens	2,3	LC50	>150			Johnson and Finley, 1980
	Pimephales promelas	2,3	LC50	15	15		Nebeker et al., 1974
	Pimephales promelas		LC50	300a			Nebeker et al., 1974
	Pimephales promelas		CV	9,000		33.33	Nebeker et al., 1974

Tier II Parameters	Tier II Values
FAV	12.9
SAV	1.163
SACR	22.02
SCV	0.053

a Because this value is more than ten times of another life stage, it is not used in the GMAV calculation. However, since the preferred life stage in deriving the A-C Ratio is juvenile, it is used in A-C Ratio derivation.

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A-C Ratio	Reference
PCBs: Aroclor® 1248							
	Gammarus pseudolimnaeus	5	LC50 MOR	29	29		Nebeker and Puglisi, 1974
	Ictalurus punctatus	2,3	LC50 MOR	>100			Johnson and Finley, 1980
	Lepomis macrochirus	2,3	LC50 MOR	278			Stalling and Mayer, 1972
	Lepomis macrochirus	2,3	LC50	690	438.0		Johnson and Finley, 1980
	Oncorhynchus clarki	1	LC50	5,750	5,750		Johnson and Finley, 1980
	Perca flavescens	2,3	LC50	>100			Johnson and Finley, 1980

Tier II Parameters	Tier II Values
FAVF	20.1
SAV	1.443
SACR	17.9
SCV	0.081

Table A.1. (continued)

Compound	Genus/species	Requirement	Endpoint	Concentration	GMAV	A/C Ratio	Reference
PCBs: Aroclor® 1254							
	Coregonus hoyi	1	LC50	>10,000			Passino and Kramer, 1980
	Gammarus fasciatus	5	LC50	2,400	2,400		Johnson and Finley, 1980
	Ictalurus punctatus	2,3	LC50	>200			Johnson and Finley, 1980
	Ischnura verticalis	6	LC50	200	200		Mayer et al., 1977
	Lepomis macrochirus	2,3	LC50	2,740	2,740		Johnson and Finley, 1980
	Oncorhynchus clarki	1	LC50	42,500	42,500		Johnson and Finley, 1980
	Orconectes nais	5	LC50	100	100		Johnson and Finley, 1980
	Perca flavescens	2,3	LC50	>150			Johnson and Finley, 1980
	Pimephales promelas	2,3	LC50	7.7	7.7		Nebeker et al., 1974
	Pimephales promelas		CV	2.878		2.676	Nebeker et al., 1974

Tier II Parameters	Tier II Values
FAVF	12.9
SAV	0.5969
SACR	17.9
SCV	0.033

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A-C Ratio	Reference
PCBs: Aroclor® 1260							
	Ictalurus punctatus	2,3	LC50	>400			Johnson and Finley, 1980
	Lepomis macrochirus	2,3	LC50	>400			Johnson and Finley, 1980
	Oncorhynchus clarki	1	LC50	61,000	61,000		Mayer et al., 1977
	Perca flavescens	2,3	LC50	>300			Johnson and Finley, 1980

Tier II Parameters	Tier II Values
FAVF	36.2
SAV	1,685
SACR	17.9
SCV	94

Table A.1. (continued)

Compound	Genus/species	Requirement	Endpoint	Concentration	GMAV	A-C ratio	Reference
1 Pentanol[a]							
	Pimephales promelas	2.3	LC50	472,000	472,000		Geiger et al., 1986

Tier II Parameters	Tier II Values
FAVF	242
SAV	1950
SACR	17.9
SCV	110

[a]Because 1 pentanol is a volatile compound, only flow through, measured test was used

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A:C Ratio	Reference
2 Propanol							
	Chironomus riparius	7	LC50	12,500,000	12,500,000		Roghair et al., 1994
	Pimephales promelas	2,3	LC50	10,400			Veith et al., 1983
	Pimephales promelas	2,3	LC50	9,640			Veith et al., 1983
	Pimephales promelas	2,3	LC50	6,550	8,692		Brooke et al., 1984

Tier II Parameters	Tier II Values
FAVF	64.8
SAV	134.1
SACR	17.9
SCV	7.5

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A:C Ratio	Reference
1,1,2,2-Tetrachloroethane[a]							
	Daphnia magna	4	EC50	23,000	23,000		Richter et al., 1983
	Daphnia magna		CV	9,829		2.34	Richter et al., 1983
	Jordanella floridae	2,3	LC50	18,450	18,450		Smith et al., 1991
	Jordanella floridae		CV	8,467		2.183	Smith et al., 1991
	Pinephales promelas	2,3	LC50	20,400			Walbridge et al., 1983
	Panephales promelas	2,3	LC50	20,300	20,350		Geiger et al., 1985
	Pinephales promelas		CV	2,366		8.601	Ahmad et al., 1984

Tier II Parameters	Tier II Values
FAVF	8.6
SAV	2,149
SACR	3.529
SCV	610

[a] Because 1,1,2,2 tetrachloroethane is a volatile compound, only flow through, measured tests were used

