

FINAL REPORT

Approach for Assessing PFAS Risk to Threatened and Endangered Species

SERDP Project ER18-1653

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TABLE OF CONTENTS

Executive Summary	1
Abstract	1
1 Objective	1
2 Background	1
3 Methods	2
3.1 Aquatic Screening Levels	3
3.1.1 Aquatic Literature Review	3
3.1.2 Aquatic Screening Level Calculations	5
3.2 Terrestrial Plant and Invertebrate Screening Levels	9
3.2.1 Toxicity Value Literature Review	9
3.2.2 Soil Screening Level Development	11
3.2.3 Sediment Screening Level Development	11
3.3 Wildlife Risk-Based Screening Levels	11
3.3.1 Threatened and Endangered Species and Representative Surrogate Selection	12
3.3.2 Development of Toxicity Reference Values	13
3.3.3 Wildlife Risk-Based Screening Level Development	18
4 Results	25
4.1 Aquatic Screening Levels	25
4.2 Screening Levels for Ecological Communities	25
4.2.1 Plant and Soil Invertebrate Screening Levels	25
4.2.2 Benthic Invertebrate Screening Levels	26
4.3 Wildlife Risk-Based Screening Levels	26
4.3.1 PFAS Risk-Based Screening Levels	26
4.3.2 Considerations for Use of RBSLs	27
5 Uncertainties Evaluation	28
5.1 Uncertainties in the AQSLs (Tier II Methodology)	29
5.1.1 Data Selection Uncertainties	29
5.1.2 Aquatic Screening Level Uncertainties	30
5.2 Terrestrial Plant and Invertebrate Screening Levels	31

5.2.1	Data Selection Uncertainties.....	31
5.2.2	Plant and Invertebrate Soil Screening Levels Uncertainties.....	32
5.3	Wildlife Risk-Based Screening Level Uncertainties	32
5.3.1	Data Selection Uncertainties.....	32
5.3.2	Bioaccumulation Uncertainties.....	33
5.3.3	Toxicity Reference Value Uncertainties.....	35
5.3.4	Wildlife Risk-Based Screening Levels Uncertainties.....	37
6	Discussion	38
7	Conclusions and Implications for Future Research	39
7.1	Conclusions.....	39
7.2	Implications for Future Implementation	39
7.2.1	Applying SLs to Site Ecological Risk Assessments	40
7.3	Implications and Recommendations for Future Research	41
8	Literature Cited	41

TABLES

Table 1a.	Freshwater Aquatic Compiled Toxicity Data
Table 1b.	Marine Aquatic Compiled Toxicity Data
Table 1c.	Aquatic Plant Compiled Toxicity Data
Table 2a.	Terrestrial Plant Compiled Toxicity Data
Table 2b.	Terrestrial Invertebrate Compiled Toxicity Data
Table 2c.	Terrestrial Mammal Compiled Toxicity Data
Table 2d.	Terrestrial Bird Compiled Toxicity Data
Table 3.	Threatened and Endangered Representative Species Selection
Table 4.	Mammal and Bird Toxicity Reference Value Summary
Table 5.	Receptor Exposure Parameters
Table 6.	Bioaccumulation Factor Summary
Table 7.	Recommended Water Quality RBSL Summary
Table 8.	Marine and Freshwater Comparison
Table 9.	Terrestrial Plant Screening Level Summary
Table 10.	Terrestrial Invertebrate Screening Level Summary

Table 11a.	Aquatic Receptor NOAEL RBSLs and Recommended Water Quality RBSLs
Table 11b.	Terrestrial Receptor NOAEL RBSLs and Terrestrial Screening Levels
Table 12a.	Aquatic Receptor LOAEL RBSLs and RWQ RBSLs
Table 12b.	Terrestrial Receptor LOAEL RBSLs and Terrestrial Screening Levels
Table 13.	Background and Impacted Soil, Sediment, and Surface Water PFAS Concentrations

FIGURES

Figure 1.	Approach to Screening Level Development for Each Receptor and Habitat
Figure 2.	Exposure Pathways Included in the Wildlife Risk-Based Screening Levels

APPENDICES

Appendix A - Threatened and Endangered Species Selection
Appendix B - Recommended Water Quality RBSL Calculations
Appendix C - Plant Screening Level Calculations
Appendix D – Wildlife Toxicity Reference Value Calculations
Appendix E - Bioaccumulation Factors
Appendix F - Wildlife Risk-Based Screening Level Calculations

ACRONYMS AND ABBREVIATIONS

AFFF	aqueous film-forming foam
ACR	acute to chronic ratio
ATSDR	Agency for Toxic Substances and Disease Registry
BAF	bioaccumulation factor
BMF	biomagnification factor
BSAF	biota sediment accumulation factor
BW	body weight
CCC	criterion continuous concentration
CHPPM	Center for Health Promotion and Preventive Medicine
CMC	criterion maximum concentration
dw	dry weight
DWR	drinking water rate

DoD	Department of Defense
EC10	effect concentration affecting 10 percent of the population
EC50	effect concentration affecting 50 percent of the population
ECOS	Environmental Conservation Online System
EcoSSL	Ecological Soil Screening Level
EFH	Exposure Factors Handbook
EPC	exposure point concentration
FAV	final acute value
FCV	final chronic value
FIR	food ingestion rate
FPV	final plant value
FTOH	fluorotelomer alcohols
g	grams
GMAV	genus mean acute value
GLI	Great Lakes Initiative
kg	kilogram
kg/day	kilograms per day
L	liters
L/day	liters per day
LC10	lethal concentration to 10 percent of the population
LC50	lethal concentration to 50 percent of the population
LOAEL	lowest-observed adverse effect level
LOEC	lowest-observed effect concentration
LOQ	limit of quantification
MDE	Michigan Department of the Environment
mg	milligrams
mg/kg	milligrams per kilogram
mg/kg-bw/day	milligrams per kilogram body weight per day
mg/L	milligrams per liter
ND	non-detect
ng	nanograms
NOAEL	no-observed adverse effect level
NOEC	no-observed effect concentration

NJDEP	New Jersey Department of Environmental Protection
PFAS	per- and polyfluoroalkyl substance
PFBA	pentafluorobenzoic acid
PFBS	perfluorobutane sulfonic acid
PFDA	perfluorodecanoic acid
PFDoA	perfluorododecanoic acid
PFHpA	perfluoroheptanoic acid
PFHxA	perfluorohexanoic acid
PFHxS	perfluorohexane sulfonic acid
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonic acid
PFUnA	perfluoroundecanoic acid
RBSL	risk-based screening level
RWQ	recommended water quality
SACR	species acute to chronic ratio
SAF	secondary adjustment factor
SAV	secondary acute value
SCC	secondary continuous concentration
SCV	secondary chronic value
SMAV	species mean acute value
SMC	secondary maximum concentration
SIR	soil ingestion rate
SL	screening level
SUF	site use factor
T&E	threatened and endangered
TRV	toxicity reference value
UF	uncertainty factor
USEPA	United States Environmental Protection Agency
WQC	water quality criteria
µg/L	micrograms per liter
µg/g	micrograms per gram

Keywords:

PFAS, threatened, endangered, ecological, RBSL, screening level

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EXECUTIVE SUMMARY

Introduction

Per- and polyfluoroalkyl substances (PFAS) are a class of compounds with wide-ranging uses in industrial and commercial products and processes. Use of aqueous film-forming foams represents a known and/or potential source of PFAS contamination at many Department of Defense (DoD) sites due to frequent use of these foams during maintenance activities and fire-training drills. The PFAS-containing aqueous film-forming foams were subsequently released directly to the ground or unlined pits. Additional sources of PFAS may also be present, as PFAS are used in a variety of applications (e.g., in certain paints, during chrome-plating, in photo-processing) employed at DoD sites.

PFAS do not degrade in the environment and have been measured in abiotic media as well as aquatic and terrestrial wildlife. In addition, there is concern regarding adverse health effects of PFAS in humans. Thus, their potential toxicity to ecological receptors (i.e., aquatic life, including fish and aquatic plants and invertebrates, terrestrial plants and invertebrates, and wildlife) is also a concern. However ecological risk-based screening levels (RBSLs) are unavailable for most individual PFAS. RBSLs were developed herein for aquatic life and aquatic and terrestrial wildlife. The screening levels (SLs) were developed using standard United States Environmental Protection Agency (USEPA) approaches (USEPA 2005; USEPA 2012) and were designed to be protective of threatened and endangered (T&E) species that are potentially found at DoD sites. These SLs are available for use at DoD sites to rapidly assess potential for risk to ecological receptors that may be exposed to PFAS-contaminated soils, sediments, water, and prey.

Objectives

A key component of Superfund ecological risk assessments is the evaluation of risk to T&E species. The primary purpose of this evaluation is to develop RBSLs protective of T&E species that are potentially present at DoD sites. Calculating RBSLs for aquatic life, terrestrial plants, soil invertebrates, and benthic invertebrates, requires acute and chronic toxicity data for individual PFAS. Calculating RBSLs for wildlife requires bioaccumulation factors and toxicity values for individual PFAS. Therefore, intermediate objectives of this evaluation include compiling appropriate toxicity and uptake data for individual PFAS and developing media and PFAS-specific bioaccumulation factors and toxicity values for wildlife.

Technical Approach

SLs were developed for aquatic life (aquatic plants, invertebrates, fish, and amphibians) terrestrial plants and soil invertebrates, and terrestrial and aquatic wildlife (birds and mammals) as outlined in **Figure ES-1** and summarized below. Appropriate toxicity data for development of SLs for reptiles and sediment SLs for benthic invertebrates and fish were not located. Although SLs for these receptors were not developed, the available toxicity information is discussed qualitatively.

For aquatic life, recommended water quality (RWQ) RBSLs were calculated for surface water following Great Lakes Initiative methodology (USEPA 2012). A comprehensive literature search was conducted to identify aquatic toxicity values, and the compiled aquatic toxicity datasets were used to calculate acute and chronic RWQ RBSLs protective of aquatic plants, aquatic

invertebrates, fish, and amphibians. The available toxicity data for individual PFAS were sufficient to calculate RWQ RBSLs for perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) using Tier I methods. Tier II methods were used to calculate RWQ RBSLs for the other 21 individual PFAS. As noted above, PFOS and PFOA had the most robust datasets, whereas the RWQ RBSLs calculated for other PFAS are based on fewer toxicity data, therefore, they are more likely to evolve as additional toxicity information becomes available.

For terrestrial plants and soil invertebrates, RBSLs for soil were calculated following Ecological Soil Screening Level (EcoSSL) methodology (USEPA 2005). The available media-specific toxicity data (i.e., based on soil concentrations in units of milligrams per kilogram [mg/kg]) for survival, reproduction, and growth/development effects were compiled from the literature. No observed adverse effect level (NOAEL)-based SLs were calculated based on the geometric mean of available NOAEL and effective concentration at 10 percent effect (EC10) data, and lowest observed adverse effect level (LOAEL)-based SLs were calculated based on the geometric mean of available LOAEL and effective concentration at 20 percent effect (EC20) data.

For wildlife (birds and mammals), RBSLs for soil, sediment, and water were also calculated following EcoSSL methodology (USEPA 2005) based on foodweb models (**Figure ES-2**). Nine mammal and six bird representative T&E receptors were selected based on consideration of T&E species potentially present at DoD sites. The selected receptors represent a variety of feeding guilds (e.g., herbivore, invertivore, carnivore) and habitat preferences (aquatic or terrestrial). Exposure factors were developed based on data for surrogate species considered representative of the selected receptors. T&E wildlife receptors and surrogate representatives for which SLs were developed are presented in **Table ES-1**.

Table ES-1. Selected T&E Representative and Surrogate Species

Feeding Guilds		T&E Representative Species	Representative Surrogate Species
Mammals			
Aquatic	Carnivore / Piscivore ¹	Guadalupe fur seal, Southern sea otter	Harbor Seal, River Otter, Mink
	Insectivore	Gray Bat	Little Brown Bat
	Herbivore	Point arena mountain beaver	Muskrat
Terrestrial	Carnivore	Black-footed ferret	Long-tailed weasel
	Insectivore	Northern Long-Eared Bat	Little brown bat
	Invertivore	Ornate shrew	Short-tailed shrew
	Herbivore	Amargosa vole	Meadow vole
Birds			
Terrestrial	Carnivore	Mexican spotted owl	Red-Tailed Hawk
	Insectivore	Red-cockaded woodpecker	House Wren
	Herbivore	Palila (honeycreeper)	American Goldfinch
Aquatic	Piscivore	California least tern	Brown Pelican

Feeding Guilds		T&E Representative Species	Representative Surrogate Species
	Invertivore	Snowy plover	Tree swallow
	Omnivore	Yellow-shouldered blackbird	Red-Winged Blackbird

Note:

1. Feeding guild is inclusive of receptors with diets of crustaceans and cephalopods such as the blue whale. Harbor seal, river otter, and mink were selected as representative surrogate species. The harbor seal was considered a representative surrogate species for Guadalupe fur seal. River otters and mink were selected to model exposure for an inland aquatic piscivore or opportunistic carnivore receptor.

Additionally, uptake and toxicity data were compiled from the literature. Toxicity values were compiled for mammals and birds and incorporated into dose-based toxicity reference values (TRVs; in units of mg/kg body weight-day) following USEPA EcoSSL methodology. TRVs were developed for nine PFAS. Bioaccumulation factors (BAFs) were identified from a targeted literature search that resulted in development of BAFs for six PFAS. Foodweb models were used to back-calculate concentrations in soil, sediment, and surface water that correspond to the NOAEL and LOAEL-based TRVs, resulting in the wildlife RBSLs. These SLs were calculated for each medium relevant to a receptor—soil and surface water for terrestrial receptors and sediment and surface water for aquatic receptors. NOAEL RBSLs are the traditional screening tool used when evaluating risk to T&E species where the goal is to protect individuals, so no observed effects are acceptable. LOAEL-based RBSLs were also provided for each medium to allow for risk estimation at sites where protection of ecological populations (instead of individuals) is considered appropriate.

Appropriate dose-based toxicity data were not identified for reptiles or fish, nor were toxicity data identified for benthic invertebrates exposed to sediment. SLs were not developed for these receptor-media pairs.

Results and Discussion

Surface water SLs protective of aquatic life were derived for 23 individual PFAS, as summarized in **Table ES-2**.

Table ES-2. Recommended Water Quality RBSL Summary

Constituent	GLI Species Groups ¹	Tier I or Tier II Methodology	Acute RWQ RBSL (mg/L) ⁴	Chronic RWQ RBSL (mg/L) ⁴
PFD _o A	1	Tier II	6.4E-01	7.2E-02
PFUnA	1	Tier II	4.4E-01	4.9E-02
PFDA	2	Tier II	1.2E+00	1.4E-01
PFNA	2	Tier II	1.1E+00	1.2E-01
PFOS	8	Tier I	5.7E-01	5.1E-02
PFOA	8	Tier I	5.3E+01	3.9E+00
PFHpA ²	1	Tier II	7.8E+00	8.7E-01
PFHxA	3	Tier II	8.8E+00	2.3E+00

PFPeA ³	2	Tier II	1.2E+00	1.4E-01
PFBS	4	Tier II	1.7E+01	3.4E+00
PFBA	2	Tier II	4.2E+00	4.7E-01
PFPrA ²	1	Tier II	1.8E+00	2.0E-01
10:2 FTCA	1	Tier II	6.8E-04	2.0E-04
10:2 FTuCA	1	Tier II	6.4E-03	1.2E-03
8:2 FTCA	1	Tier II	6.0E-02	6.7E-03
8:2 FTuCA	2	Tier II	1.4E-01	1.5E-02
7:3 Acid	2	Tier II	3.7E-02	4.1E-03
6:2 Cl-PFESA ²	1	Tier II	3.3E-01	6.9E-02
6:2 FTCA ³	1	Tier II	5.7E-01	6.4E-02
6:2 FTuCA	1	Tier II	6.8E-01	7.5E-02
6:2 FTAB ²	1	Tier II	1.5E+00	1.6E-01
5H 4:1 FTOH	1	Tier II	4.5E+00	5.0E-01
FC807 ²	1	Tier II	4.8E+00	5.4E-01

Notes:

1. The Great Lakes Initiative (GLI) species group count is the number of species groups (out of 8 possible groups) fulfilled by the dataset.
2. The GLI Tier II methodology recommends deriving a value only when a daphnia sp. toxicity value is available and a daphnia value was not identified for this PFAS.
3. The GLI Tier II methodology recommends deriving a value only when a daphnia sp. toxicity value is available and all daphnia values identified were (> or <) acute data.
4. mg/L - milligram per liter

Soil SLs for terrestrial plants were derived for six individual PFAS, as summarized in **Table ES-3**.

Table ES-3. Plant Screening Level Summary

Constituent	NOEC Count	LOEC Count	NOEC Soil SL (mg/kg soil)	LOEC Soil SL (mg/kg soil)
PFDA	1	0	51	NA
PFNA	1	0	46	NA
PFOS ¹	6	7	11	33
PFOA ²	8	14	0.084	0.84
PFBA	1	0	642	NA
5H 4:1 FTOH	1	0	23	NA

Notes:

1. NOEC count for PFOS includes only bounded NOECs.
 2. NOEC count for PFOA includes only bounded NOECs and EC10 values.
- EC10 – effect concentration affecting 10 percent of the population; LOEC - lowest-observed effect concentration; mg/kg – milligrams per kilogram; NA – not applicable; NOEC – no-observed effect concentration; SL – screening level

Soil SLs for soil invertebrates were derived for six individual PFAS, as summarized in **Table ES-4**.

Table ES-4. Soil Invertebrate Screening Level Summary

Constituent	NOEC Count	LOEC Count	NOEC Soil SL (mg/kg soil)	LOEC Soil SL (mg/kg soil)
PFNA ¹	1	1	1	100
PFOS ^{1,2}	1	1	7.7	141
PFOA ^{1,2}	1	0	50	NA
PFHpA ¹	1	1	1	100
PFHxS ¹	1	1	1	100
PFBS ^{1,2}	1	0	10	NA

Notes:

1. PFNA, PFOS, PFHpA, and PFHxS soil SLs are based on a single paired no observed effect concentration (NOEC) and lowest observed effect concentration (LOEC) (Table 2b). The PFOA and PFBS soil SLs are based on a single unbounded NOEC (Table 2b). Although all are based on survival, a UF was not applied to the PFNA, PFHpA, and PFHxS NOEC SLs as the NOEC is already two orders of magnitude lower than the LOEC.
2. A UF of 10 was applied to the PFOS NOEC of 77 mg/kg as it was less than an order of magnitude lower than the LOEC of 141 mg/kg. The PFOA and PFBS NOEC soil SLs are based on an unbounded NOEC with a survival endpoint. Based on this uncertainty, a UF of 10 was applied to calculate the final PFOA and PFBS SLs.

LOEC - lowest-observed effect concentration; mg/kg – milligrams per kilogram; NOEC – no-observed effect concentration; SL – screening level

Soil and surface water SLs for terrestrial wildlife and sediment and surface water SLs for aquatic wildlife were derived for the six individual PFAS for which both TRVs and BAFs were available. For each wildlife receptor, these RBSLs were derived for protection at both the NOAEL level, appropriate for evaluation of individual T&E species, and the LOAEL level, appropriate for evaluation of ecological populations. The values are presented for aquatic wildlife receptors in **Table ES-5**; terrestrial values are presented in **Table ES-6**.

Table ES-5. Aquatic Risk-Based Screening Level Summary for Wildlife

Habitat			Aquatic RBSL						
Feeding Guild		Herbivore	Insectivore	Carnivore	Carnivore e	Carnivore	Omnivore	Invertivore	Piscivore
Receptor		Muskrat	Little Brown Bat	River Otter	Harbor Seal	Mink	Red- Winged Blackbird	Tree Swallow	Brown Pelican
Constituent	Units								
	NOAEL-based RBSLs								
Sediment									
PFNA	mg/kg	3.6E+00	1.0E-02	2.4E-01	2.0E-01	2.5E-01	NA	NA	NA
PFOS	mg/kg	2.3E-02	5.3E-03	4.7E-02	4.6E-02	3.8E-02	7.0E-03	1.4E-03	1.4E-02
PFOA	mg/kg	1.2E+00	6.0E-03	2.8E-01	1.9E-01	4.0E-01	NA	NA	NA
PFHxA	mg/kg	2.4E+02	1.8E+00	2.9E+01	2.6E+01	2.5E+01	NA	NA	NA
PFBS	mg/kg	3.7E+02	1.1E+00	1.8E+01	1.6E+01	1.5E+01	2.4E+01	7.3E-01	1.3E+01
PFBA	mg/kg	1.6E+02	1.6E+00	2.6E+01	2.3E+01	2.2E+01	NA	NA	NA
Surface Water									

PFNA	mg/L	2.2E-03	4.7E-03	9.2E-03	9.7E-03	6.8E-03	NA	NA	NA
PFOS	mg/L	1.1E-03	3.6E-04	2.8E-04	3.1E-04	2.1E-04	3.4E-04	9.1E-05	7.5E-05
PFOA	mg/L	1.8E-02	4.4E-03	1.2E-02	1.3E-02	9.4E-03	NA	NA	NA
PFHxA	mg/L	6.1E+00	2.1E-01	6.4E+00	5.0E+00	6.9E+00	NA	NA	NA
PFBS	mg/L	7.6E+01	9.4E-01	2.0E+00	2.1E+00	1.5E+00	1.7E+01	6.4E-01	1.3E+00
PFBA	mg/L	4.9E+01	1.4E+00	8.6E-01	9.3E-01	6.6E-01	NA	NA	NA
LOAEL-based RBSLs									
Sediment									
PFNA	mg/kg	4.7E+00	1.3E-02	3.2E-01	2.7E-01	3.3E-01	NA	NA	NA
PFOS	mg/kg	3.8E-02	8.8E-03	7.7E-02	7.7E-02	6.3E-02	7.0E-02	1.4E-02	1.4E-01
PFOA	mg/kg	2.3E+00	1.2E-02	5.7E-01	3.9E-01	8.0E-01	NA	NA	NA
PFHxA	mg/kg	5.1E+02	3.8E+00	6.1E+01	5.5E+01	5.3E+01	NA	NA	NA
PFBS	mg/kg	1.5E+03	4.3E+00	7.0E+01	6.3E+01	6.0E+01	4.0E+01	1.2E+00	2.2E+01
PFBA	mg/kg	3.8E+02	3.8E+00	6.1E+01	5.5E+01	5.3E+01	NA	NA	NA
Surface Water									
PFNA	mg/L	2.9E-03	6.3E-03	1.2E-02	1.3E-02	9.0E-03	NA	NA	NA
PFOS	mg/L	1.8E-03	6.0E-04	4.7E-04	5.1E-04	3.6E-04	3.4E-03	9.1E-04	7.5E-04
PFOA	mg/L	3.6E-02	8.9E-03	2.4E-02	2.6E-02	1.9E-02	NA	NA	NA
PFHxA	mg/L	1.3E+01	4.4E-01	1.3E+01	1.0E+01	1.4E+01	NA	NA	NA
PFBS	mg/L	3.0E+02	3.8E+00	8.0E+00	8.5E+00	6.0E+00	2.9E+01	1.1E+00	2.1E+00
PFBA	mg/L	1.2E+02	3.3E+00	2.1E+00	2.2E+00	1.6E+00	NA	NA	NA

Notes: LOAEL - lowest-observed adverse effect level; mg/kg – milligrams per kilogram; mg/L – milligrams per liter; NA – not available; NOAEL – no-observed adverse effect level; RBSL – risk-based screening level; Gray shading indicates the minimum SL for each PFAS.

Table ES-6. Terrestrial Risk-Based Screening Level Summary for Wildlife

Habitat		Terrestrial RBSL						
Feeding Guild		Herbivore	Invertivore	Insectivore	Carnivore	Herbivore	Insectivore	Carnivore
Receptor		Meadow Vole	Short-Tailed Shrew	Little Brown Bat	Long-Tailed Weasel	American Goldfinch	House Wren	Red-Tailed Hawk
Constituent	Units							
NOAEL-based RBSLs								
Soil								
PFNA	mg/kg	2.3E+00	1.5E+00	1.0E+00	1.5E+00	NA	NA	NA
PFOS	mg/kg	3.1E-01	4.8E-02	3.0E-02	1.7E-01	3.8E-01	1.3E-02	8.7E-02
PFOA	mg/kg	5.8E+00	1.3E+00	8.4E-01	5.7E-01	NA	NA	NA
PFHxA	mg/kg	1.2E+02	3.4E+02	2.5E+02	1.6E+02	NA	NA	NA
PFBS	mg/kg	3.8E+01	1.4E+01	9.1E+00	7.8E+01	8.9E+01	9.3E+00	1.0E+02
PFBA	mg/kg	2.9E+01	7.8E+01	5.8E+01	1.3E+02	NA	NA	NA
Surface Water								

PFNA	mg/L	6.0E+00	5.6E+00	5.2E+00	7.2E+00	NA	NA	NA
PFOS	mg/L	7.3E-01	6.7E-01	6.3E-01	8.6E-01	3.2E-01	3.0E-01	1.4E+00
PFOA	mg/L	2.2E+00	2.0E+00	1.9E+00	2.6E+00	NA	NA	NA
PFHxA	mg/L	6.1E+02	5.6E+02	5.3E+02	7.2E+02	NA	NA	NA
PFBS	mg/L	3.6E+02	3.4E+02	3.2E+02	4.3E+02	3.7E+02	3.5E+02	1.6E+03
PFBA	mg/L	5.3E+02	4.9E+02	4.6E+02	6.3E+02	NA	NA	NA
LOAEL-based RBSLs								
Soil								
PFNA	mg/kg	3.0E+00	2.0E+00	1.3E+00	2.0E+00	NA	NA	NA
PFOS	mg/kg	5.1E-01	7.9E-02	5.0E-02	2.8E-01	3.8E+00	1.3E-01	8.7E-01
PFOA	mg/kg	1.2E+01	2.6E+00	1.7E+00	1.1E+00	NA	NA	NA
PFHxA	mg/kg	2.6E+02	7.0E+02	5.3E+02	3.3E+02	NA	NA	NA
PFBS	mg/kg	1.5E+02	5.7E+01	3.6E+01	3.1E+02	1.5E+02	1.5E+01	1.7E+02
PFBA	mg/kg	7.0E+01	1.9E+02	1.4E+02	3.2E+02	NA	NA	NA
Surface Water								
PFNA	mg/L	8.0E+00	7.4E+00	6.9E+00	9.5E+00	NA	NA	NA
PFOS	mg/L	1.2E+00	1.1E+00	1.0E+00	1.4E+00	3.2E+00	3.0E+00	1.4E+01
PFOA	mg/L	4.4E+00	4.0E+00	3.8E+00	5.2E+00	NA	NA	NA
PFHxA	mg/L	1.3E+03	1.2E+03	1.1E+03	1.5E+03	NA	NA	NA
PFBS	mg/L	1.5E+03	1.3E+03	1.3E+03	1.7E+03	6.2E+02	5.8E+02	2.7E+03
PFBA	mg/L	1.3E+03	1.2E+03	1.1E+03	1.5E+03	NA	NA	NA

Notes: LOAEL - lowest-observed adverse effect level; mg/kg – milligrams per kilogram; mg/L – milligrams per liter; NA – not available; NOAEL – no-observed adverse effect level; RBSL – risk-based screening level; Gray shading indicates the minimum SL for each PFAS.

The soil NOAEL-based RBSLs range from 0.013 mg/kg (PFOS) to 340 mg/kg (pentafluorobenzoic acid [PFHxA]). Sediment NOAEL-based RBSLs range from 0.00143 mg/kg (PFOS) to 370 mg/kg (PFBS). Aquatic receptor surface water NOAEL-based RBSLs had the greatest range of 0.000075 milligrams per liter (mg/L) (PFOS) to 76 mg/L (PFBS).

The majority of minimum NOAEL-based RBSLs for each PFAS are based on invertivore or insectivore receptors, such as the little brown bat, tree swallow, and house wren. The lowest soil NOAEL-based RBSL is associated with the house wren and the lowest sediment NOAEL-based RBSL is associated with the tree swallow. Terrestrial receptors tended to have higher relative RBSLs, as might be expected due to generally lower potential for uptake from dietary sources.

Uncertainties in the calculated SLs for aquatic life, terrestrial plants and soil invertebrates, and wildlife are related primarily to the limited data available for individual PFAS and species. As a result, there is higher confidence in the SLs calculated herein for PFAS and receptors with relatively robust datasets (e.g., PFOS and PFOA RWQ RBSLs and mammalian RBSLs) than for those SLs for PFAS and receptors based on smaller toxicity datasets (e.g., soil invertebrate SLs and bird RBSLs).

Implications for Future Research and Benefits

The SLs calculated in this evaluation provide default SLs for Superfund risk assessments at DoD sites. Prior to this effort, it was difficult to correlate PFAS measured in soil, sediment, or surface water with potential for risk to wildlife (and specifically for the T&E species evaluated). The NOAEL and LOAEL wildlife RBSLs presented in this evaluation bracket possible ecological risk, and allow for consistency in risk assessments conducted at DoD sites. The approaches used herein to calculate screening levels were derived with the goal of producing conservative values that are expected to be protective of ecological receptors. In combination the RWQ RBSLs, plant and invertebrate soil SLs, and wildlife RBSLs for surface water, sediment, and soil cover each environmental medium that would be sampled in an ecological risk assessment, and allow for rapid evaluation of potential risk via a variety of possible exposure pathways. Additionally, the input parameters in the assessment, such as dietary composition of receptors or BAFs, may be adjusted to be site-specific in future risk assessments and/or updated as additional data become available.

Soil RBSLs for reptiles, sediment RBSLs for fish, and sediment SLs for benthic invertebrates could not be developed in this evaluation as there were no available or insufficient laboratory toxicity data available for these receptors and exposure pathways. Development of appropriate toxicity data and subsequent RBSLs and SLs are potential areas of additional future work.

ABSTRACT

Per- and polyfluoroalkyl substances (PFAS) are a class of compounds with wide-ranging uses in industrial and commercial products and processes. Department of Defense sites such as military installations have historically used aqueous film-forming foams containing PFAS in training exercises and in response to onsite crashes. As PFAS do not degrade in the environment and have been measured in aquatic and terrestrial wildlife, their potential toxicity to wildlife is a concern.

A key component of Superfund ecological risk assessments is the evaluation of risk to threatened and endangered species. The purpose of this evaluation is to gather available toxicity data and exposure data and calculate screening levels protective of threatened and endangered species.

Five general groups of threatened and endangered receptors were identified based on where animals live and what they feed on: terrestrial plants, terrestrial invertebrates, terrestrial wildlife, aquatic wildlife and aquatic biota (fish, aquatic invertebrates, aquatic plants, amphibians). Risk-based screening levels can be developed for each group following United States Environmental Protection Agency methodologies. For aquatic biota, such as fish, aquatic invertebrates and aquatic plants, recommended water quality risk-based screening levels are assumed to represent risk-based screening levels protective of aquatic life. These are derived by applying the United States Environmental Protection Agency Great Lakes Initiative methodology to toxicity data identified in the literature. For terrestrial plant and invertebrate receptors, United States Environmental Protection Agency methodology uses literature based allowable concentrations in soil to develop risk-based screening levels, referred to as soil screening levels in this report. To develop terrestrial and aquatic wildlife risk-based screening levels, United States Environmental Protection Agency combines toxicity benchmarks and estimates of potential exposure. Wildlife toxicity benchmarks, called toxicity reference values, are developed separately for birds and mammals and are derived based on toxicity information identified in literature. Potential exposures are modeled based on the dietary preferences of each receptor and information on the bioaccumulation of PFAS from soil, sediment, and surface water into the dietary items comprising the diet of each receptor.

Following a comprehensive literature search for aquatic toxicity data, recommended water quality risk-based screening levels protective of aquatic plants, aquatic invertebrates, fish, and amphibians were calculated following United States Environmental Protection Agency's Great Lakes Initiative approach and the compiled aquatic toxicity data. Screening levels were developed for 23 PFAS. The majority of available toxicity data pertained to PFOS and PFOA, lending higher confidence in these values. Other PFAS screening levels are based on few toxicity data and, therefore, are more likely to evolve as additional toxicity information become available.

Terrestrial and aquatic toxicity data from a comprehensive literature review were collected to support derivation of plant and invertebrate soil screening levels and bird and mammal risk-based screening levels. Reptile toxicity data were not identified and is an important focus for future PFAS toxicity work.

Terrestrial plant and terrestrial invertebrate soil screening levels were calculated as geometric means of the available toxicity data based on growth, reproductive, or survival endpoints.

Data on the direct toxicity of PFAS to threatened and endangered species and on the exposure of threatened and endangered species to PFAS are very limited necessitating the use of surrogate species selected to be representative of threatened and endangered species when developing bird and mammal risk-based screening levels. Exposure parameters for each species, concentrations of individual PFAS in dietary items based on bioaccumulation factors, and calculated toxicity reference values comprise the basis of the model to determine final bird and mammal risk-based screening levels. These screening levels were calculated for each media relevant to a terrestrial receptor (soil and surface water) and each media relevant to an aquatic receptor (sediment and surface water).

Risk-based screening levels for mammals were calculated for six PFAS: PFNA, PFOS, PFOA, PFHxA, PFBS, and PFBA. Risk-based screening levels for birds were calculated for two PFAS: PFOS and PFBS. The PFOS no observed adverse effect level-based risk-based screening levels were the lowest of the six PFAS for soil, sediment, and surface water.. Among all six PFAS, the insectivore or invertivore receptors were most often associated with the lowest calculated screening level. The lowest surface water no-observed adverse effect level risk-based screening levels protective of wildlife were lower than the chronic recommended water quality risk-based screening levels for all six PFAS except for PFBA. Thus, the final appropriate screening level for surface water, either wildlife or recommended water quality risk-based screening level, will depend on the presence of sensitive aquatic bird or mammal receptors.

The screening levels calculated in this evaluation represent default screening values for Superfund risk assessments at Department of Defense sites. These values will provide an initial assessment of the potential ecological risk associated with PFAS measured at various sites and assist with prioritizing areas of potential concern. In combination, the recommended water quality risk-based screening levels, plant and invertebrate soil screening levels, and wildlife risk-based screening level for surface water, sediment, and soil account for each environmental media that would be sampled and each feeding guild that would be considered in an ecological risk assessment.

1 OBJECTIVE

Department of Defense (DoD) has responsibilities in the stewardship and protection of threatened and endangered (T&E) species known or suspected to be present onsite. The objective of this evaluation is to provide per- and polyfluoroalkyl substances (PFAS) risk-based screening levels (RBSLs) protective of T&E species to support ecological risk assessments on DoD sites.

Currently there are no federally promulgated criteria available to relate measured PFAS concentrations in abiotic media to concentrations associated with potential for adverse effects in ecological communities. RBSLs were developed in this project for relevant environmental media, including soil, sediment, and surface water. Air concentrations are not currently considered a concern due to the low volatility of PFAS found in aqueous film-forming foam (AFFF; Place & Field 2012; Xiao et al. 2015). Furthermore, inhalation is considered a minor pathway for most ecological exposures and is not commonly evaluated for potential ecological risk.

Aquatic and terrestrial toxicology data currently available in published literature were reviewed for all PFAS with at least two carbon-fluorine bonds on the base carbon chain structure. These data were used to derive generic screening levels (i.e., screening levels [SLs] or wildlife RBSLs for terrestrial plants, invertebrates, and wildlife; and recommended water quality risk-based screening levels [RWQ RBSLs] for protection of aquatic life) for use at DoD sites. The comprehensive review of data for PFAS as a class allows comparison between individual PFAS chemicals and provides context for lesser known PFAS that may be detected on DoD sites. Additionally, toxicity reference values (TRVs) and bioaccumulation factors (BAFs) developed in support of the RBSL calculations will be available to support future site-specific assessments. In the absence of federal ecological screening criteria for PFAS, the screening levels developed in this evaluation will provide the DoD with tools to evaluate potential risk to ecological receptors, and the methodology used provides a transparent framework that can be used to develop screening levels for additional PFAS as new data become available.

No observed adverse effect level (NOAEL) RBSLs are the traditional screening tool used when evaluating risk to T&E species when protection of individuals is the goal. Lowest observed adverse effect level (LOAEL) RBSLs were calculated to bracket the range when risk may be observed and to provide a range of screening levels to inform risk management decisions. A large difference between the NOAEL and LOAEL RBSL may indicate uncertainty around the NOAEL RBSL and further work to define the NOAEL RBSL may prove beneficial.

2 BACKGROUND

PFAS are a class of compounds with wide-ranging uses in industrial and commercial products and processes. One important use of PFAS is as ingredients in AFFF used to combat (Class B) petroleum fires.

DoD sites frequently have maintenance or fire-training areas with a history of conducting drills using AFFF, which were released directly to the ground or unlined pits. Conducting drills in fire-training areas and responding to Class B fires has resulted in release of PFAS to the environment. Following the use of PFAS in AFFF since the 1960s, PFAS are now commonly measured in the soil and surface water near military bases (Bell et al. 2019; D'Agostino &

Mabury 2017; Dauchy et al. 2017; Houtz et al. 2013). Additional releases to the environment may be related to landfills with commercial or household wastes containing PFAS, photo processing facilities, or maintenance shops. PFAS are extremely persistent in the environment and have been associated with adverse health effects in some laboratory animals. Therefore, potential for long-term effects on ecological communities related to PFAS exposure is of concern.

3 METHODS

SLs were developed for a variety of wildlife and ecological communities, including:

- Aquatic life (aquatic plants and invertebrates, fish, and amphibians): For aquatic life, the screening levels are referred to as RWQ RBSLs. Calculation of RWQ RBSLs was performed following United States Environmental Protection Agency (USEPA) Great Lakes Initiative (GLI) methodology (USEPA 2012).
- Terrestrial plants and soil invertebrates: For terrestrial plants and invertebrates, the SLs are referred to as soil SLs and were developed from available literature-based plant and invertebrate toxicity data using USEPA Ecological Soil Screening Level (EcoSSL) methodology (USEPA 2005).
- Wildlife (birds and mammals): For wildlife (birds and mammals), the screening levels are referred to as wildlife RBSLs. To develop terrestrial and aquatic wildlife RBSLs, USEPA combines TRVs and estimates of potential exposure (USEPA 2005). Available toxicity data and exposure information for T&E species are limited, necessitating use of common surrogate receptors with well-characterized exposure information. T&E species were organized into feeding guilds and appropriate surrogate species selected as the basis of developing wildlife RBSLs. TRVs are developed separately for birds and mammals and derived based on toxicity information identified in literature. Potential exposures are modeled based on the dietary preferences of each receptor and information on the bioaccumulation of PFAS from soil, sediment, and surface water into the dietary items comprising the diet of each receptor.

For some receptors, including reptiles, fish, and benthic invertebrates, SLs could not be developed for one or more media. For reptiles, toxicity data were not identified for development of soil RBSLs. For benthic invertebrates and fish, appropriate toxicity data for development of sediment screening levels were not located. Although screening levels for these receptors were not developed, the available toxicity information is discussed qualitatively in Sections 3.2.3 and 3.3.2.

The methodology used to develop SLs is presented in the sections below and summarized in **Figure 1**. Toxicity data compiled for calculation of RWQ RBSLs are presented in **Tables 1a** through **1c**, and toxicity data compiled for terrestrial plants, soil invertebrates, mammals, and birds are presented in **Tables 2a** through **2d**. Supporting information used in development of the SLs is presented in appendices attached to this report, including Selection of T&E receptors (**Appendix A**), acute and chronic RWQ RBSL calculations (**Appendix B**), terrestrial plant SLs (**Appendix C**), bird and mammal TRV calculations (**Appendix D**), BAFs (**Appendix E**), and wildlife RBSL calculations (**Appendix F**).

3.1 Recommended Water Quality Risk-Based Screening Levels

Surface water SLs for aquatic life were derived using GLI methodology (USEPA 2012) to calculate RWQ RBSL values for individual PFAS. Relevant toxicity data for aquatic invertebrates, plants, amphibians, and fish were compiled from available sources and were used to calculate RWQ RBSLs. The literature search and screening level calculation methods are described below.

Tabulated toxicity values identified during literature review are available in **Table 1a** for freshwater animals, **Table 1b** for marine species, and **Table 1c** for freshwater plants and algae. Data sets used to support RWQ RBSL calculations are presented in **Appendix B**.

3.1.1 Aquatic Literature Review

A comprehensive literature search was conducted to review and compile available PFAS aquatic toxicity data. Available data for aquatic biota were compiled for effects, endpoints, and durations to support calculation of RWQ RBSLs following GLI Tier I and Tier II methodology. The elements of the aquatic literature review are described below.

- (1) Review of published data compilations: Giesy et al. (2010) summarizes available aquatic toxicity data and calculates Tier I or II water quality criteria for perfluorooctanesulfonic acid (PFOS) and perfluorobutane sulfonic acid (PFBS). Similarly, Salice et al. (2018) compiled available toxicity values to calculate a species sensitivity distribution and to provide context to measured PFAS concentrations at a U.S. Air Force Installation. The toxicity data for aquatic plants, invertebrates, amphibian, and fish available in Giesy et al. (2010) or Salice et al. (2018) are included in **Tables 1a** through **1c**.
- (2) Following review of Giesy et al. (2010) and Salice et al. (2018), a literature search and review was conducted to incorporate additional available aquatic toxicity data. Literature searches focused on primary studies published in 2017 or later to incorporate values following submission of Salice et al. (2018) in September 2017. While timeframe of publication was considered in search terms, any primary paper found in the literature and considered relevant was included in the review. Following evaluation of Salice et al. (2018) and Giesy et al. (2010), primary toxicology papers were the focus of the literature search as secondary papers were assumed to be unlikely to provide new data. Select secondary reports such as Organisation for Economic Co-operation and Development (OECD 2002) were reviewed based on perceived availability of new information.

Literature searches were conducted on Google Scholar, PubMed, and Science.gov for primary scientific publications related to the toxicity of PFAS. In addition to scientific articles identified in the direct searches, publications cited in the scientific articles were a source of additional relevant primary literature. Specifically, toxicity data cited in papers were noted and their references obtained to be included in the review.

Primary papers identified through the literature search were included for further evaluation if they were readily available and published in a scientific journal. If full primary papers were not available for review (e.g., were not obtainable or were not available in English), the toxicity data from the paper were not included. Unpublished sources of data, such as master's theses, were not included in **Tables 1a** through **1c** or the evaluation. "Gray"

literature, i.e. reports funded by PFAS manufacturers but unpublished in the peer-reviewed literature, were included in the evaluation.

- (3) The USEPA ECOTOX database was searched for available compiled PFAS toxicity data in October 2018. Relevant papers included in the ECOTOX database were reviewed and toxicity data added to **Tables 1a** through **1c**.

Primary and secondary papers were reviewed for toxicity data with endpoints and exposure durations relevant to calculation of acute and chronic RWQ RBSLs following GLI methodology. Limited data availability for most PFAS supported using a data-inclusive approach when compiling toxicity values to include as much information as possible for PFAS. Therefore, the RWQ RBSL calculations in this evaluation did not consider age of the organism, if it was fed or unfed during the experiment, or the static or flow through conditions during the experiment. Applicable toxicity data as reported by the primary papers were included regardless of whether they were based on nominal or measured concentrations and regardless of methodology or software used to calculate the EC/LC50.

GLI methodology supports including effect concentrations with greater than values (>), as excluding them could bias the calculated RWQ RBSL conservatively. In this evaluation, > and < EC/LC10 through EC/LC100 data were excluded from the evaluation as they are non-specific and could vary widely from the concentration associated with an adverse effect.

Toxicity data relevant for calculation of acute RWQ RBSLs included the concentration where 50 percent of the population is immobilized (EC50) and the concentration that is lethal to 50 percent of the population (LC50). These EC/LC50s were based on exposure durations of 48 hours for cladocerans (e.g., *Daphnia magna*) and 96 hours for all other aquatic species. If the only EC/LC50 available for a species was less than the preferred exposure duration for the tested species, it was included in the evaluation. In some cases, such as the *Lampsilis siliquoides*, a shorter duration was chosen to account for a more sensitive lifestage.

Chronic toxicity data relevant for calculation of chronic RWQ RBSLs included no-observed effect concentrations (NOECs), lowest-observed effect concentrations (LOECs), and EC/LC10s with growth, reproduction, and survival/mortality endpoints derived in laboratory tests on single species of aquatic animals (e.g., fish, aquatic invertebrates). The NOECs, LOECs, or EC/LC10s were based on early life cycle, partial life cycle or life cycle exposure durations. Multi-generation studies were considered as well. Growth endpoints included changes in length or weight; malformations or delays in growth were not included as growth endpoints. Reproductive endpoints with a clear effect on fecundity were included in the evaluation. Adverse effects such as reduced total hatch, reduced live young, and reduced number of young per female were included. Endpoints such as reductions in sperm or oocyte quality and changes in fertilization or hatching rates were not included in the evaluation as these were not considered sufficiently related to a direct effect on fecundity.

The GLI methodology states the Tier I criterion continuous concentration (CCC) is the lower of the final continuous value (FCV) and the final plant value (FPV). Similarly, Tier II methods state the secondary continuous concentration (SCC) is the lower of the secondary continuous value (SCV) and the final plant value (FPV). In order to ensure that the RWQ RBSL values calculated herein are protective of aquatic plants, toxicity data were compiled and evaluated as described in Section 5.1.2. EC/LC10, EC/LC50, NOEC, and LOEC aquatic plant data identified in the literature review are included in **Table 1c**. The most applicable plant growth endpoint, such as

cell density or weight, was selected over other growth endpoints such as biomass or chlorophyll. Plant growth rate endpoints were not included in the evaluation.

The minimum NOEC, LOEC, or EC10 freshwater plant value with a growth, reproduction, or survival endpoint was used in the RWQ RBSL evaluation. If the lowest NOEC, LOEC, or EC10 was notably lower than the other toxicity benchmarks measured in a study and not considered biologically relevant, the lowest within the range of the rest of the data was selected. In one study, Mitchell et al. (2011), the NOECs and LOECs were substantially lower than the EC10s. Based on interpretation of the NOEC and LOEC graphs presented in the study, the EC10 data was considered more representative of biological relevance and used instead of the NOEC or LOEC data in the evaluation. If only EC/LC50s were available, the minimum EC/LC50 was presented in the RWQ RBSL calculation tables (**Appendix B**) to provide context for plant toxicity associated with each PFAS. However, EC/LC50s were not considered an appropriate basis for the FPV and no FPV was selected.

Toxicity values were cited from 104 studies (Table 1a through 1c).

3.1.2 Recommended Water Quality Risk-Based Screening Level Calculations

The methodology used to calculate acute and chronic RWQ RBSLs for PFAS is summarized below. In general, the methodology is consistent with the GLI approach (USEPA 2012), and more detail can be found in that document. Data used in the calculations, including acute toxicity data, and paired acute-chronic data used in the acute to chronic ratio (ACR) calculations, are presented in **Appendix B**. Number of species groups fulfilled is presented in **Table 7**. The available data were sufficient to calculate RWQ RBSLs for PFOS and PFOA using Tier I methodology. RWQ RBSLs were calculated for an additional 21 individual PFAS using Tier II methodology, as their data sets were insufficient to calculate screening levels using Tier I methodology.

USEPA's GLI methodology was developed to provide criterion values protective of aquatic life in mixing zones. Specifically, the Tier I acute value (criterion maximum concentration [CMC]) was developed for aquatic life at the edge of the acute mixing zone (USEPA 2012). The Tier I chronic value, the criterion continuous concentration (CCC), was developed for application at low-flow conditions according to principles of USEPA Water Quality Criteria Guidance documents (specifically the "7Q10" flow, the lowest average flow over 7 days in the past 10 years). When datasets are insufficient to calculate Tier I values, Tier II methodology can be used to calculate acute values (Secondary Maximum Concentrations [SMC]) and chronic values (SCC), which are analogous to the CMC and CCC, respectively. GLI methodology results in acute and chronic criteria that are expected to be protective of 95 percent of species. Assuming T&E species will not be among the most sensitive species to PFAS, this methodology is considered by USEPA (2012) to be adequately protective.

In this evaluation, the principles of GLI methodology are applied to calculate acute and chronic RWQ RBSL values for application to water bodies where aquatic wildlife may be exposed over acute or chronic durations without respect to mixing zones. The chronic RWQ RBSL is intended to be a concentration at which aquatic populations may be exposed indefinitely without adverse effect on the community, while the acute RWQ RBSL is protective of populations over an acute exposure. By definition (USEPA 2012), "aquatic organisms should not be affected unacceptably

if the four-day average concentration does not exceed the [chronic value] more than once every three years on the average and if the one-hour average concentration does not exceed the [acute value] more than once every three years on the average.”

The FPV is the lowest acute duration freshwater plant NOEC in the dataset, and is considered representative of a chronic endpoint. Typically, results from 72-hour or 96-hour tests with algae or cyanobacteria can be used to fulfill the FPV requirement; acute aquatic macrophyte data are also acceptable (e.g., 7-day NOEC for *Lemna* spp.). In some cases, NOECs were not reported or were higher than a LOEC from a different study. Therefore, the minimum NOEC, LOEC, or EC10 plant value with a growth, reproduction, or survival was used as the basis of the FPV in the RWQ RBSL evaluation. If the lowest NOEC, LOEC, or EC10 was notably lower than the other toxicity benchmarks measured in a study and not considered biologically relevant, the lowest within the range of the rest of the data was selected as discussed above in Section 3.1.1. The FPV for each PFAS is presented in **Appendix B**. If no toxicity values met the FPV requirements, the minimum available plant toxicity value is presented but no FPV was selected.

The final chronic RWQ RBSL value is the lower of the FCV or SCV and FPV.

Consistent with GLI methods, RWQ RBSLs were calculated only for freshwater species and may be less representative for non-freshwater species. A comparison of freshwater and marine toxicity data is presented in Section 4.1.

Tier I Acute Methodology

EPA’s Water Quality Guidance for the Great Lakes System (GLI) methodology to derive acute criteria, the CMC, and the chronic value, the CCC, were developed to be protective of wildlife in mixing zones. Specifically, the CMC was developed for aquatic life at the edge of the acute mixing zone (USEPA 2012). The chronic value was developed for application at low-flow conditions according to principles of US EPA Water Quality Criteria Guidance documents (specifically the “7Q10” flow, the lowest average flow over 7 days in the past 10 years).

For calculation of Tier I values, relevant acute data must be available for at least 8 of the 8 recommended families (**Appendix B, Table 1**) (USEPA 2012). The standard practice is to calculate the allowable acute exposure concentration based on the four lowest genus mean acute values (GMAVs) available from the total number of GMAVs. The following equations are used:

Equation 1:

$$FAV = e^A$$

Where:

FAV = final acute value

Equation 2:

$$A = S \times (\sqrt{0.05}) + L$$

Where:

Equation 3:

$$L = \frac{\sum(\ln \text{GMAV}) - S \times (\sum(\sqrt{P}))}{4}$$

Where:

GMAV = genus mean acute value

P = cumulative probability for each GMAV

Equation 4:

$$S^2 = \frac{\sum((\ln \text{GMAV})^2) - \frac{(\sum(\ln \text{GMAV}))^2}{4}}{\sum(P) - \frac{(\sum(\sqrt{P}))^2}{4}}$$

Where:

GMAV = genus mean acute value

P = cumulative probability for each GMAV

Equation 5:

$$P = \frac{R}{(N + 1)}$$

Where:

P = cumulative probability for each GMAV

R = rank for each GMAV

N = total number of GMAVs

The resulting final acute value (FAV) results in protection of 95 percent of aquatic species from mortality or other irreversible effects due to short-term exposure. The FAV is further divided by an application factor of 2 to calculate the acute screening level, a concentration that should protect aquatic species from potential higher fluctuations of concentrations over acute exposure.

Tier I Chronic Methodology

To derive the final chronic value (FCV), an acute to chronic ratio (ACR) is calculated and applied to the FAV. The acute to chronic ratio is either empirically determined or, if an empirical value cannot be determined, a standard value of 18 is used. Per GLI guidance, both freshwater and saltwater species were included in the ACR calculations.

The species selected, acute and chronic data classification, and data references used to calculate the acute to chronic ratios are presented in **Appendix B**. To calculate the ACR for a given species, the lowest effect concentration to 50 percent of the test population (EC50) or lethal

effect concentration to 50 percent of the test population (LC50) is divided by the geometric mean of the LOEC and NOEC from the chronic study. Ideally, the acute and chronic values are reported from the same study or lab. The lowest of the EC50s and LC50s from a dataset are referred to as the EC/LC₅₀ :

Equation 6:

$$ACR = \frac{acute\ EC/LC_{50}}{\sqrt{chronic\ NOEC \times chronic\ LOEC}}$$

To obtain an overall ACR, the geometric mean of default or estimated ACRs is calculated. At least three ACRs are used to calculate the overall ACR. Thus, if one empirical ACR is available, the overall ACR would be calculated as the geometric mean of the ACR and two default ACRs of 18. The FCV is calculated as:

Equation 7:

$$FCV = \frac{FAV}{ACR}$$

Tier II Acute Methodology

For the Tier II Acute value, the screening level for exposure of aquatic organisms during an acute duration is established by setting the allowable acute exposure concentration to a fraction of the lowest GMAV (geometric mean of acute EC/LC50 data for a genus) for the freshwater animal species tested. The fraction is determined using a safety factor, the secondary acute factor (SAF), that ranges from 4.3 to 21.9 depending on the number of groups of aquatic organisms tested out of the 8 groups specified in the GLI approach; the more groups with toxicity data, the lower the safety factor. The resulting secondary acute value (SAV) is protective of 95 percent of aquatic species from mortality or other irreversible effects due to short-term exposure. The SAV is further divided by an application factor of 2 to calculate a concentration that should protect aquatic species from potential higher fluctuations of concentrations over acute exposures. The following equations are used:

Equation 8:

$$SAV = \frac{GMAV}{SAF}$$

Equation 9:

$$Acute\ screening\ level = \frac{SAV}{2}$$

Where:

GMAV = minimum genus mean acute value in milligrams per liter (mg/L)

SAF = secondary acute factor (unitless)

SAV = secondary acute value in mg/L

Tier II Chronic Methodology

For calculation of Tier II chronic value, a screening level for exposure of aquatic organisms over chronic duration is established by applying an overall ACR to the SAV (USEPA 2012). The ACR is either empirically determined for each species, or, if an empirical value cannot be determined, a default value of 18 is used.

To calculate the ACR, the EC/LC50 for the acute endpoint is divided by the geometric mean of the LOEC and NOEC for the chronic endpoint as presented in Equation 6 above.

To obtain an overall ACR, the geometric mean of default or empirical ACRs is calculated. At least three ACRs are used to calculate the overall ACR. Thus, if one empirical ACR is available, the overall ACR would be calculated as the geometric mean of the ACR and two default ACRs of 18.

The SCV is calculated as:

Equation 10:

$$SCV = \frac{SAV}{ACR}$$

3.2 Terrestrial Plant and Invertebrate Screening Levels

SLs for the protection of terrestrial plants and soil invertebrates were derived for a range of PFAS using methods developed for calculation of EcoSSLs (USEPA 2005). Relevant toxicity data for terrestrial plants and soil invertebrates were compiled from published sources and were used to calculate screening levels, as described below. For plants and soil invertebrates, route-specific doses are not quantified. Potential exposures for these receptors are expressed as soil concentrations, for example, in units of milligrams per kilogram. Therefore, consideration of specific T&E species was not necessary; soil screening levels were calculated for terrestrial invertebrates and plants and can be used as screening levels for any T&E or non-threatened or endangered invertebrate and plant species.

Tabulated toxicity values identified during literature review are presented in **Tables 2a** and **2b** for plants and soil invertebrates, respectively. Data sets used to support terrestrial plant SLs are presented in **Appendix C**.

The same literature review process was used to compile toxicity data for benthic invertebrates based on exposure to PFAS in sediment. However, no available toxicity data were located. The available information is discussed in Section 3.2.3 below.

3.2.1 Toxicity Value Literature Review

A comprehensive literature search was conducted to identify available PFAS terrestrial plant, soil invertebrate, and aquatic benthic invertebrate toxicity data for soil and sediment. These data were compiled and used to develop SLs. The literature review included (1) a literature search on multiple search engines using key words and (2) a search on the USEPA ECOTOX database.

- (1) Literature searches were conducted on ProQuest Dialog, Google Scholar, PubMed, and Science.gov and relevant studies were included regardless of publication date. In addition to direct searches, references of papers reviewed were a source of additional primary literature. Specifically, toxicity data cited in papers were noted and their references

obtained to be included in the review. Primary toxicology papers were the focus of the literature search as secondary papers would potentially provide no new values. Only academic work published in peer reviewed journals was included as sources of toxicity data. Unpublished academic sources that are not peer-reviewed, such as master's theses, were not included. "Gray" literature, i.e., reports funded by PFAS manufacturers but unpublished in the peer-reviewed literature, were included in the evaluation.

- (2) The USEPA ECOTOX database was searched for available PFAS toxicity data in February 2019. Relevant papers included in the ECOTOX database were reviewed and toxicity data added to **Tables 2a** and **2b**.

Primary and secondary papers were reviewed for toxicity data for growth, reproduction, and survival endpoints that would allow derivation of soil SLs for terrestrial plants and soil invertebrates and sediment SLs for benthic invertebrates following the EcoSSL approach. NOEC, LOEC, and EC0 through EC20 values for growth, reproduction, and survival were recorded in **Tables 2a** and **2b**.

Toxicity values compiled for plants included adverse effects on growth and survival endpoints, such as decreases in root and shoot length and decreases in biomass. Growth endpoints incorporated in **Table 2a** and the SL calculations include: root and shoot elongation and length, seed germination, biomass, height, and shoot weight. Exposure durations ranged from 63 hours to 50 days.

Measured endpoints or media irrelevant to the current evaluation, such as hydroponic and agar culture studies, were excluded from further evaluation. Chlorophyll absorbance and fluorescence values were excluded as these were not sufficiently correlated with reductions in growth or survival. Increased biomass or length were observed at low concentrations in multiple studies, but were not considered an adverse effect and therefore were not included. If the timepoints or treatment groups with significant effects did not follow expected dose-response (increased frequency or magnitude of adverse effects with increasing chemical concentrations), the values were excluded from the evaluation. No reproductive toxicity endpoints for plants were identified in the literature review. As stated above, studies of plants grown in media other than soil were not included in the evaluation as they would not inform development of soil screening levels.

Toxicity values considered for terrestrial and benthic invertebrates included adverse effects on growth, reproduction, and survival endpoints, such as decreased body weight, reduced number of offspring, and increased mortality. Measured endpoints or media irrelevant to the current evaluation, such as drinking water, dietary exposure, or aqueous topical testing, were excluded from further evaluation. If the timepoints or treatment groups with significant effects did not follow expected dose-response (increased frequency or magnitude of adverse effects with increasing chemical concentrations), the values were excluded from the evaluation. For soil invertebrates the only endpoint incorporated in **Table 2b** and the screening level calculations is survival. Exposure durations ranged from 14 days to 21 days. Relevant data were not located for benthic invertebrates.

A small but statistically significant increase in mortality (5 percent for perfluorohexane sulfonic acid [PFHxS], perfluorononanoic acid [PFNA], and perfluoroheptanoic acid [PFHpA]) was observed at low doses in Karnjanapiboonwong et al. 2018. The authors stated that mortality in the experiment may not be distinguishable in nature, however, these data were conservatively included as LOECs.

3.2.2 Soil Screening Level Development

SLs were developed using the toxicity data presented in **Tables 2a** and **2b**. Terrestrial plant and terrestrial invertebrate soil SLs were calculated as the geometric mean of available NOEC/EC10 or LOEC/EC20 values. The NOEC SL was calculated as the geometric mean of all bounded NOEC/EC10 values with reproduction or growth as the endpoint. The LOEC screening level was calculated as the geometric mean of all bounded or unbounded LOEC/EC20 values with growth, reproduction, or survival as the endpoint. If the LOEC-based SL was lower than the NOEC-based SL, the LOEC-based value was divided by an uncertainty factor (UF) of 10 to calculate the final NOEC-based SL.

Several values presented in **Tables 2a** and **2b** are unbounded NOECs or LOECs. Bounded NOECs are paired with a LOEC from the same study, whereas unbounded NOECs and LOECs are not paired. Unbounded NOECs are reported when the highest test concentration does not produce effects significantly different than in the control. Unbounded LOECs are the lowest tested concentration (other than the control). Due to the uncertainties associated with unbounded NOECs (i.e., it is unknown if an effect would have occurred at a slightly higher dose or a substantially higher dose) they were excluded from calculations if bounded values were available. In the event only unbounded terrestrial plant or invertebrate values were available, they were included, often with a UF applied. Unbounded LOECs have additional uncertainty compared to a bounded LOEC; however, they were included in calculations as an effect was measured at that concentration.

If multiple NOECs and LOECs with an appropriate endpoint were reported in a study, only the lowest of each was incorporated in the SL calculations. However, if the paper reported values from multiple related tests, such as a pilot and main study, or tested multiple species, the lowest NOECs and LOECs of each study or species were incorporated.

3.2.3 Sediment Screening Level Development

For benthic invertebrates, no relevant data were located in the literature search, consistent with the findings of the review conducted by Valsecchi et al. (2017). Higgins et al. (2007) conducted sediment bioaccumulation testing with several PFAS and *Lumbriculus variegatus*; however, the only measured endpoint was a reduction in total weight of the worms, which was also observed in the control animals. Perfluoroalkyl sulfonates, perfluorocarboxylates, and 2-(N-ethylperfluorooctane sulfonamido) acetic acid (N-EtFOSAA) were tested. If it is assumed that there were no treatment-related effects on survival in the bioaccumulation studies, unbounded NOAELs could be estimated ranging from 0.000038 milligrams per kilogram (mg/kg) for perfluoroundecanoic acid (PFUnA) to 0.00228 mg/kg for PFOS based on the minimum and maximum concentrations in sediment.

Data are not sufficient to develop sediment screening levels for benthic invertebrates at this time.

3.3 Wildlife Risk-Based Screening Levels

In contrast to the RWQ RBSLs and terrestrial plant and invertebrate soil SLs, wildlife RBSLs for birds and mammals were developed using foodweb models, the approach used in calculation of EcoSSLs (USEPA 2005). Using these methods, exposure doses from relevant dietary exposure pathways are compared to dose-based toxicity thresholds (i.e., TRVs), and used to back-calculate soil or surface water concentrations that correspond to a target effect level. Thus, additional

information, such as food ingestion rate (FIR), dietary composition, and uptake data, is needed to model exposure for each bird and mammal receptor. Toxicity, uptake, and exposure information are highly limited or unavailable for T&E species; therefore, a representative surrogate species with available toxicity and uptake data was identified for each T&E feeding guild.

T&E receptors and representative surrogate receptors were selected based on identification of species potentially present at DoD sites. Associated exposure parameter data were identified from standard sources such as the USEPA Wildlife Exposure Factors Handbook (USEPA 1993) or U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) Development of Terrestrial Exposure and Bioaccumulation Information for the Army Risk Assessment Modeling System (USACHPPM 2004). Relevant toxicity and uptake data for mammals and birds were compiled from peer-reviewed literature and were used to derive TRVs and BAFs, respectively. The literature search, development of TRVs and BAFs, and SL calculation methods are described in the following sections.

With the aim of developing SLs protective of T&E species potentially present on DoD sites, RBSLs were developed based on NOAELs, as T&E species are protected at the individual level and no adverse effects are allowed. However, LOAEL-based RBSLs were also calculated to provide a range of risk estimates useful at sites where no T&E species have been identified and/or where protection at the population level may be desired.

3.3.1 Threatened and Endangered Species and Representative Surrogate Selection

A summary of the T&E species feeding guilds, identification of a representative T&E species within each feeding guild, and selection of representative surrogate species is presented in this section and in **Table 3**. More detail can be found in **Appendix A**.

The U.S. Fish and Wildlife Service Environmental Conservation Online System (ECOS) was searched in October 2018 for a list of all T&E mammal, bird, and reptile species in the United States. ECOS listed 93 mammals, 101 birds, and 42 reptiles classified as T&E. As no reptile toxicity information was identified, reptiles were not evaluated for surrogate receptors in the following steps.

The T&E wildlife species were classified by feeding guild: terrestrial or aquatic carnivore, piscivore, omnivore, invertivore, insectivore, or herbivore. Only the T&E species that were associated with a single habitat and feeding guild were included in the evaluation (listed in **Appendix A, Table 1a**). Species identified as potentially associated with two feeding guilds or two habitats depending on environmental conditions, i.e., omnivore or invertivore or terrestrial or aquatic, were excluded from evaluation. Species potentially present in multiple habitats were considered to be indirectly assessed through a combination of surrogate species with high fidelity to one feeding guild and habitat. For instance, an herbivorous receptor with aquatic and terrestrial mixed habitat would be exposed through a combination of these habitats. One habitat would be associated with a higher degree of exposure and lower RSBL. In developing RBSLs for herbivorous receptors with high fidelity to each habitat, the lower of the two is assumed to be protective of herbivorous receptors with mixed habitats. This should be considered in application of RBSLs to T&E receptors with mixed diets or habitats.

Few T&E birds were classified as wetland carnivores, and this feeding guild was not evaluated as their potential exposure was considered to be less than for wetland piscivores based on higher expected PFAS uptake to fish than small mammal prey (**Table 6**). ECOS T&E species excluded

from the evaluation and basis for elimination are listed in **Appendix A, Table 1b**. A full list of T&E species as classified by ECOS is presented in **Appendix A, Table 2**.

A single T&E representative species was selected to represent feeding guilds assumed to have similar or lower PFAS exposure and risk. For instance, developing RBSLs for both a terrestrial invertivore and terrestrial herbivore was considered protective of a terrestrial omnivore.

Representative T&E species were selected for each feeding guild based on the following factors:

1. expected high-degree of exposure and/or sensitivity (e.g., small receptors with high dietary ingestion rates chosen over larger receptors with lower FIRs),
2. applicability to other T&E species within the guild (e.g. a species of shrew chosen if several shrews listed),
3. confirmed or potential presence on DOD installations, and
4. the amount of money spent by the DOD to protect a T&E species was considered as a line of evidence in selecting representative T&E species (**Appendix A, Table 1a**).

Because adequate exposure and toxicity data are unavailable for most T&E species, a representative surrogate species was selected for each T&E representative species based on similarity to the T&E species, common use as a surrogate species in ecological risk assessment, and availability of applicable exposure and toxicity data.

3.3.2 Development of Toxicity Reference Values

TRVs were developed from the compiled toxicity data in **Tables 2c** and **2d**. NOAEL-based TRVs were calculated using EcoSSL methodology. LOAEL-based TRVs were based on the lowest appropriate bounded LOAEL. UFs were applied as needed to account for short study durations. The literature search and TRV development methods are summarized below, and selected TRVs are presented in **Table 4** for mammals and birds. More detail can be found in **Appendix D**.

Toxicity Data Literature Review

The toxicity literature review incorporated primary and secondary papers on mammalian and bird PFAS toxicity. The literature review process included (1) a review of compiled toxicity values in recent guidance documents (2) a literature search on multiple search engines using key words, and (3) a search on the USEPA ECOTOX database.

- (1) The following key guidance documents were reviewed for available toxicity values:
 - Agency for Toxic Substances and Disease Registry (ATSDR; 2018) Toxicological Profile for Perfluoroalkyls.
 - New Jersey Department of Environmental Protection (NJDEP; 2019a) Technical Support Document: Interim Specific Ground Water Criterion for Perfluorooctane Sulfonate (PFOS).
 - NJDEP (2019b) Technical Support Document: Interim Specific Ground Water Criterion for Perfluorooctanoic Acid (PFOA, C8).
 - New Jersey Drinking Water Quality Institute (2015) Health-Based Maximum Contaminant Level Support Document: Perfluorononanoic Acid (PFNA).
 - OECD (2002) Hazard Assessment of Perfluorooctane Sulfonate (PFOS) and Its Salts.

- USEPA (2016a) Drinking Water Health Advisory for Perfluorooctane Sulfonate (PFOS).
 - USEPA (2016b) Drinking Water Health Advisory for Perfluorooctanoic Acid (PFOA).
 - USEPA (2016c) Health Effects Support Document for Perfluorooctanoic Acid (PFOA).
 - USEPA (2016d) Health Effects Support Document for Perfluorooctane Sulfonate (PFOS).
 - USEPA (2018a) Human Health Toxicity Values for Perfluorobutane Sulfonic Acid and Related Potassium Perfluorobutane Sulfonate.
 - USEPA (2018b) Human Health Toxicity Values for Hexafluoropropylene Oxide (HFPO) Dimer Acids and Its Ammonium Salt.
- (2) Literature searches were conducted on ProQuest Dialog, Google Scholar, PubMed, and Science.gov. In addition to direct searches, references of papers reviewed were a source of additional relevant primary literature. Specifically, toxicity values cited in papers were noted and their references obtained to be included in the review. Primary toxicology papers were the focus of the literature search as secondary papers would potentially provide no new values. Select secondary reports such as McCarthy et al. (2017) and OECD (2002) were reviewed based on perceived availability of new information. Relevant studies were included in literature review regardless of publication date. Only published academic work were sources of toxicity data and unpublished sources, such as master's theses, were not included. "Gray" literature, i.e. reports funded by manufacturers of PFAS but unpublished, were included in the evaluation.
- (3) The USEPA ECOTOX was searched for available compiled PFAS toxicity data in February 2019. Relevant papers included in the ECOTOX database were reviewed and toxicity values added to **Tables 2c** and **2d**.

Primary and secondary papers were reviewed for toxicity data that would support development of a TRV using EcoSSL methodology (USEPA 2007a,b). Growth, reproduction, and survival effects with NOAEL, LOAEL, and EC0 through EC20 endpoints were added to **Tables 2c** and **2d**. Relevant growth endpoints included decreased body weight or body length in juvenile animals; malformations or delays in development were not included as growth endpoints. For inclusion as a growth effect rather than an adult wasting effect, ages of species at time of puberty as well as the age when adult body weight is mostly attained was considered. Mice were considered juvenile if they were less than 6 weeks old, rats if they were less than 8 weeks old, and birds were considered juvenile if they were less than approximately 15 to 16 weeks old (Dutta and Sengupta 2016; Sengupta 2013; Brennan et al. 2014; Drilling et al. 2018). Reproductive endpoints included in the current evaluation were consistent with endpoints included in the EcoSSL TRV derivation (USEPA 2007a, Table 17). Note that in the GLI approach and associated aquatic toxicity data review, the preferred endpoints have clear effects on fecundity; the bird and mammal toxicity review included more sensitive endpoints, consistent with the EcoSSL methodology. For example, EcoSSLs include endpoints such as death of young and number of viable eggs, as well as time to vaginal opening or balanopreputial separation, reproductive organ weight, and sperm cell count. These later endpoints cannot be as clearly tied to direct adverse effects at the individual level.

Only studies evaluating relevant exposure pathways for wildlife, such as ingestion of food or water or oral gavage, were included in the literature review. Studies on the toxicity of PFAS via inhalation, were excluded because inhalation is assumed to be a minor exposure pathway for wildlife and the focus of this evaluation is development of soil, sediment, and surface water RBSLs. Additionally, PFAS typically associated with fire training areas and other activities associated with the release of PFAS on DoD sites have low volatility indicating inhalation would not be a primary exposure pathway (Xiao et al. 2015). Studies relying on exposure via subcutaneous implant, injection, or egg injection were not included, as these pathways do not reflect relevant exposure pathways in wildlife and do not provide a direct relationship between oral ingestion and toxicity (USACHPPM 2004).

Acute, subchronic, and chronic data were included in the evaluation and are presented in **Tables 2c** and **2d**. Following EcoSSL methodology, studies with an exposure duration of three days or less were excluded from the bird and mammal literature review (USEPA 2005). Only the lowest applicable NOAEL and LOAEL per paper are included in **Tables 2c** and **2d** unless multiple separate studies are reported in one paper; for example, if two separate experiments with different treatment groups and/or exposure durations were reported in the same paper. As is recommended by EcoSSL, the lower of the male and female values were used in the development of TRVs to account for the more sensitive sex (USEPA 2007a).

The existing mammalian PFAS toxicity literature is extensive and often conducted to inform mechanistic understanding and potential impacts to human health (individuals rather than wildlife populations). Therefore, review of primary studies was limited to those that were focused on measuring endpoints relevant to wildlife populations (survival, reproduction, and growth) as their stated objective. Toxicity values previously compiled in guidance documents or review papers were included in **Tables 2c** and **2d** if they had a growth, reproduction, or survival endpoint generally without further review of the primary study's objective. However, when values were cited from secondary sources with growth endpoints, a high-level review of the primary paper was completed for age and body weight data to verify a growth endpoint associated with a juvenile. If the age or body weights indicated the test animals were adult at the start of the study, the endpoint was considered wasting and excluded from the toxicity tables and calculations. Primary study objective was considered as a point of exclusion at this step for consistency with primary literature review.

Bird toxicity studies are typically not discussed in the existing guidance documents and available primary literature was limited. All bird primary papers identified during the literature search were reviewed and included in **Table 2d** provided they met the exposure pathway and duration qualifications.

Fish toxicity studies with dietary dosing are needed to represent exposures to chemicals in sediment and develop fish TRVs and RBSLs using dose-based foodweb models. Fish toxicity data with growth, reproduction, or survival endpoints and dietary exposure were not identified. Two fish studies using dietary exposures measured endpoints related to sex steroids, expression of genes and enzymes, and oxidative stress (Arukwe et al. 2011; Mortensen et al. 2011). Another study also exposing fish via diet found no effects on mortality or liver somatic index (Martin et al. 2003). The Martin et al. study provides survival NOAELs for 11 PFAS ranging from 0.32 micrograms per gram ($\mu\text{g/g}$) of PFBS to 1.2 $\mu\text{g/g}$ of perfluorotetradecanoic acid (PFTA). However, this single NOAEL value is insufficient to calculate TRVs and RBSLs for fish according to EcoSSL methods (which require a minimum of three toxicity values). The RWQ

RBSL for surface water and wildlife sediment RBSLs may be used to estimate potential for adverse effects on fish exposed to sediment containing PFAS.

Data from approximately 125 primary papers or unpublished reports are included in **Tables 2a, b, c, and d**. Of these reports, 6 reports pertained to plants, 3 to invertebrates, approximately 105 to mammals, and 11 to birds.

In recording reported toxicity data, measured concentrations were preferentially chosen over nominal concentrations in each study, if available. Only the lowest applicable NOAEL and LOAEL (or EC0 to EC20) from each primary study is included in **Tables 2c and 2d**.

Concentrations (in units of mg/kg) in feed or dosing vehicle were adjusted to exposure doses (in units of mg/kg bw-day) by study reported body weights and FIRs, if available. If food ingestion rates were unavailable, surrogate values from similar studies were substituted. The equation to calculate the NOAEL or LOAEL dose in milligrams per kilogram body weight per day (mg/kg-bw/day) from a concentration in media is shown below.

Equation 11:

$$\text{Dose (mg per kg of BW per day)} = \frac{(\text{Concentration (mg per kg of feed)} \times \text{FIR (kg feed per animal per day)})}{\text{BW (kg per animal)}}$$

Definitions

BW – body weight (kg/animal)

FIR – food ingestion rate (kg/animal/d)

g – gram

mg – milligram

kg – kilogram

ppm – parts per million

Toxicity Reference Value Development

Bird TRVs and mammalian TRVs were calculated following EcoSSL methodology (USEPA 2007b). NOAELs and LOAELs selected for inclusion in the TRV datasets were based on studies with exposure durations of 3 days or greater (subchronic or chronic) and survival, growth, or reproduction endpoints. Generally, only reproduction and growth NOAELs are considered in development of the NOAEL TRV, while all three endpoints are included in the LOAEL TRV dataset. If fewer than three reproduction and growth NOAELs were available, NOAELs based on mortality were considered following EcoSSL guidance. In **Appendix D**, reproduction and growth NOAELs and reproduction, growth, or survival LOAELs are presented. NOAELs based on survival are presented in **Tables 2c and 2d**. If multiple NOAELs and LOAELs were reported in a study, only the lowest of each were incorporated in the TRV calculations. However, if the study reported values from multiple related or concurrent tests or tested multiple species, the lowest NOAELs and LOAELs of each study or species were incorporated.

As described in more detail below, EcoSSL guidance recommends the geometric mean of NOAELs with a growth or reproductive endpoint as the NOAEL-based TRV when it is lower than the lowest bounded LOAEL and if the mechanism of toxicity is addressed. Effects on

reproduction and growth in mammals and birds are consistently observed in the dataset. For the purposes of this evaluation, the mechanism of toxicity was considered sufficiently addressed by using the geometric mean of growth and reproduction NOAELs in all cases where the geometric mean is lower than the lowest bounded LOAEL (USEPA 2007a,b).

Mammalian TRVs were calculated for 9 PFAS: PFNA, PFOS, PFOA, perfluorohexanoic acid (PFHxA), PFBS, PFBA, 6:2 fluorotelomer alcohol (FTOH), GenX, and N-EtFOSE. Bird TRVs were calculated only for PFOS and PFBS, as applicable toxicity data were unavailable for other individual PFAS.

A summary of the NOAEL and LOAEL-based TRVs for mammals and birds is presented in **Table 4**. Summary sheets presenting the NOAEL and LOAEL datasets and steps followed in the derivation of NOAEL and LOAEL-based TRVs are presented for each PFAS in **Appendix D**.

NOAEL TRVs

The minimum data requirements to derive a NOAEL TRV were (1) at least 3 toxicity data (either NOAEL or LOAEL) with growth, reproduction, or mortality as the endpoint and (2) at least 2 species tested. If the geometric mean of the NOAELs based on growth or reproduction was lower than the lowest bounded LOAEL, the geometric mean was selected as the basis of the NOAEL. If not, the highest bounded NOAEL with a reproduction or growth endpoint below the lowest bounded LOAEL was selected. In a few instances, the number of appropriate NOAELs was less than three and a geometric mean could not be calculated. As the NOAELs available were below the lowest bounded LOAEL, the lowest NOAEL with a growth, reproduction, or mortality endpoint was selected as the basis of the NOAEL TRV.

LOAEL TRVs

The minimum data requirements to derive a LOAEL TRV were (1) at least three toxicity data (NOAEL or LOAEL) with growth, reproduction, or mortality as the endpoint and (2) at least two species tested.

The LOAEL selected as the basis of a LOAEL TRV was the lowest bounded LOAEL in the data set with growth, reproduction, or mortality as the endpoint.

The methodology to derive NOAEL and LOAEL TRVs follows the EcoSSL methodology (USEPA 2007b). Additional details can be found in that document.

Uncertainty Factors

Although UFs are not used in the EcoSSL approach, they were applied herein in specific cases to ensure that the final NOAEL and LOAEL TRVs are appropriately conservative for use with T&E species. A UF was applied to correct subchronic exposure durations to chronic-equivalent durations.

UFs were applied to estimate chronic effect levels from studies conducted over subchronic durations. After selecting the basis for the NOAEL and LOAEL TRVs, the exposure duration of the study was evaluated for subchronic or chronic duration (described in detail below). An UF of 10 was applied to NOAEL or LOAEL TRVs based on a subchronic study duration to calculate the final chronic-equivalent NOAEL or LOAEL TRV. Acute studies, defined in this evaluation as 3 days or less, were excluded from evaluation at the literature review step.

The length of subchronic versus chronic durations are defined by the lifespan of the species. Following EcoSSL guidance, a study duration was considered chronic if it was 10 percent or more of the species expected lifespan (USEPA 2003). Generational or reproductive studies that included exposure over the gestational period were considered chronic as they included exposure over the duration of a sensitive lifestage (fetal development). Subchronic studies were any study shorter than 10 percent of the species expected lifespan that did not include gestational exposure.

The expected lifespan for a laboratory mouse is approximately 24 months while the laboratory rat can be expected to live to approximately 24 to 42 months (USEPA 1987; USEPA 2007a; Sengupta 2013). Applying 10 percent, the minimum chronic duration study for a mouse is approximately 10 weeks and 15 weeks for rats. Rabbit chronic study durations were considered to be approximately 31 weeks, or 10 percent of their 6-year lifespan (USEPA 1987; USEPA 2007a). Rabbit studies in the dataset included gestational exposure and were considered chronic. Quail and mallards have lifespans greater than 3 years and chronic study duration is at least 16 weeks (USEPA 1987; USEPA 2007a).

3.3.3 Wildlife Risk-Based Screening Level Development

Wildlife RBSLs represent the PFAS concentration in soil (or sediment or water) that results in the receptor having an exposure equal to the TRV. RBSLs are calculated using a foodweb model and the equations presented below. In order to calculate RBSLs, the required inputs include exposure assumptions for each receptor, including BAFs to dietary items, ingestion rates, and body weights, along with toxicity assumptions, represented by an appropriate TRV. NOAEL and LOAEL-based RBSLs were calculated using the NOAEL and LOAEL-based TRVs discussed in Section 3.3.2 and presented in **Table 4** and the exposure assumptions outlined below.

Risk-Based Screening Level Calculations

For potential wildlife receptors (mammals and birds), route-specific and food-web or dietary exposure models can be used to estimate the concentration in each medium (soil, sediment, or surface water) that will result in a daily dose equivalent to the TRV. This concentration is associated with an acceptable dose based on the NOAEL or LOAEL TRV and becomes the NOAEL or LOAEL RBSL. Equations to calculate RBSLs for each medium based on exposure inputs are presented below:

Equation 12:

$$\text{Soil: } RBSL = TRV / (((SIR \times FIR) + (FIR \times BAF)) \times SUF) / BW$$

Equation 13:

$$\text{Sediment: } RBSL = TRV / (((SIR \times FIR) + (FIR \times BSAF)) \times SUF) / BW$$

Equation 14:

$$\text{Surface Water: } RBSL = TRV / ((DWR + (FIR \times BAF)) \times SUF) / BW$$

Where:

BAF – bioaccumulation factor

BSAF – biota-sediment accumulation factor

BW – body weight (kilograms [kg])

DWR – drinking water rate (liters per day [L/day])

FIR – food ingestion rate (kilograms per day [kg/day], dry weight [dw])

RBSL – risk-based screening level

SIR – soil ingestion rate (kg/day, dw)

SUF – site use factor

TRV – toxicity reference value (mg/kg-bw/day)

The details of the calculation of wildlife RBSLs is presented in **Appendix F, Tables 4** through **15**. The RBSLs were calculated based on the TRVs (**Table 4**) and exposure inputs presented below.

Exposure Assumptions

Exposure pathways for the terrestrial and aquatic receptors are presented in **Figure 2** and include:

- (1) Terrestrial receptor
 - Soil RBSL: including exposure via a terrestrial based diet and incidental soil ingestion
 - Surface water RBSL: including exposure via drinking water
- (2) Aquatic receptor
 - Sediment RBSL: including exposure via an aquatic based diet and incidental sediment ingestion
 - Surface water RBSL: including exposure via an aquatic based diet and drinking water

BAFs were used to estimate concentrations in terrestrial receptor diets from soil concentrations. BSAFs were used to calculate PFAS concentrations in the diet when deriving sediment RBSLs, while water-to-biota BAFs were used to calculate PFAS concentrations in the diet when deriving surface water RBSLs. Due to limited availability of BAF and BSAFs, particularly for PFAS other than PFOS, surrogate BAF or BSAFs were used as needed in the foodweb model. The BAFs and selected surrogate BAFs (when applied) are discussed in Section 5.3.2 and presented in **Appendix F, Table 2**.

Exposure Parameters for Surrogate Receptors

For dietary dose modelling, species-specific values used for the potential aquatic and terrestrial bird and mammal receptors are presented in **Table 5**. These exposure parameters were selected from the following published guidance documents and primary literature.

- 1)USEPA (1993)
- 2) U.S. Army CHPPM (2004)
- 3) Sample et al. (1997)
- 4) Nagy (2001)
- 4) Birds of North America Online (2017)

- 5) California Environmental Protection Agency ECOTOX (2017)
- 6) Beyer et al. (1994)

Beyer et al. (1994) was the source for soil ingestion rates for all species and Nagy (2001) was the source for FIR for all species in the foodweb. Calder and Braun 1983 as cited in the EFH (USEPA 1993) was the source for all drinking water rates.

Species-specific parameters include:

- **Body Weight** – Body weights for wildlife species were calculated as the average of adult values. Body weights for male and female (combined) were used if available.
- **Dietary Composition** – The composition of the diet was based on information on the feeding habits for each of the species. Dietary compositions were referenced from EFH (USEPA 1993), USACHPPM (2004), Sample et al. (1997), and Birds of North America Online (2017).
- **Ingestion Rate** – Total FIRs for wildlife species were either measured values reported by Nagy (2001) or calculated as a function of body weight using allometric equations (Nagy 2001). Ingestion rates are presented in terms of kilograms per day (kg/day dw) as well as normalized for body weight (kg/kg bw/day).
- **Home Range** – Home range is defined as the geographic area encompassed by an animal's activities (except migration) over a specified time (USEPA 1993). For some species, foraging distances (i.e., distances that animals are willing to travel for potential food sources) and territory size are considered more meaningful than home ranges; although, some define foraging range under home range (USEPA 1993).

The site use factor (SUF) represents the area used by an individual relative to the size of the exposure area or site. If the home range of a receptor species is larger than the potential exposure area, the following equation can be applied:

$$\text{SUF} = \text{exposure area acreage} / \text{home range of species}$$

The bird and mammal RBSLs were calculated with the default assumption of a SUF of 1. Home ranges and SUF may be incorporated in future site-specific risk assessments.

Bioaccumulation Factors

Bioaccumulation is the process where chemicals in the surrounding media are accumulated within the tissues of biota that comprise the diet of ecological receptors. Any chemical that is excreted or metabolized at a slower rate than its uptake through absorption and ingestion will increase in tissues over time, resulting in bioaccumulation. Chemicals that bioaccumulate have the potential to be taken up in the food chain.

Due to the limited amount of uptake data, regression analysis was not completed to develop uptake factors. Uptake of PFAS from water, soil, and sediment to biota tissues was estimated by calculating a BAF, as described below. These media-to-biota BAFs are summarized in **Table 6**, and details are provided in **Appendix E**.

For the purpose of this evaluation, a water-to-biota BAF for aquatic organisms was used to estimate PFAS uptake into prey tissue. The water-to-biota BAF is the ratio of biota constituent concentration to water concentration and is expressed as follows:

Equation 15:

$$BAF = C_b / C_w$$

Where:

BAF = water-to-biota bioaccumulation factor (liters [L] water/kg tissue)

C_b = constituent concentration in biota tissue (milligrams [mg] constituent/kg tissue, dry weight [dw])

C_w = constituent concentration in water (mg constituent/L water).

For plants, invertebrates, and mammals, soil-to-biota BAFs are the ratio of biota constituent concentration to soil concentration and is expressed as follows:

Equation 16:

$$BAF = C_b / C_s$$

Where:

BAF = soil-to-biota bioaccumulation factor (kg soil/kg tissue)

C_b = constituent concentration in biota tissue (mg constituent/kg tissue, dw)

C_s = constituent concentration in soil (mg constituent/kg soil, dw).

For benthic invertebrates and bivalves, crustaceans, fish, and aquatic plants, sediment-to-biota BSAFs are the ratio of biota constituent concentration to sediment concentration and is expressed as follows:

Equation 17:

$$BSAF = C_b / C_{se}$$

Where:

BSAF = biota-sediment accumulation factor (kg sediment/kg tissue)

C_b = constituent concentration in biota tissue (mg constituent/kg tissue, dw)

C_{se} = constituent concentration in sediment (mg constituent/kg sediment, dw).

BAF Literature Review

Terrestrial BAFs were compiled or calculated following a targeted literature review of available field-based and lab or greenhouse-based studies. Aquatic BAFs were compiled or calculated based on sources provided in selected review papers. Both field-based and lab or greenhouse-based studies were included in the representative terrestrial BAF geometric mean; however, studies using spiked soils (i.e. PFAS spiked directly into soils) were excluded. In comparison to the terrestrial BAFs, aquatic systems were considered more complex with potential receptor exposures from water, sediment, and the aquatic foodweb. Additionally, lab-based aquatic water-to-biota bioaccumulation studies may rely on spiked water rather than surface water collected in the field and would be considered less representative of environmental conditions than field studies. Therefore, only field-based studies were included in the aquatic representative BAF and BSAF geometric means. As the BAF literature review was completed to derive BAFs for the

foodweb and RBSL calculations, only PFAS with calculated TRVs were comprehensively compiled from reviewed sources. Due to the targeted nature of the BAF review, additional BAF and BSAF data are available and could be incorporated for refinement of the selected BAFs and BSAFs.

Aquatic BAFs

Aquatic surface water BAFs and sediment BSAFs were identified in Giesy et al. 2010, McCarthy et al. 2017, and Valsecchi et al. 2017. Selected relevant primary papers cited in these studies were reviewed as needed for additional information such whether BAFs were reported on a wet weight or dry weight-based basis. Aquatic BAFs and BSAFs were calculated for aquatic plants, invertebrates, and fish based on field data. Field data are preferred because they provide a more representative measure of uptake from all exposure routes (whereas laboratory studies typically focus on a single exposure media) and concentration of PFAS in biota in the field would be expected to have reached equilibrium with concentrations in the environment. Aquatic BAFs and BSAFs calculated for a specific organs, such as liver, were excluded in favor of whole body BAFs and BSAFs. Tissue concentrations, sediment concentrations, and/or BAFs for aquatic organisms were presented or calculated from the literature based on dry weight or wet weight measurements. For the calculation of geometric means and use in the foodweb model to calculate RBSLs, tissue and sediment concentrations or BAFs presented as wet weight were converted to dry weight using moisture contents provided in the individual studies, if available, or in the EFH (USEPA 1993). BSAFs were not calculated from studies that did not report moisture content of sediment due to the uncertainty in converting to dry weight.

Terrestrial BAFs

For soil-to-biota BAFs, a targeted literature search was conducted to identify BAFs or available terrestrial uptake data for PFAS with TRVs. Literature searches were conducted on Google Scholar and relevant studies were included regardless of publication date. In addition to direct searches, relevant citations from papers identified as part of direct searches were reviewed. Only published papers and gray literature were included as sources of bioaccumulation data, and sources such as master's theses were not included. For PFOS, linear and branched BAFs were reported and the linear BAFs were incorporated in the RBSL calculations. As presented in Table 6, linear BAFs for PFOS are higher than their branched counterparts and defaulting to linear is a conservative approach. A sensitivity analysis (Appendix E, Table 10) was conducted to determine the relationship between BAFs calculated using data from field studies, field and lab/greenhouse studies excluding spiked soils, and all field and lab/greenhouse studies. Due to similarities between the lab/greenhouse and field study BAFs as well as the similarities in plant or invertebrate exposures between field and lab/greenhouse, both field and lab/greenhouse BAFs were included in the final representative BAF geometric mean. However, lab/greenhouse studies utilizing soils directly spiked with PFAS were excluded. Final terrestrial BAFs for plants, invertebrates, and mammals are presented in **Appendix E**.

Soil-to-Terrestrial Plants

Only studies providing measurements of PFAS uptake and accumulation in plants from soil, or paired data for plants and soil were used to compile and calculate BAFs for plants. Any studies not based on paired soil and plant measurements (i.e., hydroponic studies) were not included. Studies that provide whole-plant measurements, as well as individual plant compartment measurements were included in the review. For studies that provided only plant compartment

concentrations (i.e., root and shoot), the arithmetic mean of the compartment concentrations was calculated for each plant to determine a whole plant concentration. When only paired data were available and BAFs were calculated, measured concentrations were used preferentially over nominal concentrations. If BAFs, soil concentrations, or plant concentrations were presented as less than the limit of quantification (LOQ) or non-detect (ND), they were excluded from calculations. Tissue concentrations, soil concentrations, and/or BAFs for plants were presented or calculated from the literature based on dry weight or wet weight measurements, and in some cases BAFs were presented as organic carbon-normalized. For the comparison of values between studies and the calculation of geometric means, tissue and soil concentrations or BAFs presented as wet weight were converted to dry weight using moisture contents provided in the individual studies, if available, or as reported in USEPA (1993). Published BAFs calculated on a soil organic carbon basis were converted to bulk soil basis by dividing the BAFs by the percent organic carbon, as presented in the applicable studies.

The final overall terrestrial plant BAF for each PFAS is equal to the geometric mean of the final dry weight BAFs compiled from the literature searches.

Soil-to-Soil Invertebrates

Only studies providing measurements of PFAS uptake and accumulation in invertebrates from soil, or paired data for invertebrates and soil were used to compile and calculate BAFs for invertebrates. If BAFs, soil concentrations, or biota concentrations were presented as less than the LOQ or ND, they were excluded from calculations. Tissue concentrations, soil concentrations, and/or BAFs for invertebrates were presented or calculated from the literature based on dry weight or wet weight. In some cases BAFs were presented as organic carbon-normalized. For the comparison of BAFs between studies and the calculation of geometric mean BAFs, tissue and soil concentrations or BAFs presented as wet weight were converted to dry weight using moisture contents provided in the individual studies, if available, or as reported in the EFH (USEPA 1993). Published BAFs calculated on a soil organic carbon basis were converted to bulk soil basis by dividing the BAFs by the percent organic carbon, as presented in the applicable studies.

The final overall terrestrial invertebrate BAF for each PFAS is equal to the geometric mean of the final dry weight BAFs compiled and calculated from the literature searches.

Soil-to-Small Mammals

A soil to small mammal PFAS BAF was not found in any primary paper; however, a dataset collected for the Fiskville Environmental Audit (AECOM 2014) included rabbit muscle and soil PFAS concentrations allowing for calculation of a PFOS soil to rabbit muscle BAF. Similarly, a paper by D'Hollander et al. (2014) included small mammal organ-specific and soil PFOS concentrations. For the comparison of values between studies and the calculation of geometric means, tissue and soil concentrations presented as wet weight were converted to dry weight using moisture contents provided in the EFH (USEPA 1993), USEPA Screening Level Ecological Risk Assessment Protocol Appendix C (1999), and Pla, Pascual, & Ariño (2010).

Ideally, soil to small mammal BAFs are calculated from whole body mammal values. To account for this limitation, papers describing partitioning of PFAS within small mammals were reviewed and used to convert organ- or tissue-specific BAFs to whole body BAFs. A study by Bogdanska et al. (2011) was used as the basis for converting from organ-specific BAFs to whole body

BAFs. Bogdanska et al. (2011) exposed mice to PFOS in the diet and determined the distribution of the substance in the blood and tissues after 1, 3, and 5 days.

The whole-body concentrations of PFOS in mice after 1, 3, and 5 days were calculated from Bogdanska et al. 2011 using the following equation:

Equation 18:

$$C_{\text{whole body}} = \frac{\sum_{n=1}^i C_{\text{tissue},n} \times f_{\text{tissue},n}}{m_{\text{mouse}}}$$

Where:

$C_{\text{whole body}}$ = Whole-body PFOS concentration (nanograms [ng] PFOS/grams [g] tissue)

C_{tissue} = PFOS concentration in individual tissue (ng PFOS/g tissue)

f_{tissue} = mass of individual tissue (g)

m_{mouse} = Total body weight of mouse (g)

Estimations of tissue masses and the total body weight of mice used in the study were obtained from Bogdanska et al. (2011), Taconic Biosciences (2004), and Brown et al. 1997. The ratio of PFOS concentrations in specific tissues to the whole body PFOS concentration were used to adjust the small mammal liver, kidney, and muscle BAFs from Fiskville (AECOM 2014) and D'Hollander et al. (2014) to better reflect whole body PFOS distribution. Organ-specific BAFs were converted to whole body BAFs by dividing the organ-specific BAF by the ratio of PFOS organ:whole body concentration calculated from Bogdanska et al. (2011). The whole-body PFOS concentration calculations and tissue ratios are presented in **Appendix E, Tables 8 and 9**.

A full list of individual BAF/BSAFs and associated geometric means are presented in **Appendix E** and surrogate BAFs are presented in **Appendix F, Table 2**. A summary of BAF/BSAF geometric means used in the evaluation are presented in **Table 6**. These final calculated BAFs/BSAFs were used to estimate concentrations of PFAS in biota and food item tissue (i.e., prey) from soil, sediment, and surface water. Due to limited information on PFAS bioaccumulation in mammals, the terrestrial soil-to-small mammal BAF was also used for sediment.

Biomagnification

While evaluating bioaccumulation of PFAS in aquatic and terrestrial biota, studies were identified that evaluated the potential for PFAS biomagnification and estimated biomagnification factors (BMFs) between trophic levels. Biomagnification of PFAS between trophic levels is not fully understood, and the lack of a measured K_{ow} value makes the prediction of biomagnification rates difficult. Additionally, the potential for biotransformation of PFAS into other, more-stable PFAS compounds is a complicating factor in determining BMFs.

Based on a brief review of the available literature, there is a large variation in measures of biomagnification between constituents, geographic locations, and complexity of foodwebs. Nevertheless, estimations of biomagnification and trophic magnification suggest that PFAS with carbon chain lengths of six or greater have the potential to biomagnify through the foodweb and

across trophic levels (Houde et al. 2006a, Houde et al. 2006b, Kelly et al. 2009, Tomy et al. 2009, Giesy et al. 2010, Loi et al. 2011, Müller et al. 2011).

BMFs were not available for the T&E surrogate species considered in this evaluation; therefore, biomagnification was not quantitatively included in the calculation of RBSLs. However, the BAFs and BSAFs included in the foodweb and used in the calculations of RBSLs do account for accumulation through the foodweb.

4 RESULTS

4.1 Recommended Water Quality Risk-Based Screening Levels

RWQ RBSLs were derived for 23 individual PFAS based on the GLI methodology, and are summarized in **Table 7**. The chronic values ranged from 0.0002 mg/L for 10:2 FTCA to 3.9 mg/L for PFOA. The PFOA acute and chronic values were the highest RWQ RBSLs. Among the perfluorinated compounds, the lowest acute RWQ RBSL was calculated for PFUnA and the lowest chronic RWQ RBSL was calculated for PFUnA. Acute and chronic values calculated for the fluorotelomer acids were generally lower than the RWQ RBSLs calculated for the perfluorinated compounds.