Table A.1. (continued)

Compound	Genus/species	Requirement	Endpoint	Concentration	GMAV	A:C Ratio	Reference
Tetrachloroethene[a]							
	Daphnia magna	4	EC50	8,500	8,500		Richter et al., 1983
	Daphnia magna		CV	750.0		11.33	Richter et al., 1983
	Jordanella floridae	2,3	LC50	8,430	8,430		Smith et al., 1991
	Jordanella floridae		CV	3,107		2.714	Smith et al., 1991
	Oncorhynchus mykiss	1	LC50	5,840			Shubat et al., 1982
	Oncorhynchus mykiss	1	LC50	4,990	5,398		Shubat et al., 1982
	Pimephales promelas	2,3	LC50	13,400			Walbridge et al., 1983
	Pimephales promelas	2,3	LC50	20,300	16,490		Geiger et al., 1985
	Pimephales promelas		CV	836.7		19.71	Geiger et al., 1985

Tier II Parameters	Tier II Values
FAVF	6.5
SAV	830.5
SACR	8.463
SCV	98

[a]Because tetrachloroethene is a volatile compound, only flow-through, measured tests were used.

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A:C Ratio	Reference
Toluene[a]							
	Pimephales promelas	2.3	LC50	31,700			Geiger et al., 1990
	Pimephales promelas	2.3	LC50	36,200			Geiger et al., 1986
	Pimephales promelas	2.3	LC50	30,000			DeGraeve et al., 1982
	Pimephales promelas	2.3	LC50	31,000			DeGraeve et al., 1982
	Pimephales promelas	2.3	LC50	26,000			DeGraeve et al., 1982
	Pimephales promelas	2.3	LC50	18,000	28,170		DeGraeve et al., 1982
	Pimephales promelas		CV	4,899		5.243	DeGraeve et al., 1982

Tier II Parameters	Tier II Values
FAVF	242
SAV	116.4
SACR	11.59
SCV	9.8

[a] Because toluene is a volatile compound, only flow through, measured tests were used.

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A:C Ratio	Reference
1,1,1-Trichloroethane[a]							
	Pimephales promelas	2,3	LC50	52,900			Geiger et al., 1986
	Pimephales promelas	2,3	LC50	42,300	47,300		Geiger et al., 1986

Tier II Parameters	Tier II Values
FAVF	242
SAV	195.5
SACR	17.9
SCV	11

[a] Because 1,1,1-trichloroethane is a volatile compound, only flow-through, measured tests were used.

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A-C Ratio	Reference
1,1,2-Trichloroethane[a]							
	Daphnia magna	4	EC50	81,000	81,000		Richter et al., 1983
	Daphnia magna		CV	18,385		4.406	Richter et al., 1983
	Jordanella floridae	2,3	LC50	45,117	45,117		Smith et al., 1991
	Jordanella floridae		CV	45,609		2[b]	Smith et al., 1991
	Pimephales promelas	2,3	LC50	81,600	81,600		Ahmad et al., 1984
	Pimephales promelas		CV	9,423		8.659	Ahmad et al., 1984

Tier II Parameters	Tier II Values
FAVF	8.6
SAV	5,246
SACR	4.241
SCV	1200

[a] Because 1,1,2-trichloroethane is a volatile compound, only flow-through, measured tests were used.

[b] Since the experimental A-C Ratio is less than 2, the A-C Ratio of *J. floridae* is set to 2 (Stephan et al., 1985).

Table A.1. (continued)

Compound	Genus/species	Requirement	Endpoint	Concentration	GMAV	A-C Ratio	Reference
Trichloroethene[a]							
	Jordanella floridae	2,3	LC50	28,280	28,280		Smith et al., 1991
	Jordanella floridae		CV	11,057		2.558	Smith et al., 1991
	Pimephales promelas	2,3	LC50	40,700			Alexander et al., 1978
	Pimephales promelas	2,3	LC50	45,000			Walbridge et al., 1983
	Pimephales promelas	2,3	LC50	44,100	43,230		Geiger et al., 1985

Tier II Parameters	Tier II Values
FAVF	64.8
SAV	436.4
SACR	9.358
SCV	47

[a] Because trichloroethene is a volatile compound, only flow-through, measured tests were used.

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A-C Ratio	Reference
Vinyl acetate[a]	*Carassius auratus*	2,3	LC50	42,330	42,330		Pickering and Henderson, 1966
	Lepomis macrochirus	2,3	LC50	18,000	18,000		Pickering and Henderson, 1966
	Pimephales promelas	2,3	LC50	14,000			Pickering and Henderson, 1966
	Pimephales promelas	2,3	LC50	15,000			Pickering and Henderson, 1966
	Pimephales promelas	2,3	LC50	14,000			Pickering and Henderson, 1966
	Pimephales promelas	2,3	LC50	15,000			Pickering and Henderson, 1966
	Pimephales promelas	2,3	LC50	15,000			Pickering and Henderson, 1966
	Pimephales promelas	2,3	LC50	23,000			Pickering and Henderson, 1966
	Pimephales promelas	2,3	LC50	26,000			Pickering and Henderson, 1966
	Pimephales promelas	2,3	LC50	20,000			Pickering and Henderson, 1966
	Pimephales promelas	2,3	LC50	24,000[b]			Pickering and Henderson, 1966
	Pimephales promelas	2,3	LC50	19,730[b]	18,090		Pickering and Henderson, 1966
	Poecilia reticulata	2,3	LC50	31,050	31,050		Pickering and Henderson, 1966

Tier II Parameters	Tier II Values
FAVF	61.8
SAV	277.8
SACR	17.9
SCV	16

[a] Although vinyl acetate is a volatile compound, static tests were used because flow-through, measured tests are not available.
[b] Author notes hardness influences toxicity; vinyl acetate is more toxic in soft water than hard water.

Table A.1. (continued)

Compound	Genus/Species	Requirement	Endpoint	Concentration	GMAV	A-C ratio	Reference
Xylene[a]							
	Lepomis macrochirus	2,3	LC50	15,700	15,700		Bailey et al., 1985
	Pimephales promelas	2,3	EC50	15,300[c,d]			Geiger et al., 1990
	Pimephales promelas	2,3	EC50	14,800[d]	15,050		Geiger et al., 1990

Tier II Parameters	Tier II Values
FAVF	64.8
SAV	232.3
SACR	17.9
SCV	13

[a] Because xylene is a volatile compound, only flow-through, measured tests were used.
[b] o-xylene (99+% purity) was used.
[c] m-xylene (99% purity) was used.
[d] Because analytical procedures used at waste sites do not discriminate isomers, toxicity tests on individual and mixture of isomers are considered equivalent.

Appendix B

METHODS FOR DERIVATION OF TIER II VALUES

METHODS FOR DERIVATION OF TIER II VALUES

B.1 Method for data selection

The procedure used to select and aggregate test data was adopted from the guidelines for deriving National Ambient Water Quality Criteria (NAWQC) (Stephan et al. 1985). The selection criteria are summarized in the following text.

B.1.1 Chemical Considerations

Not all forms of inorganic chemicals require unique Tier II values. Metal salts with the same oxidation state at ambient conditions (e.g., $BeCl_2$ and $BeSO_4$) are expected to exhibit similar toxicity and are given a common Tier II value. Nonionizable, covalently bonded compounds of metals or metals of different oxidation states were considered different chemicals, for which separate Tier II values were derived.

For volatile compounds, only results of flow-through tests with measured chemical concentrations were used, if available. However, if flow-through measured tests were not available, the genus mean acute value (GMAV) was based on static and flow-through unmeasured tests.

Pesticides were screened for commercial formulations; wettable powder, emulsifiable concentrates, and formulated mixtures were eliminated. Only pesticides of technical grades or better were considered.

B.1.2 Dilution water considerations

Test results were rejected if unusual dilution water was used (e.g., TOC > 5 ppm, lack of appropriate salts, low dissolved oxygen), unless toxicity has been demonstrated to be independent of these factors. Tests in which dissolved oxygen fell below 40% saturation for static or 60% saturation for flow-through were eliminated.

B.1.3 Biological parameters

Tests of certain organisms were excluded from the Tier II value derivation. Single-celled organisms and brine shrimp (*Artemia* sp.) were not used. Fish were generally limited to species with wild North American populations. However, if none of the tests with North American fish were acceptable and values for other organisms were not available, non-resident fish were used.

Tests which did not refer to a standard procedure or indicate use of a control group were excluded. Acute tests in which organisms were fed were eliminated, unless feeding was demonstrated to be independent of toxicity.

For the acute tests, only daphnids and midges (*Chironomus* sp.) have a specified starting age. Daphnids must be less than 24 hours of age at the start of the test. Midges in second or third instar larvae were preferred, but midge tests starting at fourth instar were accepted. Although the starting age for all other organisms has not been specified, juvenile stages were preferred whenever they were available (unless another life stage is more sensitive to the chemical). All organisms should receive a 96-hour exposure period, except daphnids and midges, where 48 hours is the standard exposure period. The endpoint for daphnids and midges is the EC50 for immobilization. If this is not available, LC50 is used. For fish, the preferred endpoint is the EC50 for loss of equilibrium, immobilization, and/or mortality. If those are not available, LC50 is used.

In chronic tests, the starting age, exposure duration, and endpoints may be different for daphnids and fish and for salmonids and non-salmonids. Daphnids must be less than 24 hours old at the start of the test, and the test should last at least 21 days. Endpoints are based on mortality and number of young per female.

For a given fish species, preference is given to the following types of chronic tests in the order as follows: full life cycle, partial life cycle, and early life stage. The less desirable chronic test is not included in the calculation if a more desirable type is available.