As evident from the acute dataset and GLI species groups columns, the datasets for PFOS and PFOA are relatively robust, while the data available for other PFAS are quite limited.

Additionally, several RWQ RBSLs are based on GMAVs from the same study. The RWQ RBSLs for PFDoA, PFUnA, PFNA, and 5H 4:1 FTOH are based on values derived in Ding et al. (2012b). Perfluorodecanoic acid (PFDA), perfluoro-n-pentanoic acid (PFPeA), 7:3 Acid, and 6:2 fluorotelomer unsaturated carboxylate (FTuCA) RWQ RBSLs are based on Hoke et al. (2012) and PFHxA, PFBA, and perfluoropropionic acid (PFPrA) are based on Wang et al. (2014).

While RWQ RBSLs were not calculated separately for marine aquatic life, the minimum marine acute EC50 or LC50 and chronic NOEC or LOEC available for each PFAS were compared to minimum acute and chronic freshwater data and the freshwater RWQ RBSLs calculated herein. The minimum marine aquatic toxicity data identified during review are generally higher than the corresponding minimum freshwater data with the exception of the PFOA acute duration data (**Table 8**). Freshwater RWQ RBSLs may be considered reasonable for use to evaluate marine environments on or adjacent to DoD sites because freshwater effect levels are similar to or lower than marine effect levels for the available data. However, the RWQ RBSLs calculated based on freshwater data may not be protective of marine species for certain PFAS such as PFOA. Few PFAS were available for comparison in **Table 8** and one marine value was lower than its corresponding freshwater value. Therefore, there is uncertainty around the protectiveness of freshwater RWQ RBSLs applied to marine environments. The available data indicate that the RWQ RBSLs calculated using Tier II methodology are potentially protective of marine species depending on the PFAS.

4.2 Screening Levels for Ecological Communities

4.2.1 Plant and Soil Invertebrate Screening Levels

The terrestrial plant and soil invertebrate screening levels were calculated for six PFAS with available growth or reproduction NOECs and LOECs and are presented in **Tables 9** and **10**. The

six plant NOEC-based SLs for soil range from approximately 0.084 mg/kg to 642 mg/kg. Consistent with the aquatic evaluation, the terrestrial plant PFOS and PFOA datasets include substantially more studies than are available for the remaining PFAS.

The soil invertebrate toxicity data were based on tests with earthworms. NOEC-based soil SLs ranged from 1 to 50 mg/kg and LOEC-based soil SLs ranged from 100 mg/kg to 141 mg/kg. SLs calculated for soil invertebrates are based on exceptionally limited datasets (invertebrate SLs for most PFAS are based on a single LOEC or NOEC) and are therefore, considered to have a higher degree of uncertainty in their ability to predict risk to these organisms than for most other SLs calculated herein.

4.2.2 Benthic Invertebrate Screening Levels

As discussed in Section 3.2.3, data are insufficient for development of sediment SLs for benthic invertebrates at this time.

4.3 Wildlife Risk-Based Screening Levels

As described in Section 3.3.3, both NOAEL-based and LOAEL-based wildlife RBSLs were calculated for terrestrial and aquatic T&E surrogate receptors. For protection of T&E species, the NOAEL-based RBSLs are the default screening values, and are presented in **Table 11a** for sediment and water (aquatic wildlife) and **Table 11b** for soil and surface water (terrestrial wildlife). LOAEL-based RBSLs are provided in **Tables 12a** and **12b** for aquatic and terrestrial wildlife, respectively. Concentrations of PFAS below the RBSL protective of an ecological receptor group (e.g., terrestrial mammalian herbivores) indicate that a potentially unacceptable exposure to that group of ecological receptors is unlikely to be present and that further evaluation of that receptor group is likely not warranted. Concentrations of PFAS above their respective RBSL do not indicate that an unacceptable risk is present, but rather, that the potential for a risk exists and further evaluation such as a site-specific risk assessment or additional sampling may be warranted.

The RBSLs provide context for comparison of sensitivity between feeding guilds and of toxicity between PFAS. RBSLs provided for each feeding guild and environmental media allow for selection of the surrogate receptors and media applicable to a particular DoD site, and allow for rapid screening of potential for ecological risk for the specific variety of habitat and receptors types present on individual DoD sites.

4.3.1 PFAS Risk-Based Screening Levels

Both NOAEL- and LOAEL-based RBSLs were calculated to bracket potential risk to T&E species. NOAEL-based TRVs and NOAEL-based RBSLs are based on toxicity values where no adverse effect was observed. Therefore, these RBSLs are assumed to be conservative screening benchmarks where no adverse effect to either an individual receptor or the receptor population would be expected. LOAEL-based RBSLs are derived using TRVs based on the lowest dose at which an adverse effect relevant to wildlife populations was observed. For protection of T&E species potentially found on DoD sites, the NOAEL-based RBSLs represent an appropriate conservative screening approach. However, the LOAEL-based RBSLs may be warranted in specific circumstances (e.g., consideration of population effects) and screening against both provides a more complete understanding of potential risk.

Nine mammal and two bird TRVs were calculated and presented in Table 4. TRVs and sufficient bioaccumulation information were available to calculate mammal RBSLs for six PFAS: PFNA, PFOS, PFOA, PFHxA, PFBS, and PFBA. TRVs and sufficient bioaccumulation information were available to calculate bird RBSLs for two PFAS: PFOS and PFBS. Insufficient bioaccumulation data were available to calculate RBSLs for 6:2 FTOH, GenX, or N-EtFOSE. For reptiles and fish, insufficient toxicity data were available to develop TRVs (and subsequently RBSLs) for any PFAS.

NOAEL-based RBSLs

The receptor-specific NOAEL-based RBSLs for wildlife are presented in **Table 11a** for aquatic receptors and **Table 11b** for terrestrial receptors. In these tables, all SLs for a specific medium are presented, including the wildlife receptor-specific RBSLs noted above, RWQ RBSLs for surface water, and terrestrial plant and soil invertebrate screening levels. The minimum SLs for each environmental medium and the associated receptor are also presented. The soil NOAEL-based RBSLs range from 0.013 mg/kg (PFOS RBSL for house wren) to 340 mg/kg (PFHxA RBSL for short-tailed shrew). Sediment NOAEL-based RBSLs range from 0.0014 mg/kg (PFOS RBSL for tree swallow) to 370 mg/kg (PFBS RBSL for muskrat). Surface water NOAEL-based RBSLs had the greatest range of 0.000075 mg/L (PFOS RBSL for brown pelican) to 76 mg/L (PFBS RBSL for muskrat) among aquatic receptors.

The majority of minimum NOAEL-based RBSLs for each PFAS are based on invertivore or insectivore receptors, such as the little brown bat, tree swallow, and house wren. All minimum sediment NOAEL-based RBSLs are associated with the little brown bat or tree swallow. There is greater variability in the terrestrial receptors associated with the minimum soil NOAEL-based RBSLs. For PFNA and PFBS the minimum RBSLs are associated with the brown bat and the minimum PFOS RBSL is associated with the house wren. The long-tailed weasel, a carnivore, is associated with the minimum soil NOAEL-based RBSL for PFOA, while the meadow vole, an herbivore, is associated with the minimum RBSLs for PFHxA and PFBA. Terrestrial receptors tended to have higher relative RBSLs, as might be expected due to generally lower potential for uptake from dietary sources.

PFHxA and PFBA mammal RBSLs and bird PFBS RBSLs are generally higher than the other RBSLs due in part to their higher TRVs when compared to the other three PFAS.

LOAEL-based RBSLs

The receptor-specific LOAEL-based RBSLs for wildlife are presented in **Table 12a** for aquatic receptors and **Table 12b** for terrestrial receptors. In these tables, all SLs for a specific medium are presented, including the receptor-specific RBSLs for wildlife, RWQ RBSLs for surface water, and terrestrial plant and soil invertebrate SLs. The minimum SLs for soil, sediment, and surface water are also presented in **Tables 12a** and **12b** along with the associated receptor. Soil, sediment, and surface water LOAEL-based RBSLs for each PFAS are higher than their NOAEL-based counterpart by a range of 1.3 to 10. The insectivore receptors (little brown bat and house wren) remain the receptors most frequently associated with the lowest RBSLs.

4.3.2 Considerations for Use of RBSLs

RBSLs provided for each feeding guild and environmental medium allow DoD environmental managers to select the surrogate receptors and media applicable to their site.

In **Tables 11a** and **11b**, the lowest NOAEL RBSL applicable to each receptor is presented. The comparison below provides a concise summary of the most sensitive receptors and risk driving PFAS. The values for soil, sediment, and surface water and various receptor groups provide context to concentrations in solid or aqueous media and terrestrial versus aquatic environments that may result in unacceptable risk to wildlife populations.

PFOS is the risk driving PFAS for individual terrestrial and aquatic receptors regardless of media. This is largely a result of low PFOS TRVs and high bioaccumulation factors (**Appendix F, Tables 2 and 3**).

Similar RBSLs were calculated for structurally similar PFAS such as PFBS and PFBA (**Tables 11a through 12b**). At a site with measured PFAS concentrations without a corresponding RBSL, screening against the lowest RBSL would be a conservative first approach. Alternatively, screening against an RBSL for a PFAS with a similar structure may be more appropriate depending on the similarity to the surrogate versus the PFAS with the lowest RBSL.

A comparison of the surface water RBSLs for aquatic receptors and the chronic RWQ RBSLs indicates the surface water RBSLs for aquatic wildlife are typically lower than the RWQ RBSL values (**Tables 11a through 12b**). Only the PFBA RWQ RBSL is lower than its corresponding surface water NOAEL and LOAEL RBSL. PFBA appears to be the exception based on its low surface water to biota BAFs compared to the other five PFAS and second highest mammal LOAEL TRV (**Appendix F, Tables 2 and 3**). These comparisons suggest fish and aquatic invertebrates may be less sensitive or have lower exposure to PFAS than birds and mammals exposed via an aquatic diet. The lower of the two values (i.e., chronic RWQ RBSL and minimum receptor-specific NOAEL-based RBSL) should be used as a surface water SL when aquatic bird or mammal receptors are present. If the only aquatic species present are fish, amphibians, aquatic invertebrates, or other species included in the GLI screening level derivation, the chronic RWQ RBSL may be used. Further details on selection of appropriate SLs and application are discussed in Section 7.2.1.

The pattern of lower wildlife RBSLs compared to chronic RWQ RBSLs should be considered when PFAS are identified in surface water beyond the six PFAS with RBSLs. If only a RWQ RBSL is available, it may be under protective of aquatic bird and mammal receptors in the area. A surface water RBSL for wildlife could potentially be used as a surrogate or an UF could be applied to the RWQ RBSL, if wildlife screening values are needed for PFAS without calculated RBSLs.

5 UNCERTAINTIES EVALUATION

A brief discussion of key uncertainties in the SLs derived herein is provided in this section. Although some uncertainties are difficult to quantify, the discussions are provided with the intent of identifying bias in the methodology used and any estimated effect on the calculated SLs, to the extent possible. These uncertainties can be used to inform the direction of future work. Uncertainties in the RWQ RBSL values, terrestrial plant and soil invertebrate screening values, and wildlife RBSLs are each discussed below.

5.1 Uncertainties in the RWQ RBSLs (Tier II Methodology)

5.1.1 Data Selection Uncertainties

A widely recognized uncertainty associated with PFAS toxicity is limited data availability. The majority of toxicity data compiled for RWQ RBSL calculations were associated with PFOS or PFOA. PFHxS had no identified aquatic toxicity literature applicable to deriving RWQ RBSLs using GLI Tier I or Tier II methodology. This is a considerable data gap considering PFHxS has been identified at several former fire-training areas (Baduel et al. 2015; McGuire et al. 2014; Moody et al. 2003). Compounding the uncertainties associated with limited toxicity data, only a few common test species have been tested with PFAS other than PFOS and PFOA. Overall, the amount of data and therefore the range of test species are limited, introducing uncertainty as to whether species that are more sensitive to PFAS have been tested.

The RWQ RBSLs were calculated generally following GLI methodology, with exceptions as noted in Section 3.1.1 that were intended to increase the amount of data available for the evaluation. Given the chemical stability of PFAS, some of the exceptions (e.g., using both static and flow-through results) are not expected to have a substantial impact on the resulting calculated RWQ RBSL values. While the decision to exclude “>” or “<” EC/LC10 through EC/LC100 data reduced the dataset, it was intended to decrease uncertainty associated with the final GLI dataset and avoid results potentially skewed by multiple “>” or “<” values in a limited number of toxicity values.

Values identified by the report as LOAEL, but without reported statistical significance were not included in this evaluation. NOAELs without associated statistically significant LOAELs were included on a case-by-case basis. For example, (1) if a report did not evaluate the data statistically, but no observed adverse effects were reported, a NOAEL for all endpoints evaluated at the highest dose was recorded, (2) if effects were reported without statistical evaluation for one endpoint such as reproduction and no effect for another endpoint such as survival, the potential reproduction LOAEL was not included as no significance was reported and the highest dose was recorded as a NOAEL for survival, (3) if effects were observed without statistical evaluation for one endpoint such as offspring viability and no effects were observed for a similar endpoint such as parental mortality, no NOAEL or LOAEL was recorded and the paper was excluded. The effects of this data evaluation process will vary depending on the paper and the overall effect on the SLs is unknown.

USEPA (2011) advises using caution when intraspecies acute toxicity data have considerable variability, such as more than a factor of 10. The species mean acute value (SMAVs) for *Daphnia magna* exposed to PFBA and *Dugesia japonica* exposed to PFOA both include data that vary by more than 10-fold. Due to the limited data available for these chemical-species pairs, it was not possible to determine which values were unacceptably variable from the norm of the dataset; inclusion of all data in SMAV, GMAV, and ACR calculations was generally considered more robust than excluding some of these data. One calculated PFOS ACR was excluded as it was approximately 50-fold greater than the four other PFOS ACRs (**Appendix B**).

Physical properties of specific PFAS may contribute uncertainty to test results and their applicability to environmental conditions. For example, PFBA has been demonstrated to reduce the pH of test water, affecting the toxicity results (Ding et al. 2012b; Hagenaaers et al. 2011). A study presenting both pH adjusted and unadjusted results indicated that toxicity data from

unadjusted conditions are notably lower (Ding et al. 2012b). In the evaluation presented herein, pH unadjusted data were preferentially chosen when both were provided by the primary paper. Additionally, PFOA is commonly available as an ammonium or potassium salt. The dissociated ammonia from the ammonium salt of PFAS may contribute to toxicity observed in aquatic tests, as has been observed for PFOA (ammonium perfluorooctanoate) and GenX (Colombo et al. 2008; Hoke et al. 2016).

5.1.2 Recommended Water Quality Risk-Based Screening Level Uncertainties

Examining the range of calculated PFAS SLs available in the literature can provide context for the RWQ RBSLs calculated herein. Using the GLI approach, Giesy et al. (2010) calculates a Tier I WQC for PFOS and Tier II WQC for PFOA and PFBS. Giesy et al. (2010) appears to have included a 10-day acute L/EC₅₀ of 0.087 mg/L and a 20-day L/EC₅₀ of 0.092 mg/L for the midge, *Chironomus tentans*, based on the geometric mean of survival and growth endpoints. The test duration for this species is more than twice the GLI-recommended 96-hour duration for acute tests and incorporates growth endpoints. As a result, the selected L/EC₅₀ may overestimate acute toxicity of PFOS in this species. In their Tier I calculations, Giesy et al. (2010) also include toxicity data for *Pseudacris crucifer* (spring peeper), *Hyallela azteca* (amphipod), and *Lumbriculus variegatus* (aquatic worm). These species were not found in the aquatic literature search conducted to support the current evaluation and their source studies were not cited in Giesy et al. (2010). Additionally, Giesy et al. (2010) arrived at lower *Pimephales promelas* (fathead minnow) and higher *Oncorhynchus mykiss* (rainbow trout) GMAVs, presumably through inclusion of different studies in the toxicity datasets for these species.

The acute RWQ RBSL of 0.57 mg/L and chronic RWQ RBSL of 0.051 mg/L for PFOS calculated using Tier I methodology in this evaluation are approximately 10 to 25 times higher than the Tier I acute and chronic WQC of 0.021 mg/L and 0.0051 mg/L that Giesy et al. (2010) calculated. A PFOS final chronic value (FCV) of 0.00061 mg/L calculated by Qi et al. (2011) without an ACR was approximately 100 times lower than the chronic value derived in the present evaluation. A FCV of 0.004 mg/L calculated using an acute value and an ACR in the same paper was approximately 10 times lower than the chronic value calculated herein (Qi et al. 2011). The RWQ RBSLs calculated herein are lower than the acute and chronic WQC calculated by the most recent of the studies compared, Yang et al. (2014). Yang et al. (2014) calculated PFOS Tier I acute WQC of 3.78 mg/L and chronic WQC of 0.25 mg/L. As the RWQ RBSLs calculated herein are bracketed by previously calculated WQC and not consistently higher or lower, the different values are likely a result of data availability (e.g., data available for different number of species and different minimum GMAVs) and derivation methodology.

The PFOA acute and chronic RWQ RBSLs calculated using Tier I methodology in this evaluation are 53 mg/L and 3.9 mg/L while Yang (2010) calculated 45.54 mg/L and 3.52 mg/L as the PFOA acute and chronic Tier I WQC. The slightly higher values in this evaluation may be due to a more robust dataset used in the calculations. As the number of GMAVs used in the Tier I calculation increases, the acute value also increases assuming the four lowest GMAVs are the same. Giesy et al. (2010) calculated PFOA WQC using Tier II methodology and arrived at an SAV of 49 mg/L (divided by 2 to derive a SMC would result in 24.5 mg/L) and a SCV of 2.9 mg/L. The chronic values between the three evaluations and different methodologies (Tier I or II) are notably similar. While the acute values differ by up to about two-fold, they are much more

similar than the acute values for PFOS, likely reflecting similarities in the minimum GMAV between data sets.

The PFBS acute and chronic RWQ RBSLs calculated herein are 17 mg/L and 3.4 mg/L whereas the Tier II WQC calculated in Giesy et al. (2010) are 121 mg/L (dividing the SAV calculated in Giesy et al. [2010] by 2 to derive a SMC) and a SCV of 24 mg/L. The lowest GMAV and the basis of the acute value calculation in this evaluation was published in a study by Chen et al. in 2018. Therefore, this value would have been unavailable for inclusion in Giesy et al.'s (2010) evaluation.

To provide context with existing state WQC, the PFOS and PFOA RWQ RBSLs are compared to Michigan PFOS and PFOA WQC calculated with Tier II methodology. Michigan's surface water guidance, Rule 57, follows GLI methodology to calculate Tier I or Tier II final acute values (FAV) and FCV for each chemical (Michigan Department of the Environment [MDE] 2019). The Michigan PFOS and PFOA FAV and FCV were calculated using Tier II methodology while the PFOS and PFOA RWQ RBSLs in this evaluation were calculated following Tier I methodology. The most recent Rule 57 values calculated an FAV of 1.6 mg/L and an FCV of 0.14 mg/L for PFOS, similar to the FAV of 1.15 mg/L and higher than the FCV of 0.051 mg/L in this evaluation. The acute and chronic Michigan WQC for PFOA (FAV = 15 mg/L and FCV = 0.88 mg/L) are lower than the PFOA FAV and FCV calculated in this evaluation, 105 mg/L and 3.9 mg/L, respectively. The difference in PFOS and PFOA values may be a result of Tier I versus Tier II methodology, such as application of SAF to Tier II WQC as well as an older data set used for the MDE calculations.

There is moderate to high confidence in PFOS and PFOA RWQ RBSLs as they are based on a reasonably robust data set and multiple test species. As the other 21 PFAS RWQ RBSLs are based on fewer than five acute toxicity values and four or fewer GLI species groups, there is lower confidence in these 21 RWQ RBSL values **Table 7**).

5.2 Terrestrial Plant and Invertebrate Screening Levels

5.2.1 Data Selection Uncertainties

Applicable toxicity values as reported by the primary papers were included whether nominal or measured concentrations were presented and regardless of specific methodology or software used to calculate the values.

Laboratory test species may be more or less sensitive to chemical exposures such as PFAS compared to wildlife due to genetic variation, environmental setting, and differences in exposure. For example, the plant species tested tend to be important food crop species, which may have different soil and nutrient requirements than uncultivated wild species. Additionally, the bioavailability of the PFAS in laboratory-controlled experiments may vary from the bioavailability in environmental exposures.

SLs calculated for invertebrates are based on limited datasets (invertebrate SLs are based on a single NOEC or LOEC) and are therefore likely to evolve in future evaluations as additional toxicity data become available.

It is unknown whether these uncertainties biased the calculated SLs. The SLs are expected to be revised and refined as additional published data become available.

5.2.2 Plant and Invertebrate Soil Screening Levels Uncertainties

Plant Soil Screening Levels

Plant NOECs for several PFAS reported in Ding et al. (2012a) were notably higher than the rest of the data set comprised of six published studies and LOECs were not reported. As this study was the sole basis for the PFDA, PFNA, PFBA, and 5H 4:1 FTOH NOEC SLs, there is uncertainty around these SLs. The geometric mean of the PFOA NOECs is higher than the geometric mean of the LOECs. If the Ding et al. (2012a) PFOA NOEC had been excluded, the PFOA NOEC geometric mean would be 0.83 mg/kg, slightly lower than the LOEC SL of 0.84 mg/kg.

The plant PFOA NOEC SL based on the geometric mean of available NOEC data was not considered protective because it was higher than the plant LOEC SL. The PFOA NOEC SL was revised to be based on the LOEC SL divided by a UF of 10. The final selected PFOA NOEC SL is more conservative; however, there is additional uncertainty around this value as it is based on application of an UF to a LOEC value rather than experimentally measured NOECs.

There is low to moderate confidence in the PFOS and PFOA terrestrial plant SLs. The PFOS NOEC and LOEC SLs are based on multiple values from the same study. The PFOA LOEC SL is based on multiple studies, however, the final NOEC SL is based on the LOEC SL with a UF applied.

Invertebrate Soil Screening Levels

The terrestrial invertebrate NOEC SL, like other NOEC SLs developed herein, is preferentially based on values with reproduction or growth endpoints. All terrestrial invertebrate NOECs were based on survival however, and may underestimate the potential for reproductive and growth effects. A UF of 10 was applied in certain cases to account for this uncertainty. The PFOS NOEC SL is the bounded survival NOEC, with an UF of 10 applied because the measured effect is based on a less sensitive endpoint (i.e., survival). Similarly, the PFBS NOEC SL is based on a single unbounded NOEC with a survival endpoint and a UF of 10 applied to calculate the final NOEC SL. The PFNA, PFHpA, and PFHxS LOEC SLs are based a survival NOEC and LOEC from a single study. An UF of 10 was not applied to calculate NOEC SLs in this case, as the two tested concentrations span a 100-fold range. The UF was considered unnecessary, as the true NOEC is expected to be substantially higher based on the 2-fold effect-to-no effect difference reported for PFOS. Due to the limited available dataset for soil invertebrates and use of UFs in calculations of the SLs, there is low confidence in the SLs for PFNA, PFOS, PFOA, PFHpA, PFHxS, and PFBS.

5.3 Wildlife Risk-Based Screening Level Uncertainties

5.3.1 Data Selection Uncertainties

Applicable toxicity values as reported by the primary papers were included whether nominal or measured and regardless of specific methodology or software used to calculate the EC0 to EC20.

Toxicity values reported in mg/kg or equivalent concentrations were converted to account for body weight, resulting in final toxicity values added to **Tables 2c** and **2d** in mg/kg-bw/day. Average body weight of the animals in the study was used when available. When FIR was

reported as an average of male and female ingestion, body weight was also averaged between sexes. If FIR was unreported or incomplete, a surrogate value from a study using the same test organism and similar doses was substituted. The surrogate FIR was selected from another study with an equal or lower concentration to account for any adverse effects higher treatment levels could have on FIR. The body weight averages were adjusted to match the same dosing duration as the surrogate FIR. These dose-estimation uncertainties are related to parameters of the test animals and experimental conditions and not specifically to individual PFAS characteristics. The effects of these decisions necessary to estimate exposure dose are expected to be similar in magnitude to those for other chemicals evaluated in ecological risk assessments, and are not expected to result in RBSLs that substantially over or under-estimate potential for risk.

Laboratory test species may be more or less sensitive to chemical exposures such as PFAS compared to wildlife due to genetic variation, environmental setting, and differences in exposure. Therefore, uncertainty is introduced through using TRVs derived for classic laboratory test species such as quail or mice and applying them to the identified representative surrogate species. The magnitude of these differences is currently unknown.

Studies using mixtures of PFAS were generally excluded from the evaluation unless a single PFAS comprised approximately 95 percent or more of the mixture. In that case the toxicity was assumed to be fully attributed that chemical. Including PFAS mixtures that consist of at least 95 percent of an individual compounds is not expected to substantially affect the measured toxicity values and resulting PFAS dataset used to calculate RBSLs.

Values identified by the report as LOAEL, but without reported statistical significance were not included in the evaluation. NOAELs without associated statistically significant LOAELs were included on a case by case basis, as described above in Section 5.1.1. The effects of this data evaluation process will vary depending on the paper and the overall effect is unknown.

5.3.2 Bioaccumulation Uncertainties

A key uncertainty in the selection of BAFs was the use of surrogate values. BAFs or BSAFs, or data that can be used to derive BAFs and BSAFs, were relatively available for certain dietary components such as terrestrial plants and fish but limited or unavailable for other dietary components such as reptiles and birds. When no data were available to estimate a BAF for a dietary component, surrogate BAFs from a dietary component with similar predicted exposure were used to develop RBSLs. Terrestrial invertebrate BAFs were used as surrogates for terrestrial aerial insects. The terrestrial soil to small mammal BAF was used to represent PFAS bioaccumulation by terrestrial birds, terrestrial reptiles, and aquatic mammals when developing RBSLs. The aquatic invertebrate BAFs and BSAFs were used as surrogates for aquatic aerial insect BSAFs. Fish BSAFs were used as surrogates for amphibian BSAFs. As additional bioaccumulation data become available, the uncertainty in these surrogate values can be quantified and uptake values updated, as needed.

If BAFs were available within a dietary component but not for all six PFAS identified for RBSL development, surrogate BAFs from another PFAS were selected based on similarity in carbon chain length (e.g., PFBS was commonly used as a surrogate for PFBA). RBSLs were not developed for PFHxS in this evaluation; however, BAFs and BSAFs were identified for PFHxS as part of the BAF review. The BAFs and BSAFs for PFHxS were used as surrogate BAFs and BSAFs for PFHxA, PFBS, or PFBA. In most cases, the structure of PFAS used as surrogates

were relatively similar to the PFAS for which the RBSL was being derived, varying by no more than three carbons in the fluorotelomer chain. PFHxS as a surrogate for PFBA had the largest difference in chain length. In some cases the functional groups differed as well. One exception is the PFOS soil to small mammal BAF used for all PFAS. This BAF was used for terrestrial bird and reptile dietary groups as well as the aquatic bird and mammal BSAFs (**Appendix F, Table 2**).

The inclusion and exclusion process for developing BAFs was generally conducted in favor of values more representative of field conditions or more conservative values; however, some degree of uncertainty is introduced by the BAF data selection. A terrestrial BAF sensitivity analysis (**Appendix E, Table 10**) presents alternative BAFs for reference. Incorporation of lab-based aquatic BAFs and BSAFs to the field-based aquatic BAFs and BSAFs would have led to higher BAFs and BSAFs for some PFAS and lower BAFs and BSAFs for other PFAS. As an example, Lasier et al. 2011 reported BAFs and BSAFs from lab-based studies with blackworm using field contaminated sediments. Inclusion of these values would have resulted in lower BSAFs for PFNA, PFOS, PFOA, and PFHxS (used as a surrogate for PFHxA). Inclusion of the Lasier et al. (2011) BAFs would have resulted in lower PFNA, PFOA, and PFHxA BAFs and a higher PFOS BAF. Additional uncertainty is introduced by the variabilities in bioaccumulation between similar experiments. As discussed in Lasier et al. (2011), the BAFs and BSAFs reported in their lab-based study vary substantially from BAFs and BSAFs reported in another lab-based study, Higgins et al. (2007), although both studies measured bioaccumulation in blackworm and employed similar methodologies. Although the field-based data are believed to be more representative of real world conditions, the inconsistencies between field and lab-based BAFs for different PFAS compounds and even between lab-based BAFs employing similar methods for the same compounds indicate the relatively substantial degree of uncertainty associated with what is still a limited data set for a large and diverse group of compounds.

Two studies reporting lab-based BAFs for amphibians were identified. If included, the PFOS amphibian BAF would be lower and the PFOA amphibian BAF would be higher than their field-based BAFs. The PFOS BAF incorporating lab studies would be approximately 1,227 L/kg compared to the current BAF of 3,322 L/kg, and the PFOA BAF incorporating lab values would be approximately 10 L/kg compared to the current BAF of 0.8 L/kg. Amphibians are a component of the diet of few receptors, with mink having the highest dietary fraction. At less than five percent of the diet for the mink, these differences in amphibian BAFs are not expected to have a substantial effect on final RBSLs.

The field-based aquatic invertebrate BSAFs in **Appendix E, Table 5** present BSAFs for bivalves. These BSAFs were excluded from the final calculation of the minimum and maximum BSAFs as well as the RBSL input parameters in favor of the ragworm BSAFs because shelled filter-feeding benthic invertebrates, such as bivalves, are expected to have lower exposure to sediments. The calculated BSAFs for two bivalves (oyster and peppery furrow shell) are similar to or often substantially lower than BSAFs for the ragworm. Therefore, the ragworm BSAFs were considered the more representative conservative estimates of potential exposure of benthic invertebrates to PFAS in sediments. As filter feeders, bivalve exposure to contaminants in the water column was considered similar to other species and they were included in the surface water BAF calculations.

Some additional uncertainty in the calculation of BAFs and BSAFs was introduced by the conversion of accumulation factors presented on a wet weight basis to a dry weight basis. This

uncertainty is likely to be relatively small compared to some of the other sources of uncertainty discussed above, such as use of surrogate PFAS. Where possible, moisture content information for soil or sediment was obtained from the primary paper. In the case of calculating soil-to-small mammal BAFs from D'Hollander et al. (2014), soil moisture content was not available and was therefore assumed to be 20 percent per USEPA SLERA guidance (1999). If the actual moisture content of the soil from this study was higher, resulting soil-to-small mammal BAFs would be lower. Similarly, invertebrate, plant, mammal, and aquatic organism tissues or their corresponding BAFs were frequently presented on a wet weight basis and tissue moisture content was not provided. When not provided by the study deriving the BAF or BSAF, organism tissue moisture contents were based on data provided in Table 4-1 and Table 4-2 of USEPA (1993). If actual moisture contents were higher, the resulting BAFs would be higher, and vice-versa.

RBSLs were calculated using the geometric mean of BAFs or BSAFs for each dietary group and PFAS. For some PFAS, BAFs for a dietary component varied by one or two orders of magnitude. The geometric mean was used to represent the range of available BAFs and BSAFs. Absent further information, it is unknown how geometric mean BAFs and BSAFs used to derived RBSLs affect the conservatism of the RBSLs derived in this report.

Given the uncertainties associated with derivation of BAFs and BSAFs, the exponentially increasing literature on the accumulation of PFAS in biota in the environment, differences between laboratories in the reported accumulation of the same PFAS using similar methods (Lasier et al. 2011), and the key role BAFs and BSAFs have in determining RBSLs, it is recommended that the information used to derive BAFs and BSAFs be updated regularly.

5.3.3 Toxicity Reference Value Uncertainties

Mammalian Toxicity Reference Values

Mammalian NOAEL TRVs for PFNA, PFOS, PFOA, GenX, and N-EtFOSE are all within the same order of magnitude and less than 1 mg/kg-bw/day. PFHxA, PFBS, PFBA, and 6:2 FTOH are approximately 100 times higher and range from 43 to 84 mg/kg-bw/day (**Table 4**).

The LOAEL TRVs follow a similar pattern. PFNA, PFOS, and PFOA LOAEL TRVs are the lowest perfluorinated chemical TRVs calculated and are at least 100 times lower than the PFHxA, PFBS, and PFBA LOAEL TRVs (**Table 4**). LOAEL TRVs for GenX and N-EtFOSE are approximately 10 times higher than PFOS and PFOA and similar in magnitude to PFNA. The range between the NOAEL and LOAEL TRVs is narrow. For example, the difference between the PFOS NOAEL and LOAEL TRV is only 0.066 mg/kg-bw/day. NOAEL and LOAEL TRVs for each PFAS differ by a factor of 4 or less, with the exception of GenX, and N-EtFOSE that differ by a factor of 10.

It is difficult to interpret what the consistency in both the magnitude of the TRVs and the range between NOAEL and LOAEL TRVs indicates regarding overall uncertainty in the TRVs given that the datasets for individual PFAS vary greatly in quality and quantity. One method to evaluate uncertainty in the TRVs is to compare them to other published values:

The mammalian PFOS NOAEL and LOAEL TRVs (**Table 4**) are similar to the PFOS NOAEL- and LOAEL-based TRVs estimated by McCarthy et al. (2017) of 0.1 mg/kg-bw/day and 0.4 mg/kg-bw/day, respectively. McCarthy et al. (2017) estimated PFOA NOAEL and LOAEL TRVs of 1 and 3 mg/kg-bw/day, which are higher than the PFOA TRVs calculated in this

evaluation but differ by less than a factor of 10. McCarthy et al. (2017) selected PFOS TRVs as the lowest NOAEL and its paired LOAEL and PFOA TRVs as the lowest LOAEL above the highest NOAEL. While McCarthy et al. (2017) generally followed only an abbreviated approach to EcoSSL methodology, the agreement between TRVs derived by McCarthy and in this evaluation suggests a low relative degree of uncertainty in the mammalian TRVs, at least for PFOS and PFOA.

For all PFAS with mammalian TRVs derived herein, the datasets contain at least 3 toxicity studies, the minimum required number of toxicity studies to calculate a TRV according to EcoSSL methods. The toxicity studies were reviewed and selected for inclusion in the datasets using data quality evaluations similar but somewhat less stringent than the EcoSSL approach. Therefore, the level of uncertainty in the mammalian TRVs is similar to that for other compounds for which EcoSSLs have been derived based on datasets of the same size.

Bird Toxicity Reference Values

Bird TRVs were calculated for only PFOS and PFBS (**Table 4**) as applicable toxicity data were unavailable for the remaining PFAS with mammalian TRVs. The PFOS and PFBS NOAEL-based and LOAEL-based TRVs are notably different. The PFOS NOAEL-based TRV is over 1,000 times lower than its PFBS counterpart. Both are based on a limited number of studies and the same two test species, northern bobwhite quail and mallard duck. In addition, all bird studies informing the TRV calculations were performed by the same lab, Wildlife International. As a result, sensitivities in other bird species or other exposure environments would not be captured in the TRV data set.

Similar to the mammalian TRVs, bird TRVs calculated herein were compared to other published bird TRVs in order to understand how these values compare. In following EcoSSL methodology to derive the TRVs, both the PFOS and PFBS TRVs in this evaluation are higher than previously selected values (Giesy et al. 2010; McCarthy et al. 2017). Giesy et al. (2010) previously calculated a bird PFOS TRV of 0.032 mg/kg-bw/day after applying an UF of 24 and a bird PFBS TRV of 7.3 mg/kg-bw/day after applying an UF of 12. The LOAEL selected for the PFOS TRV was 0.77 mg/kg bw/day and the NOAEL selected for the PFBS TRV was 87.7 mg/kg bw/day. McCarthy et al. (2017) suggests the same PFOS LOAEL of 0.77 mg/kg-bw/day as the basis of a bird TRV. The PFOS LOAEL selected in Giesy et al. (2010) is included in **Table 2d** as the calculated measured concentration (rather than nominal) of 0.79 mg/kg-bw/day. Although a deviation from EcoSSL as the LOAEL was unbounded, this value was selected as the basis of the LOAEL TRV in this evaluation. The NOAEL TRV was the LOAEL TRV divided by an UF of 10. Therefore, the LOAEL TRVs between the three evaluations are effectively the same and differences in NOAEL TRVs are a result of different UFs applied.

Similarly, Giesy et al.'s (2010) selected NOAEL for PFBS is in this evaluation's dataset (**Table 2d**). However, it was not the highest bounded NOAEL below the lowest bounded LOAEL and therefore was not carried through to the final NOAEL-based TRV in this evaluation based on EcoSSL methodology.

Comparison of the mammalian and bird PFOS TRVs indicates mammals and birds are similar in sensitivity to PFOS. However, it should be noted that only two test species, the bobwhite quail and mallard, were available to derive the bird TRV. Additionally, the bird PFOS TRV data set is based on a fraction of the number of studies and toxicity data that are available for the mammalian PFOS TRV data set. Comparison of the bird and mammal PFBS TRVs does not

allow for a clear interpretation of respective sensitivities as their TRV NOAEL to LOAEL ranges overlap. Both bird and mammal PFBS TRVs are at least 10 times higher than the PFOS bird and mammal TRVs.

5.3.4 Wildlife Risk-Based Screening Levels Uncertainties

The wildlife RBSL calculations are dependent on exposure assumptions for each species, geometric means of identified measured BAFs or surrogate BAFs, and additional default assumptions such as an SUF of 1. Dietary fractions are typically based on a single representative field study whereas dietary fractions at a site may vary with prey availability and climate. Drinking water rates and FIRs are measurements from a study or may be calculated based on receptor body weight. Limited availability of PFAS BAF and BSAF data resulted in surrogate BAFs assumed to be representative of PFAS with a similar carbon number or functional groups. The default assumption of an SUF of 1 can be updated in a site-specific assessment based on area of the site and the feeding range of relevant receptors. Altering the SUF and can have a substantial effect on RBSLs.

The tree swallow was selected as the representative surrogate species for the aquatic invertivore bird feeding guild. The tree swallow may have a higher aerial insect dietary fraction than some T&E species included in the guild. If the aerial insect BAFs and BSAFs are updated to be based on aerial insect bioaccumulation data rather than the aquatic invertebrate BAF and BSAF surrogates, the tree swallow RBSLs may become less representative of some aquatic invertivore T&E birds. The red-winged blackbird was selected as the representative surrogate species for the aquatic omnivore bird feeding guild. The species included within this guild may have a higher dietary fraction of aquatic invertebrates or aerial insects than the red-winged blackbird that has a diet of primarily plants. The red-winged blackbird in addition to the aquatic invertivore tree swallow and piscivorous brown pelican provide a range of representative dietary fractions. Consideration should be given to the applicable receptors at each site and their dietary fractions to select the most representative surrogate species. The harbor seal fraction soil ingested was based on the mink fraction soil ingested as a surrogate. USACHPPM (2004) indicates that soil ingestion is likely to be high for harbor seals due to their feeding habits. Therefore, the harbor seal exposure parameters may underestimate dietary exposure to PFAS in sediment.

Overall, there is moderate confidence in the mammal PFAS RBSLs based on the TRVs used to model acceptable exposure concentrations. Low confidence in specific receptor's RBSLs are associated with insufficiencies in the BAFs and BSAFs. These receptors are identified and discussed in further detail below.

Overall, there is moderate confidence in the bird PFAS RBSLs. There is moderate confidence in the PFOS NOAEL and LOAEL TRVs as they were calculated with conservative assumptions and moderate confidence in the PFBS NOAEL and LOAEL TRVs as they were calculated following EcoSSL methodology. However, it should be noted the PFOS NOAEL TRV and the PFBS LOAEL TRV were calculated with application of UFs to account for either LOAEL to NOAEL extrapolation or subchronic exposure duration.

There is low confidence in little brown bat and tree swallow RBSLs as their diets are largely comprised of aerial insects. No field-based aerial insect BAFs or BSAFs were located, therefore, the bioaccumulation of PFAS into aerial insects cannot be well-characterized. In the RBSL calculations, terrestrial invertebrate BAFs and aquatic invertebrate BAFs and BSAFs were used to

estimate uptake of PFAS to terrestrial and aquatic aerial insects. Potential differences in bioaccumulation in aerial insects between aquatic and terrestrial environments are an additional unknown. Where PFAS contamination is present in the environment, insect species with aquatic larval stages are expected to have higher tissue concentrations than insects that deposit eggs on land, based on the BAFs and BSAFs observed for aquatic and terrestrial invertebrates (**Appendix F, Table 2**).

Similarly, there is low confidence in the long-tailed weasel and red-tailed hawk RBSLs as their diets are primarily comprised of mammals and/or reptiles. The soil to small mammal BAF was calculated using estimation of whole body for only one PFAS: PFOS. This BAF was applied to all six PFAS with calculated RBSLs. No appropriate BAFs were identified for birds and reptiles and the mammal BAF was used as the surrogate for these dietary groups.

6 DISCUSSION

Based on the receptors with the lowest RBSLs for each individual PFAS, insectivorous and invertivorous receptors may be the most sensitive to PFAS concentrations in the environment. The little brown bat, house wren, and tree swallow were often the most sensitive surrogate species. Therefore, the gray bat, red-cockaded woodpecker, and the snowy plover, as well as the other T&E species within the insectivore and invertivore feeding guilds, may be expected to be the most sensitive to elevated environmental PFAS concentrations based on default exposure assumptions. Notably, the insectivorous northern long-eared bat is the T&E species present on the most DoD sites. A total of 91 DoD sites are reported to be within northern long-eared bat range in 2016 (USACE 2016). However, application of the RBSLs will ideally be paired with a site-specific SUF and SUFs of less than 1.0 would increase the site-specific RBSLs.

Bird and mammal PFOS and PFOA TRVs are based on the most robust data sets and PFOS and PFOA are among the lowest NOAEL and LOAEL RBSLs developed. As the shorter chain PFBS and PFBA RBSLs are based on fewer toxicity data, it is uncertain if their higher TRVs and subsequently higher RBSLs are truly a result of lower toxicity to wildlife or a reflection of the limited data sets.

It has been assumed that PFAS with shorter chain lengths generally demonstrate lower bioaccumulation compared to the longer chain PFAS. Short chain PFAS are considered perfluoroalkyl carboxylic acids with six carbons or less (Brendel et al. 2018). Among the PFAS with RBSLs, PFNA, PFOS, and PFOA are considered long-chain PFAS while PFHxA, PFBS, and PFBA are short-chain PFAS. However, from the data retrieved for this evaluation, there is no clear relationship between chain length and bioaccumulation for any of the terrestrial or aquatic groups. For instance, the PFNA and PFBA fish BAFs were similar and higher than PFOA, PFHxA, and PFBS. Among the terrestrial plant BAFs, PFAS with the shortest chain lengths demonstrated the highest bioaccumulation, with a BAF for PFBA that is approximately 10 times greater than BAFs for PFAS with carbon chain lengths of eight or more. A lack of a robust bioaccumulation dataset for most of the PFAS besides PFOS and PFOA makes it difficult to draw conclusions on the association between chain length and bioaccumulation. As more data are collected for additional receptors and compounds, clear relationships may become more apparent.

Although the shorter chain PFAS wildlife RBSLs are generally lower, shorter chains have been documented to be more mobile in the environment (Brendel et al. 2018). This may lead to lower

concentrations at the point of release as the shorter chain PFAS migrate through the soil or water. Short chain PFAS may have lower sitewide or hotspot exposure point concentrations (EPCs) but higher SUFs if larger areas are impacted through PFAS migration. Therefore, the lower risk associated with lower EPCs may be offset in an ERA by higher SUFs for each receptor. Increased mobility compared to long chain PFAS may result in increased migration to offsite habitats.

PFAS are one of many groups of chemicals that potentially result in unacceptable risk to T&E species on DoD sites; other chemicals present on DoD site have RBSLs lower than those derived for PFAS herein. For reference, the 4,4-DDT ecological soil SL at Vandenberg Air Force Base is 0.0019 for Bewick's wren (MWH 2012). The TCDD equivalent soil SL for townsend's big-eared bat is 0.00000071 mg/kg (MWH 2012). The soil PFOS NOAEL RBSL for the house wren developed herein is 0.013 mg/kg and 0.03 mg/kg for the little brown bat. Although the methodology used to calculate RBSLs for these other example chemicals may differ, the comparison of the PFAS soil RBSLs with existing AFB ecological soil SLs illustrates they are low but within the range of other well-known chemicals. An important differentiator for PFAS is their long half-lives in the environment and resistance to traditional methods for remediation. (Kucharzyk et al. 2017).

As presented in **Table 13**, the minimum NOAEL-based RBSLs are consistently within or below the range of PFAS concentrations at impacted sites. Areas with historical or current impacts may be above PFAS screening levels and warrant further evaluation. The minimum NOAEL-based RBSL is above the range of background concentrations for PFOS in soil. The minimum NOAEL-based RBSL is within the range of background concentrations for PFOS in sediment and surface water and PFOA in soil, sediment, and surface water. The feasibility of certain minimum NOAEL RBSLs may depend on additional refinement of background concentrations. The PFOA background soil range, impacted soil range, and minimum RBSL overlap and the PFOA background soil range spans 3 orders of magnitude.

7 CONCLUSIONS AND IMPLICATIONS FOR FUTURE RESEARCH

7.1 Conclusions

RWQ RBSLs and soil, sediment, and surface water RBSLs were developed to provide screening values for DoD sites and a starting point for a site-specific ecological risk assessment as needed. USEPA GLI (2012) methodologies were used develop RWQ RBSLs; USEPA EcoSSL (2005) methodologies were followed to develop SLs for terrestrial plants and soil invertebrate soil SLs as well as mammal and bird RBSLs. Data were insufficient for development of sediment SLs for benthic invertebrates, and dose-based RBSLs for reptiles and fish. Based on a comprehensive review of existing toxicological data culminating in TRVs and targeted review of bioaccumulation, these wildlife RBSLs reflect a current understanding of potential PFAS toxicity and wildlife exposure.

7.2 Implications for Future Implementation

The SLs developed in this evaluation are intended for broad use across DoD sites as a preliminary ecological screening tool or for use in a baseline ecological risk assessment of PFAS concentrations measured in soil, surface water, and sediment. The foodweb models used herein to calculate RBSLs were created to be forward thinking and flexible to add or revise information

such as BAFs or TRVs as they become available. Periodic incorporation of newly available BAFs and toxicity data into the toxicity and exposure parameter calculations is recommended.

Use of site-specific exposure parameters such as areas of the site and associated SUF are highly recommended as SUFs can substantially change RBSLs and the most sensitive receptor. Assuming a default SUF of 1, the little brown bat is most frequently the receptor with the lowest RBSLs. A fire training area or crash site may be a fraction of the size of the little brown bat home range, estimated at 74 acres. The surrogate receptors with home ranges less than 5 acres are as follows: the meadow vole, muskrat, short-tailed shrew, and house wren. In a site-specific evaluation factoring in small site area, RBSLs for species with small home ranges may become the lowest RBSLs.

7.2.1 Applying SLs to Site Ecological Risk Assessments

Prior to application of the RWQ RBSLs, terrestrial SLs, and wildlife RBSLs, a standard stepwise approach to risk assessment should be completed, including: (1) determining list of potential ecological receptors, (2) characterization of extent of impacts, and (3) collecting analytical data for all relevant media.

- (1) A relevant receptor list should be determined based on evaluation of onsite habitats and present or potentially present T&E species on the DoD site. Not all feeding guilds or habitats presented in the RWQ RBSL, terrestrial SL, and wildlife RBSL tables will be relevant to every site. For instance, certain sensitive receptors such as insectivorous T&E birds may not be present on a site. In this circumstance, the minimum RBSLs will change to reflect T&E species known or potentially present on-site.
- (2) Determining SUF based on area of the PFAS-impacted site is a key step as discussed above. As discussed in further detail in Section 3.3.3, the SUF is calculated as the areas of impacted environmental media divided by each receptor's home range. Adjacent but noncontiguous areas of impacted soil or sediment (e.g., if there are multiple fire training areas or maintenance shops resulting in measurable environmental PFAS concentrations) should potentially be considered cumulatively when calculating SUFs for receptors with large home ranges.
- (3) Site investigations should collect all media relevant to identified receptors. If the site has only terrestrial receptors, collecting only soil and/or surface water may be appropriate. If the site has aquatic receptors it is strongly recommended to collect both sediment and surface water as limitations in BAF and BSAF data precluded a comprehensive assessment of risk associated with surface water or sediment individually.

In addition to on-site evaluation, consideration of downstream PFAS migration and potentially exposed off-site receptors is recommended if PFAS are detected in surface water (i.e., if surface water flows into downstream lake). The wildlife RBSLs were developed based on bird and small mammal receptors. Consideration of uncertainties associated with biomagnification through upper trophic levels should be considered if evaluating an upper trophic level receptor such as a wolf, perhaps through use of an additional uncertainty factor applied to the RBSL or through collection of site-specific data to estimate dietary exposures. The RBSLs are calculated with conservative

exposure assumptions for the wildlife receptors evaluated, but may not be sufficiently conservative for an upper trophic level predator and a biomagnifying PFAS.

7.3 Implications and Recommendations for Future Research

A significant data gap in this evaluation is the lack of data on bioaccumulation and toxicity of most PFAS. The majority of relevant papers included in the evaluation studied effects of PFOS and PFOA. While this provides greater confidence in the PFOS and PFOA aquatic and terrestrial screening values, the SLs developed for the remaining PFAS are based on limited data and are more likely to be updated as new literature becomes available.

Use of surrogate BAFs based on assumptions of structural similarity introduces uncertainty in the evaluation. Additional PFAS bioaccumulation research, particularly for polyfluorinated substances and newer replacement compounds would enable more informed selection of BAFs, BSAFs, or surrogate values for each PFAS. Availability of BAFs among the full range of dietary groups was also limited. The soil to small mammal BAF is restricted to PFOS and was converted to a whole body BAF using additional calculations to account for organ weights and partitioning as described in Section 3.3.3. This BAF was then applied to all PFAS as the soil to small mammal BAF. Amphibian BSAFs, aerial insect BAFs and BSAFs, and terrestrial reptile BAFs were not identified, requiring use of surrogate BAFs from a similar dietary group. Field studies sampling these biota and soil and sediment concentrations in known areas of PFAS release would provide valuable new information to the RBSL exposure assumptions.

No benthic invertebrate or reptile toxicity studies were identified; and no relevant dose-based toxicity data were located for fish. Bird toxicity studies were identified for only PFOS and PFBS and were all conducted by the same laboratory on two test species. These species groups represent areas for continuing research.

The potential for PFAS toxicity to be additive among all or a subset of PFAS with similar structures is a current area of scientific research. Existing state and federal human health advisory levels recommend screening criteria be applied to the sum of specific PFAS. For example, the USEPA PFOS and PFOA Health Advisory Levels are individually 70 parts per trillion and well as 70 parts per trillion for the sum of PFOS and PFOA (USEPA 2016c; USEPA 2016d). There is precedent for evaluation of chemicals additively in an ecological risk assessment. Consideration of additive ecological risk among a class of chemicals is currently common practice for some classes of chemicals (e.g., polycyclic aromatic hydrocarbons and some organochlorine pesticides). However, additive toxicity of PFAS in wildlife is considered insufficiently characterized to be assessed or included in this evaluation. Furthermore, additivity of PFAS in wildlife may vary between species. A deeper understanding of the mechanisms of PFAS toxicity in various species is required in order to estimate additivity.

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Table 1a. Freshwater Aquatic Compiled Toxicity Data

Common name	Scientific name	Source Study ^{1,2}	Endpoint	Concentration (mg/L)	Nominal / Measured	Duration (hours)	Effect
Perfluorododecanoic acid (PFDoA)							
Water flea	<i>Daphnia magna</i>	Ding et al. 2012b	EC50	79	Nominal	48	Immobilization
Cladoceran	<i>Chydorus sphaericus</i>	Ding et al. 2012b	EC50	28	Nominal	48	Immobilization
Water flea	<i>Daphnia magna</i>	Ding et al. 2012b	NOEC	74	Nominal	48	Immobilization
Cladoceran	<i>Chydorus sphaericus</i>	Ding et al. 2012b	NOEC	12	Nominal	48	Immobilization
PFUnA							
Water flea	<i>Daphnia magna</i>	Ding et al. 2012b	EC50	133	Nominal	48	Immobilization
Cladoceran	<i>Chydorus sphaericus</i>	Ding et al. 2012b	EC50	19	Nominal	48	Immobilization
Water flea	<i>Daphnia magna</i>	Ding et al. 2012b	NOEC	56	Nominal	48	Immobilization
Cladoceran	<i>Chydorus sphaericus</i>	Ding et al. 2012b	NOEC	5.6	Nominal	48	Immobilization
Perfluorodecanoic acid (PFDA)							
Water flea	<i>Daphnia magna</i>	Ding et al. 2012b	EC50	163	Nominal	48	Immobilization
Cladoceran	<i>Chydorus sphaericus</i>	Ding et al. 2012b	EC50	45	Nominal	48	Immobilization
Water flea	<i>Daphnia magna</i>	Ding et al. 2012b	NOEC	77	Nominal	48	Immobilization
Cladoceran	<i>Chydorus sphaericus</i>	Ding et al. 2012b	NOEC	5.1	Nominal	48	Immobilization
Water flea	<i>Daphnia magna</i>	Hoke et al. 2012	LC50	>100	NS	48	Immobilization
Rainbow trout	<i>Oncorhynchus mykiss</i>	Hoke et al. 2012	LC50	32	Nominal	96	Survival
Zebrafish	<i>Danio rerio</i>	Ulhaq et al. 2013	LC50	8.4	Nominal	144	Survival
Perfluorononanoic acid (PFNA)							
Water flea	<i>Daphnia magna</i>	Ding et al. 2012b	EC50	151	Nominal	48	Immobilization
Cladoceran	<i>Chydorus sphaericus</i>	Ding et al. 2012b	EC50	28	Nominal	48	Immobilization
Water flea	<i>Daphnia magna</i>	Ding et al. 2012b	NOEC	93	Nominal	48	Immobilization
Cladoceran	<i>Chydorus sphaericus</i>	Ding et al. 2012b	NOEC	<23.204	Nominal	48	Immobilization
Zebrafish	<i>Danio rerio</i>	Ulhaq et al. 2013	LC50	>10	Nominal	144	Survival
Zebrafish	<i>Danio rerio</i>	Zheng et al. 2012	LC50	84	Nominal	72	Survival
Zebrafish	<i>Danio rerio</i>	Zhang et al. 2012	LOEC	0.01	Nominal	4320	Growth
Zebrafish	<i>Danio rerio</i>	Zhang et al. 2012	NOEC	0.1	Nominal	4320	Growth
Zebrafish	<i>Danio rerio</i>	Zhang et al. 2012	LOEC	1	Nominal	4320	Growth
Perfluorooctanesulfonic acid (PFOS)							
Zebrafish	<i>Danio rerio</i>	Keiter et al. 2012	LOEC	0.0006	Nominal	2160	Growth
Zebrafish	<i>Danio rerio</i>	Keiter et al. 2012	LOEC	0.0006	Nominal	2160	Growth
Damselfly	<i>Enallagma cyathigerum</i>	Bots et al. 2010	LOEC	0.01	Nominal	>7200	Growth
Zebrafish	<i>Danio rerio</i>	Du et al. 2009	NOEC	0.01	Nominal	960	Growth
Zebrafish	<i>Danio rerio</i>	Du et al. 2009	LOEC	0.05	Nominal	960	Growth
Fathead Minnow	<i>Pimephales promelas</i>	Ankley et al. 2005	EC50	0.23	Nominal	504	Reproduction
Fathead Minnow	<i>Pimephales promelas</i>	Ankley et al. 2005	NOEC	0.3	Nominal	576	Growth, Reproduction
Zebrafish	<i>Danio rerio</i>	Wang et al. 2011b	NOEC	0.005	Nominal	3600	Growth
Zebrafish	<i>Danio rerio</i>	Wang et al. 2011b	LOEC	0.05	Nominal	3600	Growth
Zebrafish	<i>Danio rerio</i>	Wang et al. 2011b	NOEC	0.05	Nominal	3600	Growth
Zebrafish	<i>Danio rerio</i>	Wang et al. 2011b	LOEC	0.25	Nominal	3600	Growth
Fatmucket Clam	<i>Lampsilis siliquoidea</i>	Hazelton et al. 2012	LOEC	0.0045	Measured	864	Survival
Fatmucket Clam	<i>Lampsilis siliquoidea</i>	Hazelton et al. 2012	EC50	17.7	Nominal	48	Survival
Black sandshell	<i>Ligumia recta</i>	Hazelton et al. 2012	EC50	17	Nominal	48	Survival
Fatmucket Clam	<i>Lampsilis siliquoidea</i>	Hazelton et al. 2012	EC50	158.1	Nominal	96	Immobilization
Black sandshell	<i>Ligumia recta</i>	Hazelton et al. 2012	EC50	141.7	Nominal	96	Immobilization
Water flea	<i>Daphnia magna</i>	Jeong et al. 2016	NOEC	0.01	Nominal	600	Reproduction
Water flea	<i>Daphnia magna</i>	Jeong et al. 2016	LOEC	0.1	Nominal	600	Reproduction
Water flea	<i>Daphnia magna</i>	Jeong et al. 2016	NOEC	0.1	Nominal	600	Reproduction
Water flea	<i>Daphnia magna</i>	Jeong et al. 2016	LOEC	1	Nominal	600	Reproduction
Water flea	<i>Daphnia magna</i>	Jeong et al. 2016	NOEC	1	Nominal	600	Growth
Water flea	<i>Daphnia magna</i>	Jeong et al. 2016	LOEC	10	Nominal	600	Growth
Water flea	<i>Daphnia magna</i>	Boudreau et al. 2003	NOEC	125	Nominal	48	Survival
Water flea	<i>Daphnia magna</i>	Boudreau et al. 2003	LC10	33.1	Nominal	48	Survival
Water flea	<i>Daphnia magna</i>	Boudreau et al. 2003	LC50	130	Nominal	48	Survival
Water flea	<i>Daphnia magna</i>	Boudreau et al. 2003	EC10	0.8	Nominal	48	Immobilization
Water flea	<i>Daphnia magna</i>	Boudreau et al. 2003	EC50	67.2	Nominal	48	Immobilization
Water flea	<i>Daphnia pulicaria</i>	Boudreau et al. 2003	NOEC	125	Nominal	48	Survival
Water flea	<i>Daphnia pulicaria</i>	Boudreau et al. 2003	LC10	46.9	Nominal	48	Survival
Water flea	<i>Daphnia pulicaria</i>	Boudreau et al. 2003	LC50	169	Nominal	48	Survival
Water flea	<i>Daphnia pulicaria</i>	Boudreau et al. 2003	EC10	13.6	Nominal	48	Immobilization

Table 1a. Freshwater Aquatic Compiled Toxicity Data

Common name	Scientific name	Source Study ^{1,2}	Endpoint	Concentration (mg/L)	Nominal / Measured	Duration (hours)	Effect
Water flea	<i>Daphnia pulicaria</i>	Boudreau et al. 2003	EC50	134	Nominal	48	Immobilization
Water flea	<i>Daphnia magna</i>	Drottat and Krueger, 2000a	NOEC	33	Measured	48	Survival, Immobilization
Water flea	<i>Daphnia magna</i>	Drottat and Krueger, 2000a	EC10	53	Measured	48	Survival, Immobilization
Water flea	<i>Daphnia magna</i>	Drottat and Krueger, 2000a	EC50	61	Measured	48	Survival
Water flea	<i>Daphnia magna</i>	Drottat and Krueger, 2000e	NOEC	12	Measured	504	Survival
Water flea	<i>Daphnia magna</i>	Drottat and Krueger, 2000e	LOEC	24	Measured	504	Survival
Water flea	<i>Daphnia magna</i>	Drottat and Krueger, 2000e	NOEC	12	Measured	48	Survival
Water flea	<i>Daphnia magna</i>	Drottat and Krueger, 2000e	LOEC	24	Measured	48	Survival
Mollusk	<i>Unio complanatus</i>	Drottat and Krueger, 2000b	EC50/LC50/IC50	59	Measured	96	Survival
African clawed frog	<i>Xenopus laevis</i>	Palmer and Krueger, 2001	LC50	13.8	Measured	96	Survival
African clawed frog	<i>Xenopus laevis</i>	Palmer and Krueger, 2001	LC50	17.6	Measured	96	Survival
African clawed frog	<i>Xenopus laevis</i>	Palmer and Krueger, 2001	LC50	15.3	Measured	96	Survival
Rainbow Trout	<i>Oncorhynchus mykiss</i>	Palmer et al. 2002a	EC50/LC50/IC50	22	NA	96	Survival
Rainbow Trout	<i>Oncorhynchus mykiss</i>	Palmer et al. 2002a	LOEC	13	NA	96	Survival
Rainbow Trout	<i>Oncorhynchus mykiss</i>	Palmer et al. 2002a	NOEC	6.3	NA	96	Survival
Water flea	<i>Daphnia magna</i>	Boudreau et al. 2003	NOEC	25	Nominal	504	Reproduction, Survival
Water flea	<i>Daphnia magna</i>	Boudreau et al. 2003	LOEC	50	Nominal	504	Reproduction, Survival
Water flea	<i>Daphnia magna</i>	Boudreau et al. 2003	LC10	5.3	Nominal	504	Survival
Water flea	<i>Daphnia magna</i>	Boudreau et al. 2003	LC50	42.9	Nominal	504	Survival
Midge	<i>Chironomus tentans</i>	MacDonald et al. 2004, range finding test	EC50	0.0274	Measured	240	Growth
Midge	<i>Chironomus tentans</i>	MacDonald et al. 2004, definitive test	EC50	0.0872	Measured	240	Growth
Midge	<i>Chironomus tentans</i>	MacDonald et al. 2004, definitive test	EC10	0.0492	Measured	240	Growth
Midge	<i>Chironomus tentans</i>	MacDonald et al. 2004, definitive test	NOEC	0.0491	Measured	240	Growth
Midge	<i>Chironomus tentans</i>	MacDonald et al. 2004, definitive test	LOEC	0.0962	Measured	240	Growth
Midge	<i>Chironomus tentans</i>	MacDonald et al. 2004, lifecycle test	EC50	0.0922	Measured	480	Survival
Midge	<i>Chironomus tentans</i>	MacDonald et al. 2004, lifecycle test	EC10	0.0864	Measured	480	Survival
Midge	<i>Chironomus tentans</i>	MacDonald et al. 2004, lifecycle test	LOEC	0.0023	Measured	480	Reproduction
Northern leopard frog	<i>Rana pipiens</i>	Ankley et al. 2004	LC50	6.21	Measured	840	Survival
Northern leopard frog	<i>Rana pipiens</i>	Ankley et al. 2004	LOEC	3	Nominal	1920	Growth
Northern leopard frog	<i>Rana pipiens</i>	Ankley et al. 2004	NOEC	1	Nominal	1920	Growth
Fathead Minnow	<i>Pimephales promelas</i>	Drottat and Krueger, 2000g	LOEC	0.6	Measured	1128	Survival
Fathead Minnow	<i>Pimephales promelas</i>	Drottat and Krueger, 2000g	NOEC	0.3	Measured	1128	Growth, Reproduction, Survival
Planarian	<i>Dugesia japonica</i>	Li, 2009	LC50	23	Nominal	96	Survival
Water flea	<i>Daphnia magna</i>	Li, 2009	LC50	63	Nominal	48	Immobilization
Green neon shrimp	<i>Neocaridina denticulate</i>	Li, 2009	LC50	10	Nominal	96	Survival
Snail	<i>Physa acuta</i>	Li, 2009	LC50	178	Nominal	96	Survival
Mussel	<i>Unio ravoisieri</i>	Amraoui et al. 2018	LC50	65.9	Nominal	96	Survival
Water flea	<i>Daphnia magna</i>	Liang et al. 2017	EC50	79.35	Nominal	48	Immobilization
Nematode	<i>Caenorhabditis elegans</i>	Chen et al. 2018	LC50	0.70	Nominal	48	Survival
Zebrafish	<i>Danio rerio</i>	Wang et al. 2013b	LC0 (NOEC)	2.9	Nominal	96	Survival
Zebrafish	<i>Danio rerio</i>	Wang et al. 2013b	LC50	56.16	NS	72	Survival
Zebrafish	<i>Danio rerio</i>	Wang et al. 2013b	LC50	17	NS	96	Survival
Zebrafish	<i>Danio rerio</i>	Sharpe et al. 2010	LC50	22.2	Measured	96	Survival
Rainbow trout	<i>Oncorhynchus mykiss</i>	Sharpe et al. 2010	LC50	2.5	Measured	96	Survival
Zebrafish	<i>Danio rerio</i>	Sharpe et al. 2010, embryo replicate 1	LC50	7.7	Measured	48	Survival
Zebrafish	<i>Danio rerio</i>	Sharpe et al. 2010, embryo replicate 2	LC50	38.9	Measured	48	Survival
Zebrafish	<i>Danio rerio</i>	Sharpe et al. 2010, embryo replicate 3	LC50	24.6	Measured	48	Survival
Water flea	<i>Daphnia magna</i>	Li, 2009	NOEC	20	Nominal	48	Immobilization
Planarian	<i>Dugesia japonica</i>	Li, 2009	NOEC	10	Nominal	96	Survival
Green neon shrimp	<i>Neocaridina denticulate</i>	Li, 2009	NOEC	5	Nominal	96	Survival
Snail	<i>Physa acuta</i>	Li, 2009	NOEC	100	Nominal	96	Survival
Zebrafish	<i>Danio rerio</i>	Huang et al. 2010	LC50	2.2	Nominal	120	Survival
Zebrafish	<i>Danio rerio</i>	Ulhaq et al. 2013	LC50	>10	Nominal	144	Survival
Zebrafish	<i>Danio rerio</i>	Wang et al. 2017	LC50	3.502	Nominal	96	Survival
Zebrafish	<i>Danio rerio</i>	Wang et al. 2017	NOEC	0.17	Nominal	96	Growth
Zebrafish	<i>Danio rerio</i>	Wang et al. 2017	LOEC	0.33	Nominal	96	Growth
Zebrafish	<i>Danio rerio</i>	Wang et al. 2017	NOEC	0.17	Nominal	96	Survival
Zebrafish	<i>Danio rerio</i>	Wang et al. 2017	LOEC	0.33	Nominal	96	Survival
Zebrafish	<i>Danio rerio</i>	Zheng et al. 2012	LC50	68	Nominal	72	Survival
Zebrafish	<i>Danio rerio</i>	Hagenaars et al. 2011	LC50	58.47	Nominal	96	Survival

Table 1a. Freshwater Aquatic Compiled Toxicity Data

Common name	Scientific name	Source Study ^{1,2}	Endpoint	Concentration (mg/L)	Nominal / Measured	Duration (hours)	Effect
Zebrafish	<i>Danio rerio</i>	Hagenaars et al. 2011	LC50	28.21	Nominal	120	Survival
Zebrafish	<i>Danio rerio</i>	Hagenaars et al. 2011	NOEC	0.5	Nominal	120	Growth
Zebrafish	<i>Danio rerio</i>	Hagenaars et al. 2011	LOEC	1	Nominal	120	Growth
Zebrafish	<i>Danio rerio</i>	Ding et al. 2013	LC50	54.4	Nominal	96	Survival
Northern leopard frog	<i>Rana pipiens</i>	Hoover et al. 2017	NOEC	1	Nominal	960	Survival
Fathead Minnow	<i>Pimephales promelas</i>	OECD, 2002 (3M 2000, Reference 1)	LC50	9.5	Measured	96	Survival
Fathead Minnow	<i>Pimephales promelas</i>	OECD, 2002 (3M 2000, Reference 16)	LC50	4.7	Nominal	96	Survival
Fathead Minnow	<i>Pimephales promelas</i>	OECD, 2002 (3M 2000, Reference 28)	LL50	197	Nominal	96	Survival
Fathead Minnow	<i>Pimephales promelas</i>	OECD, 2002 (3M 2000, Reference 28)	NOEL	<172	Nominal	96	Survival
Bluegill Sunfish	<i>Lepomis macrochirus</i>	OECD, 2002 (3M 2000, Reference 20)	LC50	7.8	Nominal	96	Survival
Fathead Minnow	<i>Pimephales promelas</i>	OECD, 2002 (3M 2000, Reference 14)	NOEC	1	Measured	720	Survival
Fathead Minnow	<i>Pimephales promelas</i>	OECD, 2002 (3M 2000, Reference 14)	LOEC	1.9	Measured	720	Survival
Planarian	<i>Dugesia japonica</i>	Yuan et al. 2014	LC50	40.72	Nominal	24	Survival
Planarian	<i>Dugesia japonica</i>	Yuan et al. 2014	LC50	38.45	Nominal	48	Survival
Planarian	<i>Dugesia japonica</i>	Yuan et al. 2014	LC50	32.92	Nominal	72	Survival
Planarian	<i>Dugesia japonica</i>	Yuan et al. 2014	LC50	29.46	Nominal	96	Survival
Planarian	<i>Dugesia japonica</i>	Li, 2008	LC50	53	Nominal	24	Survival
Planarian	<i>Dugesia japonica</i>	Li, 2008	LC50	25	Nominal	48	Survival
Planarian	<i>Dugesia japonica</i>	Li, 2008	LC50	19	Nominal	72	Survival
Planarian	<i>Dugesia japonica</i>	Li, 2008	LC50	17	Nominal	96	Survival
Planarian	<i>Dugesia japonica</i>	Li, 2008	LOAEL	20	Nominal	48	Survival
Planarian	<i>Dugesia japonica</i>	Li, 2008	NOAEL	18	Nominal	48	Survival
Planarian	<i>Dugesia japonica</i>	Li, 2008	LOAEL	18	Nominal	96	Survival
Planarian	<i>Dugesia japonica</i>	Li, 2008	NOAEL	12	Nominal	96	Survival
Zebrafish	<i>Danio rerio</i>	Chen et al. 2016	LOAEL	0.25	Nominal	5 month	Growth, Reproduction
Water flea	<i>Daphnia magna</i>	Li, 2010	NOEC	1	Nominal	504	Reproduction
Water flea	<i>Daphnia magna</i>	Li, 2010	NOEC	5.00	Nominal	504	Survival
Water flea	<i>Daphnia magna</i>	Li, 2010	LC50	9.10	Nominal	504	Survival
Water flea	<i>Daphnia pulicaria</i>	Sanderson et al. 2004	NOEC	6	NS	504	Survival
Water flea	<i>Daphnia magna</i>	Sanderson et al. 2004	NOEC	25	NS	504	Survival
Water flea	<i>Daphnia pulicaria</i>	Sanderson et al. 2004	LOEC	13	NS	504	Survival
Water flea	<i>Daphnia magna</i>	Sanderson et al. 2004	LOEC	50	NS	504	Survival
Zebrafish	<i>Danio rerio</i>	Shi et al. 2008	NOAEL	0.5	Nominal	132	Reproduction
Zebrafish	<i>Danio rerio</i>	Shi et al. 2008	LOAEL	1	Nominal	132	Reproduction
Zebrafish	<i>Danio rerio</i>	Shi et al. 2008	NOAEL	1	Nominal	84	Growth
Zebrafish	<i>Danio rerio</i>	Shi et al. 2008	LOAEL	3	Nominal	84	Growth
Water flea	<i>Daphnia magna</i>	Ji et al. 2008	EC50	37.36	Nominal	48	Immobilization
Water flea	<i>Daphnia magna</i>	Ji et al. 2008	NOEC	12.5	Nominal	48	Immobilization
Water flea	<i>Daphnia magna</i>	Ji et al. 2008	LOEC	25	Nominal	48	Immobilization
Cladoceran	<i>Moina macrocopa</i>	Ji et al. 2008	EC50	17.95	Nominal	48	Immobilization
Cladoceran	<i>Moina macrocopa</i>	Ji et al. 2008	NOEC	6.25	Nominal	48	Immobilization
Cladoceran	<i>Moina macrocopa</i>	Ji et al. 2008	LOEC	12.5	Nominal	48	Immobilization
Water flea	<i>Daphnia magna</i>	Ji et al. 2008	NOEC	1.25	Nominal	504	Reproduction
Water flea	<i>Daphnia magna</i>	Ji et al. 2008	LOEC	3	Nominal	504	Reproduction
Cladoceran	<i>Moina macrocopa</i>	Ji et al. 2008	LOEC	0.3125	Nominal	168	Reproduction
Japanese medaka	<i>Oryzias latipes</i>	Ji et al. 2008	NOEC	1	Nominal	336	Survival
Japanese medaka	<i>Oryzias latipes</i>	Ji et al. 2008	LOEC	0.01	Nominal	2400	Growth
Japanese medaka	<i>Oryzias latipes</i>	Ji et al. 2008	LOEC	0.01	Nominal	336 (F0), > 672 (F1)	Survival
African clawed frog	<i>Xenopus laevis</i>	Lou et al. 2013	NOEC	0.822	Measured	2880	Growth, Survival
African clawed frog	<i>Xenopus laevis</i>	San-Segundo et al. 2016	NOEC	96	Nominal	96	Reproduction
African clawed frog	<i>Xenopus laevis</i>	San-Segundo et al. 2016	NOEC	24	Nominal	96	Growth
African clawed frog	<i>Xenopus laevis</i>	San-Segundo et al. 2016	LOEC	48	Nominal	96	Growth
African clawed frog	<i>Xenopus laevis</i>	Cheng et al. 2011	NOEC	0.1	Nominal	>960	Survival
Green swordtail	<i>Xiphophorus helleri</i> - Male	Han and Fang, 2010	NOEC	0.1	Nominal	2160	Growth
Green swordtail	<i>Xiphophorus helleri</i> - Female	Han and Fang, 2010	LOEC	0.1	Nominal	2160	Growth
Zebrafish	<i>Danio rerio</i>	Hagenaars et al. 2014- Swim bladder range finding test	NOEC	2.5	Nominal	144	Growth
Zebrafish	<i>Danio rerio</i>	Hagenaars et al. 2014- Swim bladder range finding test	LOEC	3	Nominal	144	Growth
Zebrafish	<i>Danio rerio</i>	Hagenaars et al. 2014- Swim bladder range finding test	NOEC	4.5	Nominal	144	Survival
Zebrafish	<i>Danio rerio</i>	Hagenaars et al. 2014 - Time window test	NOEC	0.7	Nominal	24 or 48	Growth
Zebrafish	<i>Danio rerio</i>	Hagenaars et al. 2014 - Time window test	LOEC	1.14	Nominal	24 or 48	Growth

Table 1a. Freshwater Aquatic Compiled Toxicity Data

Common name	Scientific name	Source Study ^{1,2}	Endpoint	Concentration (mg/L)	Nominal / Measured	Duration (hours)	Effect
Zebrafish	<i>Danio rerio</i>	Hagenaars et al. 2014 - Time window test	NOEC	4.28	Nominal	24 or 48	Survival
Zebrafish	<i>Danio rerio</i>	Hagenaars et al. 2014 - exploratory range finding test	LC50	6.25	Nominal	144	Survival
Zebrafish	<i>Danio rerio</i>	Shi et al. 2009	NOAEL	0.4	Nominal	360	Survival
Zebrafish	<i>Danio rerio</i>	Shi et al. 2009	NOAEL	0.2	Nominal	15 dpf	Growth
Zebrafish	<i>Danio rerio</i>	Shi et al. 2009	LOAEL	0.4	Nominal	15 dpf	Growth
Zebrafish	<i>Danio rerio</i>	Shi et al. 2009	NOAEL	0.2	Nominal	15 dpf	Growth
Zebrafish	<i>Danio rerio</i>	Shi et al. 2009	LOAEL	0.4	Nominal	15 dpf	Growth
Water flea	<i>Daphnia magna</i>	OECD, 2002 (3M, Reference 15)	EC50	27	Nominal	48	Immobilization
Water flea	<i>Daphnia magna</i>	OECD, 2002 (3M, Reference 17)	EC50	51.5	Nominal	48	Survival, Immobilization
Water flea	<i>Daphnia magna</i>	OECD, 2002 (3M, Reference 29)	EL50	4	Nominal	48	Survival, Immobilization
Water flea	<i>Daphnia magna</i>	OECD, 2002 (3M, Reference 29)	NOEL	2.2	Nominal	48	Survival, Immobilization
Water flea	<i>Daphnia magna</i>	OECD, 2002 (3M, Reference 15)	EC50	14.7	Nominal	336	Reproduction
Water flea	<i>Daphnia magna</i>	OECD, 2002 (3M, Reference 15)	EC50	12.4	Nominal	504	Reproduction
Water flea	<i>Daphnia magna</i>	OECD, 2002 (3M, Reference 15)	NOEC	7	Nominal	672	Reproduction
Water flea	<i>Daphnia magna</i>	OECD, 2002 (3M, Reference 15)	EC50	11.4	Nominal	672	Reproduction
Crucian carp	<i>Carassius auratus</i>	Yang et al. 2014	LC50	81.18	Measured	96	Survival
Topmouth gudgeon	<i>Pseudorasbora parva</i>	Yang et al. 2014	LC50	67.74	Measured	96	Survival
Topmouth gudgeon	<i>Pseudorasbora parva</i>	Yang et al. 2014	EC10	2.12	Measured	720	Survival
Asiatic toad	<i>Bufo gargizans</i>	Yang et al. 2014	LC50	48.21	Measured	96	Survival
Asiatic toad	<i>Bufo gargizans</i>	Yang et al. 2014	EC10	2	Measured	720	Survival
Water flea	<i>Daphnia magna</i>	Yang et al. 2014	LC50	78.09	Measured	48	Survival
Water flea	<i>Daphnia magna</i>	Yang et al. 2014	EC10	2.26	Measured	504	Reproduction
Freshwater shrimp	<i>Macrobrachium nipponense</i>	Yang et al. 2014	LC50	19.77	Measured	96	Survival
Chironomid	<i>Chironomus plumosus</i>	Yang et al. 2014	LC50	182.12	Measured	96	Survival
Worm	<i>Limnodrilus hoffmeisteri</i>	Yang et al. 2014	LC50	120.97	Measured	96	Survival
Mud snail	<i>Cipangopaludina cathayensis</i>	Yang et al. 2014	LC50	247.14	Measured	96	Survival
Perfluorooctanoic acid (PFOA)							
Fatmucket Clam	<i>Lampsilis siliquoidea</i>	Hazelton et al. 2012	EC50	162.6	Nominal	48	Survival
Black sandshell	<i>Ligumia recta</i>	Hazelton et al. 2012	EC50	161.3	Nominal	48	Survival
Fatmucket Clam	<i>Lampsilis siliquoidea</i>	Hazelton et al. 2012	EC50	>500	Nominal	96	Immobilization
Black sandshell	<i>Ligumia recta</i>	Hazelton et al. 2012	EC50	>500	Nominal	96	Immobilization
Midge	<i>Chironomus tentans</i>	MacDonald et al. 2004, range finding test	NOEC	100	Measured	240	Growth, Survival
Water flea	<i>Daphnia magna</i>	Ding et al. 2012b	EC50	212	Nominal	48	Immobilization
Cladoceran	<i>Chydorus sphaericus</i>	Ding et al. 2012b	EC50	117	Nominal	48	Immobilization
Water flea	<i>Daphnia magna</i>	Ding et al. 2012b	NOEC	207	Nominal	48	Immobilization
Cladoceran	<i>Chydorus sphaericus</i>	Ding et al. 2012b	NOEC	<41.407	Nominal	48	Immobilization
Planarian	<i>Dugesia japonica</i>	Li, 2009	LC50	337	Nominal	96	Survival
Water flea	<i>Daphnia magna</i>	Li, 2009	LC50	181	Nominal	48	Immobilization
Green neon shrimp	<i>Neocaridina denticulate</i>	Li, 2009	LC50	454	Nominal	96	Survival
Snail	<i>Physa acuta</i>	Li, 2009	LC50	672	Nominal	96	Survival
Water flea	<i>Daphnia magna</i>	Barmentlo et al. 2015	EC50	239	NS	48	Immobilization
Water flea	<i>Daphnia magna</i>	Barmentlo et al. 2015	EC10	195	NS	48	Immobilization
Water flea	<i>Daphnia magna</i>	Li, 2009	NOEC	125	Nominal	48	Immobilization
Planarian	<i>Dugesia japonica</i>	Li, 2009	NOEC	150	Nominal	96	Survival
Green neon shrimp	<i>Neocaridina denticulate</i>	Li, 2009	NOEC	250	Nominal	96	Survival
Snail	<i>Physa acuta</i>	Li, 2009	NOEC	250	Nominal	96	Survival
Zebrafish	<i>Danio rerio</i>	Ulhaq et al. 2013	LC50	430	Nominal	144	Survival
Zebrafish	<i>Danio rerio</i>	Zheng et al. 2012	LC50	262	Nominal	72	Survival
Zebrafish	<i>Danio rerio</i>	Kalasekar et al. 2015	LC50	157	Nominal	72	Survival
Zebrafish	<i>Danio rerio</i>	Hagenaars et al. 2011	LC50	>500	Nominal	96	Survival
Zebrafish	<i>Danio rerio</i>	Hagenaars et al. 2011	LC50	>500	Nominal	120	Survival
Zebrafish	<i>Danio rerio</i>	Hagenaars et al. 2011	NOEC	75	Nominal	120	Growth
Zebrafish	<i>Danio rerio</i>	Hagenaars et al. 2011	LOEC	100	Nominal	120	Growth
Zebrafish	<i>Danio rerio</i>	Ding et al. 2013	LC50	371	Nominal	96	Survival
Northern leopard frog	<i>Rana pipiens</i>	Hoover et al. 2017	NOEC	1	Nominal	960	Survival
Planarian	<i>Dugesia japonica</i>	Yuan et al. 2015	LC50	45.17	Nominal	24	Survival
Planarian	<i>Dugesia japonica</i>	Yuan et al. 2015	LC50	42.94	Nominal	48	Survival
Planarian	<i>Dugesia japonica</i>	Yuan et al. 2015	LC50	41.09	Nominal	72	Survival
Planarian	<i>Dugesia japonica</i>	Yuan et al. 2015	LC50	39.35	Nominal	96	Survival
Planarian	<i>Dugesia japonica</i>	Li, 2008	LC50	548	Nominal	24	Survival

Table 1a. Freshwater Aquatic Compiled Toxicity Data

Common name	Scientific name	Source Study ^{1,2}	Endpoint	Concentration (mg/L)	Nominal / Measured	Duration (hours)	Effect
Planarian	<i>Dugesia japonica</i>	Li, 2008	LC50	536	Nominal	48	Survival
Planarian	<i>Dugesia japonica</i>	Li, 2008	LC50	519	Nominal	72	Survival
Planarian	<i>Dugesia japonica</i>	Li, 2008	LC50	458	Nominal	96	Survival
Planarian	<i>Dugesia japonica</i>	Li, 2008	LOAEL	500	Nominal	48	Survival
Planarian	<i>Dugesia japonica</i>	Li, 2008	NOAEL	450	Nominal	48	Survival
Planarian	<i>Dugesia japonica</i>	Li, 2008	LOAEL	450	Nominal	96	Survival
Planarian	<i>Dugesia japonica</i>	Li, 2008	NOAEL	400	Nominal	96	Survival
Water flea	<i>Daphnia magna</i>	Li, 2010	NOEC	10	Nominal	504	Reproduction
Water flea	<i>Daphnia magna</i>	Li, 2010	NOEC	>100	Nominal	504	Survival
Water flea	<i>Daphnia magna</i>	Li, 2010	LC50	>100	Nominal	504	Survival
Water flea	<i>Daphnia magna</i>	Ji et al. 2008	EC50	476.52	Nominal	48	Immobilization
Water flea	<i>Daphnia magna</i>	Ji et al. 2008	NOEC	250	Nominal	48	Immobilization
Water flea	<i>Daphnia magna</i>	Ji et al. 2008	LOEC	500	Nominal	48	Immobilization
Cladoceran	<i>Moina macrocopa</i>	Ji et al. 2008	EC50	199.51	Nominal	48	Immobilization
Cladoceran	<i>Moina macrocopa</i>	Ji et al. 2008	NOEC	62.5	Nominal	48	Immobilization
Cladoceran	<i>Moina macrocopa</i>	Ji et al. 2008	LOEC	125	Nominal	48	Immobilization
Water flea	<i>Daphnia magna</i>	Ji et al. 2008	NOEC	12.5	Nominal	504	Reproduction
Water flea	<i>Daphnia magna</i>	Ji et al. 2008	LOEC	25	Nominal	504	Reproduction
Cladoceran	<i>Moina macrocopa</i>	Ji et al. 2008	NOEC	3.125	Nominal	168	Reproduction
Cladoceran	<i>Moina macrocopa</i>	Ji et al. 2008	LOEC	6.25	Nominal	168	Reproduction
Japanese medaka	<i>Oryzias latipes</i>	Ji et al. 2008	NOEC	10	Nominal	336	Survival
Japanese medaka	<i>Oryzias latipes</i>	Ji et al. 2008	NOEC	10	Nominal	2400	Growth
Japanese medaka	<i>Oryzias latipes</i>	Ji et al. 2008	LOEC	0.01	Nominal	336 (F0), > 672 (F1)	Survival
Japanese medaka	<i>Oryzias latipes</i>	Yang et al. 2010	NOEC	100	Nominal	168	Survival
Japanese medaka	<i>Oryzias latipes</i>	Lee et al. 2017	NOEC	3	Nominal	672	Reproduction
Japanese medaka	<i>Oryzias latipes</i>	Lee et al. 2017	LOEC	30	Nominal	672	Reproduction
Zebrafish	<i>Danio rerio</i>	Jantzen et al. 2017	LOEC	0.0008	Nominal	117	Growth, Reproduction
Crucian carp	<i>Carassius auratus</i>	Yang et al. 2014	LC50	606.61	Measured	96	Survival
Topmouth gudgeon	<i>Pseudorasbora parva</i>	Yang et al. 2014	LC50	365.02	Measured	96	Survival
Topmouth gudgeon	<i>Pseudorasbora parva</i>	Yang et al. 2014	EC10	11.78	Measured	720	Survival
Asiatic toad	<i>Bufo gargarizans</i>	Yang et al. 2014	LC50	114.74	Measured	96	Survival
Asiatic toad	<i>Bufo gargarizans</i>	Yang et al. 2014	EC10	5.89	Measured	720	Survival
Water flea	<i>Daphnia magna</i>	Yang et al. 2014	LC50	201.85	Measured	48	Survival
Water flea	<i>Daphnia magna</i>	Yang et al. 2014	EC10	7.02	Measured	504	Reproduction
Freshwater shrimp	<i>Macrobrachium nipponense</i>	Yang et al. 2014	LC50	366.66	Measured	96	Survival
Chironomid	<i>Chironomus plumosus</i>	Yang et al. 2014	LC50	402.24	Measured	96	Survival
Worm	<i>Limnodrilus hoffmeisteri</i>	Yang et al. 2014	LC50	568.2	Measured	96	Survival
Mud snail	<i>Cipangopaludina cathayensis</i>	Yang et al. 2014	LC50	740.07	Measured	96	Survival
Rainbow trout	<i>Oncorhynchus mykiss</i>	Colombo et al. 2008	NOEC	500	Nominal	96	Survival
Rainbow trout	<i>Oncorhynchus mykiss</i>	Colombo et al. 2008	LOEC	1000	Nominal	96	Survival
Rainbow trout	<i>Oncorhynchus mykiss</i>	Colombo et al. 2008	LC50	707	Nominal	96	Survival
Water flea	<i>Daphnia magna</i>	Colombo et al. 2008	NOEC	>88.6	Measured	504	Immobilization
Water flea	<i>Daphnia magna</i>	Colombo et al. 2008	EC50	>88.6	Measured	504	Immobilization
Water flea	<i>Daphnia magna</i>	Colombo et al. 2008	NOEC	20	Measured	504	Reproduction
Water flea	<i>Daphnia magna</i>	Colombo et al. 2008	LOEC	44.2	Measured	504	Reproduction
Water flea	<i>Daphnia magna</i>	Colombo et al. 2008	EC50	39.6	Measured	504	Reproduction
Water flea	<i>Daphnia magna</i>	Colombo et al. 2008	NOEC	44.2	Measured	504	Growth
Water flea	<i>Daphnia magna</i>	Colombo et al. 2008	LOEC	88.6	Measured	504	Growth
Water flea	<i>Daphnia magna</i>	Colombo et al. 2008	EC50	>88.6	Measured	504	Growth
Rainbow trout	<i>Oncorhynchus mykiss</i>	Colombo et al. 2008	NOEC	40	Measured	2040	Survival
Rainbow trout	<i>Oncorhynchus mykiss</i>	Colombo et al. 2008	NOEC	40	Measured	2040	Reproduction
Rainbow trout	<i>Oncorhynchus mykiss</i>	Colombo et al. 2008	NOEC	40	Measured	2040	Reproduction
Perfluoroheptanoic acid (PFHpA)							
African clawed frog	<i>Xenopus laevis</i>	Kim et al. 2015	LC50	343.0920288	NS	96	Survival
African clawed frog	<i>Xenopus laevis</i>	Kim et al. 2015	LOEC	108.2720388	NS	96	Growth
African clawed frog	<i>Xenopus laevis</i>	Kim et al. 2015	NOEC	273.0465	NS	96	Growth
African clawed frog	<i>Xenopus laevis</i>	Kim et al. 2015	LOEC	364.062	NS	96	Growth
PFHxS							
Northern leopard frog	<i>Rana pipiens</i>	Hoover et al. 2017	NOEC	1	Nominal	960	Survival

Table 1a. Freshwater Aquatic Compiled Toxicity Data

Common name	Scientific name	Source Study ^{1,2}	Endpoint	Concentration (mg/L)	Nominal / Measured	Duration (hours)	Effect
Perfluorohexanoic acid (PFHxA)							
Water flea	<i>Daphnia magna</i>	Barmentlo et al. 2015	EC50	1048	NS	48	Immobilization
Water flea	<i>Daphnia magna</i>	Barmentlo et al. 2015	EC10	737	NS	504	Reproduction
Water flea	<i>Daphnia magna</i>	Barmentlo et al. 2015	EC10	687	NS	48	Immobilization
Water flea	<i>Daphnia magna</i>	Barmentlo et al. 2015	EC50	776	NS	504	Reproduction
Water flea	<i>Daphnia magna</i>	Barmentlo et al. 2015	LOEC	770	NS	504	Reproduction
Rotifer	<i>Brachionus calyciflorus</i>	Wang et al. 2014	LC50	140	Nominal	24	Survival
African clawed frog	<i>Xenopus laevis</i>	Kim et al. 2015	LC50	478	NS	96	Survival
African clawed frog	<i>Xenopus laevis</i>	Kim et al. 2015	LOEC	129	NS	96	Growth
African clawed frog	<i>Xenopus laevis</i>	Kim et al. 2015	NOEC	314	NS	96	Growth
African clawed frog	<i>Xenopus laevis</i>	Kim et al. 2015	LOEC	471	NS	96	Growth
Rainbow Trout	<i>Oncorhynchus mykiss</i>	Burke and Scholey, 2008	NOEC	10.1	Measured	672	Growth, Survival
Perfluoro-n-pentanoic acid (PFPeA)							
Water flea	<i>Daphnia magna</i>	Hoke et al. 2012	LC50	>112	NS	48	Immobilization
Fathead Minnow	<i>Pimephales promelas</i>	Hoke et al. 2012	LC50	32	Nominal	96	Survival
Rotifer	<i>Brachionus calyciflorus</i>	Wang et al. 2014	LC50	130	Nominal	24	Survival
Perfluorobutane sulfonic acid (PFBS)							
Fathead Minnow	<i>Pimephales promelas</i>	Wildlife International Ltd., 2001b	LC50	1938	Measured	96	Survival
Bluegill	<i>Lepomis macrochirus</i>	Wildlife International Ltd., 2001c	LC50	6452	Measured	96	Survival
Water flea	<i>Daphnia magna</i>	Wildlife International Ltd., 2001f	NOEC	995	Measured	504	Survival
Water flea	<i>Daphnia magna</i>	Wildlife International Ltd., 2001f	LOEC	1876	Measured	504	Survival
Water flea	<i>Daphnia magna</i>	Wildlife International Ltd., 2001f	NOEC	995	Measured	504	Survival
Water flea	<i>Daphnia magna</i>	Wildlife International Ltd., 2001f	NOEC	502	Measured	504	Growth, Reproduction, Survival
Water flea	<i>Daphnia magna</i>	Wildlife International Ltd., 2001f	LOEC	995	Measured	504	Growth, Reproduction
Nematode	<i>Caenorhabditis elegans</i>	Chen et al. 2018	LC50	238	Nominal	48	Survival
Zebrafish	<i>Danio rerio</i>	Sant et al. 2018	LC50	393	Nominal	120	Survival
Zebrafish	<i>Danio rerio</i>	Sant et al. 2018	NOEC	25	Nominal	120	Survival
Zebrafish	<i>Danio rerio</i>	Sant et al. 2018	LOEC	248	Nominal	120	Survival
Zebrafish	<i>Danio rerio</i>	Sant et al. 2018	NOEC	25	Nominal	72	Reproduction
Zebrafish	<i>Danio rerio</i>	Sant et al. 2018	LOEC	248	Nominal	72	Reproduction
Zebrafish	<i>Danio rerio</i>	Ulhaq et al. 2013	LC50	1500	Nominal	144	Survival
Zebrafish	<i>Danio rerio</i>	Hagenaars et al. 2011	LC50	>3000	Nominal	96	Survival
Zebrafish	<i>Danio rerio</i>	Hagenaars et al. 2011	LC50	>3000	Nominal	120	Survival
African clawed frog	<i>Xenopus laevis</i>	Lou et al. 2013	NOEC	1.09	Measured	2880	Growth, Survival
Water flea	<i>Daphnia magna</i>	Wildlife International Ltd., 2001a	EC50	2183	Measured	48	Survival
PFBA							
Water flea	<i>Daphnia magna</i>	Ding et al. 2012b	EC50	182	Nominal	48	Immobilization
Cladoceran	<i>Chydorus sphaericus</i>	Ding et al. 2012b	EC50	462	Nominal	48	Immobilization
Water flea	<i>Daphnia magna</i>	Ding et al. 2012b	NOEC	178	Nominal	48	Immobilization
Cladoceran	<i>Chydorus sphaericus</i>	Ding et al. 2012b	NOEC	428	Nominal	48	Immobilization
Water flea	<i>Daphnia magna</i>	Barmentlo et al. 2015	EC50	5251	NS	48	Immobilization
Water flea	<i>Daphnia magna</i>	Barmentlo et al. 2015	EC10	3470	NS	48	Immobilization
Zebrafish	<i>Danio rerio</i>	Ulhaq et al. 2013	LC50	>3000	Nominal	144	Survival
Rotifer	<i>Brachionus calyciflorus</i>	Wang et al. 2014	LC50	110	Nominal	24	Survival
Zebrafish	<i>Danio rerio</i>	Hagenaars et al. 2011	LC50	>3000	Nominal	96	Survival
Zebrafish	<i>Danio rerio</i>	Hagenaars et al. 2011	LC50	>3000	Nominal	120	Survival
PFPrA							
Rotifer	<i>Brachionus calyciflorus</i>	Wang et al. 2014	LC50	80	Nominal	24	Survival
10:2 Fluorotelomer carboxylic acid (FTCA)							
Water flea	<i>Daphnia magna</i>	Phillips et al. 2010	LC/EC50	> 0.06	Nominal	504	Survival
Water flea	<i>Daphnia magna</i>	Phillips et al. 2010	LC/EC50	0.048	Nominal	504	Reproduction
Water flea	<i>Daphnia magna</i>	Phillips et al. 2010	NOEC	0.03	Nominal	504	Reproduction
Water flea	<i>Daphnia magna</i>	Phillips et al. 2010	EC10	0.033	Nominal	480	Reproduction
Water flea	<i>Daphnia magna</i>	Phillips et al. 2010	LC10	0.033	Nominal	480	Survival
Amphipod	<i>Hyalella azteca</i>	Mitchell et al. 2011	LC50	5.4	Measured	240	Survival
Amphipod	<i>Hyalella azteca</i>	Mitchell et al. 2011	LC10	1.1	Measured	240	Survival
Amphipod	<i>Hyalella azteca</i>	Mitchell et al. 2011	NOEC	4.8	Measured	240	Survival
Amphipod	<i>Hyalella azteca</i>	Mitchell et al. 2011	LOEC	7.1	Measured	240	Survival
Water flea	<i>Daphnia magna</i>	Phillips et al. 2007	EC50	0.03	Measured	48	Immobilization
Midge	<i>Chironomus tentans</i>	Phillips et al. 2007	EC50	>16.27	Measured	240	Growth

Table 1a. Freshwater Aquatic Compiled Toxicity Data

Common name	Scientific name	Source Study ^{1,2}	Endpoint	Concentration (mg/L)	Nominal / Measured	Duration (hours)	Effect
10:2 Fluorotelomer unsaturated carboxylic acid (FTuCA)							
Water flea	<i>Daphnia magna</i>	Phillips et al. 2010	LC/EC50	0.15	Nominal	504	Survival
Water flea	<i>Daphnia magna</i>	Phillips et al. 2010	NOEC	0.15	Nominal	504	Survival
Water flea	<i>Daphnia magna</i>	Phillips et al. 2010	LC/EC50	0.214	Nominal	504	Reproduction
Water flea	<i>Daphnia magna</i>	Phillips et al. 2010	NOEC	0.075	Nominal	504	Reproduction
Water flea	<i>Daphnia magna</i>	Phillips et al. 2010	EC10	0.117	Nominal	480	Reproduction
Amphipod	<i>Hyalella azteca</i>	Mitchell et al. 2011	LC50	3.7	Measured	240	Survival
Amphipod	<i>Hyalella azteca</i>	Mitchell et al. 2011	LC10	0.7	Measured	240	Survival
Amphipod	<i>Hyalella azteca</i>	Mitchell et al. 2011	NOEC	0.58	Measured	240	Survival
Amphipod	<i>Hyalella azteca</i>	Mitchell et al. 2011	LOEC	4.8	Measured	240	Survival
Water flea	<i>Daphnia magna</i>	Phillips et al. 2007	EC50	0.28	Measured	48	Immobilization
Midge	<i>Chironomus tentans</i>	Phillips et al. 2007	EC50	6.43	Measured	240	Growth
8:2 Fluorotelomer carboxylic acid (FTCA)							
Midge	<i>Chironomus dilutus</i>	Phillips et al. 2010	LC/EC50	2.61	Nominal	480	Survival
Midge	<i>Chironomus dilutus</i>	Phillips et al. 2010	NOEC	1.54	Nominal	480	Survival
Midge	<i>Chironomus dilutus</i>	Phillips et al. 2010	EC50	1.25	Nominal	480	Growth
Midge	<i>Chironomus dilutus</i>	Phillips et al. 2010	NOEC	0.34	Nominal	480	Growth
Midge	<i>Chironomus dilutus</i>	Phillips et al. 2010	LOEC	0.34	Nominal	1440	Reproduction
Midge	<i>Chironomus dilutus</i>	Phillips et al. 2010	EC50	0.44	Nominal	1440	Reproduction
Midge	<i>Chironomus dilutus</i>	Phillips et al. 2010	NOEC	0.08	Nominal	1440	Reproduction
Midge	<i>Chironomus dilutus</i>	Phillips et al. 2010	LC10	0.79	Nominal	480	Survival
Midge	<i>Chironomus dilutus</i>	Phillips et al. 2010	EC10	0.47	Nominal	480	Growth
Water flea	<i>Daphnia magna</i>	Hoke et al. 2012	LC50	2.3	NS	48	Immobilization
Rainbow trout	<i>Oncorhynchus mykiss</i>	Hoke et al. 2012	LC50	>100	Nominal	96	Survival
Amphipod	<i>Hyalella azteca</i>	Mitchell et al. 2011	LC50	5.1	Measured	240	Survival
Amphipod	<i>Hyalella azteca</i>	Mitchell et al. 2011	LC10	1	Measured	240	Survival
Amphipod	<i>Hyalella azteca</i>	Mitchell et al. 2011	NOEC	0.62	Measured	240	Survival
Amphipod	<i>Hyalella azteca</i>	Mitchell et al. 2011	LOEC	4.7	Measured	240	Survival
Water flea	<i>Daphnia magna</i>	Phillips et al. 2007	EC50	3.03	Measured	48	Immobilization
Midge	<i>Chironomus tentans</i>	Phillips et al. 2007	EC50	5.86	Measured	240	Growth
8:2 Fluorotelomer unsaturated carboxylic acid (FTUCA)							
Water flea	<i>Daphnia magna</i>	Hoke et al. 2012	LC50	3.2	NS	48	Immobilization
Rainbow trout	<i>Oncorhynchus mykiss</i>	Hoke et al. 2012	LC50	81	Nominal	96	Survival
Amphipod	<i>Hyalella azteca</i>	Mitchell et al. 2011	LC50	>6.1	Measured	240	Survival
Amphipod	<i>Hyalella azteca</i>	Mitchell et al. 2011	LC10	>6.1	Measured	240	Survival
Amphipod	<i>Hyalella azteca</i>	Mitchell et al. 2011	NOEC	6.1	Measured	240	Survival
Water flea	<i>Daphnia magna</i>	Phillips et al. 2007	EC50	4.01	Measured	48	Immobilization
Midge	<i>Chironomus tentans</i>	Phillips et al. 2007	EC50	16.55	Measured	240	Growth
7:3 Acid							
Water flea	<i>Daphnia magna</i>	Hoke et al. 2012	LC50	2.3	NS	48	Immobilization
Rainbow trout	<i>Oncorhynchus mykiss</i>	Hoke et al. 2012	LC50	32	Nominal	96	Survival
Water flea	<i>Daphnia magna</i>	Hoke et al. 2012	LC50	0.4	NS	48	Immobilization
6:2 Fluorotelomer carboxylic acid (FTCA)							
Zebrafish	<i>Danio rerio</i>	Shi et al. 2017b	LC50	25.1	Nominal	72	Survival
Zebrafish	<i>Danio rerio</i>	Shi et al. 2017b	LC50	7.33	Nominal	120	Survival
Water flea	<i>Daphnia magna</i>	Hoke et al. 2012	LC50	>97.5	NS	48	Immobilization
Amphipod	<i>Hyalella azteca</i>	Mitchell et al. 2011	LC50	33.1	Measured	240	Survival
Amphipod	<i>Hyalella azteca</i>	Mitchell et al. 2011	LC10	6.7	Measured	240	Survival
Amphipod	<i>Hyalella azteca</i>	Mitchell et al. 2011	NOEC	0.19	Measured	240	Survival
Amphipod	<i>Hyalella azteca</i>	Mitchell et al. 2011	LOEC	1.6	Measured	240	Survival
Water flea	<i>Daphnia magna</i>	Phillips et al. 2007	EC50	>100	Measured	48	Immobilization
Midge	<i>Chironomus tentans</i>	Phillips et al. 2007	EC50	63.11	Measured	240	Growth
6:2 Fluorotelomer unsaturated carboxylic acid (FTUCA)							
Water flea	<i>Daphnia magna</i>	Hoke et al. 2012	LC50	29.6	NS	48	Immobilization
Amphipod	<i>Hyalella azteca</i>	Mitchell et al. 2011	LC50	>26	Measured	240	Survival
Amphipod	<i>Hyalella azteca</i>	Mitchell et al. 2011	LC10	>26	Measured	240	Survival
Amphipod	<i>Hyalella azteca</i>	Mitchell et al. 2011	NOEC	26	Measured	240	Survival
Water flea	<i>Daphnia magna</i>	Phillips et al. 2007	EC50	>100	Measured	48	Immobilization
Midge	<i>Chironomus tentans</i>	Phillips et al. 2007	EC50	>100	Measured	240	Growth

Table 1a. Freshwater Aquatic Compiled Toxicity Data

Common name	Scientific name	Source Study ^{1,2}	Endpoint	Concentration (mg/L)	Nominal / Measured	Duration (hours)	Effect
6:2 FTAB							
Zebrafish	<i>Danio rerio</i>	Shi et al. 2018a	LC50	67.12	Nominal	72	Reproduction
Zebrafish	<i>Danio rerio</i>	Shi et al. 2018a	LC50	64.39	Nominal	96	Reproduction
Zebrafish	<i>Danio rerio</i>	Shi et al. 2018a	LC50	43.73	Nominal	120	Reproduction
Zebrafish	<i>Danio rerio</i>	Shi et al. 2018a	NOEC	20	Nominal	120	Survival
Zebrafish	<i>Danio rerio</i>	Shi et al. 2018a	LOEC	40	Nominal	120	Survival
5H 4:1 FTOH							
Water flea	<i>Daphnia magna</i>	Ding et al. 2012b	EC50	284	Nominal	48	Immobilization
Cladoceran	<i>Chydorus sphaericus</i>	Ding et al. 2012b	EC50	195	Nominal	48	Immobilization
Water flea	<i>Daphnia magna</i>	Ding et al. 2012b	NOEC	232	Nominal	48	Immobilization
Cladoceran	<i>Chydorus sphaericus</i>	Ding et al. 2012b	NOEC	<116.035	Nominal	48	Immobilization
5:3 Acid							
Water flea	<i>Daphnia magna</i>	Hoke et al. 2012	LC50	>103	NS	48	Immobilization
4:2 Fluorotelomer carboxylic acid (FTCA)							
Water flea	<i>Daphnia magna</i>	Phillips et al. 2007	EC50	>100	Measured	48	Immobilization
Midge	<i>Chironomus tentans</i>	Phillips et al. 2007	EC50	>100	Measured	240	Growth
4:2 Fluorotelomer unsaturated carboxylic acid (FTUCA)							
Water flea	<i>Daphnia magna</i>	Phillips et al. 2007	EC50	>100	Measured	48	Immobilization
Midge	<i>Chironomus tentans</i>	Phillips et al. 2007	EC50	>100	Measured	240	Growth
GenX Compounds							
Rainbow Trout	<i>Oncorhynchus mykiss</i>	Hoke et al. 2016	LC50	>96.9	Measured	96	Survival
Japanese medaka	<i>Orzias latipes</i>	Hoke et al. 2016	LC50	>100	Measured	96	Survival
Rare gudgeon	<i>Gobiocypris rarus</i>	Hoke et al. 2016	LC50	>150	Measured	96	Survival
Water flea	<i>Daphnia magna</i>	Hoke et al. 2016	EC50	>102	Measured	48	Immobilization
Water flea	<i>Daphnia magna</i>	Hoke et al. 2016	NOEC	>33	Measured	504	Survival
Water flea	<i>Daphnia magna</i>	Hoke et al. 2016	NOEC	>33	Measured	504	Growth
Water flea	<i>Daphnia magna</i>	Hoke et al. 2016	NOEC	8.13	Measured	504	Immobilization
Water flea	<i>Daphnia magna</i>	Hoke et al. 2016	NOEC	4.17	Measured	504	Reproduction, Survival
Rainbow Trout	<i>Oncorhynchus mykiss</i>	Hoke et al. 2016	EC50	>8.89	Measured	2160	Growth, Reproduction, Survival
Rainbow Trout	<i>Oncorhynchus mykiss</i>	Hoke et al. 2016	NOEC	8.89	Measured	2160	Growth, Reproduction, Survival
Rainbow Trout	<i>Rainbow Trout</i>	USEPA, GenX 8(e) Filings (DCN: 89110000020)	NOEC	8.89	Measured	2160	Growth, Reproduction, Survival
Water flea	<i>Daphnia magna</i>	USEPA, GenX 8(e) Filings (DCN: 89090000069s)	EC50	>33.0	Measured	504	Survival
Water flea	<i>Daphnia magna</i>	Hoke, 2008	NOEC	4.17	Measured	504	Growth, Reproduction
Water flea	<i>Daphnia magna</i>	Hoke, 2008	LOEC	8.13	Measured	504	Growth, Reproduction
Water flea	<i>Daphnia magna</i>	Hoke, 2008	EC50	>33	Measured	504	Survival
Rare gudgeon	<i>Gobiocypris rarus</i>	Lili, 2010b, range finding test	NOEC	100	Nominal	96	Survival
Rare gudgeon	<i>Gobiocypris rarus</i>	Lili, 2010b, range finding test	LC50	>100	Nominal	96	Survival
Rare gudgeon	<i>Gobiocypris rarus</i>	Lili, 2010b, limit test	NOEC	158	Measured	96	Survival
Rare gudgeon	<i>Gobiocypris rarus</i>	Lili, 2010b, limit test	LC50	>158	Measured	96	Survival
Rare gudgeon	<i>Gobiocypris rarus</i>	Lili, 2010a, range finding test	NOEC	100	Nominal	96	Survival
Rare gudgeon	<i>Gobiocypris rarus</i>	Lili, 2010a, range finding test	LC50	>100	Nominal	96	Survival
Rare gudgeon	<i>Gobiocypris rarus</i>	Lili, 2010a, limit test	NOEC	145	Measured	96	Survival
Rare gudgeon	<i>Gobiocypris rarus</i>	Lili, 2010a, limit test	LC50	>145	Measured	96	Survival
Rainbow Trout	<i>Oncorhynchus mykiss</i>	Ferrell et al. 2008a	LC50	>96.9	Measured	96	Survival
Rainbow Trout	<i>Oncorhynchus mykiss</i>	Ferrell et al. 2008a	NOEC	96.9	Measured	96	Survival
Water flea	<i>Daphnia magna</i>	Ferrell et al. 2008b	LC50	>102	Measured	48	Immobilization
Water flea	<i>Daphnia magna</i>	Ferrell et al. 2008b	NOEC	102	Measured	48	Immobilization
FC807							
Zebrafish	<i>Danio rerio</i>	Zheng et al. 2012	LC50	211	Nominal	72	Survival
6:2 Fluorotelomer sulfonate (FTS)							
Rainbow Trout	<i>Oncorhynchus mykiss</i>	Hoke et al. 2015	LC50	>107	Measured	96	Survival
Rainbow Trout	<i>Oncorhynchus mykiss</i>	Hoke et al. 2015	NOEC	107	Measured	96	Survival
Rainbow Trout	<i>Oncorhynchus mykiss</i>	Hoke et al. 2015	LC50	>108	Measured	96	Survival
Rainbow Trout	<i>Oncorhynchus mykiss</i>	Hoke et al. 2015	NOEC	108	Measured	96	Survival
Water flea	<i>Daphnia magna</i>	Hoke et al. 2015	EC50	>109	Measured	48	Immobilization
Water flea	<i>Daphnia magna</i>	Hoke et al. 2015	EC50	>112	Measured	48	Immobilization
Water flea	<i>Daphnia magna</i>	Hoke et al. 2015	NOEC	112	Measured	48	Immobilization
Northern leopard frog	<i>Rana pipiens</i>	Hoover et al. 2017	NOEC	1	Nominal	960	Survival

Table 1a. Freshwater Aquatic Compiled Toxicity Data

Common name	Scientific name	Source Study ^{1,2}	Endpoint	Concentration (mg/L)	Nominal / Measured	Duration (hours)	Effect
TFAA							
Zebrafish	<i>Danio rerio</i>	Ulhaq et al. 2013	LC50	>3000	Nominal	144	Survival
Rotifer	<i>Brachionus calyciflorus</i>	Wang et al. 2014	LC50	70	Nominal	24	Survival
6:2 Chlorinated polyfluoroalkyl ether sulfonic acid (CI-PFESA)							
Zebrafish	<i>Danio rerio</i>	Shi et al. 2017a	LC50	13.77	Nominal	96	Survival
Zebrafish	<i>Danio rerio</i>	Wang et al. 2013b	LC0 (NOEC)	5	Nominal	96	Survival
Zebrafish	<i>Danio rerio</i>	Wang et al. 2013b	LC50	18.4	NS	72	Survival
Zebrafish	<i>Danio rerio</i>	Wang et al. 2013b	LC50	15.5	NS	96	Survival
Zebrafish	<i>Danio rerio</i>	Shi et al. 2018b	LOEC	5	Nominal	4320	Survival

Table 1a. Freshwater Aquatic Compiled Toxicity Data

Notes

1. Only endpoints, effects, and durations that would be used in GLI calculations were comprehensively compiled during the literature review.
2. The following paper was reviewed as cited in Giesy et al. 2010 and the primary study was not available for review:
Palmer, S. J., Van Hoven, R. L., & Krueger, H. O. 2002a. Perfluorooctanesulfonate, potassium salt (PFOS): A 96-hr static acute toxicity test with the rainbow trout (*Oncorhynchus mykiss*). Wildlife International, Ltd., Project. No.

The NOECs reported in Boudreau et al. 2003 are based on IC10s.

All salts are presented together with their respective PFAS, e.g. PFOS potassium salt and PFOS ammonium salt would be presented together under "Perfluorooctanesulfonic Acid (PFOS)". The Hoke et al. 2015 paper tested both K-6:2 FTS and 6:2 FTSA; they are presented together under 6:2 FTS

Concentrations reported in millimoles per liter (mM) were converted to mg/L with the following equation:

$$\text{Concentration (mM)} \times \text{PFAS molecular weight (g/mol)} = \text{Concentration (mg/L)}$$

dpf - days post fertilization

EC10 - effect concentration affecting 10 percent of the population

EC50 - effect concentration affecting 50 percent of the population

EL50 - effect level affecting 50 percent of the population

F0 - parental generation

F1 - offspring of the F0 generation

IC50 - 50 percent inhibition concentration

LC0 - lethal concentration to 0 percent of the population (equivalent to NOEC)

LC10 - lethal concentration to 10 percent of the population

LC50 - lethal concentration to 50 percent of the population

LL50 - lethal loading to 50 percent of the population

mg/L - milligram per liter

LOAEL - lowest-observed adverse effect level

LOEC - lowest-observed effect concentration

NOAEL - no-observed adverse effect level

NOEC - no-observed effect concentration

NOEL - no-observed effect level

NS - not stated

> - greater than

< - less than

Equations

Concentrations reported in moles are converted to mg/L using the following equation:

$$\text{PFAS (g/mol)} \times \text{Concentration (mM)} = \text{Concentration (g/mol)}$$

Table 1b. Marine Aquatic Compiled Toxicity Data

Common name	Scientific name	Source Study ^{1,2}	Endpoint	Concentration (mg/L)	Nominal / Measured	Duration (hours)	Effect
Perfluorooctanesulfonic acid (PFOS)							
Opossum shrimp	<i>Mysidopsis bahia</i>	Drottar and Krueger, 2000c	EC50/LC50/IC50	3.6	Measured	96	Survival
Opossum shrimp	<i>Mysidopsis bahia</i>	Drottar and Krueger, 2000f	NOEC	0.55	Measured	96	Survival
Eastern oyster	<i>Crassostrea virginica</i>	Drottar and Krueger, 2000d	EC50	>3.0	Measured	96	Growth
Eastern oyster	<i>Crassostrea virginica</i>	Drottar and Krueger, 2000d	NOEC	1.9	Measured	96	Growth
Eastern oyster	<i>Crassostrea virginica</i>	Drottar and Krueger, 2000d	LOEC	3	Measured	96	Growth
Sheepshead minnow	<i>Cyprinodon variegatus</i>	Palmer at al. 2002b	NOEC	<15	NA	96	Survival
Sheepshead minnow	<i>Cyprinodon variegatus</i>	Palmer at al. 2002b	EC50/LC50/IC50	>15	NA	96	Survival
Diatom	<i>Skeletonema costatum</i>	Desjardins et al. 2001b	NOEC	>3.2	Measured	96	Growth
Diatom	<i>Skeletonema costatum</i>	Desjardins et al. 2001b	EC50/LC50/IC50	>3.2	Measured	96	Growth
Opossum shrimp	<i>Mysidopsis bahia</i>	Drottar and Krueger, 2000f	NOEC	0.25	Measured	840	Growth, Reproduction
Alga	<i>Isochrysis galbana</i>	Mhadhbi et al. 2012	EC50	37.5	Nominal	72	Growth
Purple sea urchin	<i>Paracentrotus lividus</i>	Mhadhbi et al. 2012	EC50	20	Nominal	48	Growth
Mysid	<i>Siriella armata</i>	Mhadhbi et al. 2012	EC50	6.9	Nominal	96	Survival
Turbot	<i>Psetta maxima</i>	Mhadhbi et al. 2012	EC50	0.11	Nominal	144	Survival
Alga	<i>Isochrysis galbana</i>	Mhadhbi et al. 2012	NOEC	7.5	Nominal	72	Growth
Alga	<i>Isochrysis galbana</i>	Mhadhbi et al. 2012	LOEC	15	Nominal	72	Growth
Purple sea urchin	<i>Paracentrotus lividus</i>	Mhadhbi et al. 2012	NOEC	1	Nominal	48	Growth
Purple sea urchin	<i>Paracentrotus lividus</i>	Mhadhbi et al. 2012	LOEC	2	Nominal	48	Growth
Mysid	<i>Siriella armata</i>	Mhadhbi et al. 2012	NOEC	1.3	Nominal	96	Survival
Mysid	<i>Siriella armata</i>	Mhadhbi et al. 2012	LOEC	2.5	Nominal	96	Survival
Turbot	<i>Psetta maxima</i>	Mhadhbi et al. 2012	NOEC	0.015	Nominal	144	Survival
Turbot	<i>Psetta maxima</i>	Mhadhbi et al. 2012	LOEC	0.03	Nominal	144	Survival
Sheepshead minnow	<i>Cyprinodon variegatus</i>	OECD, 2002 (3M 2000, Reference 43)	LC50	>15	NA	96	Survival
Marine medaka	<i>Oryzia melastigma</i>	Wu et al. 2012	NOEC	1	Nominal	144	Survival
Marine medaka	<i>Oryzia melastigma</i>	Wu et al. 2012	LOEC	4	Nominal	144	Survival
Marine medaka	<i>Oryzias melastigma</i>	Fang et al. 2013	LOEC	1	NS	240	Survival
Atlantic salmon	<i>Salmo salar</i>	Spachmo and Arukwe, 2012	NOEC	0.1	Nominal	1176	Growth
Sea urchin	<i>Psammechinus miliaris</i>	Anselmo et al. 2011	NOEC	0.4	Nominal	384	Reproduction
Thicklip grey mullet	<i>Chelon labrosus</i>	Bilbao et al. 2010	NOEC	0.45	Measured	384	Survival
Opossum shrimp	<i>Mysidopsis bahia</i>	Drottar and Krueger, 2000f	LOEC	0.55	Measured	840	Growth, Reproduction
Perfluorooctanoic acid (PFOA)							
Alga	<i>Isochrysis galbana</i>	Mhadhbi et al. 2012	EC50	163.6	Nominal	72	Growth
Purple sea urchin	<i>Paracentrotus lividus</i>	Mhadhbi et al. 2012	EC50	110	Nominal	48	Growth
Mysid	<i>Siriella armata</i>	Mhadhbi et al. 2012	EC50	15.4	Nominal	96	Survival
Turbot	<i>Psetta maxima</i>	Mhadhbi et al. 2012	EC50	11.9	Nominal	144	Survival
Alga	<i>Isochrysis galbana</i>	Mhadhbi et al. 2012	NOEC	25	Nominal	72	Growth
Alga	<i>Isochrysis galbana</i>	Mhadhbi et al. 2012	LOEC	50	Nominal	72	Growth
Purple sea urchin	<i>Paracentrotus lividus</i>	Mhadhbi et al. 2012	NOEC	10	Nominal	48	Growth
Purple sea urchin	<i>Paracentrotus lividus</i>	Mhadhbi et al. 2012	LOEC	20	Nominal	48	Growth
Mysid	<i>Siriella armata</i>	Mhadhbi et al. 2012	NOEC	5	Nominal	96	Survival
Mysid	<i>Siriella armata</i>	Mhadhbi et al. 2012	LOEC	10	Nominal	96	Survival
Turbot	<i>Psetta maxima</i>	Mhadhbi et al. 2012	NOEC	1.5	Nominal	144	Survival

Table 1b. Marine Aquatic Compiled Toxicity Data

Common name	Scientific name	Source Study^{1,2}	Endpoint	Concentration (mg/L)	Nominal / Measured	Duration (hours)	Effect
Turbot	<i>Psetta maxima</i>	Mhadhbi et al. 2012	LOEC	3	Nominal	144	Survival
Atlantic salmon	<i>Salmo salar</i>	Spachmo and Arukwe, 2012	NOEC	0.1	Nominal	1176	Growth
Perfluorobutane sulfonic acid (PFBS)							
Opossum shrimp	<i>Mysidopsis bahia</i>	Wildlife International Ltd., 2001e	LC50	372	Measured	96	Survival
Opossum shrimp	<i>Mysidopsis bahia</i>	Wildlife International Ltd., 2001e	NOEC	127	Measured	96	Survival

Table 1b. Marine Aquatic Compiled Toxicity Data

Notes

1. Only endpoints, effects, and durations that would be used in GLI calculations were comprehensively compiled during the literature review.
2. The following papers were reviewed as cited in Giesy et al. 2010 or OECD 2002 and the primary studies were not available for review:
Palmer, S. J., Van Hoven, R. L., & Krueger, H. O. 2002b. Perfluorooctanesulfonate, potassium salt (PFOS): A 96-hr static renewal acute toxicity test with the sheepshead minnow (*Cyprinodon variegatus*). Wildlife International, Ltd., Project No.
OECD. 2002. Robust Study Report Reference No. 43 - Perfluorooctanesulfonate, Potassium salt (PFOS): 96-Hour Semi-Static Acute Toxicity Test with the Sheepshead Minnow (*Cyprinodon variegatus*) in saltwater.

All salts are presented together with their respective PFAS, e.g. PFOS potassium salt and PFOS ammonium salt would be presented together under "Perfluorooctanesulfonic Acid (PFOS)".

Concentrations reported in millimoles per liter (mM) were converted to mg/L with the following equation:
 $\text{Concentration (mM)} \times \text{PFAS molecular weight (g/mol)} = \text{Concentration (mg/L)}$

EC50 - effect concentration affecting 50 percent of the population

IC50 - 50 percent inhibition concentration

LC50 - lethal concentration to 50 percent of the population

LOEC - lowest-observed effect concentration

mg/L - milligram per liter

NOEC - no-observed effect concentration

NS - not stated

> - greater than

< - less than

Table 1c. Aquatic Plant Compiled Toxicity Data

Common name	Scientific name	Source Study ¹	Endpoint	Concentration (mg/L)	Nominal / Measured	Duration (hours)	Effect
Perfluorotetradecanoic acid (PFTeA)							
Green alga	<i>Scenedesmus obliquus</i>	Liu et al. 2008	IC10	29	NS	72	Growth
Green alga	<i>Scenedesmus obliquus</i>	Liu et al. 2008	IC50	96	NS	72	Growth
Perfluorododecanoic acid (PFDoA)							
Green alga	<i>Scenedesmus obliquus</i>	Liu et al. 2008	IC10	55	NS	72	Growth
Green alga	<i>Scenedesmus obliquus</i>	Liu et al. 2008	IC50	112	NS	72	Growth
Perfluorodecanoic acid (PFDA)							
Green alga	<i>Pseudokirchneriella subcapitata</i>	Hoke et al. 2012	ECb50	10.6	NS	72	Growth
Perfluorononanoic acid (PFNA)							
Green alga	<i>Chlorella vulgaris</i>	Latala et al. 2009	EC50	497	Nominal	72	Growth
Diatom	<i>Skeletonema marinoi</i>	Latala et al. 2009	EC50	195	Nominal	72	Growth
Blue-green alga	<i>Geitlerinema amphibium</i>	Latala et al. 2009	EC50	130	Nominal	72	Growth
Perfluorooctanesulfonic acid (PFOS)							
Duckweed	<i>Lemna gibba</i>	Desjardins et al. 2001c	IC50	108	Measured	168	Growth
Duckweed	<i>Lemna gibba</i>	Desjardins et al. 2001c	NOEC	15.1	Measured	168	Growth
Duckweed	<i>Lemna gibba</i>	Desjardins et al. 2001c	LOEC	31.9	Measured	168	Growth
Duckweed	<i>Lemna gibba</i>	Boudreau et al. 2003	NOEC	10	Nominal	168	Growth
Duckweed	<i>Lemna gibba</i>	Boudreau et al. 2003	LOEC	20	Nominal	168	Growth
Duckweed	<i>Lemna gibba</i>	Boudreau et al. 2003	IC10	6.6	Nominal	168	Growth
Duckweed	<i>Lemna gibba</i>	Boudreau et al. 2003	IC50	31.1	Nominal	168	Growth
Green alga	<i>Selenastrum capricornutum</i>	Boudreau et al. 2003	NOEC	25	Nominal	96	Growth
Green alga	<i>Selenastrum capricornutum</i>	Boudreau et al. 2003	LOEC	50	Nominal	96	Growth
Green alga	<i>Selenastrum capricornutum</i>	Boudreau et al. 2003	IC10	5.3	Nominal	96	Growth
Green alga	<i>Selenastrum capricornutum</i>	Boudreau et al. 2003	IC50	48.2	Nominal	96	Growth
Green alga	<i>Chlorella vulgaris</i>	Boudreau et al. 2003	NOEC	25	Nominal	96	Growth
Green alga	<i>Chlorella vulgaris</i>	Boudreau et al. 2003	LOEC	50	Nominal	96	Growth
Green alga	<i>Chlorella vulgaris</i>	Boudreau et al. 2003	IC10	8.2	Nominal	96	Growth
Green alga	<i>Chlorella vulgaris</i>	Boudreau et al. 2003	IC50	81.6	Nominal	96	Growth
Cyanobacteria	<i>Anabaena flosaquae</i>	Desjardins et al. 2001a	NOAEC	37.9	Measured	72	Growth
Cyanobacteria	<i>Anabaena flosaquae</i>	Desjardins et al. 2001a	LOAEC	63.9	Measured	72	Growth
Cyanobacteria	<i>Anabaena flosaquae</i>	Desjardins et al. 2001a	EC10	42.6	Measured	72	Growth
Cyanobacteria	<i>Anabaena flosaquae</i>	Desjardins et al. 2001a	EC50	120	Measured	72	Growth
Cyanobacteria	<i>Anabaena flosaquae</i>	Desjardins et al. 2001a	NOAEC	93.8	Measured	96	Growth
Cyanobacteria	<i>Anabaena flosaquae</i>	Desjardins et al. 2001a	LOAEC	143	Measured	96	Growth
Cyanobacteria	<i>Anabaena flosaquae</i>	Desjardins et al. 2001a	EC10	82.3	Measured	96	Growth
Cyanobacteria	<i>Anabaena flosaquae</i>	Desjardins et al. 2001a	EC50	131	Measured	96	Growth
Green alga	<i>Scenedesmus obliquus</i>	Liu et al. 2008	IC10	51	NS	72	Growth
Green alga	<i>Scenedesmus obliquus</i>	Liu et al. 2008	IC50	78	NS	72	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Rosal et al. 2010	EC50	35	Nominal	NA	Growth
Green alga	<i>Selenastrum capricornutum</i>	Drott and Krueger, 2000h	EC10	47	Measured	96	Growth
Green alga	<i>Selenastrum capricornutum</i>	Drott and Krueger, 2000h	EC50	68	Measured	96	Growth
Green alga	<i>Selenastrum capricornutum</i>	Drott and Krueger, 2000h	NOEC	42	Measured	96	Growth
Green alga	<i>Selenastrum capricornutum</i>	Drott and Krueger, 2000h	LOEC	82.5858	Measured	96	growth

Table 1c. Aquatic Plant Compiled Toxicity Data

Common name	Scientific name	Source Study ¹	Endpoint	Concentration (mg/L)	Nominal / Measured	Duration (hours)	Effect
Green alga	<i>Selenastrum capricornutum</i>	Drottar and Krueger, 2000h	EC50	67	Measured	72	Growth
Green alga	<i>Selenastrum capricornutum</i>	Drottar and Krueger, 2000h	NOEC	42	Measured	72	Growth
Green alga	<i>Selenastrum capricornutum</i>	Drottar and Krueger, 2000h	LOEC	82.5858	Measured	72	growth
Diatom	<i>Navicula pelliculosa</i>	Sutherland and Krueger, 2001	EC10	<62.3	Measured	96	growth
Diatom	<i>Navicula pelliculosa</i>	Sutherland and Krueger, 2001	EC50	242	Measured	72	growth
Diatom	<i>Navicula pelliculosa</i>	Sutherland and Krueger, 2001	EC50	263	Measured	96	growth
Diatom	<i>Navicula pelliculosa</i>	Sutherland and Krueger, 2001	NOEC	<62.3	Measured	72	growth
Diatom	<i>Navicula pelliculosa</i>	Sutherland and Krueger, 2001	NOEC	150	Measured	96	growth
Diatom	<i>Navicula pelliculosa</i>	Sutherland and Krueger, 2001	LOEC	206	Measured	96	growth
Green Algae (Four-tail scenedesmus)	<i>Scenedesmus quadricauda</i>	Yang et al. 2014	EC50	89.34	Measured	96	Growth
Perfluorooctanoic acid (PFOA)							
Green alga	<i>Chlorella vulgaris</i>	Latala et al. 2009	EC50	977	Nominal	72	Growth
Diatom	<i>Skeletonema marinoi</i>	Latala et al. 2009	EC50	369	Nominal	72	Growth
Blue-green alga	<i>Geitlerinema amphibium</i>	Latala et al. 2009	EC50	248	Nominal	72	Growth
Green alga	<i>Scenedesmus obliquus</i>	Liu et al. 2008	NOEC	828	NS	72	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Gonzalez et al. 2014	EC10	19.72	Nominal	72	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Gonzalez et al. 2014	EC20	35.47	Nominal	72	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Gonzalez et al. 2014	EC50	96.75	Nominal	72	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Rosal et al. 2010	EC50	96.2	Nominal	NA	Growth
Green Algae (Four-tail scenedesmus)	<i>Scenedesmus quadricauda</i>	Yang et al. 2014	EC50	269.63	Measured	96	Growth
Green alga	<i>Selenastrum capricornutum</i>	3M, 1981 (AR226-0506)	EC50	149	Nominal	96	Growth
Green alga	<i>Selenastrum capricornutum</i>	3M, 1981 (AR226-0506)	EC50	70	Nominal	168	Growth
Green alga	<i>Selenastrum capricornutum</i>	3M, 1981 (AR226-0506)	EC50	49	Nominal	240	Growth
Green alga	<i>Selenastrum capricornutum</i>	3M, 1981 (AR226-0506)	EC50	73	Nominal	336	Growth
Green alga	<i>Selenastrum capricornutum</i>	3M, 1981 (AR226-0506)	EC50	49	Nominal	96	Growth
Green alga	<i>Selenastrum capricornutum</i>	3M, 1981 (AR226-0506)	EC50	30	Nominal	168	Growth
Green alga	<i>Selenastrum capricornutum</i>	3M, 1981 (AR226-0506)	EC50	27	Nominal	240	Growth
Green alga	<i>Selenastrum capricornutum</i>	3M, 1981 (AR226-0506)	EC50	43	Nominal	336	Growth
Green alga	<i>Selenastrum capricornutum</i>	3M, 1981 (AR226-0506)	EC10	5.3	Nominal	96	Growth
Green alga	<i>Selenastrum capricornutum</i>	3M, 1981 (AR226-0506)	EC10	3.3	Nominal	168	Growth
Green alga	<i>Selenastrum capricornutum</i>	3M, 1981 (AR226-0506)	EC10	2.9	Nominal	240	Growth
Green alga	<i>Selenastrum capricornutum</i>	3M, 1981 (AR226-0506)	EC10	5	Nominal	336	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Colombo et al. 2008	EbC50	>100	Nominal	72	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Colombo et al. 2008	EbC50	>100	Nominal	96	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Colombo et al. 2008	NOEC	180.67	Nominal	72	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Colombo et al. 2008	NOEC	11.37	Nominal	96	Growth
Perfluoroheptanoic acid (PFHpA)							
Green alga	<i>Chlorella vulgaris</i>	Latala et al. 2009	EC50	1897	Nominal	72	Growth
Diatom	<i>Skeletonema marinoi</i>	Latala et al. 2009	EC50	874	Nominal	72	Growth
Blue-green alga	<i>Geitlerinema amphibium</i>	Latala et al. 2009	EC50	517	Nominal	72	Growth

Table 1c. Aquatic Plant Compiled Toxicity Data

Common name	Scientific name	Source Study ¹	Endpoint	Concentration (mg/L)	Nominal / Measured	Duration (hours)	Effect
Perfluorohexanoic acid (PFHxA)							
Green alga	<i>Chlorella vulgaris</i>	Latala et al. 2009	EC50	4032	Nominal	72	Growth
Diatom	<i>Skeletonema marinoi</i>	Latala et al. 2009	EC50	1482	Nominal	72	Growth
Blue-green alga	<i>Geitlerinema amphibium</i>	Latala et al. 2009	EC50	999	Nominal	72	Growth
Green alga	<i>Scenedesmus obliquus</i>	Liu et al. 2008	NOEC	628	NS	72	Growth
Perfluoro-n-pentanoic acid (PFPeA)							
Green alga	<i>Pseudokirchneriella subcapitata</i>	Hoke et al. 2012	ECb50	81.7	NS	72	Growth
Perfluorobutane sulfonic acid (PFBS)							
Green alga	<i>Scenedesmus obliquus</i>	Liu et al. 2008	NOEC	600	NS	72	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Rosal et al. 2010	EC50	>20250	Nominal	NA	Growth
Green alga	<i>Selenastrum capricornutum</i>	Wildlife International Ltd., 2001d	EC50	1469	Measured	72	Growth
Green alga	<i>Selenastrum capricornutum</i>	Wildlife International Ltd., 2001d	EC10	528	Measured	96	Growth
Green alga	<i>Selenastrum capricornutum</i>	Wildlife International Ltd., 2001d	EC50	2347	Measured	96	Growth
Green alga	<i>Selenastrum capricornutum</i>	Wildlife International Ltd., 2001d	EC90	7390	Measured	96	Growth
Green alga	<i>Selenastrum capricornutum</i>	Wildlife International Ltd., 2001d	NOAEC	< 285	Measured	72	Growth
Green alga	<i>Selenastrum capricornutum</i>	Wildlife International Ltd., 2001d	LOAEC	285	Measured	72	Growth
Green alga	<i>Selenastrum capricornutum</i>	Wildlife International Ltd., 2001d	NOAEC	1077	Measured	96	Growth
Green alga	<i>Selenastrum capricornutum</i>	Wildlife International Ltd., 2001d	LOAEC	2216	Measured	96	Growth
10:2 Fluorotelomer carboxylic acid (FTCA)							
Green alga	<i>Chlorella vulgaris</i>	Mitchell et al. 2011	EC50	4.2	Measured	96	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Mitchell et al. 2011	EC50	>5.9	Measured	96	Growth
Green alga	<i>Chlorella vulgaris</i>	Mitchell et al. 2011	EC10	0.8	Measured	96	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Mitchell et al. 2011	EC10	4	Measured	96	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Mitchell et al. 2011	NOEC	0.29	Measured	96	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Mitchell et al. 2011	LOEC	4.8	Measured	96	Growth
Green alga	<i>Chlorella vulgaris</i>	Mitchell et al. 2011	NOEC	0.02	Measured	96	Growth
Green alga	<i>Chlorella vulgaris</i>	Mitchell et al. 2011	LOEC	0.05	Measured	96	Growth
Duckweed	<i>Lemna gibba</i>	Phillips et al. 2007	EC50	4.3	Measured	168	Growth
10:2 Fluorotelomer unsaturated carboxylic acid (FTuCA)							
Green alga	<i>Chlorella vulgaris</i>	Mitchell et al. 2011	EC50	3.9	Measured	96	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Mitchell et al. 2011	EC50	>2.0	Measured	96	Growth
Green alga	<i>Chlorella vulgaris</i>	Mitchell et al. 2011	EC10	0.7	Measured	96	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Mitchell et al. 2011	EC10	>2.0	Measured	96	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Mitchell et al. 2011	NOEC	1.6	Measured	96	Growth
Green alga	<i>Chlorella vulgaris</i>	Mitchell et al. 2011	LOEC	0.02	Measured	96	Growth
Duckweed	<i>Lemna gibba</i>	Phillips et al. 2007	EC50	4.84	Measured	168	Growth
8:2 Fluorotelomer carboxylic acid (FTCA)							
Green alga	<i>Pseudokirchneriella subcapitata</i>	Hoke et al. 2012	ECb50	5	NS	72	Growth
Green alga	<i>Chlorella vulgaris</i>	Mitchell et al. 2011	EC50	5.9	Measured	96	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Mitchell et al. 2011	EC50	>9.8	Measured	96	Growth
Green alga	<i>Chlorella vulgaris</i>	Mitchell et al. 2011	EC10	1.9	Measured	96	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Mitchell et al. 2011	EC10	2.9	Measured	96	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Mitchell et al. 2011	NOEC	9.8	Measured	96	Growth

Table 1c. Aquatic Plant Compiled Toxicity Data

Common name	Scientific name	Source Study ¹	Endpoint	Concentration (mg/L)	Nominal / Measured	Duration (hours)	Effect
Green alga	<i>Chlorella vulgaris</i>	Mitchell et al. 2011	LOEC	0.01	Measured	96	Growth
Duckweed	<i>Lemna gibba</i>	Phillips et al. 2007	EC50	1.36	Measured	168	Growth
8:2 Fluorotelomer unsaturated carboxylic acid (FTUCA)							
Green alga	<i>Pseudokirchneriella subcapitata</i>	Hoke et al. 2012	ECb50	7.5	NS	72	Growth
Green alga	<i>Chlorella vulgaris</i>	Mitchell et al. 2011	EC50	>3.8	Measured	96	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Mitchell et al. 2011	EC50	>3.9	Measured	96	Growth
Green alga	<i>Chlorella vulgaris</i>	Mitchell et al. 2011	EC10	2.2	Measured	96	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Mitchell et al. 2011	EC10	2.3	Measured	96	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Mitchell et al. 2011	NOEC	3.9	Measured	96	Growth
Green alga	<i>Chlorella vulgaris</i>	Mitchell et al. 2011	LOEC	0.01	Measured	96	Growth
Duckweed	<i>Lemna gibba</i>	Phillips et al. 2007	EC50	0.71	Measured	168	Growth
7:3 Acid							
Green alga	<i>Pseudokirchneriella subcapitata</i>	Hoke et al. 2012	ECb50	2.1	NS	72	Growth
6:2 Fluorotelomer carboxylic acid (FTCA)							
Green alga	<i>Pseudokirchneriella subcapitata</i>	Hoke et al. 2012	ECb50	47.9	NS	72	Growth
Green alga	<i>Chlorella vulgaris</i>	Mitchell et al. 2011	EC50	26.2	Measured	96	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Mitchell et al. 2011	EC50	>53	Measured	96	Growth
Green alga	<i>Chlorella vulgaris</i>	Mitchell et al. 2011	EC10	5.2	Measured	96	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Mitchell et al. 2011	EC10	23.7	Measured	96	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Mitchell et al. 2011	NOEC	53	Measured	96	Growth
Green alga	<i>Chlorella vulgaris</i>	Mitchell et al. 2011	LOEC	0.01	Measured	96	Growth
Duckweed	<i>Lemna gibba</i>	Phillips et al. 2007	EC50	1.29	Measured	168	Growth
6:2 Fluorotelomer unsaturated carboxylic acid (FTUCA)							
Green alga	<i>Pseudokirchneriella subcapitata</i>	Hoke et al. 2012	ECb50	28.5	NS	72	Growth
Green alga	<i>Chlorella vulgaris</i>	Mitchell et al. 2011	EC50	31.8	Measured	96	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Mitchell et al. 2011	EC50	>37	Measured	96	Growth
Green alga	<i>Chlorella vulgaris</i>	Mitchell et al. 2011	EC10	6.4	Measured	96	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Mitchell et al. 2011	EC10	8.3	Measured	96	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Mitchell et al. 2011	NOEC	0.13	Measured	96	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Mitchell et al. 2011	LOEC	1.3	Measured	96	Growth
Green alga	<i>Chlorella vulgaris</i>	Mitchell et al. 2011	LOEC	0.01	Measured	96	Growth
Duckweed	<i>Lemna gibba</i>	Phillips et al. 2007	EC50	10.04	Measured	168	Growth
5:3 Acid							
Green alga	<i>Pseudokirchneriella subcapitata</i>	Hoke et al. 2012	ECb50	22.5	NS	72	Growth
4:2 Fluorotelomer carboxylic acid (FTCA)							
Duckweed	<i>Lemna gibba</i>	Phillips et al. 2007	EC50	9.39	Measured	168	Growth
4:2 Fluorotelomer unsaturated carboxylic acid (FTUCA)							
Duckweed	<i>Lemna gibba</i>	Phillips et al. 2007	EC50	6.64	Measured	168	Growth
GenX Compounds							
Green alga	<i>Pseudokirchneriella subcapitata</i>	Hoke et al. 2016	EC50	>107	Measured	72	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Hoke et al. 2016	NOEC	>107	Measured	72	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Sloman, 2008	NOEC	106	Measured	72	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Sloman, 2008	LOEC	>106	Measured	72	Growth

Table 1c. Aquatic Plant Compiled Toxicity Data

Common name	Scientific name	Source Study ¹	Endpoint	Concentration (mg/L)	Nominal / Measured	Duration (hours)	Effect
Green alga	<i>Pseudokirchneriella subcapitata</i>	Sloman, 2008	EC50	>106	Measured	72	Growth
6:2 Fluorotelomer sulfonate (FTS)							
Green alga	<i>Pseudokirchneriella subcapitata</i>	Hoke et al. 2015	EbC50	>96	Measured	72	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Hoke et al. 2015	NOEC	96	Measured	72	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Hoke et al. 2015	EbC50	>125	Measured	72	Growth
Green alga	<i>Pseudokirchneriella subcapitata</i>	Hoke et al. 2015	NOEC	125	Measured	72	Growth
6:2 Chlorinated polyfluoroalkyl ether sulfonic acid (CI-PFESA)							
Green alga	<i>Scenedesmus obliquus</i>	Liu et al. 2018	NOEC	5.42	Measured	72	Growth
Green alga	<i>Scenedesmus obliquus</i>	Liu et al. 2018	LOEC	11.6	Measured	72	Growth
Green alga	<i>Scenedesmus obliquus</i>	Liu et al. 2018	IC10	24.1	Measured	72	Growth
Green alga	<i>Scenedesmus obliquus</i>	Liu et al. 2018	IC50	40.3	Measured	72	Growth

Table 1c. Aquatic Plant Compiled Toxicity Data

Notes

1. Only endpoints, effects, and durations that would be used in GLI calculations were comprehensively compiled during the literature review.

All salts are presented together with their respective PFAS, e.g. PFOS potassium salt and PFOS ammonium salt would be presented together under "Perfluorooctanesulfonic Acid (PFOS)". The Hoke et al. 2015 paper tested both K-6:2 FTS and 6:2 FTSA; they are presented together under 6:2 FTS.

Concentrations reported in millimoles per liter (mM) were converted to mg/L with the following equation:

$$\text{Concentration (mM)} \times \text{PFAS molecular weight (g/mol)} = \text{Concentration (mg/L)}$$

EC10 - effect concentration affecting 10 percent of the population

EC20 - effect concentration affecting 20 percent of the population

EC50 - effect concentration affecting 50 percent of the population

EC90 - effect concentration affecting 90 percent of the population

ECb50 or EbC50 - 50 percent reduction in biomass growth

IC10 - 10 percent inhibition concentration

IC50 - 50 percent inhibition concentration

LC50 - lethal concentration to 50 percent of the population

LOEC - lowest-observed effect concentration

mg/L - milligram per liter

NA - not available

NOAEC - no-observed adverse effect concentration

NOEC - no-observed effect concentration

NS - not stated

> - greater than

< - less than

Table 2a. Terrestrial Plant Compiled Toxicity Data

Common Name	Source Study	Endpoint ¹	Unbounded or Bounded value?	Concentration (mg/kg)	Duration (hours)	Effect
Perfluorodecanoic Acid (PFDA)						
Lettuce	Ding et al. 2012a	NOEC	NA	51	120	Growth
Perfluorononanoic Acid (PFNA)						
Lettuce	Ding et al. 2012a	NOEC	NA	46	120	Growth
Perfluorooctanesulfonic Acid (PFOS)						
Tomato	Brignole et al. 2003	LOEC	Bounded	33.5	504	Survival, Growth
Alfalfa	Brignole et al. 2003	LOEC	Bounded	216.5	504	Survival, Growth
Flax	Brignole et al. 2003	LOEC	Bounded	216.5	504	Survival, Growth
Tomato	Brignole et al. 2003	NOEC	Bounded	7.33	504	Survival, Growth
Alfalfa	Brignole et al. 2003	NOEC	Bounded	33.5	504	Survival, Growth
Flax	Brignole et al. 2003	NOEC	Bounded	33.5	504	Survival, Growth
Lettuce	Brignole et al. 2003	LOEC	Unbounded	2.45	504	Growth
Ryegrass	Brignole et al. 2003	LOEC	Bounded	7.33	504	Growth
Soybean	Brignole et al. 2003	LOEC	Bounded	216.5	504	Growth
Ryegrass	Brignole et al. 2003	NOEC	Bounded	2.45	504	Growth
Soybean	Brignole et al. 2003	NOEC	Bounded	33.5	504	Growth
Onion	Brignole et al. 2003	LOEC	Bounded	7.33	504	Growth
Onion	Brignole et al. 2003	NOEC	Bounded	2.45	504	Growth
Cucumber (Pepinova)	Lechner and Knapp, 2011	NOEC	Unbounded	0.556	96	Growth
Carrot (Flyaway, F1 Hybrid)	Lechner and Knapp, 2011	NOEC	Unbounded	0.458	63	Growth
Potato (Christa-Z)	Lechner and Knapp, 2011	NOEC	Unbounded	0.317	71	Growth
Perfluorooctanoic Acid (PFOA)						
Lettuce	Ding et al. 2012a	NOEC	NA	621	120	Growth
Monocotyledonous	González-Naranjo et al. 2014	EC10	NA	5.98	72	Growth
Monocotyledonous	González-Naranjo et al. 2014	EC20	NA	19.21	72	Growth
Monocotyledonous	González-Naranjo et al. 2014	EC50	NA	140.63	72	Growth
Wheat	Zhou et al. 2016	NOEC	Bounded	200	192	Growth
Wheat	Zhou et al. 2016	LOEC	Bounded	800	192	Growth
Cucumber (Pepinova)	Lechner and Knapp, 2011	NOEC	Unbounded	0.805	96	Growth
Carrot (Flyaway, F1 Hybrid)	Lechner and Knapp, 2011	NOEC	Unbounded	0.676	63	Growth
Potato (Christa-Z)	Lechner and Knapp, 2011	NOEC	Unbounded	0.795	71	Growth
Italian Lettuce (SJ)	Xiang et al. 2018	NOEC	Unbounded	0.962	1200	Growth
Italian Lettuce (WN)	Xiang et al. 2018	NOEC	Bounded	0.186	1200	Growth
Italian Lettuce (WN)	Xiang et al. 2018	LOEC	Bounded	0.942	1200	Growth
Romaine Lettuce	Xiang et al. 2018	NOEC	Unbounded	0.916	1200	Growth
Romaine Zicui	Xiang et al. 2018	NOEC	Unbounded	0.959	1200	Growth
Hongfeng Lettuce	Xiang et al. 2018	NOEC	Bounded	0.192	1200	Growth
Hongfeng Lettuce	Xiang et al. 2018	LOEC	Bounded	0.962	1200	Growth
Butterhead Lettuce	Xiang et al. 2018	NOEC	Unbounded	0.976	1200	Growth
Hanbaofeicui Lettuce	Xiang et al. 2018	LOEC	Unbounded	0.186	1200	Growth
Oriental Hans-518 Lettuce	Xiang et al. 2018	NOEC	Unbounded	0.943	1200	Growth

Table 2a. Terrestrial Plant Compiled Toxicity Data

Common Name	Source Study	Endpoint ¹	Unbounded or Bounded value?	Concentration (mg/kg)	Duration (hours)	Effect
Hongyun Lettuce	Xiang et al. 2018	NOEC	Unbounded	0.94	1200	Growth
Red Wave Lettuce	Xiang et al. 2018	NOEC	Bounded	0.191	1200	Growth
Red Wave Lettuce	Xiang et al. 2018	LOEC	Bounded	0.976	1200	Growth
Hongyoualasi Lettuce	Xiang et al. 2018	NOEC	Unbounded	0.967	1200	Growth
Kafeimaidangcai Lettuce	Xiang et al. 2018	LOEC	Unbounded	0.183	1200	Growth
Lvxiu Lettuce	Xiang et al. 2018	NOEC	Unbounded	0.958	1200	Growth
Chicory	Xiang et al. 2018	LOEC	Unbounded	0.183	1200	Growth
Italian Lettuce (SM)	Xiang et al. 2018	NOEC	Bounded	0.188	1200	Growth
Italian Lettuce (SM)	Xiang et al. 2018	LOEC	Bounded	0.945	1200	Growth
Italian Lettuce (HC)	Xiang et al. 2018	NOEC	Bounded	0.183	1200	Growth
Italian Lettuce (HC)	Xiang et al. 2018	LOEC	Bounded	0.889	1200	Growth
Italian Lettuce (QK)	Xiang et al. 2018	LOEC	Unbounded	0.184	1200	Growth
American Frisee Lettuce	Xiang et al. 2018	LOEC	Unbounded	0.187	1200	Growth
Italian Frisee Lettuce	Xiang et al. 2018	LOEC	Unbounded	0.192	1200	Growth
Local Red Lettuce	Xiang et al. 2018	LOEC	Unbounded	0.186	1200	Growth
Perfluorobutyric Acid (PFBA)						
Lettuce	Ding et al. 2012a	NOEC	NA	642	120	Growth
5H 4:1 Fluorotelomer Alcohol (FTOH)						
Lettuce	Ding et al. 2012a	NOEC	NA	23	120	Growth

Table 2a. Terrestrial Plant Compiled Toxicity Data

Notes

1. Only endpoints, effects, and durations that would be used in EcoSSL soil screening level calculations were comprehensively compiled during the literature review.

All salts are presented together with their respective PFAS, e.g. PFOS potassium salt and PFOS ammonium salt would be presented together under "Perfluorooctanesulfonic Acid (PFOS)".

> - greater than

Bounded - a NOEC paired with a LOEC or vice versa

F1 - offspring of the parental generation

LOEC - lowest-observed effect concentration

mg/kg - milligram per kilogram

mg/L - milligram per liter

NA - not applicable

NOEC - no-observed effect concentration

Unbounded - a NOEC without a paired LOEC or vice versa

Table 2b. Terrestrial Invertebrate Compiled Toxicity Data

Common Name	Source Study	Endpoint ¹	Unbounded or Bounded value?	Concentration (mg/kg)	Duration (hours)	Effect
Perfluorononanoic Acid (PFNA)						
Earthworm	Karnjanapiboonwong et al. 2018	NOEC	Bounded	1	504	Survival
Earthworm	Karnjanapiboonwong et al. 2018	LOEC	Bounded	100	504	Survival
Perfluorooctanesulfonic Acid (PFOS)						
Earthworm	Joung et al. 2010	NOEC	Unbounded	160	336	Survival
Earthworm	Sindermann et al. 2002	NOEC	Bounded	77	336	Survival
Earthworm	Sindermann et al. 2002	LOEC	Bounded	141	336	Survival
Perfluorooctanoic Acid (PFOA)						
Earthworm	Joung et al. 2010	NOEC	Unbounded	500	336	Survival
Perfluoroheptanoic Acid (PFHpA)						
Earthworm	Karnjanapiboonwong et al. 2018	NOEC	Bounded	1	504	Survival
Earthworm	Karnjanapiboonwong et al. 2018	LOEC	Bounded	100	504	Survival
Perfluorohexanesulfonic Acid (PFHxS)						
Earthworm	Karnjanapiboonwong et al. 2018	NOEC	Bounded	1	504	Survival
Earthworm	Karnjanapiboonwong et al. 2018	LOEC	Bounded	100	504	Survival
Perfluorobutanesulfonic Acid (PFBS)						
Earthworm	Karnjanapiboonwong et al. 2018	NOEC	Unbounded	100	504	Survival

Table 2b. Terrestrial Invertebrate Compiled Toxicity Data

Notes

1. Only endpoints, effects, and durations that would be used in EcoSSL soil screening level calculations were comprehensively compiled during the literature review.

All salts are presented together with their respective PFAS, e.g. PFOS potassium salt and PFOS ammonium salt would be presented together under "Perfluorooctanesulfonic Acid (PFOS)".

> - greater than

Bounded - a NOEC paired with a LOEC or vice versa

LOEC - lowest-observed effect concentration

mg/kg - milligram per kilogram

mg/L - milligram per liter

NA - not applicable

NOEC - no-observed effect concentration

Unbounded - a NOEC without a paired LOEC or vice versa

Table 2c. Terrestrial Mammal Compiled Toxicity Data

Common Name	Source Study	Endpoint ¹	Unbounded or Bounded value?	Concentration (mg/kg-bw/day)	Duration (days)	Effect
Perfluorododecanoic Acid (PFDoA)						
Rat (Sprague-Dawley)	Shi et al. 2007	NOAEL	Bounded	1	14	Reproduction
Rat (Sprague-Dawley)	Shi et al. 2007	LOAEL	Bounded	5	14	Reproduction
Perfluoroundecanoic Acid (PFUnA)						
Rat	Takahashi et al. 2014	NOAEL	Bounded	0.3	41-46	Growth, Reproduction
Rat	Takahashi et al. 2014	LOAEL	Bounded	1	41-46	Growth, Reproduction
Perfluorodecanoic Acid (PFDA)						
Mouse (C57BL/6N)	Harris and Birnbaum, 1989	NOAEL	Bounded	0.3	10	Growth, Reproduction
Mouse (C57BL/6N)	Harris and Birnbaum, 1989	LOAEL	Bounded	1	10	Growth, Reproduction
Perfluorononanoic Acid (PFNA)						
Mice (CD-1)	Das et al. 2015	NOAEL	Bounded	1	17	Reproduction, Growth
Mice (CD-1)	Das et al. 2015	LOAEL	Bounded	3	17	Reproduction, Growth
Mouse	Wolf et al. 2010	NOAEL	Bounded	0.83	18	Reproduction, Survival
Mouse	Wolf et al. 2010	LOAEL	Bounded	1.1	18	Reproduction, Survival
Mouse (CD-1)	Kennedy, 1987	LOAEL	Unbounded	54	14	Survival
Rat (Sprague-Dawley)	Rogers et al. 2014	LOAEL	Unbounded	5	20	Growth, Reproduction
Perfluorooctanesulfonic Acid (PFOS)						
Rat (Sprague-Dawley)	Gortner et al. 1980	NOAEL	Bounded	5	10	Growth, Reproduction
Rat (Sprague-Dawley)	Gortner et al. 1980	LOAEL	Bounded	10	10	Growth
Rat	Seacat et al. 2003	NOAEL	Unbounded	1.51 (M), 1.77 (F)	28	Growth
Rat (Sprague-Dawley)	Seacat et al. 2003	NOAEL	Unbounded	1.33 (M), 1.56 (F)	98	Growth
Rat	Chen et al. 2012	NOAEL	Bounded	0.1	21	Survival, Growth
Rat	Chen et al. 2012	LOAEL	Bounded	2	21	Survival, Growth
Rat	Lv et al. 2013	LOAEL	Unbounded	0.5	GD0-PND20	Growth, Reproduction
Rat	Zhao et al. 2014a	LOAEL	Unbounded	5	8	Growth, Reproduction
Rat	Luebker et al. 2005b	NOAEL	Bounded	0.4	84	Reproduction
Rat	Luebker et al. 2005b	LOAEL	Bounded	1.6	84	Reproduction
Rat	Luebker et al. 2005a	NOAEL	Bounded	0.4	63	Reproduction, Growth
Rat	Luebker et al. 2005a	LOAEL	Bounded	0.8	63	Reproduction, Growth
Mouse	Fuentes et al. 2007	LOAEL	Unbounded	6	7 (F0)	Growth, Reproduction
Mouse	Yahia et al. 2008	NOAEL	Bounded	1	18 (F0)	Reproduction
Mouse	Yahia et al. 2008	LOAEL	Bounded	10	18 (F0)	Reproduction
Rat (Sprague-Dawley)	Grasty et al. 2003	LOAEL	Unbounded	25	4	Growth, Reproduction, Survival
Mouse (wild type 129S1/SvIm)	Abbott et al. 2009	LOAEL	Unbounded	4.5	4	Reproduction, Survival
Mouse (ICR)	Era et al. 2009, test 1	LOAEL	Unbounded	50	5	Growth, Reproduction
Mouse (ICR)	Era et al. 2009, test 2	LOAEL	Unbounded	20	17	Growth, Reproduction
Mouse (CD-1)	Fuentes et al. 2006	NOAEL	Unbounded	6	13	Reproduction
Mouse (CD-1)	Lee et al. 2015	LOAEL	Unbounded	0.5	6	Growth, Reproduction, Survival
Rabbit (New Zealand)	Case et al. 2001	NOAEL	Bounded	0.1	15	Reproduction
Rabbit (New Zealand)	Case et al. 2001	LOAEL	Bounded	1	15	Reproduction
Rat (Sprague-Dawley)	Lau et al. 2003	NOAEL	Bounded	1	20	Reproduction, Survival
Rat (Sprague-Dawley)	Lau et al. 2003	LOAEL	Bounded	2	20	Reproduction, Survival
Rat (Sprague-Dawley)	Lopez-Doval et al. 2014	NOAEL	Bounded	0.5	28	Reproduction
Rat (Sprague-Dawley)	Lopez-Doval et al. 2014	LOAEL	Bounded	1	28	Reproduction
Rat (Sprague-Dawley)	Rogers et al. 2014	LOAEL	Unbounded	18.75	5	Growth, Reproduction
Rat (Sprague-Dawley)	Xia et al. 2011	NOAEL	Bounded	0.6	20	Reproduction, Survival
Rat (Sprague-Dawley)	Xia et al. 2011	LOAEL	Bounded	2	20	Reproduction, Survival
Mouse (C57BL/6J-Apc+/+)	Ngo et al. 2014	NOAEL	Bounded	0.1	7	Reproduction
Mouse (C57BL/6J-Apc+/+)	Ngo et al. 2014	LOAEL	Bounded	3	7	Reproduction
Mouse (CD-1)	Wan et al. 2011	NOAEL	Bounded	5	21	Reproduction
Mouse (CD-1)	Wan et al. 2011	LOAEL	Bounded	10	21	Reproduction

Table 2c. Terrestrial Mammal Compiled Toxicity Data

Common Name	Source Study	Endpoint ¹	Unbounded or Bounded value?	Concentration (mg/kg-bw/day)	Duration (days)	Effect
Rat (Sprague-Dawley)	Butenhoff et al. 2012b; Thomford 2002	NOAEL	Bounded	0.25 (F)	728	Growth
Rat (Sprague-Dawley)	Butenhoff et al. 2012b; Thomford 2002	LOAEL	Bounded	1.04 (F)	728	Growth
Rat (CrI:CD [SD])	Butenhoff et al. 2009b	NOAEL	Bounded	0.3	>30	Growth
Rat (CrI:CD [SD])	Butenhoff et al. 2009b	LOAEL	Bounded	1	>30	Growth
Mouse (B6C3F1)	Keil et al. 2008	NOAEL	Unbounded	5	17	Reproduction, Growth
Mouse (CD-1)	Lau et al. 2003	NOAEL	Bounded	5	17	Reproduction, Survival
Mouse (CD-1)	Lau et al. 2003	LOAEL	Bounded	10	17	Reproduction, Survival
Mouse (CD1)	Rosen et al. 2009	NOAEL	Unbounded	10	17	Growth, Reproduction
Mouse (CD-1)	Thibodeaux et al. 2003	NOAEL	Bounded	15	17	Reproduction
Mouse (CD-1)	Thibodeaux et al. 2003	LOAEL	Bounded	20	17	Reproduction
Rat (Sprague-Dawley)	Thibodeaux et al. 2003	NOAEL	Bounded	5	20	Reproduction, Growth
Rat (Sprague-Dawley)	Thibodeaux et al. 2003	LOAEL	Bounded	10	20	Reproduction, Growth
Rat (Sprague-Dawley)	Wan et al. 2010	NOAEL	Bounded	0.6	20	Reproduction, Survival
Rat (Sprague-Dawley)	Wan et al. 2010	LOAEL	Bounded	2	20	Reproduction, Survival
Mouse (CD-1)	Wan et al. 2014	NOAEL	Unbounded	3	>30 (GD3-PND21)	Growth, Reproduction
Rat (Wistar)	Wang et al. 2011a	NOAEL	Bounded	3.2	>30 (GD1-PND14)	Growth, Reproduction
Rat (Wistar)	Wang et al. 2011a	LOAEL	Bounded	32	>30 (GD1-PND14)	Growth, Reproduction
Rat (Sprague-Dawley)	Ye et al. 2012	NOAEL	Unbounded	20	7	Survival
Mouse (B6C3F1)	Fair et al. 2011	NOAEL	Bounded	0.0331	28	Reproduction
Mouse (B6C3F1)	Fair et al. 2011	LOAEL	Bounded	0.166	28	Reproduction
Mouse (ICR)	Qiu et al. 2013	NOAEL	Bounded	0.25	28	Reproduction
Mouse (ICR)	Qiu et al. 2013	LOAEL	Bounded	2.5	28	Reproduction
Rat (Sprague-Dawley CD)	Wetzel, 1983	NOAEL	Bounded	1	10	Growth, Reproduction
Rat (Sprague-Dawley CD)	Wetzel, 1983	LOAEL	Bounded	5	10	Growth, Reproduction
Perfluorooctanoic Acid (PFOA)						
Rat	Butenhoff et al. 2004; York et al. 2010	NOAEL	bounded	10	70	Growth
Rat	Butenhoff et al. 2004; York et al. 2010	LOAEL	Bounded	30	70	Growth
Mouse	Lu et al. 2016	LOAEL	Unbounded	5	28	Growth, Reproduction
Female Mouse (CD-1)	White et al. 2009; Wolf et al. 2007	LOAEL	Unbounded	3	17	Growth, Reproduction
Female Mouse (CD-1)	White et al. 2009; Wolf et al. 2007	LOAEL	Unbounded	5	11	Growth, Reproduction
Rat (ChR-CD albino)	Griffith and Long, 1980	NOAEL	Bounded	300 (M), 340 (F)	28	Survival
Rat (ChR-CD albino)	Griffith and Long, 1980	LOAEL	Bounded	1000 (M), 1130 (F)	28	Survival
Rat (Sprague-Dawley)	Li et al. 2016	NOAEL	Bounded	5	7	Growth, Reproduction
Rat (Sprague-Dawley)	Li et al. 2016	LOAEL	Bounded	20	7	Growth, Reproduction
Mouse (wild-type Sv/129)	Albrecht et al. 2013	LOAEL	Unbounded	3	17	Reproduction
Mouse (CD)	Griffith and Long, 1980	LOAEL	Unbounded	5.4 (M)	28	Growth
Mouse (C57BL/6J-Apc ^{+/+})	Ngo et al. 2014	NOAEL	Bounded	0.1	17	Reproduction
Mouse (C57BL/6J-Apc ^{+/+})	Ngo et al. 2014	LOAEL	Bounded	3	17	Reproduction
Mouse (CD-1)	White et al. 2007	LOAEL	Unbounded	5	17	Growth, Reproduction, Survival
Mouse (CD-1)	White et al. 2011	NOAEL	Bounded	1	17	Reproduction, Survival
Mouse (CD-1)	White et al. 2011	LOAEL	Bounded	5	17	Reproduction, Survival
Rat (Sprague-Dawley)	3M, 1983	NOAEL	Bounded	1.5	730	Growth
Rat (Sprague-Dawley)	3M, 1983	LOAEL	Bounded	15	730	Growth
Rat (Sprague-Dawley)	Staples et al. 1984	LOAEL	Unbounded	100	10	Growth
Mouse (129S1/SvImJ wild type)	Abbott et al. 2007	NOAEL	Bounded	0.3	17	Reproduction, Survival
Mouse (129S1/SvImJ wild type)	Abbott et al. 2007	LOAEL	Bounded	0.6	17	Reproduction, Survival
Mouse (CD-1)	Hines et al. 2009	NOAEL	Bounded	0.3	17	Growth, Reproduction
Mouse (CD-1)	Hines et al. 2009	LOAEL	Bounded	1	17	Growth, Reproduction
Mouse (C57BL/6N)	Hu et al. 2010	LOAEL	Unbounded	0.5	12	Growth, Reproduction
Mouse (C57BL/6N)	Hu et al. 2012	NOAEL	Bounded	0.2	56	Growth, Reproduction
Mouse (C57BL/6N)	Hu et al. 2012	LOAEL	Bounded	2	56	Growth, Reproduction

Table 2c. Terrestrial Mammal Compiled Toxicity Data

Common Name	Source Study	Endpoint ¹	Unbounded or Bounded value?	Concentration (mg/kg-bw/day)	Duration (days)	Effect
Mouse (CD-1)	Lau et al. 2006	NOAEL	Bounded	1	18	Growth, Reproduction
Mouse (CD-1)	Lau et al. 2006	LOAEL	Bounded	3	18	Growth, Reproduction
Mouse (CD-1)	Macon et al. 2011	NOAEL	Unbounded	3	17	Growth, Reproduction
Mouse (CD-1)	Macon et al. 2011	NOAEL	Unbounded	1	8	Growth, Reproduction
Mouse (CD-1)	Suh et al. 2011	LOAEL	Unbounded	2	6	Reproduction
Mouse (CD-1)	Tucker et al. 2015	NOAEL	Unbounded	1	17	Growth, Reproduction
Mouse (C57B1/6)	Tucker et al. 2015	NOAEL	Unbounded	1	17	Growth, Reproduction
Mouse (ICR)	Yahia et al. 2010	NOAEL	Bounded	1	18	Growth, Reproduction
Mouse (ICR)	Yahia et al. 2010	LOAEL	Bounded	5	18	Growth, Reproduction
Mouse (Balb/c)	Zhao et al. 2012	LOAEL	Unbounded	2.5	20	Reproduction
Mouse (C57Bl/6 Wild Type)	Zhao et al. 2012	LOAEL	Unbounded	7.5	20	Reproduction
Mouse (Kunming)	Liu et al. 2015	LOAEL	Unbounded	2.5	14	Reproduction
Mouse (Balb/c)	Yang et al. 2009	LOAEL	Unbounded	1	20	Reproduction
Mouse (C57BL/6)	Yang et al. 2009	NOAEL	Bounded	1	20	Reproduction
Mouse (C57BL/6)	Yang et al. 2009	LOAEL	Bounded	5	20	Reproduction
Rat	Hinderliter et al. 2005	NOAEL	Unbounded	30	GD20 - PPD21	Growth, Reproduction, Survival
Rat (Sprague-Dawley derived CD)	Gortner et al. 1981	NOAEL	Bounded	5	10	Growth
Rat (Sprague-Dawley derived CD)	Gortner et al. 1981	LOAEL	Bounded	150	10	Growth
Rat (CrI:CD)	Goldenthal, 1978b	NOAEL	Unbounded	68.9	90	Survival
Mice (BALB/c)	Zhang et al. 2014	LOAEL	Unbounded	5	28	Reproduction
Perfluorohexanesulfonic Acid (PFHxS)						
Rat (Sprague-Dawley)	Butenhoff et al. 2009a; Hoberman and York, 2003	NOAEL	Unbounded	10	42	Reproduction
Perfluorohexanoic Acid (PFHxA)						
Rat (Sprague-Dawley)	Klaunig et al. 2015	LOAEL	Bounded	200	104 weeks	Survival
Rat (Sprague-Dawley)	Klaunig et al. 2015	NOAEL	Bounded	100 M, 200 F	104 weeks	Growth
Mouse (CD1)	Iwai and Hoberman, 2014 - test 1	NOAEL	Bounded	100	14	Reproduction
Mouse (CD1)	Iwai and Hoberman, 2014 - test 1	LOAEL	Bounded	350	14	Reproduction
Mouse (CD1)	Iwai and Hoberman, 2014 - test 2	NOAEL	Bounded	35	14	Reproduction, Survival
Mouse (CD1)	Iwai and Hoberman, 2014 - test 2	LOAEL	Bounded	175	14	Reproduction, Survival
Rat (CrI:CD(SD))	Loveless et al. 2009 - test 1	NOAEL	Bounded	100	126	Reproduction, Growth
Rat (CrI:CD(SD))	Loveless et al. 2009 - test 1	LOAEL	Bounded	500	126	Reproduction, Growth
Rat (CrI:CD(SD))	Loveless et al. 2009 - test 2	NOAEL	Bounded	100	15	Growth
Rat (CrI:CD(SD))	Loveless et al. 2009 - test 2	LOAEL	Bounded	500	15	Growth
Rat (CrI:CD(SD))	Loveless et al. 2009 - test 3	NOAEL	Bounded	100	92	Growth
Rat (CrI:CD(SD))	Loveless et al. 2009 - test 3	LOAEL	Bounded	500	92	Growth
Rat (Wistar CrI:(WI) BR) - female	Teunissen, 2004	NOAEL	Unbounded	3000	1	Survival
Perfluorobutanesulfonic Acid (PFBS)						
Rat (Sprague-Dawley)	Lieder et al. 2009	NOAEL	Unbounded	1000	>70 (P0), F1	Reproduction
Mice (ICR)	Feng et al. 2017	NOAEL	Bounded	50	20	Reproduction
Mice (ICR)	Feng et al. 2017	LOAEL	Bounded	200	20	Reproduction
Rat (Sprague-Dawley)	York, 2003	NOAEL	Bounded	1000	15	Growth, Reproduction
Rat (Sprague-Dawley)	York, 2003	LOAEL	Bounded	2000	15	Growth, Reproduction
Rat (CrI:CD[SD]IGS BR VAF/Plus)	York, 2002	NOAEL	Bounded	300	15	Growth, Reproduction
Rat (CrI:CD[SD]IGS BR VAF/Plus)	York, 2002	LOAEL	Bounded	1000	15	Growth, Reproduction
Rat (Sprague-Dawley)	3M, 2000	NOAEL	Unbounded	1000	10	Growth, Reproduction, Survival
Rat (Sprague-Dawley)	3M, 2001	NOAEL	Unbounded	900	28	Growth, Reproduction, Survival
Perfluorobutyrate Acid (PFBA)						
Rat (Sprague-Dawley)	Butenhoff et al. 2012a; van Otterdijk 2007b	NOAEL	Unbounded	30	90 days	Growth
Rat (Sprague-Dawley)	Butenhoff et al. 2012a; van Otterdijk 2007a	NOAEL	Unbounded	150	28 days	Growth
Rat (Sprague-Dawley)	3M, 2007	NOAEL	Unbounded	184	5	Reproduction
Mouse (CD-1)	Das et al. 2008	NOAEL	Bounded	35	17	Reproduction

Table 2c. Terrestrial Mammal Compiled Toxicity Data

Common Name	Source Study	Endpoint ¹	Unbounded or Bounded value?	Concentration (mg/kg-bw/day)	Duration (days)	Effect
Mouse (CD-1)	Das et al. 2008	LOAEL	Bounded	175	17	Reproduction
1-butanefluoramide, 1,1,2,2,3,3,4,4,4-nonafluoro-n-(2-hydroxyethyl)-N-methyl ((T-599.7)						
Rat [(CrI:CD)(SD)IGS VAF/Plus]	3M, 2003	NOAEL	Bounded	50	>=28 (M), est. 41 (F)	Reproduction, Survival
Rat [(CrI:CD)(SD)IGS VAF/Plus]	3M, 2003	LOAEL	Bounded	250	>=28 (M), est. 41 (F)	Reproduction, Survival
8:2 Fluorotelomer Alcohol (FTOH)						
Rat (CrI:CD [SD]IGS BR)	Mylchreest et al. 2005	NOAEL	Bounded	200	15	Survival, Growth
Rat (CrI:CD [SD]IGS BR)	Mylchreest et al. 2005	LOAEL	Bounded	500	15	Survival, Growth
Rat (CrI:CD [SD]IGS BR)	Ladics et al. 2008	NOAEL	Unbounded	125	>=90	Survival, Reproduction
6:2 Chlorinated Polyfluoroalkyl Ether Sulfonic Acid (CI-PFESA)						
Mouse (Balb/c)	Zhou et al. 2018	NOAEL	Unbounded	1	56	Growth, Reproduction
6:2 Fluorotelomer Alcohol (FTOH)						
Mice (CD-1)	Mukerji et al. 2015	NOAEL	Bounded	25	GD0 - PND21	Growth, Reproduction, Survival
Mice (CD-1)	Mukerji et al. 2015	LOAEL	Bounded	100	GD0 - PND21	Growth, Reproduction, Survival
Rat (CrI:CD[SD])	Serex et al. 2014	NOAEL	Bounded	125 (M)	90	Survival
Rat (CrI:CD[SD])	Serex et al. 2014	LOAEL	Bounded	250 (M)	90	Survival
Rat, Sprague-Dawley (CrI:CD[SD])	O'Connor et al. 2014	NOAEL	Bounded	125	14	Growth
Rat, Sprague-Dawley (CrI:CD[SD])	O'Connor et al. 2014	LOAEL	Bounded	250	14	Growth
Rat, Sprague-Dawley (CrI:CD[SD])	O'Connor et al. 2014	NOAEL	Bounded	25	127 (F0, F), 84 (F0, M)	Growth, Survival, Reproduction
Rat, Sprague-Dawley (CrI:CD[SD])	O'Connor et al. 2014	LOAEL	Bounded	125	127 (F0, F), 84 (F0, M)	Growth, Survival, Reproduction
GenX						
Mice	DuPont, 2010b	NOAEL	Bounded	0.5	GD0 - PND40	Growth, Reproduction
Mice	DuPont, 2010b	LOAEL	Bounded	5	GD0 - PND40	Growth, Reproduction
Rats	DuPont, 2010a	NOAEL	Bounded	10	15	Reproduction
Rats	DuPont, 2010a	LOAEL	Bounded	100	15	Reproduction
Rat (CrI:CD [SD]) - female	Craig, 2013	NOAEL	Bounded	50	730	Growth
Rat (CrI:CD [SD]) - female	Craig, 2013	LOAEL	Bounded	500	730	Growth
Mouse (CrI:CD1 [ICR])	MacKenzie, 2010	NOAEL	Unbounded	5	96	Growth, Survival
Rat (Sprague-Dawley)	Conley et al. 2019, main study	NOAEL	Bounded	125	5	Growth
Rat (Sprague-Dawley)	Conley et al. 2019, main study	LOAEL	Bounded	250	5	Growth
Rat (Sprague-Dawley)	Conley et al. 2019, pilot study	LOAEL	Unbounded	125	5	Growth, Reproduction
Rat (CrI:CD [SD])	Nabb, 2008b	NOAEL	Bounded	300	7	Growth
Rat (CrI:CD [SD])	Nabb, 2008b	LOAEL	Bounded	1000	7	Growth
Rat (Sprague-Dawley)	Caverly Rae et al. 2015	NOAEL	Unbounded	500 (F), 50 (M)	707-728	Survival, Reproduction
Mouse (CrI:CD1 [ICR])	Nabb, 2008a	NOAEL	Unbounded	30	6	Growth, Survival
Rat (CrI:CD[SD])	Haas, 2008a	NOAEL	Unbounded	30 (M), 300 (F)	28	Growth, Survival
Mouse (CrI:CD1 [ICR])	Haas, 2008b	NOAEL	Unbounded	30	28	Growth, Survival
Rat CrI:CD(SD)	USEPA, GenX 8(e) Filings (DCN: 89100000282)	NOAEL	Bounded	10	15	Growth, Reproduction
Rat CrI:CD(SD)	USEPA, GenX 8(e) Filings (DCN: 89100000282)	LOAEL	Bounded	100	15	Growth, Reproduction
Mice (CrI:CD1)	USEPA, GenX 8(e) Filings (DCN: 891000000891)	NOAEL	Unbounded	5	96 (M), 97 (F)	Survival
Mice	USEPA, GenX 8(e) Filings (page 52, No. 310027)	NOAEL	Unbounded	30	7	Reproduction
Mice (CrI:CD-1) (ICR)	USEPA, GenX 8(e) Filings (pages 53-55, No. 31900)	NOAEL	Bounded	3	28	Reproduction
Mice (CrI:CD-1) (ICR)	USEPA, GenX 8(e) Filings (pages 53-55, No. 31900)	LOAEL	Bounded	30	28	Reproduction
Rat (CrI:CD) (SD)	USEPA, GenX 8(e) Filings (DCN: 89130000231)	NOAEL	Unbounded	0.1 (M), 500 (F)	730	Survival
Rat (CrI:CD) (SD)	Nabb, 2008c	NOAEL	Unbounded	300	7	Survival, Reproduction, Growth
N-Ethyl Perfluorooctane Sulfonamide Ethanol (N-EtFOSE)						
Rat (CrI:CD)	Goldenthal, 1978a	NOAEL	Bounded	19.0	90	Survival
Rat (CrI:CD)	Goldenthal, 1978a	LOAEL	Bounded	57.2	90	Survival
Rabbit (New Zealand White [Hra:NZW	3M, 1999	NOAEL	Bounded	0.1	14	Growth
Rabbit (New Zealand White [Hra:NZW	3M, 1999	LOAEL	Bounded	1	14	Growth

Table 2c. Terrestrial Mammal Compiled Toxicity Data

Notes

1. Only endpoints, effects, and durations that would be used in EcoSSL soil screening level calculations were comprehensively compiled during the literature review.

All salts are presented together with their respective PFAS, e.g. PFOS potassium salt and PFOS ammonium salt would be presented together under "Perfluorooctanesulfonic Acid (PFOS)".

Due to potential variation in gestation length, when exposures spanned gestation and postnatal periods the gestational day (GD) that exposure started and postnatal day (PND) that exposure ended are presented in the duration column rather than a specific number of days.

> - greater than

Bounded - a NOAEL paired with a LOAEL or vice versa

F - female

F0 - first generation, the number that follows indicates the generation (e.g. F1 is the first offspring generation)

LOAEL - lowest-observed adverse effect level

M - male

mg/kg-bw/day - milligram per kilogram of body weight per day

NOAEL - no-observed adverse effect level

PPD - post-partum day

Unbounded - a NOAEL without a paired LOAEL or vice versa

Table 2d. Terrestrial Bird Compiled Toxicity Data

Common Name	Source Study	Endpoint ¹	Unbounded or Bounded value?	Concentration (mg/kg-bw/day)	Duration (days)	Effect
Perfluorooctanesulfonic Acid (PFOS)						
Mallard duck	Gallagher et al. 2003f	NOAEL	Unbounded	3.6	42	Reproduction, Growth, Survival
Chicken	Tarazona et al. 2015	NOAEL	Unbounded	0.000085	102	Survival
Northern Bobwhite quail	Gallagher et al. 2003e	NOAEL	Unbounded	2.0	133	Survival, Reproduction, Growth
Northern Bobwhite quail	Gallagher et al. 2003c	LOAEL	Unbounded	0.79	147	Reproduction, Survival
Mallard duck	Gallagher et al. 2004a	NOAEL	Bounded	20	5	Growth
Mallard duck	Gallagher et al. 2004a	LOAEL	Bounded	28	5	Growth
Northern Bobwhite quail	Gallagher et al. 2004b	NOAEL	Bounded	29	5	Growth
Northern Bobwhite quail	Gallagher et al. 2004b	LOAEL	Bounded	59	5	Growth
Mallard duck	Gallagher et al. 2003d	NOAEL	Bounded	1.51	147	Reproduction, Survival, Growth
Mallard duck	Gallagher et al. 2003d	LOAEL	Bounded	6.47	49	Survival
Perfluorobutanesulfonic Acid (PFBS)						
Northern Bobwhite quail	Gallagher et al. 2005	NOAEL	Unbounded	92	147	Reproduction, Survival
Northern Bobwhite quail	Gallagher et al. 2003a	NOAEL	Bounded	698	5	Growth
Northern Bobwhite quail	Gallagher et al. 2003a	LOAEL	Bounded	1531	5	Growth
Mallard	Gallagher et al. 2003b	NOAEL	Bounded	2139	5	Growth
Mallard	Gallagher et al. 2003b	LOAEL	Bounded	3895	5	Growth
GenX						
Northern Bobwhite quail	Temple et al. 2010	NOEC	Unbounded	81.0	140	Growth, Reproduction, Survival

Table 2d. Terrestrial Bird Compiled Toxicity Data

Notes

1. Only endpoints, effects, and durations that would be used in EcoSSL soil screening level calculations were comprehensively compiled during the literature review.

All salts are presented together with their respective PFAS, e.g. PFOS potassium salt and PFOS ammonium salt would be presented together under "Perfluorooctanesulfonic Acid (PFOS)".

Due to potential variation in gestation length, when exposures spanned gestation and postnatal periods the gestational day (GD) that exposure started and postnatal day (PND) that exposure ended are presented in the duration column rather than a specific number of days.

> - greater than

Bounded - a NOAEL paired with a LOAEL or vice versa

LOAEL - lowest-observed adverse effect level

mg/kg-bw/day - milligram per kilogram of body weight per day

NOAEL - no-observed adverse effect level

NOEC - no-observed effect concentration

Unbounded - a NOAEL without a paired LOAEL or vice versa

Table 3. Threatened and Endangered Representative Species Selection

Habitat	Bird/Mammal	Feeding Guild	Number of T&E Species in Guild	Representative T&E Species	U.S. Range by State ¹	Representative Surrogate Species
Aquatic	Mammal	Carnivore / Piscivore ²	18	Guadalupe fur seal, Southern sea otter	California	Harbor Seal, River Otter, Mink ³
Aquatic	Mammal	Insectivore	1	Gray Bat	Alabama, Arkansas, Florida, Georgia, Illinois, Indiana, Kansas, Kentucky, Mississippi, Missouri, North Carolina, Oklahoma, Tennessee, Virginia, West Virginia	Little Brown Bat
Aquatic	Mammal	Herbivore	4	Point arena mountain beaver	California	Muskrat
Aquatic	Bird	Piscivore	8	California least tern	Arizona, California	Pelican
Aquatic	Bird	Invertivore	7	Western snowy plover	California, Oregon, Washington	Tree swallow
Aquatic / Wetland	Bird	Omnivore	11	Yellow-shouldered blackbird	Puerto Rico	Red-winged blackbird
Terrestrial	Mammal	Carnivore	13	Black-footed ferret	Arizona, Colorado, Kansas, Montana, New Mexico, South Dakota ⁴	Long-tailed weasel
Terrestrial	Mammal	Insectivore	6	Northern Long-Eared Bat	Alabama , Arkansas , Connecticut , Delaware , District of Columbia , Georgia , Illinois , Indiana , Iowa , Kansas , Kentucky , Louisiana , Maine , Maryland , Massachusetts , Michigan , Minnesota , Mississippi , Missouri , Montana , Nebraska , New Hampshire , New Jersey , New York , North Carolina , North Dakota , Ohio , Oklahoma , Pennsylvania , Rhode Island , South Carolina , South Dakota , Tennessee , Vermont , Virginia , West Virginia , Wisconsin , Wyoming	Little brown bat
Terrestrial	Mammal	Invertivore	1	Buena Vista Lake Ormate Shrew	California	Short-tailed shrew
Terrestrial	Mammal	Herbivore	38	Amargosa vole	California	Meadow vole
Terrestrial	Bird	Carnivore	8	Mexican spotted owl	Arizona , Colorado , New Mexico , Texas , Utah	Red-tailed hawk
Terrestrial	Bird	Insectivore	26	Red-cockaded woodpecker	Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, Texas, Virginia	House wren
Terrestrial	Bird	Herbivore / Frugivore / Nectivore	7	Palila (honeycreeper)	Hawaii	American Goldfinch

Notes:

1. Environmental Conservation Online System - Species Profiles. Available at: <https://ecos.fws.gov/ecp/>
2. Piscivore in this table is inclusive of receptors with diets of crustaceans and cephalopods such as the blue whale.
3. Harbor seal, river otter, and mink were selected as representative surrogate species. The harbor seal was considered a representative surrogate species for Guadalupe fur seal. River otters and mink were selected to model exposure for an inland aquatic piscivore or opportunistic carnivore receptor.
4. States with experimental populations, non-essential were not included in the listed states with receptor range.

T&E - threatened and endangered species

Table 4. Mammal and Bird Toxicity Reference Value Summary

Constituent	NOAEL Count ¹	LOAEL Count ¹	NOAEL TRV (mg/kg-bw/day)	LOAEL TRV (mg/kg-bw/day)
Mammal Toxicity Reference Values				
PFNA	2	4	0.83	1.1
PFOS	27	30	0.1	0.166
PFOA	17	27	0.3	0.6
PFHxA	6	6	84	175
PFBS	6	3	50	200
PFBA	4	1	73	175
6:2 FTOH	3	4	43	100
GenX	14	8	0.5	5
N-EtFOSE	1	2	0.1	1
Bird Toxicity Reference Values				
PFOS	5	4	0.079	0.79
PFBS	3	2	92	153

Notes:

1. The NOAEL count is based on the number of NOAELs with reproduction and growth as endpoints and the LOAEL count is based on the number of LOAELs with reproduction, growth, or survival as endpoints.

LOAEL - lowest-observed adverse effect level

mg/kg-bw/day - milligram per kilogram of body weight per day

NOAEL - no-observed adverse effect level

Table 5. Exposure Parameters

Media Exposed	Soil/Surface Water		Soil/Surface Water		Soil/Sediment/Surface Water	
Receptor	Meadow Vole		Short-Tailed Shrew		Little Brown Bat	
Exposure Parameters						
Body Weight (g) ¹	36.9	Measured body weight for meadow vole; Nagy (2001)	16.8	Mean of available adult male/female body weights EFH (1993)	9	Measured body weight from Table 1 of Nagy (2001)
Body Weight (kg) ¹	0.0369	Measured body weight for meadow vole; Nagy (2001)	0.017	Mean of available adult male/female body weights EFH (1993)	0.009	Measured body weight from Table 1 of Nagy (2001)
Drinking Water Rate (L/day) ²	0.0051	WIR = 0.099*(BW) ^{0.90} ; Calder and Braun (1983)	0.0025	WIR = 0.099*(BW) ^{0.90} ; Calder and Braun (1983)	0.001	WIR = 0.099*(BW) ^{0.90} ; Calder and Braun (1983)
Food Ingestion Rate (g/day, dw) ³	11.5	Nagy 2001 (measured value) from Table 1	2.16	FIR (g/day, dw) = 0.373*BW ^{0.622} (insectivores equation from Nagy 2001)	1.6	Measured FIR from Table 1 of Nagy (2001)
Food Ingestion Rate (kg/day, dw) ³	0.012		0.002		0.0016	
Fraction Soil Ingested (unitless) ⁴	0.024	Beyer et al. 1994	0.024	Beyer et al. 1994 (meadow vole surrogate)	0	Assumed negligible based on feeding strategy (Sample et al. 1997)
Site Area						
Site Use Factor (unitless)	1	Conservative assumption	1	Conservative assumption	1	Conservative assumption
Home Range (acres)	0.07	Ranges in Virginia, Montana, and Massachusetts (Madison 1980; Douglass 1976; Ostfeld et al. 1988); cited in EFH 1993	0.96	Range in Manitoba tamarack bog and includes both juveniles and adults (Buckner 1966); cited in EFH 1993	74	Home-range size of pregnant Myotis lucifugus on Grosse-Ile, Quebec, Canada, summers of 1999 and 2000 (Henry et al. 2002).
Dietary Composition (fraction of diet) ⁵						
Plant Tissue	0.98	Average of two habitats as described by Lindroth and Bratzli (1984); cited in EFH 1993	0.13	Whitaker and Ferraro (1963); cited in EFH 1993	0	Fenton and Barclay 1980; cited in Sample et al. 1997
Invertebrate Tissue	0.02		0.83		0	
Aerial Insect Tissue	0		0.04		1	
Crustacean Tissue	0		0		0	
Fish Tissue	0		0		0	
Mammal/Bird	0		0		0	
Amphibian tissue	0		0		0	
Reptile tissue	0		0		0	
Other (food)	0		0		0	

Table 5. Exposure Parameters

Media Exposed	Soil/Surface Water		Sediment/Surface Water		Sediment/Surface Water	
Receptor	Long-tailed Weasel		Muskrat		River Otter	
Exposure Parameters						
Body Weight (g) ¹	206	Mean of available adult male/female body weights from CHPPM (2004)	873	Mean of available adult male/female body weights EFH (1993)	7990	Mean of available adult male/female body weights EFH (1993)
Body Weight (kg) ¹	0.206	Mean of available adult male/female body weights from CHPPM (2004)	0.873	Mean of available adult male/female body weights EFH (1993)	7.99	Mean of available adult male/female body weights EFH (1993)
Drinking Water Rate (L/day) ²	0.024	WIR = 0.099*(BW) ^{0.90} ; Calder and Braun (1983)	0.088	WIR = 0.099*(BW) ^{0.90} ; Calder and Braun (1983)	0.643	WIR = 0.099*(BW) ^{0.90} ; Calder and Braun (1983)
Food Ingestion Rate (g/day, dw) ³	10.2	FIR (g/day, dw) = 0.102*BW ^{0.864} (Carnivora equation from Nagy 2001)	62.7	FIR (g/day, dw) = 0.332*BW ^{0.774} (Rodentia equation from Nagy 2001)	240.1	FIR (g/day, dw) = 0.102*BW ^{0.864} (Carnivora equation from Nagy 2001)
Food Ingestion Rate (kg/day, dw) ³	0.010		0.063		0.240	
Fraction Soil Ingested (unitless) ⁴	0.028	Beyer et al. 1994 (red fox surrogate; CHPPM 2004)	0.094	Beyer et al. 1994 (raccoon surrogate; CHPPM 2004)	0	Assumed negligible (CHPPM 2004)
Site Area						
Site Use Factor (unitless)	1	Conservative assumption	1	Conservative assumption	1	Conservative assumption
Home Range (acres)	26	Ranges from 5 to 16 ha in Iowa (Polderboer et al. 1941); cited in CHPPM (2004)	0.270	Ranges from 0.048 to 0.17 ha in Ontario (Proulx and Gilbert 1983); cited in EFH 1993	859	Ranges from 295 to 400 ha in Texas (Foy et al. 1984); cited in EFH 1993
Dietary Composition (fraction of diet)						
Plant Tissue	0	Quick (1951) cited in CHPPM (2004)	1	Martin et al. (1951); cited in EFH 1993	0	Estimated from Melquist & Hornocker (1983) Idaho/mountain lakes and streams, average across 4 seasons; cited in EFH 1993
Invertebrate Tissue	0.02		0		0.070	
Aerial Insect Tissue	0.06		0		0.000	
Crustacean Tissue	0		0		0.000	
Fish Tissue	0		0		0.88	
Mammal/Bird	0.92		0		0.050	
Amphibian tissue	0		0		0	
Reptile tissue	0		0		0	
Other (food)	0		0		0	

Table 5. Exposure Parameters

Media Exposed	Sediment/Surface Water		Sediment/Surface Water		Soil/Surface Water	
Receptor	Harbor Seal		Mink		American Goldfinch	
Exposure Parameters						
Body Weight (g) ¹	98.91	Mean of available adult male/female body weights EFH (1993)	1019.5	Mean of available adult male/female body weights EFH (1993)	13.12	Appendix 1, average of adult values (Carey et al. 1978)
Body Weight (kg) ¹	0.099	Mean of available adult male/female body weights EFH (1993)	1.020	Mean of available adult male/female body weights EFH (1993)	0.013	Appendix 1, average of adult values (Carey et al. 1978)
Drinking Water Rate (L/day) ²	0.012	WIR = 0.099*(BW) ^{0.90} ; Calder and Braun (1983)	0.101	WIR = 0.099*(BW) ^{0.90} ; Calder and Braun (1983)	0.0032	WIR = 0.059*(BW) ^{0.67} ; Calder and Braun (1983)
Food Ingestion Rate (g/day, dw) ³	2807	Measured value for common seal; Nagy (2001)	40.5	FIR (g/day, dw) = 0.102*BW ^{0.864} (Carnivora equation from Nagy 2001)	3.65	FIR (g/day, dw) = 0.630*BW ^{0.683} (Passerine equation from Nagy 2001)
Food Ingestion Rate (kg/day, dw) ³	2.807		0.041		0.0037	
Fraction Soil Ingested (unitless) ⁴	0.02	Minimum reported for 15 mammals in Beyer et al. (1994); mink surrogate	0.02	Minimum reported for 15 mammals in Beyer et al. (1994); CHPPM 2004	0.093	Beyer et al. 1994 (Wild turkey surrogate)
Site Area						
Site Use Factor (unitless)	1	Conservative assumption	1	Conservative assumption	1	Conservative assumption
Home Range (acres)	698671	Foraging radius of 5 km (California/Bay; Stewart et al., 1989) to 30 to 55 km (Washington/Columbia River; Beach et al., 1985); cited in EFH 1993	710	Ranges from 7.8 ha (Montana/riverine; Mitchell, 1961) to 770 ha (Manitoba, Canada/prairie potholes; Arnold and Fritzell 1987); cited in EFH 1993	12421	McGraw, K. J. and A. L. Middleton (2017)
Dietary Composition (fraction of diet)						
Plant Tissue	0	Washington/coastal island (Everitt et al., 1981), Kodiak Island and Alaska/coastal marine (Pitcher & Calkins, 1979), Gulf of Alaska/coastal marine (Pitcher, 1980); cited in EFH 1993	0.010	Alexander (1977) river year round; cited in EFH 1993	1	McGraw, K. J. and A. L. Middleton (2017)
Invertebrate Tissue	0.14		0		0	
Aerial Insect Tissue	0		0		0	
Crustacean Tissue	0.01		0.04		0	
Fish Tissue	0.85		0.860		0	
Mammal/Bird	0		0.060		0	
Amphibian tissue	0		0.03		0	
Reptile tissue	0		0		0	
Other (food)	0		0		0	

Table 5. Exposure Parameters

Media Exposed	Soil/Surface Water		Soil/Surface Water		Sediment/Surface Water	
Receptor	House Wren		Red-Tailed Hawk		Red-Winged Blackbird	
Exposure Parameters						
Body Weight (g) ¹	10.6	Measured body weight from Table 1 of Nagy (2001)	1134	Mean of available adult male/female body weights EFH (1993)	57.15	Holcomb and Twiest, 1968; cited in CHPPM 2004
Body Weight (kg) ¹	0.0106	Measured body weight from Table 1 of Nagy (2001)	1.13	Mean of available adult male/female body weights EFH (1993)	0.057	Holcomb and Twiest, 1968; cited in CHPPM 2004
Drinking Water Rate (L/day) ²	0.003	WIR = 0.059*(BW) ^{0.67} ; Calder and Braun (1983)	0.064	WIR = 0.059*(BW) ^{0.67} ; Calder and Braun (1983)	0.009	WIR = 0.059*(BW) ^{0.67} ; Calder and Braun (1983)
Food Ingestion Rate (g/day, dw) ³	3.38	Measured value for house wren; Nagy (2001)	90.0	FIR (g/day, dw) = 0.849*BW ^{0.663} (carnivorous birds equation from Nagy 2001)	9.99	FIR (g/day, dw) = 0.630*BW ^{0.683} (Passerine equation from Nagy 2001)
Food Ingestion Rate (kg/day, dw) ³	0.00338		0.090		0.0100	
Fraction Soil Ingested (unitless) ⁴	0.104	Beyer et al. 1994 (American woodcock surrogate)	0	Assumed negligible; CHPPM 2004	0.093	Beyer et al. 1994 (Wild turkey surrogate; CHPPM 2004)
Site Area						
Site Use Factor (unitless)	1	Conservative assumption	1	Conservative assumption	1	Conservative assumption
Home Range (acres)	2.3	Estimated territory size at a site in w. Oregon is 0.93 ha (range 0.45–1.78 ha); Kroodsma (1973) cited in Johnson (2014)	1660	Average territory size from EFH (USEPA 1993)	152155	White et al. 1985; cited in CHPPM 2004
Dietary Composition (fraction of diet)						
Plant Tissue	0	Johnson (2014)	0	Janes (1984); cited in EFH (1993)	0.92	Williams and Jackson (1981); cited in CHPPM 2004
Invertebrate Tissue	0.85		0		0.08	
Aerial Insect Tissue	0.15		0		0.0	
Crustacean Tissue	0		0		0	
Fish Tissue	0		0		0	
Mammal/Bird	0		0.870		0	
Amphibian tissue	0		0		0	
Reptile tissue	0		0.130		0	
Other (food)	0		0		0	

Table 5. Exposure Parameters

Media Exposed	Sediment/Surface Water		Sediment/Surface Water	
Receptor	Tree Swallow		Brown Pelican	
Exposure Parameters				
Body Weight (g) ¹	20.2	Measured value for tree swallow; Nagy (2001)	3400	Adult body weight from Schreiber (1976); cited in CalEPA ECOTOX
Body Weight (kg) ¹	0.0202	Measured value for tree swallow; Nagy (2001)	3.40	Adult body weight from Schreiber (1976); cited in CalEPA ECOTOX
Drinking Water Rate (L/day) ²	0.004	WIR = 0.059*(BW) ^{0.67} ; Calder and Braun (1983)	0.134	WIR = 0.059*(BW) ^{0.67} ; Calder and Braun (1983)
Food Ingestion Rate (g/day, dw) ³	11.6	Measured value for tree swallow; Nagy (2001)	269	FIR (g/day, dw) = 0.279*BW ^{0.845} (Pelecaniformes equation from Nagy 2001)
Food Ingestion Rate (kg/day, dw) ³	0.0116		0.269	
Fraction Soil Ingested (unitless) ⁴	0	Assumed negligible based on feeding strategy	0.02	Assumed minimal incidental sediment ingestion based on feeding strategy (capture fish near surface); blue-winged teal and ring- necked duck used as surrogate (Beyer et al. 1994)
Site Area				
Site Use Factor (unitless)	1	Conservative assumption	1	Conservative assumption
Home Range (acres)	9513	Average of male/female during incubation. Robertson et al., (1992); CHPPM 2004	310611	Forages mainly within 20 km of nesting islands (Briggs et al. 1981; cited in Shields 2014)
Dietary Composition (fraction of diet)				
Plant Tissue	0.17	Beal (1918); CHPPM 2004	0	Shields (2014)
Invertebrate Tissue	0.26		0	
Aerial Insect Tissue	0.57		0	
Crustacean Tissue	0		0	
Fish Tissue	0		1	
Mammal/Bird	0		0	
Amphibian tissue	0		0	
Reptile tissue	0		0	
Other (food)	0.00		0	

Table 5. Exposure Parameters

Notes:

1. Body weights are the average of available male and female adult values in United States Environmental Protection Agency (USEPA) (1993) unless otherwise indicated.
2. Drinking water rate was calculated based on equations provided by USEPA (1993):
Avian Water Intake (liter/day) = $0.059 * \text{Body Weight}^{0.67} \text{ (kg)}$
Mammal Water Intake (liter/day) = $0.099 * \text{Body Weight}^{0.90} \text{ (kg)}$
3. Food ingestion rates were derived from Nagy (2001), using the species-specific rates given by Nagy (2001) in Table 1, if available, or calculated using dry matter intake equations provided by Nagy (2001) in Table 2 (mammals) or Table 3 (birds). All references to tables in this row refer to tables in the Nagy (2001) paper.
4. Soil/sediment incidental ingestion rates provided by Beyer et al. (1994) unless otherwise noted. Surrogate species selected if no value was available for receptor.
5. Dietary fractions were assumed to 100% aquatic for the aquatic receptors or 100% terrestrial for the terrestrial receptors.