B.1.4 Variation of Acute Values within the same genus

If the acute values within a species or among species in a genus differ by a factor of 10 or more, the higher values were excluded, and those that are within the factor of 10 range were used to attain a conservative estimate. If the acute concentrations of a given species differ by a factor of two or more among different life stages, the more sensitive life stage is used to protect the organisms in all life stages.

B.1.5 ACR Considerations

If the acute chronic ratios (ACRs) for a chemical differ by more than a factor of 10, the tests were carefully examined to determine whether outliers should be rejected. ACRs from saltwater species should be used along with the freshwater ACRs when less than three ACRs from freshwater species are available. If the lowest GMAV is from larvae of barnacles, bivalves, lobsters, crabs, shrimp, or abalones, the secondary acute chronic ratio (SACR) is assumed to be 2. If an ACR is less than 2, acclimation may have occurred. The ACR is then set to 2.

Preference was given to acute and chronic tests done in the same study. If these are not available, an acute value with water characteristics similar to the chronic value was used. If values from similar water are not available, the GMAV of the species is used with the chronic value to derive an ACR. If multiple chronic values for a species are available but none are part of the same study as an acute test, the geometric mean of the chronic values was calculated and used with the GMAV to derive an ACR for that species.

B.1.6 Acceptable exposure types and life stage used to derive ACR

For daphnids, renewal is required for chronic tests; while for acute tests, static exposure is acceptable. All chronic test concentrations should be measured. The life stage of daphnids has to be 24 hours or younger at the start of both acute and chronic tests.

For fish, both acute and chronic tests require flow-through measured tests. For acute fish tests, the life stage of the organism should be juvenile.

B.1.7 Other considerations

Concentrations above the solubility of chemicals and "greater than" values were used only when at least one definitive concentration was available.

B.2 Calculation method

Tier II values are derived if fewer than eight of the acute data requirements or three chronic data requirements presented in EPA (1993a) are met. The eight acute data requirements include:

1. The family *Salmonidae* in the class *Osteichthyes*
2. One other family (preferably a commercially, or recreationally important, warmwater species) in the class *Osteichthyes* (e.g., bluegill, channel catfish, etc.)
3. A third family in the phylum *Chordata* (e.g., fish, amphibian, etc.)
4. A planktonic crustacean (e.g., a cladoceceran, copepod, etc.)
5. A benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
6. An insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
7. A family in a phylum other than *Arthropoda* or *Chordata* (e.g., *Rotifera, Annelida, Mollusca,* etc.)
8. A family in any order of insect or any phylum not already represented

If all of these data requirements are not met, then an FAV is calculated. The FAV is a Tier I criterion, and its derivation is documented in Stephan et al. (1985) and in Appendix A of EPA (1993a). The FAV, however, is used in the derivation of the SCV if the chronic data requirements are not met.

Tier II values, as mentioned previously, are calculated when the data requirements are not met. The first calculation of the Tier II criteria is the SAV. The SAV is derived by taking the lowest genus mean acute value (GMAV) for any of the genera present and dividing it by a Final Acute Value Factor (FAVF). The FAVF is selected from Table B.1 where n is the number of the eight acute data requirements that are satisfied. FAVFs are selected from the two columns depending on whether an acute value (LC50 or EC50) for a daphnid is included in the data set.

Once the SAV is calculated, the Secondary Acute-Chronic Ratio (SACR) is derived. If three or more Acute-Chronic Ratios (ACRs) are present, then the SACR is determined by finding the geometric mean of the ACRs. There must be at least three ACRs. If there are not three chronic values from the literature, then a default value of 17.9 (EPA 1991) is used until the total number of ACRs is three. If multiple ACRs are given for the same genus, then the geometric mean of those ACRs must be calculated. This genus mean ACR can then be used in the derivation of the SACR. Therefore, several members of the same genus can only present one value towards the mandatory three. If no ACRs are given, then the SACR is 17.9.

The final calculation for Tier II values is the derivation of an SCV. The SCV is calculated by dividing the FAV or SAV by the SACR.

Table B.1. Factors for estimation of the Tier II values (EPA 1993 and Stephan 1991)

Number of GMAVs[a]	Factor for data sets that include an acute value for a daphnid[b]	Factors for data sets that do not include an acute value for a daphnid[b]
1	20.5	242
2	13.2	64.8
3	8.6	36.2
4	6.5	20.1
5	5.0	12.9
6	4.0	9.2
7	3.6	7.2

[a] GMAV is Genus Mean Acute Value
[b] Daphnids includes members of the genera *Daphnia*, *Ceriodaphnia*, and *Simocephalus*.