BW - body weight

dw - dry weight

FIR - food ingestion rate

g - gram

ha - hectare

kg - kilogram

km - kilometer

L - liter

DWR - drinking water rate

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Table 6. Bioaccumulation Factor Summary

Bioaccumulation Factors	Terrestrial Plants	Terrestrial Invertebrates	Terrestrial Small Mammals	Aquatic Plants	Aquatic Invertebrates and Bivalves	Aquatic Crustaceans
Perfluorinated Compounds	BAF	BAF	BAF	BSAF	BSAF	BSAF
PFTeA	0.22	--	--	--	16	22
PFTriDA	0.043	--	--	--	34	23
PFD _o A	0.55	42.0	--	5.2	8	17
PFUnA	0.71	14.8	--	3.8	10	12
PFDS	0.19	12.6	--	--	31	12
PFDA	0.70	6.5	--	4.6	35	17
PFNA	1.1	4.6	--	3.1	463	65
PFOS	0.66	18.6	11	61	106	25
PFOS (branched)	0.29	--	--	--	--	--
PFOA	0.11	2.0	--	3.5	281	77
PFHpS	2.6	--	--	--	--	--
PFHpA	1.2	0.82	--	2.9	119	50
PFHxS	1.5	54	--	0.2	263	154
PFHxS (branched)	8.0	--	--	--	--	--
PFHxA	2.2	1.9	--	4.7	--	--
PFPeA	3.7	4.1	--	1.0	--	--
PFBS	3.6	31	--	1.8	--	--
PFBA	8.0	7	--	6.2	--	--
HFPO-TA	--	--	--	--	--	--
Polyfluorinated Fluorotelomer Acids and Alcohols						
8:2 Cl-PFESA	--	--	--	--	--	--
6:2 Cl-PFESA	--	--	--	--	--	--
6:2 FTOH	0.065	--	--	--	--	--
6:2 FTCA	3.1	--	--	--	--	--
6:2 FTUCA	2.6	--	--	--	--	--
6:2 FTSA	35	--	--	--	--	--

Notes:

Presented bioaccumulation factors (BAFs) and biota-sediment accumulation factors (BSAFs) are the geometric mean of the BAF or BSAF calculated for each group.

Table 6. Bioaccumulation Factor Summary

Bioaccumulation Factors	Aquatic Fish	Aquatic Amphibians	Aquatic Plants	Aquatic Benthic Invertebrates	Aquatic Crustaceans	Aquatic Fish
Perfluorinated Compounds	BSAF	BAF	BAF	BAF	BAF	BAF
PFTeA	16	127,936	--	--	--	--
PFTriDA	17	214,290	--	--	--	--
PFDoA	15	82,996	--	--	--	--
PFUnA	17	36,156	--	--	--	--
PFDS	60	--	--	--	--	--
PFDA	38	2,210	12,360	707	6,602	8,953
PFNA	92	49	5,188	983	3,511	3,344
PFOS	72	3,322	1,305	1,549	5,608	13,229
PFOS (branched)	--	--	--	--	--	--
PFOA	17	0.8	228	379	703	894
PFHpS	--	--	--	--	--	--
PFHpA	5.6	--	--	351	150	252
PFHxS	86	1,198	12	1,327	1,477	1,253
PFHxS (branched)	--	--	--	--	--	--
PFHxA	--	2.9	191	2,238	777	317
PFPeA	--	--	--	--	--	24,273
PFBS	--	--	8	298	388	916
PFBA	--	--	19	--	--	3,200
HFPO-TA	--	5.1	--	--	--	--
Polyfluorinated Fluorotelomer Acids and Alcohols						
8:2 Cl-PFESA	--	90,628	--	--	--	--
6:2 Cl-PFESA	--	8,355	--	--	--	--
6:2 FTOH	--	--	--	--	--	--
6:2 FTCA	--	--	--	--	--	--
6:2 FTUCA	--	--	--	--	--	--
6:2 FTSA	--	--	--	--	--	--

Notes:

Presented bioaccumulation factors (BAFs) and biota-sediment accumulation factors (BSAFs) are the geometric mean of the BAF or BSAF calculated for each group.

Table 7. Recommended Water Quality Risk-Based Screening Levels

					Minimum GMAV							
Constituent	Units	Acute Dataset Count	GLI Species Groups ¹	Tier I or Tier II Methodology	Species - Common Name	Species - Scientific Name	GMAV Study	GMAV Value	SAF	Acute RWQ RBSL	ACR	Chronic RWQ RBSL
Perfluorinated Compounds												
PFDoA	mg/L	2	1	Tier II	Cladoceran	<i>Chydorus sphaericus</i>	Ding et al. 2012b	2.8E+01	2.2E+01	6.4E-01	1.8E+01	7.2E-02
PFUnA	mg/L	2	1	Tier II	Cladoceran	<i>Chydorus sphaericus</i>	Ding et al. 2012b	1.9E+01	2.2E+01	4.4E-01	1.8E+01	4.9E-02
PFDA	mg/L	3	2	Tier II	Rainbow trout	<i>Oncorhynchus mykiss</i>	Hoke et al. 2012	3.2E+01	1.3E+01	1.2E+00	1.8E+01	1.4E-01
PFNA	mg/L	3	2	Tier II	Cladoceran	<i>Chydorus sphaericus</i>	Ding et al. 2012b	2.8E+01	1.3E+01	1.1E+00	1.8E+01	1.2E-01
PFOS	mg/L	50	8	Tier I	Nematode	<i>Caenorhabditis elegans</i>	Chen et al. 2018	7.0E-01	NA	5.7E-01	2.3E+01	5.1E-02
PFOA	mg/L	24	8	Tier I	Asiatic toad	<i>Bufo gargizans</i>	Yang et al. 2014	1.1E+02	NA	5.3E+01	2.7E+01	3.9E+00
PFHpA ²	mg/L	1	1	Tier II	African clawed frog	<i>Xenopus laevis</i>	Kim et al. 2015	3.4E+02	2.2E+01	7.8E+00	1.8E+01	8.7E-01
PFHxA	mg/L	3	3	Tier II	Rotifer	<i>Brachionus calyciflorus</i>	Wang et al. 2014	1.4E+02	8.0E+00	8.8E+00	7.6E+00	2.3E+00
PFPeA ³	mg/L	2	2	Tier II	Fathead minnow	<i>Pimephales promelas</i>	Hoke et al. 2012	3.2E+01	1.3E+01	1.2E+00	1.8E+01	1.4E-01
PFBS	mg/L	4	4	Tier II	Nematode	<i>Caenorhabditis elegans</i>	Chen et al. 2018	2.4E+02	7.0E+00	1.7E+01	1.0E+01	3.4E+00
PFBA	mg/L	4	2	Tier II	Rotifer	<i>Brachionus calyciflorus</i>	Wang et al. 2014	1.1E+02	1.3E+01	4.2E+00	1.8E+01	4.7E-01
PFPrA ²	mg/L	1	1	Tier II	Rotifer	<i>Brachionus calyciflorus</i>	Wang et al. 2014	8.0E+01	2.2E+01	1.8E+00	1.8E+01	2.0E-01
Polyfluorinated Fluorotelomer Acids and Alcohols												
10:2 FTCA	mg/L	1	1	Tier II	Water flea	<i>Daphnia magna</i>	Phillips et al. 2007	3.0E-02	2.2E+01	6.8E-04	6.9E+00	2.0E-04
10:2 FTuCA	mg/L	1	1	Tier II	Water flea	<i>Daphnia magna</i>	Phillips et al. 2007	2.8E-01	2.2E+01	6.4E-03	1.1E+01	1.2E-03
8:2 FTCA	mg/L	2	1	Tier II	Water flea	<i>Daphnia magna</i>	Multiple	2.6E+00	2.2E+01	6.0E-02	1.8E+01	6.7E-03
8:2 FTuCA	mg/L	3	2	Tier II	Water flea	<i>Daphnia magna</i>	Multiple	3.6E+00	1.3E+01	1.4E-01	1.8E+01	1.5E-02
7:3 Acid	mg/L	3	2	Tier II	Water flea	<i>Daphnia magna</i>	Hoke et al. 2012	9.6E-01	1.3E+01	3.7E-02	1.8E+01	4.1E-03
6:2 Cl-PFESA ²	mg/L	2	1	Tier II	Water flea	<i>Danio rerio</i>	Multiple	1.5E+01	2.2E+01	3.3E-01	9.6E+00	6.9E-02
6:2 FTCA ³	mg/L	1	1	Tier II	Zebrafish	<i>Danio rerio</i>	Shi et al. 2017b	2.5E+01	2.2E+01	5.7E-01	1.8E+01	6.4E-02
6:2 FTuCA	mg/L	1	1	Tier II	Rotifer	<i>Daphnia magna</i>	Hoke et al. 2012	3.0E+01	2.2E+01	6.8E-01	1.8E+01	7.5E-02
6:2 FTAB ²	mg/L	1	1	Tier II	Zebrafish	<i>Danio rerio</i>	Shi et al. 2018a	6.4E+01	2.2E+01	1.5E+00	1.8E+01	1.6E-01
5H 4:1 FTOH	mg/L	2	1	Tier II	Cladoceran	<i>Brachionus calyciflorus</i>	Ding et al. 2012b	2.0E+02	2.2E+01	4.5E+00	1.8E+01	5.0E-01
FC807 ²	mg/L	1	1	Tier II	Zebrafish	<i>Danio rerio</i>	Zheng et al. 2012	2.1E+02	2.2E+01	4.8E+00	1.8E+01	5.4E-01

Notes:

1. The Great Lakes Initiative species group count is the number of species groups (out of 8 possible groups) fulfilled by the dataset and is used to determine the secondary acute factor.
2. The GLI Tier II methodology recommends deriving a value only when a daphnia sp. toxicity value is available and a daphnia value was not identified for this PFAS.
3. The GLI Tier II methodology recommends deriving a value only when a daphnia sp. toxicity value is available and all daphnia values identified were ">" or "<".

ACR - acute to chronic ratio

GMAV - genus mean acute values

mg/L - milligram per liter

RBSL - risk-based screening level

RWQ - recommended water quality

SAF - secondary acute factor

Reference:

United States Environmental Protection Agency. 2012. Water Quality Guidance for the Great Lakes System. Part 132. Available at: <https://www.govinfo.gov/app/details/CFR-2012-title40-vol23/CFR-2012-title40-vol23-part132>.

Table 8. Marine and Freshwater Comparison

		Marine		Freshwater		Freshwater	
		Minimum Acute ¹	Minimum Chronic ^{2,3}	Minimum Acute ¹	Minimum Chronic ²	Acute RWQ RBSL	Chronic RWQ RBSL
PFOS	mg/L	3.6E+00	1.0E-01	7.0E-01	6.0E-04	5.7E-01	5.1E-02
PFOA	mg/L	1.5E+01	1.0E-01	3.9E+01	1.0E-02	5.3E+01	3.9E+00
PFBS	mg/L	3.7E+02	NA	2.4E+02	1.1E+00	1.7E+01	3.4E+00

Notes

1. The minimum acute value presented is the minimum EC50 or LC50 based on an exposure duration of 96 hours (or 48 hours for cladocerans) or less with immobilization or mortality as an endpoint.
2. The minimum chronic value presented is the minimum NOEC or LOEC with a duration over at least the early lifestage.
3. A study exposing turbot to PFOS over 144 hours resulted in a NOEC of 0.015 mg/L. This value was not included as the minimum chronic value for PFOS as 144 hours was not evaluated as a chronic duration for turbot; however, this lower value is available in the data set and may be indicative of turbot as a more sensitive species.

mg/L - milligram per liter

RBSL - risk-based screening level

RWQ - recommended water quality

Table 9. Terrestrial Plant Screening Level Summary

Constituent	NOEC Count	LOEC Count	NOEC Soil SL (mg/kg soil)	LOEC Soil SL (mg/kg soil)
PFDA	1	0	51	NA
PFNA	1	0	46	NA
PFOS ¹	6	7	11	33
PFOA ²	8	14	0.084	0.84
PFBA	1	0	642	NA
5H 4:1 FTOH	1	0	23	NA

Notes:

Calculations of the PFOS and PFOA no observed effect concentration (NOEC) and lowest observed effect concentration (LOEC) soil screening level (SL) using the geometric mean are available in Appendix C. The PFDA, PFNA, PFBA, and 5H 4:1 FTOH soil SLs are based on the single value presented in this table.

1. NOEC count for PFOS includes only bounded NOECs.

2. NOEC count for PFOA includes only bounded NOECs and effect concentration for 10 percent of the population (EC10) values.

mg/kg - milligram per kilogram

Table 10. Terrestrial Invertebrate Screening Level Summary

Constituent	NOEC Count	LOEC Count	NOEC Soil SL (mg/kg soil)	LOEC Soil SL (mg/kg soil)
PFNA ¹	1	1	1	100
PFOS ^{1,2}	1	1	7.7	141
PFOA ^{1,2}	1	0	50	NA
PFHpA ¹	1	1	1	100
PFHxS ¹	1	1	1	100
PFBS ^{1,2}	1	0	10	NA

Notes:

1. PFNA, PFOS, PFHpA, and PFHxS soil SLs are based on a single paired no observed effect concentration (NOEC) and lowest observed effect concentration (LOEC) (Table 2b). The PFOA and PFBS soil SLs are based on a single unbounded NOEC (Table 2b). Although all are based on survival, a UF was not applied to the PFNA, PFHpA, and PFHxS NOEC SLs as the NOEC is already two orders of magnitude lower than the LOEC.
2. A UF of 10 was applied to the PFOS NOEC of 77 mg/kg as it was less than an order of magnitude lower than the LOEC of 141 mg/kg. The PFOA and PFBS NOEC soil SLs are based on an unbounded NOEC with a survival endpoint. Based on this uncertainty, a UF of 10 was applied to calculate the final PFOA and PFBS SLs.

mg/kg - milligram per kilogram

Table 11a
Aquatic Receptor NOAEL RBSLs and RWQ RBSLs

Habitat Feeding Guild		Aquatic RBSL								RWQ RBSL		Minimum	
		Herbivore	Insectivore	Carnivore	Carnivore	Carnivore	Omnivore	Invertivore	Piscivore	Acute	Chronic	Minimum Wildlife RBSL or RWQ RBSL	Basis
Receptor Units	Muskrat	Little Brown Bat	River Otter	Harbor Seal	Mink	Red-Winged Blackbird	Tree Swallow	Brown Pelican					
Constituent													
Sediment													
PFNA	mg/kg	3.6E+00	1.0E-02	2.4E-01	2.0E-01	2.5E-01	NA	NA	NA	--	--	1.0E-02	RBSL
PFOS	mg/kg	2.3E-02	5.3E-03	4.7E-02	4.6E-02	3.8E-02	7.0E-03	1.4E-03	1.4E-02	--	--	1.4E-03	RBSL
PFOA	mg/kg	1.2E+00	6.0E-03	2.8E-01	1.9E-01	4.0E-01	NA	NA	NA	--	--	6.0E-03	RBSL
PFHxA	mg/kg	2.4E+02	1.8E+00	2.9E+01	2.6E+01	2.5E+01	NA	NA	NA	--	--	1.8E+00	RBSL
PFBS	mg/kg	3.7E+02	1.1E+00	1.8E+01	1.6E+01	1.5E+01	2.4E+01	7.3E-01	1.3E+01	--	--	7.3E-01	RBSL
PFBA	mg/kg	1.6E+02	1.6E+00	2.6E+01	2.3E+01	2.2E+01	NA	NA	NA	--	--	1.6E+00	RBSL
Surface Water													
PFNA	mg/L	2.2E-03	4.7E-03	9.2E-03	9.7E-03	6.8E-03	NA	NA	NA	1.1E+00	1.2E-01	2.2E-03	RBSL
PFOS	mg/L	1.1E-03	3.6E-04	2.8E-04	3.1E-04	2.1E-04	3.4E-04	9.1E-05	7.5E-05	5.7E-01	5.1E-02	7.5E-05	RBSL
PFOA	mg/L	1.8E-02	4.4E-03	1.2E-02	1.3E-02	9.4E-03	NA	NA	NA	5.3E+01	3.9E+00	4.4E-03	RBSL
PFHxA	mg/L	6.1E+00	2.1E-01	6.4E+00	5.0E+00	6.9E+00	NA	NA	NA	8.8E+00	2.3E+00	2.1E-01	RBSL
PFBS	mg/L	7.6E+01	9.4E-01	2.0E+00	2.1E+00	1.5E+00	1.7E+01	6.4E-01	1.3E+00	1.7E+01	3.4E+00	6.4E-01	RBSL
PFBA	mg/L	4.9E+01	1.4E+00	8.6E-01	9.3E-01	6.6E-01	NA	NA	NA	4.2E+00	4.7E-01	4.7E-01	RWQ RBSL

Notes:

The minimum RBSL is highlighted gray for each PFAS and media (sediment or surface water).

mg/kg - milligram per kilogram

mg/L - milligram per liter

NA - not available

RBSL - risk-based screening level

RWQ - recommended water quality

Table 11b
Terrestrial Receptor NOAEL RBSLs and Terrestrial Screening Levels

Constituent	Habitat	Terrestrial RBSL							Terrestrial Plant SL	Terrestrial Invertebrate SL	Minimum	
	Feeding Guild	Herbivore	Invertivore	Insectivore	Carnivore	Herbivore	Insectivore	Carnivore	NOAEL	NOAEL	Minimum RBSL or SL	Basis
	Receptor	Meadow Vole	Short-Tailed Shrew	Little Brown Bat	Long-Tailed Weasel	American Goldfinch	House Wren	Red-Tailed Hawk				
	Units											
Soil												
PFNA	mg/kg	2.3E+00	1.5E+00	1.0E+00	1.5E+00	NA	NA	NA	4.6E+01	1.0E+00	1.0E+00	Invertebrate SL
PFOS	mg/kg	3.1E-01	4.8E-02	3.0E-02	1.7E-01	3.8E-01	1.3E-02	8.7E-02	1.1E+01	7.7E+00	1.3E-02	RBSL
PFOA	mg/kg	5.8E+00	1.3E+00	8.4E-01	5.7E-01	NA	NA	NA	8.4E-02	5.0E+01	8.4E-02	Plant SL
PFHxA	mg/kg	1.2E+02	3.4E+02	2.5E+02	1.6E+02	NA	NA	NA	NA	NA	1.2E+02	RBSL
PFBS	mg/kg	3.8E+01	1.4E+01	9.1E+00	7.8E+01	8.9E+01	9.3E+00	1.0E+02	NA	1.0E+01	9.1E+00	RBSL
PFBA	mg/kg	2.9E+01	7.8E+01	5.8E+01	1.3E+02	NA	NA	NA	6.4E+02	NA	2.9E+01	RBSL
Surface Water												
PFNA	mg/L	6.0E+00	5.6E+00	5.2E+00	7.2E+00	NA	NA	NA	--	--	5.2E+00	RBSL
PFOS	mg/L	7.3E-01	6.7E-01	6.3E-01	8.6E-01	3.2E-01	3.0E-01	1.4E+00	--	--	3.0E-01	RBSL
PFOA	mg/L	2.2E+00	2.0E+00	1.9E+00	2.6E+00	NA	NA	NA	--	--	1.9E+00	RBSL
PFHxA	mg/L	6.1E+02	5.6E+02	5.3E+02	7.2E+02	NA	NA	NA	--	--	5.3E+02	RBSL
PFBS	mg/L	3.6E+02	3.4E+02	3.2E+02	4.3E+02	3.7E+02	3.5E+02	1.6E+03	--	--	3.2E+02	RBSL
PFBA	mg/L	5.3E+02	4.9E+02	4.6E+02	6.3E+02	NA	NA	NA	--	--	4.6E+02	RBSL

Notes:

The minimum RBSL among the terrestrial receptor species is highlighted gray for each PFAS and media (soil or surface water).

mg/kg - milligram per kilogram

mg/L - milligram per liter

NA - not available

RBSL - risk-based screening level

SL - screening level

Table 12a
Aquatic Receptor LOAEL RBSLs and RWQ RBSLs

Habitat Feeding Guild		Aquatic RBSL								RWQ RBSL		Minimum	
		Herbivore	Insectivore	Carnivore	Carnivore	Carnivore	Omnivore	Invertivore	Piscivore				
Constituent	Receptor Units	Muskrat	Little Brown Bat	River Otter	Harbor Seal	Mink	Red-Winged Blackbird	Tree Swallow	Brown Pelican	Acute	Chronic	Minimum Wildlife RBSL or RWQ RBSL	Basis
Sediment													
PFNA	mg/kg	4.7E+00	1.3E-02	3.2E-01	2.7E-01	3.3E-01	NA	NA	NA	--	--	1.3E-02	RBSL
PFOS	mg/kg	3.8E-02	8.8E-03	7.7E-02	7.7E-02	6.3E-02	7.0E-02	1.4E-02	1.4E-01	--	--	8.8E-03	RBSL
PFOA	mg/kg	2.3E+00	1.2E-02	5.7E-01	3.9E-01	8.0E-01	NA	NA	NA	--	--	1.2E-02	RBSL
PFHxA	mg/kg	5.1E+02	3.8E+00	6.1E+01	5.5E+01	5.3E+01	NA	NA	NA	--	--	3.8E+00	RBSL
PFBS	mg/kg	1.5E+03	4.3E+00	7.0E+01	6.3E+01	6.0E+01	4.0E+01	1.2E+00	2.2E+01	--	--	1.2E+00	RBSL
PFBA	mg/kg	3.8E+02	3.8E+00	6.1E+01	5.5E+01	5.3E+01	NA	NA	NA	--	--	3.8E+00	RBSL
Surface Water													
PFNA	mg/L	2.9E-03	6.3E-03	1.2E-02	1.3E-02	9.0E-03	NA	NA	NA	1.1E+00	1.2E-01	2.9E-03	RBSL
PFOS	mg/L	1.8E-03	6.0E-04	4.7E-04	5.1E-04	3.6E-04	3.4E-03	9.1E-04	7.5E-04	5.7E-01	5.1E-02	3.6E-04	RBSL
PFOA	mg/L	3.6E-02	8.9E-03	2.4E-02	2.6E-02	1.9E-02	NA	NA	NA	5.3E+01	3.9E+00	8.9E-03	RBSL
PFHxA	mg/L	1.3E+01	4.4E-01	1.3E+01	1.0E+01	1.4E+01	NA	NA	NA	8.8E+00	2.3E+00	4.4E-01	RBSL
PFBS	mg/L	3.0E+02	3.8E+00	8.0E+00	8.5E+00	6.0E+00	2.9E+01	1.1E+00	2.1E+00	1.7E+01	3.4E+00	1.1E+00	RBSL
PFBA	mg/L	1.2E+02	3.3E+00	2.1E+00	2.2E+00	1.6E+00	NA	NA	NA	4.2E+00	4.7E-01	4.7E-01	RWQ RBSL

Notes:

The minimum RBSL among the aquatic receptor species is highlighted gray for each PFAS and media (sediment or surface water).

mg/kg - milligram per kilogram

mg/L - milligram per liter

NA - not available

RBSL - risk-based screening level

RWQ - recommended water quality

Table 12b
Terrestrial Receptor LOAEL RBSLs and Terrestrial Screening Levels

Habitat		Terrestrial RBSL							Terrestrial Plant SL	Terrestrial Invertebrate SL	Minimum	
Feeding Guild	Receptor	Herbivore	Invertivore	Insectivore	Carnivore	Herbivore	Insectivore	Carnivore				
Constituent	Units	Meadow Vole	Short-Tailed Shrew	Little Brown Bat	Long-Tailed Weasel	American Goldfinch	House Wren	Red-Tailed Hawk	LOAEL	LOAEL	Minimum RBSL or SL	Basis
Soil												
PFNA	mg/kg	3.0E+00	2.0E+00	1.3E+00	2.0E+00	NA	NA	NA	NA	1.0E+02	1.3E+00	RBSL
PFOS	mg/kg	5.1E-01	7.9E-02	5.0E-02	2.8E-01	3.8E+00	1.3E-01	8.7E-01	3.3E+01	1.4E+02	5.0E-02	RBSL
PFOA	mg/kg	1.2E+01	2.6E+00	1.7E+00	1.1E+00	NA	NA	NA	8.4E-01	NA	8.4E-01	Plant SL
PFHxA	mg/kg	2.6E+02	7.0E+02	5.3E+02	3.3E+02	NA	NA	NA	NA	NA	2.6E+02	RBSL
PFBS	mg/kg	1.5E+02	5.7E+01	3.6E+01	3.1E+02	1.5E+02	1.5E+01	1.7E+02	NA	NA	1.5E+01	RBSL
PFBA	mg/kg	7.0E+01	1.9E+02	1.4E+02	3.2E+02	NA	NA	NA	NA	NA	7.0E+01	RBSL
Surface Water												
PFNA	mg/L	8.0E+00	7.4E+00	6.9E+00	9.5E+00	NA	NA	NA	--	--	6.9E+00	RBSL
PFOS	mg/L	1.2E+00	1.1E+00	1.0E+00	1.4E+00	3.2E+00	3.0E+00	1.4E+01	--	--	1.0E+00	RBSL
PFOA	mg/L	4.4E+00	4.0E+00	3.8E+00	5.2E+00	NA	NA	NA	--	--	3.8E+00	RBSL
PFHxA	mg/L	1.3E+03	1.2E+03	1.1E+03	1.5E+03	NA	NA	NA	--	--	1.1E+03	RBSL
PFBS	mg/L	1.5E+03	1.3E+03	1.3E+03	1.7E+03	6.2E+02	5.8E+02	2.7E+03	--	--	5.8E+02	RBSL
PFBA	mg/L	1.3E+03	1.2E+03	1.1E+03	1.5E+03	NA	NA	NA	--	--	1.1E+03	RBSL

Notes:

The minimum RBSL among the terrestrial receptor species is highlighted gray for each PFAS and media (soil or surface water).

mg/kg - milligram per kilogram

mg/L - milligram per liter

NA - not available

RBSL - risk-based screening level

SL - screening level

Table 13. Background and Impacted Soil, Sediment, and Surface Water PFAS Concentrations

Media	Constituent	Background Concentration Range	Ref	Impacted Concentration Range ⁶	Min RBSL or SL
Soil (mg/kg)	PFOS	5.8E-04 - 2.6E-03	5	1.7E+00 - 1.9E+00	1.3E-02
	PFOA	3.2E-04 - 3.2E-01	1	5.8E-02 - 1.4E-01	8.4E-02
Sediment (mg/kg)	PFOS	2.0E-04 - 3.0E-03	4	1.9E+02	1.4E-03
	PFOA	1.4E-04 - 3.9E-03	1, 4	9.5E-01	6.0E-03
Surface Water (mg/L)	PFOS	1.6E-06 - 7.6E-04	2	9.0E+01	7.5E-05
	PFOA	6.5E-07 - 6.0E-04	1, 3	2.1E-01	4.4E-03

Notes:
mg/L - milligram per liter
mg/kg - milligram per kilogram
min - minimum
RBSL - risk-based screening level
SL - screening level

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Figure 1. Approach to Screening Level Development for Each Receptor and Habitat

Receptor	Receptor Group	Methodology	Exposure Pathway Evaluated	Soil (mg/kg)	Sediment(mg/kg)	Surface Water (mg/L)
Terrestrial Receptor	Plant	EcoSSL	Media	Soil SL	NA	NA
	Invertebrate	EcoSSL	Media	Soil SL	NA	NA
	Bird	EcoSSL	Foodweb	Wildlife RBSL	NA	Wildlife RBSL
	Mammal	EcoSSL	Foodweb	Wildlife RBSL	NA	Wildlife RBSL
	Reptile	NE	NE	NE	NA	NE
Aquatic Receptor	Plant	GLI	Media	NA	NA	Tier II WQC
	Aquatic Invertebrate ¹	GLI	Media	NA	NE	Tier II WQC
	Benthic Invertebrate ¹	EcoSSL	Media	NA	NE	NA
	Fish ²	GLI / EcoSSL	Media / Foodweb	NA	NE	Tier II WQC
	Amphibian	GLI	Media	NA	NA	Tier II WQC
	Bird	EcoSSL	Foodweb	NA	Wildlife RBSL	Wildlife RBSL
	Mammal	EcoSSL	Foodweb	NA	Wildlife RBSL	Wildlife RBSL
	Reptile	NE	NE	NA	NE	NE

Notes

- Insufficient data are available to evaluate benthic invertebrate toxicity from exposure to sediments using EcoSSL methodology. The aquatic data set used to calculate GLI Tier II WQC based on water exposure includes benthic invertebrates exposed via water.
- Insufficient data are available to evaluate fish toxicity from exposure to sediments using dietary exposure studies and EcoSSL RBSL methodology. The aquatic data set used to calculate GLI Tier II WQC based on water exposure includes fish exposed via water.

EcoSSL - Ecological Soil Screening Level

GLI - Great Lakes Initiative

mg/kg - milligrams per kilogram

mg/L - milligrams per liter

NA - exposure pathway not applicable to methodology

NE - not evaluated due to insufficient data

WQC - Water Quality Criteria

SL - screening level

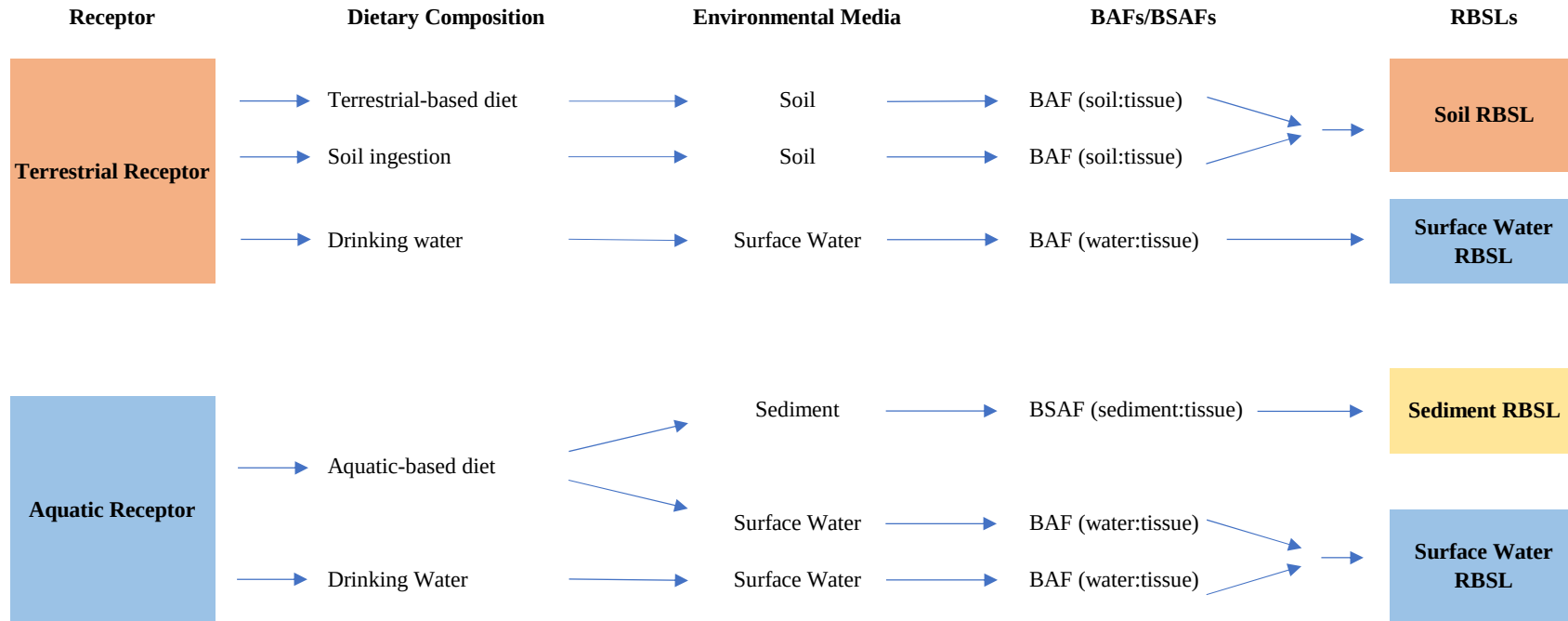
RBSL - risk-based screening level

References

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Figure 2. Exposure Pathways Included in the Wildlife Risk-Based Screening Levels



Appendix A

Threatened and Endangered Species Selection

Appendix A - Threatened and Endangered Species Selection
Table 1a. Representative and Surrogate Species Selection

ECOS T&E Species					Representative T&E Species	U.S. Range by State ⁵	Reasoning	Representative Surrogate Species	Reasoning
Common Name	Federal Listing Status	Size	Feeding Guild	Habitat					
Bearded Seal	threatened	large	Carnivore / Piscivore ¹	Aquatic	Guadalupe fur seal, Southern sea otter	California	most similar to common surrogate species; river otter presence on or adjacent to DOD installation ³	Harbor Seal, River Otter, Mink	common surrogate species
Beluga whale	endangered	large							
Blue whale	endangered	large							
Bowhead whale	endangered	large							
False killer whale	endangered	large							
Finback whale	endangered	large							
Guadalupe fur seal	threatened	large							
Hawaiian monk seal	endangered	large							
Humpback whale	threatened	large							
North Atlantic Right Whale	endangered	large							
North Pacific Right Whale	endangered	large							
Ringed Seal	endangered / threatened ⁷	large							
Sei whale	endangered	large							
Sperm whale	endangered	large							
Spotted Seal	threatened	large							
Steller sea lion	endangered	large							
Northern sea otter	threatened	small							
Southern sea otter	threatened	small							

ECOS T&E Species					Representative T&E Species	U.S. Range by State ⁵	Reasoning	Representative Surrogate Species	Reasoning
Common Name	Federal Listing Status	Size	Feeding Guild	Habitat					
Gray Bat	endangered	small	Insectivore	Aquatic	Gray Bat	Alabama, Arkansas, Florida, Georgia, Illinois, Indiana, Kansas, Kentucky, Mississippi, Missouri, North Carolina, Oklahoma, Tennessee, Virginia, West Virginia	small size, aquatic insectivore receptor	Little brown bat	similar to T&E species, common surrogate species

ECOS T&E Species					Representative T&E Species	U.S. Range by State ⁵	Reasoning	Representative Surrogate Species	Reasoning
Common Name	Federal Listing Status	Size	Feeding Guild	Habitat					
Florida salt marsh vole	endangered	small	Herbivore	Aquatic	Point arena mountain beaver	California	small size, similar to common surrogate species	Muskrat	common surrogate species
Salt marsh harvest mouse	endangered	small							
Point Arena mountain beaver	endangered	small							
West Indian Manatee	threatened	large							

Appendix A - Threatened and Endangered Species Selection
Table 1a. Representative and Surrogate Species Selection

ECOS T&E Species					Representative T&E Species	U.S. Range by State ^{5,6}	Reasoning	Representative Surrogate Species	Reasoning
Common Name	Federal Listing Status	Size	Feeding Guild	Habitat					
Black-footed ferret	endangered	small	Carnivore	Terrestrial	Black-footed ferret	Arizona, Colorado, Kansas, Montana, New Mexico, South Dakota	small size, similar to common surrogate species, large potential range in U.S.	Long-tailed weasel	common surrogate species
Canada Lynx	threatened	large							
Florida panther	endangered	large							
Gray wolf	endangered / threatened ⁷	large							
Gulf Coast jaguarundi	endangered	large							
Jaguar	endangered	large							
Margay	endangered	large							
Mexican wolf	endangered	large							
Ocelot	endangered	large							
Red wolf	endangered	large							
San Joaquin kit fox	endangered	large							
Santa Catalina Island Fox	threatened	large							
Sinaloan Jaguarundi	endangered	large							

ECOS T&E Species					Representative T&E Species	U.S. Range by State ⁵	Reasoning	Representative Surrogate Species	Reasoning
Common Name	Federal Listing Status	Size	Feeding Guild	Habitat					
Florida bonneted bat	endangered	small	Insectivore	Terrestrial	Northern Long-Eared Bat	Alabama , Arkansas , Connecticut , Delaware , District of Columbia , Georgia , Illinois , Indiana , Iowa , Kansas , Kentucky , Louisiana , Maine , Maryland , Massachusetts , Michigan , Minnesota , Mississippi , Missouri , Montana , Nebraska , New Hampshire , New Jersey , New York , North Carolina , North Dakota , Ohio , Oklahoma , Pennsylvania , Rhode Island , South Carolina , South Dakota , Tennessee , Vermont , Virginia , West Virginia , Wisconsin , Wyoming	found on approximately 91 DOD installations ⁴ , similar to other T&E species in guild	Little brown bat	similar to T&E species, common surrogate species
Hawaiian hoary bat	endangered	small							
Northern Long-Eared Bat	threatened	small							
Ozark big-eared bat	endangered	small							
Pacific sheath-tailed Bat	endangered	small							
Virginia big-eared bat	endangered	small							

ECOS T&E Species					Representative T&E Species	U.S. Range by State ⁵	Reasoning	Representative Surrogate Species	Reasoning
Common Name	Federal Listing Status	Size	Feeding Guild	Habitat					
Buena Vista Lake ornate Shrew	endangered	small	Invertivore	Terrestrial	Buena Vista Lake Ornate Shrew	California	Only T&E species in feeding guild	Short-tailed shrew	similar to T&E species, common surrogate species

Appendix A - Threatened and Endangered Species Selection
Table 1a. Representative and Surrogate Species Selection

ECOS T&E Species					Representative T&E Species	U.S. Range by State ⁵	Reasoning	Representative Surrogate Species	Reasoning
Common Name	Federal Listing Status	Size	Feeding Guild	Habitat					
Alabama beach mouse	endangered	small	Herbivore	Terrestrial	Amargosa vole	California	small, similar to common surrogate species, similar to majority of other T&E species in feeding guild	Meadow vole	similar to T&E species, common surrogate species
Amargosa vole	endangered	small							
Anastasia Island beach mouse	endangered	small							
Carolina northern flying squirrel	endangered	small							
Choctawhatchee beach mouse	endangered	small							
Columbia Basin Pygmy Rabbit	endangered	small							
Columbian white-tailed deer	threatened	large							
Fresno kangaroo rat	endangered	small							
Giant kangaroo rat	endangered	small							
Key deer	endangered	large							
Key Largo woodrat	endangered	small							
Lower Keys marsh rabbit	endangered	small							
Mariana fruit Bat (Mariana flying fox)	threatened	small							
Little Mariana fruit Bat	endangered	small							
Mexican long-nosed bat	endangered	small							
Morro Bay kangaroo rat	endangered	small							
Mount Graham red squirrel	endangered	small							
Northern Idaho Ground Squirrel	threatened	small							
Olympia pocket gopher	threatened	small							
Pacific pocket mouse	endangered	small							
Peninsular bighorn sheep	endangered	large							
Perdido Key beach mouse	endangered	small							
Preble's meadow jumping mouse	threatened	small							
Riparian brush rabbit	endangered	small							
Riparian woodrat (San Joaquin Valley)	endangered	small							
Roy Prairie pocket gopher	threatened	small							
San Bernardino Merriam's kangaroo rat	endangered	small							
Sierra Nevada bighorn sheep	endangered	large							
Sonoran pronghorn	endangered	large							
Southeastern beach mouse	threatened	small							
St. Andrew beach mouse	endangered	small							
Stephens' kangaroo rat	endangered	small							
Tenino pocket gopher	threatened	small							
Tipton kangaroo rat	endangered	small							
Utah prairie dog	threatened	small							
Wood Bison	threatened	large							
Woodland Caribou	endangered	large							
Yelm pocket gopher	threatened	small							

ECOS T&E Species					Representative T&E Species	U.S. Range by State ⁵	Reasoning	Representative Surrogate Species	Reasoning
Common Name	Federal Listing Status	Size	Feeding Guild	Habitat					
Puerto Rican sharp-shinned hawk	endangered	large	Carnivore	Terrestrial	Mexican spotted owl	Arizona , Colorado , New Mexico , Texas , Utah	Included in top ten cumulative DOD expenditures on T&E species ²	Red-tailed hawk	similar to T&E species, common surrogate species
Puerto Rican broad-winged hawk	endangered	large							
Hawaiian (=lo) Hawk	endangered	large							
Northern Aplomado Falcon	endangered	large							
California condor	endangered	large							
Audubon's crested caracara	threatened	large							
Northern spotted owl	threatened	large							
Mexican spotted owl	threatened	large							

Appendix A - Threatened and Endangered Species Selection
Table 1a. Representative and Surrogate Species Selection

ECOS T&E Species					Representative T&E Species	U.S. Range by State ⁵	Reasoning	Representative Surrogate Species	Reasoning
Common Name	Federal Listing Status	Size	Feeding Guild	Habitat					
Nihoa millerbird (old world warbler)	endangered	small	Insectivore	Terrestrial	Red-cockaded woodpecker	Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, Texas, Virginia	Included in top ten cumulative DOD expenditures on T&E species ²	House wren	similar to T&E species, common surrogate species
Mariana gray swiftlet	endangered	small							
Ivory-billed woodpecker	endangered	large							
Puerto Rican nightjar	endangered	small							
Oahu elepaio	endangered	small							
Yellow-billed Cuckoo	threatened	small							
Golden-cheeked warbler (=wood)	endangered	small							
Southwestern willow flycatcher	endangered	small							
Maui nukupuu	endangered	small							
Kauai nukupuu	endangered	small							
akiapolaau	endangered	small							
Akekee	endangered	small							
Hawaii akepa	endangered	small							
Maui akepa	endangered	small							
Akikiki	endangered	small							
Hawaii creeper	endangered	small							
Molokai creeper	endangered	small							
Oahu creeper	endangered	small							
Red-cockaded woodpecker	endangered	small							
Coastal California gnatcatcher	threatened	small							
Maui parrotbill (Kiwikiu)	endangered	small							
Elfin-woods warbler	threatened	small							
Kirtland's Warbler	endangered	small							
Bachman's warbler (=wood)	endangered	small							
Least Bell's vireo	endangered	small							
Rota bridled White-eye	endangered	small							

ECOS T&E Species					Representative T&E Species	U.S. Range by State ⁵	Reasoning	Representative Surrogate Species	Reasoning
Common Name	Federal Listing Status	Size	Feeding Guild	Habitat					
Puerto Rican parrot	endangered	large	Herbivore / Frugivore / Nectivore	Terrestrial	Palila (honeycreeper)	Hawaii	small, similar to common surrogate species	American goldfinch	common surrogate species
Hawaiian goose	endangered	large							
Puerto Rican plain Pigeon	endangered	small							
Tiwi	threatened	small							
Friendly Ground-Dove	endangered	small							
Palila (honeycreeper)	endangered	small							
Thick-billed parrot	endangered	large							

ECOS T&E Species					Representative T&E Species	U.S. Range by State ⁵	Reasoning	Representative Surrogate Species	Reasoning
Common Name	Federal Listing Status	Size	Feeding Guild	Habitat					
Marbled murrelet	threatened	small	Piscivore	Aquatic	California least tern	Arizona, California	Included in top ten cumulative DOD expenditures on T&E species ²	Brown pelican	similar to T&E species, common surrogate species
Band-rumped storm-petrel	endangered	small							
Short-tailed albatross	endangered	large							
Bermuda petrel	endangered	small							
Hawaiian petrel	endangered	small							
Newell's Townsend's shearwater	threatened	large							
California least tern	endangered	small							
Roseate tern	endangered	small							

Appendix A - Threatened and Endangered Species Selection
Table 1a. Representative and Surrogate Species Selection

ECOS T&E Species					Representative T&E Species	U.S. Range by State ⁵	Reasoning	Representative Surrogate Species	Reasoning
Common Name	Federal Listing Status	Size	Feeding Guild	Habitat					
Red knot	threatened	large	Invertivore	Aquatic	Western snowy plover	California, Oregon, Washington	Included in top ten cumulative DOD expenditures on T&E species ²	Tree swallow	similar to T&E species, common surrogate species
Piping Plover	endangered	small							
Western snowy plover	threatened	small							
Steller's Eider	threatened	large							
Everglade snail kite	endangered	large							
Spectacled eider	threatened	large							
Least tern	endangered	small							

ECOS T&E Species					Representative T&E Species	U.S. Range by State ⁵	Reasoning	Representative Surrogate Species	Reasoning
Common Name	Federal Listing Status	Size	Feeding Guild	Habitat					
Yellow-shouldered blackbird	endangered	small	Omnivore	Aquatic / Wetland	Yellow-shouldered blackbird	Puerto Rico	small, similar to commonly used surrogate species	Red-winged blackbird	common surrogate species
Laysan duck	endangered	large							
Hawaiian (=koloa) Duck	endangered	large							
Hawaiian coot	endangered	large							
Mariana common moorhen	endangered	large							
Hawaiian common gallinule	endangered	large							
Whooping crane	endangered	large							
Mississippi sandhill crane	endangered	large							
Light-footed clapper rail	endangered	large							
California clapper rail	endangered	large							
Yuma clapper rail	endangered	large							

Notes and References

T&E - threatened and endangered species

1. Feeding guild is inclusive of receptors with diets of crustaceans and cephalopods such as the blue whale. Harbor seal, river otter, and mink were selected as representative surrogate species. The harbor seal was considered a representative surrogate species for Guadalupe fur seal. River otters and mink were selected to model exposure for an inland aquatic piscivore or opportunistic carnivore receptor.
2. Dalsimer. 2017. Threatened and Endangered Species on DOD Lands. March.
3. U.S. Fish and Wildlife Service. 2011. Programmatic Biological Opinion, Vandenberg Air Force Base, Santa Barbara County, California. September.
4. U.S. Army Corps of Engineers. 2016. Evaluation of 757 Species Under U.S. Endangered Species Act Review on U.S. Department of Defense Lands and their Potential Impact on Army Training. March.
5. Environmental Conservation Online System - Species Profiles. Available at: <https://ecos.fws.gov/ecp/>
6. States with experimental populations, non-essential were not included in the listed states with receptor range.
7. Species with populations or subspecies listed as both threatened and endangered on ECOS present both under listing status.

Appendix A - Threatened and Endangered Species Selection
Table 1b. Threatened and Endangered Species Excluded from Evaluation

ECOS T&E Species					
Common Name	Federal Listing Status	Size	Feeding Guild	Habitat	Reason for Excluding
Indiana bat	endangered	small	insectivore	aquatic/terrestrial	multiple habitats
New Mexico meadow jumping mouse	endangered	small	herbivore	aquatic/terrestrial	
Guam Micronesian kingfisher	endangered	small	carnivore	terrestrial/aquatic	
Eskimo curlew	endangered	small	omnivore	terrestrial/aquatic	
Killer whale	endangered	large	piscivorous/carnivore	aquatic	multiple feeding guilds
Rice rat	endangered	small	omnivore/invertivore	terrestrial/aquatic	
Kauai akialoa (honeycreeper)	endangered	small	insectivore/nectivore	terrestrial	
Hawaiian stilt	endangered	large	invertivore/carnivore	aquatic	
San Clemente loggerhead shrike	endangered	small	insectivore/carnivore	terrestrial	
Cape Sable seaside sparrow	endangered	small	omnivore	terrestrial	few T&E species in guild, considered protected by terrestrial avian herbivore and carnivore
Florida grasshopper sparrow	endangered	small	omnivore	terrestrial	
San Clemente sage sparrow	threatened	small	omnivore	terrestrial	
Florida scrub-jay	threatened	small	omnivore	terrestrial	
Gunnison sage-grouse	threatened	large	omnivore	terrestrial	
Masked bobwhite (quail)	endangered	small	omnivore	terrestrial	
Hawaiian (=alala) Crow	endangered	large	omnivore	terrestrial	
Mariana (=aga) Crow	endangered	large	omnivore	terrestrial	
White-necked crow	endangered	large	omnivore	terrestrial	
Streaked Horned lark	threatened	small	omnivore	terrestrial	
Mao (= maomao) (honeyeater)	endangered	small	omnivore	terrestrial	
Micronesian megapode	endangered	large	omnivore	terrestrial	
Kauai `o`o (honeyeater)	endangered	small	omnivore	terrestrial	
Molokai thrush	endangered	small	omnivore	terrestrial	
Guam rail	endangered	small	omnivore	terrestrial	
Laysan finch (honeycreeper)	endangered	small	omnivore	terrestrial	
Nihoa finch (honeycreeper)	endangered	small	omnivore	terrestrial	
Attwater's greater prairie- chicken	endangered	large	omnivore	terrestrial	
Bridled white-eye	endangered	small	omnivore	terrestrial	
Large Kauai (=kamao) Thrush	endangered	small	omnivore (primarily frugivorous)	terrestrial	
Small Kauai (=puaiohi) Thrush	endangered	small	omnivore (primarily frugivorous)	terrestrial	
crested honeycreeper (Akohekohe)	endangered	small	omnivore (primarily frugivorous)	terrestrial	
Inyo California towhee	threatened	small	omnivore (primarily herbivorous)	terrestrial	
ʻOʻu (honeycreeper)	endangered	small	omnivore (primarily frugivorous)	terrestrial	
Poʻouli (honeycreeper)	endangered	small	invertivore	terrestrial	few T&E species in guild, considered protected by terrestrial avian herbivore and carnivore
Grizzly bear	threatened	large	omnivore	terrestrial	few T&E species in guild, considered protected by terrestrial mammal herbivore and carnivore
Key Largo cotton mouse	endangered	small	omnivore	terrestrial	
Polar bear	threatened	large	carnivore	aquatic	few T&E species in guild, considered protected by terrestrial carnivores or aquatic piscivore
Nightingale reed warbler (old world warbler)	endangered	small	carnivore	wetland	
Wood stork	threatened	large	carnivore	wetland	

Notes

T&E - threatened and endangered species



U.S. Fish & Wildlife Service

ECOS
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Species Search Results

93 Records

Parameters:

- Species Groups: Mammals
- Listing Statuses: Endangered, Threatened, Emergency Listing, Endangered, Emergency Listing, Threatened
- Listed in the US

Scientific Name	Common Name	Family	Species Group	Federal Listing Status
<u><i>Peromyscus polionotus ammobates</i></u>	Alabama beach mouse	Muridae	Mammals	🚫 Endangered
<u><i>Microtus californicus scirpensis</i></u>	Amargosa vole	Cricetidae	Mammals	🚫 Endangered
<u><i>Peromyscus polionotus phasma</i></u>	Anastasia Island beach mouse	Muridae	Mammals	🚫 Endangered
<u><i>Erignathus barbatus nauticus</i></u>	bearded Seal	Phocidae	Mammals	🚫 Threatened
<u><i>Delphinapterus leucas</i></u>	beluga whale	Monodontidae	Mammals	🚫 Endangered
<u><i>Mustela nigripes</i></u>	Black-footed ferret	Mustelidae	Mammals	🚫 Endangered
<u><i>Balaenoptera musculus</i></u>	Blue whale	Balaenopteridae	Mammals	🚫 Endangered
<u><i>Balaena mysticetus</i></u>	Bowhead whale	Balaenidae	Mammals	🚫 Endangered
<u><i>Sorex ornatus relictus</i></u>	Buena Vista Lake ornate Shrew	Soricidae	Mammals	🚫 Endangered
<u><i>Lynx canadensis</i></u>	Canada Lynx	Felidae	Mammals	🚫 Threatened
<u><i>Glaucomys sabrinus coloratus</i></u>	Carolina northern flying squirrel	Sciuridae	Mammals	🚫 Endangered
<u><i>Peromyscus polionotus allophrys</i></u>	Choctawhatchee beach mouse	Muridae	Mammals	🚫 Endangered
<u><i>Brachylagus idahoensis</i></u>	Columbia Basin Pygmy Rabbit	Leporidae	Mammals	🚫 Endangered
<u><i>Odocoileus virginianus leucurus</i></u>	Columbian white-tailed deer	Cervidae	Mammals	🚫 Threatened
<u><i>Pseudorca crassidens</i></u>	false killer whale	Delphinidae	Mammals	🚫 Endangered
<u><i>Balaenoptera physalus</i></u>	Finback whale	Balaenopteridae	Mammals	🚫 Endangered
<u><i>Eumops floridanus</i></u>	Florida bonneted bat	Molossidae	Mammals	🚫 Endangered
<u><i>Puma (=Felis) concolor coryi</i></u>	Florida panther	Felidae	Mammals	🚫 Endangered

Scientific Name	Common Name	Family	Species Group	Federal Listing Status
<u><i>Microtus pennsylvanicus dukecampbelli</i></u>	Florida salt marsh vole	Cricetidae	Mammals	❗ Endangered
<u><i>Dipodomys nitratoideis exilis</i></u>	Fresno kangaroo rat	Heteromyidae	Mammals	❗ Endangered
<u><i>Dipodomys ingens</i></u>	Giant kangaroo rat	Heteromyidae	Mammals	❗ Endangered
<u><i>Myotis grisescens</i></u>	Gray bat	Vespertilionidae	Mammals	❗ Endangered
<u><i>Canis lupus</i></u>	Gray wolf	Canidae	Mammals	❗ Endangered
<u><i>Canis lupus</i></u>	Gray wolf	Canidae	Mammals	❗ Threatened
<u><i>Ursus arctos horribilis</i></u>	Grizzly bear	Ursidae	Mammals	❗ Threatened
<u><i>Arctocephalus townsendi</i></u>	Guadalupe fur seal	Phocidae	Mammals	❗ Threatened
<u><i>Herpailurus (=Felis) yagouaroundi cacomitti</i></u>	Gulf Coast jaguarundi	Felidae	Mammals	❗ Endangered
<u><i>Lasiurus cinereus semotus</i></u>	Hawaiian hoary bat	Vespertilionidae	Mammals	❗ Endangered
<u><i>Monachus schauinslandi</i></u>	Hawaiian monk seal	Phocidae	Mammals	❗ Endangered
<u><i>Megaptera novaeangliae</i></u>	Humpback whale	Balaenopteridae	Mammals	❗ Threatened
<u><i>Myotis sodalis</i></u>	Indiana bat	Vespertilionidae	Mammals	❗ Endangered
<u><i>Panthera onca</i></u>	Jaguar	Felidae	Mammals	❗ Endangered
<u><i>Odocoileus virginianus clavium</i></u>	Key deer	Cervidae	Mammals	❗ Endangered
<u><i>Peromyscus gossypinus allapaticola</i></u>	Key Largo cotton mouse	Muridae	Mammals	❗ Endangered
<u><i>Neotoma floridana smalli</i></u>	Key Largo woodrat	Cricetidae	Mammals	❗ Endangered
<u><i>Orcinus orca</i></u>	Killer whale	Delphinidae	Mammals	❗ Endangered
<u><i>Pteropus tokudae</i></u>	Little Mariana fruit Bat	Pteropidae	Mammals	❗ Endangered
<u><i>Sylvilagus palustris hefneri</i></u>	Lower Keys marsh rabbit	Leporidae	Mammals	❗ Endangered
<u><i>Leopardus (=Felis) wiedii</i></u>	Margay	Felidae	Mammals	❗ Endangered
<u><i>Pteropus mariannus mariannus</i></u>	Mariana fruit Bat (=Mariana flying fox)	Pteropodidae	Mammals	❗ Threatened
<u><i>Leptonycteris nivalis</i></u>	Mexican long-nosed bat	Phyllostomidae	Mammals	❗ Endangered
<u><i>Canis lupus baileyi</i></u>	Mexican wolf	Canidae	Mammals	❗ Endangered
<u><i>Dipodomys heermanni morroensis</i></u>	Morro Bay kangaroo rat	Heteromyidae	Mammals	❗ Endangered
<u><i>Tamiasciurus hudsonicus grahamensis</i></u>	Mount Graham red squirrel	Sciuridae	Mammals	❗ Endangered

Scientific Name	Common Name	Family	Species Group	Federal Listing Status
<u><i>Zapus hudsonius luteus</i></u>	New Mexico meadow jumping mouse	Zapodidae	Mammals	❗ Endangered
<u><i>Eubalaena glacialis</i></u>	North Atlantic Right Whale	Balaenidae	Mammals	❗ Endangered
<u><i>Eubalaena japonica</i></u>	North Pacific Right Whale	Balaenidae	Mammals	❗ Endangered
<u><i>Urocitellus brunneus</i></u>	Northern Idaho Ground Squirrel	Sciuridae	Mammals	❗ Threatened
<u><i>Myotis septentrionalis</i></u>	Northern Long-Eared Bat	Vespertilionidae	Mammals	❗ Threatened
<u><i>Enhydra lutris kenyonii</i></u>	Northern Sea Otter	Mustelidae	Mammals	❗ Threatened
<u><i>Leopardus (=Felis). pardalis</i></u>	Ocelot	Felidae	Mammals	❗ Endangered
<u><i>Thomomys mazama pugetensis</i></u>	Olympia pocket gopher	Geomyidae	Mammals	❗ Threatened
<u><i>Corynorhinus (=Plecotus). townsendii ingens</i></u>	Ozark big-eared bat	Vespertilionidae	Mammals	❗ Endangered
<u><i>Perognathus longimembris pacificus</i></u>	Pacific pocket mouse	Heteromyidae	Mammals	❗ Endangered
<u><i>Emballonura semicaudata rotensis</i></u>	Pacific sheath-tailed Bat	Emballonuridae	Mammals	❗ Endangered
<u><i>Emballonura semicaudata semicaudata</i></u>	Pacific sheath-tailed Bat	Emballonuridae	Mammals	❗ Endangered
<u><i>Ovis canadensis nelsoni</i></u>	Peninsular bighorn sheep	Bovidae	Mammals	❗ Endangered
<u><i>Peromyscus polionotus trissyllepsis</i></u>	Perdido Key beach mouse	Muridae	Mammals	❗ Endangered
<u><i>Aplodontia rufa nigra</i></u>	Point Arena mountain beaver	Aplodontidae	Mammals	❗ Endangered
<u><i>Ursus maritimus</i></u>	Polar bear	Ursidae	Mammals	❗ Threatened
<u><i>Zapus hudsonius preblei</i></u>	Preble's meadow jumping mouse	Zapodidae	Mammals	❗ Threatened
<u><i>Canis rufus</i></u>	Red wolf	Canidae	Mammals	❗ Endangered
<u><i>Oryzomys palustris natator</i></u>	Rice rat	Muridae	Mammals	❗ Endangered
<u><i>Phoca (=Pusa) hispida botnica</i></u>	Ringed Seal	Phocidae	Mammals	❗ Threatened
<u><i>Phoca (=Pusa) hispida hispida</i></u>	Ringed Seal	Phocidae	Mammals	❗ Threatened
<u><i>Phoca (=Pusa) hispida ladogensis</i></u>	Ringed seal	Phocidae	Mammals	❗ Endangered
<u><i>Phoca (=Pusa) hispida ochotensis</i></u>	Ringed Seal	Phocidae	Mammals	❗ Threatened

Scientific Name	Common Name	Family	Species Group	Federal Listing Status
<u><i>Sylvilagus bachmani riparius</i></u>	Riparian brush rabbit	Leporidae	Mammals	❗ Endangered
<u><i>Neotoma fuscipes riparia</i></u>	Riparian woodrat (=San Joaquin Valley)	Muridae	Mammals	❗ Endangered
<u><i>Thomomys mazama glacialis</i></u>	Roy Prairie pocket gopher	Geomyidae	Mammals	❗ Threatened
<u><i>Reithrodontomys raviventris</i></u>	Salt marsh harvest mouse	Cricetidae	Mammals	❗ Endangered
<u><i>Dipodomys merriami parvus</i></u>	San Bernardino Merriam's kangaroo rat	Heteromyidae	Mammals	❗ Endangered
<u><i>Vulpes macrotis mutica</i></u>	San Joaquin kit fox	Canidae	Mammals	❗ Endangered
<u><i>Urocyon littoralis catalinae</i></u>	Santa Catalina Island Fox	Canidae	Mammals	❗ Threatened
<u><i>Balaenoptera borealis</i></u>	Sei whale	Balaenopteridae	Mammals	❗ Endangered
<u><i>Ovis canadensis sierrae</i></u>	Sierra Nevada bighorn sheep	Bovidae	Mammals	❗ Endangered
<u><i>Herpailurus (=Felis). yagouaroundi tolteca</i></u>	Sinaloa Jaguarundi	Felidae	Mammals	❗ Endangered
<u><i>Antilocapra americana sonoriensis</i></u>	Sonoran pronghorn	Antilocapridae	Mammals	❗ Endangered
<u><i>Peromyscus polionotus niveiventris</i></u>	Southeastern beach mouse	Muridae	Mammals	❗ Threatened
<u><i>Enhydra lutris nereis</i></u>	Southern sea otter	Mustelidae	Mammals	❗ Threatened
<u><i>Physeter catodon (=macrocephalus)</i></u>	Sperm whale	Physeteridae	Mammals	❗ Endangered
<u><i>Phoca largha</i></u>	Spotted Seal	Phocidae	Mammals	❗ Threatened
<u><i>Peromyscus polionotus peninsularis</i></u>	St. Andrew beach mouse	Muridae	Mammals	❗ Endangered
<u><i>Eumetopias jubatus</i></u>	Steller sea lion	Otariidae	Mammals	❗ Endangered
<u><i>Dipodomys stephensi (incl. D. cactus)</i></u>	Stephens' kangaroo rat	Heteromyidae	Mammals	❗ Endangered
<u><i>Thomomys mazama tumuli</i></u>	Tenino pocket gopher	Geomyidae	Mammals	❗ Threatened
<u><i>Dipodomys nitratoideus nitratoideus</i></u>	Tipton kangaroo rat	Heteromyidae	Mammals	❗ Endangered
<u><i>Cynomys parvidens</i></u>	Utah prairie dog	Sciuridae	Mammals	❗ Threatened
<u><i>Corynorhinus (=Plecotus). townsendii virginianus</i></u>	Virginia big-eared bat	Vespertilionidae	Mammals	❗ Endangered
<u><i>Trichechus manatus</i></u>	West Indian Manatee	Trichechidae	Mammals	❗ Threatened
<u><i>Bison bison athabasca</i></u>	Wood Bison	Bovidae	Mammals	❗ Threatened
<u><i>Rangifer tarandus caribou</i></u>	Woodland Caribou	Cervidae	Mammals	❗ Endangered

Scientific Name	Common Name	Family	Species Group	Federal Listing Status
<u><i>Thomomys mazama yelmensis</i></u>	Yelm pocket gopher	Geomyidae	Mammals	Threatened

Showing 1 to 93 of 93 entries



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Species Search Results

101 Records

Parameters:

- Species Groups: Birds
- Listing Statuses: Endangered, Threatened, Emergency Listing, Endangered, Emergency Listing, Threatened
- Listed in the US

Scientific Name	Common Name	Family	Species Group	Federal Listing Status
<u>Accipiter striatus venator</u>	Puerto Rican sharp-shinned hawk	Accipitridae	Birds	i Endangered
<u>Acrocephalus familiaris kingi</u>	Nihoa millerbird (old world warbler)	Muscicapidae	Birds	i Endangered
<u>Acrocephalus luscini</u>	Nightingale reed warbler (old world warbler)	Sylviidae	Birds	i Endangered
<u>Aerodramus vanikorensis bartschi</u>	Mariana gray swiftlet	Apodidae	Birds	i Endangered
<u>Agelaius xanthomus</u>	Yellow-shouldered blackbird	Icteridae	Birds	i Endangered
<u>Akialoa stejnegeri</u>	Kauai akialoa (honeycreeper)	Drepanidinae	Birds	i Endangered
<u>Amazona vittata</u>	Puerto Rican parrot	Psittacidae	Birds	i Endangered
<u>Ammodramus maritimus mirabilis</u>	Cape Sable seaside sparrow	Emberizidae	Birds	i Endangered
<u>Ammodramus savannarum floridanus</u>	Florida grasshopper sparrow	Emberizidae	Birds	i Endangered
<u>Amphispiza belli clementeae</u>	San Clemente sage sparrow	Emberizidae	Birds	i Threatened
<u>Anas laysanensis</u>	Laysan duck	Anatidae	Birds	i Endangered
<u>Anas wyvilliana</u>	Hawaiian (=koloa) Duck	Anatidae	Birds	i Endangered
<u>Aphelocoma coerulescens</u>	Florida scrub-jay	Corvidae	Birds	i Threatened
<u>Brachyramphus marmoratus</u>	Marbled murrelet	Alcidae	Birds	i Threatened
<u>Branta (=Nesochen). sandvicensis</u>	Hawaiian goose	Anatidae	Birds	i Endangered
<u>Buteo platypterus brunnescens</u>	Puerto Rican broad-winged hawk	Accipitridae	Birds	i Endangered
<u>Buteo solitarius</u>	Hawaiian (=‘lo) Hawk	Accipitridae	Birds	i Endangered
<u>Calidris canutus rufa</u>	Red knot	Scolopacidae	Birds	i Threatened

Scientific Name	Common Name	Family	Species Group	Federal Listing Status
<u><i>Campephilus principalis</i></u>	Ivory-billed woodpecker	Picidae	Birds	❗ Endangered
<u><i>Caprimulgus noctitherus</i></u>	Puerto Rican nightjar	Caprimulgidae	Birds	❗ Endangered
<u><i>Centrocercus minimus</i></u>	Gunnison sage-grouse	Phasianidae	Birds	❗ Threatened
<u><i>Charadrius melodus</i></u>	Piping Plover	Charadriidae	Birds	❗ Endangered
<u><i>Charadrius melodus</i></u>	Piping Plover	Charadriidae	Birds	❗ Threatened
<u><i>Charadrius nivosus nivosus</i></u>	Western snowy plover	Charadriidae	Birds	❗ Threatened
<u><i>Chasiempis ibidis</i></u>	Oahu elepaio	Monarchidae	Birds	❗ Endangered
<u><i>Coccyzus americanus</i></u>	Yellow-billed Cuckoo	Cuculidae	Birds	❗ Threatened
<u><i>Colinus virginianus ridgwayi</i></u>	Masked bobwhite (quail)	Phasianidae	Birds	❗ Endangered
<u><i>Columba inornata wetmorei</i></u>	Puerto Rican plain Pigeon	Columbidae	Birds	❗ Endangered
<u><i>Corvus hawaiiensis</i></u>	Hawaiian (=‘alala) Crow	Corvidae	Birds	❗ Endangered
<u><i>Corvus kubaryi</i></u>	Mariana (=aga) Crow	Corvidae	Birds	❗ Endangered
<u><i>Corvus leucognaphalus</i></u>	White-necked crow	Corvidae	Birds	❗ Endangered
<u><i>Dendroica chrysoparia</i></u>	Golden-cheeked warbler (=wood)	Parulidae	Birds	❗ Endangered
<u><i>Drepanis coccinea</i></u>	‘I‘iwi	Fringillidae	Birds	❗ Threatened
<u><i>Empidonax traillii extimus</i></u>	Southwestern willow flycatcher	Tyrannidae	Birds	❗ Endangered
<u><i>Eremophila alpestris strigata</i></u>	Streaked Horned lark	Alaudidae	Birds	❗ Threatened
<u><i>Falco femoralis septentrionalis</i></u>	Northern Aplomado Falcon	Falconidae	Birds	❗ Endangered
<u><i>Fulica americana alai</i></u>	Hawaiian coot	Rallidae	Birds	❗ Endangered
<u><i>Gallicolumba stairi</i></u>	Friendly Ground-Dove	Columbidae	Birds	❗ Endangered
<u><i>Gallinula chloropus guami</i></u>	Mariana common moorhen	Rallidae	Birds	❗ Endangered
<u><i>Gallinula galeata sandvicensis</i></u>	Hawaiian common gallinule	Rallidae	Birds	❗ Endangered
<u><i>Grus americana</i></u>	Whooping crane	Gruidae	Birds	❗ Endangered
<u><i>Grus canadensis pulla</i></u>	Mississippi sandhill crane	Gruidae	Birds	❗ Endangered
<u><i>Gymnogyps californianus</i></u>	California condor	Cathartidae	Birds	❗ Endangered
<u><i>Gymnomyza samoensis</i></u>	Mao (= maomao) (honeyeater)	Meliphagidae	Birds	❗ Endangered
<u><i>Halcyon cinnamomina cinnamomina</i></u>	Guam Micronesia kingfisher	Alcedinidae	Birds	❗ Endangered

Scientific Name	Common Name	Family	Species Group	Federal Listing Status
<u><i>Hemignathus affinis</i></u>	Maui nukupuu	Fringillidae	Birds	❗ Endangered
<u><i>Hemignathus hanapepe</i></u>	Kauai nukupuu	Fringillidae	Birds	❗ Endangered
<u><i>Hemignathus wilsoni</i></u>	akiapolaau	Drepanidinae	Birds	❗ Endangered
<u><i>Himantopus mexicanus knudseni</i></u>	Hawaiian stilt	Recurvirostridae	Birds	❗ Endangered
<u><i>Lanius ludovicianus mearnsi</i></u>	San Clemente loggerhead shrike	Laniidae	Birds	❗ Endangered
<u><i>Loxioides bailleui</i></u>	Palila (honeycreeper)	Drepanidinae	Birds	❗ Endangered
<u><i>Loxops caeruleirostris</i></u>	Akekee	Fringillidae	Birds	❗ Endangered
<u><i>Loxops coccineus</i></u>	Hawaii akepa	Drepanidinae	Birds	❗ Endangered
<u><i>Loxops ochraceus</i></u>	Maui akepa	Drepanidinae	Birds	❗ Endangered
<u><i>Megapodius laperouse</i></u>	Micronesian megapode	Megapodiidae	Birds	❗ Endangered
<u><i>Melamprosops phaeosoma</i></u>	Po'ouli (honeycreeper)	Drepanidinae	Birds	❗ Endangered
<u><i>Moho braccatus</i></u>	Kauai 'o'o (honeyeater)	Meliphagidae	Birds	❗ Endangered
<u><i>Myadestes lanaiensis rutha</i></u>	Molokai thrush	Muscicapidae	Birds	❗ Endangered
<u><i>Myadestes myadestinus</i></u>	Large Kauai (=kamao) Thrush	Muscicapidae	Birds	❗ Endangered
<u><i>Myadestes palmeri</i></u>	Small Kauai (=puaiohi) Thrush	Muscicapidae	Birds	❗ Endangered
<u><i>Mycteria americana</i></u>	Wood stork	Ciconiidae	Birds	❗ Threatened
<u><i>Numenius borealis</i></u>	Eskimo curlew	Scolopacidae	Birds	❗ Endangered
<u><i>Oceanodroma castro</i></u>	Band-rumped storm-petrel	Hydrobatidae	Birds	❗ Endangered
<u><i>Oreomystis bairdi</i></u>	Akikiki	Fringillidae	Birds	❗ Endangered
<u><i>Oreomystis mana</i></u>	Hawaii creeper	Drepanidinae	Birds	❗ Endangered
<u><i>Palmeria dolei</i></u>	crested honeycreeper (Akohekohe)	Drepanidinae	Birds	❗ Endangered
<u><i>Paroreomyza flammea</i></u>	Molokai creeper	Drepanidinae	Birds	❗ Endangered
<u><i>Paroreomyza maculata</i></u>	Oahu creeper	Drepanidinae	Birds	❗ Endangered
<u><i>Phoebastria (=Diomedea) albatrus</i></u>	Short-tailed albatross	Diomedidae	Birds	❗ Endangered
<u><i>Picoides borealis</i></u>	Red-cockaded woodpecker	Picidae	Birds	❗ Endangered
<u><i>Pipilo crissalis eremophilus</i></u>	Inyo California towhee	Emberizidae	Birds	❗ Threatened
<u><i>Poliophtila californica californica</i></u>	Coastal California gnatcatcher	Muscicapidae	Birds	❗ Threatened

Scientific Name	Common Name	Family	Species Group	Federal Listing Status
<u><i>Polyborus plancus audubonii</i></u>	Audubon's crested caracara	Falconidae	Birds	❗ Threatened
<u><i>Polysticta stelleri</i></u>	Steller's Eider	Anatidae	Birds	❗ Threatened
<u><i>Pseudonestor xanthophrys</i></u>	Maui parrotbill (Kiwikiu)	Drepanidinae	Birds	❗ Endangered
<u><i>Psittirostra psittacea</i></u>	`O`u (honeycreeper)	Drepanidinae	Birds	❗ Endangered
<u><i>Pterodroma cahow</i></u>	Bermuda petrel	Procellariidae	Birds	❗ Endangered
<u><i>Pterodroma sandwichensis</i></u>	Hawaiian petrel	Procellariidae	Birds	❗ Endangered
<u><i>Puffinus auricularis newelli</i></u>	Newell's Townsend's shearwater	Procellariidae	Birds	❗ Threatened
<u><i>Rallus longirostris levipes</i></u>	Light-footed clapper rail	Rallidae	Birds	❗ Endangered
<u><i>Rallus longirostris obsoletus</i></u>	California clapper rail	Rallidae	Birds	❗ Endangered
<u><i>Rallus longirostris yumanensis</i></u>	Yuma clapper rail	Rallidae	Birds	❗ Endangered
<u><i>Rallus owstoni</i></u>	Guam rail	Rallidae	Birds	❗ Endangered
<u><i>Rhynchopsitta pachyrhyncha</i></u>	Thick-billed parrot	Psittacidae	Birds	❗ Endangered
<u><i>Rostrhamus sociabilis plumbeus</i></u>	Everglade snail kite	Accipitridae	Birds	❗ Endangered
<u><i>Setophaga angelae</i></u>	Elfin-woods warbler	Parulidae	Birds	❗ Threatened
<u><i>Setophaga kirtlandii</i> (= <i>Dendroica kirtlandii</i>)</u>	Kirtland's Warbler	Parulidae	Birds	❗ Endangered
<u><i>Somateria fischeri</i></u>	Spectacled eider	Anatidae	Birds	❗ Threatened
<u><i>Sterna antillarum</i></u>	Least tern	Laridae	Birds	❗ Endangered
<u><i>Sterna antillarum browni</i></u>	California least tern	Laridae	Birds	❗ Endangered
<u><i>Sterna dougallii dougallii</i></u>	Roseate tern	Laridae	Birds	❗ Endangered
<u><i>Sterna dougallii dougallii</i></u>	Roseate tern	Laridae	Birds	❗ Threatened
<u><i>Strix occidentalis caurina</i></u>	Northern spotted owl	Strigidae	Birds	❗ Threatened
<u><i>Strix occidentalis lucida</i></u>	Mexican spotted owl	Strigidae	Birds	❗ Threatened
<u><i>Telespyza cantans</i></u>	Laysan finch (honeycreeper)	Drepanidinae	Birds	❗ Endangered
<u><i>Telespyza ultima</i></u>	Nihoa finch (honeycreeper)	Drepanidinae	Birds	❗ Endangered
<u><i>Tympanuchus cupido attwateri</i></u>	Attwater's greater prairie-chicken	Phasianidae	Birds	❗ Endangered
<u><i>Vermivora bachmanii</i></u>	Bachman's warbler (=wood)	Emberizidae	Birds	❗ Endangered
<u><i>Vireo bellii pusillus</i></u>	Least Bell's vireo	Vireonidae	Birds	❗ Endangered

Scientific Name	Common Name	Family	Species Group	Federal Listing Status
<u><i>Zosterops conspicillatus</i></u> <u><i>conspicillatus</i></u>	Bridled white-eye	Zosteropidae	Birds	🚫 Endangered
<u><i>Zosterops rotensis</i></u>	Rota bridled White-eye	Zosteropidae	Birds	🚫 Endangered

Showing 1 to 101 of 101 entries



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ECOS
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Species Search Results

34 Records

Parameters:

- Species Groups: Amphibians
- Listing Statuses: Endangered, Threatened, Emergency Listing, Endangered, Emergency Listing, Threatened
- Listed in the US

Scientific Name	Common Name	Family	Species Group	Federal Listing Status
<i>Ambystoma bishopi</i>	Reticulated flatwoods salamander	Ambystomatidae	Amphibians	i Endangered
<i>Ambystoma californiense</i>	California tiger Salamander	Ambystomatidae	Amphibians	i Endangered
<i>Ambystoma californiense</i>	California tiger Salamander	Ambystomatidae	Amphibians	i Threatened
<i>Ambystoma cingulatum</i>	Frosted Flatwoods salamander	Ambystomatidae	Amphibians	i Threatened
<i>Ambystoma macrodactylum croceum</i>	Santa Cruz long-toed salamander	Ambystomatidae	Amphibians	i Endangered
<i>Ambystoma tigrinum stebbinsi</i>	Sonora tiger Salamander	Ambystomatidae	Amphibians	i Endangered
<i>Anaxyrus californicus</i>	Arroyo (=arroyo southwestern) toad	Bufo	Amphibians	i Endangered
<i>Anaxyrus canorus</i>	Yosemite toad	Bufo	Amphibians	i Threatened
<i>Batrachoseps aridus</i>	Desert slender salamander	Plethodontidae	Amphibians	i Endangered
<i>Bufo hemiophrys baxteri</i>	Wyoming Toad	Bufo	Amphibians	i Endangered
<i>Bufo houstonensis</i>	Houston toad	Bufo	Amphibians	i Endangered
<i>Cryptobranchus alleganiensis bishopi</i>	Ozark Hellbender	Cryptobranchidae	Amphibians	i Endangered
<i>Eleutherodactylus cooki</i>	Guajon	Leptodactylidae	Amphibians	i Threatened
<i>Eleutherodactylus jasperi</i>	Golden coqui	Leptodactylidae	Amphibians	i Threatened
<i>Eleutherodactylus juanariveroi</i>	Llanero Coqui	Leptodactylidae	Amphibians	i Endangered
<i>Eurycea chisholmensis</i>	Salado Salamander	Plethodontidae	Amphibians	i Threatened
<i>Eurycea nana</i>	San Marcos salamander	Plethodontidae	Amphibians	i Threatened
<i>Eurycea naufragia</i>	Georgetown Salamander	Plethodontidae	Amphibians	i Threatened
<i>Eurycea sosorum</i>	Barton Springs salamander	Plethodontidae	Amphibians	i Endangered
<i>Eurycea tonkawae</i>	Jollyville Plateau Salamander	Plethodontidae	Amphibians	i Threatened

Scientific Name	Common Name	Family	Species Group	Federal Listing Status
<u><i>Eurycea waterlooensis</i></u>	Austin blind Salamander	Plethodontidae	Amphibians	i Endangered
<u><i>Necturus alabamensis</i></u>	Black warrior (=Sipsey Fork) Waterdog	Proteidae	Amphibians	i Endangered
<u><i>Peltophryne lemur</i></u>	Puerto Rican crested toad	Bufoidea	Amphibians	i Threatened
<u><i>Phaeognathus hubrichti</i></u>	Red Hills salamander	Plethodontidae	Amphibians	i Threatened
<u><i>Plethodon neomexicanus</i></u>	Jemez Mountains salamander	Plethodontidae	Amphibians	i Endangered
<u><i>Plethodon nettingi</i></u>	Cheat Mountain salamander	Plethodontidae	Amphibians	i Threatened
<u><i>Plethodon shenandoah</i></u>	Shenandoah salamander	Plethodontidae	Amphibians	i Endangered
<u><i>Rana chiricahuensis</i></u>	Chiricahua leopard frog	Ranidae	Amphibians	i Threatened
<u><i>Rana draytonii</i></u>	California red-legged frog	Ranidae	Amphibians	i Threatened
<u><i>Rana muscosa</i></u>	Mountain yellow-legged frog	Ranidae	Amphibians	i Endangered
<u><i>Rana pretiosa</i></u>	Oregon spotted frog	Ranidae	Amphibians	i Threatened
<u><i>Rana sevosia</i></u>	dusky gopher frog	Ranidae	Amphibians	i Endangered
<u><i>Rana sierrae</i></u>	Sierra Nevada Yellow-legged Frog	Ranidae	Amphibians	i Endangered
<u><i>Typhlomolge rathbuni</i></u>	Texas blind salamander	Plethodontidae	Amphibians	i Endangered

Showing 1 to 34 of 34 entries



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ECOS
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Species Search Results

42 Records

Parameters:

- Species Groups: Reptiles
- Listing Statuses: Endangered, Threatened, Emergency Listing, Endangered, Emergency Listing, Threatened
- Listed in the US

Scientific Name	Common Name	Family	Species Group	Federal Listing Status
<i>Ameiva polops</i>	St. Croix ground lizard	Teiidae	Reptiles	i Endangered
<i>Anolis roosevelti</i>	Culebra Island giant anole	Iguanidae	Reptiles	i Endangered
<i>Caretta caretta</i>	Loggerhead sea turtle	Cheloniidae	Reptiles	i Endangered
<i>Caretta caretta</i>	Loggerhead sea turtle	Cheloniidae	Reptiles	i Threatened
<i>Chelonia mydas</i>	Green sea turtle	Cheloniidae	Reptiles	i Endangered
<i>Chelonia mydas</i>	Green sea turtle	Cheloniidae	Reptiles	i Threatened
<i>Clemmys muhlenbergii</i>	bog turtle	Emydidae	Reptiles	i Threatened
<i>Crocodylus acutus</i>	American crocodile	Crocodylidae	Reptiles	i Threatened
<i>Crotalus willardi obscurus</i>	New Mexican ridge-nosed rattlesnake	Crotalidae	Reptiles	i Threatened
<i>Cyclura stejnegeri</i>	Mona ground Iguana	Iguanidae	Reptiles	i Threatened
<i>Dermochelys coriacea</i>	Leatherback sea turtle	Dermochelyidae	Reptiles	i Endangered
<i>Drymarchon corais couperi</i>	Eastern indigo snake	Colubridae	Reptiles	i Threatened
<i>Emoia slevini</i>	Slevin's skink	Scincidae	Reptiles	i Endangered
<i>Epicrates inornatus</i>	Puerto Rican boa	Boidae	Reptiles	i Endangered
<i>Epicrates monensis granti</i>	Virgin Islands tree boa	Boidae	Reptiles	i Endangered
<i>Epicrates monensis monensis</i>	Mona boa	Boidae	Reptiles	i Threatened
<i>Eretmochelys imbricata</i>	Hawksbill sea turtle	Cheloniidae	Reptiles	i Endangered
<i>Eumeces egregius lividus</i>	Bluetail mole skink	Scincidae	Reptiles	i Threatened
<i>Gambelia silus</i>	Blunt-nosed leopard lizard	Crotaphytidae	Reptiles	i Endangered
<i>Gopherus agassizii</i>	Desert tortoise	Testudinidae	Reptiles	i Threatened
<i>Gopherus polyphemus</i>	Gopher tortoise	Testudinidae	Reptiles	i Threatened
<i>Graptemys flavimaculata</i>	Yellow-blotched map turtle	Emydidae	Reptiles	i Threatened

Scientific Name	Common Name	Family	Species Group	Federal Listing Status
<u>Graptemys oculifera</u>	Ringed map turtle	Emydidae	Reptiles	i Threatened
<u>Kinosternon sonoriense longifemorale</u>	Sonoyta mud turtle	Kinosternidae	Reptiles	i Endangered
<u>Lepidochelys kempii</u>	Kemp's ridley sea turtle	Cheloniidae	Reptiles	i Endangered
<u>Lepidochelys olivacea</u>	Olive ridley sea turtle	Cheloniidae	Reptiles	i Threatened
<u>Masticophis lateralis euryxanthus</u>	Alameda whipsnake (=striped racer)	Colubridae	Reptiles	i Threatened
<u>Neoseps reynoldsi</u>	Sand skink	Scincidae	Reptiles	i Threatened
<u>Nerodia clarkii taeniata</u>	Atlantic salt marsh snake	Colubridae	Reptiles	i Threatened
<u>Nerodia erythrogaster neglecta</u>	Copperbelly water snake	Colubridae	Reptiles	i Threatened
<u>Pituophis melanoleucus lodingi</u>	Black pine snake	Colubridae	Reptiles	i Threatened
<u>Pituophis ruthveni</u>	Louisiana pine snake	Colubridae	Reptiles	i Threatened
<u>Pseudemys alabamensis</u>	Alabama red-bellied turtle	Emydidae	Reptiles	i Endangered
<u>Pseudemys rubriventris bangsi</u>	Plymouth Redbelly Turtle	Emydidae	Reptiles	i Endangered
<u>Sistrurus catenatus</u>	Eastern Massasauga (=rattlesnake)	Viperidae	Reptiles	i Threatened
<u>Sphaerodactylus micropithecus</u>	Monito gecko	Gekkonidae	Reptiles	i Endangered
<u>Sternotherus depressus</u>	Flattened musk turtle	Kinosternidae	Reptiles	i Threatened
<u>Thamnophis eques megalops</u>	Northern Mexican gartersnake	Colubridae	Reptiles	i Threatened
<u>Thamnophis gigas</u>	Giant garter snake	Colubridae	Reptiles	i Threatened
<u>Thamnophis rufipunctatus</u>	Narrow-headed gartersnake	Colubridae	Reptiles	i Threatened
<u>Thamnophis sirtalis tetrataenia</u>	San Francisco garter snake	Colubridae	Reptiles	i Endangered
<u>Uma inornata</u>	Coachella Valley fringe-toed lizard	Phrynosomatidae	Reptiles	i Threatened

Showing 1 to 42 of 42 entries

Appendix B

Aquatic Screening Level Calculations

Appendix B - Great Lakes Initiative Recommended Water Quality RBSL Calculations
Table 1. PFOS Acute and Chronic RWQ RBSLs (Tier I Methodology)

Acute										
Species Scientific Name	Species Common Name	Species Group ²	Duration (hours)	Effect	Endpoint	Concentration (mg/L)	GMAV	Rank	Probability	Study
<i>Caenorhabditis elegans</i>	Nematode	H	48	Survival	LC50	0.70	0.70	1	0.04	Chen et al. 2018
<i>Pimephales promelas</i>	Fathead Minnow	B	96	Survival	LC50	6.7	6.7	2	0.09	OECD, 2002 (3M 2000, References 1, 16, and 28)
<i>Oncorhynchus mykiss</i>	Rainbow trout	A	96	Survival	LC50	7.42	7.42	3	0.13	Robertson, 1986; Palmer et al. 2002a; Sharpe et al. 2010
<i>Lepomis macrochirus</i>	Bluegill Sunfish	B	96	Survival	LC50	7.8	7.8	4	0.17	OECD, 2002 (3M 2000, Reference 20)
<i>Neocaridina denticulate</i>	Cherry shrimp	E	96	Survival	LC50	10	10	5	0.22	Li, 2009
<i>Xenopus laevis</i>	African clawed frog	C	3	Survival	EC50	15.5	15.5	6	0.26	Palmer and Krueger, 2001
<i>Ligumia recta</i>	Black sandshell	G	96	Immobilization	EC50	17.1	17.1	7	0.30	Hazelton et al. 2012
<i>Lampsilis siliquoidea</i>	Fatmucket clam	G	96	Immobilization	EC50	17.7	17.7	8	0.35	Hazelton et al. 2012
<i>Moina macrocopa</i>	Cladoceran	D	48	Immobilization	EC50	17.95	17.95	9	0.39	Ji et al. 2008
<i>Macrobrachium nipponense</i>	Shrimp	E	96	Survival	LC50	19.77	19.77	10	0.43	Yang et al. 2014
<i>Danio rerio</i>	Zebrafish	C	96	Survival	LC50	21.1	21.1	11	0.48	Multiple
<i>Dugesia japonica</i>	Planarian	H	96	Survival	LC50	22.6	22.6	12	0.52	Li, 2009; Yuan et al. 2014; Li, 2008
<i>Bufo gargarizans</i>	Asiatic toad	C	96	Survival	LC50	48.21	48.21	13	0.57	Yang et al. 2014
<i>Unio complanatus</i>	Mussel	G	96	Survival	LC50	59	59	14	0.61	Drottler and Krueger, 2000b
<i>Unio ravoisieri</i>	Mussel	G	96	Survival	LC50	65.9	65.9	15	0.65	Amraoui et al. 2018
<i>Pseudorasbora parva</i>	Topmouth gudgeon	B	96	Survival	LC50	67.74	67.74	16	0.70	Yang et al. 2014
<i>Daphnia sp.</i>	Water flea	D	48	Survival	LC50	69	69	17	0.74	Multiple
<i>Carassius auratus</i> ¹	Crucian carp	B	96	Survival	LC50	81.18	81.18	18	0.78	Yang et al. 2014
<i>Limnodrilus hoffmeisteri</i>	Worm	H	96	Survival	LC50	120.97	120.97	19	0.83	Yang et al. 2014
<i>Physa acuta</i>	Snail	G	96	Survival	LC50	178	178	20	0.87	Li, 2009
<i>Chironomus plumosus</i>	Chironomid	F	96	Survival	LC50	182.12	182.12	21	0.91	Yang et al. 2014
<i>Cipangopaludina cathayensis</i>	Mud snail	G	96	Survival	LC50	247.14	247.14	22	0.96	Yang et al. 2014

$$\begin{aligned}
 S^2 &= 171 \\
 S &= 13 \\
 L &= -2.8 \\
 A &= 0.135 \\
 FAV &= 1.15 \quad \text{mg/L} \\
 \text{Acute RWQ RBSL} &= \mathbf{0.57} \quad \text{mg/L}
 \end{aligned}$$

Appendix B - Great Lakes Initiative Recommended Water Quality RBSL Calculations
Table 1. PFOS Acute and Chronic RWQ RBSLs (Tier I Methodology)

Acute to Chronic Ratio							
Species Scientific Name	Species Common Name	Acute or Chronic	Duration (hours)	Endpoint	Effect	PFOS (mg/L)	Study
ACR(1a)							
Daphnia magna	Water flea	acute	48	Immobilization	EC50	27	OECD 2002, Reference 15
Daphnia magna	Water flea	chronic	672	Reproduction	NOEC	7	OECD 2002, Reference 15
ACR(1b)							
Daphnia magna	Water flea	acute	48	Immobilization	EC50	67.2	Boudreau et al. 2003a
Daphnia magna	Water flea	chronic	504	Survival	LC10	5.3	Boudreau et al. 2003a
ACR(1c)							
Daphnia magna	Water flea	acute	48	Immobilization	EC50	37.36	Ji et al. 2008
Daphnia magna	Water flea	chronic	504	Reproduction	NOEC	1.25	Ji et al. 2008
Daphnia magna	Water flea	chronic	504	Reproduction	LOEC	2.5	Ji et al. 2008
ACR(1d)							
Daphnia magna	Water flea	acute	48	Survival	LC50	78.09	Yang et al. 2014
Daphnia magna	Water flea	chronic	504	Reproduction	EC10	2.26	Yang et al. 2014
ACR(2)							
Moina macrocopa	Cladoceran	acute	48	Immobilization	EC50	17.95	Ji et al. 2008
Moina macrocopa	Cladoceran	chronic	168	Reproduction	LOEC	0.3125	Ji et al. 2008
ACR(3)							
Mysidopsis bahia	Opossum shrimp	acute	96	Survival Growth,	LC50	3.6	Drottar and Krueger, 2000c
Mysidopsis bahia	Opossum shrimp	chronic	840	Reproduction Growth,	NOEC	0.25	Drottar and Krueger, 2000f
Mysidopsis bahia	Opossum shrimp	chronic	840	Reproduction	LOEC	0.55	Drottar and Krueger, 2000f
ACR(4)							
Pimephales promelas	Fathead minnow	acute	96	Survival Growth, Reproduction,	LC50	9.5	OECD 2002, Reference 1
Pimephales promelas	Fathead minnow	chronic	1128	Survival	NOEC	0.3	Drottar and Krueger 2000g
Pimephales promelas	Fathead minnow	chronic	1128	Survival	LOEC	0.6	Drottar and Krueger 2000g
ACR(5)							
Bufo gargizans	Asiatic toad	acute	96	Survival	LC50	48.21	Yang et al. 2014
Bufo gargizans	Asiatic toad	chronic	720	Survival	EC10	2.00	Yang et al. 2014
ACR(6)							
Pseudorasobra parva	Topmouth gudgeon	acute	96	Survival	LC50	67.74	Yang et al. 2014
Pseudorasobra parva	Topmouth gudgeon	chronic	720	Survival	EC10	2.12	Yang et al. 2014
ACR(7)							
Lampsilis siliquoidea	Fatmucket clam	acute	48	Valve closure in glochidia	EC50 ⁶	17.7	Hazelton et al. 2012
Lampsilis siliquoidea	Fatmucket clam	chronic	864	Probability of glochidia viability	LOEC	0.0045	Hazelton et al. 2012
						ACR(1) =	14
						ACR(2) =	57
						ACR(3) =	9.7
						ACR(4) =	22
						ACR(5) =	24
						ACR(6) =	32
						ACR(7) =	3933
						FACR (final)² =	23

Appendix B - Great Lakes Initiative Recommended Water Quality RBSL Calculations
Table 1. PFOS Acute and Chronic RWQ RBSLs (Tier I Methodology)

Minimum Plant Value							
Species	Species Common Name	Acute or Chronic	Duration (hours)	Endpoint	Effect	PFOS (mg/L)	Study
Selenastrum capricornutum	Green alga	chronic-equivalent	96	Growth	NOEC	5.3	Boudreau et al. 2003
Chronic							
					FCV =	0.051	mg/L
					FPV =	5.30	mg/L
					Chronic RWQ RBSL =	0.051	mg/L

Appendix B - Great Lakes Initiative Recommended Water Quality RBSL Calculations
Table 1. PFOS Acute and Chronic RWQ RBSLs (Tier I Methodology)

Notes

EC50 - effect concentration for 50 percent of the population	LOEC - lowest observed effect concentration
FACR - final acute chronic ratio	NOEC - no observed effect concentration
FAV - final acute value	NOEL - no observed effect level
FCV - final chronic values	mg/L - milligram per liter
LC50 - lethal concentration for 50 percent of the population	RBSL - risk-based screening level
LL50 - lethal level for 50 percent of the population	RWQ - recommended water quality

1. The scientific name associated with crucian carp in Yang et al. was *Carassius auratus*, the scientific name for goldfish. Therefore, there is uncertainty in regards to which species was tested.
2. All 8 species groups indicated in GLI must be fulfilled to calculate a Tier I value. The group fulfilled by each species listed is indicated in the table. The 8 species to fulfill are as follows
 - A. The family Salmonidae in the class Osteichthyes
 - B. One other family (preferably a commercially or recreationally important, warmwater species) in the class Osteichthyes (e.g., bluegill, channel catfish)
 - C. A third family in the phylum Chordata (e.g. fish, amphibian)
 - D. A planktonic crustacean (e.g. cladoceran, copepod)
 - E. a benthic crustacean (e.g. ostracod, isopod, amphipod, crayfish)
 - F. An insect (e.g. mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge)
 - G. A family in a phylum other than Arthropoda or Chordata (e.g. Rotifera, Annelida, Mollusca)
 - H. A family in any order of insect or any phylum not already represented

The acute RWQ RBSL using Tier I methodology is calculated from LC50 or EC50s with durations of 48 hours for cladocerans or 96 for all other species. If the preferred duration was unavailable for a species, a shorter duration was considered. Only freshwater species were included in the acute RWQ RBSL calculation.

The fathead minnow (*Pimephales promelas*) LL50 from a 3M study (OECD 2002 [3M 2000, Reference 28]) was excluded from RWQ RBSL calculations as the acute value was substantially higher than other acute values reported for PFOS and fathead minnow.

The zebrafish (*Danio rerio*) LC50s for embryo replicates from Sharpe et al. (2010) were excluded from RWQ RBSL calculations due to a lack of reliability for zebrafish embryo replicates.

The Boudreau et al. (2003) LC10 was selected for ACR calculations over the NOEC or LOEC from the same study as it is the lowest value and considered more representative of the reported statistics in the paper.

The geometric mean of appropriate data within a species was calculated to derive the species mean acute value (SMAV). If multiple species within a genus were present (e.g. daphnia magna and daphnia pulex are both daphnia sp.), the geometric mean of each of their SMAVs was calculated to derive the genus mean acute value (GMAV). If only one LC50 or EC50 was available for a species, it was the SMAV and/or GMAV.

The standard practice is to calculate the allowable acute exposure concentration based on the four lowest genus mean acute values (GMAVs) available from the total number of GMAVs. The following equations are used:

$$\text{Equation 1} \quad P = \frac{R}{(N + 1)}$$

$$\text{Equation 2} \quad S^2 = \frac{\sum((\ln GMAV)^2) - \frac{(\sum(\ln GMAV))^2}{4}}{\sum(P) - \frac{(\sum(\sqrt{P}))^2}{4}}$$

$$\text{Equation 3} \quad L = \frac{\sum(\ln GMAV) - S \times (\sum(\sqrt{P}))}{4}$$

$$\text{Equation 4} \quad A = S \times (\sqrt{0.05}) + L$$

$$\text{Equation 5} \quad FAV = e^A$$

$$\text{Equation 6} \quad \text{Acute RWQ RBSL} = \frac{FAV}{2}$$

$$\text{Equation 7} \quad ACR = \frac{\text{acute EC/LC}_{50}}{\sqrt{\text{chronic NOEC} \times \text{chronic LOEC}}}$$

$$\text{Equation 8} \quad \text{Chronic RWQ RBSL} = \frac{FAV}{ACR}$$

Reference

United States Environmental Protection Agency. 2012. Water Quality Guidance for the Great Lakes System. Part 132. Available at: <https://www.govinfo.gov/app/details/CFR-2012-title40-vol23/CFR-2012-title40-vol23-part132>.

Appendix B - Great Lakes Initiative Recommended Water Quality RBSL Calculations
Table 2. PFOA Acute and Chronic RWQ RBSLs (Tier I Methodology)

Acute										
Species Scientific Name	Species Common Name	Species Group ²	Duration (hours)	Effect	Endpoint	Concentration (mg/L)	GMAV	Rank	Probability	Study
<i>Bufo gargizans</i>	Asiatic toad	C	96	Survival	LC50	114.74	114.74	1	0.06	Yang et al. 2014
<i>Chydorus sphaericus</i>	Cladoceran	D	48	Immobilization	EC50	117	117	2	0.11	Ding et al. 2012b
<i>Ligumia recta</i>	Black sandshell	G	48	Survival	EC50	161.3	161.3	3	0.17	Hazelton et al. 2012
<i>Lampsilis siliquoides</i>	Fatmucket Clam	G	48	Survival	EC50	162.6	162.6	4	0.22	Hazelton et al. 2012
<i>Dugesia japonica</i>	Planarian	H	96	Survival	LC50	182	182	5	0.28	Multiple
<i>Moina macrocopa</i>	Cladoceran	D	48	Immobilization	EC50	199.51	199.51	6	0.33	Ji et al. 2008
<i>Daphnia magna</i>	Water flea	D	48	Immobilization	EC50	257	257	7	0.39	Multiple
<i>Pseudorasbora parva</i>	Topmouth gudgeon	B	96	Survival	LC50	365.02	365.02	8	0.44	Yang et al. 2014
<i>Macrobrachium nipponense</i>	Shrimp	E	96	Survival	LC50	366.66	366.66	9	0.50	Yang et al. 2014
<i>Danio rerio</i>	Zebrafish	C	96	Survival	LC50	371	371	10	0.56	Ding et al. 2013
<i>Chironomus plumosus</i>	Chironomid	F	96	Survival	LC50	402.24	402.24	11	0.61	Yang et al. 2014
<i>Neocaridina denticulate</i>	Green neon shrimp	E	96	Survival	LC50	454	454	12	0.67	Li, 2009
<i>Limnodrilus hoffmeisteri</i>	Worm	H	96	Survival	LC50	568.2	568.2	13	0.72	Yang et al. 2014
<i>Carassius auratus</i> ¹	Crucian carp	B	96	Survival	LC50	606.61	606.61	14	0.78	Yang et al. 2014
<i>Physa acuta</i>	Snail	G	96	Survival	LC50	672	672	15	0.83	Li, 2009
<i>Oncorhynchus mykiss</i>	Rainbow trout	A	96	Survival	LC50	707	707	16	0.89	Colombo et al. 2008
<i>Cipangopaludina cathayensis</i>	Mud snail	G	96	Survival	LC50	740.07	740.07	17	0.94	Yang et al. 2014

$$\begin{aligned}
 S^2 &= 3.7 \\
 S &= 1.91 \\
 L &= 4.2 \\
 A &= 4.7 \\
 FAV &= 105 \text{ mg/L} \\
 \text{Acute RWQ RBSL} &= 53 \text{ mg/L}
 \end{aligned}$$

Appendix B - Great Lakes Initiative Recommended Water Quality RBSL Calculations
Table 2. PFOA Acute and Chronic RWQ RBSLs (Tier I Methodology)

Acute to Chronic Ratio							
Species Scientific Name	Species Common Name	Acute or Chronic	Duration (hours)	Endpoint	Effect	PFOA (mg/L)	Study
ACR(1a)							
Daphnia magna	Water flea	acute	48	Immobilization	EC50	476.52	Ji et al. 2008
Daphnia magna	Water flea	chronic	504	Reproduction	NOEC	12.5	Ji et al. 2008
Daphnia magna	Water flea	chronic	504	Reproduction	LOEC	25	Ji et al. 2008
ACR(1b)							
Daphnia magna	Water flea	acute	48	Survival	LC50	201.85	Yang et al. 2014
Daphnia magna	Water flea	chronic	504	Reproduction	EC10	7.02	Yang et al. 2014
ACR(2)							
Moina macrocopa	Cladoceran	acute	48	Immobilization	EC50	199.51	Ji et al. 2008
Moina macrocopa	Cladoceran	chronic	168	Reproduction	NOEC	3.125	Ji et al. 2008
Moina macrocopa	Cladoceran	chronic	168	Reproduction	LOEC	6.25	Ji et al. 2008
ACR(3)							
Oncorhynchus mykiss	Rainbow trout	acute	96	Survival	LC50	707	Colombo et al. 2008
Oncorhynchus mykiss	Rainbow trout	chronic	2040	Survival	NOEC	40	Colombo et al. 2008
Oncorhynchus mykiss	Rainbow trout	chronic	2040	Reproduction	NOEC	40	Colombo et al. 2008
Oncorhynchus mykiss	Rainbow trout	chronic	2040	Reproduction	NOEC	40	Colombo et al. 2008
ACR(4)							
Bufo gargizans	Asiatic toad	acute	96	Survival	LC50	114.74	Yang et al. 2014
Bufo gargizans	Asiatic toad	chronic	720	Survival	EC10	5.89	Yang et al. 2014
ACR(5)							
Pseudorasbora parva	Topmouth gudgeon	acute	96	Survival	LC50	365.02	Yang et al. 2014
Pseudorasbora parva	Topmouth gudgeon	chronic	720	Survival	EC10	11.78	Yang et al. 2014
						ACR(1) =	28
						ACR(2) =	45
						ACR(3) =	17.7
						ACR(4) =	19.5
						ACR(5) =	31.0
						FACR (final)² =	27
Minimum Plant Value							
Species	Species Common Name	Acute or Chronic	Duration (hours)	Endpoint	Effect	PFOA (mg/L)	Study
Selenastrum capricornutum	Green alga	chronic-equivalent	96	EC10	Growth	5.3	3M, 1981
Chronic							
						FCV =	3.9 mg/L
						FPV =	5.3 mg/L
						Chronic RWQ RBSL =	3.9 mg/L

Appendix B - Great Lakes Initiative Recommended Water Quality RBSL Calculations
Table 2. PFOA Acute and Chronic RWQ RBSLs (Tier I Methodology)

Notes

EC50 - effect concentration for 50 percent of the population	LC50 - lethal concentration for 50 percent of the population
FACR - final acute chronic ratio	mg/L - milligram per liter
FAV - final acute value	RBSL - risk-based screening level
FCV - final chronic values	RWQ - recommended water quality

1. The scientific name associated with crucian carp in Yang et al. was *Carassius auratus*, the scientific name for goldfish. Therefore, there is uncertainty in regards to which species was tested.
2. All 8 species groups indicated in GLI must be fulfilled to calculate a Tier I value. The group fulfilled by each species listed is indicated in the table. The 8 species to fulfill are as follows
 - A. The family Salmonidae in the class Osteichthyes
 - B. One other family (preferably a commercially or recreationally important, warmwater species) in the class Osteichthyes (e.g., bluegill, channel catfish)
 - C. A third family in the phylum Chordata (e.g. fish, amphibian)
 - D. A planktonic crustacean (e.g. cladoceran, copepod)
 - E. a benthic crustacean (e.g. ostracod, isopod, amphipod, crayfish)
 - F. An insect (e.g. mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge)
 - G. A family in a phylum other than Arthropoda or Chordata (e.g. Rotifera, Annelida, Mollusca)
 - H. A family in any order of insect or any phylum not already represented

The acute RWQ RBSL using Tier I methodology is calculated from LC50 or EC50s with durations of 48 hours for cladocerans or 96 for all other species. If the preferred duration was unavailable for a species, a shorter duration was considered. Only freshwater species were included in the acute RWQ RBSL calculation.

The geometric mean of appropriate data within a species was calculated to derive the species mean acute value (SMAV). If multiple species within a genus were present (e.g. daphnia magna and daphnia pulex are both daphnia sp.), the geometric mean of each of their SMAVs was calculated to derive the genus mean acute value (GMAV). If only one LC50 or EC50 was available for a species, it was the SMAV and/or GMAV.

The standard practice is to calculate the allowable acute exposure concentration based on the four lowest genus mean acute values (GMAVs) available from the total number of GMAVs. The following equations are used:

$$\text{Equation 1} \quad P = \frac{R}{(N + 1)}$$

$$\text{Equation 2} \quad S^2 = \frac{\sum((\ln GMAV)^2) - \frac{(\sum(\ln GMAV))^2}{4}}{\sum(P) - \frac{(\sum(\sqrt{P}))^2}{4}}$$

$$\text{Equation 3} \quad L = \frac{\sum(\ln GMAV) - S \times (\sum(\sqrt{P}))}{4}$$

$$\text{Equation 4} \quad A = S \times (\sqrt{0.05}) + L$$

$$\text{Equation 5} \quad FAV = e^A$$

$$\text{Equation 6} \quad \text{Acute RWQ RBSL} = \frac{FAV}{2}$$

$$\text{Equation 7} \quad ACR = \frac{\text{acute EC/LC}_{50}}{\sqrt{\text{chronic NOEC} \times \text{chronic LOEC}}}$$

$$\text{Equation 8} \quad \text{Chronic RWQ RBSL} = \frac{FAV}{ACR}$$

Reference

United States Environmental Protection Agency. 2012. Water Quality Guidance for the Great Lakes System. Part 132. Available at: <https://www.govinfo.gov/app/details/CFR-2012-title40-vol23/CFR-2012-title40-vol23-part132>.

Appendix B - Great Lakes Initiative Recommended Water Quality RBSL Calculations
Table 3. PFDoA RWQ RBSLs (Tier II Methodology)

Acute						
Minimum GMAV ¹						
Species	Effect	PFDoA (mg/L)	Duration (hr)	Endpoint	Study	
Chydorus sphaericus	EC50	28.2	48	Immobilization	Ding et al. 2012b	
Minimum GMAV =	28.2	mg/L				
SAF =	21.9	mg/L				
SAV =	1.29	mg/L				
Acute RWQ RBSL =	0.64	mg/L				
Acute to Chronic Ratio						
No data available to calculate an ACR.						
ACR(1) =	18					
ACR(2) =	18					
ACR(3) =	18					
SACR (final) =	18					
Minimum Plant Value						
Species	Effect	PFDoA (mg/L)	Duration (hr)	Endpoint	Study	Acute or Chronic
Scenedesmus obliquus	IC10	55.3	72	Growth	Liu et al. 2008	chronic-equivalent
Chronic						
SCV =	0.07	mg/L				
FPV =	55	mg/L				
Chronic RWQ RBSL =	0.07	mg/L				

Notes:

1. The genus mean acute value (GMAV) is the geometric mean of acute values within a genus. If multiple species within a genus are present then a geometric mean of acute values per species, the species mean acute value (SMAV), is first calculated. The geometric mean of SMAVs within a genus is calculated to determine the GMAV. If only one value is available for a genus, it is used as the GMAV. Only the basis for the minimum GMAV in the PFDoA dataset is presented above.
2. The ACR(final) is the geometric mean of all ACRs calculated from the dataset. A minimum of 3 ACRs must be included in the geometric mean and a default ACR of 18 is used when fewer than 3 calculated ACRs are available.
3. The FPV is the minimum NOEC plant value in the dataset with an endpoint related to growth, reproduction, or survival.
4. The chronic RWQ RBSL is the lower of the SCV and the FPV.

Definitions

ACR - acute to chronic ratio	SAF - secondary adjustment factor
FPV - final plant value	SAV - secondary acute value
hr - hour	SCV - secondary chronic value
LOEC - lowest observed effect concentration	RBSL - risk-based screening level
NOEC - no observed effect concentration	RWQ - recommended water quality
SACR - secondary acute-chronic ratio	

Equations

$$SAV = GMAV / SAF$$

$$Acute\ RWQ\ RBSL = SAV / 2$$

$$ACR = \text{Geometric mean}(EC50, LC50) / \text{Geometric mean}(NOEC, LOEC)$$

$$ACR(\text{final}) = \text{Geometric mean}(ACR(1), ACR(2), ACR(3))$$

$$SCV = SAV/SACR$$

Reference

United States Environmental Protection Agency. 2012. Water Quality Guidance for the Great Lakes System. Part 132. Available at: <https://www.govinfo.gov/app/details/CFR-2012-title40-vol23/CFR-2012-title40-vol23-part132>.

Appendix B - Great Lakes Initiative Recommended Water Quality RBSL Calculations
Table 4. PFUnA RWQ RBSLs (Tier II Methodology)

Acute					
Minimum GMAV¹					
Species	Effect	PFUnA (mg/L)	Duration (hr)	Endpoint	Study
Chydorus sphaericus	EC50	19.2	48	Immobilization	Ding et al. 2012b
Minimum GMAV =	19.2	mg/L			
SAF =	21.9	mg/L			
SAV =	0.88	mg/L			
Acute RWQ RBSL =	0.44	mg/L			
Acute to Chronic Ratio					
No data available to calculate an ACR.					
ACR(1) =	18				
ACR(2) =	18				
ACR(3) =	18				
SACR (final) =	18				
Minimum Plant Value					
No aquatic plant data available.					
Chronic					
SCV =	0.05	mg/L			
FPV =	NA	mg/L			
Chronic RWQ RBSL =	0.05	mg/L			

Notes:

1. The genus mean acute value (GMAV) is the geometric mean of acute values within a genus. If multiple species within a genus are present then a geometric mean of acute values per species, the species mean acute value (SMAV), is first calculated. The geometric mean of SMAVs within a genus is calculated to determine the GMAV. If only one value is available for a genus, it is used as the GMAV. Only the basis for the minimum GMAV in the PFUnA dataset is presented above.
2. The ACR(final) is the geometric mean of all ACRs calculated from the dataset. A minimum of 3 ACRs must be included in the geometric mean and a default ACR of 18 is used when fewer than 3 calculated ACRs are available.
3. The FPV is the minimum NOEC plant value in the dataset with an endpoint related to growth, reproduction, or survival.
4. The chronic RWQ RBSL is the lower of the SCV and the FPV.

Definitions

ACR - acute to chronic ratio

FPV - final plant value

hr - hour

LOEC - lowest observed effect concentration

NOEC - no observed effect concentration

SACR - secondary acute-chronic ratio

SAF - secondary adjustment factor

SAV - secondary acute value

SCV - secondary chronic value

RBSL - risk-based screening level

RWQ - recommended water quality

Equations

SAV = GMAV / SAF

Acute RWQ RBSL = SAV / 2

ACR = Geometric mean(EC50, LC50) / Geometric mean(NOEC, LOEC)

ACR(final) = Geometric mean(ACR(1), ACR(2), ACR(3))

SCV = SAV/SACR

Reference

United States Environmental Protection Agency. 2012. Water Quality Guidance for the Great Lakes System. Part 132. Available at: <https://www.govinfo.gov/app/details/CFR-2012-title40-vol23/CFR-2012-title40-vol23-part132>.

Appendix B - Great Lakes Initiative Recommended Water Quality RBSL Calculations
Table 5. PFDA RWQ RBSLs (Tier II Methodology)

Acute						
Minimum GMAV¹						
Species	Effect	PFDA (mg/L)	Duration (hr)	Endpoint	Study	
Oncorhynchus mykiss	EC50	32	96	Survival	Hoke et al. 2012	
	Minimum GMAV =	32 mg/L				
	SAF =	13 mg/L				
	SAV =	2.5 mg/L				
	Acute RWQ RBSL =	1.2 mg/L				
Acute to Chronic Ratio						
No data available to calculate an ACR.						
	ACR(1) =	18				
	ACR(2) =	18				
	ACR(3) =	18				
	SACR (final) =	18				
Minimum Plant Value						
Species	Effect	PFDA (mg/L)	Duration (hr)	Endpoint	Study	Acute or Chronic chronic-equivalent
Pseudokirchneriella subcapitata	EC50	10.6	72	Growth	Hoke et al. 2012	
Chronic						
	SCV =	0.1 mg/L				
	FPV =	NA mg/L				
	Chronic RWQ RBSL =	0.1 mg/L				

Notes:

1. The genus mean acute value (GMAV) is the geometric mean of acute values within a genus. If multiple species within a genus are present then a geometric mean of acute values per species, the species mean acute value (SMAV), is first calculated. The geometric mean of SMAVs within a genus is calculated to determine the GMAV. If only one value is available for a genus, it is used as the GMAV. Only the basis for the minimum GMAV in the PFDA dataset is presented above.
2. The ACR(final) is the geometric mean of all ACRs calculated from the dataset. A minimum of 3 ACRs must be included in the geometric mean and a default ACR of 18 is used when fewer than 3 calculated ACRs are available.
3. The FPV is the minimum NOEC plant value in the dataset with an endpoint related to growth, reproduction, or survival.
4. The chronic RWQ RBSL is the lower of the SCV and the FPV.

Definitions

ACR - acute to chronic ratio

FPV - final plant value

hr - hour

LOEC - lowest observed effect concentration

NOEC - no observed effect concentration

SACR - secondary acute-chronic ratio

SAF - secondary adjustment factor

SAV - secondary acute value

SCV - secondary chronic value

RBSL - risk-based screening level

RWQ - recommended water quality

Equations

SAV = GMAV / SAF

Acute RWQ RBSL = SAV / 2

ACR = Geometric mean(EC50, LC50) / Geometric mean(NOEC, LOEC)

ACR(final) = Geometric mean(ACR(1), ACR(2), ACR(3))

SCV = SAV/SACR

Reference

United States Environmental Protection Agency. 2012. Water Quality Guidance for the Great Lakes System. Part 132. Available at: <https://www.govinfo.gov/app/details/CFR-2012-title40-vol23/CFR-2012-title40-vol23-part132>.

Appendix B - Great Lakes Initiative Recommended Water Quality RBSL Calculations
Table 6. PFNA RWQ RBSLs (Tier II Methodology)

Acute						
Minimum GMAV ¹						
Species	Effect	PFNA (mg/L)	Duration (hr)	Endpoint	Study	
Chydorus sphaericus	EC50	27.8	48	Immobilization	Ding et al. 2012b	
Minimum GMAV =	27.8	mg/L				
SAF =	13	mg/L				
SAV =	2.1	mg/L				
Acute RWQ RBSL =	1.1	mg/L				
Acute to Chronic Ratio						
No data available to calculate an ACR.						
ACR(1) =	18					
ACR(2) =	18					
ACR(3) =	18					
SACR (final) =	18					
Minimum Plant Value						
Species	Effect	PFNA (mg/L)	Duration (hr)	Endpoint	Study	Acute or Chronic
Geitlerinema amphibium	EC50	130	72	Growth	Latala et al. 2009	chronic-equivalent
Chronic						
SCV =	0.12	mg/L				
FPV =	NA	mg/L				
Chronic RWQ RBSL =	0.12	mg/L				

Appendix B - Great Lakes Initiative Recommended Water Quality RBSL Calculations
Table 6. PFNA RWQ RBSLs (Tier II Methodology)

Notes:

1. The genus mean acute value (GMAV) is the geometric mean of acute values within a genus. If multiple species within a genus are present then a geometric mean of acute values per species, the species mean acute value (SMAV), is first calculated. The geometric mean of SMAVs within a genus is calculated to determine the GMAV. If only one value is available for a genus, it is used as the GMAV. Only the basis for the minimum GMAV in the PFNA dataset is presented above.
2. The ACR(final) is the geometric mean of all ACRs calculated from the dataset. A minimum of 3 ACRs must be included in the geometric mean and a default ACR of 18 is used when fewer than 3 calculated ACRs are available.
3. The FPV is the minimum NOEC plant value in the dataset with an endpoint related to growth, reproduction, or survival.
4. The chronic RWQ RBSL is the lower of the SCV and the FPV.

Definitions

ACR - acute to chronic ratio	SAF - secondary adjustment factor
FPV - final plant value	SAV - secondary acute value
hr - hour	SCV - secondary chronic value
LOEC - lowest observed effect concentration	RBSL - risk-based screening level
NOEC - no observed effect concentration	RWQ - recommended water quality
SACR - secondary acute-chronic ratio	

Equations

$$SAV = GMAV / SAF$$

$$\text{Acute RWQ RBSL} = SAV / 2$$

$$ACR = \text{Geometric mean}(EC50, LC50) / \text{Geometric mean}(NOEC, LOEC)$$

$$ACR(\text{final}) = \text{Geometric mean}(ACR(1), ACR(2), ACR(3))$$

$$SCV = SAV/SACR$$

Reference

United States Environmental Protection Agency. 2012. Water Quality Guidance for the Great Lakes System. Part 132. Available at: <https://www.govinfo.gov/app/details/CFR-2012-title40-vol23/CFR-2012-title40-vol23-part132>.

Appendix B - Great Lakes Initiative Recommended Water Quality RBSL Calculations
Table 7. PFHpA RWQ RBSLs (Tier II Methodology)

Acute						
Minimum GMAV ¹						
Species	Effect	PFHpA (mg/L)	Duration (hr)	Endpoint	Study	
Xenopus laevis	LC50	343.1	96	Survival	Kim et al. 2015	
Minimum GMAV =	343.1	mg/L				
SAF =	21.9	mg/L				
SAV =	15.7	mg/L				
Acute RWQ RBSL =	7.83	mg/L				
Acute to Chronic Ratio						
No data available to calculate an ACR.						
ACR(1) =	18					
ACR(2) =	18					
ACR(3) =	18					
SACR (final) =	18					
Minimum Plant Value						
Species	Effect	PFHpA (mg/L)	Duration (hr)	Endpoint	Study	Acute or Chronic
Geitlerinema amphibium	EC50	517	72	Growth	Latala et al. 2009	chronic-equivalent
Chronic						
SCV =	0.87	mg/L				
FPV =	NA	mg/L				
Chronic RWQ RBSL =	0.87	mg/L				

Notes:

1. The genus mean acute value (GMAV) is the geometric mean of acute values within a genus. If multiple species within a genus are present then a geometric mean of acute values per species, the species mean acute value (SMAV), is first calculated. The geometric mean of SMAVs within a genus is calculated to determine the GMAV. If only one value is available for a genus, it is used as the GMAV. Only the basis for the minimum GMAV in the PFHpA dataset is presented above.
2. The ACR(final) is the geometric mean of all ACRs calculated from the dataset. A minimum of 3 ACRs must be included in the geometric mean and a default ACR of 18 is used when fewer than 3 calculated ACRs are available.
3. The FPV is the minimum NOEC plant value in the dataset with an endpoint related to growth, reproduction, or survival.
4. The chronic RWQ RBSL is the lower of the SCV and the FPV.

Definitions

ACR - acute to chronic ratio	SAF - secondary adjustment factor
FPV - final plant value	SAV - secondary acute value
hr - hour	SCV - secondary chronic value
LOEC - lowest observed effect concentration	RBSL - risk-based screening level
NOEC - no observed effect concentration	RWQ - recommended water quality
SACR - secondary acute-chronic ratio	

Equations

$$SAV = GMAV / SAF$$

$$Acute\ RWQ\ RBSL = SAV / 2$$

$$ACR = \text{Geometric mean}(EC50, LC50) / \text{Geometric mean}(NOEC, LOEC)$$

$$ACR(\text{final}) = \text{Geometric mean}(ACR(1), ACR(2), ACR(3))$$

$$SCV = SAV/SACR$$

Reference

United States Environmental Protection Agency. 2012. Water Quality Guidance for the Great Lakes System. Part 132. Available at: <https://www.govinfo.gov/app/details/CFR-2012-title40-vol23/CFR-2012-title40-vol23-part132>.

Appendix B - Great Lakes Initiative Recommended Water Quality RBSL Calculations
Table 8. PFHxA RWQ RBSLs (Tier II Methodology)

Acute						
Minimum GMAV¹						
Species	Effect	PFHxA (mg/L)	Duration (hr)	Endpoint	Study	
Brachionus calyciflorus	LC50	140	24	Survival	Wang et al. 2014	
Minimum GMAV =	140	mg/L				
SAF =	8	mg/L				
SAV =	17.5	mg/L				
Acute RWQ RBSL =	8.8	mg/L				
Acute to Chronic Ratio						
Species	Effect	PFHxA (mg/L)	Duration (hr)	Endpoint	Study	Acute or Chronic
ACR(1)						
Daphnia magna	EC50	1048	48	Immobilization	Barmentlo et al. 2015	acute
Daphnia magna	LOEC	770	504	Reproduction	Barmentlo et al. 2015	chronic
ACR(1) =	1.4					
ACR(2) =	18					
ACR(3) =	18					
SACR (final) =	7.6					
Minimum Plant Value						
Species	Effect	PFHxA (mg/L)	Duration (hr)	Endpoint	Study	Acute or Chronic
Scenedesmus obliquus	NOEC	628	72	Growth	Liu et al. 2008	chronic-equivalent
Chronic						
SCV =	2.3	mg/L				
FPV =	628	mg/L				
Chronic RWQ RBSL =	2.3	mg/L				

Appendix B - Great Lakes Initiative Recommended Water Quality RBSL Calculations
Table 8. PFHxA RWQ RBSLs (Tier II Methodology)

Notes:

1. The genus mean acute value (GMAV) is the geometric mean of acute values within a genus. If multiple species within a genus are present then a geometric mean of acute values per species, the species mean acute value (SMAV), is first calculated. The geometric mean of SMAVs within a genus is calculated to determine the GMAV. If only one value is available for a genus, it is used as the GMAV. Only the basis for the minimum GMAV in the PFHxA dataset is presented above.
2. The ACR(final) is the geometric mean of all ACRs calculated from the dataset. A minimum of 3 ACRs must be included in the geometric mean and a default ACR of 18 is used when fewer than 3 calculated ACRs are available.
3. The FPV is the minimum NOEC plant value in the dataset with an endpoint related to growth, reproduction, or survival.
4. The chronic RWQ RBSL is the lower of the SCV and the FPV.

Definitions

ACR - acute to chronic ratio	SAF - secondary adjustment factor
FPV - final plant value	SAV - secondary acute value
hr - hour	SCV - secondary chronic value
LOEC - lowest observed effect concentration	RBSL - risk-based screening level
NOEC - no observed effect concentration	RWQ - recommended water quality
SACR - secondary acute-chronic ratio	

Equations

$$\text{SAV} = \text{GMAV} / \text{SAF}$$

$$\text{Acute RWQ RBSL} = \text{SAV} / 2$$

$$\text{ACR} = \text{Geometric mean}(\text{EC50}, \text{LC50}) / \text{Geometric mean}(\text{NOEC}, \text{LOEC})$$

$$\text{ACR}(\text{final}) = \text{Geometric mean}(\text{ACR}(1), \text{ACR}(2), \text{ACR}(3))$$

$$\text{SCV} = \text{SAV} / \text{SACR}$$

Reference

United States Environmental Protection Agency. 2012. Water Quality Guidance for the Great Lakes System. Part 132. Available at: <https://www.govinfo.gov/app/details/CFR-2012-title40-vol23/CFR-2012-title40-vol23-part132>.

Appendix B - Great Lakes Initiative Recommended Water Quality RBSL Calculations
Table 9. PFPeA RWQ RBSLs (Tier II Methodology)

Acute						
Minimum GMAV ¹						
Species	Effect	PFPeA (mg/L)	Duration (hr)	Endpoint	Study	
Pimephales promelas	EC50	32	48	Immobilization	Hoke et al. 2012	
	Minimum GMAV =	32 mg/L				
	SAF =	13 mg/L				
	SAV =	2.46 mg/L				
	Acute RWQ RBSL =	1.23 mg/L				
Acute to Chronic Ratio						
No data available to calculate an ACR.						
	ACR(1) =	18				
	ACR(2) =	18				
	ACR(3) =	18				
	SACR (final) =	18				
Minimum Plant Value						
Species	Effect	PFPeA (mg/L)	Duration (hr)	Endpoint	Study	Acute or Chronic chronic-equivalent
Pseudokirchneriella subcapitata	EC50	81.7	72	Growth	Hoke et al. 2012	
Chronic						
	SCV =	0.14 mg/L				
	FPV =	NA mg/L				
	Chronic RWQ RBSL =	0.14 mg/L				

Notes:

1. The genus mean acute value (GMAV) is the geometric mean of acute values within a genus. If multiple species within a genus are present then a geometric mean of acute values per species, the species mean acute value (SMAV), is first calculated. The geometric mean of SMAVs within a genus is calculated to determine the GMAV. If only one value is available for a genus, it is used as the GMAV. Only the basis for the minimum GMAV in the PFPeA dataset is presented above.
2. The ACR(final) is the geometric mean of all ACRs calculated from the dataset. A minimum of 3 ACRs must be included in the geometric mean and a default ACR of 18 is used when fewer than 3 calculated ACRs are available.
3. The FPV is the minimum NOEC plant value in the dataset with an endpoint related to growth, reproduction, or survival.
4. The chronic RWQ RBSL is the lower of the SCV and the FPV.

Definitions

ACR - acute to chronic ratio	SAF - secondary adjustment factor
FPV - final plant value	SAV - secondary acute value
hr - hour	SCV - secondary chronic value
LOEC - lowest observed effect concentration	RBSL - risk-based screening level
NOEC - no observed effect concentration	RWQ - recommended water quality
SACR - secondary acute-chronic ratio	

Equations

$$\text{SAV} = \text{GMAV} / \text{SAF}$$

$$\text{Acute RWQ RBSL} = \text{SAV} / 2$$

$$\text{ACR} = \text{Geometric mean}(\text{EC50}, \text{LC50}) / \text{Geometric mean}(\text{NOEC}, \text{LOEC})$$

$$\text{ACR}(\text{final}) = \text{Geometric mean}(\text{ACR}(1), \text{ACR}(2), \text{ACR}(3))$$

$$\text{SCV} = \text{SAV} / \text{SACR}$$

Reference

United States Environmental Protection Agency. 2012. Water Quality Guidance for the Great Lakes System. Part 132. Available at: <https://www.govinfo.gov/app/details/CFR-2012-title40-vol23/CFR-2012-title40-vol23-part132>.

Appendix B - Great Lakes Initiative Recommended Water Quality RBSL Calculations
Table 10. PFBS RWQ RBSLs (Tier II Methodology)

Acute						
Minimum GMAV¹						
Species	Effect	PFBS (mg/L)	Duration (hr)	Endpoint	Study	
Caenorhabditis elegans	LC50	238	48	Survival	Chen et al. 2018	
Minimum GMAV =	238	mg/L				
SAF =	7	mg/L				
SAV =	34	mg/L				
Acute RWQ RBSL =	17	mg/L				
Acute to Chronic Ratio						
Species	Effect	PFBS (mg/L)	Duration (hr)	Endpoint	Study	Acute or Chronic
ACR(1)						
Daphnia magna	LC50	2183	48	Survival	Wildlife International Ltd., 2001a	acute
Daphnia magna	NOEC	502	504	Reproduction	Wildlife International Ltd., 2001f	chronic
Daphnia magna	LOEC	995	504	Reproduction	Wildlife International Ltd., 2001f	chronic
ACR(1) =	3.1					
ACR(2) =	18					
ACR(3) =	18					
SACR (final) =	10					
Minimum Plant Value						
Species	Effect	PFBS (mg/L)	Duration (hr)	Endpoint	Study	Acute or Chronic
Selenastrum capricornutum	NOAEC	<285	72	Growth	Wildlife International Ltd., 2001d	chronic-equivalent
Chronic						
SCV =	3.4	mg/L				
FPV =	<285	mg/L				
Chronic RWQ RBSL =	3.4	mg/L				

Appendix B - Great Lakes Initiative Recommended Water Quality RBSL Calculations
Table 10. PFBS RWQ RBSLs (Tier II Methodology)

Notes:

1. The genus mean acute value (GMAV) is the geometric mean of acute values within a genus. If multiple species within a genus are present then a geometric mean of acute values per species, the species mean acute value (SMAV), is first calculated. The geometric mean of SMAVs within a genus is calculated to determine the GMAV. If only one value is available for a genus, it is used as the GMAV. Only the basis for the minimum GMAV in the PFBS dataset is presented above.
2. The ACR(final) is the geometric mean of all ACRs calculated from the dataset. A minimum of 3 ACRs must be included in the geometric mean and a default ACR of 18 is used when fewer than 3 calculated ACRs are available.
3. The FPV is the minimum NOEC plant value in the dataset with an endpoint related to growth, reproduction, or survival.
4. The chronic RWQ RBSL is the lower of the SCV and the FPV.

Definitions

ACR - acute to chronic ratio	SAF - secondary adjustment factor
FPV - final plant value	SAV - secondary acute value
hr - hour	SCV - secondary chronic value
LOEC - lowest observed effect concentration	RBSL - risk-based screening level
NOEC - no observed effect concentration	RWQ - recommended water quality
SACR - secondary acute-chronic ratio	

Equations

$$SAV = GMAV / SAF$$

$$Acute\ RWQ\ RBSL = SAV / 2$$

$$ACR = \text{Geometric mean}(EC50, LC50) / \text{Geometric mean}(NOEC, LOEC)$$

$$ACR(final) = \text{Geometric mean}(ACR(1), ACR(2), ACR(3))$$

$$SCV = SAV/SACR$$

Reference

United States Environmental Protection Agency. 2012. Water Quality Guidance for the Great Lakes System. Part 132. Available at: <https://www.govinfo.gov/app/details/CFR-2012-title40-vol23/CFR-2012-title40-vol23-part132>.

Appendix B - Great Lakes Initiative Recommended Water Quality RBSL Calculations
Table 11. PFBA RWQ RBSLs (Tier II Methodology)

Acute					
Minimum GMAV¹					
Species	Effect	PFBA (mg/L)	Duration (hr)	Endpoint	Study
Brachionus calyciflorus	LC50	110	24	Survival	Wang et al. 2014
Minimum GMAV =	110	mg/L			
SAF =	13	mg/L			
SAV =	8.5	mg/L			
Acute RWQ RBSL =	4.2	mg/L			
Acute to Chronic Ratio					
No data available to calculate an ACR.					
ACR(1) =	18				
ACR(2) =	18				
ACR(3) =	18				
SACR (final) =	18.0				
Minimum Plant Value					
No aquatic plant data available.					
Chronic					
SCV =	0.5	mg/L			
FPV =	NA	mg/L			
Chronic RWQ RBSL =	0.5	mg/L			

Notes:

1. The genus mean acute value (GMAV) is the geometric mean of acute values within a genus. If multiple species within a genus are present then a geometric mean of acute values per species, the species mean acute value (SMAV), is first calculated. The geometric mean of SMAVs within a genus is calculated to determine the GMAV. If only one value is available for a genus, it is used as the GMAV. Only the basis for the minimum GMAV in the PFBA dataset is presented above.
2. The ACR(final) is the geometric mean of all ACRs calculated from the dataset. A minimum of 3 ACRs must be included in the geometric mean and a default ACR of 18 is used when fewer than 3 calculated ACRs are available.
3. The FPV is the minimum NOEC plant value in the dataset with an endpoint related to growth, reproduction, or survival.
4. The chronic RWQ RBSL is the lower of the SCV and the FPV.

Definitions

ACR - acute to chronic ratio	SAF - secondary adjustment factor
FPV - final plant value	SAV - secondary acute value
hr - hour	SCV - secondary chronic value
LOEC - lowest observed effect concentration	RBSL - risk-based screening level
NOEC - no observed effect concentration	RWQ - recommended water quality
SACR - secondary acute-chronic ratio	

Equations

$$SAV = GMAV / SAF$$

$$Acute\ RWQ\ RBSL = SAV / 2$$

$$ACR = \text{Geometric mean}(EC50, LC50) / \text{Geometric mean}(NOEC, LOEC)$$

$$ACR(\text{final}) = \text{Geometric mean}(ACR(1), ACR(2), ACR(3))$$

$$SCV = SAV/SACR$$

Reference

United States Environmental Protection Agency. 2012. Water Quality Guidance for the Great Lakes System. Part 132. Available at: <https://www.govinfo.gov/app/details/CFR-2012-title40-vol23/CFR-2012-title40-vol23-part132>.

Appendix B - Great Lakes Initiative Recommended Water Quality RBSL Calculations
Table 12. PFPrA RWQ RBSLs (Tier II Methodology)

Acute					
Minimum GMAV¹					
Species	Effect	PFPrA (mg/L)	Duration (hr)	Endpoint	Study
Brachionus calyciflorus	EC50	80	24	Survival	Wang et al. 2014
Minimum GMAV =	80	mg/L			
SAF =	21.9	mg/L			
SAV =	3.65	mg/L			
Acute RWQ RBSL =	1.83	mg/L			
Acute to Chronic Ratio					
No data available to calculate an ACR.					
ACR(1) =	18				
ACR(2) =	18				
ACR(3) =	18				
SACR (final) =	18				
Minimum Plant Value					
No aquatic plant data available.					
Chronic					
SCV =	0.20	mg/L			
FPV =	NA	mg/L			
Chronic RWQ RBSL =	0.20	mg/L			

Notes:

1. The genus mean acute value (GMAV) is the geometric mean of acute values within a genus. If multiple species within a genus are present then a geometric mean of acute values per species, the species mean acute value (SMAV), is first calculated. The geometric mean of SMAVs within a genus is calculated to determine the GMAV. If only one value is available for a genus, it is used as the GMAV. Only the basis for the minimum GMAV in the PFPrA dataset is presented above.
2. The ACR(final) is the geometric mean of all ACRs calculated from the dataset. A minimum of 3 ACRs must be included in the geometric mean and a default ACR of 18 is used when fewer than 3 calculated ACRs are available.
3. The FPV is the minimum NOEC plant value in the dataset with an endpoint related to growth, reproduction, or survival.
4. The chronic RWQ RBSL is the lower of the SCV and the FPV.

Definitions

ACR - acute to chronic ratio	SAF - secondary adjustment factor
FPV - final plant value	SAV - secondary acute value
hr - hour	SCV - secondary chronic value
LOEC - lowest observed effect concentration	RBSL - risk-based screening level
NOEC - no observed effect concentration	RWQ - recommended water quality
SACR - secondary acute-chronic ratio	

Equations

SAV = GMAV / SAF

Acute RWQ RBSL = SAV / 2

ACR = Geometric mean(EC50, LC50) / Geometric mean(NOEC, LOEC)

ACR(final) = Geometric mean(ACR(1), ACR(2), ACR(3))

SCV = SAV/SACR

Reference

United States Environmental Protection Agency. 2012. Water Quality Guidance for the Great Lakes System. Part 132. Available at: <https://www.govinfo.gov/app/details/CFR-2012-title40-vol23/CFR-2012-title40-vol23-part132>.

Appendix B - Great Lakes Initiative Recommended Water Quality RBSL Calculations
Table 13. 10:2 FTCA RWQ RBSLs (Tier II Methodology)

Acute						
Minimum GMAV¹						
Species	Effect	10:2 FTCA (mg/L)	Duration (hr)	Endpoint	Study	
Daphnia magna	EC50	0.03	48	Immobilization	Phillips et al. 2007	
Minimum GMAV =	0.03	mg/L				
SAF =	21.9	mg/L				
SAV =	0.0014	mg/L				
Acute RWQ RBSL =	0.0007	mg/L				
Acute to Chronic Ratio						
Species	Effect	10:2 FTCA (mg/L)	Duration (hr)	Endpoint	Study	Acute or Chronic
ACR(1)						
Daphnia magna	EC50	0.03	48	Immobilization	Phillips et al. 2007	acute
Daphnia magna	NOEC	0.03	504	Reproduction	Phillips et al. 2010	chronic
ACR(1) =	1.0					
ACR(2) =	18					
ACR(3) =	18					
SACR (final) =	6.9					
Minimum Plant Value						
Species	Effect	10:2 FTCA (mg/L)	Duration (hr)	Endpoint	Study	Acute or Chronic
Chlorella vulgaris	EC10	0.8	96	Growth	Mitchell et al. 2011	chronic-equivalent
Chronic						
SCV =	0.00020	mg/L				
FPV =	0.8	mg/L				
Chronic RWQ RBSL =	0.00020	mg/L				

Appendix B - Great Lakes Initiative Recommended Water Quality RBSL Calculations
Table 13. 10:2 FTCA RWQ RBSLs (Tier II Methodology)

Notes:

1. The genus mean acute value (GMAV) is the geometric mean of acute values within a genus. If multiple species within a genus are present then a geometric mean of acute values per species, the species mean acute value (SMAV), is first calculated. The geometric mean of SMAVs within a genus is calculated to determine the GMAV. If only one value is available for a genus, it is used as the GMAV. Only the basis for the minimum GMAV in the 10:2 FTCA dataset is presented above.
2. The ACR(final) is the geometric mean of all ACRs calculated from the dataset. A minimum of 3 ACRs must be included in the geometric mean and a default ACR of 18 is used when fewer than 3 calculated ACRs are available.
3. The FPV is the minimum NOEC plant value in the dataset with an endpoint related to growth, reproduction, or survival.
4. The chronic RWQ RBSL is the lower of the SCV and the FPV.
5. A lower NOEC and LOEC for *C. vulgaris* and NOEC for *P. subcapitata* were available from Mitchell et al. 2011, but were not selected because on review of the paper, the effects did not appear to be biologically significant.

Definitions

ACR - acute to chronic ratio	SAF - secondary adjustment factor
FPV - final plant value	SAV - secondary acute value
hr - hour	SCV - secondary chronic value
LOEC - lowest observed effect concentration	RBSL - risk-based screening level
NOEC - no observed effect concentration	RWQ - recommended water quality
SACR - secondary acute-chronic ratio	

Equations

SAV = GMAV / SAF

Acute RWQ RBSL = SAV / 2

ACR = Geometric mean(EC50, LC50) / Geometric mean(NOEC, LOEC)

ACR(final) = Geometric mean(ACR(1), ACR(2), ACR(3))

SCV = SAV/SACR

Reference

United States Environmental Protection Agency. 2012. Water Quality Guidance for the Great Lakes System. Part 132. Available at: <https://www.govinfo.gov/app/details/CFR-2012-title40-vol23/CFR-2012-title40-vol23-part132>.

Appendix B - Great Lakes Initiative Recommended Water Quality RBSL Calculations
Table 14. 10:2 FTuCA RWQ RBSLs (Tier II Methodology)

Acute						
Minimum GMAV¹						
Species	Effect	10:2 FTuCA (mg/L)	Duration (hr)	Endpoint	Study	
Daphnia magna	EC50	0.28	48	Immobilization	Phillips et al. 2007	
Minimum GMAV =	0.28	mg/L				
SAF =	21.9	mg/L				
SAV =	0.013	mg/L				
Acute RWQ RBSL =	0.0064	mg/L				
Acute to Chronic Ratio						
Species	Effect	10:2 FTuCA (mg/L)	Duration (hr)	Endpoint	Study	Acute or Chronic
ACR(1)						
Daphnia magna	EC50	0.28	48	Immobilization	Phillips et al. 2007	acute
Daphnia magna	NOEC	0.075	504	Reproduction	Phillips et al. 2010	chronic
No data available to calculate an ACR.						
ACR(1) =	3.7					
ACR(2) =	18					
ACR(3) =	18					
SACR (final) =	10.7					
Minimum Plant Value						
Species	Effect	10:2 FTuCA (mg/L)	Duration (hr)	Endpoint	Study	Acute or Chronic
Chlorella vulgaris	EC10	0.7	96	Growth	Mitchell et al. 2011	chronic-equivalent
Chronic						
SCV =	0.00120	mg/L				
FPV =	0.7	mg/L				
Chronic RWQ RBSL =	0.0012	mg/L				

Appendix B - Great Lakes Initiative Recommended Water Quality RBSL Calculations
Table 14. 10:2 FTuCA RWQ RBSLs (Tier II Methodology)

Notes:

1. The genus mean acute value (GMAV) is the geometric mean of acute values within a genus. If multiple species within a genus are present then a geometric mean of acute values per species, the species mean acute value (SMAV), is first calculated. The geometric mean of SMAVs within a genus is calculated to determine the GMAV. If only one value is available for a genus, it is used as the GMAV. Only the basis for the minimum GMAV in the 10:2 FTuCA dataset is presented above.
2. The ACR(final) is the geometric mean of all ACRs calculated from the dataset. A minimum of 3 ACRs must be included in the geometric mean and a default ACR of 18 is used when fewer than 3 calculated ACRs are available.
3. The FPV is the minimum NOEC plant value in the dataset with an endpoint related to growth, reproduction, or survival.
4. The chronic RWQ RBSL is the lower of the SCV and the FPV.
5. A lower LOEC for *C. vulgaris* was available from Mitchell et al. 2011, but it was not selected because on review of the paper, the effects did not appear to be biologically significant.

Definitions

ACR - acute to chronic ratio	SAF - secondary adjustment factor
FPV - final plant value	SAV - secondary acute value
hr - hour	SCV - secondary chronic value
LOEC - lowest observed effect concentration	RBSL - risk-based screening level
NOEC - no observed effect concentration	RWQ - recommended water quality
SACR - secondary acute-chronic ratio	

Equations

$SAV = GMAV / SAF$

$Acute\ RWQ\ RBSL = SAV / 2$

$ACR = Geometric\ mean(EC50, LC50) / Geometric\ mean(NOEC, LOEC)$

$ACR(final) = Geometric\ mean(ACR(1), ACR(2), ACR(3))$

$SCV = SAV/SACR$

Reference

United States Environmental Protection Agency. 2012. Water Quality Guidance for the Great Lakes System. Part 132. Available at: <https://www.govinfo.gov/app/details/CFR-2012-title40-vol23/CFR-2012-title40-vol23-part132>.

Appendix B - Great Lakes Initiative Recommended Water Quality RBSL Calculations
Table 15. 8:2 FTCA RWQ RBSLs (Tier II Methodology)

Acute						
Minimum GMAV¹						
Species	Effect	8:2 FTCA (mg/L)	Duration (hr)	Endpoint	Study	
Daphnia magna	EC50	2.3	48	Immobilization	Hoke et al. 2012	
Daphnia magna	EC50	3.03	48	Immobilization	Phillips et al. 2007	
Minimum GMAV =	2.6	mg/L				
SAF =	21.9	mg/L				
SAV =	0.12	mg/L				
Acute RWQ RBSL =	0.06	mg/L				
Acute to Chronic Ratio						
No data available to calculate an ACR.						
ACR(1) =	18					
ACR(2) =	18					
ACR(3) =	18					
SACR (final) =	18					
Minimum Plant Value						
Species	Effect	8:2 FTCA (mg/L)	Duration (hr)	Endpoint	Study	Acute or Chronic chronic-equivalent
Chlorella vulgaris	EC10	1.9	96	Growth	Mitchell et al. 2011	
Chronic						
SCV =	0.01	mg/L				
FPV =	1.90	mg/L				
Chronic RWQ RBSL =	0.01	mg/L				

Notes:

1. The genus mean acute value (GMAV) is the geometric mean of acute values within a genus. If multiple species within a genus are present then a geometric mean of acute values per species, the species mean acute value (SMAV), is first calculated. The geometric mean of SMAVs within a genus is calculated to determine the GMAV. If only one value is available for a genus, it is used as the GMAV. Only the basis for the minimum GMAV in the 8:2 FTCA dataset is presented above.
2. The ACR(final) is the geometric mean of all ACRs calculated from the dataset. A minimum of 3 ACRs must be included in the geometric mean and a default ACR of 18 is used when fewer than 3 calculated ACRs are available.
3. The FPV is the minimum NOEC plant value in the dataset with an endpoint related to growth, reproduction, or survival.
4. The chronic RWQ RBSL is the lower of the SCV and the FPV.
5. A lower NOEC was available for *C. vulgaris* from Mitchell et al. 2011, but it was not selected because on review of the paper, the effects did not appear to be biologically significant. A lower value for *L. gibba* was available from Phillips et al. 2007, but as an EC50 it was not considered for the FPV.

Definitions

ACR - acute to chronic ratio	SAF - secondary adjustment factor
FPV - final plant value	SAV - secondary acute value
hr - hour	SCV - secondary chronic value
LOEC - lowest observed effect concentration	RBSL - risk-based screening level
NOEC - no observed effect concentration	RWQ - recommended water quality
SACR - secondary acute-chronic ratio	

Equations

SAV = GMAV / SAF

Acute RWQ RBSL = SAV / 2

ACR = Geometric mean(EC50, LC50) / Geometric mean(NOEC, LOEC)

ACR(final) = Geometric mean(ACR(1), ACR(2), ACR(3))

SCV = SAV/SACR

Reference

United States Environmental Protection Agency. 2012. Water Quality Guidance for the Great Lakes System. Part 132. Available at: <https://www.govinfo.gov/app/details/CFR-2012-title40-vol23/CFR-2012-title40-vol23-part132>.

Appendix B - Great Lakes Initiative Recommended Water Quality RBSL Calculations
Table 16. 8:2 FTuCA RWQ RBSLs (Tier II Methodology)

Acute						
Minimum GMAV ¹						
Species	Effect	8:2 FTuCA (mg/L)	Duration (hr)	Endpoint	Study	
Daphnia magna	EC50	3.2	48	Immobilization	Hoke et al. 2012	
Daphnia magna	EC50	4.01	48	Immobilization	Phillips et al. 2007	
Minimum GMAV =	3.58	mg/L				
SAF =	13	mg/L				
SAV =	0.28	mg/L				
Aquatic RWQ RBSL =	0.14	mg/L				
Acute to Chronic Ratio						
No data available to calculate an ACR.						
ACR(1) =	18					
ACR(2) =	18					
ACR(3) =	18					
SACR (final) =	18					
Minimum Plant Value						
Species	Effect	8:2 FTuCA (mg/L)	Duration (hr)	Endpoint	Study	Acute or Chronic
Chlorella vulgaris	EC10	2.2	96	Growth	Mitchell et al. 2011	chronic-equivalent
Chronic						
SCV =	0.02	mg/L				
FPV =	2.2	mg/L				
Chronic RWQ RBSL =	0.02	mg/L				

Notes:

1. The genus mean acute value (GMAV) is the geometric mean of acute values within a genus. If multiple species within a genus are present then a geometric mean of acute values per species, the species mean acute value (SMAV), is first calculated. The geometric mean of SMAVs within a genus is calculated to determine the GMAV. If only one value is available for a genus, it is used as the GMAV. Only the basis for the minimum GMAV in the 8:2 FTuCA dataset is presented above.
2. The ACR(final) is the geometric mean of all ACRs calculated from the dataset. A minimum of 3 ACRs must be included in the geometric mean and a default ACR of 18 is used when fewer than 3 calculated ACRs are available.
3. The FPV is the minimum NOEC plant value in the dataset with an endpoint related to growth, reproduction, or survival.
4. The chronic RWQ RBSL is the lower of the SCV and the FPV.
5. A lower NOEC was available for *C. vulgaris* from Mitchell et al. 2011, but it was not selected because on review of the paper, the effects did not appear to be biologically significant. A lower value for *L. gibba* was available from Phillips et al. 2007, but as an EC50 it was not considered for the FPV.

Definitions

ACR - acute to chronic ratio	SAF - secondary adjustment factor
FPV - final plant value	SAV - secondary acute value
hr - hour	SCV - secondary chronic value
LOEC - lowest observed effect concentration	RBSL - risk-based screening level
NOEC - no observed effect concentration	RWQ - recommended water quality
SACR - secondary acute-chronic ratio	

Equations

$$SAV = GMAV / SAF$$

$$Acute\ RWQ\ RBSL = SAV / 2$$

$$ACR = \text{Geometric mean}(EC50, LC50) / \text{Geometric mean}(NOEC, LOEC)$$

$$ACR(\text{final}) = \text{Geometric mean}(ACR(1), ACR(2), ACR(3))$$

$$SCV = SAV/SACR$$

Reference

United States Environmental Protection Agency. 2012. Water Quality Guidance for the Great Lakes System. Part 132. Available at: <https://www.govinfo.gov/app/details/CFR-2012-title40-vol23/CFR-2012-title40-vol23-part132>.

Appendix B - Great Lakes Initiative Recommended Water Quality RBSL Calculations
Table 17. 7:3 Acid RWQ RBSLs (Tier II Methodology)

Acute						
Minimum GMAV ¹						
Species	Effect	7:3 Acid (mg/L)	Duration (hr)	Endpoint	Study	
Daphnia magna	EC50	0.96	48	Immobilization	Hoke et al. 2012	
	Minimum GMAV =	0.96 mg/L				
	SAF =	13 mg/L				
	SAV =	0.07 mg/L				
	Acute RWQ RBSL =	0.04 mg/L				
Acute to Chronic Ratio						
No data available to calculate an ACR.						
	ACR(1) =	18				
	ACR(2) =	18				
	ACR(3) =	18				
	SACR (final) =	18				
Minimum Plant Value						
Species	Effect	7:3 Acid (mg/L)	Duration (hr)	Endpoint	Study	Acute or Chronic
Pseudokirchneriella subcapitata	EC50	2.1	72	Growth	Hoke et al. 2012	chronic-equivalent
Chronic						
	SCV =	0.004 mg/L				
	FPV =	NA mg/L				
	Chronic RWQ RBSL =	0.004 mg/L				

Notes:

1. The genus mean acute value (GMAV) is the geometric mean of acute values within a genus. If multiple species within a genus are present then a geometric mean of acute values per species, the species mean acute value (SMAV), is first calculated. The geometric mean of SMAVs within a genus is calculated to determine the GMAV. If only one value is available for a genus, it is used as the GMAV. Only the basis for the minimum GMAV in the 7:3 Acid dataset is presented above.
2. The ACR(final) is the geometric mean of all ACRs calculated from the dataset. A minimum of 3 ACRs must be included in the geometric mean and a default ACR of 18 is used when fewer than 3 calculated ACRs are available.
3. The FPV is the minimum NOEC plant value in the dataset with an endpoint related to growth, reproduction, or survival.
4. The chronic RWQ RBSL is the lower of the SCV and the FPV.

Definitions

ACR - acute to chronic ratio	SAF - secondary adjustment factor
FPV - final plant value	SAV - secondary acute value
hr - hour	SCV - secondary chronic value
LOEC - lowest observed effect concentration	RBSL - risk-based screening level
NOEC - no observed effect concentration	RWQ - recommended water quality
SACR - secondary acute-chronic ratio	

Equations

$$SAV = GMAV / SAF$$

$$Acute\ RWQ\ RBSL = SAV / 2$$

$$ACR = \text{Geometric mean}(EC50, LC50) / \text{Geometric mean}(NOEC, LOEC)$$

$$ACR(final) = \text{Geometric mean}(ACR(1), ACR(2), ACR(3))$$

$$SCV = SAV/SACR$$

Reference

United States Environmental Protection Agency. 2012. Water Quality Guidance for the Great Lakes System. Part 132. Available at: <https://www.govinfo.gov/app/details/CFR-2012-title40-vol23/CFR-2012-title40-vol23-part132>.

Appendix B - Great Lakes Initiative Recommended Water Quality RBSL Calculations
Table 18. 6:2 CI-PFESA RWQ RBSLs (Tier II Methodology)

Acute						
Minimum GMAV¹						
Species	Effect	6:2 CI-PFESA (mg/L)	Duration (hr)	Endpoint	Study	
Danio rerio	LC50	13.77	96	Survival	Shi et al. 2017a	
Danio rerio	LC50	15.5	96	Survival	Wang et al. 2013b	
Minimum GMAV =	14.6	mg/L				
SAF =	21.9	mg/L				
SAV =	0.667	mg/L				
Acute RWQ RBSL =	0.334	mg/L				
Acute to Chronic Ratio						
Species	Effect	6:2 CI-PFESA (mg/L)	Duration (hr)	Endpoint	Study	Acute or Chronic
ACR(1)						
Danio rerio	LC50	13.77	96	Survival	Shi et al. 2017a	Acute
Danio rerio	LOEC	5	4320	Survival	Shi et al. 2018b	Chronic
ACR(1) =	2.8					
ACR(2) =	18					
ACR(3) =	18					
SACR (final) =	10					
Minimum Plant Value						
Species	Effect	6:2 CI-PFESA (mg/L)	Duration (hr)	Endpoint	Study	Acute or Chronic
Scenedesmus obliquus	NOEC	5.42	72	Growth	Liu et al. 2018	chronic-equivalent
Chronic						
SCV =	0.069	mg/L				
FPV =	5.42	mg/L				
Chronic RWQ RBSL =	0.069	mg/L				

Notes:

1. The genus mean acute value (GMAV) is the geometric mean of acute values within a genus. If multiple species within a genus are present then a geometric mean of acute values per species, the species mean acute value (SMAV), is first calculated. The geometric mean of SMAVs within a genus is calculated to determine the GMAV. If only one value is available for a genus, it is used as the GMAV. Only the basis for the minimum GMAV in the F-53B dataset is presented above.
2. The ACR(final) is the geometric mean of all ACRs calculated from the dataset. A minimum of 3 ACRs must be included in the geometric mean and a default ACR of 18 is used when fewer than 3 calculated ACRs are available.
3. The FPV is the minimum NOEC plant value in the dataset with an endpoint related to growth, reproduction, or survival.
4. The chronic RWQ RBSL is the lower of the SCV and the FPV.

Definitions

ACR - acute to chronic ratio	SAF - secondary adjustment factor
FPV - final plant value	SAV - secondary acute value
hr - hour	SCV - secondary chronic value
LOEC - lowest observed effect concentration	RBSL - risk-based screening level
NOEC - no observed effect concentration	RWQ - recommended water quality
SACR - secondary acute-chronic ratio	

Equations

SAV = GMAV / SAF

Acute RWQ RBSL = SAV / 2

ACR = Geometric mean(EC50, LC50) / Geometric mean(NOEC, LOEC)

ACR(final) = Geometric mean(ACR(1), ACR(2), ACR(3))

SCV = SAV/SACR

Reference

United States Environmental Protection Agency. 2012. Water Quality Guidance for the Great Lakes System. Part 132. Available at: <https://www.govinfo.gov/app/details/CFR-2012-title40-vol23/CFR-2012-title40-vol23-part132>.

Appendix B - Great Lakes Initiative Recommended Water Quality RBSL Calculations
Table 19. 6:2 FTCA RWQ RBSLs (Tier II Methodology)

Acute						
Minimum GMAV ¹						
Species	Effect	6:2 FTCA (mg/L)	Duration (hr)	Endpoint	Study	
Danio rerio	LC50	25.1	72	Survival	Shi et al. 2017b	
Minimum GMAV =	25.1	mg/L				
SAF =	21.9	mg/L				
SAV =	1.15	mg/L				
Acute RWQ RBSL =	0.57	mg/L				
Acute to Chronic Ratio						
No data available to calculate an ACR.						
ACR(1) =	18					
ACR(2) =	18					
ACR(3) =	18					
SACR (final) =	18					
Minimum Plant Value ⁵						
Species	Effect	6:2 FTCA (mg/L)	Duration (hr)	Endpoint	Study	Acute or Chronic
Chlorella vulgaris	EC10	5.2	96	Growth	Mitchell et al. 2011	chronic-equivalent
Chronic						
SCV =	0.064	mg/L				
FPV =	5.2	mg/L				
Chronic RWQ RBSL =	0.064	mg/L				

Notes:

1. The genus mean acute value (GMAV) is the geometric mean of acute values within a genus. If multiple species within a genus are present then a geometric mean of acute values per species, the species mean acute value (SMAV), is first calculated. The geometric mean of SMAVs within a genus is calculated to determine the GMAV. If only one value is available for a genus, it is used as the GMAV. Only the basis for the minimum GMAV in the 6:2 FTCA dataset is presented above.
2. The ACR(final) is the geometric mean of all ACRs calculated from the dataset. A minimum of 3 ACRs must be included in the geometric mean and a default ACR of 18 is used when fewer than 3 calculated ACRs are available.
3. The FPV is the minimum NOEC plant value in the dataset with an endpoint related to growth, reproduction, or survival.
4. The chronic RWQ RBSL is the lower of the SCV and the FPV.
5. A lower LOEC was available for *C. vulgaris* from Mitchell et al. 2011, but it was not selected because on review of the paper, the effects did not appear to be biologically significant. A lower value for *L. gibba* was available from Phillips et al. 2007, but as an EC50 it was not considered for the FPV.

Definitions

ACR - acute to chronic ratio	SAF - secondary adjustment factor
FPV - final plant value	SAV - secondary acute value
hr - hour	SCV - secondary chronic value
LOEC - lowest observed effect concentration	RBSL - risk-based screening level
NOEC - no observed effect concentration	RWQ - recommended water quality
SACR - secondary acute-chronic ratio	

Equations

SAV = GMAV / SAF

Acute RWQ RBSL = SAV / 2

ACR = Geometric mean(EC50, LC50) / Geometric mean(NOEC, LOEC)

ACR(final) = Geometric mean(ACR(1), ACR(2), ACR(3))

SCV = SAV/SACR

Reference

United States Environmental Protection Agency. 2012. Water Quality Guidance for the Great Lakes System. Part 132. Available at: <https://www.govinfo.gov/app/details/CFR-2012-title40-vol23/CFR-2012-title40-vol23-part132>.

Appendix B - Great Lakes Initiative Recommended Water Quality RBSL Calculations
Table 20. 6:2 FTuCA RWQ RBSLs (Tier II Methodology)

Acute						
Minimum GMAV ¹						
Species	Effect	6:2 FTuCA (mg/L)	Duration (hr)	Endpoint	Study	
Daphnia magna	EC50	29.6	48	Immobilization	Hoke et al. 2012	
Minimum GMAV =	29.6	mg/L				
SAF =	21.9	mg/L				
SAV =	1.35	mg/L				
Acute RWQ RBSL =	0.676	mg/L				
Acute to Chronic Ratio						
No data available to calculate an ACR.						
ACR(1) =	18					
ACR(2) =	18					
ACR(3) =	18					
SACR (final) =	18					
Minimum Plant Value						
Species	Effect	6:2 FTuCA (mg/L)	Duration (hr)	Endpoint	Study	Acute or Chronic
Chlorella vulgaris	EC10	6.4	96	Growth	Mitchell et al. 2011	chronic-equivalent
Chronic						
SCV =	0.075	mg/L				
FPV =	6.4	mg/L				
Chronic RWQ RBSL =	0.075	mg/L				

Notes:

1. The genus mean acute value (GMAV) is the geometric mean of acute values within a genus. If multiple species within a genus are present then a geometric mean of acute values per species, the species mean acute value (SMAV), is first calculated. The geometric mean of SMAVs within a genus is calculated to determine the GMAV. If only one value is available for a genus, it is used as the GMAV. Only the basis for the minimum GMAV in the 6:2 FTuCA dataset is presented above.
2. The ACR(final) is the geometric mean of all ACRs calculated from the dataset. A minimum of 3 ACRs must be included in the geometric mean and a default ACR of 18 is used when fewer than 3 calculated ACRs are available.
3. The FPV is the minimum NOEC plant value in the dataset with an endpoint related to growth, reproduction, or survival.
4. The chronic RWQ RBSL is the lower of the SCV and the FPV.
5. A lower NOEC and LOEC for *P. subcapitata* and a lower LOEC for *C. vulgaris* were available from Mitchell et al. 2011, but were not selected because on review of the paper, the effects did not appear to be biologically significant.

Definitions

ACR - acute to chronic ratio	SAF - secondary adjustment factor
FPV - final plant value	SAV - secondary acute value
hr - hour	SCV - secondary chronic value
LOEC - lowest observed effect concentration	RBSL - risk-based screening level
NOEC - no observed effect concentration	RWQ - recommended water quality
SACR - secondary acute-chronic ratio	

Equations

$$\text{SAV} = \text{GMAV} / \text{SAF}$$

$$\text{Acute RWQ RBSL} = \text{SAV} / 2$$

$$\text{ACR} = \text{Geometric mean}(\text{EC50}, \text{LC50}) / \text{Geometric mean}(\text{NOEC}, \text{LOEC})$$

$$\text{ACR}(\text{final}) = \text{Geometric mean}(\text{ACR}(1), \text{ACR}(2), \text{ACR}(3))$$

$$\text{SCV} = \text{SAV} / \text{SACR}$$

Reference

United States Environmental Protection Agency. 2012. Water Quality Guidance for the Great Lakes System. Part 132. Available at: <https://www.govinfo.gov/app/details/CFR-2012-title40-vol23/CFR-2012-title40-vol23-part132>.

Appendix B - Great Lakes Initiative Recommended Water Quality RBSL Calculations
Table 21. 6:2 FTAB RWQ RBSLs (Tier II Methodology)

Acute					
Minimum GMAV ¹					
Species	Effect	6:2 FTAB (mg/L)	Duration (hr)	Endpoint	Study
Danio rerio	LC50	64.39	96	Survival	Shi et al. 2018a
Minimum GMAV =	64.39	mg/L			
SAF =	21.9	mg/L			
SAV =	2.94	mg/L			
Acute RWQ RBSL =	1.47	mg/L			
Acute to Chronic Ratio					
No data available to calculate an ACR.					
ACR(1) =	18				
ACR(2) =	18				
ACR(3) =	18				
SACR (final) =	18				
Minimum Plant Value					
No aquatic plant data available.					
Chronic					
SCV =	0.16	mg/L			
FPV =	NA	mg/L			
Chronic RWQ RBSL =	0.16	mg/L			

Notes:

1. The genus mean acute value (GMAV) is the geometric mean of acute values within a genus. If multiple species within a genus are present then a geometric mean of acute values per species, the species mean acute value (SMAV), is first calculated. The geometric mean of SMAVs within a genus is calculated to determine the GMAV. If only one value is available for a genus, it is used as the GMAV. Only the basis for the minimum GMAV in the 6:2 FTAB dataset is presented above.
2. The ACR(final) is the geometric mean of all ACRs calculated from the dataset. A minimum of 3 ACRs must be included in the geometric mean and a default ACR of 18 is used when fewer than 3 calculated ACRs are available.
3. The FPV is the minimum NOEC plant value in the dataset with an endpoint related to growth, reproduction, or survival.
4. The chronic RWQ RBSL is the lower of the SCV and the FPV.

Definitions

ACR - acute to chronic ratio	SAF - secondary adjustment factor
FPV - final plant value	SAV - secondary acute value
hr - hour	SCV - secondary chronic value
LOEC - lowest observed effect concentration	RBSL - risk-based screening level
NOEC - no observed effect concentration	RWQ - recommended water quality
SACR - secondary acute-chronic ratio	

Equations

$$SAV = GMAV / SAF$$

$$Acute\ RWQ\ RBSL = SAV / 2$$

$$ACR = \text{Geometric mean}(EC50, LC50) / \text{Geometric mean}(NOEC, LOEC)$$

$$ACR(\text{final}) = \text{Geometric mean}(ACR(1), ACR(2), ACR(3))$$

$$SCV = SAV/SACR$$

Reference

United States Environmental Protection Agency. 2012. Water Quality Guidance for the Great Lakes System. Part 132. Available at: <https://www.govinfo.gov/app/details/CFR-2012-title40-vol23/CFR-2012-title40-vol23-part132>.

Appendix B - Great Lakes Initiative Recommended Water Quality RBSL Calculations
Table 22. 5H 4:1 FTOH RWQ RBSLs (Tier II Methodology)

Acute					
Minimum GMAV¹					
Species	Effect	5H 4:1 FTOH (mg/L)	Duration (hr)	Endpoint	Study
Brachionus calyciflorus	EC50	195.4	48	Immobilization	Ding et al. 2012b
Minimum GMAV =	195.4	mg/L			
SAF =	21.9	mg/L			
SAV =	8.9	mg/L			
Acute RWQ RBSL =	4.5	mg/L			
Acute to Chronic Ratio					
No data available to calculate an ACR.					
ACR(1) =	18				
ACR(2) =	18				
ACR(3) =	18				
SACR (final) =	18				
Minimum Plant Value					
No aquatic plant data available.					
Chronic					
SCV =	0.5	mg/L			
FPV =	NA	mg/L			
Chronic RWQ RBSL =	0.5	mg/L			

Notes:

1. The genus mean acute value (GMAV) is the geometric mean of acute values within a genus. If multiple species within a genus are present then a geometric mean of acute values per species, the species mean acute value (SMAV), is first calculated. The geometric mean of SMAVs within a genus is calculated to determine the GMAV. If only one value is available for a genus, it is used as the GMAV. Only the basis for the minimum GMAV in the 5H 4:1 FTOH dataset is presented above.
2. The ACR(final) is the geometric mean of all ACRs calculated from the dataset. A minimum of 3 ACRs must be included in the geometric mean and a default ACR of 18 is used when fewer than 3 calculated ACRs are available.
3. The FPV is the minimum NOEC plant value in the dataset with an endpoint related to growth, reproduction, or survival.
4. The chronic RWQ RBSL is the lower of the SCV and the FPV.

Definitions

ACR - acute to chronic ratio

FPV - final plant value

hr - hour

LOEC - lowest observed effect concentration

NOEC - no observed effect concentration

SACR - secondary acute-chronic ratio

SAF - secondary adjustment factor

SAV - secondary acute value

SCV - secondary chronic value

RBSL - risk-based screening level

RWQ - recommended water quality

Equations

SAV = GMAV / SAF

Acute RWQ RBSL = SAV / 2

ACR = Geometric mean(EC50, LC50) / Geometric mean(NOEC, LOEC)

ACR(final) = Geometric mean(ACR(1), ACR(2), ACR(3))

SCV = SAV/SACR

Reference

United States Environmental Protection Agency. 2012. Water Quality Guidance for the Great Lakes System. Part 132. Available at: <https://www.govinfo.gov/app/details/CFR-2012-title40-vol23/CFR-2012-title40-vol23-part132>.

Appendix B - Great Lakes Initiative Recommended Water Quality RBSL Calculations
Table 23. FC807 RWQ RBSLs (Tier II Methodology)

Acute					
Minimum GMAV¹					
Species	Effect	FC807 (mg/L)	Duration (hr)	Endpoint	Study
Danio rerio	EC50	211	24	Reproduction	Zheng et al. 2012
Minimum GMAV =	211	mg/L			
SAF =	21.9	mg/L			
SAV =	9.63	mg/L			
Acute RWQ RBSL =	4.82	mg/L			
Acute to Chronic Ratio					
No data available to calculate an ACR.					
ACR(1) =	18				
ACR(2) =	18				
ACR(3) =	18				
SACR (final) =	18				
Minimum Plant Value					
No aquatic plant data available.					
Chronic					
SCV =	0.54	mg/L			
FPV =	NA	mg/L			
Chronic RWQ RBSL =	0.54	mg/L			

Notes:

1. The genus mean acute value (GMAV) is the geometric mean of acute values within a genus. If multiple species within a genus are present then a geometric mean of acute values per species, the species mean acute value (SMAV), is first calculated. The geometric mean of SMAVs within a genus is calculated to determine the GMAV. If only one value is available for a genus, it is used as the GMAV. Only the basis for the minimum GMAV in the FC807 dataset is presented above.
2. The ACR(final) is the geometric mean of all ACRs calculated from the dataset. A minimum of 3 ACRs must be included in the geometric mean and a default ACR of 18 is used when fewer than 3 calculated ACRs are available.
3. The FPV is the minimum NOEC plant value in the dataset with an endpoint related to growth, reproduction, or survival.
4. The chronic RWQ RBSL is the lower of the SCV and the FPV.

Definitions

ACR - acute to chronic ratio	SAF - secondary adjustment factor
FPV - final plant value	SAV - secondary acute value
hr - hour	SCV - secondary chronic value
LOEC - lowest observed effect concentration	RBSL - risk-based screening level
NOEC - no observed effect concentration	RWQ - recommended water quality
SACR - secondary acute-chronic ratio	

Equations

$$\text{SAV} = \text{GMAV} / \text{SAF}$$

$$\text{Acute RWQ RBSL} = \text{SAV} / 2$$

$$\text{ACR} = \text{Geometric mean}(\text{EC50}, \text{LC50}) / \text{Geometric mean}(\text{NOEC}, \text{LOEC})$$

$$\text{ACR}(\text{final}) = \text{Geometric mean}(\text{ACR}(1), \text{ACR}(2), \text{ACR}(3))$$

$$\text{SCV} = \text{SAV} / \text{SACR}$$

Reference

United States Environmental Protection Agency. 2012. Water Quality Guidance for the Great Lakes System. Part 132. Available at: <https://www.govinfo.gov/app/details/CFR-2012-title40-vol23/CFR-2012-title40-vol23-part132>.

Appendix C

Plant Screening Level Calculations

Appendix C - Plant Screening Level Calculations
Table 1. PFOS Plant Screening Level

NOEC and LOEC Values (mg/kg of soil)					
Species	Study	NOEC (mg/kg)	Bounded/Unbounded	Duration (hours)	Endpoint
Tomato	Brignole et al. 2003	7.33	Bounded	504	Survival, Growth
Alfalfa	Brignole et al. 2003	33.5	Bounded	504	Survival, Growth
Flax	Brignole et al. 2003	33.5	Bounded	504	Survival, Growth
Ryegrass	Brignole et al. 2003	2.45	Bounded	504	Growth
Soybean	Brignole et al. 2003	33.5	Bounded	504	Growth
Onion	Brignole et al. 2003	2.45	Bounded	504	Growth
Geometric mean of NOECs		11			
Species	Study	LOEC (mg/kg)	Bounded/Unbounded	Duration (hours)	Endpoint
Tomato	Brignole et al. 2003	33.5	Bounded	504	Survival, Growth
Alfalfa	Brignole et al. 2003	216.5	Bounded	504	Survival, Growth
Flax	Brignole et al. 2003	216.5	Bounded	504	Survival, Growth
Lettuce	Brignole et al. 2003	2.45	Unbounded	504	Growth
Ryegrass	Brignole et al. 2003	7.33	Bounded	504	Growth
Soybean	Brignole et al. 2003	216.5	Bounded	504	Growth
Onion	Brignole et al. 2003	7.33	Bounded	504	Growth
Geometric mean of LOECs		33			
Final NOEC SL¹		11			
Final LOEC SL²		33			

Notes:

1. The NOEC soil SL is based on growth or reproduction endpoints if available.
2. The LOEC soil SL is based on growth, reproductive, or survival endpoints if available.

Bounded - a LOEC with a paired NOEC or vice versa
 LOEC - lowest observed effect concentration
 mg/kg - milligram per kilogram
 NOEC - no observed effect concentration
 SL - screening level
 Unbounded - NOEC without a paired LOEC or vice versa

Appendix C - Plant Screening Level Calculations

Table 2. PFOA Plant Screening Level

NOEC and LOEC Values (mg/kg of soil)					
Species	Study	NOEC (mg/kg)	Bounded/Unbounded	Duration (hours)	Endpoint
Lettuce	Ding et al. 2012 ¹	621	NA	120	Growth
Monocotyledonous	González-Naranjo et al. 2014	5.98	EC10	72	Growth
Wheat	Zhou et al. 2016	200	Bounded	192	Growth
Italian Lettuce (WN)	Xiang et al. 2018	0.186	Bounded	1200	Growth
Hongfeng Lettuce	Xiang et al. 2018	0.192	Bounded	1200	Growth
Red Wave Lettuce	Xiang et al. 2018	0.191	Bounded	1200	Growth
Italian Lettuce (SM)	Xiang et al. 2018	0.188	Bounded	1200	Growth
Italian Lettuce (HC)	Xiang et al. 2018	0.183	Bounded	1200	Growth
Geometric mean of NOECs		1.91			
Species	Study	LOEC (mg/kg)	Bounded/Unbounded	Duration (hours)	Endpoint
Monocotyledonous	González-Naranjo et al. 2014	19.21	EC20	72	Growth
Wheat	Zhou et al. 2016	800	Bounded	192	Growth
Italian Lettuce (WN)	Xiang et al. 2018	0.942	Bounded	1200	Growth
Hongfeng Lettuce	Xiang et al. 2018	0.962	Bounded	1200	Growth
Hanbaofeicui Lettuce	Xiang et al. 2018	0.186	Unbounded	1200	Growth
Red Wave Lettuce	Xiang et al. 2018	0.976	Bounded	1200	Growth
Kafeimaidangcai Lettuce	Xiang et al. 2018	0.183	Unbounded	1200	Growth
Chicory	Xiang et al. 2018	0.183	Unbounded	1200	Growth
Italian Lettuce (SM)	Xiang et al. 2018	0.945	Bounded	1200	Growth
Italian Lettuce (HC)	Xiang et al. 2018	0.889	Bounded	1200	Growth
Italian Lettuce (QK)	Xiang et al. 2018	0.184	Unbounded	1200	Growth
American Frisee Lettuce	Xiang et al. 2018	0.187	Unbounded	1200	Growth
Italian Frisee Lettuce	Xiang et al. 2018	0.192	Unbounded	1200	Growth
Local Red Lettuce	Xiang et al. 2018	0.186	Unbounded	1200	Growth
Geometric mean of LOECs		0.84			
Final NOEC SL^{2,3}		0.084			
Final LOEC SL⁴		0.84			

Notes:

1. The Ding et al. 2012 NOEC is a statistically derived NOEC without a corresponding LOEC; however, it is not the highest treatment, therefore, it was not considered unbounded and was included in the NOEC plant SL calculation.
2. The geometric mean of the presented NOECs is higher than the geometric mean of the presented LOECs. To calculate a protective NOEC SL, an uncertainty factor of 10 was applied to the LOEC SL and the final NOEC SL is the LOEC SL divided by 10.
3. The NOEC soil SL is based on growth or reproduction endpoints if available. Available EC10 are included as approximate NOECs.
4. The LOEC soil SL is based on growth, reproductive, or survival endpoints if available. Available EC20 are included as approximate LOECs.

Bounded - a LOEC with a paired NOEC or vice versa

EC10 - effect concentration where 10 percent of the population is affected

EC20 - effect concentration where 20 percent of the population is affected

LOEC - lowest observed effect concentration

mg/kg - milligram per kilogram

NOEC - no observed effect concentration

SL - screening level

Unbounded - NOEC without a paired LOEC or vice versa

Appendix D

Wildlife Toxicity Reference Value Calculations

Appendix D - Wildlife Toxicity Reference Value Calculations

Table 1. PFNA Mammal Toxicity Reference Values

Step 1 - NOAEL and LOAEL Selection					
Species	Study	Value (mg/kg bw-day)	Bounded/Unbounded	Duration (days)	Endpoint
No Observed Adverse Effect Levels Based on Reproduction and Growth					
Mice (CD-1)	Das et al. 2015	1	Bounded	17	Growth
Mouse	Wolf et al. 2010	0.83	Bounded	18	Reproduction, Survival
Lowest Observed Adverse Effect Levels Based on Reproduction, Growth, and Survival					
Mice (CD-1)	Das et al. 2015	3	Bounded	17	Growth
Mouse	Wolf et al. 2010	1.1	Bounded	18	Reproduction, Survival
Mouse (CD-1)	Kennedy, 1987	54	Unbounded	14	Survival
Rat (Sprague-Dawley)	Rogers et al. 2014	5	Unbounded	20	Growth, Reproduction
Step 2 - Final NOAEL and LOAEL					
Application of Uncertainty Factors (UF)					
Final NOAEL	UF = NA	0.83	Bounded	17	Growth
Final LOAEL	UF = NA	1.1	Bounded	18	Reproduction
Step 3 - TRV Selection					
		Final TRV	Basis		
NOAEL-based TRV		0.83	Final NOAEL		
LOAEL-based TRV		1.1	Final LOAEL		

Notes:

NOAEL- and LOAEL-based TRVs were derived following USEPA EcoSSL methodology in Steps 1 through 3 (USEPA 2007) .

Step 1: the lowest NOAEL and the lowest bounded LOAEL are shaded gray. As there are fewer than 3 NOAELs in the data set, the lowest NOAEL is selected as the basis of the TRV and is shaded gray.

Step 2: the final NOAEL and LOAEL as presented in Step 2 are the NOAEL and LOAEL selected in Step 1 with uncertainty factors (UFs) applied to values from studies with subchronic durations. Chronic duration studies are considered studies with gestational exposure and effects observed on offspring or studies with adults for 10 percent or more of their lifespan. UFs were not applied to chronic studies. Subchronic duration studies were less than 10 percent of the test species lifespan and not including gestational exposure. An UF of 10 was applied to subchronic studies.

Step 3: The NOAEL-based TRV and LOAEL-based TRV are the final NOAEL and LOAEL as presented in Step 2.

Bounded - a NOAEL paired with a LOAEL or vice versa

LOAEL - lowest observed adverse effect concentration

mg/kg-bw/day - milligram per kilogram of body weight per day

NA - not applicable

NOAEL - no observed adverse effect concentration

TRV - toxicity reference value

Unbounded - NOAEL without a paired LOAEL or vice versa

Reference

United States Environmental Protection Agency. 2007. Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs), Attachment 4-5. June.

Appendix D - Wildlife Toxicity Reference Value Calculations
Table 2. PFOS Mammal Toxicity Reference Values

Step 1 - NOAEL and LOAEL Selection					
Species	Study	Value (mg/kg bw-day)	Bounded/Unbounded	Duration (days)	Endpoint
No Observed Adverse Effect Levels Based on Reproduction and Growth					
Rat (Sprague-Dawley)	Gortner et al. 1980	5	Bounded	10	Growth, Reproduction
Rat	Seacat et al. 2003	1.51	Unbounded	28	Growth
Rat (Sprague-Dawley)	Seacat et al. 2003	1.33	Unbounded	98	Growth
Rat	Chen et al. 2012	0.1	Bounded	21	Survival, Growth
Rat	Luebker et al. 2005b	0.4	Bounded	84	Reproduction
Rat	Luebker et al. 2005a	0.4	Bounded	63	Reproduction, Growth
Mouse	Yahia et al. 2008	1	Bounded	18 (F0)	Reproduction
Mouse (CD-1)	Fuentes et al. 2006	6	Unbounded	13	Reproduction
Rabbit (New Zealand)	Case et al. 2001	0.1	Bounded	15	Reproduction
Rat (Sprague-Dawley)	Lau et al. 2003	1	Bounded	20	Reproduction, Survival
Rat (Sprague-Dawley)	Lopez-Doval et al. 2014	0.5	Bounded	28	Reproduction
Rat (Sprague-Dawley)	Xia et al. 2011	0.6	Bounded	20	Reproduction, Survival
Mouse (C57BL/6J-Apc+/+)	Ngo et al. 2014	0.1	Bounded	7	Reproduction
Mouse (CD-1)	Wan et al. 2011	5	Bounded	21	Reproduction
Rat (Sprague-Dawley)	Butenhoff et al. 2012b; Thomford 2002	0.25	Bounded	728	Growth
Rat (CrI:CD [SD])	Butenhoff et al. 2009b	0.3	Bounded	>30	Growth
Mouse (B6C3F1)	Keil et al. 2008	5	Unbounded	17	Reproduction, Growth
Mouse (CD-1)	Lau et al. 2003	5	Bounded	17	Reproduction, Survival
Mouse (CD1)	Rosen et al. 2009	10	Unbounded	17	Growth, Reproduction
Mouse (CD-1)	Thibodeaux et al. 2003	15	Bounded	17	Reproduction
Rat (Sprague-Dawley)	Thibodeaux et al. 2003	5	Bounded	20	Reproduction, Growth
Rat (Sprague-Dawley)	Wan et al. 2010	0.6	Bounded	20	Reproduction, Survival
Mouse (CD-1)	Wan et al. 2014	3	Unbounded	>30 (GD3-PND21)	Growth, Reproduction
Rat (Wistar)	Wang et al. 2011a	3.2	Bounded	>30 (GD1-PND14)	Growth, Reproduction
Mouse (B6C3F1)	Fair et al. 2011	0.0331	Bounded	28	Reproduction
Mouse (ICR)	Qiu et al. 2013	0.25	Bounded	28	Reproduction
Rat (Sprague-Dawley CD)	Wetzel, 1983	1	Bounded	10	Growth, Reproduction
Lowest Observed Adverse Effect Levels Based on Reproduction, Growth, and Survival					
Rat (Sprague-Dawley)	Gortner et al. 1980	10	Bounded	10	Growth
Rat	Chen et al. 2012	2	Bounded	21	Survival, Growth
Rat	Lv et al. 2013	0.5	Unbounded	GD0-PND20	Growth, Reproduction
Rat	Zhao et al. 2014a	5	Unbounded	8	Growth, Reproduction
Rat	Luebker et al. 2005b	1.6	Bounded	84	Reproduction
Rat	Luebker et al. 2005a	0.8	Bounded	63	Reproduction, Growth
Mouse	Fuentes et al. 2007	6	Unbounded	7 (F0)	Growth, Reproduction
Mouse	Yahia et al. 2008	10	Bounded	18 (F0)	Reproduction
Rat (Sprague-Dawley)	Grasty et al. 2003	25	Unbounded	4	Growth, Reproduction, Survival
Mouse (wild type 129S1/SvIm)	Abbott et al. 2009	4.5	Unbounded	4	Reproduction, Survival
Mouse (ICR)	Era et al. 2009, test 1	50	Unbounded	5	Growth, Reproduction
Mouse (ICR)	Era et al. 2009, test 2	20	Unbounded	17	Growth, Reproduction
Mouse (CD-1)	Lee et al. 2015	0.5	Unbounded	6	Growth, Reproduction, Survival
Rabbit (New Zealand)	Case et al. 2001	1	Bounded	15	Reproduction
Rat (Sprague-Dawley)	Lau et al. 2003	2	Bounded	20	Reproduction, Survival
Rat (Sprague-Dawley)	Lopez-Doval et al. 2014	1	Bounded	28	Reproduction
Rat (Sprague-Dawley)	Rogers et al. 2014	18.75	Unbounded	5	Growth, Reproduction
Rat (Sprague-Dawley)	Xia et al. 2011	2	Bounded	20	Reproduction, Survival
Mouse (C57BL/6J-Apc+/+)	Ngo et al. 2014	3	Bounded	7	Reproduction
Mouse (CD-1)	Wan et al. 2011	10	Bounded	21	Reproduction
Rat (Sprague-Dawley)	Butenhoff et al. 2012b; Thomford 2002	1.04 (F)	Bounded	728	Growth
Rat (CrI:CD [SD])	Butenhoff et al. 2009b	1	Bounded	>30	Growth
Mouse (CD-1)	Lau et al. 2003	10	Bounded	17	Reproduction, Survival
Mouse (CD-1)	Thibodeaux et al. 2003	20	Bounded	17	Reproduction
Rat (Sprague-Dawley)	Thibodeaux et al. 2003	10	Bounded	20	Reproduction, Growth
Rat (Sprague-Dawley)	Wan et al. 2010	2	Bounded	20	Reproduction, Survival
Rat (Wistar)	Wang et al. 2011a	32	Bounded	>30 (GD1-PND14)	Growth, Reproduction

Appendix D - Wildlife Toxicity Reference Value Calculations
Table 2. PFOS Mammal Toxicity Reference Values

Mouse (B6C3F1)	Fair et al. 2011	0.166	Bounded	28	Reproduction
Mouse (ICR)	Qiu et al. 2013	2.5	Bounded	28	Reproduction
Rat (Sprague-Dawley CD)	Wetzel, 1983	5	Bounded	10	Growth, Reproduction
Step 2 - NOAEL Geometric Mean					
Reproduction and Growth NOAEL Geomean		1.00			
Step 3 - Final NOAEL and LOAEL					
Application of Uncertainty Factors (UF)					
Final NOAEL	UF = NA	0.1	Bounded	multiple	Reproduction, Growth, Survival
Final LOAEL	UF = NA	0.17	Bounded	28	Reproduction
Step 4 - TRV Selection					
		Final TRV	Basis		
NOAEL-based TRV		0.1	Final NOAEL		
LOAEL-based TRV		0.17	Final LOAEL		

Notes:

NOAEL- and LOAEL-based TRVs were derived following USEPA EcoSSL methodology in Steps 1 through 4 (USEPA 2007) .

Step 1: the highest bounded NOAEL below the lowest bounded LOAEL and the lowest bounded LOAEL are shaded gray.

Step 2: the NOAEL geometric mean is the geometric mean of the NOAELs in the dataset with a growth or reproductive endpoint.

Step 3: the final NOAEL and LOAEL as presented in Step 3 are the NOAEL and LOAEL selected in Step 1 with uncertainty factors (UFs) applied to values from studies with subchronic durations. Chronic duration studies are considered studies with gestational exposure and effects observed on offspring or studies with adults for 10 percent or more of their lifespan. UFs were not applied to chronic studies. Subchronic duration studies were less than 10 percent of the test species lifespan and not including gestational exposure. An UF of 10 was applied to subchronic studies.

Step 4: if the NOAEL geometric mean is below the final LOAEL, the NOAEL-based TRV is the NOAEL geometric mean. If the NOAEL geometric mean is above the final LOAEL, the NOAEL-based TRV is the final NOAEL. The LOAEL-based TRV is the final LOAEL with uncertainty factors applied as presented in Step 3.

Bounded - a NOAEL paired with a LOAEL or vice versa

LOAEL - lowest observed adverse effect concentration

mg/kg-bw/day - milligram per kilogram of body weight per day

NA - not applicable

NOAEL - no observed adverse effect concentration

TRV - toxicity reference value

Unbounded - NOAEL without a paired LOAEL or vice versa

Reference

United States Environmental Protection Agency. 2007. Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs), Attachment 4-5. June.

Appendix D - Wildlife Toxicity Reference Value Calculations
Table 3. PFOA Mammal Toxicity Reference Values

Step 1 - NOAEL and LOAEL Selection					
Species	Study	Value (mg/kg bw-day)	Bounded/Unbounded	Duration (days)	Endpoint
No Observed Adverse Effect Levels Based on Reproduction and Growth					
Rat	Butenhoff et al. 2004; York et al. 2010	10	Bounded	70	Growth
Rat (Sprague-Dawley)	Li et al. 2016	5	Bounded	7	Growth, Reproduction
Mouse (C57BL/6J-Apc+/+)	Ngo et al. 2014	0.1	Bounded	17	Reproduction
Mouse (CD-1)	White et al. 2011	1	Bounded	17	Reproduction, Survival
Rat (Sprague-Dawley)	3M, 1983	1.5	Bounded	730	Growth
Mouse (129S1/SvImJ wild type)	Abbott et al. 2007	0.3	Bounded	17	Reproduction, Survival
Mouse (CD-1)	Hines et al. 2009	0.3	Bounded	17	Growth, Reproduction
Mouse (C57BL/6N)	Hu et al. 2012	0.2	Bounded	56	Growth, Reproduction
Mouse (CD-1)	Lau et al. 2006	1	Bounded	18	Growth, Reproduction
Mouse (CD-1)	Macon et al. 2011	3	Unbounded	17	Growth, Reproduction
Mouse (CD-1)	Macon et al. 2011	1	Unbounded	8	Growth, Reproduction
Mouse (CD-1)	Tucker et al. 2015	1	Unbounded	17	Growth, Reproduction
Mouse (C57B1/6)	Tucker et al. 2015	1	Unbounded	17	Growth, Reproduction
Mouse (ICR)	Yahia et al. 2010	1	Bounded	18	Growth, Reproduction
Mouse (C57BL/6)	Yang et al. 2009	1	Bounded	20	Reproduction
Rat	Hinderliter et al. 2005	30	Unbounded	GD20 - PPD21	Growth, Reproduction, Survival
Rat (Sprague-Dawley derived CD)	Gortner et al. 1981	5	Bounded	10	Growth
Lowest Observed Adverse Effect Levels Based on Reproduction, Growth, and Survival					
Rat	Butenhoff et al. 2004; York et al. 2010	30	Bounded	70	Growth
Mouse	Lu et al. 2016	5	Unbounded	28	Reproduction, Growth
Female Mouse (CD-1)	White et al. 2009; Wolf et al. 2007	3	Unbounded	17	Reproduction, Growth
Female Mouse (CD-1)	White et al. 2009; Wolf et al. 2007	5	Unbounded	11	Reproduction, Growth
Rat (ChR-CD albino)	Griffith and Long, 1980	1000	Bounded	28	Survival
Rat (Sprague-Dawley)	Li et al. 2016	20	Bounded	7	Growth, Reproduction
Mouse (wild-type Sv/129)	Albrecht et al. 2012	3	Unbounded	17	Reproduction
Mouse (CD)	Griffith and Long, 1980	5.4	Unbounded	28	Growth
Mouse (C57BL/6J-Apc+/+)	Ngo et al. 2014	3	Bounded	17	Reproduction
Mouse (CD-1)	White et al. 2007	5	Unbounded	17	Growth, Reproduction, Survival
Mouse (CD-1)	White et al. 2011	5	Bounded	17	Reproduction, Survival
Rat (Sprague-Dawley)	3M, 1983	15	Bounded	730	Growth
Rat (Sprague-Dawley)	Staples et al. 1984	100	Unbounded	10	Growth
Mouse (129S1/SvImJ wild type)	Abbott et al. 2007	0.6	Bounded	17	Reproduction, Survival
Mouse (CD-1)	Hines et al. 2009	1	Bounded	17	Growth, Reproduction
Mouse (C57BL/6N)	Hu et al. 2010	0.5	Unbounded	12	Growth, Reproduction
Mouse (C57BL/6N)	Hu et al. 2012	2	Bounded	56	Growth, Reproduction
Mouse (CD-1)	Lau et al. 2006	3	Bounded	18	Growth, Reproduction
Mouse (CD-1)	Suh et al. 2011	2	Unbounded	6	Reproduction
Mouse (ICR)	Yahia et al. 2010	5	Bounded	18	Growth, Reproduction
Mouse (Balb/c)	Zhao et al. 2012	2.5	Unbounded	20	Reproduction
Mouse (C57Bl/6 Wild Type)	Zhao et al. 2012	7.5	Unbounded	20	Reproduction
Mouse (Kunming)	Liu et al. 2015	2.5	Unbounded	14	Reproduction
Mouse (Balb/c)	Yang et al. 2009	1	Unbounded	20	Reproduction
Mouse (C57BL/6)	Yang et al. 2009	5	Bounded	20	Reproduction
Rat (Sprague-Dawley derived CD)	Gortner et al. 1981	150	Bounded	10	Growth
Mice (BALB/c)	Zhang et al. 2014	5	Unbounded	28	Reproduction
Step 2 - NOAEL Geometric Mean					
Reproduction and Growth NOAEL Geomean		1.27			
Step 3 - Final NOAEL and LOAEL					
Application of Uncertainty Factors (UF)					
Final NOAEL	UF = NA	0.3	Bounded	147	Reproduction, Growth, Survival
Final LOAEL	UF = NA	0.6	Bounded	49	Reproduction, Survival
Step 4 - TRV Selection					
		Final TRV	Basis		
NOAEL-based TRV		0.3	Final NOAEL		
LOAEL-based TRV		0.6	Final LOAEL		

Appendix D - Wildlife Toxicity Reference Value Calculations
Table 3. PFOA Mammal Toxicity Reference Values

Notes:

NOAEL- and LOAEL-based TRVs were derived following USEPA EcoSSL methodology in Steps 1 through 4 (USEPA 2007) .

Step 1: the highest bounded NOAEL below the lowest bounded LOAEL and the lowest bounded LOAEL are shaded gray.

Step 2: the NOAEL geometric mean is the geometric mean of the NOAELs in the dataset with a growth or reproductive endpoint.

Step 3: the final NOAEL and LOAEL as presented in Step 3 are the NOAEL and LOAEL selected in Step 1 with uncertainty factors (UFs) applied to values from studies with subchronic durations. Chronic duration studies are considered studies with gestational exposure and effects observed on offspring or studies with adults for 10 percent or more of their lifespan. UFs were not applied to chronic studies. Subchronic duration studies were less than 10 percent of the test species lifespan and not including gestational exposure. An UF of 10 was applied to subchronic studies.

Step 4: if the NOAEL geometric mean is below the final LOAEL, the NOAEL-based TRV is the NOAEL geometric mean. If the NOAEL geometric mean is above the final LOAEL, the NOAEL-based TRV is the final NOAEL. The LOAEL-based TRV is the final LOAEL with uncertainty factors applied as presented in Step 3.