Appendix C

TABLE SHOWING CONCENTRATIONS ESTIMATED TO CAUSE A 20% REDUCTION IN THE RECRUIT ABUNDANCE OF LARGEMOUTH BASS, WITH UPPER AND LOWER 95% CONFIDENCE BOUNDS

Table C.1. Concentrations estimated to cause a 20% reduction in the recruit abundance of largemouth bass, with upper and lower 95% confidence bounds. All units are ug/L

Chemical	Test Species	Test Type	Lower 95% CL	Median	Upper 95%CL	Source
Ammonia	Fathead minnow	Chronic	3.98	100	1585	Mayes et al. 1986
	Fathead minnow	Chronic	3.98	32	200	Thurston et al 1986
Antimony	Fathead minnow	Acute	5.01	79	501	EPA 1980b
Arsenic III	Fathead minnow	Chronic	100	1995	31623	Call et al. 1983
Arsenic V	Fathead minnow	Acute	20	159	1000	EPA 1985a
	Rainbow trout	Acute	10	100	501	EPA 1985a
	Mosquitofish	Acute	32	398	2512	EPA 1985a
Beryllium	Fathead minnow	Acute	0.35	7.08	40	EPA 1980f
	Bluegill	Acute	2.00	32	126	EPA 1980f
	Flagfish	Acute	2.00	32	126	EPA 1980f
	Guppy	Acute	1.58	25	126	EPA 1980f
Cadmium	Fathead minnow	Chronic	1	10	79	Pickering and Gast 1972
	Bluegill	Chronic	1.99	13	50	Eaton 1974
	Brook trout	Chronic	0.13	1.26	6.31	Benoit et al. 1976
	Brook trout	Chronic	0.32	3.16	25	Sauter et al. 1976
	Flagfish	Chronic	0.63	3.98	50	Carlson et al. 1982
	Flagfish	Chronic	0.79	3.16	7.94	Spehar 1976
Chromium III	Rainbow trout	Chronic	13	126	1000	Stevens and Chapman 1984
Chromium VI	Fathead minnow	Chronic	25	158	1260	Pickering 1980
	Rainbow trout	Chronic	100	631	5010	Sauter et al. 1976
Cobalt	Fathead minnow	Acute	0.16	3.98	32	Lind et al. 1978
Copper	Fathead minnow	Chronic	0.40	3.98	40	Mount 1968
	Fathead minnow	Chronic	0.32	3.16	16	Mount and Stephan 1969
	Bluegill	Chronic	1.995	13	50	Benoit 1975
	Brook trout	Chronic	1	3.98	16	McKim and Benoit 1971
	Brook trout	Chronic	1	5.01	40	Sauter et al. 1976
	Coho salmon	Chronic	3.16	32	316	Hazel and Meith 1970

Table C.1. (continued)

Chemical	Test Species	Test Type	Lower 95% CL	Median	Upper 95% CL	Source
	Rainbow trout	Chronic	3.98	32	200	Seim et al. 1984
Cyanide	Fathead minnow	Chronic	0.20	2.51	16	Smith et al. 1979
	Atlantic Salmon	Chronic	1.99	16	200	Leduc 1978
	Bluegill	Chronic	5.01	25	158	Smith et al. 1979
	Brook trout	Chronic	1.58	13	79	Smith et al. 1979
Lead	Brook trout	Chronic	13	50	316	Holcombe et al. 1976
	Rainbow trout	Chronic	13	100	631	Sauter et al. 1976
Manganese	Fathead minnow	Acute	11	112	794	Kimball n.d.
Mercury, inorganic	Fathead minnow	Chronic	0.04	0.79	13	Call et al. 1983
	Fathead minnow	Chronic	0.01	0.13	3.16	Snarski and Olson 1982
Mercury, methyl	Rainbow trout	Acute	0.004	0.16	1.26	EPA 1985e
	Brook trout	Acute	0.02	0.50	3.98	EPA 1985e
Nickel	Fathead minnow	Chronic	32	126	501	Pickering 1974
	Rainbow trout	Chronic	13	63	398	Nebeker et al. 1985
	Rainbow trout	Chronic	126	1260	15800	Nebeker et al. 1985
Silver	Fathead minnow	Chronic	0.01	0.1	1	Holcombe et al. 1983
	Rainbow trout	Chronic	0.1	1	7.94	Nebeker et al. 1983
Thallium	Fathead minnow	Acute	0.25	4.47	40	EPA 1980bb
	Bluegill	Acute	73	1000	6310	EPA 1980bb
Uranium	Fathead minnow	Acute	0.398	10	50	Cushman et al. 1977
	Fathead minnow	Acute	0.501	10	50	Cushman et al. 1977
	Fathead minnow	Acute	0.631	13	79	Cushman et al. 1977
	Fathead minnow	Acute	32	398	3980	Cushman et al. 1977
Vanadium	Fathead minnow	Acute	0.28	5.01	40	Kimball n.d.
	Brook trout	Acute	5.01	63	398	Ernst and Garside 1987
	Flagfish	Acute	10	100	501	Holdway and Sprague 1979
Zinc	Fathead minnow	Chronic	3.98	40	316	Benoit and Holcombe 1978

Table C.1. (continued)