Bounded - a NOAEL paired with a LOAEL or vice versa

LOAEL - lowest observed adverse effect concentration

mg/kg-bw/day - milligram per kilogram of body weight per day

NA - not applicable

NOAEL - no observed adverse effect concentration

TRV - toxicity reference value

Unbounded - NOAEL without a paired LOAEL or vice versa

Reference

United States Environmental Protection Agency. 2007. Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs), Attachment 4-5. June.

Appendix D - Wildlife Toxicity Reference Value Calculations
Table 4. PFHxA Mammal Toxicity Reference Values

Step 1 - NOAEL and LOAEL Selection					
Species	Study	Value (mg/kg bw-day)	Bounded/Unbounded	Duration (days)	Endpoint
No Observed Adverse Effect Levels Based on Reproduction and Growth					
Rat (Sprague-Dawley)	Klaunig et al. 2015	100	Bounded	104 weeks	Growth
Mouse (CD1)	Iwai and Hoberman, 2014 - test 1	100	Bounded	14	Reproduction
Mouse (CD1)	Iwai and Hoberman, 2014 - test 2	35	Bounded	14	Reproduction, Survival
Rat (CrI:CD(SD))	Loveless et al. 2009 - test 1	100	Bounded	126	Reproduction, Growth
Rat (CrI:CD(SD))	Loveless et al. 2009 - test 2	100	Bounded	15	Growth
Rat (CrI:CD(SD))	Loveless et al. 2009 - test 3	100	Bounded	92	Growth
Lowest Observed Adverse Effect Levels Based on Reproduction, Growth, and Survival					
Rat (Sprague-Dawley)	Klaunig et al. 2015	200	Bounded	104 weeks	Survival
Mouse (CD1)	Iwai and Hoberman, 2014 - test 1	350	Bounded	14	Reproduction
Mouse (CD1)	Iwai and Hoberman 2014, - test 2	175	Bounded	14	Reproduction, Survival
Rat (CrI:CD(SD))	Loveless et al. 2009 - test 1	500	Bounded	126	Reproduction, Growth
Rat (CrI:CD(SD))	Loveless et al. 2009 - test 2	500	Bounded	15	Growth
Rat (CrI:CD(SD))	Loveless et al. 2009 - test 3	500	Bounded	92	Growth
Step 2 - NOAEL Geometric Mean					
Reproduction and Growth NOAEL Geomean		84			
Step 3 - Final NOAEL and LOAEL					
Application of Uncertainty Factors (UF)					
Final NOAEL	UF = NA	100	Bounded	multiple	Growth, Reproduction, Survival
Final LOAEL	UF = NA	175	Bounded	14	Reproduction
Step 4 - TRV Selection					
		Final TRV	Basis		
NOAEL-based TRV		84	NOAEL Geometric Mean		
LOAEL-based TRV		175	Final LOAEL		

Notes:

NOAEL- and LOAEL-based TRVs were derived following USEPA EcoSSL methodology in Steps 1 through 4 (USEPA 2007) .

Step 1: the highest bounded NOAEL below the lowest bounded LOAEL and the lowest bounded LOAEL are shaded gray.

Step 2: the NOAEL geometric mean is the geometric mean of the NOAELs in the dataset with a growth or reproductive endpoint.

Step 3: the final NOAEL and LOAEL as presented in Step 3 are the NOAEL and LOAEL selected in Step 1 with uncertainty factors (UFs) applied to values from studies with subchronic durations. Chronic duration studies are considered studies with gestational exposure and effects observed on offspring or studies with adults for 10 percent or more of their lifespan. UFs were not applied to chronic studies.

Subchronic duration studies were less than 10 percent of the test species lifespan and not including gestational exposure. An UF of 10 was applied to subchronic studies.

Step 4: if the NOAEL geometric mean is below the final LOAEL, the NOAEL-based TRV is the NOAEL geometric mean. If the NOAEL geometric mean is above the final LOAEL, the NOAEL-based TRV is the final NOAEL. The LOAEL-based TRV is the final LOAEL with uncertainty factors applied as presented in Step 3.

Bounded - a NOAEL paired with a LOAEL or vice versa

LOAEL - lowest observed adverse effect concentration

mg/kg-bw/day - milligram per kilogram of body weight per day

NA - not applicable

NOAEL - no observed adverse effect concentration

TRV - toxicity reference value

Unbounded - NOAEL without a paired LOAEL or vice versa

Reference

United States Environmental Protection Agency. 2007. Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs), Attachment 4-5. June.

Appendix D - Wildlife Toxicity Reference Value Calculations
Table 5. PFBS Mammal Toxicity Reference Values

Step 1 - NOAEL and LOAEL Selection					
Species	Study	Value (mg/kg bw-day)	Bounded/Unbounded	Duration (days)	Endpoint
No Observed Adverse Effect Levels Based on Reproduction and Growth					
Rat (Sprague-Dawley)	Lieder et al. 2009	1000	Unbounded	>70 (P0), F1	Reproduction
Mice (ICR)	Feng et al. 2017	50	Bounded	20	Reproduction
Rat (Sprague-Dawley)	York, 2003	1000	Bounded	15	Growth, Reproduction
Rat (CrI:CD[SD]IGS BR VAF/Plu	York, 2002	300	Bounded	15	Growth, Reproduction
Rat (Sprague-Dawley)	3M, 2000	1000	Unbounded	10	Growth, Reproduction, Survival
Rat (Sprague-Dawley)	3M, 2001	900	Unbounded	28	Growth, Reproduction, Survival
Lowest Observed Adverse Effect Levels Based on Reproduction, Growth, and Survival					
Mice (ICR)	Feng et al. 2017	200	Bounded	20	Reproduction
Rat (Sprague-Dawley)	York, 2003	2000	Bounded	15	Growth, Reproduction
Rat (CrI:CD[SD]IGS BR VAF/Plu	York, 2002	1000	Bounded	15	Growth, Reproduction
Step 2 - NOAEL Geometric Mean					
Reproduction and Growth NOAEL Geomean		488			
Step 3 - Final NOAEL and LOAEL					
Application of Uncertainty Factors (UF)					
Final NOAEL	UF = NA	50	Bounded	20	Reproduction
Final LOAEL	UF = NA	200	Bounded	20	Reproduction
Step 4 - TRV Selection					
		Final TRV	Basis		
NOAEL-based TRV		50	Final NOAEL		
LOAEL-based TRV		200	Final LOAEL		

Notes:

NOAEL- and LOAEL-based TRVs were derived following USEPA EcoSSL methodology in Steps 1 through 4 (USEPA 2007) .

Step 1: the highest bounded NOAEL below the lowest bounded LOAEL and the lowest bounded LOAEL are shaded gray.

Step 2: the NOAEL geometric mean is the geometric mean of the NOAELs in the dataset with a growth or reproductive endpoint.

Step 3: the final NOAEL and LOAEL as presented in Step 3 are the NOAEL and LOAEL selected in Step 1 with uncertainty factors (UFs) applied to values from studies with subchronic durations. Chronic duration studies are considered studies with gestational exposure and effects observed on offspring or studies with adults for 10 percent or more of their lifespan. UFs were not applied to chronic studies. Subchronic duration studies were less than 10 percent of the test species lifespan and not including gestational exposure. An UF of 10 was applied to subchronic studies.

Step 4: if the NOAEL geometric mean is below the final LOAEL, the NOAEL-based TRV is the NOAEL geometric mean. If the NOAEL geometric mean is above the final LOAEL, the NOAEL-based TRV is the final NOAEL. The LOAEL-based TRV is the final LOAEL with uncertainty factors applied as presented in Step 3.

Bounded - a NOAEL paired with a LOAEL or vice versa

LOAEL - lowest observed adverse effect concentration

mg/kg-bw/day - milligram per kilogram of body weight per day

NA - not applicable

NOAEL - no observed adverse effect concentration

TRV - toxicity reference value

Unbounded - NOAEL without a paired LOAEL or vice versa

Reference

United States Environmental Protection Agency. 2007. Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs), Attachment 4-5. June.

Appendix D - Wildlife Toxicity Reference Value Calculations
Table 6. PFBA Mammal Toxicity Reference Values

Step 1 - NOAEL and LOAEL Selection					
Species	Study	Value (mg/kg bw-day)	Bounded/Unbounded	Duration (days)	Endpoint
No Observed Adverse Effect Levels Based on Reproduction and Growth					
Rat (Sprague-Dawley)	Butenhoff et al. 2012a; van Otterdijk 2007b	30	Unbounded	90	Growth
Rat (Sprague-Dawley)	Butenhoff et al. 2012a; van Otterdijk 2007a	150	Unbounded	28	Growth
Rat (Sprague-Dawley)	3M, 2007	184	Unbounded	5	Reproduction
Mouse (CD-1)	Das et al. 2008	35	Bounded	17	Reproduction
Lowest Observed Adverse Effect Levels Based on Reproduction, Growth, and Survival					
Mouse (CD-1)	Das et al. 2008	175	Bounded	17	Reproduction
Step 2 - NOAEL Geometric Mean					
Reproduction and Growth NOAEL Geomean		73			
Step 3 - Final NOAEL and LOAEL					
Application of Uncertainty Factors (UF)					
Final NOAEL	UF = NA	35	Bounded	17	Reproduction
Final LOAEL	UF = NA	175	Bounded	17	Reproduction
Step 4 - TRV Selection					
		Final TRV	Basis		
NOAEL-based TRV		73	NOAEL Geometric Mean		
LOAEL-based TRV		175	Final LOAEL		

Notes:

NOAEL- and LOAEL-based TRVs were derived following USEPA EcoSSL methodology in Steps 1 through 4 (USEPA 2007) .

Step 1: the highest bounded NOAEL below the lowest bounded LOAEL and the lowest bounded LOAEL are shaded gray.

Step 2: the NOAEL geometric mean is the geometric mean of the NOAELs in the dataset with a growth or reproductive endpoint.

Step 3: the final NOAEL and LOAEL as presented in Step 3 are the NOAEL and LOAEL selected in Step 1 with uncertainty factors (UFs) applied to values from studies with subchronic durations. Chronic duration studies are considered studies with gestational exposure and effects observed on offspring or studies with adults for 10 percent or more of their lifespan. UFs were not applied to chronic studies. Subchronic duration studies were less than 10 percent of the test species lifespan and not including gestational exposure. An UF of 10 was applied to subchronic studies.

Step 4: if the NOAEL geometric mean is below the final LOAEL, the NOAEL-based TRV is the NOAEL geometric mean. If the NOAEL geometric mean is above the final LOAEL, the NOAEL-based TRV is the final NOAEL. The LOAEL-based TRV is the final LOAEL with uncertainty factors applied as presented in Step 3.

Bounded - a NOAEL paired with a LOAEL or vice versa

LOAEL - lowest observed adverse effect concentration

mg/kg-bw/day - milligram per kilogram of body weight per day

NA - not applicable

NOAEL - no observed adverse effect concentration

TRV - toxicity reference value

Unbounded - NOAEL without a paired LOAEL or vice versa

Reference

United States Environmental Protection Agency. 2007. Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs), Attachment 4-5. June.

Appendix D - Wildlife Toxicity Reference Value Calculations
Table 7. 6:2 FTOH Mammal Toxicity Reference Values

Step 1 - NOAEL and LOAEL Selection					
Species	Study	Value (mg/kg bw-day)	Bounded/Unbounded	Duration (days)	Endpoint
No Observed Adverse Effect Levels Based on Reproduction and Growth					
Mice (CD-1)	Mukerji et al. 2015	25	Bounded	GD0 - PND21	Growth, Reproduction, Survival
Rat, Sprague-Dawley (CrI:CD[SD])	O'Connor et al. 2014	125	Bounded	14	Growth
Rat, Sprague-Dawley (CrI:CD[SD])	O'Connor et al. 2014	25	Bounded	127 (F0, F), 84 (F0, M)	Growth, Survival, Reproduction
Lowest Observed Adverse Effect Levels Based on Reproduction, Growth, and Survival					
Mice (CD-1)	Mukerji et al. 2015	100	Bounded	GD0 - PND21	Growth, Reproduction, Survival
Rat (CrI:CD[SD])	Serex et al. 2014	250	Bounded	90	Survival
Rat, Sprague-Dawley (CrI:CD[SD])	O'Connor et al. 2014	250	Bounded	14	Growth
Rat, Sprague-Dawley (CrI:CD[SD])	O'Connor et al. 2014	125	Bounded	127 (F0, F), 84 (F0, M)	Growth, Survival, Reproduction
Step 2 - NOAEL Geometric Mean					
Reproduction and Growth NOAEL Geomean		43			
Step 3 - Final NOAEL and LOAEL					
Application of Uncertainty Factors (UF)					
Final NOAEL	UF = NA	25	Bounded	Multiple	Reproduction, Survival
Final LOAEL	UF = NA	100	Bounded	Est. 43 or 71	Reproduction, Growth
Step 4 - TRV Selection					
		Final TRV	Basis		
NOAEL-based TRV		43	NOAEL Geometric Mean		
LOAEL-based TRV		100	Final LOAEL		

Notes:

NOAEL- and LOAEL-based TRVs were derived following USEPA EcoSSL methodology in Steps 1 through 4 (USEPA 2007) .

Step 1: the highest bounded NOAEL below the lowest bounded LOAEL and the lowest bounded LOAEL are shaded gray.

Step 2: the NOAEL geometric mean is the geometric mean of the NOAELs in the dataset with a growth or reproductive endpoint.

Step 3: the final NOAEL and LOAEL as presented in Step 3 are the NOAEL and LOAEL selected in Step 1 with uncertainty factors (UFs) applied to values from studies with subchronic durations. Chronic duration studies are considered studies with gestational exposure and effects observed on offspring or studies with adults for 10 percent or more of their lifespan. UFs were not applied to chronic studies. Subchronic duration studies were less than 10 percent of the test species lifespan and not including gestational exposure. An UF of 10 was applied to subchronic studies.

Step 4: if the NOAEL geometric mean is below the final LOAEL, the NOAEL-based TRV is the NOAEL geometric mean. If the NOAEL geometric mean is above the final LOAEL, the NOAEL-based TRV is the final NOAEL. The LOAEL-based TRV is the final LOAEL with uncertainty factors applied as presented in Step 3.

Bounded - a NOAEL paired with a LOAEL or vice versa

LOAEL - lowest observed adverse effect concentration

mg/kg-bw/day - milligram per kilogram of body weight per day

NA - not applicable

NOAEL - no observed adverse effect concentration

TRV - toxicity reference value

Reference

United States Environmental Protection Agency. 2007. Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs), Attachment 4-5. June.

Appendix D - Wildlife Toxicity Reference Value Calculations
Table 8. GenX Mammal Toxicity Reference Values

Step 1 - NOAEL and LOAEL Selection					
Species	Study	Value (mg/kg bw/day)	Bounded/Unbounded	Duration (days)	Endpoint
No Observed Adverse Effect Levels Based on Reproduction and Growth					
Mice	DuPont, 2010b	0.5	Bounded	GD0 - PND40	Growth, Reproduction
Rats	DuPont, 2010a	10	Bounded	15	Reproduction
Rat (Crl:CD [SD]) - female	Craig, 2013	50	Bounded	730	Growth
Mouse (Crl:CD1 [ICR])	MacKenzie, 2010	5	Unbounded	96	Growth, Survival
Rat (Sprague-Dawley)	Conley et al. 2019, main study	125	Bounded	5	Growth
Rat (Crl:CD [SD])	Nabb, 2008b	300	Bounded	7	Growth
Rat (Sprague-Dawley)	Caverly Rae et al. 2015	50	Unbounded	707-728	Survival, Reproduction
Mouse (Crl:CD1 [ICR])	Nabb, 2008a	30	Unbounded	6	Growth, Survival
Rat (Crl:CD(SD))	Haas, 2008a	30	Unbounded	28	Growth, Survival
Mouse (Crl:CD1 [ICR])	Haas, 2008b	30	Unbounded	28	Growth, Survival
Rat Crl:CD(SD)	USEPA, GenX 8(e) Filings (DCN: 89100000282)	10	Bounded	15	Growth, Reproduction
Mice	USEPA, GenX 8(e) Filings (page 52, No. 310027)	30	Unbounded	7	Reproduction
Mice (Crl:CD-1) (ICR)	USEPA, GenX 8(e) Filings (pages 53-55, No. 31900)	3	Bounded	28	Reproduction
Rat (Crl:CD) (SD)	Nabb, 2008c	300	Unbounded	7	Survival, Reproduction, Growth
Lowest Observed Adverse Effect Levels Based on Reproduction, Growth, and Survival					
Mice	DuPont, 2010b	5	Bounded	GD0 - PND40	Growth, Reproduction
Rats	DuPont, 2010a	100	Bounded	15	Reproduction
Rat (Crl:CD [SD]) - female	Craig, 2013	500	Bounded	730	Growth
Rat (Sprague-Dawley)	Conley et al. 2019, main study	250	Bounded	5	Growth
Rat (Sprague-Dawley)	Conley et al. 2019, pilot study	125	Unbounded	5	Growth, Reproduction
Rat (Crl:CD [SD])	Nabb, 2008b	1000	Bounded	7	Growth
Rat Crl:CD(SD)	USEPA, GenX 8(e) Filings (DCN: 89100000282)	100	Bounded	15	Growth, Reproduction
Mice (Crl:CD-1) (ICR)	USEPA, GenX 8(e) Filings (pages 53-55, No. 31900)	30	Bounded	28	Reproduction
Step 2 - NOAEL Geometric Mean					
Reproduction and Growth NOAEL Geomean		24			
Step 3 - Final NOAEL and LOAEL					
Application of Uncertainty Factors (UF)					
Final NOAEL ³	UF = NA	0.5	Bounded	GD0 - PND40	Reproduction
Final LOAEL	UF = NA	5	Bounded	GD0 - PND40	Reproduction
Step 4 - TRV Selection					
		Final TRV	Basis		
NOAEL-based TRV		0.5	Final NOAEL		
LOAEL-based TRV		5	Final LOAEL		

Appendix D - Wildlife Toxicity Reference Value Calculations
Table 8. GenX Mammal Toxicity Reference Values

Notes:

NOAEL- and LOAEL-based TRVs were derived following USEPA EcoSSL methodology in Steps 1 through 4 (USEPA 2007) .

Step 1: the second highest bounded NOAEL below the lowest bounded LOAEL and the lowest bounded LOAEL are shaded gray. The second highest NOAEL below the lowest bounded LOAEL, 0.5 mg/kg-bw/day, was selected as over the highest, 3 mg/kg-bw/day, as the 3 mg/kg-bw/day value would have been considered subchronic and divided by an UF of 10 resulting in a final NOAEL of 0.3 mg/kg-bw/day.

Step 2: the NOAEL geometric mean is the geometric mean of the NOAELs in the dataset with a growth or reproductive endpoint.

Step 3: the final NOAEL and LOAEL as presented in Step 3 are the NOAEL and LOAEL selected in Step 1 with uncertainty factors (UFs) applied to values from studies with subchronic durations. Chronic duration studies are considered studies with gestational exposure and effects observed on offspring or studies with adults for 10 percent or more of their lifespan. UFs were not applied to chronic studies. Subchronic duration studies were less than 10 percent of the test species lifespan and not including gestational exposure. An UF of 10 was applied to subchronic studies.

Step 4: if the NOAEL geometric mean is below the final LOAEL, the NOAEL-based TRV is the NOAEL geometric mean. If the NOAEL geometric mean is above the final LOAEL, the NOAEL-based TRV is the final NOAEL. The LOAEL-based TRV is the final LOAEL with uncertainty factors applied as presented in Step 3.

Bounded - a NOAEL paired with a LOAEL or vice versa

GD - gestation day

LOAEL - lowest observed adverse effect concentration

mg/kg-bw/day - milligram per kilogram of body weight per day

NA - not applicable

NOAEL - no observed adverse effect concentration

PND - postnatal day

TRV - toxicity reference value

Unbounded - NOAEL without a paired LOAEL or vice versa

Reference

United States Environmental Protection Agency. 2007. Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs), Attachment 4-5. June.

Appendix D - Wildlife Toxicity Reference Value Calculations
Table 9. N-EtFOSE Mammal Toxicity Reference Values

Step 1 - NOAEL and LOAEL Selection					
Species	Study	Value (mg/kg bw-day)	Bounded/Unbounded	Duration (days)	Endpoint
No Observed Adverse Effect Levels Based on Reproduction and Growth					
Rabbit (New Zealand White [Hra:(NZW)SPF])	3M, 1999	0.1	Bounded	14	Growth, Reproduction
Lowest Observed Adverse Effect Levels Based on Reproduction, Growth, and Survival					
Rat (CrI:CD)	Goldenthal 1978a	57	Bounded	90	Survival
Rabbit (New Zealand White [Hra:(NZW)SPF])	3M, 1999	1	Bounded	14	Growth, Reproduction
Step 2 - Final NOAEL and LOAEL					
Application of Uncertainty Factors (UF)					
Final NOAEL	UF = NA	0.1	Bounded	14	Growth, Reproduction
Final LOAEL	UF = NA	1	Bounded	14	Growth, Reproduction
Step 3 - TRV Selection					
		Final TRV	Basis		
NOAEL-based TRV		0.1	Final NOAEL		
LOAEL-based TRV		1	Final LOAEL		

Notes:

NOAEL- and LOAEL-based TRVs were derived following USEPA EcoSSL methodology in Steps 1 through 3 (USEPA 2007) .

Step1: the lowest bounded LOAEL and the lowest bounded LOAEL are shaded gray. As there are fewer than 3 NOAELs in the data set, the lowest NOAEL is selected as the basis of the TRV and is shaded gray.

Step 2: the final NOAEL and LOAEL as presented in Step 3 are the NOAEL and LOAEL selected in Step 1 with uncertainty factors (UFs) applied to values from studies with subchronic durations. Chronic duration studies are considered studies with gestational exposure and effects observed on offspring or studies with adults for 10 percent or more of their lifespan. UFs were not applied to chronic studies. Subchronic duration studies were less than 10 percent of the test species lifespan and not including gestational exposure. An UF of 10 was applied to subchronic studies.

Step 3: The NOAEL-based TRV and LOAEL-based TRV are the final NOAEL and LOAEL as presented in Step 2.

Bounded - a NOAEL paired with a LOAEL or vice versa

LOAEL - lowest observed adverse effect concentration

mg/kg-bw/day - milligram per kilogram of body weight per day

NA - not applicable

NOAEL - no observed adverse effect concentration

TRV - toxicity reference value

Unbounded - NOAEL without a paired LOAEL or vice versa

Reference

United States Environmental Protection Agency. 2007. Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs), Attachment 4-5. June.

Appendix D - Wildlife Toxicity Reference Value Calculations

Table 10. PFOS Bird Toxicity Reference Values

Step 1 - NOAEL and LOAEL Selection					
Species	Study	Value (mg/kg-bw/day)	Bounded/Unbounded	Duration (days)	Endpoint
No Observed Adverse Effect Levels Based on Reproduction and Growth					
Mallard duck	Gallagher et al. 2003f	3.6	Unbounded	42	Reproduction, Growth, Survival
Northern Bobwhite quail	Gallagher et al. 2003e	2.0	Unbounded	133	Survival, Reproduction, Growth
Mallard duck	Gallagher et al. 2004a	20	Bounded	5	Growth
Northern Bobwhite quail	Gallagher et al. 2004b	29	Bounded	5	Growth
Mallard duck	Gallagher et al. 2003d	1.51	Bounded	147	Reproduction, Survival, Growth
Lowest Observed Adverse Effect Levels Based on Reproduction, Growth, and Survival					
Northern Bobwhite quail	Gallagher et al. 2003c	0.79	Unbounded	147	Reproduction, Survival
Mallard duck	Gallagher et al. 2004a	28	Bounded	5	Growth
Northern Bobwhite quail	Gallagher et al. 2004b	59	Bounded	5	Growth
Mallard duck	Gallagher et al. 2003d	6.47	Bounded	49	Survival
Step 2 - Final NOAEL and LOAEL					
Application of Uncertainty Factors (UF)					
Final NOAEL	UF = 10	0.079	Bounded	147	Reproduction, Survival
Final LOAEL	UF = NA	0.79	Bounded	147	Reproduction, Survival
Step 3 - TRV Selection					
		Final TRV	Basis		
NOAEL-based TRV		0.079	Final NOAEL		
LOAEL-based TRV		0.79	Final LOAEL		

Notes:

The EcoSSL steps were not applied to the PFOS bird data set. The lowest LOAEL in the data set is unbounded and based on survivorship of offspring where parental quail were exposed over 20 weeks including 10 weeks of exposure during egg-laying. Although this LOAEL is unbounded and would typically be excluded from TRV calculations, it was selected as the basis of the LOAEL TRV because the available data set is small, an effect was measured, and the study design included exposure over a sensitive lifestage (egg-laying). As all NOAELs are higher than the selected LOAEL, the NOAEL TRV is the LOAEL TRV with an uncertainty factor (UF) of 10 applied.

Bounded - a NOAEL paired with a LOAEL or vice versa

LOAEL - lowest observed adverse effect concentration

mg/kg-bw/day - milligram per kilogram of body weight per day

NA - not applicable

NOAEL - no observed adverse effect concentration

TRV - toxicity reference value

Unbounded - NOAEL without a paired LOAEL or vice versa

Reference

United States Environmental Protection Agency. 2007. Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs), Attachment 4-5. June.

Appendix D - Wildlife Toxicity Reference Value Calculations

Table 11. PFBS Bird Toxicity Reference Values

Step 1 - NOAEL and LOAEL Selection					
Species	Study	Value (mg/kg bw-day)	Bounded/Unbounded	Duration (days)	Endpoint
No Observed Adverse Effect Levels Based on Reproduction and Growth					
Northern Bobwhite quail	Gallagher et al. 2005	92	Unbounded	147	Reproduction, Survival
Northern Bobwhite quail	Gallagher et al. 2003a	698	Bounded	5	Growth
Mallard	Gallagher et al. 2003b	2139	Bounded	5	Growth
Lowest Observed Adverse Effect Levels Based on Reproduction, Growth, and Survival					
Northern Bobwhite quail	Gallagher et al. 2003a	1531	Bounded	5	Growth
Mallard	Gallagher et al. 2003b	3895	Bounded	5	Growth
Step 2 - NOAEL Geometric Mean					
Reproduction and Growth NOAEL Geomean		516			
Step 3 - Final NOAEL and LOAEL					
Application of Uncertainty Factors (UF)					
Final NOAEL	UF = NA	92	Unbounded	147	Reproduction, Survival
Final LOAEL	UF = 10	153	Bounded	5	Growth
Step 4 - TRV Selection					
		Final TRV	Basis		
NOAEL-based TRV		92	Final NOAEL		
LOAEL-based TRV		153	Final LOAEL		

Notes:

NOAEL- and LOAEL-based TRVs were derived following USEPA EcoSSL methodology in Steps 1 through 4 (USEPA 2007) .

Step 1: the highest bounded NOAEL below the lowest bounded LOAEL and the lowest bounded LOAEL are shaded gray.

Step 2: the NOAEL geometric mean is the geometric mean of the NOAELs in the dataset with a growth or reproductive endpoint.

Step 3: the final NOAEL and LOAEL as presented in Step 3 are the NOAEL and LOAEL selected in Step 1 with uncertainty factors (UFs) applied to values from studies with subchronic durations. Chronic duration studies are considered studies with gestational exposure and effects observed on offspring or studies with adults for 10 percent or more of their lifespan. UFs were not applied to chronic studies. Subchronic duration studies were less than 10 percent of the test species lifespan and not including gestational exposure. An UF of 10 was applied to subchronic studies.

An unbounded NOAEL was selected as the final NOAEL as it is the lowest available NOAEL and is based on a longer exposure duration included evaluation of reproductive endpoints while the two bounded NOAELs are based on shorter durations and growth endpoints.

Step 4: if the NOAEL geometric mean is below the final LOAEL, the NOAEL-based TRV is the NOAEL geometric mean. If the NOAEL geometric mean is above the final LOAEL, the NOAEL-based TRV is the final NOAEL. The LOAEL-based TRV is the final LOAEL with uncertainty factors applied as presented in Step 3.

Bounded - a NOAEL paired with a LOAEL or vice versa

LOAEL - lowest observed adverse effect concentration

mg/kg-bw/day - milligram per kilogram of body weight per day

NA - not applicable

NOAEL - no observed adverse effect concentration

TRV - toxicity reference value

Unbounded - NOAEL without a paired LOAEL or vice versa

References:

United States Environmental Protection Agency. 2007. Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs), Attachment 4-5. June.

Appendix E

Bioaccumulation Factors

Appendix E - Bioaccumulation Factors
Table 1. Individual Soil-to-Plant Bioaccumulation Factors

Organism	Source	Study Type	Soil-to-Plant Bioaccumulation Factor ¹
Perfluorotetradecanoic acid (PFTeA)			
Wheat ²	Wen et al. 2014	Field	3.8
Wheat ²	Wen et al. 2014	Field	1.8
Wheat ²	Wen et al. 2014	Field	1.8
Wheat ²	Wen et al. 2014	Field	1.3
Kentucky Blue Grass	Yoo et al. 2011	Field	0.07
Tall Fescue (Grass)	Yoo et al. 2011	Field	0.04
Tall Fescue (Grass)	Yoo et al. 2011	Field	0.02
Bermuda Grass	Yoo et al. 2011	Field	0.006
Geometric Mean³			0.22
Minimum³			0.0061
Maximum³			3.8
Perfluorotridecanoic acid (PFTriDA)			
Kentucky Blue Grass	Yoo et al. 2011	Field	0.10
Tall Fescue (Grass)	Yoo et al. 2011	Field	0.05
Tall Fescue (Grass)	Yoo et al. 2011	Field	0.06
Bermuda Grass	Yoo et al. 2011	Field	0.01
Geometric Mean³			0.043
Minimum³			0.014
Maximum³			0.097
Perfluorododecanoic acid (PFDoA)			
Grass ²	Zhu et al. 2019	Field	0.4
Grass ²	Zhu et al. 2019	Field	0.2
Grass ²	Zhu et al. 2019	Field	0.22
Grass ²	Zhu et al. 2019	Field	0.8
Grass ²	Zhu et al. 2019	Field	0.5
Grass ²	Zhu et al. 2019	Field	0.8
Grass ²	Zhu et al. 2019	Field	6.0
Grass ²	Zhu et al. 2019	Field	0.5
Grass ²	Zhu et al. 2019	Field	0.9
Grass ²	Zhu et al. 2019	Field	0.8
Grass ²	Zhu et al. 2019	Field	0.6
Grass ²	Zhu et al. 2019	Field	0.4
Grass ²	Zhu et al. 2019	Field	0.5
Grass ²	Zhu et al. 2019	Field	1.7
Grass ²	Zhu et al. 2019	Field	0.4
Grass ²	Zhu et al. 2019	Field	0.5
Grass ²	Zhu et al. 2019	Field	3.7
Tree (leaf)	Zhu et al. 2019	Field	0.6
Tree (leaf)	Zhu et al. 2019	Field	0.4
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	1.0
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	0.7
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	1.0
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	0.7
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	0.9
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	0.6
Kentucky Blue Grass	Yoo et al. 2011	Field	0.2
Tall Fescue (Grass)	Yoo et al. 2011	Field	0.1
Tall Fescue (Grass)	Yoo et al. 2011	Field	0.02
Tall Fescue (Grass)	Yoo et al. 2011	Field	0.1
Bermuda Grass	Yoo et al. 2011	Field	0.02
Wheat	Liu et al. 2017	Field	3.5
Wheat	Liu et al. 2017	Field	0.7
Wheat	Liu et al. 2017	Field	0.7
Wheat	Liu et al. 2017	Field	2.7
Wheat	Liu et al. 2017	Field	2.0

Appendix E - Bioaccumulation Factors
Table 1. Individual Soil-to-Plant Bioaccumulation Factors

Organism	Source	Study Type	Soil-to-Plant Bioaccumulation Factor ¹
Perfluorododecanoic acid (PFDoA)			
Wheat	Liu et al. 2017	Field	3.5
Geometric Mean³			0.55
Minimum³			0.016
Maximum³			6.0
Perfluoroundecanoic acid (PFUnA)			
Grass ²	Zhu et al. 2019	Field	0.4
Grass ²	Zhu et al. 2019	Field	0.4
Grass ²	Zhu et al. 2019	Field	0.2
Grass ²	Zhu et al. 2019	Field	0.5
Grass ²	Zhu et al. 2019	Field	0.5
Grass ²	Zhu et al. 2019	Field	0.7
Grass ²	Zhu et al. 2019	Field	2.5
Grass ²	Zhu et al. 2019	Field	0.3
Grass ²	Zhu et al. 2019	Field	0.7
Grass ²	Zhu et al. 2019	Field	1.1
Grass ²	Zhu et al. 2019	Field	0.8
Grass ²	Zhu et al. 2019	Field	0.4
Grass ²	Zhu et al. 2019	Field	0.7
Grass ²	Zhu et al. 2019	Field	1.3
Grass ²	Zhu et al. 2019	Field	0.5
Grass ²	Zhu et al. 2019	Field	0.6
Grass ²	Zhu et al. 2019	Field	1.8
Tree (leaf)	Zhu et al. 2019	Field	0.4
Tree (leaf)	Zhu et al. 2019	Field	1.1
Tree (leaf)	Zhu et al. 2019	Field	0.6
Tree (leaf)	Zhu et al. 2019	Field	0.3
Wheat ²	Wen et al. 2014	Field	5.2
Wheat ²	Wen et al. 2014	Field	2.6
Wheat ²	Wen et al. 2014	Field	2.0
Wheat ²	Wen et al. 2014	Field	2.1
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	1.6
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	1.1
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	1.5
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	1.1
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	1.4
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	0.97
Kentucky Blue Grass	Yoo et al. 2011	Field	0.2
Tall Fescue (Grass)	Yoo et al. 2011	Field	0.1
Tall Fescue (Grass)	Yoo et al. 2011	Field	0.02
Tall Fescue (Grass)	Yoo et al. 2011	Field	0.2
Bermuda Grass	Yoo et al. 2011	Field	0.02
Maize	Liu et al. 2017	Field	30
Wheat	Liu et al. 2017	Field	0.3
Wheat	Liu et al. 2017	Field	6.5
Wheat	Liu et al. 2017	Field	3.1
Wheat	Liu et al. 2017	Field	5
Geometric Mean³			0.71
Minimum³			0.024
Maximum³			30
Perfluorodecane sulfonate (PFDS)			
Lettuce	Blaine et al. 2013	Greenhouse	0.19
Geometric Mean³			0.19
Minimum³			0.19
Maximum³			0.19

Appendix E - Bioaccumulation Factors
Table 1. Individual Soil-to-Plant Bioaccumulation Factors

Organism	Source	Study Type	Soil-to-Plant Bioaccumulation Factor ¹
Perfluorodecanoic acid (PFDA)			
Wheat Grass	Bräunig et al. 2019	Greenhouse	<0.05
Wheat Grass	Bräunig et al. 2019	Greenhouse	<0.5
Lettuce	Blaine et al. 2013	Greenhouse	0.34
Lettuce	Blaine et al. 2013	Greenhouse	0.52
Birch tree ² (Site 1)	Gobelius et al. 2017	Field	8.5
Spruce tree ² (Site 2)	Gobelius et al. 2017	Field	0.7
Radish ²	Blaine et al. 2014	Greenhouse	0.8
Celery ²	Blaine et al. 2014	Greenhouse	0.7
Tomato ²	Blaine et al. 2014	Greenhouse	1.6
Sugar snap pea ²	Blaine et al. 2014	Greenhouse	0.8
Grass ²	Zhu et al. 2019	Field	0.3
Grass ²	Zhu et al. 2019	Field	0.4
Grass ²	Zhu et al. 2019	Field	1.1
Grass ²	Zhu et al. 2019	Field	2.3
Grass ²	Zhu et al. 2019	Field	0.6
Grass ²	Zhu et al. 2019	Field	0.9
Grass ²	Zhu et al. 2019	Field	1.5
Grass ²	Zhu et al. 2019	Field	0.3
Grass ²	Zhu et al. 2019	Field	0.9
Grass ²	Zhu et al. 2019	Field	0.5
Grass ²	Zhu et al. 2019	Field	1.0
Grass ²	Zhu et al. 2019	Field	0.7
Grass ²	Zhu et al. 2019	Field	0.9
Tree (leaf)	Zhu et al. 2019	Field	0.6
Tree (leaf)	Zhu et al. 2019	Field	0.95
Tree (leaf)	Zhu et al. 2019	Field	0.8
Tree (leaf)	Zhu et al. 2019	Field	0.8
Wheat ²	Wen et al. 2014	Field	1.6
Wheat ²	Wen et al. 2014	Field	1.0
Wheat ²	Wen et al. 2014	Field	1.0
Wheat ²	Zhao et al. 2017a	Greenhouse, Spiked Soil	0.6
Wheat ²	Zhao et al. 2017a	Greenhouse, Spiked Soil	0.3
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	1.8
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	1.3
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	1.7
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	1.3
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	1.5
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	1.1
Maize ²	Krippner et al. 2015	Greenhouse, Spiked Soil	0.03
Maize ²	Krippner et al. 2015	Greenhouse, Spiked Soil	0.04
Kentucky Blue Grass	Yoo et al. 2011	Field	0.1
Tall Fescue (Grass)	Yoo et al. 2011	Field	0.2
Tall Fescue (Grass)	Yoo et al. 2011	Field	0.03
Tall Fescue (Grass)	Yoo et al. 2011	Field	0.2
Bermuda Grass	Yoo et al. 2011	Field	0.03
Maize	Liu et al. 2017	Field	1.0
Maize	Liu et al. 2017	Field	2.0
Maize	Liu et al. 2017	Field	1.8
Wheat	Liu et al. 2017	Field	1.3
Wheat	Liu et al. 2017	Field	1.5
Wheat	Liu et al. 2017	Field	0.1
Wheat	Liu et al. 2017	Field	1.0
Wheat	Liu et al. 2017	Field	1.2
Wheat	Liu et al. 2017	Field	1.8
Wheat	Liu et al. 2017	Field	1.8

Appendix E - Bioaccumulation Factors
Table 1. Individual Soil-to-Plant Bioaccumulation Factors

Organism	Source	Study Type	Soil-to-Plant Bioaccumulation Factor ¹
Perfluorodecanoic acid (PFDA)			
Wheat	Liu et al. 2017	Field	1.5
Wheat	Liu et al. 2017	Field	1.1
Geometric Mean³			0.7
Minimum³			0.025
Maximum³			8.5
Perfluorononanoic acid (PFNA)			
Wheat Grass	Bräunig et al. 2019	Greenhouse	0.3
Wheat Grass	Bräunig et al. 2019	Greenhouse	<0.85
Lettuce	Blaine et al. 2013	Greenhouse	0.8
Lettuce	Blaine et al. 2013	Greenhouse	2.9
Birch tree ² (Site 2)	Gobelius et al. 2017	Field	15.2
Birch tree ² (Site 3)	Gobelius et al. 2017	Field	0.1
Spruce tree ² (Site 2)	Gobelius et al. 2017	Field	2.1
Radish ²	Blaine et al. 2014	Greenhouse	3.3
Celery ²	Blaine et al. 2014	Greenhouse	1.3
Tomato ²	Blaine et al. 2014	Greenhouse	2.1
Sugar snap pea ²	Blaine et al. 2014	Greenhouse	0.7
Grass ²	Zhu et al. 2019	Field	1.5
Grass ²	Zhu et al. 2019	Field	1.8
Grass ²	Zhu et al. 2019	Field	0.6
Grass ²	Zhu et al. 2019	Field	1.7
Grass ²	Zhu et al. 2019	Field	1.2
Grass ²	Zhu et al. 2019	Field	1.3
Grass ²	Zhu et al. 2019	Field	0.3
Grass ²	Zhu et al. 2019	Field	0.6
Grass ²	Zhu et al. 2019	Field	1.0
Grass ²	Zhu et al. 2019	Field	1.0
Tree (leaf)	Zhu et al. 2019	Field	0.9
Tree (leaf)	Zhu et al. 2019	Field	0.3
Tree (leaf)	Zhu et al. 2019	Field	1.8
Tree (leaf)	Zhu et al. 2019	Field	1.5
Wheat ²	Wen et al. 2014	Field	1.9
Wheat ²	Wen et al. 2014	Field	1.4
Wheat ²	Wen et al. 2014	Field	1.2
Wheat ²	Wen et al. 2014	Field	1.3
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	2.1
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	1.8
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	2.0
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	1.5
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	1.6
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	1.3
Maize ²	Krippner et al. 2015	Greenhouse, Spiked Soil	0.1
Maize ²	Krippner et al. 2015	Greenhouse, Spiked Soil	0.2
Kentucky Blue Grass	Yoo et al. 2011	Field	0.1
Tall Fescue (Grass)	Yoo et al. 2011	Field	0.2
Tall Fescue (Grass)	Yoo et al. 2011	Field	0.05
Tall Fescue (Grass)	Yoo et al. 2011	Field	0.2
Bermuda Grass	Yoo et al. 2011	Field	0.05
Maize ²	Zhang et al. 2015	Field	2.5
Maize ²	Zhang et al. 2015	Field	4.6
Carrot	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	0.7
Carrot	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	0.7
Carrot	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	0.8
Carrot	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	1.1
Maize	Liu et al. 2017	Field	0.06

Appendix E - Bioaccumulation Factors
Table 1. Individual Soil-to-Plant Bioaccumulation Factors

Organism	Source	Study Type	Soil-to-Plant Bioaccumulation Factor ¹
Perfluorononanoic acid (PFNA)			
Maize	Liu et al. 2017	Field	2.3
Maize	Liu et al. 2017	Field	11.3
Maize	Liu et al. 2017	Field	2.8
Wheat	Liu et al. 2017	Field	0.6
Wheat	Liu et al. 2017	Field	0.5
Wheat	Liu et al. 2017	Field	2.3
Wheat	Liu et al. 2017	Field	0.6
Wheat	Liu et al. 2017	Field	2.3
Wheat	Liu et al. 2017	Field	0.1
Wheat	Liu et al. 2017	Field	0.3
Wheat	Liu et al. 2017	Field	1.4
Wheat	Liu et al. 2017	Field	1.2
Wheat	Liu et al. 2017	Field	7.0
Wheat	Liu et al. 2017	Field	1.3
Wheat	Liu et al. 2017	Field	0.5
Wheat	Liu et al. 2017	Field	1.5
Wheat	Liu et al. 2017	Field	1.9
Wheat	Liu et al. 2017	Field	0.9
Wheat	Liu et al. 2017	Field	1.2
Wheat	Liu et al. 2017	Field	1.0
Wheat	Liu et al. 2017	Field	1.8
Wheat	Liu et al. 2017	Field	2.5
Wheat	Liu et al. 2017	Field	3.3
Wheat	Liu et al. 2017	Field	1.0
Wheat	Liu et al. 2017	Field	1.4
Wheat	Liu et al. 2017	Field	3.5
Wheat	Liu et al. 2017	Field	11
Wheat	Liu et al. 2017	Field	0.8
Wheat	Liu et al. 2017	Field	0.9
Wheat	Liu et al. 2017	Field	3.5
Wheat	Liu et al. 2017	Field	1.8
Wheat	Liu et al. 2017	Field	3
Wheat	Liu et al. 2017	Field	3.5
Wheat	Liu et al. 2017	Field	1.3
Geometric Mean³			1.1
Minimum³			0.045
Maximum³			15.2
Perfluorooctane sulfonate (PFOS)			
Wheat Grass	Bräunig et al. 2019	Greenhouse	0.4
Wheat Grass	Bräunig et al. 2019	Greenhouse	0.95
Wheat Grass	Bräunig et al. 2019	Greenhouse	0.3
Lettuce	Blaine et al. 2013	Greenhouse	0.3
Lettuce	Blaine et al. 2013	Greenhouse	1.7
Lettuce	Blaine et al. 2013	Field	0.1
Blackberry	D'Hollander et al. 2014	Field	0.4
Edlerberry	D'Hollander et al. 2014	Field	1.6
Maize ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.06
Maize ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.05
Maize ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.1
Maize ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.1
Maize ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.1
Oat ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.02
Oat ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.1
Oat ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.1
Oat ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.4
Oat ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.4
Potato ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.04

Appendix E - Bioaccumulation Factors
Table 1. Individual Soil-to-Plant Bioaccumulation Factors

Organism	Source	Study Type	Soil-to-Plant Bioaccumulation Factor ¹
Perfluorooctane sulfonate (PFOS)			
Potato ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.03
Potato ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.02
Potato ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.02
Potato ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.03
Wheat ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.06
Wheat ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.1
Wheat ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.5
Wheat ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.4
Wheat ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.8
Birch tree ² (Site 1)	Gobelius et al. 2017	Field	0.1
Birch tree ² (Site 2)	Gobelius et al. 2017	Field	1.0
Birch tree ² (Site 3)	Gobelius et al. 2017	Field	0.06
Spruce tree ² (Site 2)	Gobelius et al. 2017	Field	0.9
Spruce tree ² (Site 3)	Gobelius et al. 2017	Field	0.008
Bird cherry tree ² (Site 2)	Gobelius et al. 2017	Field	0.03
Bird cherry tree ² (Site 3)	Gobelius et al. 2017	Field	0.06
Mountain ash tree ² (Site 2)	Gobelius et al. 2017	Field	0.003
Ground elder tree ² (Site 2)	Gobelius et al. 2017	Field	0.06
Beechfern tree ² (Site 1)	Gobelius et al. 2017	Field	251.5
Radish ²	Blaine et al. 2014	Greenhouse	2.2
Celery ²	Blaine et al. 2014	Greenhouse	2.8
Tomato ²	Blaine et al. 2014	Greenhouse	4.4
Sugar snap pea ²	Blaine et al. 2014	Greenhouse	1.2
Lettuce	Bizkarguenaga et al. 2016b	Greenhouse, Spiked Soil	0.6
Lettuce	Bizkarguenaga et al. 2016b	Greenhouse, Spiked Soil	0.7
Carrot (Chantenay variety)	Bizkarguenaga et al. 2016b	Greenhouse, Spiked Soil	0.9
Carrot (Chantenay variety)	Bizkarguenaga et al. 2016b	Greenhouse, Spiked Soil	1.1
Carrot (Nantes variety)	Bizkarguenaga et al. 2016b	Greenhouse, Spiked Soil	0.8
Carrot (Nantes variety)	Bizkarguenaga et al. 2016b	Greenhouse, Spiked Soil	1.0
Carrot (Chantenay variety)	Bizkarguenaga et al. 2016b	Greenhouse, Spiked Soil	0.4
Carrot (Chantenay variety)	Bizkarguenaga et al. 2016b	Greenhouse, Spiked Soil	0.5
Carrot (Nantes variety)	Bizkarguenaga et al. 2016b	Greenhouse, Spiked Soil	0.3
Carrot (Nantes variety)	Bizkarguenaga et al. 2016b	Greenhouse, Spiked Soil	0.2
Wheat ²	Wen et al. 2014	Field	0.7
Wheat ²	Wen et al. 2014	Field	0.5
Wheat ²	Wen et al. 2014	Field	0.5
Wheat ²	Wen et al. 2014	Field	0.6
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	3.7
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	2.5
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	3.1
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	1.9
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	2.5
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	1.7
Potatoes	Lechner and Knapp, 2011	Greenhouse, Spiked Soil	1.2
Potatoes	Lechner and Knapp, 2011	Greenhouse, Spiked Soil	2.0
Carrots	Lechner and Knapp, 2011	Greenhouse, Spiked Soil	1.4
Carrots	Lechner and Knapp, 2011	Greenhouse, Spiked Soil	1.9
Cucumbers	Lechner and Knapp, 2011	Greenhouse, Spiked Soil	0.5
Cucumbers	Lechner and Knapp, 2011	Greenhouse, Spiked Soil	0.9
Maize ²	Krippner et al. 2015	Greenhouse, Spiked Soil	0.3
Maize ²	Krippner et al. 2015	Greenhouse, Spiked Soil	0.6
Kentucky Blue Grass	Yoo et al. 2011	Field	0.08
Tall Fescue (Grass)	Yoo et al. 2011	Field	0.06
Tall Fescue (Grass)	Yoo et al. 2011	Field	0.03

Appendix E - Bioaccumulation Factors
Table 1. Individual Soil-to-Plant Bioaccumulation Factors

Organism	Source	Study Type	Soil-to-Plant Bioaccumulation Factor ¹
Perfluorooctane sulfonate (PFOS)			
Tall Fescue (Grass)	Yoo et al. 2011	Field	0.1
Bermuda Grass	Yoo et al. 2011	Field	0.04
Alfalfa	Brignole et al. 2003	Greenhouse, Spiked Soil	1.6
Alfalfa	Brignole et al. 2003	Greenhouse, Spiked Soil	0.3
Alfalfa	Brignole et al. 2003	Greenhouse, Spiked Soil	0.2
Alfalfa	Brignole et al. 2003	Greenhouse, Spiked Soil	0.06
Flax ²	Brignole et al. 2003	Greenhouse, Spiked Soil	0.7
Flax ²	Brignole et al. 2003	Greenhouse, Spiked Soil	0.7
Flax ²	Brignole et al. 2003	Greenhouse, Spiked Soil	0.5
Lettuce	Brignole et al. 2003	Greenhouse, Spiked Soil	2.2
Lettuce	Brignole et al. 2003	Greenhouse, Spiked Soil	0.7
Lettuce	Brignole et al. 2003	Greenhouse, Spiked Soil	0.7
Onion (fruit)	Brignole et al. 2003	Greenhouse, Spiked Soil	0.8
Onion ²	Brignole et al. 2003	Greenhouse, Spiked Soil	1.1
Ryegrass	Brignole et al. 2003	Greenhouse, Spiked Soil	2.1
Ryegrass	Brignole et al. 2003	Greenhouse, Spiked Soil	2.0
Ryegrass	Brignole et al. 2003	Greenhouse, Spiked Soil	0.8
Ryegrass	Brignole et al. 2003	Greenhouse, Spiked Soil	0.3
Soybean ²	Brignole et al. 2003	Greenhouse, Spiked Soil	2.2
Soybean ²	Brignole et al. 2003	Greenhouse, Spiked Soil	1.2
Soybean ²	Brignole et al. 2003	Greenhouse, Spiked Soil	0.5
Soybean ²	Brignole et al. 2003	Greenhouse, Spiked Soil	0.2
Tomato ²	Brignole et al. 2003	Greenhouse, Spiked Soil	1.1
Tomato ²	Brignole et al. 2003	Greenhouse, Spiked Soil	0.4
Alfalfa ²	Wen et al. 2016	Greenhouse	1.8
Lettuce ²	Wen et al. 2016	Greenhouse	2.1
Maize ²	Wen et al. 2016	Greenhouse	1.4
Mung bean ²	Wen et al. 2016	Greenhouse	2.4
Radish ²	Wen et al. 2016	Greenhouse	1.5
Ryegrass ²	Wen et al. 2016	Greenhouse	0.8
Soybean ²	Wen et al. 2016	Greenhouse	2.5
Maize	Liu et al. 2017	Field	3.3
Maize	Liu et al. 2017	Field	0.001
Maize	Liu et al. 2017	Field	0.8
Maize	Liu et al. 2017	Field	1.50
Maize	Liu et al. 2017	Field	0.4
Maize	Liu et al. 2017	Field	0.5
Maize	Liu et al. 2017	Field	1.2
Maize	Liu et al. 2017	Field	0.6
Maize	Liu et al. 2017	Field	0.8
Maize	Liu et al. 2017	Field	0.3
Maize	Liu et al. 2017	Field	3.0
Maize	Liu et al. 2017	Field	1.1
Maize	Liu et al. 2017	Field	2.2
Maize	Liu et al. 2017	Field	13.8
Maize	Liu et al. 2017	Field	0.9
Maize	Liu et al. 2017	Field	1.2
Maize	Liu et al. 2017	Field	2.0
Maize	Liu et al. 2017	Field	3.5
Wheat	Liu et al. 2017	Field	1.3
Wheat	Liu et al. 2017	Field	0.1
Wheat	Liu et al. 2017	Field	2.7
Wheat	Liu et al. 2017	Field	0.6
Wheat	Liu et al. 2017	Field	0.6
Wheat	Liu et al. 2017	Field	0.4
Wheat	Liu et al. 2017	Field	0.5
Wheat	Liu et al. 2017	Field	0.8

Appendix E - Bioaccumulation Factors
Table 1. Individual Soil-to-Plant Bioaccumulation Factors

Organism	Source	Study Type	Soil-to-Plant Bioaccumulation Factor ¹
Perfluorooctane sulfonate (PFOS)			
Wheat	Liu et al. 2017	Field	0.3
Wheat	Liu et al. 2017	Field	2.4
Wheat	Liu et al. 2017	Field	0.5
Wheat	Liu et al. 2017	Field	0.4
Wheat	Liu et al. 2017	Field	1.0
Wheat	Liu et al. 2017	Field	1.2
Wheat	Liu et al. 2017	Field	1.8
Wheat	Liu et al. 2017	Field	17.2
Wheat	Liu et al. 2017	Field	2.9
Wheat	Liu et al. 2017	Field	2.0
Wheat	Liu et al. 2017	Field	40
Wheat	Liu et al. 2017	Field	1.1
Wheat	Liu et al. 2017	Field	1.0
Wheat	Liu et al. 2017	Field	0.2
Wheat	Liu et al. 2017	Field	3.5
Wheat	Liu et al. 2017	Field	0.9
Rapeseed	Zhao et al. 2017b	Greenhouse, Spiked Soil	0.03
Wheat	Zhao et al. 2017b	Greenhouse, Spiked Soil	0.02
Geometric Mean³			0.66
Minimum³			0.0011
Maximum³			251.5
Perfluorooctane sulfonate (PFOS) - Branched isomer			
Birch tree ² (Site 1)	Gobelius et al. 2017	Field	0.2
Birch tree ² (Site 2)	Gobelius et al. 2017	Field	1.1
Birch tree ² (Site 3)	Gobelius et al. 2017	Field	0.05
Spruce tree ² (Site 2)	Gobelius et al. 2017	Field	2.3
Spruce tree ² (Site 3)	Gobelius et al. 2017	Field	0.02
Bird cherry tree ² (Site 2)	Gobelius et al. 2017	Field	0.1
Bird cherry tree ² (Site 3)	Gobelius et al. 2017	Field	0.2
Ground elder tree ² (Site 2)	Gobelius et al. 2017	Field	0.08
Ground elder tree ² (Site 3)	Gobelius et al. 2017	Field	0.06
Beechfern tree ² (Site 1)	Gobelius et al. 2017	Field	48.6
Geometric Mean³			0.29
Minimum³			0.016
Maximum³			48.6
Perfluorooctanoic acid (PFOA)			
Wheat Grass	Bräunig et al. 2019	Greenhouse	1.5
Wheat Grass	Bräunig et al. 2019	Greenhouse	3.1
Wheat Grass	Bräunig et al. 2019	Greenhouse	<1.4
Lettuce	Blaine et al. 2013	Greenhouse	1.3
Lettuce	Blaine et al. 2013	Greenhouse	2.5
Tomato	Blaine et al. 2013	Greenhouse	0.1
Maize ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.1
Maize ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.06
Maize ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.1
Maize ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.2
Maize ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.2
Oat ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.4
Oat ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.3
Oat ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.1
Oat ²	Stahl et al. 2009	Greenhouse, Spiked Soil	1.8
Oat ²	Stahl et al. 2009	Greenhouse, Spiked Soil	2.2
Potato ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.02
Potato ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.004

Appendix E - Bioaccumulation Factors
Table 1. Individual Soil-to-Plant Bioaccumulation Factors

Organism	Source	Study Type	Soil-to-Plant Bioaccumulation Factor ¹
Perfluorooctanoic acid (PFOA)			
Potato ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.006
Potato ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.005
Potato ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.01
Wheat ²	Stahl et al. 2009	Greenhouse, Spiked Soil	1.6
Wheat ²	Stahl et al. 2009	Greenhouse, Spiked Soil	0.9
Wheat ²	Stahl et al. 2009	Greenhouse, Spiked Soil	2.2
Wheat ²	Stahl et al. 2009	Greenhouse, Spiked Soil	1.9
Wheat ²	Stahl et al. 2009	Greenhouse, Spiked Soil	3.4
Birch tree ² (Site 1)	Gobelius et al. 2017	Field	0.1
Birch tree ² (Site 2)	Gobelius et al. 2017	Field	0.4
Birch tree ² (Site 3)	Gobelius et al. 2017	Field	1.8
Spruce tree ² (Site 2)	Gobelius et al. 2017	Field	13.6
Spruce tree ² (Site 3)	Gobelius et al. 2017	Field	1.5
Bird cherry tree ² (Site 2)	Gobelius et al. 2017	Field	0.07
Bird cherry tree ² (Site 3)	Gobelius et al. 2017	Field	0.2
Beechfern tree ² (Site 1)	Gobelius et al. 2017	Field	12.3
Radish ²	Blaine et al. 2014	Greenhouse	4.2
Celery ²	Blaine et al. 2014	Greenhouse	1.1
Tomato ²	Blaine et al. 2014	Greenhouse	1.2
Sugar snap pea ²	Blaine et al. 2014	Greenhouse	0.4
Grass ²	Zhu et al. 2019	Field	0.3
Grass ²	Zhu et al. 2019	Field	0.7
Grass ²	Zhu et al. 2019	Field	0.2
Grass ²	Zhu et al. 2019	Field	0.3
Grass ²	Zhu et al. 2019	Field	0.2
Grass ²	Zhu et al. 2019	Field	0.3
Grass ²	Zhu et al. 2019	Field	0.07
Grass ²	Zhu et al. 2019	Field	0.6
Grass ²	Zhu et al. 2019	Field	0.8
Grass ²	Zhu et al. 2019	Field	0.3
Grass ²	Zhu et al. 2019	Field	1.2
Grass ²	Zhu et al. 2019	Field	0.5
Grass ²	Zhu et al. 2019	Field	0.3
Grass ²	Zhu et al. 2019	Field	0.5
Grass ²	Zhu et al. 2019	Field	1.0
Grass ²	Zhu et al. 2019	Field	0.3
Grass ²	Zhu et al. 2019	Field	0.5
Grass ²	Zhu et al. 2019	Field	0.4
Grass ²	Zhu et al. 2019	Field	0.5
Tree (leaf)	Zhu et al. 2019	Field	3.3
Tree (leaf)	Zhu et al. 2019	Field	4.0
Tree (leaf)	Zhu et al. 2019	Field	5.6
Tree (leaf)	Zhu et al. 2019	Field	5.6
Tree (leaf)	Zhu et al. 2019	Field	2.3
Lettuce	Bizkarguenaga et al. 2016b	Greenhouse, Spiked Soil	3.2
Lettuce	Bizkarguenaga et al. 2016b	Greenhouse, Spiked Soil	2.5
Carrot (Chantenay variety)	Bizkarguenaga et al. 2016b	Greenhouse, Spiked Soil	0.8
Carrot (Chantenay variety)	Bizkarguenaga et al. 2016b	Greenhouse, Spiked Soil	0.9
Carrot (Nantes variety)	Bizkarguenaga et al. 2016b	Greenhouse, Spiked Soil	0.7
Carrot (Nantes variety)	Bizkarguenaga et al. 2016b	Greenhouse, Spiked Soil	1.3
Carrot (Chantenay variety)	Bizkarguenaga et al. 2016b	Greenhouse, Spiked Soil	0.9
Carrot (Chantenay variety)	Bizkarguenaga et al. 2016b	Greenhouse, Spiked Soil	1.0

Appendix E - Bioaccumulation Factors
Table 1. Individual Soil-to-Plant Bioaccumulation Factors

Organism	Source	Study Type	Soil-to-Plant Bioaccumulation Factor ¹
Perfluorooctanoic acid (PFOA)			
Carrot (Nantes variety)	Bizkarguenaga et al. 2016b	Greenhouse, Spiked Soil	0.3
Carrot (Nantes variety)	Bizkarguenaga et al. 2016b	Greenhouse, Spiked Soil	0.3
Wheat ²	Wen et al. 2014	Field	2.2
Wheat ²	Wen et al. 2014	Field	1.1
Wheat ²	Wen et al. 2014	Field	0.9
Wheat ²	Wen et al. 2014	Field	0.9
Italian Lettuce (SJ) ²	Xiang et al. 2018	Greenhouse, Spiked Soil	3.4
Italian Lettuce (SM) ²	Xiang et al. 2018	Greenhouse, Spiked Soil	2.6
Italian Lettuce (HC) ²	Xiang et al. 2018	Greenhouse, Spiked Soil	7.3
Italian Lettuce (QK) ²	Xiang et al. 2018	Greenhouse, Spiked Soil	10
Italian Lettuce (WN) ²	Xiang et al. 2018	Greenhouse, Spiked Soil	5.5
Romaine Lettuce ²	Xiang et al. 2018	Greenhouse, Spiked Soil	5.7
Romaine Zicui (Lettuce) ²	Xiang et al. 2018	Greenhouse, Spiked Soil	4.7
Hongfeng Lettuce ²	Xiang et al. 2018	Greenhouse, Spiked Soil	6.7
American Frisee Lettuce ²	Xiang et al. 2018	Greenhouse, Spiked Soil	3.1
Italian Frisee Lettuce ²	Xiang et al. 2018	Greenhouse, Spiked Soil	1.8
Butterhead Lettuce ²	Xiang et al. 2018	Greenhouse, Spiked Soil	3.3
Banbaofeicui (Lettuce) ²	Xiang et al. 2018	Greenhouse, Spiked Soil	2.9
Oriental Hans-518 (Lettuce) ²	Xiang et al. 2018	Greenhouse, Spiked Soil	2.7
Hongyun (Lettuce) ²	Xiang et al. 2018	Greenhouse, Spiked Soil	2.8
Red wave Lettuce ²	Xiang et al. 2018	Greenhouse, Spiked Soil	2.3
Local Red Lettuce ²	Xiang et al. 2018	Greenhouse, Spiked Soil	2.95
Hongyoualasi (Lettuce) ²	Xiang et al. 2018	Greenhouse, Spiked Soil	2.9
Kafeimaidangcai (Lettuce) ²	Xiang et al. 2018	Greenhouse, Spiked Soil	3.9
Lyxiu Lettuce ²	Xiang et al. 2018	Greenhouse, Spiked Soil	5.7
Chicory (C. intybus L.) ²	Xiang et al. 2018	Greenhouse, Spiked Soil	11.5
Italian Lettuce (SJ) ²	Xiang et al. 2018	Greenhouse, Spiked Soil	4.4
Italian Lettuce (SM) ²	Xiang et al. 2018	Greenhouse, Spiked Soil	4.6
Italian Lettuce (HC) ²	Xiang et al. 2018	Greenhouse, Spiked Soil	8.3
Italian Lettuce (QK) ²	Xiang et al. 2018	Greenhouse, Spiked Soil	7.7
Italian Lettuce (WN) ²	Xiang et al. 2018	Greenhouse, Spiked Soil	4.5
Romaine Lettuce ²	Xiang et al. 2018	Greenhouse, Spiked Soil	8
Romaine Zicui (Lettuce) ²	Xiang et al. 2018	Greenhouse, Spiked Soil	3.2
Hongfeng Lettuce ²	Xiang et al. 2018	Greenhouse, Spiked Soil	2.2
American Frisee Lettuce ²	Xiang et al. 2018	Greenhouse, Spiked Soil	5.2
Italian Frisee Lettuce ²	Xiang et al. 2018	Greenhouse, Spiked Soil	2.3
Butterhead Lettuce ²	Xiang et al. 2018	Greenhouse, Spiked Soil	2.6
Banbaofeicui (Lettuce) ²	Xiang et al. 2018	Greenhouse, Spiked Soil	2.2
Oriental Hans-518 (Lettuce) ²	Xiang et al. 2018	Greenhouse, Spiked Soil	4.3
Hongyun (Lettuce) ²	Xiang et al. 2018	Greenhouse, Spiked Soil	7.6
Red wave Lettuce ²	Xiang et al. 2018	Greenhouse, Spiked Soil	2.3
Local Red Lettuce ²	Xiang et al. 2018	Greenhouse, Spiked Soil	2.6
Hongyoualasi (Lettuce) ²	Xiang et al. 2018	Greenhouse, Spiked Soil	2.7
Kafeimaidangcai (Lettuce) ²	Xiang et al. 2018	Greenhouse, Spiked Soil	4.0
Lyxiu Lettuce ²	Xiang et al. 2018	Greenhouse, Spiked Soil	4.2
Chicory (C. intybus L.) ²	Xiang et al. 2018	Greenhouse, Spiked Soil	4.1
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	2.7
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	4.0
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	2.1
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	2.7
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	1.7

Appendix E - Bioaccumulation Factors
Table 1. Individual Soil-to-Plant Bioaccumulation Factors

Organism	Source	Study Type	Soil-to-Plant Bioaccumulation Factor ¹
Perfluorooctanoic acid (PFOA)			
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	2.6
Potatoes	Lechner and Knapp, 2011	Greenhouse, Spiked Soil	1.7
Potatoes	Lechner and Knapp, 2011	Greenhouse, Spiked Soil	1.8
Carrots	Lechner and Knapp, 2011	Greenhouse, Spiked Soil	2.3
Carrots	Lechner and Knapp, 2011	Greenhouse, Spiked Soil	2.3
Cucumbers	Lechner and Knapp, 2011	Greenhouse, Spiked Soil	3.3
Cucumbers	Lechner and Knapp, 2011	Greenhouse, Spiked Soil	4.3
Maize ²	Krippner et al. 2015	Greenhouse, Spiked Soil	0.6
Maize ²	Krippner et al. 2015	Greenhouse, Spiked Soil	0.3
Kentucky Blue Grass	Yoo et al. 2011	Field	0.3
Tall Fescue (Grass)	Yoo et al. 2011	Field	0.7
Tall Fescue (Grass)	Yoo et al. 2011	Field	0.09
Tall Fescue (Grass)	Yoo et al. 2011	Field	0.1
Bermuda Grass	Yoo et al. 2011	Field	0.1
Maize ²	Zhang et al. 2015	Field	0.02
Maize ²	Zhang et al. 2015	Field	0.01
Alfalfa ²	Wen et al. 2016	Greenhouse	6.7
Lettuce ²	Wen et al. 2016	Greenhouse	3.6
Maize ²	Wen et al. 2016	Greenhouse	0.9
Mung bean ²	Wen et al. 2016	Greenhouse	8.1
Radish ²	Wen et al. 2016	Greenhouse	4.2
Ryegrass ²	Wen et al. 2016	Greenhouse	1.8
Soybean ²	Wen et al. 2016	Greenhouse	1.8
Carrot	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	0.9
Carrot	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	1.4
Carrot	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	0.6
Carrot	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	0.4
Lettuce	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	0.09
Lettuce	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	0.09
Lettuce	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	0.02
Lettuce	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	0.02
Maize	Liu et al. 2017	Field	0.003
Maize	Liu et al. 2017	Field	0.002
Maize	Liu et al. 2017	Field	0.004
Maize	Liu et al. 2017	Field	0.0005
Maize	Liu et al. 2017	Field	0.01
Maize	Liu et al. 2017	Field	0.02
Maize	Liu et al. 2017	Field	0.007
Maize	Liu et al. 2017	Field	0.009
Maize	Liu et al. 2017	Field	0.0008
Maize	Liu et al. 2017	Field	0.003
Maize	Liu et al. 2017	Field	0.005
Maize	Liu et al. 2017	Field	0.02
Maize	Liu et al. 2017	Field	0.03
Maize	Liu et al. 2017	Field	0.02
Maize	Liu et al. 2017	Field	0.0002
Maize	Liu et al. 2017	Field	0.001
Maize	Liu et al. 2017	Field	0.004
Maize	Liu et al. 2017	Field	0.003
Maize	Liu et al. 2017	Field	0.04
Maize	Liu et al. 2017	Field	0.003
Maize	Liu et al. 2017	Field	0.001
Maize	Liu et al. 2017	Field	0.008
Maize	Liu et al. 2017	Field	0.007
Maize	Liu et al. 2017	Field	0.02
Maize	Liu et al. 2017	Field	0.02
Maize	Liu et al. 2017	Field	0.02
Maize	Liu et al. 2017	Field	0.01

Appendix E - Bioaccumulation Factors
Table 1. Individual Soil-to-Plant Bioaccumulation Factors

Organism	Source	Study Type	Soil-to-Plant Bioaccumulation Factor ¹
Perfluorooctanoic acid (PFOA)			
Maize	Liu et al. 2017	Field	0.01
Maize	Liu et al. 2017	Field	0.02
Maize	Liu et al. 2017	Field	0.03
Maize	Liu et al. 2017	Field	0.02
Maize	Liu et al. 2017	Field	0.02
Maize	Liu et al. 2017	Field	0.04
Maize	Liu et al. 2017	Field	0.03
Maize	Liu et al. 2017	Field	0.07
Maize	Liu et al. 2017	Field	0.01
Maize	Liu et al. 2017	Field	0.02
Maize	Liu et al. 2017	Field	0.02
Maize	Liu et al. 2017	Field	0.03
Maize	Liu et al. 2017	Field	0.006
Maize	Liu et al. 2017	Field	0.01
Maize	Liu et al. 2017	Field	0.02
Maize	Liu et al. 2017	Field	0.04
Wheat	Liu et al. 2017	Field	0.07
Wheat	Liu et al. 2017	Field	0.04
Wheat	Liu et al. 2017	Field	0.08
Wheat	Liu et al. 2017	Field	0.1
Wheat	Liu et al. 2017	Field	0.3
Wheat	Liu et al. 2017	Field	0.2
Wheat	Liu et al. 2017	Field	0.2
Wheat	Liu et al. 2017	Field	0.1
Wheat	Liu et al. 2017	Field	0.02
Wheat	Liu et al. 2017	Field	0.04
Wheat	Liu et al. 2017	Field	0.3
Wheat	Liu et al. 2017	Field	0.4
Wheat	Liu et al. 2017	Field	0.4
Wheat	Liu et al. 2017	Field	0.3
Wheat	Liu et al. 2017	Field	0.01
Wheat	Liu et al. 2017	Field	0.008
Wheat	Liu et al. 2017	Field	0.06
Wheat	Liu et al. 2017	Field	0.04
Wheat	Liu et al. 2017	Field	0.2
Wheat	Liu et al. 2017	Field	0.08
Wheat	Liu et al. 2017	Field	0.01
Wheat	Liu et al. 2017	Field	0.1
Wheat	Liu et al. 2017	Field	0.05
Wheat	Liu et al. 2017	Field	0.1
Wheat	Liu et al. 2017	Field	0.08
Wheat	Liu et al. 2017	Field	0.07
Wheat	Liu et al. 2017	Field	0.06
Wheat	Liu et al. 2017	Field	0.08
Wheat	Liu et al. 2017	Field	0.07
Wheat	Liu et al. 2017	Field	0.1
Wheat	Liu et al. 2017	Field	0.1
Wheat	Liu et al. 2017	Field	0.2
Wheat	Liu et al. 2017	Field	0.2
Wheat	Liu et al. 2017	Field	0.07
Wheat	Liu et al. 2017	Field	0.05
Wheat	Liu et al. 2017	Field	0.1
Wheat	Liu et al. 2017	Field	0.2
Wheat	Liu et al. 2017	Field	0.07
Wheat	Liu et al. 2017	Field	0.05
Wheat	Liu et al. 2017	Field	0.08
Wheat	Liu et al. 2017	Field	0.2
Wheat	Liu et al. 2017	Field	0.06
Wheat	Liu et al. 2017	Field	0.06
Wheat	Liu et al. 2017	Field	0.3

Appendix E - Bioaccumulation Factors
Table 1. Individual Soil-to-Plant Bioaccumulation Factors

Organism	Source	Study Type	Soil-to-Plant Bioaccumulation Factor ¹
Perfluorooctanoic acid (PFOA)			
Rapeseed	Zhao et al. 2017b	Greenhouse, Spiked Soil	0.06
Wheat	Zhao et al. 2017b	Greenhouse, Spiked Soil	0.01
Geometric Mean³			0.11
Minimum³			0.0002
Maximum³			13.6
Perfluoroheptane sulfonate (PFHpS)			
Lettuce	Blaine et al. 2013	Greenhouse	1.0
Lettuce	Blaine et al. 2013	Greenhouse	6.6
Geometric Mean³			2.6
Minimum³			1.03
Maximum³			6.57
Perfluoroheptanoic acid (PFHpA)			
Wheat Grass	Bräunig et al. 2019	Greenhouse	7.5
Wheat Grass	Bräunig et al. 2019	Greenhouse	15
Lettuce	Blaine et al. 2013	Greenhouse	3.3
Lettuce	Blaine et al. 2013	Greenhouse	2.7
Tomato	Blaine et al. 2013	Greenhouse	0.9
Birch tree ² (Site 1)	Gobelius et al. 2017	Field	0.2
Birch tree ² (Site 2)	Gobelius et al. 2017	Field	0.8
Birch tree ² (Site 3)	Gobelius et al. 2017	Field	1.97
Spruce tree ² (Site 2)	Gobelius et al. 2017	Field	3.97
Spruce tree ² (Site 3)	Gobelius et al. 2017	Field	0.2
Bird cherry tree ² (Site 2)	Gobelius et al. 2017	Field	0.1
Bird cherry tree ² (Site 3)	Gobelius et al. 2017	Field	0.1
Mountain ash tree ² (Site 1)	Gobelius et al. 2017	Field	46.4
Mountain ash tree ² (Site 2)	Gobelius et al. 2017	Field	0.2
Mountain ash tree ² (Site 3)	Gobelius et al. 2017	Field	0.1
Ground elder tree ² (Site 3)	Gobelius et al. 2017	Field	0.08
Beechfern tree ² (Site 1)	Gobelius et al. 2017	Field	157.5
Radish ²	Blaine et al. 2014	Greenhouse	3.2
Celery ²	Blaine et al. 2014	Greenhouse	2.7
Tomato ²	Blaine et al. 2014	Greenhouse	2.2
Sugar snap pea ²	Blaine et al. 2014	Greenhouse	0.99
Grass ²	Zhu et al. 2019	Field	0.2
Grass ²	Zhu et al. 2019	Field	4.99
Grass ²	Zhu et al. 2019	Field	0.4
Grass ²	Zhu et al. 2019	Field	0.5
Tree (leaf)	Zhu et al. 2019	Field	2.1
Tree (leaf)	Zhu et al. 2019	Field	2.2
Tree (leaf)	Zhu et al. 2019	Field	2.9
Tree (leaf)	Zhu et al. 2019	Field	3.9
Tree (leaf)	Zhu et al. 2019	Field	2.7
Wheat ²	Wen et al. 2014	Field	3.2
Wheat ²	Wen et al. 2014	Field	2.6
Wheat ²	Wen et al. 2014	Field	1.2
Wheat ²	Wen et al. 2014	Field	1.4
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	4.1
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	5.9
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	3.1
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	5.3
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	2.6
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	4.9
Maize ²	Krippner et al. 2015	Greenhouse, Spiked Soil	0.7
Maize ²	Krippner et al. 2015	Greenhouse, Spiked Soil	0.8

Appendix E - Bioaccumulation Factors
Table 1. Individual Soil-to-Plant Bioaccumulation Factors

Organism	Source	Study Type	Soil-to-Plant Bioaccumulation Factor ¹
Perfluoroheptanoic acid (PFHpA)			
Kentucky Blue Grass	Yoo et al. 2011	Field	0.8
Tall Fescue (Grass)	Yoo et al. 2011	Field	2.1
Tall Fescue (Grass)	Yoo et al. 2011	Field	0.8
Tall Fescue (Grass)	Yoo et al. 2011	Field	0.4
Bermuda Grass	Yoo et al. 2011	Field	0.5
Maize ²	Zhang et al. 2015	Field	0.9
Maize ²	Zhang et al. 2015	Field	0.3
Carrot	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	0.6
Carrot	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	1.2
Carrot	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	2.4
Carrot	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	2.5
Maize	Liu et al. 2017	Field	0.04
Maize	Liu et al. 2017	Field	1.1
Maize	Liu et al. 2017	Field	0.8
Maize	Liu et al. 2017	Field	0.07
Maize	Liu et al. 2017	Field	0.2
Maize	Liu et al. 2017	Field	0.9
Maize	Liu et al. 2017	Field	0.7
Maize	Liu et al. 2017	Field	2.6
Maize	Liu et al. 2017	Field	2.7
Maize	Liu et al. 2017	Field	1.7
Maize	Liu et al. 2017	Field	3.0
Wheat	Liu et al. 2017	Field	1.1
Wheat	Liu et al. 2017	Field	1.2
Wheat	Liu et al. 2017	Field	1.8
Wheat	Liu et al. 2017	Field	1.3
Wheat	Liu et al. 2017	Field	4.3
Wheat	Liu et al. 2017	Field	2.5
Wheat	Liu et al. 2017	Field	3.4
Wheat	Liu et al. 2017	Field	2.3
Wheat	Liu et al. 2017	Field	0.7
Wheat	Liu et al. 2017	Field	0.6
Wheat	Liu et al. 2017	Field	2.3
Wheat	Liu et al. 2017	Field	2.6
Wheat	Liu et al. 2017	Field	3.0
Wheat	Liu et al. 2017	Field	0.9
Wheat	Liu et al. 2017	Field	0.3
Wheat	Liu et al. 2017	Field	1.9
Wheat	Liu et al. 2017	Field	3.1
Wheat	Liu et al. 2017	Field	1.1
Wheat	Liu et al. 2017	Field	0.3
Wheat	Liu et al. 2017	Field	0.5
Wheat	Liu et al. 2017	Field	1.1
Wheat	Liu et al. 2017	Field	2.4
Wheat	Liu et al. 2017	Field	0.97
Wheat	Liu et al. 2017	Field	1.5
Wheat	Liu et al. 2017	Field	3.7
Wheat	Liu et al. 2017	Field	0.6
Wheat	Liu et al. 2017	Field	1.5
Wheat	Liu et al. 2017	Field	2.6
Wheat	Liu et al. 2017	Field	4.6
Geometric Mean³			1.23
Minimum³			0.038
Maximum³			157.5
Perfluorohexane sulfonate (PFHxS)			
Wheat Grass	Bräunig et al. 2019	Greenhouse	31
Wheat Grass	Bräunig et al. 2019	Greenhouse	24
Wheat Grass	Bräunig et al. 2019	Greenhouse	7.5
Lettuce	Blaine et al. 2013	Greenhouse	1.08

Appendix E - Bioaccumulation Factors
Table 1. Individual Soil-to-Plant Bioaccumulation Factors

Organism	Source	Study Type	Soil-to-Plant Bioaccumulation Factor¹
Perfluorohexane sulfonate (PFHxS)			
Lettuce	Blaine et al. 2013	Greenhouse	7.56
Lettuce	Blaine et al. 2013	Field	1.51
Tomato	Blaine et al. 2013	Greenhouse	0.5
Birch tree ² (Site 1)	Gobelius et al. 2017	Field	0.6
Birch tree ² (Site 2)	Gobelius et al. 2017	Field	0.6
Birch tree ² (Site 3)	Gobelius et al. 2017	Field	1.3
Spruce tree ² (Site 2)	Gobelius et al. 2017	Field	13.2
Spruce tree ² (Site 3)	Gobelius et al. 2017	Field	0.7
Bird cherry tree ² (Site 2)	Gobelius et al. 2017	Field	0.2
Bird cherry tree ² (Site 3)	Gobelius et al. 2017	Field	0.9
Mountain ash tree ² (Site 1)	Gobelius et al. 2017	Field	18.5
Mountain ash tree ² (Site 2)	Gobelius et al. 2017	Field	0.09
Mountain ash tree ² (Site 3)	Gobelius et al. 2017	Field	0.2
Ground elder tree ² (Site 2)	Gobelius et al. 2017	Field	0.1
Ground elder tree ² (Site 3)	Gobelius et al. 2017	Field	0.1
Beechfern tree ² (Site 1)	Gobelius et al. 2017	Field	93.6
Strawberry (leaf)	Gobelius et al. 2017	Field	0.06
Radish ²	Blaine et al. 2014	Greenhouse	4.8
Celery ²	Blaine et al. 2014	Greenhouse	3.6
Tomato ²	Blaine et al. 2014	Greenhouse	2.6
Sugar snap pea ²	Blaine et al. 2014	Greenhouse	2.3
Wheat ²	Wen et al. 2014	Field	1.2
Wheat ²	Wen et al. 2014	Field	0.9
Wheat ²	Wen et al. 2014	Field	0.9
Wheat ²	Wen et al. 2014	Field	0.8
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	4.2
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	3.4
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	4.0
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	3.0
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	3.6
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	2.9
Maize ²	Krippner et al. 2015	Greenhouse, Spiked Soil	0.8
Maize ²	Krippner et al. 2015	Greenhouse, Spiked Soil	0.9
Geometric Mean³			1.46
Minimum³			0.063
Maximum³			93.6
Perfluorohexane sulfonate (PFHxS) - Branched isomer			
Mountain ash tree ² (Site 1)	Gobelius et al. 2017	Field	4.7
Beechfern tree ² (Site 1)	Gobelius et al. 2017	Field	13.5
Geometric Mean³			8
Minimum³			4.74
Maximum³			13.5
Perfluorohexanoic acid (PFHxA)			
Wheat Grass	Bräunig et al. 2019	Greenhouse	38
Wheat Grass	Bräunig et al. 2019	Greenhouse	44
Wheat Grass	Bräunig et al. 2019	Greenhouse	5
Lettuce	Blaine et al. 2013	Greenhouse	11.7
Lettuce	Blaine et al. 2013	Greenhouse	9.9
Tomato	Blaine et al. 2013	Greenhouse	2.9
Tomato	Blaine et al. 2013	Field	6.84
Birch tree ² (Site 3)	Gobelius et al. 2017	Field	3.0
Spruce tree ² (Site 2)	Gobelius et al. 2017	Field	46.3
Spruce tree ² (Site 3)	Gobelius et al. 2017	Field	0.5

Appendix E - Bioaccumulation Factors
Table 1. Individual Soil-to-Plant Bioaccumulation Factors

Organism	Source	Study Type	Soil-to-Plant Bioaccumulation Factor ¹
Perfluorohexanoic acid (PFHxA)			
Bird cherry tree ² (Site 2)	Gobelius et al. 2017	Field	0.7
Bird cherry tree ² (Site 3)	Gobelius et al. 2017	Field	0.3
Ground elder tree ² (Site 3)	Gobelius et al. 2017	Field	0.2
Radish ²	Blaine et al. 2014	Greenhouse	2.5
Celery ²	Blaine et al. 2014	Greenhouse	8.3
Tomato ²	Blaine et al. 2014	Greenhouse	4.4
Sugar snap pea ²	Blaine et al. 2014	Greenhouse	2.0
Wheat ²	Wen et al. 2014	Field	2.0
Wheat ²	Wen et al. 2014	Field	1.6
Wheat ²	Wen et al. 2014	Field	1.3
Wheat ²	Wen et al. 2014	Field	1.5
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	15.8
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	18.8
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	14.6
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	16.7
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	13.7
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	15.3
Maize ²	Krippner et al. 2015	Greenhouse, Spiked Soil	1.7
Maize ²	Krippner et al. 2015	Greenhouse, Spiked Soil	1.5
Tall Fescue (Grass)	Yoo et al. 2011	Field	5.2
Tall Fescue (Grass)	Yoo et al. 2011	Field	1.6
Maize ²	Zhang et al. 2015	Field	8.6
Maize ²	Zhang et al. 2015	Field	6.5
Carrot	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	4.6
Carrot	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	11
Carrot	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	2.1
Carrot	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	2.8
Maize	Liu et al. 2017	Field	2.9
Maize	Liu et al. 2017	Field	2.5
Maize	Liu et al. 2017	Field	9.4
Maize	Liu et al. 2017	Field	0.9
Maize	Liu et al. 2017	Field	3.4
Maize	Liu et al. 2017	Field	5.6
Maize	Liu et al. 2017	Field	0.6
Maize	Liu et al. 2017	Field	4.1
Maize	Liu et al. 2017	Field	0.8
Maize	Liu et al. 2017	Field	1.4
Maize	Liu et al. 2017	Field	0.8
Maize	Liu et al. 2017	Field	2.5
Maize	Liu et al. 2017	Field	4.7
Maize	Liu et al. 2017	Field	7.6
Maize	Liu et al. 2017	Field	0.6
Maize	Liu et al. 2017	Field	0.3
Maize	Liu et al. 2017	Field	1.1
Maize	Liu et al. 2017	Field	0.3
Maize	Liu et al. 2017	Field	0.9
Maize	Liu et al. 2017	Field	0.3
Maize	Liu et al. 2017	Field	0.5
Maize	Liu et al. 2017	Field	0.8
Maize	Liu et al. 2017	Field	0.7
Maize	Liu et al. 2017	Field	1.4
Maize	Liu et al. 2017	Field	1.5
Maize	Liu et al. 2017	Field	3.3
Maize	Liu et al. 2017	Field	1.4
Maize	Liu et al. 2017	Field	0.9
Maize	Liu et al. 2017	Field	2.7
Maize	Liu et al. 2017	Field	1.4

Appendix E - Bioaccumulation Factors
Table 1. Individual Soil-to-Plant Bioaccumulation Factors

Organism	Source	Study Type	Soil-to-Plant Bioaccumulation Factor¹
Perfluorohexanoic acid (PFHxA)			
Maize	Liu et al. 2017	Field	1.3
Maize	Liu et al. 2017	Field	0.8
Maize	Liu et al. 2017	Field	4.0
Maize	Liu et al. 2017	Field	5.8
Maize	Liu et al. 2017	Field	3.0
Maize	Liu et al. 2017	Field	1.5
Maize	Liu et al. 2017	Field	3.0
Maize	Liu et al. 2017	Field	6.5
Maize	Liu et al. 2017	Field	1.2
Maize	Liu et al. 2017	Field	2.0
Maize	Liu et al. 2017	Field	2.0
Maize	Liu et al. 2017	Field	2.0
Maize	Liu et al. 2017	Field	4.5
Maize	Liu et al. 2017	Field	2.4
Wheat	Liu et al. 2017	Field	2.8
Wheat	Liu et al. 2017	Field	16.8
Wheat	Liu et al. 2017	Field	6.0
Wheat	Liu et al. 2017	Field	5.8
Wheat	Liu et al. 2017	Field	3.9
Wheat	Liu et al. 2017	Field	4.0
Wheat	Liu et al. 2017	Field	4.1
Wheat	Liu et al. 2017	Field	0.6
Wheat	Liu et al. 2017	Field	8.4
Wheat	Liu et al. 2017	Field	3.3
Wheat	Liu et al. 2017	Field	2.2
Wheat	Liu et al. 2017	Field	5.2
Wheat	Liu et al. 2017	Field	0.6
Wheat	Liu et al. 2017	Field	5.0
Wheat	Liu et al. 2017	Field	10.3
Wheat	Liu et al. 2017	Field	1.4
Wheat	Liu et al. 2017	Field	6.9
Wheat	Liu et al. 2017	Field	6.4
Wheat	Liu et al. 2017	Field	2.0
Wheat	Liu et al. 2017	Field	6.2
Wheat	Liu et al. 2017	Field	2.4
Wheat	Liu et al. 2017	Field	5.0
Wheat	Liu et al. 2017	Field	2.0
Wheat	Liu et al. 2017	Field	1.2
Wheat	Liu et al. 2017	Field	0.5
Wheat	Liu et al. 2017	Field	0.5
Wheat	Liu et al. 2017	Field	0.5
Wheat	Liu et al. 2017	Field	1.9
Wheat	Liu et al. 2017	Field	1.9
Wheat	Liu et al. 2017	Field	0.8
Wheat	Liu et al. 2017	Field	2.2
Wheat	Liu et al. 2017	Field	0.6
Wheat	Liu et al. 2017	Field	0.7
Wheat	Liu et al. 2017	Field	2.4
Wheat	Liu et al. 2017	Field	2.5
Wheat	Liu et al. 2017	Field	2.3
Wheat	Liu et al. 2017	Field	0.6
Wheat	Liu et al. 2017	Field	0.6
Wheat	Liu et al. 2017	Field	4.6
Wheat	Liu et al. 2017	Field	1.1
Wheat	Liu et al. 2017	Field	0.4
Wheat	Liu et al. 2017	Field	2.1
Geometric Mean³			2.17
Minimum³			0.22
Maximum³			46.3

Appendix E - Bioaccumulation Factors
Table 1. Individual Soil-to-Plant Bioaccumulation Factors

Organism	Source	Study Type	Soil-to-Plant Bioaccumulation Factor ¹
Perfluoropentanoic acid (PFPeA)			
Wheat Grass	Bräunig et al. 2019	Greenhouse	145
Wheat Grass	Bräunig et al. 2019	Greenhouse	160
Lettuce	Blaine et al. 2013	Greenhouse	10.2
Lettuce	Blaine et al. 2013	Greenhouse	20.4
Lettuce	Blaine et al. 2013	Field	16.3
Tomato	Blaine et al. 2013	Greenhouse	17.1
Tomato	Blaine et al. 2013	Field	14.9
Corn (Stover)	Blaine et al. 2013	Field	41.1
Birch tree ² (Site 2)	Gobelius et al. 2017	Field	0.7
Birch tree ² (Site 3)	Gobelius et al. 2017	Field	2.9
Spruce tree ² (Site 2)	Gobelius et al. 2017	Field	4.8
Spruce tree ² (Site 3)	Gobelius et al. 2017	Field	1.8
Bird cherry tree ² (Site 2)	Gobelius et al. 2017	Field	0.5
Bird cherry tree ² (Site 3)	Gobelius et al. 2017	Field	0.09
Mountain ash tree ² (Site 1)	Gobelius et al. 2017	Field	1296.5
Mountain ash tree ² (Site 2)	Gobelius et al. 2017	Field	1.03
Mountain ash tree ² (Site 3)	Gobelius et al. 2017	Field	0.4
Beechfern tree ² (Site 1)	Gobelius et al. 2017	Field	4905
Strawberry (leaf)	Gobelius et al. 2017	Field	1.3
Radish ²	Blaine et al. 2014	Greenhouse	2.6
Celery ²	Blaine et al. 2014	Greenhouse	8.3
Tomato ²	Blaine et al. 2014	Greenhouse	8.8
Sugar snap pea ²	Blaine et al. 2014	Greenhouse	3
Wheat ²	Wen et al. 2014	Field	3.1
Wheat ²	Wen et al. 2014	Field	2.6
Wheat ²	Wen et al. 2014	Field	1.1
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	46.8
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	51.6
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	38.3
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	41.4
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	24.0
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	28.3
Maize ²	Krippner et al. 2015	Greenhouse, Spiked Soil	7.5
Maize ²	Krippner et al. 2015	Greenhouse, Spiked Soil	4.4
Maize ²	Zhang et al. 2015	Field	104.5
Maize ²	Zhang et al. 2015	Field	72.2
Carrot	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	8
Carrot	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	12.4
Carrot	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	4.1
Carrot	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	7.9
Maize	Liu et al. 2017	Field	1.6
Maize	Liu et al. 2017	Field	0.2
Maize	Liu et al. 2017	Field	3.0
Maize	Liu et al. 2017	Field	0.4
Maize	Liu et al. 2017	Field	1.2
Maize	Liu et al. 2017	Field	3.8
Maize	Liu et al. 2017	Field	0.2
Maize	Liu et al. 2017	Field	2.3
Maize	Liu et al. 2017	Field	0.2
Maize	Liu et al. 2017	Field	1.1
Maize	Liu et al. 2017	Field	0.4
Maize	Liu et al. 2017	Field	0.8
Maize	Liu et al. 2017	Field	1.1
Maize	Liu et al. 2017	Field	2.8
Maize	Liu et al. 2017	Field	0.2
Maize	Liu et al. 2017	Field	0.7

Appendix E - Bioaccumulation Factors
Table 1. Individual Soil-to-Plant Bioaccumulation Factors

Organism	Source	Study Type	Soil-to-Plant Bioaccumulation Factor ¹
Perfluoropentanoic acid (PFPeA)			
Maize	Liu et al. 2017	Field	0.9
Maize	Liu et al. 2017	Field	0.7
Maize	Liu et al. 2017	Field	0.4
Maize	Liu et al. 2017	Field	0.1
Maize	Liu et al. 2017	Field	0.8
Maize	Liu et al. 2017	Field	1.3
Maize	Liu et al. 2017	Field	0.8
Maize	Liu et al. 2017	Field	2.2
Maize	Liu et al. 2017	Field	5
Maize	Liu et al. 2017	Field	0.9
Maize	Liu et al. 2017	Field	1.2
Maize	Liu et al. 2017	Field	1.3
Maize	Liu et al. 2017	Field	1.0
Maize	Liu et al. 2017	Field	1.0
Maize	Liu et al. 2017	Field	0.6
Wheat	Liu et al. 2017	Field	13.2
Wheat	Liu et al. 2017	Field	38.6
Wheat	Liu et al. 2017	Field	16.5
Wheat	Liu et al. 2017	Field	13.6
Wheat	Liu et al. 2017	Field	13.5
Wheat	Liu et al. 2017	Field	43.6
Wheat	Liu et al. 2017	Field	5.8
Wheat	Liu et al. 2017	Field	2.7
Wheat	Liu et al. 2017	Field	14.6
Wheat	Liu et al. 2017	Field	9.7
Wheat	Liu et al. 2017	Field	3.7
Wheat	Liu et al. 2017	Field	4.8
Wheat	Liu et al. 2017	Field	6
Wheat	Liu et al. 2017	Field	10.4
Wheat	Liu et al. 2017	Field	17.1
Wheat	Liu et al. 2017	Field	4.2
Wheat	Liu et al. 2017	Field	23.7
Wheat	Liu et al. 2017	Field	34.8
Wheat	Liu et al. 2017	Field	12
Wheat	Liu et al. 2017	Field	5.5
Wheat	Liu et al. 2017	Field	16.4
Wheat	Liu et al. 2017	Field	8.7
Wheat	Liu et al. 2017	Field	6.6
Wheat	Liu et al. 2017	Field	3.5
Wheat	Liu et al. 2017	Field	2.6
Wheat	Liu et al. 2017	Field	4.3
Wheat	Liu et al. 2017	Field	3.8
Wheat	Liu et al. 2017	Field	3.2
Wheat	Liu et al. 2017	Field	2.3
Wheat	Liu et al. 2017	Field	3.7
Wheat	Liu et al. 2017	Field	2
Wheat	Liu et al. 2017	Field	1.8
Wheat	Liu et al. 2017	Field	8
Wheat	Liu et al. 2017	Field	5.0
Wheat	Liu et al. 2017	Field	4.8
Wheat	Liu et al. 2017	Field	4.9
Wheat	Liu et al. 2017	Field	4.1
Wheat	Liu et al. 2017	Field	1.4
Wheat	Liu et al. 2017	Field	3.5
Geometric Mean³			3.7
Minimum³			0.089
Maximum³			4905

Appendix E - Bioaccumulation Factors
Table 1. Individual Soil-to-Plant Bioaccumulation Factors

Organism	Source	Study Type	Soil-to-Plant Bioaccumulation Factor ¹
Perfluorobutane sulfonate (PFBS)			
Wheat Grass	Bräunig et al. 2019	Greenhouse	70
Wheat Grass	Bräunig et al. 2019	Greenhouse	90
Wheat Grass	Bräunig et al. 2019	Greenhouse	>26.5
Lettuce	Blaine et al. 2013	Greenhouse	14.5
Lettuce	Blaine et al. 2013	Greenhouse	4.2
Lettuce	Blaine et al. 2013	Field	2.0
Tomato	Blaine et al. 2013	Greenhouse	0.4
Birch tree ² (Site 1)	Gobelius et al. 2017	Field	1.5
Birch tree ² (Site 2)	Gobelius et al. 2017	Field	5.2
Birch tree ² (Site 3)	Gobelius et al. 2017	Field	9.1
Spruce tree ² (Site 2)	Gobelius et al. 2017	Field	5.1
Spruce tree ² (Site 3)	Gobelius et al. 2017	Field	0.5
Bird cherry tree ² (Site 2)	Gobelius et al. 2017	Field	1.3
Bird cherry tree ² (Site 3)	Gobelius et al. 2017	Field	1.4
Mountain ash tree ² (Site 2)	Gobelius et al. 2017	Field	2.1
Mountain ash tree ² (Site 3)	Gobelius et al. 2017	Field	0.5
Ground elder tree (Leaf; Site 1)	Gobelius et al. 2017	Field	117
Ground elder tree ² (Site 2)	Gobelius et al. 2017	Field	2.5
Ground elder tree ² (Site 3)	Gobelius et al. 2017	Field	1.8
Beechfern tree ² (Site 1)	Gobelius et al. 2017	Field	46.8
Radish ²	Blaine et al. 2014	Greenhouse	2.3
Celery ²	Blaine et al. 2014	Greenhouse	2.4
Tomato ²	Blaine et al. 2014	Greenhouse	1.6
Sugar snap pea ²	Blaine et al. 2014	Greenhouse	1.8
Wheat ²	Wen et al. 2014	Field	1.7
Wheat ²	Wen et al. 2014	Field	1.3
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	38.5
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	31.3
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	34.2
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	28.8
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	25.5
Wheat	Zhao et al. 2014b	Greenhouse, Spiked Soil	21.9
Maize ²	Krippner et al. 2015	Greenhouse, Spiked Soil	1.9
Maize ²	Krippner et al. 2015	Greenhouse, Spiked Soil	0.9
Geometric Mean³			3.6
Minimum³			0.42
Maximum³			117
Perfluorobutanoic acid (PFBA)			
Wheat Grass	Bräunig et al. 2019	Greenhouse	350
Wheat Grass	Bräunig et al. 2019	Greenhouse	255
Wheat Grass	Bräunig et al. 2019	Greenhouse	70
Lettuce	Blaine et al. 2013	Greenhouse	28.4
Lettuce	Blaine et al. 2013	Greenhouse	56.8
Lettuce	Blaine et al. 2013	Field	40
Tomato	Blaine et al. 2013	Greenhouse	12.2
Tomato	Blaine et al. 2013	Field	18.2
Corn (Stover)	Blaine et al. 2013	Field	64.8
Birch tree ² (Site 1)	Gobelius et al. 2017	Field	0.1
Birch tree ² (Site 2)	Gobelius et al. 2017	Field	0.3
Spruce tree ² (Site 2)	Gobelius et al. 2017	Field	84
Spruce tree ² (Site 3)	Gobelius et al. 2017	Field	5.2
Bird cherry tree ² (Site 2)	Gobelius et al. 2017	Field	2.9
Beechfern tree ² (Site 1)	Gobelius et al. 2017	Field	4.2
Radish ²	Blaine et al. 2014	Greenhouse	8.4

Appendix E - Bioaccumulation Factors
Table 1. Individual Soil-to-Plant Bioaccumulation Factors

Organism	Source	Study Type	Soil-to-Plant Bioaccumulation Factor ¹
Perfluorobutanoic acid (PFBA)			
Celery ²	Blaine et al. 2014	Greenhouse	33.4
Tomato ²	Blaine et al. 2014	Greenhouse	14.4
Sugar snap pea ²	Blaine et al. 2014	Greenhouse	15.0
Wheat ²	Wen et al. 2014	Field	2.6
Wheat ²	Wen et al. 2014	Field	2.5
Wheat ²	Wen et al. 2014	Field	1.8
Wheat ²	Wen et al. 2014	Field	1.6
Maize ²	Krippner et al. 2015	Greenhouse, Spiked Soil	31.9
Maize ²	Krippner et al. 2015	Greenhouse, Spiked Soil	17.7
Maize ²	Zhang et al. 2015	Field	9.8
Maize ²	Zhang et al. 2015	Field	18.4
Carrot	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	23.3
Carrot	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	33
Carrot	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	17
Carrot	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	8.6
Maize	Liu et al. 2017	Field	7.4
Maize	Liu et al. 2017	Field	1.0
Maize	Liu et al. 2017	Field	8.2
Maize	Liu et al. 2017	Field	2.8
Maize	Liu et al. 2017	Field	3.1
Maize	Liu et al. 2017	Field	6.8
Maize	Liu et al. 2017	Field	0.5
Maize	Liu et al. 2017	Field	5.0
Maize	Liu et al. 2017	Field	2.7
Maize	Liu et al. 2017	Field	11.3
Maize	Liu et al. 2017	Field	1.1
Maize	Liu et al. 2017	Field	1.2
Maize	Liu et al. 2017	Field	2.4
Maize	Liu et al. 2017	Field	1.7
Maize	Liu et al. 2017	Field	1.1
Maize	Liu et al. 2017	Field	1.4
Maize	Liu et al. 2017	Field	2.4
Maize	Liu et al. 2017	Field	1.1
Maize	Liu et al. 2017	Field	2.7
Maize	Liu et al. 2017	Field	0.7
Maize	Liu et al. 2017	Field	0.7
Maize	Liu et al. 2017	Field	2.3
Maize	Liu et al. 2017	Field	1.5
Maize	Liu et al. 2017	Field	2.1
Maize	Liu et al. 2017	Field	4.5
Maize	Liu et al. 2017	Field	2.1
Maize	Liu et al. 2017	Field	1.9
Maize	Liu et al. 2017	Field	3.4
Maize	Liu et al. 2017	Field	4.0
Maize	Liu et al. 2017	Field	1.5
Maize	Liu et al. 2017	Field	1.9
Maize	Liu et al. 2017	Field	5.0
Maize	Liu et al. 2017	Field	1.6
Wheat	Liu et al. 2017	Field	66.1
Wheat	Liu et al. 2017	Field	6.6
Wheat	Liu et al. 2017	Field	71.8
Wheat	Liu et al. 2017	Field	69.4
Wheat	Liu et al. 2017	Field	59.2
Wheat	Liu et al. 2017	Field	116.1
Wheat	Liu et al. 2017	Field	32.5
Wheat	Liu et al. 2017	Field	14.2
Wheat	Liu et al. 2017	Field	97
Wheat	Liu et al. 2017	Field	65.6

Appendix E - Bioaccumulation Factors
Table 1. Individual Soil-to-Plant Bioaccumulation Factors

Organism	Source	Study Type	Soil-to-Plant Bioaccumulation Factor ¹
Perfluorobutanoic acid (PFBA)			
Wheat	Liu et al. 2017	Field	7.9
Wheat	Liu et al. 2017	Field	12.9
Wheat	Liu et al. 2017	Field	16.1
Wheat	Liu et al. 2017	Field	12.6
Wheat	Liu et al. 2017	Field	105
Wheat	Liu et al. 2017	Field	33.3
Wheat	Liu et al. 2017	Field	73.1
Wheat	Liu et al. 2017	Field	182
Wheat	Liu et al. 2017	Field	4.3
Wheat	Liu et al. 2017	Field	37.3
Wheat	Liu et al. 2017	Field	42.0
Wheat	Liu et al. 2017	Field	26.4
Wheat	Liu et al. 2017	Field	32.5
Wheat	Liu et al. 2017	Field	12.7
Wheat	Liu et al. 2017	Field	9.2
Wheat	Liu et al. 2017	Field	3.4
Wheat	Liu et al. 2017	Field	2.8
Wheat	Liu et al. 2017	Field	5.4
Wheat	Liu et al. 2017	Field	15.4
Wheat	Liu et al. 2017	Field	15.7
Wheat	Liu et al. 2017	Field	4.3
Wheat	Liu et al. 2017	Field	2.7
Wheat	Liu et al. 2017	Field	11.7
Wheat	Liu et al. 2017	Field	5.8
Wheat	Liu et al. 2017	Field	4.9
Wheat	Liu et al. 2017	Field	3.2
Wheat	Liu et al. 2017	Field	33.9
Wheat	Liu et al. 2017	Field	15.9
Wheat	Liu et al. 2017	Field	3.6
Wheat	Liu et al. 2017	Field	3.6
Wheat	Liu et al. 2017	Field	21.5
Wheat	Liu et al. 2017	Field	17.2
Wheat	Liu et al. 2017	Field	4.9
Wheat	Liu et al. 2017	Field	17.9
Geometric Mean³			7.99
Minimum³			0.13
Maximum³			350
10:2 Fluorotelomer alcohol (FTOH)			
Wheat ²	Zhao et al. 2017a	Greenhouse, Spiked Soil	0.13
Wheat ²	Zhao et al. 2017a	Greenhouse, Spiked Soil	0.05
Geometric Mean³			--
Minimum³			--
Maximum³			--
6:2 Fluorotelomer alcohol (FTOH)			
Maize ²	Zhang et al. 2015	Field	0.06
Maize ²	Zhang et al. 2015	Field	0.07
Geometric Mean³			0.065
Minimum³			0.057
Maximum³			0.073
6:2 Fluorotelomer carboxylic acid (FTCA)			
Maize ²	Zhang et al. 2015	Field	3.1
Maize ²	Zhang et al. 2015	Field	3.0
Geometric Mean³			3.06
Minimum³			3.04
Maximum³			3.08

Appendix E - Bioaccumulation Factors
Table 1. Individual Soil-to-Plant Bioaccumulation Factors

Organism	Source	Study Type	Soil-to-Plant Bioaccumulation Factor ¹
6:2 Fluorotelomer unsaturated carboxylic acid (FTUCA)			
Maize ²	Zhang et al. 2015	Field	3.95
Maize ²	Zhang et al. 2015	Field	1.8
Geometric Mean³			2.64
Minimum³			1.77
Maximum³			3.95
6:2 Fluorotelomer sulfonic acid (FTSA)			
Birch tree ² (Site 1)	Gobelius et al. 2017	Field	1244
Birch tree ² (Site 2)	Gobelius et al. 2017	Field	147.5
Birch tree ² (Site 3)	Gobelius et al. 2017	Field	14.4
Spruce tree ² (Site 2)	Gobelius et al. 2017	Field	17.3
Spruce tree ² (Site 3)	Gobelius et al. 2017	Field	0.3
Bird cherry tree ² (Site 2)	Gobelius et al. 2017	Field	3.8
Bird cherry tree ² (Site 3)	Gobelius et al. 2017	Field	255.1
Mountain ash tree ² (Site 1)	Gobelius et al. 2017	Field	79.8
Mountain ash tree ² (Site 2)	Gobelius et al. 2017	Field	1.9
Mountain ash tree ² (Site 3)	Gobelius et al. 2017	Field	28.1
Ground elder tree (Leaf; Site 1)	Gobelius et al. 2017	Field	2560.5
Ground elder tree ² (Site 2)	Gobelius et al. 2017	Field	145.6
Ground elder tree ² (Site 3)	Gobelius et al. 2017	Field	15.4
Strawberry (leaf)	Gobelius et al. 2017	Field	12.6
Geometric Mean³			35.1
Minimum³			0.32
Maximum³			2561
Perfluorooctane sulfonamide (FOSA)			
Lettuce	Bizkarguenaga et al. 2016b	Greenhouse, Spiked Soil	0.08
Lettuce	Bizkarguenaga et al. 2016b	Greenhouse, Spiked Soil	0.1
Lettuce	Bizkarguenaga et al. 2016b	Greenhouse, Spiked Soil	0.2
Lettuce	Bizkarguenaga et al. 2016b	Greenhouse, Spiked Soil	0.1
Carrot (Chantenay variety)	Bizkarguenaga et al. 2016b	Greenhouse, Spiked Soil	0.1
Carrot (Chantenay variety)	Bizkarguenaga et al. 2016b	Greenhouse, Spiked Soil	0.2
Geometric Mean³			--
Minimum³			--
Maximum³			--
8:2 Fluorotelomer phosphate diester (8:2 diPAP)			
Carrot	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	0.04
Carrot	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	0.03
Carrot	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	0.03
Carrot	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	0.04
Lettuce	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	0.007
Lettuce	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	0.003
Lettuce	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	0.003
Lettuce	Bizkarguenaga et al. 2016a	Greenhouse, Spiked Soil	0.01
Geometric Mean³			--
Minimum³			--
Maximum³			--

Appendix E - Bioaccumulation Factors
Table 1. Individual Soil-to-Plant Bioaccumulation Factors

Notes:

1. All BAFs presented on a dry-weight basis.

2. Presented BAF is the arithmetic average of plant parts measured (i.e roots and shoot; leaves and fruit).

3. The geometric mean, minimum, and maximum values exclude data from "greenhouse, spiked soil" studies.

Tissue and soil concentrations or BAFs presented in individual papers on a wet-weight basis were converted to dry-weight using moisture contents provided in the individual studies, if applicable, or in Table 4-2 of USEPA (1993).

Published BAFs calculated on a soil organic carbon basis were converted to bulk soil basis by dividing the BAFs by the percent organic carbon, as presented in the applicable studies.

Values presented as > or < were not included in geometric mean calculations.

-- - not identified

Reference

USEPA. 1993. Wildlife Exposure Factors Handbook. Volumes I and II. Office of Research and Development. EPA/600/R-93/187. United States Environmental Protection Agency. December.

Appendix E - Bioaccumulation Factors

Table 2. Individual Soil-to-Soil Invertebrate Bioaccumulation Factors

Organism	Source	Study Type	Soil-to-Soil Invertebrate Bioaccumulation Factor ¹
Perfluorododecanoic acid (PFDoA)			
Earthworm	Bräunig et al. 2019	Lab	56.3
Earthworm	Bräunig et al. 2019	Lab	143.8
Earthworm	Bräunig et al. 2019	Lab	>17.5
Earthworm	Rich et al. 2015	Lab	9.8
Earthworm	Rich et al. 2015	Lab	41.4
Earthworm	Rich et al. 2015	Lab	90.7
Earthworm	Rich et al. 2015	Lab	50.8
Earthworm	Zhu et al. 2019	Field	40.8
Earthworm	Zhu et al. 2019	Field	13.9
Earthworm	Zhu et al. 2019	Field	27.8
Earthworm	Zhu et al. 2019	Field	34
Earthworm	Zhu et al. 2019	Field	7.5
Earthworm	Zhu et al. 2019	Field	13.5
Earthworm	Zhu et al. 2019	Field	24.2
Earthworm	Zhu et al. 2019	Field	89.9
Earthworm	Zhu et al. 2019	Field	57.2
Earthworm	Zhu et al. 2019	Field	153.6
Earthworm	Zhu et al. 2019	Field	55.3
Earthworm	Zhu et al. 2019	Field	34.2
Earthworm	Zhu et al. 2019	Field	31.5
Earthworm	Zhu et al. 2019	Field	66.4
Earthworm	Zhu et al. 2019	Field	12.4
Earthworm	Zhu et al. 2019	Field	97.4
Earthworm	Zhu et al. 2019	Field	11.9
Earthworm	Zhu et al. 2019	Field	34
Earthworm	Zhu et al. 2019	Field	5.0
Earthworm	Zhao et al. 2013	Lab, Spiked Soil	68.8
Earthworm	Zhao et al. 2013	Lab, Spiked Soil	40.9
Earthworm	Zhao et al. 2013	Lab, Spiked Soil	33.4
Earthworm	Navarro et al. 2016	Lab	171
Earthworm	Navarro et al. 2016	Lab	402
Earthworm	Navarro et al. 2016	Lab	82.9
Earthworm	Navarro et al. 2016	Lab	138.0
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	111.9
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	126.2
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	87.7
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	122
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	79.9
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	110.5
Geometric Mean³			42
Minimum³			5.0
Maximum³			402
Perfluoroundecanoic acid (PFUnA)			
Earthworm	Bräunig et al. 2019	Lab	26.3
Earthworm	Bräunig et al. 2019	Lab	56.3
Earthworm	Bräunig et al. 2019	Lab	>12.5
Earthworm	Rich et al. 2015	Lab	3.5
Earthworm	Rich et al. 2015	Lab	14.8
Earthworm	Rich et al. 2015	Lab	52.7
Earthworm	Rich et al. 2015	Lab	14.4

Appendix E - Bioaccumulation Factors

Table 2. Individual Soil-to-Soil Invertebrate Bioaccumulation Factors

Organism	Source	Study Type	Soil-to-Soil Invertebrate Bioaccumulation Factor ¹
Perfluoroundecanoic acid (PFUnA)			
Earthworm	Zhu et al. 2019	Field	12
Earthworm	Zhu et al. 2019	Field	6.5
Earthworm	Zhu et al. 2019	Field	10.4
Earthworm	Zhu et al. 2019	Field	11.2
Earthworm	Zhu et al. 2019	Field	3.0
Earthworm	Zhu et al. 2019	Field	4.7
Earthworm	Zhu et al. 2019	Field	8.0
Earthworm	Zhu et al. 2019	Field	29.7
Earthworm	Zhu et al. 2019	Field	19.9
Earthworm	Zhu et al. 2019	Field	56.4
Earthworm	Zhu et al. 2019	Field	16.1
Earthworm	Zhu et al. 2019	Field	10.9
Earthworm	Zhu et al. 2019	Field	20.2
Earthworm	Zhu et al. 2019	Field	25.3
Earthworm	Zhu et al. 2019	Field	8.4
Earthworm	Zhu et al. 2019	Field	26.8
Earthworm	Zhu et al. 2019	Field	4.4
Earthworm	Zhu et al. 2019	Field	13.8
Earthworm	Zhu et al. 2019	Field	2.9
Earthworm	Zhao et al. 2013	Lab, Spiked Soil	42.5
Earthworm	Zhao et al. 2013	Lab, Spiked Soil	25
Earthworm	Zhao et al. 2013	Lab, Spiked Soil	21.5
Earthworm	Navarro et al. 2016	Lab	50.5
Earthworm	Navarro et al. 2016	Lab	123
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	68.1
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	79.6
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	56
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	75.7
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	53
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	63.3
Geometric Mean³			14.8
Minimum³			2.9
Maximum³			123
Perfluorodecane sulfonate (PFDS)			
Earthworm	Rich et al. 2015	Lab	1.6
Earthworm	Rich et al. 2015	Lab	68.3
Earthworm	Rich et al. 2015	Lab	18.6
Geometric Mean³			12.6
Minimum³			1.6
Maximum³			68.3
Perfluorodecanoic acid (PFDA)			
Earthworm	Bräunig et al. 2019	Lab	10
Earthworm	Bräunig et al. 2019	Lab	22.5
Earthworm	Bräunig et al. 2019	Lab	>14.375
Earthworm	Rich et al. 2015	Lab	5.2
Earthworm	Rich et al. 2015	Lab	18.1
Earthworm	Rich et al. 2015	Lab	21.6
Earthworm	Rich et al. 2015	Lab	6.3
Earthworm	Zhu et al. 2019	Field	6.5

Appendix E - Bioaccumulation Factors

Table 2. Individual Soil-to-Soil Invertebrate Bioaccumulation Factors

Organism	Source	Study Type	Soil-to-Soil Invertebrate Bioaccumulation Factor ¹
Perfluorodecanoic acid (PFDA)			
Earthworm	Zhu et al. 2019	Field	3.3
Earthworm	Zhu et al. 2019	Field	4.2
Earthworm	Zhu et al. 2019	Field	5.4
Earthworm	Zhu et al. 2019	Field	1.1
Earthworm	Zhu et al. 2019	Field	1.3
Earthworm	Zhu et al. 2019	Field	6.3
Earthworm	Zhu et al. 2019	Field	9.2
Earthworm	Zhu et al. 2019	Field	7.5
Earthworm	Zhu et al. 2019	Field	14.6
Earthworm	Zhu et al. 2019	Field	6.5
Earthworm	Zhu et al. 2019	Field	6.0
Earthworm	Zhu et al. 2019	Field	6.8
Earthworm	Zhu et al. 2019	Field	11.5
Earthworm	Zhu et al. 2019	Field	2.2
Earthworm	Zhu et al. 2019	Field	10.3
Earthworm	Zhu et al. 2019	Field	3.8
Earthworm	Zhu et al. 2019	Field	5.9
Earthworm	Zhu et al. 2019	Field	1.7
Earthworm	Zhao et al. 2013	Lab, Spiked Soil	15
Earthworm	Zhao et al. 2013	Lab, Spiked Soil	13.3
Earthworm	Zhao et al. 2013	Lab, Spiked Soil	10
Earthworm	Navarro et al. 2016	Lab	9
Earthworm	Navarro et al. 2016	Lab	23.3
Earthworm	Navarro et al. 2016	Lab	4.8
Earthworm	Navarro et al. 2016	Lab	9.2
Earthworm	Zhao et al. 2017a	Lab, Spiked Soil	46.8
Earthworm	Zhao et al. 2017a	Lab, Spiked Soil	50
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	43.6
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	56.3
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	39.3
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	53.3
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	37.7
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	51.1
Geometric Mean³			6.5
Minimum³			1.1
Maximum³			23.3
Perfluorononanoic acid (PFNA)			
Earthworm	Bräunig et al. 2019	Lab	6.3
Earthworm	Bräunig et al. 2019	Lab	12.5
Earthworm	Rich et al. 2015	Lab	3.6
Earthworm	Rich et al. 2015	Lab	5
Earthworm	Rich et al. 2015	Lab	18.4
Earthworm	Rich et al. 2015	Lab	13.9
Earthworm	Zhu et al. 2019	Field	6.2
Earthworm	Zhu et al. 2019	Field	2.1
Earthworm	Zhu et al. 2019	Field	1.8
Earthworm	Zhu et al. 2019	Field	2.5
Earthworm	Zhu et al. 2019	Field	1.4
Earthworm	Zhu et al. 2019	Field	0.8
Earthworm	Zhu et al. 2019	Field	1.8

Appendix E - Bioaccumulation Factors

Table 2. Individual Soil-to-Soil Invertebrate Bioaccumulation Factors

Organism	Source	Study Type	Soil-to-Soil Invertebrate Bioaccumulation Factor ¹
Perfluorononanoic acid (PFNA)			
Earthworm	Zhu et al. 2019	Field	7
Earthworm	Zhu et al. 2019	Field	6.6
Earthworm	Zhu et al. 2019	Field	6.3
Earthworm	Zhu et al. 2019	Field	11.6
Earthworm	Zhu et al. 2019	Field	2.3
Earthworm	Zhu et al. 2019	Field	4.1
Earthworm	Zhu et al. 2019	Field	7.3
Earthworm	Zhu et al. 2019	Field	2.2
Earthworm	Zhu et al. 2019	Field	10.7
Earthworm	Zhu et al. 2019	Field	2.9
Earthworm	Zhu et al. 2019	Field	20.6
Earthworm	Zhu et al. 2019	Field	3.4
Earthworm	Zhao et al. 2013	Lab, Spiked Soil	10.2
Earthworm	Zhao et al. 2013	Lab, Spiked Soil	5.9
Earthworm	Zhao et al. 2013	Lab, Spiked Soil	5.6
Earthworm	Zhao et al. 2017a	Lab, Spiked Soil	62
Earthworm	Zhao et al. 2017a	Lab, Spiked Soil	156.4
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	16.5
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	30.9
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	13.1
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	26.3
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	12.4
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	25.1
Geometric Mean³			4.64
Minimum³			0.79
Maximum³			20.6
Perfluorooctane sulfonate (PFOS)			
Earthworm	Bräunig et al. 2019	Lab	31.3
Earthworm	Bräunig et al. 2019	Lab	50
Earthworm	Bräunig et al. 2019	Lab	62.5
Slugs	D'Hollander et al. 2014	Field	297.1
Millipedes	D'Hollander et al. 2014	Field	176.1
Earthworm	D'Hollander et al. 2014	Field	340.6
Isopod	D'Hollander et al. 2014	Field	18.3
Earthworm	Rich et al. 2015	Lab	18.1
Earthworm	Rich et al. 2015	Lab	23.6
Earthworm	Rich et al. 2015	Lab	74.5
Earthworm	Rich et al. 2015	Lab	54.9
Earthworm	Zhao et al. 2013	Lab, Spiked Soil	18.6
Earthworm	Zhao et al. 2013	Lab, Spiked Soil	16.6
Earthworm	Zhao et al. 2013	Lab, Spiked Soil	12.4
Earthworm	Navarro et al. 2016	Lab	8.6
Earthworm	Navarro et al. 2016	Lab	30.3
Earthworm	Navarro et al. 2016	Lab	28.1
Earthworm	Navarro et al. 2016	Lab	24.9
Earthworm	Navarro et al. 2016	Lab	10.7
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	101.9
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	114.6
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	81.6
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	104

Appendix E - Bioaccumulation Factors

Table 2. Individual Soil-to-Soil Invertebrate Bioaccumulation Factors

Organism	Source	Study Type	Soil-to-Soil Invertebrate Bioaccumulation Factor ¹
Perfluorooctane sulfonate (PFOS)			
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	71.7
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	99.6
Earthworm	Sinderman et al. 2002	Lab, Spiked Soil	15.8
Earthworm	Sinderman et al. 2002	Lab, Spiked Soil	9
Earthworm	Sinderman et al. 2002	Lab, Spiked Soil	5.4
Earthworm	Sinderman et al. 2002	Lab, Spiked Soil	14.2
Earthworm	Wen et al. 2015	Lab	4.1
Earthworm	Wen et al. 2015	Lab	3.5
Earthworm	Wen et al. 2015	Lab	3.3
Earthworm	Wen et al. 2015	Lab	2.8
Earthworm	Wen et al. 2015	Lab	3.1
Earthworm	Wen et al. 2015	Lab	2.3
Earthworm	Wen et al. 2015	Lab	1.5
Earthworm	Zhao et al. 2016	Lab, Spiked Soil	24.5
Geometric Mean³			18.6
Minimum³			1.5
Maximum³			340.6
Perfluorooctanoic acid (PFOA)			
Earthworm	Bräunig et al. 2019	Lab	5
Earthworm	Bräunig et al. 2019	Lab	4.4
Earthworm	Bräunig et al. 2019	Lab	6.9
Earthworm	Rich et al. 2015	Lab	2.1
Earthworm	Rich et al. 2015	Lab	4
Earthworm	Rich et al. 2015	Lab	8.3
Earthworm	Rich et al. 2015	Lab	6
Earthworm	Zhu et al. 2019	Field	6.6
Earthworm	Zhu et al. 2019	Field	1.9
Earthworm	Zhu et al. 2019	Field	1.4
Earthworm	Zhu et al. 2019	Field	4.3
Earthworm	Zhu et al. 2019	Field	0.6
Earthworm	Zhu et al. 2019	Field	0.6
Earthworm	Zhu et al. 2019	Field	0.3
Earthworm	Zhu et al. 2019	Field	3
Earthworm	Zhu et al. 2019	Field	3.8
Earthworm	Zhu et al. 2019	Field	4.5
Earthworm	Zhu et al. 2019	Field	1.3
Earthworm	Zhu et al. 2019	Field	1.3
Earthworm	Zhu et al. 2019	Field	1.2
Earthworm	Zhu et al. 2019	Field	2.2
Earthworm	Zhu et al. 2019	Field	2.7
Earthworm	Zhu et al. 2019	Field	16.5
Earthworm	Zhu et al. 2019	Field	1.1
Earthworm	Zhu et al. 2019	Field	3.7
Earthworm	Zhu et al. 2019	Field	1
Earthworm	Zhao et al. 2013	Lab, Spiked Soil	4.7
Earthworm	Zhao et al. 2013	Lab, Spiked Soil	3.1
Earthworm	Zhao et al. 2013	Lab, Spiked Soil	1.8
Earthworm	Navarro et al. 2016	Lab	2.4
Earthworm	Navarro et al. 2016	Lab	1.2
Earthworm	Navarro et al. 2016	Lab	2.9

Appendix E - Bioaccumulation Factors

Table 2. Individual Soil-to-Soil Invertebrate Bioaccumulation Factors

Organism	Source	Study Type	Soil-to-Soil Invertebrate Bioaccumulation Factor ¹
Perfluorooctanoic acid (PFOA)			
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	7.7
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	17.1
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	7.2
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	14.7
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	6.8
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	13.8
Earthworm	Wen et al. 2015	Lab	1.4
Earthworm	Wen et al. 2015	Lab	1.1
Earthworm	Wen et al. 2015	Lab	1.1
Earthworm	Wen et al. 2015	Lab	0.9
Earthworm	Wen et al. 2015	Lab	0.9
Earthworm	Wen et al. 2015	Lab	0.8
Earthworm	Wen et al. 2015	Lab	0.5
Geometric Mean³			2.0
Minimum³			0.27
Maximum³			16.5
Perfluoroheptanoic acid (PFHpA)			
Earthworm	Bräunig et al. 2019	Lab	1.3
Earthworm	Bräunig et al. 2019	Lab	0.6
Earthworm	Zhu et al. 2019	Field	1.4
Earthworm	Zhu et al. 2019	Field	0.8
Earthworm	Zhu et al. 2019	Field	0.2
Earthworm	Zhu et al. 2019	Field	1.9
Earthworm	Zhu et al. 2019	Field	0.1
Earthworm	Zhu et al. 2019	Field	0.9
Earthworm	Zhu et al. 2019	Field	1.5
Earthworm	Zhu et al. 2019	Field	1.0
Earthworm	Zhu et al. 2019	Field	0.6
Earthworm	Zhu et al. 2019	Field	1.1
Earthworm	Zhu et al. 2019	Field	3.6
Earthworm	Zhu et al. 2019	Field	0.3
Earthworm	Zhu et al. 2019	Field	2.0
Earthworm	Zhao et al. 2013	Lab, Spiked Soil	5.1
Earthworm	Zhao et al. 2013	Lab, Spiked Soil	2.4
Earthworm	Zhao et al. 2013	Lab, Spiked Soil	1.0
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	2.7
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	3.8
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	1.6
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	2.7
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	1.4
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	2.4
Geometric Mean³			0.82
Minimum³			0.07
Maximum³			3.57
Perfluorohexane sulfonate (PFHxS)			
Earthworm	Bräunig et al. 2019	Lab	38.1
Earthworm	Bräunig et al. 2019	Lab	37.5
Earthworm	Bräunig et al. 2019	Lab	193.8
Earthworm	Rich et al. 2015	Lab	24.6

Appendix E - Bioaccumulation Factors

Table 2. Individual Soil-to-Soil Invertebrate Bioaccumulation Factors

Organism	Source	Study Type	Soil-to-Soil Invertebrate Bioaccumulation Factor ¹
Perfluorohexane sulfonate (PFHxS)			
Earthworm	Rich et al. 2015	Lab	14.2
Earthworm	Rich et al. 2015	Lab	139
Earthworm	Rich et al. 2015	Lab	99.6
Earthworm	Zhao et al. 2013	Lab, Spiked Soil	9.2
Earthworm	Zhao et al. 2013	Lab, Spiked Soil	7.4
Earthworm	Zhao et al. 2013	Lab, Spiked Soil	5
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	57.8
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	83.7
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	49.8
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	74.6
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	48.1
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	70.7
Geometric Mean³			54
Minimum³			14.2
Maximum³			193.8
Perfluorohexanoic acid (PFHxA)			
Earthworm	Bräunig et al. 2019	Lab	1.9
Earthworm	Bräunig et al. 2019	Lab	0.6
Earthworm	Bräunig et al. 2019	Lab	5.6
Earthworm	Zhao et al. 2013	Lab, Spiked Soil	4.2
Earthworm	Zhao et al. 2013	Lab, Spiked Soil	2.3
Earthworm	Zhao et al. 2013	Lab, Spiked Soil	1.7
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	2.4
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	4.0
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	1.6
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	2.7
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	1.3
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	2.0
Geometric Mean³			1.88
Minimum³			0.63
Maximum³			5.63
Perfluoropentanoic acid (PFPeA)			
Earthworm	Bräunig et al. 2019	Lab	8.8
Earthworm	Bräunig et al. 2019	Lab	1.9
Earthworm	Bräunig et al. 2019	Lab	>18.75
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	0.9
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	3.2
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	0.4
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	2.5
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	0.4
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	1.5
Geometric Mean³			4.05
Minimum³			1.88
Maximum³			8.75
Perfluorobutane sulfonate (PFBS)			
Earthworm	Bräunig et al. 2019	Lab	32.5
Earthworm	Bräunig et al. 2019	Lab	29.4
Earthworm	Bräunig et al. 2019	Lab	>306.25
Earthworm	Zhao et al. 2013	Lab, Spiked Soil	2.7

Appendix E - Bioaccumulation Factors

Table 2. Individual Soil-to-Soil Invertebrate Bioaccumulation Factors

Organism	Source	Study Type	Soil-to-Soil Invertebrate Bioaccumulation Factor ¹
Perfluorobutane sulfonate (PFBS)			
Earthworm	Zhao et al. 2013	Lab, Spiked Soil	1.4
Earthworm	Zhao et al. 2013	Lab, Spiked Soil	1.0
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	15.4
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	27.4
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	14.4
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	26.2
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	12.4
Earthworm	Zhao et al. 2014b	Lab, Spiked Soil	22.4
Geometric Mean³			30.9
Minimum³			29.4
Maximum³			32.5
Perfluorobutanoic acid (PFBA)			
Earthworm	Bräunig et al. 2019	Lab	10
Earthworm	Bräunig et al. 2019	Lab	2.5
Earthworm	Bräunig et al. 2019	Lab	14.4
Geometric Mean³			7.1
Minimum³			2.5
Maximum³			14.4
10:2 Fluorotelomer alcohol (FTOH)			
Earthworm	Zhao et al. 2017a	Lab, Spiked Soil	13.1
Earthworm	Zhao et al. 2017a	Lab, Spiked Soil	20
N-ethyl perfluorooctane sulfonamido ethanol (N-EtFOSE)			
Earthworm	Zhao et al. 2016	Lab, Spiked Soil	3.9
Perfluorooctane sulfonamide (FOSA)			
Earthworm	Zhao et al. 2016	Lab, Spiked Soil	23.1
Perfluorooctane sulfonamido acetic acid (FOSAA)			
Earthworm	Zhao et al. 2016	Lab, Spiked Soil	12.7
N-ethyl perfluorooctane sulfonamido acetic acid (N-EtFOSAA)			
Earthworm	Zhao et al. 2016	Lab, Spiked Soil	17.7

Notes:

1. All bioaccumulation factors (BAFs) presented on a dry-weight basis. Tissue and soil concentrations or BAFs presented in individual studies on a wet-weight basis were converted to dry-weight using moisture contents provided in the individual studies, if applicable, or in Table 4-1 of USEPA (1993). Published BAFs calculated on a soil organic carbon basis were converted to bulk soil basis by dividing the BAFs by the percent organic carbon, as presented in the applicable studies.

2. The geometric mean, minimum, and maximum values exclude data from "lab, spiked soil" studies. Values presented as > or < were not included in geometric mean calculations.

-- - not identified

Reference

USEPA. 1993. Wildlife Exposure Factors Handbook. Volumes I and II. Office of Research and Development. EPA/600/R-93/187. United States Environmental Protection Agency. December.

Appendix E - Bioaccumulation Factors

Table 3. Individual Soil-to-Small Mammal Bioaccumulation Factors

Organism	Source	Study Type	Soil-to-Small Mammal Bioaccumulation Factors ¹
Perfluorooctane sulfonate (PFOS)			
Wood Mouse	D'Hollander et al. 2014	Field	29
Bank Vole	D'Hollander et al. 2014	Field	24
Rabbit	AECOM, 2014	Field	2.2
Geometric Mean			11
Minimum			2.2
Maximum			29

Notes:

1. All BAFs presented on a dry-weight basis.

BAFs presented are whole body BAFs, converted from tissue measurements as presented in Appendix E, Tables 8 and 9.

Mouse and vole BAFs were converted to dry-weight using mammal moisture contents from Table 4-1 of USEPA (1993) and an assumed 20% moisture content per USEPA SLERA Appendix C (1999).

from the fore legs, thoracic cage, abdominal walls, spine, and hind leg meat from Pla, Pascual, & Ariño (2010).

Reference

Pla, M., Pascual, M., & Ariño, B. 2010. Protein, fat and moisture content of retail cuts of rabbit meat evaluated with the NIRS methodology. World Rabbit Science, 12(3), 149-158. July.

USEPA. 1993. Wildlife Exposure Factors Handbook. Volumes I and II. Office of Research and Development.

EPA/600/R-93/187. United States Environmental Protection Agency. December.

USEPA. 1999. Screening Level Risk Assessment Protocol – Appendix C: Media-to-Receptor Bioconcentration Factors (BCFs). Office of Solid Waste. United States Environmental Protection Agency.

Appendix E - Bioaccumulation Factors
Table 4. Individual Plant Biota-Sediment Accumulation Factors

Individual Plant Biota-Sediment Accumulation Factors¹														
Organism	Source	Study Type	PFDoA	PFUnA	PFDA	PFNA	PFOS	PFOA	PFHpA	PFHxS	PFHxA	PFPeA	PFBS	PFBA
Softstem bulrus (<i>S. tabernaemontani</i>) ²	Zhou et al. 2017b	Field	3.8	4.9	8.3	2.6	59	5.6	7.1	1.0	5.4	2.1	0.8	10
Calamus ²	Zhou et al. 2017b	Field	7.8	2.6	6.4	2.2	75	3.0	1.6	0.03	2.5	0.3	2.1	5.9
Reed ²	Zhou et al. 2017b	Field	4.7	4.3	1.9	5.7	52	2.5	2.1	--	7.7	1.9	3.7	4.0
Geometric Mean			5.2	3.8	4.6	3.1	61	3.5	2.9	0.2	4.7	1.0	1.8	6.2
Minimum			3.8	2.6	1.9	2.2	52	2.5	1.6	0.03	2.5	0.3	0.8	4.0
Maximum			7.8	4.9	8.3	5.7	75	5.6	7.1	1.0	7.7	2.1	3.7	10

1. All biota-sediment accumulation factors (BSAFs) presented on a dry-weight basis. Published BSAFs calculated on a soil organic carbon basis were converted to bulk soil basis by dividing the BAFs by the percent organic carbon, as presented in the applicable studies. Tissue and sediment concentrations or BSAFs presented in individual papers on a wet-weight basis were converted to dry-weight using moisture contents provided in the individual studies, if applicable, or in Table 4-2 of USEPA (1993).

2. Presented BSAF is the arithmetic average of plant parts measured (i.e roots and foliage).

-- - not identified

Reference

USEPA. 1993. Wildlife Exposure Factors Handbook. Volumes I and II. Office of Research and Development. EPA/600/R-93/187. United States Environmental Protection Agency. December.

Appendix E - Bioaccumulation Factors
Table 5. Individual Aquatic Biota-Sediment Accumulation Factors

Individual Aquatic Biota-Sediment Accumulation Factors ¹															
Organism	Source	Study Type ²	PFTeA	PFTriDA	PFDaA	PFUnA	PFDS	PFDA	PFNA	PFOS	PFOA	PFHpA	PFHxS	PFHxA	PFBS
Benthic Invertebrates and Bivalves															
Ragworm	Munoz et al. 2017	Field	16	34	7.5	10	31	35	463	106	281	119	263	--	--
Sydney rock oyster ³	Thompson et al. 2011	Field	--	--	--	--	--	7.1	--	3.2	--	--	--	--	--
Peppery furrow shell ³	Munoz et al. 2017	Field	17	16	8.3	5.2	6.7	3.7	2.1	4.7	1.3	--	8.9	--	--
Geometric Mean			--	--	--	--	--	--	--	--	--	--	--	--	--
Minimum			16	34	8	10	31	35	463	106	281	119	263	--	--
Maximum			16	34	8	10	31	35	463	106	281	119	263	--	--
Crustaceans															
Shore crab	Munoz et al. 2017	Field	22	23	17	12	12	17	65	25	77	50	154	--	--
Geometric Mean			--	--	--	--	--	--	--	--	--	--	--	--	--
Minimum			22	23	17	12	12	17	65	25	77	50	154	--	--
Maximum			22	23	17	12	12	17	65	25	77	50	154	--	--
Fish															
Sole ⁴	Munoz et al. 2017	Field	16	14	11	15	47	47	150	87	22	8.7	93	--	--
Flounder ⁴	Munoz et al. 2017	Field	17	21	21	20	76	30	56	60	13	3.6	80	--	--
Geometric Mean			16	17	15	17	60	38	92	72	17	5.6	86	--	--
Minimum			16	14	11	15	47	30	56	60.0	13	3.6	80	--	--
Maximum			17	21	21	20	76	47	150	87	22	8.7	93	--	--

- Notes:**
1. All biota-sediment accumulation factors (BSAFs) presented on a dry-weight basis. Published BSAFs calculated on a soil organic carbon basis were converted to bulk soil basis by dividing the BSAFs by the percent organic carbon, as presented in the applicable studies. Tissue and sediment concentrations or BSAFs presented in individual papers on a wet-weight basis were converted to dry-weight using moisture contents provided in the individual studies, if applicable, or in Table 4-1 of USEPA (1993).
 2. Only field-measured aquatic BSAFs were recorded, as they provide a better estimate of bioaccumulation from all exposure pathways including food, water, and sediment. Furthermore, field-collected biota are expected to have reached uptake equilibrium with the concentrations in the surrounding environment.
 3. BSAFs for the sydney rock oyster and peppery furrow shell were excluded from the BSAF calculations as they are shelled invertebrates and expected to have reduced exposure to sediments compared to the ragworm.
 4. The sole and flounder concentrations reported in Munoz et al. 2017 were measured as tissue concentrations and converted to whole body concentrations using a conversion factor. The converted whole body concentrations are used in the evaluation.
- - not identified

Reference
 USEPA. 1993. Wildlife Exposure Factors Handbook. Volumes I and II. Office of Research and Development. EPA/600/R-93/187. United States Environmental Protection Agency. December.

Appendix E - Bioaccumulation Factors
Table 6. Individual Amphibian Bioaccumulation Factors

Individual Amphibian Bioaccumulation Factors ¹ (L/kg)															
Organism	Source	Study Type	PFTeA	PFTriDA	PFDoA	PFUnA	PFDA	PFNA	PFOS	PFOA	PFHxS	PFHxA	8:2 Cl-PFESA	6:2 Cl-PFESA	HFPO-TA
Black-Spotted Frog ³	Cui et al. 2018	Field	121,114	204,580	63,329	21,141	2,591	56	3,844	1.3	1,094	6.3	85,494	7,985	--
Black-Spotted Frog ³	Cui et al. 2018	Field	369,600	322,266	144,621	42,805	5,844	95	10,667	1.6	2,349	3.1	131,070	12,687	--
Black-Spotted Frog ³	Cui et al. 2018	Field	46,779	149,255	62,422	52,229	713	23	894	0.2	669	1.3	66,427	5,756	5.1
Geometric Mean			127,936	214,290	82,996	36,156	2,210	49	3,322	0.8	1,198	2.9	90,628	8,355	5.1
Minimum			46,779	149,255	62,422	21,141	713	23	894	0.2	669	1.3	66,427	5,756	5.1
Maximum			369,600	322,266	144,621	52,229	5,844	95	10,667	1.6	2,349	6.3	131,070	12,687	5.1

Notes:

1. All bioaccumulation factors (BAFs) presented on a dry-weight basis. Tissue concentrations or BAFs presented in individual papers on a wet-weight basis were converted to dry-weight using moisture contents provided in the individual studies, if applicable, or in Table 4-1 of USEPA (1993).
 2. Only field-measured aquatic BAFs were recorded, as they provide a better estimate of bioaccumulation from all exposure pathways including food, water, and sediment. Furthermore, field-collected biota are expected to have reached uptake equilibrium with the concentrations in the surrounding environment.
 3. The black-spotted frog concentrations reported in Cui et al. 2018 were measured as tissue concentrations and converted to whole body concentrations in the study. The converted whole body concentrations are used in the
- - not identified

Reference

USEPA. 1993. Wildlife Exposure Factors Handbook. Volumes I and II. Office of Research and Development. EPA/600/R-93/187. United States Environmental Protection Agency. December.

Appendix E - Bioaccumulation Factors
Table 7. Individual Aquatic Bioaccumulation Factors

Individual Aquatic Bioaccumulation Factors ¹ (L/kg)												
Organism	Source	Study Type ²	PFDA	PFNA	PFOS	PFOA	PFHpA	PFHxS	PFHxA	PFPeA	PFBS	PFBA
Aquatic Plants												
Ceratophyllum demersum	Zhou et al. 2012	Field	56,234	4,467	8,128	407	--	--	3,236	--	--	--
Salvinia natans	Zhou et al. 2012	Field	69,183	6,026	9,550	603	--	--	219	--	--	--
Common duckweed	Zhou et al. 2013	Field	485	--	485	48	--	39	48	--	25	19
Lotus root	Zhou et al. 2013	Field	--	--	--	--	--	--	--	--	1.2	12
Common water hyacinth	Zhou et al. 2013	Field	--	--	77	--	--	3.9	38	--	15	31
Geometric Mean			12,360	5,188	1,305	228	--	12	191	--	8	19
Minimum			485	4,467	77	48	--	4	38	--	1	12
Maximum			69,183	6,026	9,550	603	--	39	3,236	--	25	31
Benthic Invertebrates, Bivalves, Gastropods, and Mollusks												
Sydney rock oyster	Thompson et al. 2011	Field	1,528	--	476	--	--	--	--	--	--	--
Bivalve	Naile et al. 2013	Field	90	39	431	248	272	2,263	--	--	68	--
Bivalve	Hong et al. 2015	Field	441	5,556	1,757	699	351	1,108	1,395	--	176	--
Zebra Mussel	Kannan et al. 2005	Field	--	--	4,921	--	--	--	--	--	--	--
Oyster (C. gigas)	Munoz et al. 2017	Field	494	267	678	111	--	56	--	--	--	--
Gastropod	Naile et al. 2013	Field	180	232	1,188	278	359	10,586	--	--	596	--
Gastropod	Hong et al. 2015	Field	880	6,994	2,784	1,757	441	2,784	880	--	1,108	--
River snail	Zhou et al. 2012	Field	18,621	9,550	8,318	316	--	--	9,120	--	--	--
Geometric Mean			707	983	1,549	379	351	1,327	2,238	--	298	--
Minimum			90	39	431	111	272	56	880	--	68	--
Maximum			18,621	9,550	8,318	1,757	441	10,586	9,120	--	1,108	--
Crustaceans												
Crab (whole body)	Naile et al. 2013	Field	367	197	989	113	97	2,213	--	--	422	--
Oriental river prawn	Wang et al. 2013a	Field	13,636	3,909	2,045	386	--	--	--	--	--	--
Crab	Zhou et al. 2012	Field	29,512	1,698	9,772	209	--	--	4,074	--	--	--
Shrimp	Zhou et al. 2012	Field	30,903	9,120	15,849	363	--	--	2,042	--	--	--
Crab	Hong et al. 2015	Field	385	3,846	1,216	1,531	122	484	153	--	767	--
Shrimp	Hong et al. 2015	Field	1,810	2,868	3,611	287	287	907	287	--	181	--
Amphipods	Kannan et al. 2005	Field	--	--	3,314	--	--	--	--	--	--	--
Crayfish	Kannan et al. 2005	Field	--	--	4,725	--	--	--	--	--	--	--
Crayfish	Kannan et al. 2005	Field	--	--	3,550	--	--	--	--	--	--	--
Copepods (Copepoda, ind.)	Munoz et al. 2017	Field	5,773	2,032	6,273	1,627	--	986	--	--	--	--
Mysids (Mysidacea, ind.)	Munoz et al. 2017	Field	10,182	2,777	16,182	491	--	2,095	--	--	--	--
Gammarids (Gammarus spp.)	Munoz et al. 2017	Field	12,800	8,320	9,520	5,000	--	1,744	--	--	--	--
White shrimp (P. longirostris)	Munoz et al. 2017	Field	12,955	6,273	12,741	1,714	--	2,036	--	--	--	--
Brown shrimp (Crangon crangon)	Munoz et al. 2017	Field	33,500	25,727	32,318	2,082	--	3,168	--	--	--	--
Geometric Mean			6,602	3,511	5,608	703	150	1,477	777	--	388	--
Minimum			367	197	989	113	97	484	153	--	181	--
Maximum			33,500	25,727	32,318	5,000	287	3,168	4,074	--	767	--

Appendix E - Bioaccumulation Factors
Table 7. Individual Aquatic Bioaccumulation Factors

Individual Aquatic Bioaccumulation Factors ¹ (L/kg)												
Organism	Source	Study Type ²	PFDA	PFNA	PFOS	PFOA	PFHpA	PFHxS	PFHxA	PFPeA	PFBS	PFBA
Fish												
Lake trout - Lake Superior	Furdui et al. 2007	Field	31,773	20,047	79,810	7,981	--	1,265	--	--	--	--
Lake trout - Lake Huron	Furdui et al. 2007	Field	20,047	15,924	63,396	15,924	--	7,981	--	--	--	--
Lake trout - Lake Erie	Furdui et al. 2007	Field	79,810	25,238	100,475	3,177	--	252	--	--	--	--
Lake trout - Lake Ontario	Furdui et al. 2007	Field	20,047	5,036	31,773	1,592	--	4,000	--	--	--	--
Lake trout - Lake Michigan	Furdui et al. 2007	Field	--	--	25,238	10,048	--	--	--	--	--	--
Fish (whole body)	Naile et al. 2013	Field	1,005	47	10,766	45	200	1,521	--	--	277	--
Silver carp	Wang et al. 2013a	Field	7,200	13,600	15,200	480	--	--	--	--	--	--
Common carp	Wang et al. 2013a	Field	640	560	720	--	--	--	--	--	--	--
Northern snakehead	Wang et al. 2013a	Field	38,400	8,000	12,000	168	--	--	--	--	--	--
Tire track eel	Wang et al. 2013a	Field	3,280	3,720	4,400	236	--	--	--	--	--	--
Loach	Zhou et al. 2012	Field	7,586	6,310	1,698	589	--	--	398	--	--	--
Fish	Hong et al. 2015	Field	798	1,592	3,177	318	318	798	252	--	400	--
Fish (C. carpio, B. graellsii, M. salmoides)	Campo et al. 2015	Field	80,650	--	126,302	3,217	--	--	--	24,273	6,943	3,200
Round Goby	Kannan et al. 2005	Field	--	--	9,524	--	--	--	--	--	--	--
Round Goby	Kannan et al. 2005	Field	--	--	18,865	--	--	--	--	--	--	--
Crucian carp	Wang et al. 2013a	Field	1,800	1,520	960	84	--	--	--	--	--	--
Goby (Pomatoschistus spp.)	Munoz et al. 2017	Field	11,360	2,540	9,600	--	--	--	--	--	--	--
Anchovy (E. encrasicolus)	Munoz et al. 2017	Field	5,440	1,820	16,200	612	--	844	--	--	--	--
Sprat (Sprattus sprattus)	Munoz et al. 2017	Field	5,960	2,580	7,440	--	--	1,260	--	--	--	--
Mullet (L. ramada)	Munoz et al. 2017	Field	22,800	2,600	11,280	--	--	--	--	--	--	--
Meagre (A. regius)	Munoz et al. 2017	Field	10,880	3,280	22,960	--	--	992	--	--	--	--
Common seabass (D. labrax)	Munoz et al. 2017	Field	22,840	4,320	29,960	712	--	844	--	--	--	--
Spotted seabass (D. punctatus)	Munoz et al. 2017	Field	10,040	3,144	23,320	1,372	--	1,088	--	--	--	--
Geometric Mean			8,953	3,344	13,229	894	252	1,253	317	24,273	916	3,200
Minimum			640	47	720	45	200	252	252	24,273	276.8	3,200.0
Maximum			80,650	25,238	126,302	15,924	318	7,981	398	24,273	6,943	3,200

1. All bioaccumulation factors (BAFs) presented on a dry-weight basis. Tissue and sediment concentrations or BSAFs presented in individual papers on a wet-weight basis were converted to dry-weight using moisture contents provided in the individual studies, if applicable, or in Table 4-1 of USEPA (1993). Published BSAFs calculated on a soil organic carbon basis were converted to bulk soil basis by dividing the BAFs by the percent organic carbon, as presented in the applicable studies.

2. Only field-measured aquatic BAFs were recorded, as they provide a better estimate of bioaccumulation from all exposure pathways including food, water, and sediment. Furthermore, field-collected biota are expected to have reached uptake equilibrium with the concentrations in the surrounding environment.

-- not identified

Reference

USEPA. 1993. Wildlife Exposure Factors Handbook. Volumes I and II. Office of Research and Development. EPA/600/R-93/187. United States Environmental Protection Agency. December.

Appendix E - Bioaccumulation Factors
Table 8. PFOS Whole Body Concentration Calculations

Organ/Tissue	PFOS Concentration (ng/g)			Estimated Tissue/Organ Mass ¹			Calculated PFOS Mass (ng) ²		
	1 day	3 days	5 days	grams	Notes	Source	1 day	3 days	5 days
Low Dose Scenario									
Blood	30.5	64.5	49.5	1.68	from text	Bogdanska et al. 2011	51.3	108.4	83.2
Liver	57.0	171.5	289.1	0.92	Liver weight of 7 week old male C57BL/6 mice	Taconic Biosciences	52.7	158.5	267.1
Lung	19.5	44.0	70.5	0.17	Lung weight of 7 week old male C57BL/6 mice	Taconic Biosciences	3.3	7.4	11.9
Kidney	19.0	32.5	46.5	0.11	Average L and R kidney weight of 7 week old male C57BL/6 mice	Taconic Biosciences	2.1	3.6	5.2
Skin	8.5	18.0	24.5	3.47	from text	Bogdanska et al. 2011	29.5	62.4	84.9
Whole Bone	56.5	49.0	54.5	2.25	from text	Bogdanska et al. 2011	127.0	110.1	122.5
Pancreas	11.5	23.0	32.5	0.13	Midpoint of range for pancreas percent body weight in mice	Brown et al. 1997	1.4	2.9	4.1
Large intestines	24.5	18.5	31.0	0.23	Mean percent body weight in mice from Table 4	Brown et al. 1997	5.6	4.2	7.1
Stomach	18.0	18.0	29.5	0.21	Stomach weight of 7 week old male C57BL/6 mice	Taconic Biosciences	3.8	3.8	6.2
Spleen	5.5	10.5	23.0	0.07	Mean percent body weight in mice from Table 4	Brown et al. 1997	0.4	0.8	1.7
Small intestines	16.0	24.5	39.5	0.53	Mean percent body weight in mice from Table 4	Brown et al. 1997	8.5	13.0	21.0
Thymus	10.5	13.0	20.0	0.03	Percent body weight in male mice from Table 8	Brown et al. 1997	0.3	0.3	0.5
Heart	6.0	10.0	14.0	0.11	Heart weight of 7 week old male C57BL/6 mice	Taconic Biosciences	0.6	1.1	1.5
Testis	6.0	10.5	15.5	0.06	Average L and R testes weight of 7 week old male C57BL/6 mice	Taconic Biosciences	0.3	0.6	0.9
Epididymal fat	2.5	5.0	5.5	NA	Not available	NA	NA	NA	NA
Fat pads	5.0	6.0	6.5	NA	Not available	NA	NA	NA	NA
Fat ³	7.5	11.0	12.0	1.61	Geometric mean percent body weight of fat in C57BL/6 mice from Table 10	Brown et al. 1997	12.1	17.7	19.3
Brain	4.5	6.0	8.5	0.33	Average percent body weight of brain in mice from Table 4 and male mice from Table 8	Brown et al. 1997	1.5	2.0	2.8
Muscle	4.0	6.0	11.0	8.06	from text	Bogdanska et al. 2011	32.3	48.4	88.7
Thyroid Gland ⁴	NM	NM	NM	0.0021	Surrogate value: percent body weight in guinea pig and rabbit from Tables 33 and 34	Brown et al. 1997	NA	NA	NA
Other-remaining ⁵	11.5	18.0	25.7	1.04	Calculated; total body weight minus sum of evaluated tissue/organ masses	NA	11.9	18.8	26.8
Total PFOS Mass (g):							344.5	564.0	755.4
Whole Body Concentration (ng/g) ⁶ :							16.4	26.9	36.0

Appendix E - Bioaccumulation Factors
Table 8. PFOS Whole Body Concentration Calculations

Organ/Tissue	PFOS Concentration (ng/g)			Estimated Tissue/Organ Mass ¹			Calculated PFOS Mass (ng) ²		
High Dose Scenario	1 day	3 days	5 days	grams	Notes	Source	1 day	3 days	5 days
Blood	33.5	85.5	143.5	1.68	from text	Bogdanska et al. 2011	56.3	143.7	241.1
Liver	123.0	349.1	522.1	0.92	Liver weight of 7 week old male C57BL/6 mice	Taconic Biosciences	113.7	322.6	482.4
Lung	67.5	168.0	222.6	0.17	Lung weight of 7 week old male C57BL/6 mice	Taconic Biosciences	11.4	28.4	37.6
Kidney	31.0	83.0	116.5	0.11	Average L and R kidney weight of 7 week old male C57BL/6 mice	Taconic Biosciences	3.5	9.3	13.1
Skin	27.0	70.5	111.0	3.47	from text	Bogdanska et al. 2011	93.6	244.3	384.7
Whole Bone	27.5	77.5	103.5	2.25	from text	Bogdanska et al. 2011	61.8	174.2	232.6
Pancreas	24.0	64.5	77.5	0.13	Midpoint of range for pancreas percent body weight in mice	Brown et al. 1997	3.0	8.1	9.8
Large intestines	17.5	41.0	62.5	0.23	Mean percent body weight in mice from Table 4	Brown et al. 1997	4.0	9.4	14.3
Stomach	17.5	40.5	61.5	0.21	Stomach weight of 7 week old male C57BL/6 mice	Taconic Biosciences	3.7	8.5	12.9
Spleen	14.5	51.0	56.5	0.07	Mean percent body weight in mice from Table 4	Brown et al. 1997	1.1	3.7	4.2
Small intestines	17.0	40.0	55.0	0.53	Mean percent body weight in mice from Table 4	Brown et al. 1997	9.0	21.3	29.2
Thymus	11.5	31.5	52.0	0.03	Percent body weight in male mice from Table 8	Brown et al. 1997	0.3	0.8	1.3
Heart	11.0	32.5	47.0	0.11	Heart weight of 7 week old male C57BL/6 mice	Taconic Biosciences	1.2	3.5	5.1
Testis	8.0	25.5	43.0	0.06	Average L and R testes weight of 7 week old male C57BL/6 mice	Taconic Biosciences	0.5	1.4	2.4
Epididymal fat	6.0	15.0	26.5	NA	Not available	NA	NA	NA	NA
Fat pads	6.0	22.0	24.5	NA	Not available	NA	NA	NA	NA
Fat ³	12.0	37.0	51.0	1.61	Geometric mean percent body weight of fat in C57BL/6 mice from Table 10	Brown et al. 1997	19.3	59.5	82.1
Brain	4.5	14.5	22.0	0.33	Average percent body weight of brain in mice from Table 4 and male mice from Table 8	Brown et al. 1997	1.5	4.8	7.3
Muscle	4.5	14.0	18.5	8.06	from text	Bogdanska et al. 2011	36.3	112.9	149.2
Thyroid Gland	15.5	40.5	67.0	0.0021	Surrogate value: percent body weight in guinea pig and rabbit from Tables 33 and 34	Brown et al. 1997	0.03	0.09	0.14
Other-remaining ⁵	16.5	45.8	66.1	1.04	Calculated; total body weight minus sum of evaluated tissue/organ masses	NA	17.1	47.6	68.8
Total PFOS Mass (g):							437.2	1204.1	1778.2
Whole Body Concentration (ng/g)⁶:							20.8	57.3	84.7

Appendix E - Bioaccumulation Factors
Table 8. PFOS Whole Body Concentration Calculations

Abbreviations:

g - gram
NA - not available
ng - nanogram
NM - not measured

Notes:

1. Mice used in the study were male C57BL/6 mice, approximately 6-8 weeks old. As such, organ/tissue masses calculated based on reported percentages of body weight are based on an assumed total body weight of 21 grams.
2. PFOS mass was calculated by multiplying organ/tissue concentrations by the associated organ/tissue weight in grams.
3. No estimates of mass or mass fractions for epididymal fat or fat pads were identified in the literature. Therefore, the PFOS concentrations in fat are equal to the sum of the concentration in epididymal fat and fat pads. PFOS mass in fat was calculated by multiplying the summed concentration of PFOS in epididymal fat and fat pads by the estimated total fat mass.
4. PFOS concentrations in the thyroid gland were not measured in the low dose scenario.
5. In order to account for PFOS in tissues not measured by Bogdanska et al., the geometric mean concentration of all measured organs/tissues was used as a surrogate concentration for the remaining tissues in calculating the whole body concentration. The estimated mass of the other-remaining tissues is equal to the total body weight (21 grams) minus the mass of the tissues measured in the study.
6. Whole body concentration calculated by dividing total PFOS mass by the assumed mouse body weight (21 grams).

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Appendix E - Bioaccumulation Factors
Table 9. Small Mammal Organ to Whole Body BAF Conversions

Organ/Tissue	Measured PFOS Concentration (ng/g) ¹			Ratio of Tissue to Whole Body Concentration ²		
Low Dose Scenario	1 day	3 days	5 days	1 day	3 days	5 days
Liver	57.0	171.5	289.1	3.5	6.4	8.0
Kidney	19.0	32.5	46.5	1.2	1.2	1.3
Muscle	4.0	6.0	11.0	0.2	0.2	0.3
Whole Body Concentration (ng/g)³:	16.4	26.9	36.0	--	--	--
High Dose Scenario	1 day	3 days	5 days	1 day	3 days	5 days
Liver	123.0	349.1	522.1	5.9	6.1	6.2
Kidney	31.0	83.0	116.5	1.5	1.4	1.4
Muscle	4.5	14.0	18.5	0.2	0.2	0.2
Whole Body Concentration (ng/g)³:	20.8	57.3	84.7	--	--	--
					Average Tissue:Whole Body Ratio ⁴ :	
					Liver	6.0
					Kidney	1.3
					Muscle	0.2
Tissue to Whole Body PFOS BAF Conversions						
Species	Tissue	Tissue BAF	Wet/Dry ⁵	Source	Whole Body BAF ⁶	
Wood Mouse	Liver	211.4	Ct,dw/Cs,dw	D'Hollander et al. 2014	35.2	
Wood Mouse	Kidney	32.2	Ct,dw/Cs,dw	D'Hollander et al. 2014	24.2	
Bank Vole	Liver	141.6	Ct,dw/Cs,dw	D'Hollander et al. 2014	23.6	
Rabbit	Muscle	0.53	Ct,dw/Cs,dw	AECOM (2014)	2.17	

Notes:

1. From Bogdanska et al. 2011.
2. Measured PFOS concentration in the tissue divided by the calculated whole body concentration.
3. Whole body concentration calculated in Appendix E Table 8 by dividing total PFOS mass by the mouse body weight (21 grams).
4. Average of organ/tissue:whole body ratios for low and high dose scenarios at 1, 3, and 5 days.
5. Mouse and vole BAFs were converted to dry weight using mammal moisture contents from USEPA (1993) and an assumed 20% moisture content per USEPA SLERA Appendix C (1999); rabbit tissue BAFs were converted to dry weight using the geometric mean moisture contents of rabbit meat from the fore legs, thoracic cage, abdominal walls, spine, and hind leg meat from Pla, Pascual, & Ariño (2010).
6. Whole body BAF is calculated by dividing the Tissue BAF by the average tissue:whole body ratio.

BAF - bioaccumulation factor

Cs - concentration in soil

Ct - concentration in tissue

dw - dry weight

ng/g - nanogram per gram

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Appendix F

Wildlife Risk-Based Screening Level Calculations

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 1. Exposure Parameters

Media Exposed	Soil/Surface Water		Soil/Surface Water		Soil/Sediment/Surface Water		Soil/Surface Water	
Receptor	Meadow Vole		Short-Tailed Shrew		Little Brown Bat		Long-tailed Weasel	
Exposure Parameters								
Body Weight (g) ¹	36.9	Measured body weight for meadow vole; Nagy (2001)	16.8	Mean of available adult male/female body weights EFH (1993)	9	Measured body weight from Table 1 of Nagy (2001)	206	Mean of available adult male/female body weights from CHPPM (2004)
Body Weight (kg) ¹	0.0369	Measured body weight for meadow vole; Nagy (2001)	0.017	Mean of available adult male/female body weights EFH (1993)	0.009	Measured body weight from Table 1 of Nagy (2001)	0.206	Mean of available adult male/female body weights from CHPPM (2004)
Drinking Water Rate (L/day) ²	0.0051	WIR = 0.099*(BW) ^{0.90} ; Calder and Braun (1983)	0.0025	WIR = 0.099*(BW) ^{0.90} ; Calder and Braun (1983)	0.001	WIR = 0.099*(BW) ^{0.90} ; Calder and Braun (1983)	0.024	WIR = 0.099*(BW) ^{0.90} ; Calder and Braun (1983)
Food Ingestion Rate (g/day, dw) ³	11.5	Nagy 2001 (measured value) from Table 1	2.16	FIR (g/day, dw) = 0.373*BW ^{0.622} (insectivores equation from Nagy 2001)	1.6	Measured FIR from Table 1 of Nagy (2001)	10.2	FIR (g/day, dw) = 0.102*BW ^{0.864} (Carnivora equation from Nagy 2001)
Food Ingestion Rate (kg/day, dw) ³	0.012		0.002		0.0016		0.010	
Fraction Soil Ingested (unitless) ⁴	0.024	Beyer et al. 1994	0.024	Beyer et al. 1994 (meadow vole surrogate)	0	Assumed negligible based on feeding strategy (Sample et al. 1997)	0.028	Beyer et al. 1994 (red fox surrogate; CHPPM 2004)
Site Area								
Site Use Factor (unitless)	1	Conservative assumption	1	Conservative assumption	1	Conservative assumption	1	Conservative assumption
Home Range (acres)	0.07	Ranges in Virginia, Montana, and Massachusetts (Madison 1980; Douglass 1976; Ostfeld et al. 1988); cited in EFH 1993	0.96	Range in Manitoba tamarack bog and includes both juveniles and adults (Buckner 1966); cited in EFH 1993	74	Home-range size of pregnant Myotis lucifugus on Grosse-Ile, Quebec, Canada, summers of 1999 and 2000 (Henry et al. 2002).	26	Ranges from 5 to 16 ha in Iowa (Polderboer et al. 1941); cited in CHPPM (2004)
Dietary Composition (fraction of diet) ⁵								
Plant Tissue	0.98	Average of two habitats as described by Lindroth and Bratzli (1984); cited in EFH 1993	0.13	Whitaker and Ferraro (1963); cited in EFH 1993	0	Fenton and Barclay 1980; cited in Sample et al. 1997	0	Quick (1951) cited in CHPPM (2004)
Invertebrate Tissue	0.02		0.83		0		0.02	
Aerial Insect Tissue	0		0.04		1		0.06	
Crustacean Tissue	0		0		0		0	
Fish Tissue	0		0		0		0	
Mammal/Bird	0		0		0		0.92	
Amphibian tissue	0		0		0		0	
Reptile tissue	0		0		0		0	
Other (food)	0		0		0		0	

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 1. Exposure Parameters

Sediment/Surface Water		Sediment/Surface Water		Sediment/Surface Water		Sediment/Surface Water	
Muskrat		River Otter		Harbor Seal		Mink	
873	Mean of available adult male/female body weights EFH (1993)	7990	Mean of available adult male/female body weights EFH (1993)	98910	Mean of available adult male/female body weights EFH (1993)	1019.5	Mean of available adult male/female body weights EFH (1993)
0.873	Mean of available adult male/female body weights EFH (1993)	7.99	Mean of available adult male/female body weights EFH (1993)	98.910	Mean of available adult male/female body weights EFH (1993)	1.020	Mean of available adult male/female body weights EFH (1993)
0.088	WIR = 0.099*(BW)^0.90; Calder and Braun (1983)	0.643	WIR = 0.099*(BW)^0.90; Calder and Braun (1983)	6.185	WIR = 0.099*(BW)^0.90; Calder and Braun (1983)	0.101	WIR = 0.099*(BW)^0.90; Calder and Braun (1983)
62.7	FIR (g/day, dw) = 0.332*BW^0.774 (Rodentia equation from Nagy 2001)	240.1	FIR (g/day, dw) = 0.102*BW^0.864 (Carnivora equation from Nagy 2001)	2807	Measured value for common seal; Nagy (2001)	40.5	FIR (g/day, dw) = 0.102*BW^0.864 (Carnivora equation from Nagy 2001)
0.063		0.240		2.807		0.041	
0.094	Beyer et al. 1994 (raccoon surrogate; CHPPM 2004)	0	Assumed negligible (CHPPM 2004)	0.02	Minimum reported for 15 mammals in Beyer et al. (1994); mink surrogate	0.02	Minimum reported for 15 mammals in Beyer et al. (1994); CHPPM 2004
1	Conservative assumption	1	Conservative assumption	1	Conservative assumption	1	Conservative assumption
0.270	Ranges from 0.048 to 0.17 ha in Ontario (Proulx and Gilbert 1983); cited in EFH 1993	859	Ranges from 295 to 400 ha in Texas (Foy et al. 1984); cited in EFH 1993	698671	Foraging radius of 5 km (California/Bay; Stewart et al., 1989) to 30 to 55 km (Washington/Columbia River; Beach et al., 1985); cited in EFH 1993	710	Ranges from 7.8 ha (Montana/riverine; Mitchell, 1961) to 770 ha (Manitoba, Canada/prairie potholes; Arnold and Fritzell 1987); cited in EFH 1993
1	Martin et al. (1951); cited in EFH 1993	0	Estimated from Melquist & Hornocker (1983) Idaho/mountain lakes and streams, average across 4 seasons; cited in EFH 1993	0	Washington/coastal island (Everitt et al., 1981), Kodiak Island and Alaska/coastal marine (Pitcher & Calkins, 1979), Gulf of Alaska/coastal marine (Pitcher, 1980); cited in EFH 1993	0.010	Alexander (1977) river year round; cited in EFH 1993
0		0.070		0.14		0	
0		0.000		0		0	
0		0.000		0.01		0.04	
0		0.88		0.85		0.860	
0		0.050		0		0.060	
0		0		0		0.03	
0		0		0		0	
0		0		0		0	

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 1. Exposure Parameters

Soil/Surface Water		Soil/Surface Water		Soil/Surface Water	
American Goldfinch		House Wren		Red-Tailed Hawk	
13.12	Appendix 1, average of adult values (Carey et al. 1978)	10.6	Measured body weight from Table 1 of Nagy (2001)	1134	Mean of available adult male/female body weights EFH (1993)
0.013	Appendix 1, average of adult values (Carey et al. 1978)	0.0106	Measured body weight from Table 1 of Nagy (2001)	1.13	Mean of available adult male/female body weights EFH (1993)
0.0032	WIR = $0.059 \cdot (BW)^{0.67}$; Calder and Braun (1983)	0.003	WIR = $0.059 \cdot (BW)^{0.67}$; Calder and Braun (1983)	0.064	WIR = $0.059 \cdot (BW)^{0.67}$; Calder and Braun (1983)
3.65	FIR (g/day, dw) = $0.630 \cdot BW^{0.683}$ (Passerine equation from Nagy 2001)	3.38	Measured value for house wren; Nagy (2001)	90.0	FIR (g/day, dw) = $0.849 \cdot BW^{0.663}$ (carnivorous birds equation from Nagy 2001)
0.0037		0.00338		0.090	
0.093	Beyer et al. 1994 (Wild turkey surrogate)	0.104	Beyer et al. 1994 (American woodcock surrogate)	0	Assumed negligible; CHPPM 2004
1	Conservative assumption	1	Conservative assumption	1	Conservative assumption
12421	McGraw, K. J. and A. L. Middleton (2017)	2.298	Estimated territory size at a site in w. Oregon is 0.93 ha (range 0.45–1.78 ha); Kroodsma (1973) cited in Johnson (2014)	1660	Average territory size from EFH (USEPA 1993)
1	McGraw, K. J. and A. L. Middleton (2017)	0	Johnson (2014)	0	Janes (1984); cited in EFH (1993)
0		0.85		0	
0		0.15		0	
0		0		0	
0		0		0	
0		0		0.870	
0		0		0	
0		0		0.130	
0		0		0	

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 1. Exposure Parameters

Sediment/Surface Water		Sediment/Surface Water		Sediment/Surface Water	
Red-Winged Blackbird		Tree Swallow		Brown Pelican	
57.15	Holcomb and Twiest, 1968; cited in CHPPM 2004	20.2	Measured value for tree swallow; Nagy (2001)	3400	Adult body weight from Schreiber (1976); cited in CalEPA ECOTOX
0.057	Holcomb and Twiest, 1968; cited in CHPPM 2004	0.0202	Measured value for tree swallow; Nagy (2001)	3.40	Adult body weight from Schreiber (1976); cited in CalEPA ECOTOX
0.009	WIR = 0.059*(BW)^0.67; Calder and Braun (1983)	0.004	WIR = 0.059*(BW)^0.67; Calder and Braun (1983)	0.134	WIR = 0.059*(BW)^0.67; Calder and Braun (1983)
9.99	FIR (g/day, dw) = 0.630*BW^0.683 (Passerine equation from Nagy 2001)	11.6	Measured value for tree swallow; Nagy (2001)	269	FIR (g/day, dw) = 0.279*BW^0.845 (Pelecaniformes equation from Nagy 2001)
0.0100		0.0116		0.269	
0.093	Beyer et al. 1994 (Wild turkey surrogate; CHPPM 2004)	0	Assumed negligible based on feeding strategy	0.02	Assumed minimal incidental sediment ingestion based on feeding strategy (capture fish near surface); blue-winged teal and ring-necked duck used as surrogate (Beyer et al. 1994)
1	Conservative assumption	1	Conservative assumption	1	Conservative assumption
152155	White et al. 1985; cited in CHPPM 2004	9513	Average of male/female during incubation. Robertson et al., (1992); CHPPM 2004	310611	Forages mainly within 20 km of nesting islands (Briggs et al. 1981; cited in Shields 2014)
0.92	Williams and Jackson (1981); cited in CHPPM 2004	0.17	Beal (1918); CHPPM 2004	0	Shields (2014)
0.08		0.26		0	
0.0		0.57		0	
0		0		0	
0		0		1	
0		0		0	
0		0		0	
0		0		0	
0		0.00		0	

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 1. Exposure Parameters

Notes:

1. Body weights are the average of available male and female adult values in United States Environmental Protection Agency (USEPA) (1993) unless otherwise indicated.
2. Drinking water rate was calculated based on equations provided by USEPA (1993):
Avian Water Intake (liter/day) = $0.059 * \text{Body Weight}^{0.67}$ (kg)
Mammal Water Intake (liter/day) = $0.099 * \text{Body Weight}^{0.90}$ (kg)
3. Food ingestion rates were derived from Nagy (2001), using the species-specific rates given by Nagy (2001) in Table 1, if available, or calculated using dry matter intake equations provided by Nagy (2001) in Table 2 (mammals) or Table 3 (birds). All references to tables in this row refer to tables in the Nagy (2001) paper.
4. Soil/sediment incidental ingestion rates provided by Beyer et al. (1994) unless otherwise noted. Surrogate species selected if no value was available for receptor.
5. Dietary fractions were assumed to 100% aquatic for the aquatic receptors or 100% terrestrial for the terrestrial receptors.

BW - body weight
dw - dry weight
FIR - food ingestion rate
g - gram
ha - hectare
kg - kilogram
km - kilometer
L - liter
DWR - drinking water rate

References:

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Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 2. Bioaccumulation Factor Summary

Media	Soil		Soil		
Constituent	Terrestrial Plant - BAF (unitless)	Source	Terrestrial Invertebrate - BAF (unitless)	Source	Aerial Insect - BAF (unitless)
PFNA	1.1	Geometric mean, Appendix E	4.6	Geometric mean, Appendix E	4.6
PFOS	0.66	Geometric mean, Appendix E	19	Geometric mean, Appendix E	18.6
PFOA	0.11	Geometric mean, Appendix E	2.0	Geometric mean, Appendix E	2.0
PFHxA	2.2	Geometric mean, Appendix E	1.9	Geometric mean, Appendix E	1.9
PFBS	3.6	Geometric mean, Appendix E	31	Geometric mean, Appendix E	30.9
PFBA	8.0	Geometric mean, Appendix E	7.1	Geometric mean, Appendix E	7.1

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 2. Bioaccumulation Factor Summary

Media	Soil	Soil		Soil	
Constituent	Source	Mammal ¹ - BAF (unitless)	Source	Reptile - BAF (unitless)	Source
PFNA	Terrestrial Invertebrate BAF	11	PFOS BAF	11	PFOS mammal BAF
PFOS	Terrestrial Invertebrate BAF	11	Geometric mean, Appendix E	11	PFOS mammal BAF
PFOA	Terrestrial Invertebrate BAF	11	PFOS BAF	11	PFOS mammal BAF
PFHxA	Terrestrial Invertebrate BAF	11	PFOS BAF	11	PFOS mammal BAF
PFBS	Terrestrial Invertebrate BAF	11	PFOS BAF	11	PFOS mammal BAF
PFBA	Terrestrial Invertebrate BAF	11	PFOS BAF	11	PFOS mammal BAF

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 2. Bioaccumulation Factor Summary

Media	Sediment		Sediment		
Constituent	Aquatic Plant - BSAF (unitless)	Source	Aquatic Invertebrate - BSAF (unitless)	Source	Aerial Insect - BSAF (unitless)
PFNA	3.1	Geometric mean, Appendix E	463	Geometric mean, Appendix E	463
PFOS	61	Geometric mean, Appendix E	106	Geometric mean, Appendix E	106
PFOA	3.5	Geometric mean, Appendix E	281	Geometric mean, Appendix E	281
PFHxA	4.7	Geometric mean, Appendix E	263	PFHxS BAF	263
PFBS	1.8	Geometric mean, Appendix E	263	PFHxS BAF	263
PFBA	6.2	Geometric mean, Appendix E	263	PFHxS BAF	263

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 2. Bioaccumulation Factor Summary

Media	Sediment	Sediment		
Constituent	Source	Aquatic Crustacean - BSAF (unitless)	Source	Fish - BSAF (unitless)
PFNA	Aquatic Invertebrate BSAF	65	Geometric mean, Appendix E	92
PFOS	Aquatic Invertebrate BSAF	25	Geometric mean, Appendix E	72
PFOA	Aquatic Invertebrate BSAF	77	Geometric mean, Appendix E	17
PFHxA	Aquatic Invertebrate BSAF	154	PFHxS BSAF	86
PFBS	Aquatic Invertebrate BSAF	154	PFHxS BSAF	86
PFBA	Aquatic Invertebrate BSAF	154	PFHxS BSAF	86

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 2. Bioaccumulation Factor Summary

Media	Sediment	Sediment	
Constituent	Source	Amphibian - BSAF (unitless)	Source
PFNA	Geometric mean, Appendix E	92	Fish BSAF
PFOS	Geometric mean, Appendix E	72	Fish BSAF
PFOA	Geometric mean, Appendix E	17	Fish BSAF
PFHxA	PFHxS BSAF	86	Fish BSAF
PFBS	PFHxS BSAF	86	Fish BSAF
PFBA	PFHxS BSAF	86	Fish BSAF

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 2. Bioaccumulation Factor Summary

Media	Surface Water		Surface Water		
Constituent	Aquatic Plant - BAF (L/kg)	Source	Aquatic Invertebrate - BAF (L/kg)	Source	Aerial Insect - BAF (L/kg)
PFNA	5188	Geometric mean, Appendix E	983	Geometric mean, Appendix E	983
PFOS	1305	Geometric mean, Appendix E	1549	Geometric mean, Appendix E	1549
PFOA	228	Geometric mean, Appendix E	379	Geometric mean, Appendix E	379
PFHxA	191	Geometric mean, Appendix E	2238	Geometric mean, Appendix E	2238
PFBS	8	Geometric mean, Appendix E	298	Geometric mean, Appendix E	298
PFBA	19	Geometric mean, Appendix E	298	PFBS BAF	298

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 2. Bioaccumulation Factor Summary

Media	Surface Water	Surface Water		Surface Water	
Constituent	Source	Aquatic Crustacean - BAF (L/kg)	Source	Fish - BAF (L/kg)	Source
PFNA	Aquatic Invertebrate BAF	3511	Geometric mean, Appendix E	3344	Geometric mean, Appendix E
PFOS	Aquatic Invertebrate BAF	5608	Geometric mean, Appendix E	13229	Geometric mean, Appendix E
PFOA	Aquatic Invertebrate BAF	703	Geometric mean, Appendix E	894	Geometric mean, Appendix E
PFHxA	Aquatic Invertebrate BAF	777	Geometric mean, Appendix E	317	Geometric mean, Appendix E
PFBS	Aquatic Invertebrate BAF	388	Geometric mean, Appendix E	916	Geometric mean, Appendix E
PFBA	Aquatic Invertebrate BAF	388	PFBS BAF	3200	Geometric mean, Appendix E

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 2. Bioaccumulation Factor Summary

Media	Surface Water	
Constituent	Amphibian - BAF (L/kg)	Source
PFNA	49	Geometric mean, Appendix E
PFOS	3322	Geometric mean, Appendix E
PFOA	0.8	Geometric mean, Appendix E
PFHxA	2.9	Geometric mean, Appendix E
PFBS	1198	PFHxS BAF
PFBA	2.9	PFHxA BAF

Appendix F - Wildlife Risk-Based Screening Level Calculations

Table 2. Bioaccumulation Factor Summary

Notes:

1. The mammal and bird dietary fractions are combined in the Risk-Based Screening Level tables. This combined fraction uses the soil to small mammal bioaccumulation factor (BAF) to model dietary concentrations as no applicable bird BAF was identified. Similarly, the soil to small mammal BAF was used as to model concentrations in aquatic mammal or bird dietary fractions exposed to sediment. In the future if bird BAFs or biota to sediment accumulation factors (BSAFs) become available, the terrestrial bird dietary fraction or aquatic bird and mammal BSAFs may be split out and modeled separately.
2. BAFs or BSAFs are based primarily on field studies to incorporate exposure from the dietary fraction as well as direct contact exposure. Due to the limited availability of field-derived BAFs for terrestrial invertebrates and terrestrial plants, lab-derived BAFs were included in the evaluation for those groups. Similarly, lab-derived BSAFs for aquatic invertebrates were included. Additional information on studies cited and the values used in each geometric mean are available in Appendix E.

Cells shaded gray are surrogate BAF or BSAFs from another PFAS. The surrogate selected is indicated in the adjacent source column.

L/kg - liter of water per kilogram of tissue

Appendix F - Wildlife Risk-Based Screening Level Calculations

Table 3. Toxicity Reference Value Summary

Constituent	Toxicity Reference Values (mg/kg bw/day)					
	Mammal (NOAEL)	Mammal (LOAEL)	Source	Bird (NOAEL)	Bird (LOAEL)	Source
PFNA	0.83	1.1	Appendix D	NA	NA	NA
PFOS	0.1	0.166	Appendix D	0.079	0.79	Appendix D
PFOA	0.3	0.6	Appendix D	NA	NA	NA
PFHxA	84	175	Appendix D	NA	NA	NA
PFBS	50	200	Appendix D	92	153	Appendix D
PFBA	73	175	Appendix D	NA	NA	NA

Notes:

LOAEL - lowest observed adverse effect level

NOAEL - no observed adverse effect level

mg/kg-bw/day - milligram per kilogram of body weight per day

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 4. PFNA NOAEL Risk-Based Screening Levels

Receptor		Terrestrial Mammal			
		Meadow Vole	Short-Tailed Shrew	Little Brown Bat	Long-Tailed Weasel
Media Exposed		Soil	Soil	Soil	Soil
NOAEL-based TRV (mg/kg-bw/day)	Units	0.83	0.83	0.83	0.83
Risk-Based Screening Levels¹					
Soil Risk-Based Screening Level	mg/kg	2.3E+00	1.5E+00	1.0E+00	1.5E+00
Sediment Risk-Based Screening Level	mg/kg	NA	NA	NA	NA
Surface Water Risk-Based Screening Level ³	mg/L	6.0E+00	5.6E+00	5.2E+00	7.2E+00
Dietary Composition					
Plant tissue	fraction	9.8E-01	1.3E-01	0.0E+00	0.0E+00
Invertebrate tissue	fraction	2.0E-02	8.3E-01	0.0E+00	2.0E-02
Aerial insect tissue	fraction	0.0E+00	4.3E-02	1.0E+00	6.0E-02
Crustacean tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mammal/Bird tissue	fraction	0.0E+00	0.0E+00	0.0E+00	9.2E-01
Amphibian tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Reptile tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Fish tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Bioaccumulation Factors - Soil, Sediment, and Surface Water					
Plant tissue - Soil	unitless	1.1E+00	1.1E+00	1.1E+00	1.1E+00
Plant tissue - Sediment	unitless	3.1E+00	3.1E+00	3.1E+00	3.1E+00
Plant tissue - Surface Water	unitless	5.2E+03	5.2E+03	5.2E+03	5.2E+03
Terrestrial invertebrate tissue - Soil	unitless	4.6E+00	4.6E+00	4.6E+00	4.6E+00
Aquatic invertebrate tissue - Sediment	unitless	4.6E+02	4.6E+02	4.6E+02	4.6E+02
Aquatic invertebrate tissue - Surface Water	unitless	9.8E+02	9.8E+02	9.8E+02	9.8E+02
Aerial insect tissue - Soil	unitless	4.6E+00	4.6E+00	4.6E+00	4.6E+00
Aerial insect tissue - Sediment	unitless	4.6E+02	4.6E+02	4.6E+02	4.6E+02
Aquatic crustacean - Sediment	unitless	6.5E+01	6.5E+01	6.5E+01	6.5E+01
Aquatic crustacean - Surface Water	unitless	3.5E+03	3.5E+03	3.5E+03	3.5E+03
Mammal/Bird tissue - Soil or Sediment	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Amphibian tissue - Sediment	unitless	9.2E+01	9.2E+01	9.2E+01	9.2E+01
Amphibian tissue - Surface Water	unitless	4.9E+01	4.9E+01	4.9E+01	4.9E+01
Reptile tissue - Soil	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Fish tissue - Sediment	unitless	9.2E+01	9.2E+01	9.2E+01	9.2E+01
Fish tissue - Surface Water	unitless	3.3E+03	3.3E+03	3.3E+03	3.3E+03
Exposure Parameters					
Body weight	kg	3.7E-02	1.7E-02	9.0E-03	2.1E-01
Drinking water rate	L/day	5.1E-03	2.5E-03	1.4E-03	2.4E-02
Food ingestion rate	kg/day, dw	1.2E-02	2.2E-03	1.6E-03	1.0E-02
Fraction soil ingested	unitless	2.4E-02	2.4E-02	0.0E+00	2.8E-02
Site use factor	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Home range	acres	6.6E-02	9.6E-01	7.4E+01	2.6E+01
Concentrations in Diet Items (Modeled from Soil/Sediment)²					
Plant tissue	mg/kg, dw	2.4E+00	1.7E+00	NA	NA
Invertebrate tissue	mg/kg, dw	1.0E+01	7.1E+00	NA	7.1E+00
Crustacean tissue	mg/kg, dw	NA	NA	NA	NA
Mammal/Bird tissue	mg/kg, dw	NA	NA	NA	1.8E+01
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA
Reptile tissue	mg/kg, dw	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	NA	NA
Concentrations in Diet Items (Modeled from Surface Water)²					
Plant tissue	mg/kg, dw	NA	NA	NA	NA
Invertebrate tissue	mg/kg, dw	NA	NA	NA	NA
Aerial insect tissue	mg/kg, dw	NA	NA	NA	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	NA
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	NA	NA

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 4. PFNA NOAEL Risk-Based Screening Levels

Receptor		Terrestrial Mammal			
		Meadow Vole	Short-Tailed Shrew	Little Brown Bat	Long-Tailed Weasel
Media Exposed		Soil	Soil	Soil	Soil
Bioaccessibility Factors					
Soil/Sediment	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Plant tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Prey tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Average Daily Dose - Soil or Sediment (ADD; mg/kg-bw/day)					
Plant tissue	mg/kg-day	7.5E-01	2.8E-02	0.0E+00	0.0E+00
Invertebrate tissue	mg/kg-day	6.5E-02	7.6E-01	0.0E+00	7.1E-03
Aerial insect tissue	mg/kg-day	0.0E+00	3.9E-02	8.3E-01	2.1E-02
Crustacean tissue	mg/kg-day	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mammal tissue	mg/kg-day	0.0E+00	0.0E+00	0.0E+00	8.0E-01
Bird tissue	mg/kg-day	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Amphibian tissue	mg/kg-day	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Reptile tissue	mg/kg-day	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Fish tissue	mg/kg-day	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Soil/Sediment	mg/kg-day	1.7E-02	4.7E-03	0.0E+00	2.1E-03
Total (Food + Soil/Sediment)	mg/kg-day	8.3E-01	8.3E-01	8.3E-01	8.3E-01
Average Daily Dose - Surface Water (ADD; mg/kg-bw/day)					
Plant tissue	mg/kg-day	NA	NA	NA	NA
Invertebrate tissue	mg/kg-day	NA	NA	NA	NA
Crustacean tissue	mg/kg-day	NA	NA	NA	NA
Fish tissue	mg/kg-day	NA	NA	NA	NA
Drinking water	mg/kg-day	8.3E-01	8.3E-01	8.3E-01	8.3E-01
Total (Food + Drinking Water)	mg/kg-day	8.3E-01	8.3E-01	8.3E-01	8.3E-01
Hazard Quotient (Soil/Sediment Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Hazard Quotient (Surface Water Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 4. PFNA NOAEL Risk-Based Screening Levels

		Aquatic Mammal				
Receptor		Muskrat	Little Brown Bat	River Otter	Harbor Seal	Mink
Media Exposed		Sediment	Sediment	Sediment	Sediment	Sediment
NOAEL-based TRV (mg/kg-bw/day)	Units	0.83	0.83	0.83	0.83	0.83
Risk-Based Screening Levels¹						
Soil Risk-Based Screening Level	mg/kg	NA	NA	NA	NA	NA
Sediment Risk-Based Screening Level	mg/kg	3.6E+00	1.0E-02	2.4E-01	2.0E-01	2.5E-01
Surface Water Risk-Based Screening Level ³	mg/L	2.2E-03	4.7E-03	9.2E-03	9.7E-03	6.8E-03
Dietary Composition						
Plant tissue	fraction	1.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E-02
Invertebrate tissue	fraction	0.0E+00	0.0E+00	7.0E-02	1.4E-01	0.0E+00
Aerial insect tissue	fraction	0.0E+00	1.0E+00	0.0E+00	0.0E+00	0.0E+00
Crustacean tissue	fraction	0.0E+00	0.0E+00	0.0E+00	1.0E-02	4.0E-02
Mammal/Bird tissue	fraction	0.0E+00	0.0E+00	5.0E-02	0.0E+00	6.0E-02
Amphibian tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.0E-02
Reptile tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Fish tissue	fraction	0.0E+00	0.0E+00	8.8E-01	8.5E-01	8.6E-01
Bioaccumulation Factors - Soil, Sediment, and Surface Water						
Plant tissue - Soil	unitless	1.1E+00	1.1E+00	1.1E+00	1.1E+00	1.1E+00
Plant tissue - Sediment	unitless	3.1E+00	3.1E+00	3.1E+00	3.1E+00	3.1E+00
Plant tissue - Surface Water	unitless	5.2E+03	5.2E+03	5.2E+03	5.2E+03	5.2E+03
Terrestrial invertebrate tissue - Soil	unitless	4.6E+00	4.6E+00	4.6E+00	4.6E+00	4.6E+00
Aquatic invertebrate tissue - Sediment	unitless	4.6E+02	4.6E+02	4.6E+02	4.6E+02	4.6E+02
Aquatic invertebrate tissue - Surface Water	unitless	9.8E+02	9.8E+02	9.8E+02	9.8E+02	9.8E+02
Aerial insect tissue - Soil	unitless	4.6E+00	4.6E+00	4.6E+00	4.6E+00	4.6E+00
Aerial insect tissue - Sediment	unitless	4.6E+02	4.6E+02	4.6E+02	4.6E+02	4.6E+02
Aquatic crustacean - Sediment	unitless	6.5E+01	6.5E+01	6.5E+01	6.5E+01	6.5E+01
Aquatic crustacean - Surface Water	unitless	3.5E+03	3.5E+03	3.5E+03	3.5E+03	3.5E+03
Mammal/Bird tissue - Soil or Sediment	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Amphibian tissue - Sediment	unitless	9.2E+01	9.2E+01	9.2E+01	9.2E+01	9.2E+01
Amphibian tissue - Surface Water	unitless	4.9E+01	4.9E+01	4.9E+01	4.9E+01	4.9E+01
Reptile tissue - Soil	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Fish tissue - Sediment	unitless	9.2E+01	9.2E+01	9.2E+01	9.2E+01	9.2E+01
Fish tissue - Surface Water	unitless	3.3E+03	3.3E+03	3.3E+03	3.3E+03	3.3E+03
Exposure Parameters						
Body weight	kg	8.7E-01	9.0E-03	8.0E+00	9.9E+01	1.0E+00
Drinking water rate	L/day	8.8E-02	1.4E-03	6.4E-01	6.2E+00	1.0E-01
Food ingestion rate	kg/day, dw	6.3E-02	1.6E-03	2.4E-01	2.8E+00	4.1E-02
Fraction soil ingested	unitless	9.4E-02	0.0E+00	0.0E+00	2.0E-02	2.0E-02
Site use factor	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Home range	acres	2.7E-01	7.4E+01	8.6E+02	7.0E+05	7.1E+02
Concentrations in Diet Items (Modeled from Soil/Sediment)²						
Plant tissue	mg/kg, dw	1.1E+01	NA	NA	NA	7.7E-01
Invertebrate tissue	mg/kg, dw	NA	NA	1.1E+02	9.4E+01	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	1.3E+01	1.6E+01
Mammal/Bird tissue	mg/kg, dw	NA	NA	2.8E+00	NA	2.8E+00
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA	2.3E+01
Reptile tissue	mg/kg, dw	NA	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	2.2E+01	1.9E+01	2.3E+01
Concentrations in Diet Items (Modeled from Surface Water)²						
Plant tissue	mg/kg, dw	1.2E+01	NA	NA	NA	3.5E+01
Invertebrate tissue	mg/kg, dw	NA	NA	9.0E+00	9.5E+00	NA
Aerial insect tissue	mg/kg, dw	NA	4.7E+00	NA	NA	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	3.4E+01	2.4E+01
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA	3.4E-01
Fish tissue	mg/kg, dw	NA	NA	3.1E+01	3.2E+01	2.3E+01

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 4. PFNA NOAEL Risk-Based Screening Levels

		Aquatic Mammal				
Receptor		Muskrat	Little Brown Bat	River Otter	Harbor Seal	Mink
Media Exposed		Sediment	Sediment	Sediment	Sediment	Sediment
Bioaccessibility Factors						
Soil/Sediment	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Plant tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Prey tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Average Daily Dose - Soil or Sediment (ADD; mg/kg-bw/day)						
Plant tissue	mg/kg-day	8.1E-01	0.0E+00	0.0E+00	0.0E+00	3.1E-04
Invertebrate tissue	mg/kg-day	0.0E+00	0.0E+00	2.4E-01	3.7E-01	0.0E+00
Aerial insect tissue	mg/kg-day	0.0E+00	8.3E-01	0.0E+00	0.0E+00	0.0E+00
Crustacean tissue	mg/kg-day	0.0E+00	0.0E+00	0.0E+00	3.8E-03	2.6E-02
Mammal tissue	mg/kg-day	0.0E+00	0.0E+00	4.2E-03	0.0E+00	6.7E-03
Bird tissue	mg/kg-day	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Amphibian tissue	mg/kg-day	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.7E-02
Reptile tissue	mg/kg-day	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Fish tissue	mg/kg-day	0.0E+00	0.0E+00	5.9E-01	4.5E-01	7.7E-01
Soil/Sediment	mg/kg-day	2.4E-02	0.0E+00	0.0E+00	1.2E-04	2.0E-04
Total (Food + Soil/Sediment)	mg/kg-day	8.3E-01	8.3E-01	8.3E-01	8.3E-01	8.3E-01
Average Daily Dose - Surface Water (ADD; mg/kg-bw/day)						
Plant tissue	mg/kg-day	8.30E-01	0.00E+00	0.00E+00	0.00E+00	1.40E-02
Invertebrate tissue	mg/kg-day	0.00E+00	0.00E+00	1.89E-02	3.79E-02	0.00E+00
Crustacean tissue	mg/kg-day	0.00E+00	0.00E+00	0.00E+00	9.66E-03	3.79E-02
Fish tissue	mg/kg-day	0.00E+00	0.00E+00	8.10E-01	7.82E-01	7.77E-01
Drinking water	mg/kg-day	2.2E-04	7.5E-04	7.4E-04	6.1E-04	6.7E-04
Total (Food + Drinking Water)	mg/kg-day	8.3E-01	8.3E-01	8.3E-01	8.3E-01	8.3E-01
Hazard Quotient (Soil/Sediment Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Hazard Quotient (Surface Water Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00

Appendix F - Wildlife Risk-Based Screening Level Calculations

Table 4. PFNA NOAEL Risk-Based Screening Levels

Notes

- The risk-based screening level (RBSL) is the concentration in soil, sediment, or surface water where the average daily dose (ADD) is equal to the toxicity reference value (TRV), resulting in a hazard quotient (HQ) of 1.
- Concentration in diet items is calculated as: $RBSL_{media} \times \text{bioaccumulation factor (BAF or BSAF)}$ where:
 - * the terrestrial plant, invertebrate, or mammal bioaccumulation factor (BAF) is used to calculate terrestrial receptor exposure from concentrations in soil (soil RBSL)
 - * the aquatic plant or invertebrate biota-sediment accumulation factor (BSAF) is used to calculate aquatic receptor exposure from concentrations in sediment (sediment RBSL)
 - * and the aquatic plant or invertebrate BAF is used to calculate aquatic receptor exposure from concentrations in surface water (SW RBSL)
- The surface water (SW) RBSL incorporates only drinking water ingestion for terrestrial receptors. The aquatic receptor SW RBSL includes drinking water ingestion as well as bioaccumulation in the receptor's dietary items including aquatic plants, invertebrates, and fish.