Chemical	Test Species	Test Type	Lower 95% CL	Median	Upper 95% CL	Source
	Fathead minnow	Chronic	3.16	40	316	Brungs 1969
	Coho salmon	Chronic	16	126	794	Finlayson and Verrue 1980
	Flagfish	Chronic	6.31	32	126	Spehar 1976
	Rainbow trout	Chronic	40	501	5010	Sinley et al. 1974
Zirconium	Fathead minnow	Acute	3.16	50	316	Cushman et al. 1977
	Fathead minnow	Acute	3.16	50	398	Cushman et al. 1977
	Fathead minnow	Acute	32	398	3160	Cushman et al. 1977
	Fathead minnow	Acute	63	794	6310	Cushman et al. 1977
	Bluegill	Acute	10	126	501	Cushman et al. 1977
	Bluegill	Acute	200	2510	15800	Cushman et al. 1977
Organics						
AC 222,705	Fathead minnow	Chronic	0.0006	0.01	0.063	Spehar et al. 1983
Acetone	Fathead minnow	Acute	1780	19900	25100	AQUIRE'
	Bluegill	Acute	3160	50100	501000	AQUIRE'
	Rainbow trout	Acute	1260	31600	316000	AQUIRE'
	Mosquitofish	Acute	631	10000	100000	AQUIRE'
AG thiosulfate complex	Fathead minnow	Chronic	1000	10000	79400	LeBlanc et al. 1984
Aldicarb	Fathead minnow	Chronic	3.16	50	631	Pickering and Gilliam 1982
Atrazine	Brook trout	Chronic	100	1000	12600	Macek et al. 1976b
Benzene	Fathead minnow	Acute	10	100	794	EPA 1980d
	Bluegill	Acute	13	158	1000	EPA 1980d
	Rainbow trout	Acute	3.16	40	316	EPA 1980d
	Mosquitofish	Acute	200	3160	25100	EPA 1980d
	Guppy	Acute	32	316	1580	EPA 1980d
Benzidene	Rainbow trout	Acute	5.01	63	398	EPA 1980e
	Lake trout	Acute	3.16	40	251	EPA 1980e
	Flagfish	Acute	10	126	794	EPA 1980e
Benzoic acid	Mosquitofish	Acute	126	1260	10000	AQUIRE'
Benzyl alcohol	Fathead minnow	Acute	16	1780	12600	AQUIRE'
	Bluegill	Acute	6.31	79	398	AQUIRE'
Bis(2-ethylhexyl)phthalate	Rainbow trout	Acute	100	1000	7940	AQUIRE'
	Largemouth bass	Acute	25	316	1580	AQUIRE'

Table C.1. (continued)

Chemical	Test Species	Test Type	Lower 95% CL	Median	Upper 95%CL	Source
	Channel catfish	Acute	0.006	0.40	6.31	AQUIRE[a]
2-Butanone	Fathead minnow	Acute	501	10000	100000	AQUIRE[a]
	Mosquitofish	Acute	1990	31600	398000	AQUIRE[a]
Captan	Fathead minnow	Chronic	0.32	3.16	20	Hermanutz et al. 1973
Carbaryl	Fathead minnow	Chronic	3.16	32	1000	Carlson 1971
Carbon disulfide	Mosquitofish	Acute	100	1000	7940	AQUIRE[a]
Carbon tetrachloride	Fathead minnow	Acute	11	126	1260	EPA 1980h
	Bluegill	Acute	40	398	3160	EPA 1980h
Chloramine	Fathead minnow	Chronic	0.32	3.16	13	Arthur and Eaton 1971
Chlordane	Bluegill	Chronic	0.13	0.40	2.51	Cardwell et al. 1977
	Brook trout	Chronic	0.20	1.26	7.94	Cardwell et al. 1977
Chlorobenzene	Fathead minnow	Acute	11	112	794	EPA 1980j
	Bluegill	Acute	10	126	1000	EPA 1980j
	Guppy	Acute	32	316	2510	EPA 1980j
Chloroform	Bluegill	Acute	79	794	5010	EPA 1980l
	Rainbow trout	Acute	40	398	3160	EPA 1980l
p,p'DDD	Fathead minnow	Acute	0.79	13	100	AQUIRE[a]
	Bluegill	Acute	0.002	0.1	1	AQUIRE[a]
	Rainbow trout	Acute	0.02	0.40	3.16	AQUIRE[a]
	Largemouth bass	Acute	0.003	0.13	1	AQUIRE[a]
	Channel catfish	Acute	0.025	1.26	16	AQUIRE[a]
2,4-D Butoxyethanol ester	Coho salmon	Chronic	10	100	1260	Finlayson and Verrue 1985
Diazinon	Fathead minnow	Chronic	0.32	3.16	25	Allison and Hermanutz 1977
	Flagfish	Chronic	10	50	316	Allison and Hermanutz 1977
Di-n-butyl phthalate	Fathead minnow	Chronic	13	251	3980	McCarthy and Whitmore 1985
2,6-Dichlorobenzamide	Rainbow trout	Chronic	1260	12600	50100	Van Leeuwen and Maas 1985
1,3-Dichlorobenzene	Fathead minnow	Chronic	316	1585	15849	Ahmad et al. 1984

Table C.1. (continued)

Chemical	Test Species	Test Type	Lower 95% CL	Median	Upper 95%CL	Source
1,4-Dichlorobenzene	Fathead minnow	Chronic	32	398	6310	Ahmad et al. 1984
1,1-Dichloroethane	Guppy	Acute	158	1580	12600	AQUIRE[a]
1,2-Dichloroethane	Fathead minnow	Acute	40	398	3160	EPA 1980k
	Bluegill	Acute	316	3980	31600	EPA 1980k
1,1-Dichloroethene	Fathead minnow	Acute	40	398	3160	EPA 1980n
	Bluegill	Acute	50	501	3980	EPA 1980n
2,4-Dichlorophenol	Fathead minnow	Chronic	32	200	1580	Holcombe et al. 1982
1,2-Dichloropropane	Fathead minnow	Chronic	398	3980	39800	Benoit et al. 1982
1,3-Dichloropropane	Fathead minnow	Chronic	501	5010	50100	Benoit et al. 1982
1,3-Dichloropropene	Bluegill	Acute	3.16	40	251	EPA 1980o
Diethyl phthalate	Bluegill	Acute	79	1000	6310	AQUIRE[a]
2,4-Dimethylphenol	Fathead minnow	Chronic	100	1260	19900	Holcombe et al. 1982
Dimethyl phthalate	Rainbow trout	Chronic	0.004	0.04	0.40	Ward and Boeri 1991b
1,3-Dinitrobenzene	Rainbow trout	Chronic	100	1000	7940	Van Der Schalie 1983
	Rainbow trout	Chronic	63	794	6310	Van Der Schalie 1983
Dinoseb	Fathead minnow	Chronic	0.13	3.16	40	Call et al. 1983
Di n-octyl phthalate	Fathead minnow	Chronic	200	1990	39800	McCarthy and Whitmore 1985
Diuron	Fathead minnow	Chronic	1	16	158	Call et al. 1983
Dursban	Fathead minnow	Chronic	0.002	0.032	0.20	Jarvinen et al. 1983
DNBP	Rainbow trout	Chronic	0.00004	0.0004	0.005	Ward and Boeri 1991a
Endrin	Fathead minnow	Chronic	0.005	0.13	1.58	Carlson et al. 1982
Endosulfan	Fathead minnow	Chronic	0.002	0.016	0.13	Macek et al. 1976b
Ethyl benzene	Fathead minnow	Acute	10	158	1000	EPA 1980p
	Bluegill	Acute	50	501	3980	EPA 1980p
	Guppy	Acute	79	794	5010	EPA 1980p
Fenitrothion	Fathead minnow	Chronic	0.1	126	1990	Kleiner et al. 1984

Table C.1. (continued)

Chemical	Test Species	Test Type	Lower 95% CL	Median	Upper 95%CL	Source
Fluoranthene	Bluegill	Acute	2.00	32	126	EPA 1980q
Fluridone	Fathead minnow	Chronic	32	398	10000	Hamelink et al. 1986
Fonofos	Fathead minnow	Chronic	3.16	20	158	Pickering and Gilliam 1982
Guthion	Fathead minnow	Chronic	0.013	0.13	3.98	Adelman et al. 1976
Heptachlor	Fathead minnow	Chronic	0.01	0.1	0.63	Macek et al. 1976b
Hexachlorobutadiene	Fathead minnow	Chronic	0.32	3.98	63	Benoit et al. 1982
Hexachlorocyclohexane (lindane)	Bluegill Macek et al. 1976a	Chronic	0.16	1	6.31	
Hexachloroethane	Fathead minnow	Chronic	3.98	100	1580	Ahmad et al. 1984
2-Hexanone	Fathead minnow	Acute	100	1260	12600	AQUIRE
Kelthane	Fathead minnow	Chronic	0.32	7.94	100	Spehar et al. 1982
LAS 11.2	Fathead minnow	Chronic	126	1580	25100	Holman et al. 1980
LAS 11.7	Fathead minnow	Chronic	13	200	2510	Holman et al. 1980
LAS Mixture	Fathead minnow	Chronic	20	316	1580	Pickering and Thatcher 1970
Malathion	Flagfish	Chronic	3.162	20	126	Hermanutz 1978
1-Methylnaphthalene	Fathead minnow	Acute	1.78	31.62	200	AQUIRE
4-Methyl-2-pentanone	Fathead minnow	Acute	141	1580	15800	AQUIRE
2-Methylphenol	Fathead minnow	Acute	3.98	40	398	AQUIRE
	Bluegill	Acute	13	126	1000	AQUIRE
	Rainbow trout	Acute	6.31	79	398	AQUIRE
Methylene chloride	Fathead minnow	Acute	63.10	1000	10000	AQUIRE
	Bluegill	Acute	158	1580	12600	AQUIRE
Naphthalene	Fathead minnow	Chronic	73	1000	12600	DeGraeve et al. 1982
4-Nitrophenol	Fathead minnow	Acute	13	159	1260	AQUIRE
	Bluegill	Acute	3.98	50	316	AQUIRE
	Rainbow trout	Acute	6.31	79	398	AQUIRE

Table C.1. (continued)

Chemical	Test Species	Test Type	Lower 95% CL	Median	Upper 95%CL	Source
	Channel catfish	Acute	0.79	20	200	AQUIRE[a]
N-nitrosodiphenylamine	Bluegill	Acute	3.16	40	251	AQUIRE[a]
PCBs: Aroclor 1221	Cutthroat trout	Acute	0.63	10	50	AQUIRE[a]
PCBs: Aroclor 1232	Cutthroat trout	Acute	1.26	16	126	AQUIRE[a]
PCBs: Aroclor 1242	Fathead minnow	Chronic	0.13	1.58	40	Nebeker et al. 1974
PCBs: Aroclor 1248	Flagfish	Chronic	0.13	1.26	7.94	Nebeker et al. 1974
PCBs: Aroclor 1254	Fathead minnow	Chronic	0.1	0.63	7.94	Nebeker et al. 1974
PCBs: Aroclor 1260	Cutthroat trout	Acute	32	316	2510	AQUIRE[a]
Pentachloroethane	Fathead minnow	Chronic	100	1260	19900	Ahmad et al. 1984
Pentachlorophenol	Fathead minnow	Chronic	1.58	32	501	Holcombe et al. 1982
	Fathead minnow	Chronic	0.32	1.99	20	Spehar et al. 1985
	Fathead minnow	Chronic	0.63	6.31	63	Spehar et al. 1985
	Fathead minnow	Chronic	1.26	13	126	Spehar et al. 1985
	Fathead minnow	Chronic	1.99	16	158	Spehar et al. 1985
	Rainbow trout	Chronic	1.58	10	50	Dominguez and Chapman 1984
1-Pentanol	Bluegill	Acute	398	5010	39800	AQUIRE[a]
	Rainbow trout	Acute	200	2510	19900	AQUIRE[a]
Permethrin	Fathead minnow	Chronic	0.02	0.40	5.01	Spehar et al. 1983
Phenol	Fathead minnow	Chronic	1000	12600	199000	Degraeve et al. 1980
	Rainbow trout	Chronic	126	1580	15800	Degraeve et al. 1980
Propanil	Fathead minnow	Chronic	0.01	0.1	0.63	Call et al. 1983
2-Propanol	Fathead minnow	Acute	200	3160	31600	AQUIRE[a]
Pydrin	Fathead minnow	Chronic	0.006	0.13	1.58	Spehar et al. 1982
1,1,2,2-Tetrachloroethane	Fathead minnow	Chronic	251	1580	50100	Ahmad et al. 1984
Tetrachloroethene	Fathead minnow	Acute	3.16	50	398	EPA 1980aa
	Bluegill	Acute	10	100	501	EPA 1980aa
	Rainbow trout	Acute	3.16	40	316	EPA 1980aa

Table C.1. (continued)

Chemical	Test Species	Test Type	Lower 95% CL	Median	Upper 95% CL	Source
Tetrachloroethylene	Fathead minnow	Chronic	40	1000	12600	Ahmad et al. 1984
Toluene	Fathead minnow	Acute	10	126	1000	EPA 1980cc
	Bluegill	Acute	13	126	1000	EPA 1980cc
	Guppy	Acute	50	501	3160	EPA 1980cc
Toxaphene	Brook trout	Chronic	0.01	0.063	0.40	Mayer et al. 1975
1,1,1-Trichloroethane	Fathead minnow	Acute	18	200	1580	AQUIRE[a]
	Bluegill	Acute	32	316	1580	AQUIRE[a]
1,1,2-Trichloroethane	Fathead minnow	Chronic	1000	15890	251000	Ahmad et al. 1984
Trichloroethene	Fathead minnow	Acute	13	158	1260	EPA 1980dd
	Flagfish	Acute	20	251	1260	Smith et al. 1991
	Bluegill	Acute	32	316	1990	EPA 1980dd
2-Trifluoromethyl-4-phenol	Brook trout	Chronic	100	501	3160	Dwyer et al. 1978
Trifluralin	Fathead minnow	Chronic	0.063	0.63	7.94	Macek et al. 1976b
1,3,5-Trinitrobenzene	Fathead minnow	Chronic	3.16	50	631	Van der Schalie 1983
	Rainbow trout	Chronic	13	158	1580	Van der Schalie 1983
	Rainbow trout	Chronic	13	158	1580	Van der Schalie 1983
Vinyl acetate	Fathead minnow	Acute	3.16	40	398	AQUIRE[a]
	Bluegill	Acute	10	126	794	AQUIRE[a]
	Guppy	Acute	25	251	1580	AQUIRE[a]

[a] EPA (n.d.)