Risk-Based Screening Level Equations

$$\text{Soil: } \frac{TRV}{\left(\frac{[(FIR * SIR) + (FIR * BAF)] * SUF}{BW} \right)}$$

$$\text{Sediment: } \frac{TRV}{\left(\frac{[(FIR * SIR) + (FIR * BSAF)] * SUF}{BW} \right)}$$

$$\text{Surface water: } \frac{TRV}{\left(\frac{DWR + (FIR * BAF)] * SUF}{BW} \right)}$$

% - percent

BAF - bioaccumulation factor

BSAF - biota-sediment accumulation factor

BW - body weight

DWR - drinking water rate

dw - dry weight

FIR - food ingestion rate

g - gram

L - liters

kg - kilogram

mg/L - milligrams per liter of surface water

mg/kg - milligrams per kilogram of soil or sediment

mg/kg-bw/day - milligrams per kilogram of body weight per day

NOAEL - no observed adverse effect level

RBSL - risk-based screening level

SIR - soil ingestion rate

SUF - site use factor

SW - surface water

TRV - toxicity reference value

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 5. PFOS NOEL Risk-Based Screening Levels

Receptor		Terrestrial Mammal			
		Meadow Vole	Short-Tailed Shrew	Little Brown Bat	Long-Tailed Weasel
Media Exposed		Soil	Soil	Soil	Soil
NOEL-based TRV (mg/kg-bw/day)	Units	0.1	0.1	0.1	0.1
Risk-Based Screening Levels¹					
Soil Risk-Based Screening Level	mg/kg	3.1E-01	4.8E-02	3.0E-02	1.7E-01
Sediment Risk-Based Screening Level	mg/kg	NA	NA	NA	NA
Surface Water Risk-Based Screening Level ³	mg/L	7.3E-01	6.7E-01	6.3E-01	8.6E-01
Dietary Composition					
Plant tissue	fraction	9.8E-01	1.3E-01	0.0E+00	0.0E+00
Invertebrate tissue	fraction	2.0E-02	8.3E-01	0.0E+00	2.0E-02
Aerial insect tissue	fraction	0.0E+00	4.3E-02	1.0E+00	6.0E-02
Crustacean tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mammal/Bird tissue	fraction	0.0E+00	0.0E+00	0.0E+00	9.2E-01
Amphibian tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Reptile tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Fish tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Bioaccumulation Factors - Soil, Sediment, and Surface Water					
Plant tissue - Soil	unitless	6.6E-01	6.6E-01	6.6E-01	6.6E-01
Plant tissue - Sediment	unitless	6.1E+01	6.1E+01	6.1E+01	6.1E+01
Plant tissue - Surface Water	unitless	1.3E+03	1.3E+03	1.3E+03	1.3E+03
Terrestrial invertebrate tissue - Soil	unitless	1.9E+01	1.9E+01	1.9E+01	1.9E+01
Aquatic invertebrate tissue - Sediment	unitless	1.1E+02	1.1E+02	1.1E+02	1.1E+02
Aquatic invertebrate tissue - Surface Water	unitless	1.5E+03	1.5E+03	1.5E+03	1.5E+03
Aerial insect tissue - Soil	unitless	1.9E+01	1.9E+01	1.9E+01	1.9E+01
Aerial insect tissue - Sediment	unitless	1.1E+02	1.1E+02	1.1E+02	1.1E+02
Aquatic crustacean - Sediment	unitless	2.5E+01	2.5E+01	2.5E+01	2.5E+01
Aquatic crustacean - Surface Water	unitless	5.6E+03	5.6E+03	5.6E+03	5.6E+03
Mammal/Bird tissue - Soil or Sediment	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Amphibian tissue - Sediment	unitless	7.2E+01	7.2E+01	7.2E+01	7.2E+01
Amphibian tissue - Surface Water	unitless	3.3E+03	3.3E+03	3.3E+03	3.3E+03
Reptile tissue - Soil	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Fish tissue - Sediment	unitless	7.2E+01	7.2E+01	7.2E+01	7.2E+01
Fish tissue - Surface Water	unitless	1.3E+04	1.3E+04	1.3E+04	1.3E+04
Exposure Parameters					
Body weight	kg	3.7E-02	1.7E-02	9.0E-03	2.1E-01
Drinking water rate	L/day	5.1E-03	2.5E-03	1.4E-03	2.4E-02
Food ingestion rate	kg/day, dw	1.2E-02	2.2E-03	1.6E-03	1.0E-02
Fraction soil ingested	unitless	2.4E-02	2.4E-02	0.0E+00	2.8E-02
Site use factor	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Home range	acres	6.6E-02	9.6E-01	7.4E+01	2.6E+01
Concentrations in Diet Items (Modeled from Soil/Sediment)²					
Plant tissue	mg/kg, dw	2.0E-01	3.1E-02	NA	NA
Invertebrate tissue	mg/kg, dw	5.7E+00	8.9E-01	NA	3.1E+00
Crustacean tissue	mg/kg, dw	NA	NA	NA	NA
Mammal/Bird tissue	mg/kg, dw	NA	NA	NA	1.9E+00
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA
Reptile tissue	mg/kg, dw	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	NA	NA
Concentrations in Diet Items (Modeled from Surface Water)²					
Plant tissue	mg/kg, dw	NA	NA	NA	NA
Invertebrate tissue	mg/kg, dw	NA	NA	NA	NA
Aerial insect tissue	mg/kg, dw	NA	NA	NA	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	NA
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	NA	NA

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 5. PFOS NOAEL Risk-Based Screening Levels

		Terrestrial Mammal			
Receptor		Meadow Vole	Short-Tailed Shrew	Little Brown Bat	Long-Tailed Weasel
Media Exposed		Soil	Soil	Soil	Soil
Bioaccessibility Factors					
Soil/Sediment	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Plant tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Prey tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Average Daily Dose - Soil or Sediment (ADD; mg/kg-bw/day)					
Plant tissue	mg/kg-day	6E-02	5E-04	0E+00	0E+00
Invertebrate tissue	mg/kg-day	4E-02	9E-02	0E+00	3E-03
Aerial insect tissue	mg/kg-day	0E+00	5E-03	1E-01	9E-03
Crustacean tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Mammal tissue	mg/kg-day	0E+00	0E+00	0E+00	9E-02
Bird tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Amphibian tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Reptile tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Fish tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Soil/Sediment	mg/kg-day	2E-03	1E-04	0E+00	2E-04
Total (Food + Soil/Sediment)	mg/kg-day	1.0E-01	1.0E-01	1.0E-01	1.0E-01
Average Daily Dose - Surface Water (ADD; mg/kg-bw/day)					
Plant tissue	mg/kg-day	NA	NA	NA	NA
Invertebrate tissue	mg/kg-day	NA	NA	NA	NA
Crustacean tissue	mg/kg-day	NA	NA	NA	NA
Fish tissue	mg/kg-day	NA	NA	NA	NA
Drinking water	mg/kg-day	1.0E-01	1.0E-01	1.0E-01	1.0E-01
Total (Food + Drinking Water)	mg/kg-day	1.0E-01	1.0E-01	1.0E-01	1.0E-01
Hazard Quotient (Soil/Sediment Exposure)					
	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Hazard Quotient (Surface Water Exposure)					
	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 5. PFOS NOAEL Risk-Based Screening Levels

		Aquatic Mammal				
Receptor		Muskrat	Little Brown Bat	River Otter	Harbor Seal	Mink
Media Exposed		Sediment	Sediment	Sediment	Sediment	Sediment
NOAEL-based TRV (mg/kg-bw/day)	Units	0.1	0.1	0.1	0.1	0.1
Risk-Based Screening Levels¹						
Soil Risk-Based Screening Level	mg/kg	NA	NA	NA	NA	NA
Sediment Risk-Based Screening Level	mg/kg	2.3E-02	5.3E-03	4.7E-02	4.6E-02	3.8E-02
Surface Water Risk-Based Screening Level ³	mg/L	1.1E-03	3.6E-04	2.8E-04	3.1E-04	2.1E-04
Dietary Composition						
Plant tissue	fraction	1.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E-02
Invertebrate tissue	fraction	0.0E+00	0.0E+00	7.0E-02	1.4E-01	0.0E+00
Aerial insect tissue	fraction	0.0E+00	1.0E+00	0.0E+00	0.0E+00	0.0E+00
Crustacean tissue	fraction	0.0E+00	0.0E+00	0.0E+00	1.0E-02	4.0E-02
Mammal/Bird tissue	fraction	0.0E+00	0.0E+00	5.0E-02	0.0E+00	6.0E-02
Amphibian tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.0E-02
Reptile tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Fish tissue	fraction	0.0E+00	0.0E+00	8.8E-01	8.5E-01	8.6E-01
Bioaccumulation Factors - Soil, Sediment, and Surface Water						
Plant tissue - Soil	unitless	6.6E-01	6.6E-01	6.6E-01	6.6E-01	6.6E-01
Plant tissue - Sediment	unitless	6.1E+01	6.1E+01	6.1E+01	6.1E+01	6.1E+01
Plant tissue - Surface Water	unitless	1.3E+03	1.3E+03	1.3E+03	1.3E+03	1.3E+03
Terrestrial invertebrate tissue - Soil	unitless	1.9E+01	1.9E+01	1.9E+01	1.9E+01	1.9E+01
Aquatic invertebrate tissue - Sediment	unitless	1.1E+02	1.1E+02	1.1E+02	1.1E+02	1.1E+02
Aquatic invertebrate tissue - Surface Water	unitless	1.5E+03	1.5E+03	1.5E+03	1.5E+03	1.5E+03
Aerial insect tissue - Soil	unitless	1.9E+01	1.9E+01	1.9E+01	1.9E+01	1.9E+01
Aerial insect tissue - Sediment	unitless	1.1E+02	1.1E+02	1.1E+02	1.1E+02	1.1E+02
Aquatic crustacean - Sediment	unitless	2.5E+01	2.5E+01	2.5E+01	2.5E+01	2.5E+01
Aquatic crustacean - Surface Water	unitless	5.6E+03	5.6E+03	5.6E+03	5.6E+03	5.6E+03
Mammal/Bird tissue - Soil or Sediment	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Amphibian tissue - Sediment	unitless	7.2E+01	7.2E+01	7.2E+01	7.2E+01	7.2E+01
Amphibian tissue - Surface Water	unitless	3.3E+03	3.3E+03	3.3E+03	3.3E+03	3.3E+03
Reptile tissue - Soil	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Fish tissue - Sediment	unitless	7.2E+01	7.2E+01	7.2E+01	7.2E+01	7.2E+01
Fish tissue - Surface Water	unitless	1.3E+04	1.3E+04	1.3E+04	1.3E+04	1.3E+04
Exposure Parameters						
Body weight	kg	8.7E-01	9.0E-03	8.0E+00	9.9E+01	1.0E+00
Drinking water rate	L/day	8.8E-02	1.4E-03	6.4E-01	6.2E+00	1.0E-01
Food ingestion rate	kg/day, dw	6.3E-02	1.6E-03	2.4E-01	2.8E+00	4.1E-02
Fraction soil ingested	unitless	9.4E-02	0.0E+00	0.0E+00	2.0E-02	2.0E-02
Site use factor	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Home range	acres	2.7E-01	7.4E+01	8.6E+02	7.0E+05	7.1E+02
Concentrations in Diet Items (Modeled from Soil/Sediment)²						
Plant tissue	mg/kg, dw	1.4E+00	NA	NA	NA	2.3E+00
Invertebrate tissue	mg/kg, dw	NA	NA	4.9E+00	4.9E+00	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	1.1E+00	9.3E-01
Mammal/Bird tissue	mg/kg, dw	NA	NA	5.3E-01	NA	4.3E-01
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA	2.7E+00
Reptile tissue	mg/kg, dw	NA	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	3.4E+00	3.3E+00	2.7E+00
Concentrations in Diet Items (Modeled from Surface Water)²						
Plant tissue	mg/kg, dw	1.4E+00	NA	NA	NA	2.8E-01
Invertebrate tissue	mg/kg, dw	NA	NA	4.4E-01	4.7E-01	NA
Aerial insect tissue	mg/kg, dw	NA	5.6E-01	NA	NA	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	1.7E+00	1.2E+00
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA	7.1E-01
Fish tissue	mg/kg, dw	NA	NA	3.7E+00	4.0E+00	2.8E+00

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 5. PFOS NOAEL Risk-Based Screening Levels

		Aquatic Mammal				
Receptor		Muskrat	Little Brown Bat	River Otter	Harbor Seal	Mink
Media Exposed		Sediment	Sediment	Sediment	Sediment	Sediment
Bioaccessibility Factors						
Soil/Sediment	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Plant tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Prey tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Average Daily Dose - Soil or Sediment (ADD; mg/kg-bw/day)						
Plant tissue	mg/kg-day	1E-01	0E+00	0E+00	0E+00	9E-04
Invertebrate tissue	mg/kg-day	0E+00	0E+00	1E-02	2E-02	0E+00
Aerial insect tissue	mg/kg-day	0E+00	1E-01	0E+00	0E+00	0E+00
Crustacean tissue	mg/kg-day	0E+00	0E+00	0E+00	3E-04	1E-03
Mammal tissue	mg/kg-day	0E+00	0E+00	8E-04	0E+00	1E-03
Bird tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00
Amphibian tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	3E-03
Reptile tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00
Fish tissue	mg/kg-day	0E+00	0E+00	9E-02	8E-02	9E-02
Soil/Sediment	mg/kg-day	2E-04	0E+00	0E+00	3E-05	3E-05
Total (Food + Soil/Sediment)	mg/kg-day	1.0E-01	1.0E-01	1.0E-01	1.0E-01	1.0E-01
Average Daily Dose - Surface Water (ADD; mg/kg-bw/day)						
Plant tissue	mg/kg-day	9.99E-02	0.00E+00	0.00E+00	0.00E+00	1.11E-04
Invertebrate tissue	mg/kg-day	0.00E+00	0.00E+00	9.22E-04	1.88E-03	0.00E+00
Crustacean tissue	mg/kg-day	0.00E+00	0.00E+00	0.00E+00	4.87E-04	1.91E-03
Fish tissue	mg/kg-day	0.00E+00	0.00E+00	9.91E-02	9.76E-02	9.71E-02
Drinking water	mg/kg-day	1.1E-04	5.8E-05	2.3E-05	1.9E-05	2.1E-05
Total (Food + Drinking Water)	mg/kg-day	1.0E-01	1.0E-01	1.0E-01	1.0E-01	1.0E-01
Hazard Quotient (Soil/Sediment Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Hazard Quotient (Surface Water Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 5. PFOS NOEL Risk-Based Screening Levels

		Terrestrial Bird			Aquatic Bird		
Receptor		American Goldfinch	House Wren	Red-Tailed Hawk	Red-Winged Blackbird	Tree Swallow	Brown Pelican
Media Exposed		Soil	Soil	Soil	Sediment	Sediment	Sediment
NOEL-based TRV (mg/kg-bw/day)	Units	0.079	0.079	0.079	0.079	0.079	0.079
Risk-Based Screening Levels¹							
Soil Risk-Based Screening Level	mg/kg	3.8E-01	1.3E-02	8.7E-02	NA	NA	NA
Sediment Risk-Based Screening Level	mg/kg	NA	NA	NA	7.0E-03	1.4E-03	1.4E-02
Surface Water Risk-Based Screening Level ³	mg/L	3.2E-01	3.0E-01	1.4E+00	3.4E-04	9.1E-05	7.5E-05
Dietary Composition							
Plant tissue	fraction	1.0E+00	0.0E+00	0.0E+00	9.2E-01	1.7E-01	0.0E+00
Invertebrate tissue	fraction	0.0E+00	8.5E-01	0.0E+00	7.6E-02	2.6E-01	0.0E+00
Aerial insect tissue	fraction	0.0E+00	1.5E-01	0.0E+00	0.0E+00	5.7E-01	0.0E+00
Crustacean tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mammal/Bird tissue	fraction	0.0E+00	0.0E+00	8.7E-01	0.0E+00	0.0E+00	0.0E+00
Amphibian tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Reptile tissue	fraction	0.0E+00	0.0E+00	1.3E-01	0.0E+00	0.0E+00	0.0E+00
Fish tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00
Bioaccumulation Factors - Soil, Sediment, and Surface Water							
Plant tissue - Soil	unitless	6.6E-01	6.6E-01	6.6E-01	6.6E-01	6.6E-01	6.6E-01
Plant tissue - Sediment	unitless	6.1E+01	6.1E+01	6.1E+01	6.1E+01	6.1E+01	6.1E+01
Plant tissue - Surface Water	unitless	1.3E+03	1.3E+03	1.3E+03	1.3E+03	1.3E+03	1.3E+03
Terrestrial invertebrate tissue - Soil	unitless	1.9E+01	1.9E+01	1.9E+01	1.9E+01	1.9E+01	1.9E+01
Aquatic invertebrate tissue - Sediment	unitless	1.1E+02	1.1E+02	1.1E+02	1.1E+02	1.1E+02	1.1E+02
Aquatic invertebrate tissue - Surface Water	unitless	1.5E+03	1.5E+03	1.5E+03	1.5E+03	1.5E+03	1.5E+03
Aerial insect tissue - Soil	unitless	1.9E+01	1.9E+01	1.9E+01	1.9E+01	1.9E+01	1.9E+01
Aerial insect tissue - Sediment	unitless	1.1E+02	1.1E+02	1.1E+02	1.1E+02	1.1E+02	1.1E+02
Aquatic crustacean - Sediment	unitless	2.5E+01	2.5E+01	2.5E+01	2.5E+01	2.5E+01	2.5E+01
Aquatic crustacean - Surface Water	unitless	5.6E+03	5.6E+03	5.6E+03	5.6E+03	5.6E+03	5.6E+03
Mammal/Bird tissue - Soil or Sediment	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Amphibian tissue - Sediment	unitless	7.2E+01	7.2E+01	7.2E+01	7.2E+01	7.2E+01	7.2E+01
Amphibian tissue - Surface Water	unitless	3.3E+03	3.3E+03	3.3E+03	3.3E+03	3.3E+03	3.3E+03
Reptile tissue - Soil	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Fish tissue - Sediment	unitless	7.2E+01	7.2E+01	7.2E+01	7.2E+01	7.2E+01	7.2E+01
Fish tissue - Surface Water	unitless	1.3E+04	1.3E+04	1.3E+04	1.3E+04	1.3E+04	1.3E+04
Exposure Parameters							
Body weight	kg	1.3E-02	1.1E-02	1.1E+00	5.7E-02	2.0E-02	3.4E+00
Drinking water rate	L/day	3.2E-03	2.8E-03	6.4E-02	8.7E-03	4.3E-03	1.3E-01
Food ingestion rate	kg/day, dw	3.7E-03	3.4E-03	9.0E-02	1.0E-02	1.2E-02	2.7E-01
Fraction soil ingested	unitless	9.3E-02	1.0E-01	0.0E+00	9.3E-02	0.0E+00	2.0E-02
Site use factor	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Home range	acres	1.2E+04	2.3E+00	1.7E+03	1.5E+05	9.5E+03	3.1E+05
Concentrations in Diet Items (Modeled from Soil/Sediment)²							
Plant tissue	mg/kg, dw	2.5E-01	NA	NA	4.3E-01	8.6E-02	NA
Invertebrate tissue	mg/kg, dw	NA	2.5E-01	NA	7.4E-01	1.5E-01	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	NA	NA	NA
Mammal/Bird tissue	mg/kg, dw	NA	NA	1.0E+00	NA	NA	NA
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA	NA	NA
Reptile tissue	mg/kg, dw	NA	NA	1.0E+00	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	NA	NA	NA	1.0E+00
Concentrations in Diet Items (Modeled from Surface Water)²							
Plant tissue	mg/kg, dw	NA	NA	NA	4.5E-01	1.2E-01	NA
Invertebrate tissue	mg/kg, dw	NA	NA	NA	5.3E-01	1.4E-01	NA
Aerial insect tissue	mg/kg, dw	NA	NA	NA	NA	1.4E-01	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	NA	NA	NA
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	NA	NA	NA	1.0E+00

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 5. PFOS NOAEL Risk-Based Screening Levels

Receptor		Terrestrial Bird			Aquatic Bird		
		American Goldfinch	House Wren	Red-Tailed Hawk	Red-Winged Blackbird	Tree Swallow	Brown Pelican
Media Exposed		Soil	Soil	Soil	Sediment	Sediment	Sediment
Bioaccessibility Factors							
Soil/Sediment	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Plant tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Prey tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Average Daily Dose - Soil or Sediment (ADD; mg/kg-bw/day)							
Plant tissue	mg/kg-day	7E-02	0E+00	0E+00	7E-02	8E-03	0E+00
Invertebrate tissue	mg/kg-day	0E+00	7E-02	0E+00	1E-02	2E-02	0E+00
Aerial insect tissue	mg/kg-day	0E+00	1E-02	0E+00	0E+00	5E-02	0E+00
Crustacean tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00
Mammal tissue	mg/kg-day	0E+00	0E+00	7E-02	0E+00	0E+00	0E+00
Bird tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00
Amphibian tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00
Reptile tissue	mg/kg-day	0E+00	0E+00	1E-02	0E+00	0E+00	0E+00
Fish tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00	8E-02
Soil/Sediment	mg/kg-day	1E-02	4E-04	0E+00	1E-04	0E+00	2E-05
Total (Food + Soil/Sediment)	mg/kg-day	7.9E-02	7.9E-02	7.9E-02	7.9E-02	7.9E-02	7.9E-02
Average Daily Dose - Surface Water (ADD; mg/kg-bw/day)							
Plant tissue	mg/kg-day	NA	NA	NA	7.19E-02	1.16E-02	0.00E+00
Invertebrate tissue	mg/kg-day	NA	NA	NA	7.02E-03	2.11E-02	0.00E+00
Crustacean tissue	mg/kg-day	NA	NA	NA	0.00E+00	0.00E+00	0.00E+00
Fish tissue	mg/kg-day	NA	NA	NA	0.00E+00	0.00E+00	7.90E-02
Drinking water	mg/kg-day	7.9E-02	7.9E-02	7.9E-02	5.2E-05	2.0E-05	3.0E-06
Total (Food + Drinking Water)	mg/kg-day	7.9E-02	7.9E-02	7.9E-02	7.9E-02	7.9E-02	7.9E-02
Hazard Quotient (Soil/Sediment Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Hazard Quotient (Surface Water Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00

Appendix F - Wildlife Risk-Based Screening Level Calculations

Table 5. PFOS NOAEL Risk-Based Screening Levels

Notes

1. The risk-based screening level (RBSL) is the concentration in soil, sediment, or surface water where the average daily dose (ADD) is equal to the toxicity reference value (TRV), resulting in a hazard quotient (HQ) of 1.
2. Concentration in diet items is calculated as: $RBSL_{media} \times \text{bioaccumulation factor (BAF or BSAF)}$ where:
 - * the terrestrial plant, invertebrate, or mammal bioaccumulation factor (BAF) is used to calculate terrestrial receptor exposure from concentrations in soil (soil RBSL)
 - * the aquatic plant or invertebrate biota-sediment accumulation factor (BSAF) is used to calculate aquatic receptor exposure from concentrations in sediment (sediment RBSL)
 - * and the aquatic plant or invertebrate BAF is used to calculate aquatic receptor exposure from concentrations in surface water (SW RBSL)
3. The surface water (SW) RBSL incorporates only drinking water ingestion for terrestrial receptors. The aquatic receptor SW RBSL includes drinking water ingestion as well as bioaccumulation in the receptor's dietary items including aquatic plants, invertebrates, and fish.

Risk-Based Screening Level Equations

$$\text{Soil: } \frac{TRV}{\left(\frac{[(FIR * SIR) + (FIR * BAF)] * SUF}{BW} \right)}$$

$$\text{Sediment: } \frac{TRV}{\left(\frac{[(FIR * SIR) + (FIR * BSAF)] * SUF}{BW} \right)}$$

$$\text{Surface water: } \frac{TRV}{\left(\frac{DWR + (FIR * BAF)] * SUF}{BW} \right)}$$

% - percent

BAF - bioaccumulation factor

BSAF - biota-sediment accumulation factor

BW - body weight

DWR - drinking water rate

dw - dry weight

FIR - food ingestion rate

g - gram

L - liters

kg - kilogram

mg/L - milligrams per liter of surface water

mg/kg - milligrams per kilogram of soil or sediment

mg/kg-bw/day - milligrams per kilogram of body weight per day

NOAEL - no observed adverse effect level

RBSL - risk-based screening level

SIR - soil ingestion rate

SUF - site use factor

SW - surface water

TRV - toxicity reference value

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 6. PFOA NOAEL Risk-Based Screening Levels

Receptor		Terrestrial Mammal			
		Meadow Vole	Short-Tailed Shrew	Little Brown Bat	Long-Tailed Weasel
Media Exposed		Soil	Soil	Soil	Soil
NOAEL-based TRV (mg/kg-bw/day)	Units	0.3	0.3	0.3	0.3
Risk-Based Screening Levels¹					
Soil Risk-Based Screening Level	mg/kg	5.8E+00	1.3E+00	8.4E-01	5.7E-01
Sediment Risk-Based Screening Level	mg/kg	NA	NA	NA	NA
Surface Water Risk-Based Screening Level ³	mg/L	2.2E+00	2.0E+00	1.9E+00	2.6E+00
Dietary Composition					
Plant tissue	fraction	9.8E-01	1.3E-01	0.0E+00	0.0E+00
Invertebrate tissue	fraction	2.0E-02	8.3E-01	0.0E+00	2.0E-02
Aerial insect tissue	fraction	0.0E+00	4.3E-02	1.0E+00	6.0E-02
Crustacean tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mammal/Bird tissue	fraction	0.0E+00	0.0E+00	0.0E+00	9.2E-01
Amphibian tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Reptile tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Fish tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Bioaccumulation Factors - Soil, Sediment, and Surface Water					
Plant tissue - Soil	unitless	1.1E-01	1.1E-01	1.1E-01	1.1E-01
Plant tissue - Sediment	unitless	3.5E+00	3.5E+00	3.5E+00	3.5E+00
Plant tissue - Surface Water	unitless	2.3E+02	2.3E+02	2.3E+02	2.3E+02
Terrestrial invertebrate tissue - Soil	unitless	2.0E+00	2.0E+00	2.0E+00	2.0E+00
Aquatic invertebrate tissue - Sediment	unitless	2.8E+02	2.8E+02	2.8E+02	2.8E+02
Aquatic invertebrate tissue - Surface Water	unitless	3.8E+02	3.8E+02	3.8E+02	3.8E+02
Aerial insect tissue - Soil	unitless	2.0E+00	2.0E+00	2.0E+00	2.0E+00
Aerial insect tissue - Sediment	unitless	2.8E+02	2.8E+02	2.8E+02	2.8E+02
Aquatic crustacean - Sediment	unitless	7.7E+01	7.7E+01	7.7E+01	7.7E+01
Aquatic crustacean - Surface Water	unitless	7.0E+02	7.0E+02	7.0E+02	7.0E+02
Mammal/Bird tissue - Soil or Sediment	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Amphibian tissue - Sediment	unitless	1.7E+01	1.7E+01	1.7E+01	1.7E+01
Amphibian tissue - Surface Water	unitless	8.0E-01	8.0E-01	8.0E-01	8.0E-01
Reptile tissue - Soil	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Fish tissue - Sediment	unitless	1.7E+01	1.7E+01	1.7E+01	1.7E+01
Fish tissue - Surface Water	unitless	8.9E+02	8.9E+02	8.9E+02	8.9E+02
Exposure Parameters					
Body weight	kg	3.7E-02	1.7E-02	9.0E-03	2.1E-01
Drinking water rate	L/day	5.1E-03	2.5E-03	1.4E-03	2.4E-02
Food ingestion rate	kg/day, dw	1.2E-02	2.2E-03	1.6E-03	1.0E-02
Fraction soil ingested	unitless	2.4E-02	2.4E-02	0.0E+00	2.8E-02
Site use factor	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Home range	acres	6.6E-02	9.6E-01	7.4E+01	2.6E+01
Concentrations in Diet Items (Modeled from Soil/Sediment)²					
Plant tissue	mg/kg, dw	6.1E-01	1.4E-01	NA	NA
Invertebrate tissue	mg/kg, dw	1.2E+01	2.6E+00	NA	1.1E+00
Crustacean tissue	mg/kg, dw	NA	NA	NA	NA
Mammal/Bird tissue	mg/kg, dw	NA	NA	NA	6.5E+00
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA
Reptile tissue	mg/kg, dw	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	NA	NA
Concentrations in Diet Items (Modeled from Surface Water)²					
Plant tissue	mg/kg, dw	NA	NA	NA	NA
Invertebrate tissue	mg/kg, dw	NA	NA	NA	NA
Aerial insect tissue	mg/kg, dw	NA	NA	NA	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	NA
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	NA	NA

Appendix F - Wildlife Risk-Based Screening Level Calculations

Table 6. PFOA NOAEL Risk-Based Screening Levels

		Terrestrial Mammal			
Receptor		Meadow Vole	Short-Tailed Shrew	Little Brown Bat	Long-Tailed Weasel
Media Exposed		Soil	Soil	Soil	Soil
Bioaccessibility Factors					
Soil/Sediment	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Plant tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Prey tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Average Daily Dose - Soil or Sediment (ADD; mg/kg-bw/day)					
Plant tissue	mg/kg-day	2E-01	2E-03	0E+00	0E+00
Invertebrate tissue	mg/kg-day	7E-02	3E-01	0E+00	1E-03
Aerial insect tissue	mg/kg-day	0E+00	1E-02	3E-01	3E-03
Crustacean tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Mammal tissue	mg/kg-day	0E+00	0E+00	0E+00	3E-01
Bird tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Amphibian tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Reptile tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Fish tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Soil/Sediment	mg/kg-day	4E-02	4E-03	0E+00	8E-04
Total (Food + Soil/Sediment)	mg/kg-day	3.0E-01	3.0E-01	3.0E-01	3.0E-01
Average Daily Dose - Surface Water (ADD; mg/kg-bw/day)					
Plant tissue	mg/kg-day	NA	NA	NA	NA
Invertebrate tissue	mg/kg-day	NA	NA	NA	NA
Crustacean tissue	mg/kg-day	NA	NA	NA	NA
Fish tissue	mg/kg-day	NA	NA	NA	NA
Drinking water	mg/kg-day	3.0E-01	3.0E-01	3.0E-01	3.0E-01
Total (Food + Drinking Water)	mg/kg-day	3.0E-01	3.0E-01	3.0E-01	3.0E-01
Hazard Quotient (Soil/Sediment Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Hazard Quotient (Surface Water Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 6. PFOA NOAEL Risk-Based Screening Levels

		Aquatic Mammal				
Receptor		Muskrat	Little Brown Bat	River Otter	Harbor Seal	Mink
Media Exposed		Sediment	Sediment	Sediment	Sediment	Sediment
NOAEL-based TRV (mg/kg-bw/day)	Units	0.3	0.3	0.3	0.3	0.3
Risk-Based Screening Levels¹						
Soil Risk-Based Screening Level	mg/kg	NA	NA	NA	NA	NA
Sediment Risk-Based Screening Level	mg/kg	1.2E+00	6.0E-03	2.8E-01	1.9E-01	4.0E-01
Surface Water Risk-Based Screening Level ³	mg/L	1.8E-02	4.4E-03	1.2E-02	1.3E-02	9.4E-03
Dietary Composition						
Plant tissue	fraction	1.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E-02
Invertebrate tissue	fraction	0.0E+00	0.0E+00	7.0E-02	1.4E-01	0.0E+00
Aerial insect tissue	fraction	0.0E+00	1.0E+00	0.0E+00	0.0E+00	0.0E+00
Crustacean tissue	fraction	0.0E+00	0.0E+00	0.0E+00	1.0E-02	4.0E-02
Mammal/Bird tissue	fraction	0.0E+00	0.0E+00	5.0E-02	0.0E+00	6.0E-02
Amphibian tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.0E-02
Reptile tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Fish tissue	fraction	0.0E+00	0.0E+00	8.8E-01	8.5E-01	8.6E-01
Bioaccumulation Factors - Soil, Sediment, and Surface Water						
Plant tissue - Soil	unitless	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01
Plant tissue - Sediment	unitless	3.5E+00	3.5E+00	3.5E+00	3.5E+00	3.5E+00
Plant tissue - Surface Water	unitless	2.3E+02	2.3E+02	2.3E+02	2.3E+02	2.3E+02
Terrestrial invertebrate tissue - Soil	unitless	2.0E+00	2.0E+00	2.0E+00	2.0E+00	2.0E+00
Aquatic invertebrate tissue - Sediment	unitless	2.8E+02	2.8E+02	2.8E+02	2.8E+02	2.8E+02
Aquatic invertebrate tissue - Surface Water	unitless	3.8E+02	3.8E+02	3.8E+02	3.8E+02	3.8E+02
Aerial insect tissue - Soil	unitless	2.0E+00	2.0E+00	2.0E+00	2.0E+00	2.0E+00
Aerial insect tissue - Sediment	unitless	2.8E+02	2.8E+02	2.8E+02	2.8E+02	2.8E+02
Aquatic crustacean - Sediment	unitless	7.7E+01	7.7E+01	7.7E+01	7.7E+01	7.7E+01
Aquatic crustacean - Surface Water	unitless	7.0E+02	7.0E+02	7.0E+02	7.0E+02	7.0E+02
Mammal/Bird tissue - Soil or Sediment	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Amphibian tissue - Sediment	unitless	1.7E+01	1.7E+01	1.7E+01	1.7E+01	1.7E+01
Amphibian tissue - Surface Water	unitless	8.0E-01	8.0E-01	8.0E-01	8.0E-01	8.0E-01
Reptile tissue - Soil	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Fish tissue - Sediment	unitless	1.7E+01	1.7E+01	1.7E+01	1.7E+01	1.7E+01
Fish tissue - Surface Water	unitless	8.9E+02	8.9E+02	8.9E+02	8.9E+02	8.9E+02
Exposure Parameters						
Body weight	kg	8.7E-01	9.0E-03	8.0E+00	9.9E+01	1.0E+00
Drinking water rate	L/day	8.8E-02	1.4E-03	6.4E-01	6.2E+00	1.0E-01
Food ingestion rate	kg/day, dw	6.3E-02	1.6E-03	2.4E-01	2.8E+00	4.1E-02
Fraction soil ingested	unitless	9.4E-02	0.0E+00	0.0E+00	2.0E-02	2.0E-02
Site use factor	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Home range	acres	2.7E-01	7.4E+01	8.6E+02	7.0E+05	7.1E+02
Concentrations in Diet Items (Modeled from Soil/Sediment)²						
Plant tissue	mg/kg, dw	4.1E+00	NA	NA	NA	1.4E+00
Invertebrate tissue	mg/kg, dw	NA	NA	8.0E+01	5.5E+01	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	1.5E+01	3.1E+01
Mammal/Bird tissue	mg/kg, dw	NA	NA	3.2E+00	NA	4.6E+00
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA	6.8E+00
Reptile tissue	mg/kg, dw	NA	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	4.8E+00	3.3E+00	6.8E+00
Concentrations in Diet Items (Modeled from Surface Water)²						
Plant tissue	mg/kg, dw	4.1E+00	NA	NA	NA	2.1E+00
Invertebrate tissue	mg/kg, dw	NA	NA	4.6E+00	4.9E+00	NA
Aerial insect tissue	mg/kg, dw	NA	1.7E+00	NA	NA	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	9.0E+00	6.6E+00
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA	7.6E-03
Fish tissue	mg/kg, dw	NA	NA	1.1E+01	1.1E+01	8.4E+00

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 6. PFOA NOAEL Risk-Based Screening Levels

		Aquatic Mammal				
Receptor		Muskrat	Little Brown Bat	River Otter	Harbor Seal	Mink
Media Exposed		Sediment	Sediment	Sediment	Sediment	Sediment
Bioaccessibility Factors						
Soil/Sediment	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Plant tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Prey tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Average Daily Dose - Soil or Sediment (ADD; mg/kg-bw/day)						
Plant tissue	mg/kg-day	3E-01	0E+00	0E+00	0E+00	6E-04
Invertebrate tissue	mg/kg-day	0E+00	0E+00	2E-01	2E-01	0E+00
Aerial insect tissue	mg/kg-day	0E+00	3E-01	0E+00	0E+00	0E+00
Crustacean tissue	mg/kg-day	0E+00	0E+00	0E+00	4E-03	5E-02
Mammal tissue	mg/kg-day	0E+00	0E+00	5E-03	0E+00	1E-02
Bird tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00
Amphibian tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	8E-03
Reptile tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00
Fish tissue	mg/kg-day	0E+00	0E+00	1E-01	8E-02	2E-01
Soil/Sediment	mg/kg-day	8E-03	0E+00	0E+00	1E-04	3E-04
Total (Food + Soil/Sediment)	mg/kg-day	3.0E-01	3.0E-01	3.0E-01	3.0E-01	3.0E-01
Average Daily Dose - Surface Water (ADD; mg/kg-bw/day)						
Plant tissue	mg/kg-day	2.98E-01	0.00E+00	0.00E+00	0.00E+00	8.54E-04
Invertebrate tissue	mg/kg-day	0.00E+00	0.00E+00	9.77E-03	1.94E-02	0.00E+00
Crustacean tissue	mg/kg-day	0.00E+00	0.00E+00	0.00E+00	2.57E-03	1.05E-02
Fish tissue	mg/kg-day	0.00E+00	0.00E+00	2.89E-01	2.77E-01	2.88E-01
Drinking water	mg/kg-day	1.8E-03	7.0E-04	9.8E-04	8.0E-04	9.3E-04
Total (Food + Drinking Water)	mg/kg-day	3.0E-01	3.0E-01	3.0E-01	3.0E-01	3.0E-01
Hazard Quotient (Soil/Sediment Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Hazard Quotient (Surface Water Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00

Appendix F - Wildlife Risk-Based Screening Level Calculations

Table 6. PFOA NOAEL Risk-Based Screening Levels

Notes

1. The risk-based screening level (RBSL) is the concentration in soil, sediment, or surface water where the average daily dose (ADD) is equal to the toxicity reference value (TRV), resulting in a hazard quotient (HQ) of 1.
2. Concentration in diet items is calculated as: $RBSL_{media} \times \text{bioaccumulation factor (BAF or BSAF)}$ where:
 - * the terrestrial plant, invertebrate, or mammal bioaccumulation factor (BAF) is used to calculate terrestrial receptor exposure from concentrations in soil (soil RBSL)
 - * the aquatic plant or invertebrate biota-sediment accumulation factor (BSAF) is used to calculate aquatic receptor exposure from concentrations in sediment (sediment RBSL)
 - * and the aquatic plant or invertebrate BAF is used to calculate aquatic receptor exposure from concentrations in surface water (SW RBSL)
3. The surface water (SW) RBSL incorporates only drinking water ingestion for terrestrial receptors. The aquatic receptor SW RBSL includes drinking water ingestion as well as bioaccumulation in the receptor's dietary items including aquatic plants, invertebrates, and fish.

Risk-Based Screening Level Equations

$$\text{Soil: } \frac{TRV}{\left(\frac{[(FIR * SIR) + (FIR * BAF)] * SUF}{BW} \right)}$$

$$\text{Sediment: } \frac{TRV}{\left(\frac{[(FIR * SIR) + (FIR * BSAF)] * SUF}{BW} \right)}$$

$$\text{Surface water: } \frac{TRV}{\left(\frac{DWR + (FIR * BAF)] * SUF}{BW} \right)}$$

% - percent

BAF - bioaccumulation factor

BSAF - biota-sediment accumulation factor

BW - body weight

DWR - drinking water rate

dw - dry weight

FIR - food ingestion rate

g - gram

L - liters

kg - kilogram

mg/L - milligrams per liter of surface water

mg/kg - milligrams per kilogram of soil or sediment

mg/kg-bw/day - milligrams per kilogram of body weight per day

NOAEL - no observed adverse effect level

RBSL - risk-based screening level

SIR - soil ingestion rate

SUF - site use factor

SW - surface water

TRV - toxicity reference value

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 7. PFHxA NOAEL Risk-Based Screening Levels

Receptor		Terrestrial Mammal			
		Meadow Vole	Short-Tailed Shrew	Little Brown Bat	Long-Tailed Weasel
Media Exposed		Soil	Soil	Soil	Soil
NOAEL-based TRV (mg/kg-bw/day)	Units	84	84	84	84
Risk-Based Screening Levels¹					
Soil Risk-Based Screening Level	mg/kg	1.2E+02	3.4E+02	2.5E+02	1.6E+02
Sediment Risk-Based Screening Level	mg/kg	NA	NA	NA	NA
Surface Water Risk-Based Screening Level ³	mg/L	6.1E+02	5.6E+02	5.3E+02	7.2E+02
Dietary Composition					
Plant tissue	fraction	9.8E-01	1.3E-01	0.0E+00	0.0E+00
Invertebrate tissue	fraction	2.0E-02	8.3E-01	0.0E+00	2.0E-02
Aerial insect tissue	fraction	0.0E+00	4.3E-02	1.0E+00	6.0E-02
Crustacean tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mammal/Bird tissue	fraction	0.0E+00	0.0E+00	0.0E+00	9.2E-01
Amphibian tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Reptile tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Fish tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Bioaccumulation Factors - Soil, Sediment, and Surface Water					
Plant tissue - Soil	unitless	2.2E+00	2.2E+00	2.2E+00	2.2E+00
Plant tissue - Sediment	unitless	4.7E+00	4.7E+00	4.7E+00	4.7E+00
Plant tissue - Surface Water	unitless	1.9E+02	1.9E+02	1.9E+02	1.9E+02
Terrestrial invertebrate tissue - Soil	unitless	1.9E+00	1.9E+00	1.9E+00	1.9E+00
Aquatic invertebrate tissue - Sediment	unitless	2.6E+02	2.6E+02	2.6E+02	2.6E+02
Aquatic invertebrate tissue - Surface Water	unitless	2.2E+03	2.2E+03	2.2E+03	2.2E+03
Aerial insect tissue - Soil	unitless	1.9E+00	1.9E+00	1.9E+00	1.9E+00
Aerial insect tissue - Sediment	unitless	2.6E+02	2.6E+02	2.6E+02	2.6E+02
Aquatic crustacean - Sediment	unitless	1.5E+02	1.5E+02	1.5E+02	1.5E+02
Aquatic crustacean - Surface Water	unitless	7.8E+02	7.8E+02	7.8E+02	7.8E+02
Mammal/Bird tissue - Soil or Sediment	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Amphibian tissue - Sediment	unitless	8.6E+01	8.6E+01	8.6E+01	8.6E+01
Amphibian tissue - Surface Water	unitless	2.9E+00	2.9E+00	2.9E+00	2.9E+00
Reptile tissue - Soil	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Fish tissue - Sediment	unitless	8.6E+01	8.6E+01	8.6E+01	8.6E+01
Fish tissue - Surface Water	unitless	3.2E+02	3.2E+02	3.2E+02	3.2E+02
Exposure Parameters					
Body weight	kg	3.7E-02	1.7E-02	9.0E-03	2.1E-01
Drinking water rate	L/day	5.1E-03	2.5E-03	1.4E-03	2.4E-02
Food ingestion rate	kg/day, dw	1.2E-02	2.2E-03	1.6E-03	1.0E-02
Fraction soil ingested	unitless	2.4E-02	2.4E-02	0.0E+00	2.8E-02
Site use factor	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Home range	acres	6.6E-02	9.6E-01	7.4E+01	2.6E+01
Concentrations in Diet Items (Modeled from Soil/Sediment)²					
Plant tissue	mg/kg, dw	2.7E+02	7.3E+02	NA	NA
Invertebrate tissue	mg/kg, dw	2.3E+02	6.3E+02	NA	3.0E+02
Crustacean tissue	mg/kg, dw	NA	NA	NA	NA
Mammal/Bird tissue	mg/kg, dw	NA	NA	NA	1.8E+03
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA
Reptile tissue	mg/kg, dw	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	NA	NA
Concentrations in Diet Items (Modeled from Surface Water)²					
Plant tissue	mg/kg, dw	NA	NA	NA	NA
Invertebrate tissue	mg/kg, dw	NA	NA	NA	NA
Aerial insect tissue	mg/kg, dw	NA	NA	NA	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	NA
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	NA	NA

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 7. PFHxA NOAEL Risk-Based Screening Levels

Receptor		Terrestrial Mammal			
		Meadow Vole	Short-Tailed Shrew	Little Brown Bat	Long-Tailed Weasel
Media Exposed		Soil	Soil	Soil	Soil
Bioaccessibility Factors					
Soil/Sediment	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Plant tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Prey tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Average Daily Dose - Soil or Sediment (ADD; mg/kg-bw/day)					
Plant tissue	mg/kg-day	8E+01	1E+01	0E+00	0E+00
Invertebrate tissue	mg/kg-day	1E+00	7E+01	0E+00	3E-01
Aerial insect tissue	mg/kg-day	0E+00	3E+00	8E+01	9E-01
Crustacean tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Mammal tissue	mg/kg-day	0E+00	0E+00	0E+00	8E+01
Bird tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Amphibian tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Reptile tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Fish tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Soil/Sediment	mg/kg-day	9E-01	1E+00	0E+00	2E-01
Total (Food + Soil/Sediment)	mg/kg-day	8.4E+01	8.4E+01	8.4E+01	8.4E+01
Average Daily Dose - Surface Water (ADD; mg/kg-bw/day)					
Plant tissue	mg/kg-day	NA	NA	NA	NA
Invertebrate tissue	mg/kg-day	NA	NA	NA	NA
Crustacean tissue	mg/kg-day	NA	NA	NA	NA
Fish tissue	mg/kg-day	NA	NA	NA	NA
Drinking water	mg/kg-day	8.4E+01	8.4E+01	8.4E+01	8.4E+01
Total (Food + Drinking Water)	mg/kg-day	8.4E+01	8.4E+01	8.4E+01	8.4E+01
Hazard Quotient (Soil/Sediment Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Hazard Quotient (Surface Water Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 7. PFHxA NOAEL Risk-Based Screening Levels

		Aquatic Mammal				
Receptor		Muskrat	Little Brown Bat	River Otter	Harbor Seal	Mink
Media Exposed		Sediment	Sediment	Sediment	Sediment	Sediment
NOAEL-based TRV (mg/kg-bw/day)	Units	84	84	84	84	84
Risk-Based Screening Levels¹						
Soil Risk-Based Screening Level	mg/kg	NA	NA	NA	NA	NA
Sediment Risk-Based Screening Level	mg/kg	2.4E+02	1.8E+00	2.9E+01	2.6E+01	2.5E+01
Surface Water Risk-Based Screening Level ³	mg/L	6.1E+00	2.1E-01	6.4E+00	5.0E+00	6.9E+00
Dietary Composition						
Plant tissue	fraction	1.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E-02
Invertebrate tissue	fraction	0.0E+00	0.0E+00	7.0E-02	1.4E-01	0.0E+00
Aerial insect tissue	fraction	0.0E+00	1.0E+00	0.0E+00	0.0E+00	0.0E+00
Crustacean tissue	fraction	0.0E+00	0.0E+00	0.0E+00	1.0E-02	4.0E-02
Mammal/Bird tissue	fraction	0.0E+00	0.0E+00	5.0E-02	0.0E+00	6.0E-02
Amphibian tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.0E-02
Reptile tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Fish tissue	fraction	0.0E+00	0.0E+00	8.8E-01	8.5E-01	8.6E-01
Bioaccumulation Factors - Soil, Sediment, and Surface Water						
Plant tissue - Soil	unitless	2.2E+00	2.2E+00	2.2E+00	2.2E+00	2.2E+00
Plant tissue - Sediment	unitless	4.7E+00	4.7E+00	4.7E+00	4.7E+00	4.7E+00
Plant tissue - Surface Water	unitless	1.9E+02	1.9E+02	1.9E+02	1.9E+02	1.9E+02
Terrestrial invertebrate tissue - Soil	unitless	1.9E+00	1.9E+00	1.9E+00	1.9E+00	1.9E+00
Aquatic invertebrate tissue - Sediment	unitless	2.6E+02	2.6E+02	2.6E+02	2.6E+02	2.6E+02
Aquatic invertebrate tissue - Surface Water	unitless	2.2E+03	2.2E+03	2.2E+03	2.2E+03	2.2E+03
Aerial insect tissue - Soil	unitless	1.9E+00	1.9E+00	1.9E+00	1.9E+00	1.9E+00
Aerial insect tissue - Sediment	unitless	2.6E+02	2.6E+02	2.6E+02	2.6E+02	2.6E+02
Aquatic crustacean - Sediment	unitless	1.5E+02	1.5E+02	1.5E+02	1.5E+02	1.5E+02
Aquatic crustacean - Surface Water	unitless	7.8E+02	7.8E+02	7.8E+02	7.8E+02	7.8E+02
Mammal/Bird tissue - Soil or Sediment	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Amphibian tissue - Sediment	unitless	8.6E+01	8.6E+01	8.6E+01	8.6E+01	8.6E+01
Amphibian tissue - Surface Water	unitless	2.9E+00	2.9E+00	2.9E+00	2.9E+00	2.9E+00
Reptile tissue - Soil	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Fish tissue - Sediment	unitless	8.6E+01	8.6E+01	8.6E+01	8.6E+01	8.6E+01
Fish tissue - Surface Water	unitless	3.2E+02	3.2E+02	3.2E+02	3.2E+02	3.2E+02
Exposure Parameters						
Body weight	kg	8.7E-01	9.0E-03	8.0E+00	9.9E+01	1.0E+00
Drinking water rate	L/day	8.8E-02	1.4E-03	6.4E-01	6.2E+00	1.0E-01
Food ingestion rate	kg/day, dw	6.3E-02	1.6E-03	2.4E-01	2.8E+00	4.1E-02
Fraction soil ingested	unitless	9.4E-02	0.0E+00	0.0E+00	2.0E-02	2.0E-02
Site use factor	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Home range	acres	2.7E-01	7.4E+01	8.6E+02	7.0E+05	7.1E+02
Concentrations in Diet Items (Modeled from Soil/Sediment)²						
Plant tissue	mg/kg, dw	1.1E+03	NA	NA	NA	1.2E+02
Invertebrate tissue	mg/kg, dw	NA	NA	7.7E+03	7.0E+03	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	4.1E+03	3.9E+03
Mammal/Bird tissue	mg/kg, dw	NA	NA	3.4E+02	NA	2.9E+02
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA	2.2E+03
Reptile tissue	mg/kg, dw	NA	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	2.5E+03	2.3E+03	2.2E+03
Concentrations in Diet Items (Modeled from Surface Water)²						
Plant tissue	mg/kg, dw	1.2E+03	NA	NA	NA	1.3E+03
Invertebrate tissue	mg/kg, dw	NA	NA	1.4E+04	1.1E+04	NA
Aerial insect tissue	mg/kg, dw	NA	4.7E+02	NA	NA	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	3.9E+03	5.3E+03
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA	2.0E+01
Fish tissue	mg/kg, dw	NA	NA	2.0E+03	1.6E+03	2.2E+03

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 7. PFHxA NOAEL Risk-Based Screening Levels

		Aquatic Mammal				
Receptor		Muskrat	Little Brown Bat	River Otter	Harbor Seal	Mink
Media Exposed		Sediment	Sediment	Sediment	Sediment	Sediment
Bioaccessibility Factors						
Soil/Sediment	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Plant tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Prey tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Average Daily Dose - Soil or Sediment (ADD; mg/kg-bw/day)						
Plant tissue	mg/kg-day	8E+01	0E+00	0E+00	0E+00	5E-02
Invertebrate tissue	mg/kg-day	0E+00	0E+00	2E+01	3E+01	0E+00
Aerial insect tissue	mg/kg-day	0E+00	8E+01	0E+00	0E+00	0E+00
Crustacean tissue	mg/kg-day	0E+00	0E+00	0E+00	1E+00	6E+00
Mammal tissue	mg/kg-day	0E+00	0E+00	5E-01	0E+00	7E-01
Bird tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00
Amphibian tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	3E+00
Reptile tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00
Fish tissue	mg/kg-day	0E+00	0E+00	7E+01	6E+01	7E+01
Soil/Sediment	mg/kg-day	2E+00	0E+00	0E+00	2E-02	2E-02
Total (Food + Soil/Sediment)	mg/kg-day	8.4E+01	8.4E+01	8.4E+01	8.4E+01	8.4E+01
Average Daily Dose - Surface Water (ADD; mg/kg-bw/day)						
Plant tissue	mg/kg-day	8.34E+01	0.00E+00	0.00E+00	0.00E+00	5.19E-01
Invertebrate tissue	mg/kg-day	0.00E+00	0.00E+00	3.00E+01	4.44E+01	0.00E+00
Crustacean tissue	mg/kg-day	0.00E+00	0.00E+00	0.00E+00	1.10E+00	8.48E+00
Fish tissue	mg/kg-day	0.00E+00	0.00E+00	5.35E+01	3.82E+01	7.43E+01
Drinking water	mg/kg-day	6.1E-01	3.3E-02	5.1E-01	3.1E-01	6.8E-01
Total (Food + Drinking Water)	mg/kg-day	8.4E+01	8.4E+01	8.4E+01	8.4E+01	8.4E+01
Hazard Quotient (Soil/Sediment Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Hazard Quotient (Surface Water Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00

Appendix F - Wildlife Risk-Based Screening Level Calculations

Table 7. PFHxA NOAEL Risk-Based Screening Levels

Notes

1. The risk-based screening level (RBSL) is the concentration in soil, sediment, or surface water where the average daily dose (ADD) is equal to the toxicity reference value (TRV), resulting in a hazard quotient (HQ) of 1.
2. Concentration in diet items is calculated as: $RBSL_{media} \times \text{bioaccumulation factor (BAF or BSAF)}$ where:
 - * the terrestrial plant, invertebrate, or mammal bioaccumulation factor (BAF) is used to calculate terrestrial receptor exposure from concentrations in soil (soil RBSL)
 - * the aquatic plant or invertebrate biota-sediment accumulation factor (BSAF) is used to calculate aquatic receptor exposure from concentrations in sediment (sediment RBSL)
 - * and the aquatic plant or invertebrate BAF is used to calculate aquatic receptor exposure from concentrations in surface water (SW RBSL)
3. The surface water (SW) RBSL incorporates only drinking water ingestion for terrestrial receptors. The aquatic receptor SW RBSL includes drinking water ingestion as well as bioaccumulation in the receptor's dietary items including aquatic plants, invertebrates, and fish.

Risk-Based Screening Level Equations

$$\text{Soil: } \frac{TRV}{\left(\frac{[(FIR * SIR) + (FIR * BAF)] * SUF}{BW} \right)}$$

$$\text{Sediment: } \frac{TRV}{\left(\frac{[(FIR * SIR) + (FIR * BSAF)] * SUF}{BW} \right)}$$

$$\text{Surface water: } \frac{TRV}{\left(\frac{DWR + (FIR * BAF)] * SUF}{BW} \right)}$$

% - percent

BAF - bioaccumulation factor

BSAF - biota-sediment accumulation factor

BW - body weight

DWR - drinking water rate

dw - dry weight

FIR - food ingestion rate

g - gram

L - liters

kg - kilogram

mg/L - milligrams per liter of surface water

mg/kg - milligrams per kilogram of soil or sediment

mg/kg-bw/day - milligrams per kilogram of body weight per day

NOAEL - no observed adverse effect level

RBSL - risk-based screening level

SIR - soil ingestion rate

SUF - site use factor

SW - surface water

TRV - toxicity reference value

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 8. PFBS NOAEL Risk-Based Screening Levels

Receptor		Terrestrial Mammal			
		Meadow Vole	Short-Tailed Shrew	Little Brown Bat	Long-Tailed Weasel
Media Exposed		Soil	Soil	Soil	Soil
NOAEL-based TRV (mg/kg-bw/day)	Units	50	50	50	50
Risk-Based Screening Levels¹					
Soil Risk-Based Screening Level	mg/kg	3.8E+01	1.4E+01	9.1E+00	7.8E+01
Sediment Risk-Based Screening Level	mg/kg	NA	NA	NA	NA
Surface Water Risk-Based Screening Level ³	mg/L	3.6E+02	3.4E+02	3.2E+02	4.3E+02
Dietary Composition					
Plant tissue	fraction	9.8E-01	1.3E-01	0.0E+00	0.0E+00
Invertebrate tissue	fraction	2.0E-02	8.3E-01	0.0E+00	2.0E-02
Aerial insect tissue	fraction	0.0E+00	4.3E-02	1.0E+00	6.0E-02
Crustacean tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mammal/Bird tissue	fraction	0.0E+00	0.0E+00	0.0E+00	9.2E-01
Amphibian tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Reptile tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Fish tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Bioaccumulation Factors - Soil, Sediment, and Surface Water					
Plant tissue - Soil	unitless	3.6E+00	3.6E+00	3.6E+00	3.6E+00
Plant tissue - Sediment	unitless	1.8E+00	1.8E+00	1.8E+00	1.8E+00
Plant tissue - Surface Water	unitless	7.8E+00	7.8E+00	7.8E+00	7.8E+00
Terrestrial invertebrate tissue - Soil	unitless	3.1E+01	3.1E+01	3.1E+01	3.1E+01
Aquatic invertebrate tissue - Sediment	unitless	2.6E+02	2.6E+02	2.6E+02	2.6E+02
Aquatic invertebrate tissue - Surface Water	unitless	3.0E+02	3.0E+02	3.0E+02	3.0E+02
Aerial insect tissue - Soil	unitless	3.1E+01	3.1E+01	3.1E+01	3.1E+01
Aerial insect tissue - Sediment	unitless	2.6E+02	2.6E+02	2.6E+02	2.6E+02
Aquatic crustacean - Sediment	unitless	1.5E+02	1.5E+02	1.5E+02	1.5E+02
Aquatic crustacean - Surface Water	unitless	3.9E+02	3.9E+02	3.9E+02	3.9E+02
Mammal/Bird tissue - Soil or Sediment	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Amphibian tissue - Sediment	unitless	8.6E+01	8.6E+01	8.6E+01	8.6E+01
Amphibian tissue - Surface Water	unitless	1.2E+03	1.2E+03	1.2E+03	1.2E+03
Reptile tissue - Soil	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Fish tissue - Sediment	unitless	8.6E+01	8.6E+01	8.6E+01	8.6E+01
Fish tissue - Surface Water	unitless	9.2E+02	9.2E+02	9.2E+02	9.2E+02
Exposure Parameters					
Body weight	kg	3.7E-02	1.7E-02	9.0E-03	2.1E-01
Drinking water rate	L/day	5.1E-03	2.5E-03	1.4E-03	2.4E-02
Food ingestion rate	kg/day, dw	1.2E-02	2.2E-03	1.6E-03	1.0E-02
Fraction soil ingested	unitless	2.4E-02	2.4E-02	0.0E+00	2.8E-02
Site use factor	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Home range	acres	6.6E-02	9.6E-01	7.4E+01	2.6E+01
Concentrations in Diet Items (Modeled from Soil/Sediment)²					
Plant tissue	mg/kg, dw	1.4E+02	5.1E+01	NA	NA
Invertebrate tissue	mg/kg, dw	1.2E+03	4.4E+02	NA	2.4E+03
Crustacean tissue	mg/kg, dw	NA	NA	NA	NA
Mammal/Bird tissue	mg/kg, dw	NA	NA	NA	8.9E+02
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA
Reptile tissue	mg/kg, dw	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	NA	NA
Concentrations in Diet Items (Modeled from Surface Water)²					
Plant tissue	mg/kg, dw	NA	NA	NA	NA
Invertebrate tissue	mg/kg, dw	NA	NA	NA	NA
Aerial insect tissue	mg/kg, dw	NA	NA	NA	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	NA
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	NA	NA

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 8. PFBS NOAEL Risk-Based Screening Levels

		Terrestrial Mammal			
Receptor		Meadow Vole	Short-Tailed Shrew	Little Brown Bat	Long-Tailed Weasel
Media Exposed		Soil	Soil	Soil	Soil
Bioaccessibility Factors					
Soil/Sediment	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Plant tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Prey tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Average Daily Dose - Soil or Sediment (ADD; mg/kg-bw/day)					
Plant tissue	mg/kg-day	4E+01	9E-01	0E+00	0E+00
Invertebrate tissue	mg/kg-day	7E+00	5E+01	0E+00	2E+00
Aerial insect tissue	mg/kg-day	0E+00	2E+00	5E+01	7E+00
Crustacean tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Mammal tissue	mg/kg-day	0E+00	0E+00	0E+00	4E+01
Bird tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Amphibian tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Reptile tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Fish tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Soil/Sediment	mg/kg-day	3E-01	4E-02	0E+00	1E-01
Total (Food + Soil/Sediment)	mg/kg-day	5.0E+01	5.0E+01	5.0E+01	5.0E+01
Average Daily Dose - Surface Water (ADD; mg/kg-bw/day)					
Plant tissue	mg/kg-day	NA	NA	NA	NA
Invertebrate tissue	mg/kg-day	NA	NA	NA	NA
Crustacean tissue	mg/kg-day	NA	NA	NA	NA
Fish tissue	mg/kg-day	NA	NA	NA	NA
Drinking water	mg/kg-day	5.0E+01	5.0E+01	5.0E+01	5.0E+01
Total (Food + Drinking Water)	mg/kg-day	5.0E+01	5.0E+01	5.0E+01	5.0E+01
Hazard Quotient (Soil/Sediment Exposure)					
	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Hazard Quotient (Surface Water Exposure)					
	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 8. PFBS NOAEL Risk-Based Screening Levels

		Aquatic Mammal				
Receptor		Muskrat	Little Brown Bat	River Otter	Harbor Seal	Mink
Media Exposed		Sediment	Sediment	Sediment	Sediment	Sediment
NOAEL-based TRV (mg/kg-bw/day)	Units	50	50	50	50	50
Risk-Based Screening Levels¹						
Soil Risk-Based Screening Level	mg/kg	NA	NA	NA	NA	NA
Sediment Risk-Based Screening Level	mg/kg	3.7E+02	1.1E+00	1.8E+01	1.6E+01	1.5E+01
Surface Water Risk-Based Screening Level ³	mg/L	7.6E+01	9.4E-01	2.0E+00	2.1E+00	1.5E+00
Dietary Composition						
Plant tissue	fraction	1.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E-02
Invertebrate tissue	fraction	0.0E+00	0.0E+00	7.0E-02	1.4E-01	0.0E+00
Aerial insect tissue	fraction	0.0E+00	1.0E+00	0.0E+00	0.0E+00	0.0E+00
Crustacean tissue	fraction	0.0E+00	0.0E+00	0.0E+00	1.0E-02	4.0E-02
Mammal/Bird tissue	fraction	0.0E+00	0.0E+00	5.0E-02	0.0E+00	6.0E-02
Amphibian tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.0E-02
Reptile tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Fish tissue	fraction	0.0E+00	0.0E+00	8.8E-01	8.5E-01	8.6E-01
Bioaccumulation Factors - Soil, Sediment, and Surface Water						
Plant tissue - Soil	unitless	3.6E+00	3.6E+00	3.6E+00	3.6E+00	3.6E+00
Plant tissue - Sediment	unitless	1.8E+00	1.8E+00	1.8E+00	1.8E+00	1.8E+00
Plant tissue - Surface Water	unitless	7.8E+00	7.8E+00	7.8E+00	7.8E+00	7.8E+00
Terrestrial invertebrate tissue - Soil	unitless	3.1E+01	3.1E+01	3.1E+01	3.1E+01	3.1E+01
Aquatic invertebrate tissue - Sediment	unitless	2.6E+02	2.6E+02	2.6E+02	2.6E+02	2.6E+02
Aquatic invertebrate tissue - Surface Water	unitless	3.0E+02	3.0E+02	3.0E+02	3.0E+02	3.0E+02
Aerial insect tissue - Soil	unitless	3.1E+01	3.1E+01	3.1E+01	3.1E+01	3.1E+01
Aerial insect tissue - Sediment	unitless	2.6E+02	2.6E+02	2.6E+02	2.6E+02	2.6E+02
Aquatic crustacean - Sediment	unitless	1.5E+02	1.5E+02	1.5E+02	1.5E+02	1.5E+02
Aquatic crustacean - Surface Water	unitless	3.9E+02	3.9E+02	3.9E+02	3.9E+02	3.9E+02
Mammal/Bird tissue - Soil or Sediment	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Amphibian tissue - Sediment	unitless	8.6E+01	8.6E+01	8.6E+01	8.6E+01	8.6E+01
Amphibian tissue - Surface Water	unitless	1.2E+03	1.2E+03	1.2E+03	1.2E+03	1.2E+03
Reptile tissue - Soil	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Fish tissue - Sediment	unitless	8.6E+01	8.6E+01	8.6E+01	8.6E+01	8.6E+01
Fish tissue - Surface Water	unitless	9.2E+02	9.2E+02	9.2E+02	9.2E+02	9.2E+02
Exposure Parameters						
Body weight	kg	8.7E-01	9.0E-03	8.0E+00	9.9E+01	1.0E+00
Drinking water rate	L/day	8.8E-02	1.4E-03	6.4E-01	6.2E+00	1.0E-01
Food ingestion rate	kg/day, dw	6.3E-02	1.6E-03	2.4E-01	2.8E+00	4.1E-02
Fraction soil ingested	unitless	9.4E-02	0.0E+00	0.0E+00	2.0E-02	2.0E-02
Site use factor	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Home range	acres	2.7E-01	7.4E+01	8.6E+02	7.0E+05	7.1E+02
Concentrations in Diet Items (Modeled from Soil/Sediment)²						
Plant tissue	mg/kg, dw	6.6E+02	NA	NA	NA	2.7E+01
Invertebrate tissue	mg/kg, dw	NA	NA	4.6E+03	4.1E+03	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	2.4E+03	2.3E+03
Mammal/Bird tissue	mg/kg, dw	NA	NA	2.0E+02	NA	1.7E+02
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA	1.3E+03
Reptile tissue	mg/kg, dw	NA	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	1.5E+03	1.4E+03	1.3E+03
Concentrations in Diet Items (Modeled from Surface Water)²						
Plant tissue	mg/kg, dw	5.9E+02	NA	NA	NA	1.2E+01
Invertebrate tissue	mg/kg, dw	NA	NA	6.0E+02	6.4E+02	NA
Aerial insect tissue	mg/kg, dw	NA	2.8E+02	NA	NA	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	8.3E+02	5.8E+02
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA	1.8E+03
Fish tissue	mg/kg, dw	NA	NA	1.8E+03	2.0E+03	1.4E+03

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 8. PFBS NOAEL Risk-Based Screening Levels

Receptor	Media Exposed	Aquatic Mammal				
		Muskrat	Little Brown Bat	River Otter	Harbor Seal	Mink
		Sediment	Sediment	Sediment	Sediment	Sediment
Bioaccessibility Factors						
Soil/Sediment	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Plant tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Prey tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Average Daily Dose - Soil or Sediment (ADD; mg/kg-bw/day)						
Plant tissue	mg/kg-day	5E+01	0E+00	0E+00	0E+00	1E-02
Invertebrate tissue	mg/kg-day	0E+00	0E+00	1E+01	2E+01	0E+00
Aerial insect tissue	mg/kg-day	0E+00	5E+01	0E+00	0E+00	0E+00
Crustacean tissue	mg/kg-day	0E+00	0E+00	0E+00	7E-01	4E+00
Mammal tissue	mg/kg-day	0E+00	0E+00	3E-01	0E+00	4E-01
Bird tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00
Amphibian tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	2E+00
Reptile tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00
Fish tissue	mg/kg-day	0E+00	0E+00	4E+01	3E+01	4E+01
Soil/Sediment	mg/kg-day	2E+00	0E+00	0E+00	9E-03	1E-02
Total (Food + Soil/Sediment)	mg/kg-day	5.0E+01	5.0E+01	5.0E+01	5.0E+01	5.0E+01
Average Daily Dose - Surface Water (ADD; mg/kg-bw/day)						
Plant tissue	mg/kg-day	4.24E+01	0.00E+00	0.00E+00	0.00E+00	4.61E-03
Invertebrate tissue	mg/kg-day	0.00E+00	0.00E+00	1.26E+00	2.53E+00	0.00E+00
Crustacean tissue	mg/kg-day	0.00E+00	0.00E+00	0.00E+00	2.35E-01	9.22E-01
Fish tissue	mg/kg-day	0.00E+00	0.00E+00	4.86E+01	4.71E+01	4.68E+01
Drinking water	mg/kg-day	7.6E+00	1.5E-01	1.6E-01	1.3E-01	1.5E-01
Total (Food + Drinking Water)	mg/kg-day	5.0E+01	5.0E+01	5.0E+01	5.0E+01	5.0E+01
Hazard Quotient (Soil/Sediment Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Hazard Quotient (Surface Water Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 8. PFBS NOAEL Risk-Based Screening Levels

		Terrestrial Bird			Aquatic Bird		
Receptor		American Goldfinch	House Wren	Red-Tailed Hawk	Red-Winged Blackbird	Tree Swallow	Brown Pelican
Media Exposed		Soil	Soil	Soil	Sediment	Sediment	Sediment
NOAEL-based TRV (mg/kg-bw/day)	Units	92	92	92	92	92	92
Risk-Based Screening Levels¹							
Soil Risk-Based Screening Level	mg/kg	8.9E+01	9.3E+00	1.0E+02	NA	NA	NA
Sediment Risk-Based Screening Level	mg/kg	NA	NA	NA	2.4E+01	7.3E-01	1.3E+01
Surface Water Risk-Based Screening Level ³	mg/L	3.7E+02	3.5E+02	1.6E+03	1.7E+01	6.4E-01	1.3E+00
Dietary Composition							
Plant tissue	fraction	1.0E+00	0.0E+00	0.0E+00	9.2E-01	1.7E-01	0.0E+00
Invertebrate tissue	fraction	0.0E+00	8.5E-01	0.0E+00	7.6E-02	2.6E-01	0.0E+00
Aerial insect tissue	fraction	0.0E+00	1.5E-01	0.0E+00	0.0E+00	5.7E-01	0.0E+00
Crustacean tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mammal/Bird tissue	fraction	0.0E+00	0.0E+00	8.7E-01	0.0E+00	0.0E+00	0.0E+00
Amphibian tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Reptile tissue	fraction	0.0E+00	0.0E+00	1.3E-01	0.0E+00	0.0E+00	0.0E+00
Fish tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00
Bioaccumulation Factors - Soil, Sediment, and Surface Water							
Plant tissue - Soil	unitless	3.6E+00	3.6E+00	3.6E+00	3.6E+00	3.6E+00	3.6E+00
Plant tissue - Sediment	unitless	1.8E+00	1.8E+00	1.8E+00	1.8E+00	1.8E+00	1.8E+00
Plant tissue - Surface Water	unitless	7.8E+00	7.8E+00	7.8E+00	7.8E+00	7.8E+00	7.8E+00
Terrestrial invertebrate tissue - Soil	unitless	3.1E+01	3.1E+01	3.1E+01	3.1E+01	3.1E+01	3.1E+01
Aquatic invertebrate tissue - Sediment	unitless	2.6E+02	2.6E+02	2.6E+02	2.6E+02	2.6E+02	2.6E+02
Aquatic invertebrate tissue - Surface Water	unitless	3.0E+02	3.0E+02	3.0E+02	3.0E+02	3.0E+02	3.0E+02
Aerial insect tissue - Soil	unitless	3.1E+01	3.1E+01	3.1E+01	3.1E+01	3.1E+01	3.1E+01
Aerial insect tissue - Sediment	unitless	2.6E+02	2.6E+02	2.6E+02	2.6E+02	2.6E+02	2.6E+02
Aquatic crustacean - Sediment	unitless	1.5E+02	1.5E+02	1.5E+02	1.5E+02	1.5E+02	1.5E+02
Aquatic crustacean - Surface Water	unitless	3.9E+02	3.9E+02	3.9E+02	3.9E+02	3.9E+02	3.9E+02
Mammal/Bird tissue - Soil or Sediment	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Amphibian tissue - Sediment	unitless	8.6E+01	8.6E+01	8.6E+01	8.6E+01	8.6E+01	8.6E+01
Amphibian tissue - Surface Water	unitless	1.2E+03	1.2E+03	1.2E+03	1.2E+03	1.2E+03	1.2E+03
Reptile tissue - Soil	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Fish tissue - Sediment	unitless	8.6E+01	8.6E+01	8.6E+01	8.6E+01	8.6E+01	8.6E+01
Fish tissue - Surface Water	unitless	9.2E+02	9.2E+02	9.2E+02	9.2E+02	9.2E+02	9.2E+02
Exposure Parameters							
Body weight	kg	1.3E-02	1.1E-02	1.1E+00	5.7E-02	2.0E-02	3.4E+00
Drinking water rate	L/day	3.2E-03	2.8E-03	6.4E-02	8.7E-03	4.3E-03	1.3E-01
Food ingestion rate	kg/day, dw	3.7E-03	3.4E-03	9.0E-02	1.0E-02	1.2E-02	2.7E-01
Fraction soil ingested	unitless	9.3E-02	1.0E-01	0.0E+00	9.3E-02	0.0E+00	2.0E-02
Site use factor	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Home range	acres	1.2E+04	2.3E+00	1.7E+03	1.5E+05	9.5E+03	3.1E+05
Concentrations in Diet Items (Modeled from Soil/Sediment)²							
Plant tissue	mg/kg, dw	3.2E+02	NA	NA	4.4E+01	1.3E+00	NA
Invertebrate tissue	mg/kg, dw	NA	2.9E+02	NA	6.4E+03	1.9E+02	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	NA	NA	NA
Mammal/Bird tissue	mg/kg, dw	NA	NA	1.2E+03	NA	NA	NA
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA	NA	NA
Reptile tissue	mg/kg, dw	NA	NA	1.2E+03	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	NA	NA	NA	1.2E+03
Concentrations in Diet Items (Modeled from Surface Water)²							
Plant tissue	mg/kg, dw	NA	NA	NA	1.3E+02	5.0E+00	NA
Invertebrate tissue	mg/kg, dw	NA	NA	NA	5.1E+03	1.9E+02	NA
Aerial insect tissue	mg/kg, dw	NA	NA	NA	NA	1.9E+02	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	NA	NA	NA
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	NA	NA	NA	1.2E+03

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 8. PFBS NOAEL Risk-Based Screening Levels

Receptor		Terrestrial Bird			Aquatic Bird		
		American Goldfinch	House Wren	Red-Tailed Hawk	Red-Winged Blackbird	Tree Swallow	Brown Pelican
Media Exposed		Soil	Soil	Soil	Sediment	Sediment	Sediment
Bioaccessibility Factors							
Soil/Sediment	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Plant tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Prey tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Average Daily Dose - Soil or Sediment (ADD; mg/kg-bw/day)							
Plant tissue	mg/kg-day	9E+01	0E+00	0E+00	7E+00	1E-01	0E+00
Invertebrate tissue	mg/kg-day	0E+00	8E+01	0E+00	8E+01	3E+01	0E+00
Aerial insect tissue	mg/kg-day	0E+00	1E+01	0E+00	0E+00	6E+01	0E+00
Crustacean tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00
Mammal tissue	mg/kg-day	0E+00	0E+00	8E+01	0E+00	0E+00	0E+00
Bird tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00
Amphibian tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00
Reptile tissue	mg/kg-day	0E+00	0E+00	1E+01	0E+00	0E+00	0E+00
Fish tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00	9E+01
Soil/Sediment	mg/kg-day	2E+00	3E-01	0E+00	4E-01	0E+00	2E-02
Total (Food + Soil/Sediment)	mg/kg-day	9.2E+01	9.2E+01	9.2E+01	9.2E+01	9.2E+01	9.2E+01
Average Daily Dose - Surface Water (ADD; mg/kg-bw/day)							
Plant tissue	mg/kg-day	NA	NA	NA	2.15E+01	4.83E-01	0.00E+00
Invertebrate tissue	mg/kg-day	NA	NA	NA	6.79E+01	2.86E+01	0.00E+00
Crustacean tissue	mg/kg-day	NA	NA	NA	0.00E+00	0.00E+00	0.00E+00
Fish tissue	mg/kg-day	NA	NA	NA	0.00E+00	0.00E+00	9.20E+01
Drinking water	mg/kg-day	9.2E+01	9.2E+01	9.2E+01	2.6E+00	1.4E-01	5.0E-02
Total (Food + Drinking Water)	mg/kg-day	9.2E+01	9.2E+01	9.2E+01	9.2E+01	9.2E+01	9.2E+01
Hazard Quotient (Soil/Sediment Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Hazard Quotient (Surface Water Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00

Appendix F - Wildlife Risk-Based Screening Level Calculations

Table 8. PFBS NOAEL Risk-Based Screening Levels

Notes

1. The risk-based screening level (RBSL) is the concentration in soil, sediment, or surface water where the average daily dose (ADD) is equal to the toxicity reference value (TRV), resulting in a hazard quotient (HQ) of 1.
2. Concentration in diet items is calculated as: $RBSL_{media} \times \text{bioaccumulation factor (BAF or BSAF)}$ where:
 - * the terrestrial plant, invertebrate, or mammal bioaccumulation factor (BAF) is used to calculate terrestrial receptor exposure from concentrations in soil (soil RBSL)
 - * the aquatic plant or invertebrate biota-sediment accumulation factor (BSAF) is used to calculate aquatic receptor exposure from concentrations in sediment (sediment RBSL)
 - * and the aquatic plant or invertebrate BAF is used to calculate aquatic receptor exposure from concentrations in surface water (SW RBSL)
3. The surface water (SW) RBSL incorporates only drinking water ingestion for terrestrial receptors. The aquatic receptor SW RBSL includes drinking water ingestion as well as bioaccumulation in the receptor's dietary items including aquatic plants, invertebrates, and fish.

Risk-Based Screening Level Equations

$$\text{Soil: } \frac{TRV}{\left(\frac{[(FIR * SIR) + (FIR * BAF)] * SUF}{BW} \right)}$$

$$\text{Sediment: } \frac{TRV}{\left(\frac{[(FIR * SIR) + (FIR * BSAF)] * SUF}{BW} \right)}$$

$$\text{Surface water: } \frac{TRV}{\left(\frac{DWR + (FIR * BAF)] * SUF}{BW} \right)}$$

% - percent

BAF - bioaccumulation factor

BSAF - biota-sediment accumulation factor

BW - body weight

DWR - drinking water rate

dw - dry weight

FIR - food ingestion rate

g - gram

L - liters

kg - kilogram

mg/L - milligrams per liter of surface water

mg/kg - milligrams per kilogram of soil or sediment

mg/kg-bw/day - milligrams per kilogram of body weight per day

NOAEL - no observed adverse effect level

RBSL - risk-based screening level

SIR - soil ingestion rate

SUF - site use factor

SW - surface water

TRV - toxicity reference value

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 9. PFBA NOAEL Risk-Based Screening Levels

Receptor		Terrestrial Mammal			
		Meadow Vole	Short-Tailed Shrew	Little Brown Bat	Long-Tailed Weasel
Media Exposed		Soil	Soil	Soil	Soil
NOAEL-based TRV (mg/kg-bw/day)	Units	73	73	73	73
Risk-Based Screening Levels¹					
Soil Risk-Based Screening Level	mg/kg	2.9E+01	7.8E+01	5.8E+01	1.3E+02
Sediment Risk-Based Screening Level	mg/kg	NA	NA	NA	NA
Surface Water Risk-Based Screening Level ³	mg/L	5.3E+02	4.9E+02	4.6E+02	6.3E+02
Dietary Composition					
Plant tissue	fraction	9.8E-01	1.3E-01	0.0E+00	0.0E+00
Invertebrate tissue	fraction	2.0E-02	8.3E-01	0.0E+00	2.0E-02
Aerial insect tissue	fraction	0.0E+00	4.3E-02	1.0E+00	6.0E-02
Crustacean tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mammal/Bird tissue	fraction	0.0E+00	0.0E+00	0.0E+00	9.2E-01
Amphibian tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Reptile tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Fish tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Bioaccumulation Factors - Soil, Sediment, and Surface Water					
Plant tissue - Soil	unitless	8.0E+00	8.0E+00	8.0E+00	8.0E+00
Plant tissue - Sediment	unitless	6.2E+00	6.2E+00	6.2E+00	6.2E+00
Plant tissue - Surface Water	unitless	1.9E+01	1.9E+01	1.9E+01	1.9E+01
Terrestrial invertebrate tissue - Soil	unitless	7.1E+00	7.1E+00	7.1E+00	7.1E+00
Aquatic invertebrate tissue - Sediment	unitless	2.6E+02	2.6E+02	2.6E+02	2.6E+02
Aquatic invertebrate tissue - Surface Water	unitless	3.0E+02	3.0E+02	3.0E+02	3.0E+02
Aerial insect tissue - Soil	unitless	7.1E+00	7.1E+00	7.1E+00	7.1E+00
Aerial insect tissue - Sediment	unitless	2.6E+02	2.6E+02	2.6E+02	2.6E+02
Aquatic crustacean - Sediment	unitless	1.5E+02	1.5E+02	1.5E+02	1.5E+02
Aquatic crustacean - Surface Water	unitless	3.9E+02	3.9E+02	3.9E+02	3.9E+02
Mammal/Bird tissue - Soil or Sediment	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Amphibian tissue - Sediment	unitless	8.6E+01	8.6E+01	8.6E+01	8.6E+01
Amphibian tissue - Surface Water	unitless	2.9E+00	2.9E+00	2.9E+00	2.9E+00
Reptile tissue - Soil	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Fish tissue - Sediment	unitless	8.6E+01	8.6E+01	8.6E+01	8.6E+01
Fish tissue - Surface Water	unitless	3.2E+03	3.2E+03	3.2E+03	3.2E+03
Exposure Parameters					
Body weight	kg	3.7E-02	1.7E-02	9.0E-03	2.1E-01
Drinking water rate	L/day	5.1E-03	2.5E-03	1.4E-03	2.4E-02
Food ingestion rate	kg/day, dw	1.2E-02	2.2E-03	1.6E-03	1.0E-02
Fraction soil ingested	unitless	2.4E-02	2.4E-02	0.0E+00	2.8E-02
Site use factor	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Home range	acres	6.6E-02	9.6E-01	7.4E+01	2.6E+01
Concentrations in Diet Items (Modeled from Soil/Sediment)²					
Plant tissue	mg/kg, dw	2.3E+02	6.2E+02	NA	NA
Invertebrate tissue	mg/kg, dw	2.1E+02	5.6E+02	NA	9.5E+02
Crustacean tissue	mg/kg, dw	NA	NA	NA	NA
Mammal/Bird tissue	mg/kg, dw	NA	NA	NA	1.5E+03
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA
Reptile tissue	mg/kg, dw	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	NA	NA
Concentrations in Diet Items (Modeled from Surface Water)²					
Plant tissue	mg/kg, dw	NA	NA	NA	NA
Invertebrate tissue	mg/kg, dw	NA	NA	NA	NA
Aerial insect tissue	mg/kg, dw	NA	NA	NA	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	NA
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	NA	NA

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 9. PFBA NOAEL Risk-Based Screening Levels

Receptor		Terrestrial Mammal			
		Meadow Vole	Short-Tailed Shrew	Little Brown Bat	Long-Tailed Weasel
Media Exposed		Soil	Soil	Soil	Soil
Bioaccessibility Factors					
Soil/Sediment	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Plant tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Prey tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Average Daily Dose - Soil or Sediment (ADD; mg/kg-bw/day)					
Plant tissue	mg/kg-day	7E+01	1E+01	0E+00	0E+00
Invertebrate tissue	mg/kg-day	1E+00	6E+01	0E+00	9E-01
Aerial insect tissue	mg/kg-day	0E+00	3E+00	7E+01	3E+00
Crustacean tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Mammal tissue	mg/kg-day	0E+00	0E+00	0E+00	7E+01
Bird tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Amphibian tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Reptile tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Fish tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Soil/Sediment	mg/kg-day	2E-01	2E-01	0E+00	2E-01
Total (Food + Soil/Sediment)	mg/kg-day	7.3E+01	7.3E+01	7.3E+01	7.3E+01
Average Daily Dose - Surface Water (ADD; mg/kg-bw/day)					
Plant tissue	mg/kg-day	NA	NA	NA	NA
Invertebrate tissue	mg/kg-day	NA	NA	NA	NA
Crustacean tissue	mg/kg-day	NA	NA	NA	NA
Fish tissue	mg/kg-day	NA	NA	NA	NA
Drinking water	mg/kg-day	7.3E+01	7.3E+01	7.3E+01	7.3E+01
Total (Food + Drinking Water)	mg/kg-day	7.3E+01	7.3E+01	7.3E+01	7.3E+01
Hazard Quotient (Soil/Sediment Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Hazard Quotient (Surface Water Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 9. PFBA NOAEL Risk-Based Screening Levels

		Aquatic Mammal				
Receptor		Muskrat	Little Brown Bat	River Otter	Harbor Seal	Mink
Media Exposed		Sediment	Sediment	Sediment	Sediment	Sediment
NOAEL-based TRV (mg/kg-bw/day)	Units	73	73	73	73	73
Risk-Based Screening Levels¹						
Soil Risk-Based Screening Level	mg/kg	NA	NA	NA	NA	NA
Sediment Risk-Based Screening Level	mg/kg	1.6E+02	1.6E+00	2.6E+01	2.3E+01	2.2E+01
Surface Water Risk-Based Screening Level ³	mg/L	4.9E+01	1.4E+00	8.6E-01	9.3E-01	6.6E-01
Dietary Composition						
Plant tissue	fraction	1.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E-02
Invertebrate tissue	fraction	0.0E+00	0.0E+00	7.0E-02	1.4E-01	0.0E+00
Aerial insect tissue	fraction	0.0E+00	1.0E+00	0.0E+00	0.0E+00	0.0E+00
Crustacean tissue	fraction	0.0E+00	0.0E+00	0.0E+00	1.0E-02	4.0E-02
Mammal/Bird tissue	fraction	0.0E+00	0.0E+00	5.0E-02	0.0E+00	6.0E-02
Amphibian tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.0E-02
Reptile tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Fish tissue	fraction	0.0E+00	0.0E+00	8.8E-01	8.5E-01	8.6E-01
Bioaccumulation Factors - Soil, Sediment, and Surface Water						
Plant tissue - Soil	unitless	8.0E+00	8.0E+00	8.0E+00	8.0E+00	8.0E+00
Plant tissue - Sediment	unitless	6.2E+00	6.2E+00	6.2E+00	6.2E+00	6.2E+00
Plant tissue - Surface Water	unitless	1.9E+01	1.9E+01	1.9E+01	1.9E+01	1.9E+01
Terrestrial invertebrate tissue - Soil	unitless	7.1E+00	7.1E+00	7.1E+00	7.1E+00	7.1E+00
Aquatic invertebrate tissue - Sediment	unitless	2.6E+02	2.6E+02	2.6E+02	2.6E+02	2.6E+02
Aquatic invertebrate tissue - Surface Water	unitless	3.0E+02	3.0E+02	3.0E+02	3.0E+02	3.0E+02
Aerial insect tissue - Soil	unitless	7.1E+00	7.1E+00	7.1E+00	7.1E+00	7.1E+00
Aerial insect tissue - Sediment	unitless	2.6E+02	2.6E+02	2.6E+02	2.6E+02	2.6E+02
Aquatic crustacean - Sediment	unitless	1.5E+02	1.5E+02	1.5E+02	1.5E+02	1.5E+02
Aquatic crustacean - Surface Water	unitless	3.9E+02	3.9E+02	3.9E+02	3.9E+02	3.9E+02
Mammal/Bird tissue - Soil or Sediment	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Amphibian tissue - Sediment	unitless	8.6E+01	8.6E+01	8.6E+01	8.6E+01	8.6E+01
Amphibian tissue - Surface Water	unitless	2.9E+00	2.9E+00	2.9E+00	2.9E+00	2.9E+00
Reptile tissue - Soil	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Fish tissue - Sediment	unitless	8.6E+01	8.6E+01	8.6E+01	8.6E+01	8.6E+01
Fish tissue - Surface Water	unitless	3.2E+03	3.2E+03	3.2E+03	3.2E+03	3.2E+03
Exposure Parameters						
Body weight	kg	8.7E-01	9.0E-03	8.0E+00	9.9E+01	1.0E+00
Drinking water rate	L/day	8.8E-02	1.4E-03	6.4E-01	6.2E+00	1.0E-01
Food ingestion rate	kg/day, dw	6.3E-02	1.6E-03	2.4E-01	2.8E+00	4.1E-02
Fraction soil ingested	unitless	9.4E-02	0.0E+00	0.0E+00	2.0E-02	2.0E-02
Site use factor	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Home range	acres	2.7E-01	7.4E+01	8.6E+02	7.0E+05	7.1E+02
Concentrations in Diet Items (Modeled from Soil/Sediment)²						
Plant tissue	mg/kg, dw	1.0E+03	NA	NA	NA	1.4E+02
Invertebrate tissue	mg/kg, dw	NA	NA	6.7E+03	6.0E+03	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	3.5E+03	3.4E+03
Mammal/Bird tissue	mg/kg, dw	NA	NA	2.9E+02	NA	2.5E+02
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA	1.9E+03
Reptile tissue	mg/kg, dw	NA	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	2.2E+03	2.0E+03	1.9E+03
Concentrations in Diet Items (Modeled from Surface Water)²						
Plant tissue	mg/kg, dw	9.5E+02	NA	NA	NA	1.3E+01
Invertebrate tissue	mg/kg, dw	NA	NA	2.6E+02	2.8E+02	NA
Aerial insect tissue	mg/kg, dw	NA	4.1E+02	NA	NA	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	3.6E+02	2.6E+02
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA	2.0E+00
Fish tissue	mg/kg, dw	NA	NA	2.7E+03	3.0E+03	2.1E+03

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 9. PFBA NOAEL Risk-Based Screening Levels

		Aquatic Mammal				
Receptor		Muskrat	Little Brown Bat	River Otter	Harbor Seal	Mink
Media Exposed		Sediment	Sediment	Sediment	Sediment	Sediment
Bioaccessibility Factors						
Soil/Sediment	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Plant tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Prey tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Average Daily Dose - Soil or Sediment (ADD; mg/kg-bw/day)						
Plant tissue	mg/kg-day	7E+01	0E+00	0E+00	0E+00	5E-02
Invertebrate tissue	mg/kg-day	0E+00	0E+00	1E+01	2E+01	0E+00
Aerial insect tissue	mg/kg-day	0E+00	7E+01	0E+00	0E+00	0E+00
Crustacean tissue	mg/kg-day	0E+00	0E+00	0E+00	1E+00	5E+00
Mammal tissue	mg/kg-day	0E+00	0E+00	4E-01	0E+00	6E-01
Bird tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00
Amphibian tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	2E+00
Reptile tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00
Fish tissue	mg/kg-day	0E+00	0E+00	6E+01	5E+01	6E+01
Soil/Sediment	mg/kg-day	1E+00	0E+00	0E+00	1E-02	2E-02
Total (Food + Soil/Sediment)	mg/kg-day	7.3E+01	7.3E+01	7.3E+01	7.3E+01	7.3E+01
Average Daily Dose - Surface Water (ADD; mg/kg-bw/day)						
Plant tissue	mg/kg-day	6.81E+01	0.00E+00	0.00E+00	0.00E+00	5.11E-03
Invertebrate tissue	mg/kg-day	0.00E+00	0.00E+00	5.37E-01	1.10E+00	0.00E+00
Crustacean tissue	mg/kg-day	0.00E+00	0.00E+00	0.00E+00	1.02E-01	4.09E-01
Fish tissue	mg/kg-day	0.00E+00	0.00E+00	7.24E+01	7.17E+01	7.25E+01
Drinking water	mg/kg-day	4.9E+00	2.2E-01	6.9E-02	5.8E-02	6.5E-02
Total (Food + Drinking Water)	mg/kg-day	7.3E+01	7.3E+01	7.3E+01	7.3E+01	7.3E+01
Hazard Quotient (Soil/Sediment Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Hazard Quotient (Surface Water Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00

Appendix F - Wildlife Risk-Based Screening Level Calculations

Table 9. PFBA NOAEL Risk-Based Screening Levels

Notes

1. The risk-based screening level (RBSL) is the concentration in soil, sediment, or surface water where the average daily dose (ADD) is equal to the toxicity reference value (TRV), resulting in a hazard quotient (HQ) of 1.
2. Concentration in diet items is calculated as: $RBSL_{media} \times \text{bioaccumulation factor (BAF or BSAF)}$ where:
 - * the terrestrial plant, invertebrate, or mammal bioaccumulation factor (BAF) is used to calculate terrestrial receptor exposure from concentrations in soil (soil RBSL)
 - * the aquatic plant or invertebrate biota-sediment accumulation factor (BSAF) is used to calculate aquatic receptor exposure from concentrations in sediment (sediment RBSL)
 - * and the aquatic plant or invertebrate BAF is used to calculate aquatic receptor exposure from concentrations in surface water (SW RBSL)
3. The surface water (SW) RBSL incorporates only drinking water ingestion for terrestrial receptors. The aquatic receptor SW RBSL includes drinking water ingestion as well as bioaccumulation in the receptor's dietary items including aquatic plants, invertebrates, and fish.

Risk-Based Screening Level Equations

$$\text{Soil: } \frac{TRV}{\left(\frac{[(FIR * SIR) + (FIR * BAF)] * SUF}{BW} \right)}$$

$$\text{Sediment: } \frac{TRV}{\left(\frac{[(FIR * SIR) + (FIR * BSAF)] * SUF}{BW} \right)}$$

$$\text{Surface water: } \frac{TRV}{\left(\frac{DWR + (FIR * BAF)] * SUF}{BW} \right)}$$

% - percent

BAF - bioaccumulation factor

BSAF - biota-sediment accumulation factor

BW - body weight

DWR - drinking water rate

dw - dry weight

FIR - food ingestion rate

g - gram

L - liters

kg - kilogram

mg/L - milligrams per liter of surface water

mg/kg - milligrams per kilogram of soil or sediment

mg/kg-bw/day - milligrams per kilogram of body weight per day

NOAEL - no observed adverse effect level

RBSL - risk-based screening level

SIR - soil ingestion rate

SUF - site use factor

SW - surface water

TRV - toxicity reference value

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 10. PFNA LOAEL Risk-Based Screening Levels

Receptor		Terrestrial Mammal			
		Meadow Vole	Short-Tailed Shrew	Little Brown Bat	Long-Tailed Weasel
Media Exposed		Soil	Soil	Soil	Soil
NOAEL-based TRV (mg/kg-bw/day)	Units	1.1	1.1	1.1	1.1
Risk-Based Screening Levels¹					
Soil Risk-Based Screening Level	mg/kg	3.0E+00	2.0E+00	1.3E+00	2.0E+00
Sediment Risk-Based Screening Level	mg/kg	NA	NA	NA	NA
Surface Water Risk-Based Screening Level ³	mg/L	8.0E+00	7.4E+00	6.9E+00	9.5E+00
Dietary Composition					
Plant tissue	fraction	9.8E-01	1.3E-01	0.0E+00	0.0E+00
Invertebrate tissue	fraction	2.0E-02	8.3E-01	0.0E+00	2.0E-02
Aerial insect tissue	fraction	0.0E+00	4.3E-02	1.0E+00	6.0E-02
Crustacean tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mammal/Bird tissue	fraction	0.0E+00	0.0E+00	0.0E+00	9.2E-01
Amphibian tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Reptile tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Fish tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Bioaccumulation Factors - Soil, Sediment, and Surface Water					
Plant tissue - Soil	unitless	1.1E+00	1.1E+00	1.1E+00	1.1E+00
Plant tissue - Sediment	unitless	3.1E+00	3.1E+00	3.1E+00	3.1E+00
Plant tissue - Surface Water	unitless	5.2E+03	5.2E+03	5.2E+03	5.2E+03
Terrestrial invertebrate tissue - Soil	unitless	4.6E+00	4.6E+00	4.6E+00	4.6E+00
Aquatic invertebrate tissue - Sediment	unitless	4.6E+02	4.6E+02	4.6E+02	4.6E+02
Aquatic invertebrate tissue - Surface Water	unitless	9.8E+02	9.8E+02	9.8E+02	9.8E+02
Aerial insect tissue - Soil	unitless	4.6E+00	4.6E+00	4.6E+00	4.6E+00
Aerial insect tissue - Sediment	unitless	4.6E+02	4.6E+02	4.6E+02	4.6E+02
Aquatic crustacean - Sediment	unitless	6.5E+01	6.5E+01	6.5E+01	6.5E+01
Aquatic crustacean - Surface Water	unitless	3.5E+03	3.5E+03	3.5E+03	3.5E+03
Mammal/Bird tissue - Soil or Sediment	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Amphibian tissue - Sediment	unitless	9.2E+01	9.2E+01	9.2E+01	9.2E+01
Amphibian tissue - Surface Water	unitless	4.9E+01	4.9E+01	4.9E+01	4.9E+01
Reptile tissue - Soil	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Fish tissue - Sediment	unitless	9.2E+01	9.2E+01	9.2E+01	9.2E+01
Fish tissue - Surface Water	unitless	3.3E+03	3.3E+03	3.3E+03	3.3E+03
Exposure Parameters					
Body weight	kg	3.7E-02	1.7E-02	9.0E-03	2.1E-01
Drinking water rate	L/day	5.1E-03	2.5E-03	1.4E-03	2.4E-02
Food ingestion rate	kg/day, dw	1.2E-02	2.2E-03	1.6E-03	1.0E-02
Fraction soil ingested	unitless	2.4E-02	2.4E-02	0.0E+00	2.8E-02
Site use factor	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Home range	acres	6.6E-02	9.6E-01	7.4E+01	2.6E+01
Concentrations in Diet Items (Modeled from Soil/Sediment)²					
Plant tissue	mg/kg, dw	3.2E+00	2.2E+00	NA	NA
Invertebrate tissue	mg/kg, dw	1.4E+01	9.4E+00	NA	9.5E+00
Crustacean tissue	mg/kg, dw	NA	NA	NA	NA
Mammal/Bird tissue	mg/kg, dw	NA	NA	NA	2.3E+01
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA
Reptile tissue	mg/kg, dw	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	NA	NA
Concentrations in Diet Items (Modeled from Surface Water)²					
Plant tissue	mg/kg, dw	NA	NA	NA	NA
Invertebrate tissue	mg/kg, dw	NA	NA	NA	NA
Aerial insect tissue	mg/kg, dw	NA	NA	NA	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	NA
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	NA	NA

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 10. PFNA LOAEL Risk-Based Screening Levels

Receptor		Terrestrial Mammal			
		Meadow Vole	Short-Tailed Shrew	Little Brown Bat	Long-Tailed Weasel
Media Exposed		Soil	Soil	Soil	Soil
Bioaccessibility Factors					
Soil/Sediment	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Plant tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Prey tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Average Daily Dose - Soil or Sediment (ADD; mg/kg-bw/day)					
Plant tissue	mg/kg-day	1E+00	4E-02	0E+00	0E+00
Invertebrate tissue	mg/kg-day	9E-02	1E+00	0E+00	9E-03
Aerial insect tissue	mg/kg-day	0E+00	5E-02	1E+00	3E-02
Crustacean tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Mammal tissue	mg/kg-day	0E+00	0E+00	0E+00	1E+00
Bird tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Amphibian tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Reptile tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Fish tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Soil/Sediment	mg/kg-day	2E-02	6E-03	0E+00	3E-03
Total (Food + Soil/Sediment)	mg/kg-day	1.1E+00	1.1E+00	1.1E+00	1.1E+00
Average Daily Dose - Surface Water (ADD; mg/kg-bw/day)					
Plant tissue	mg/kg-day	NA	NA	NA	NA
Invertebrate tissue	mg/kg-day	NA	NA	NA	NA
Crustacean tissue	mg/kg-day	NA	NA	NA	NA
Fish tissue	mg/kg-day	NA	NA	NA	NA
Drinking water	mg/kg-day	1.1E+00	1.1E+00	1.1E+00	1.1E+00
Total (Food + Drinking Water)	mg/kg-day	1.1E+00	1.1E+00	1.1E+00	1.1E+00
Hazard Quotient (Soil/Sediment Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Hazard Quotient (Surface Water Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 10. PFNA LOAEL Risk-Based Screening Levels

		Aquatic Mammal				
Receptor		Muskrat	Little Brown Bat	River Otter	Harbor Seal	Mink
Media Exposed		Sediment	Sediment	Sediment	Sediment	Sediment
NOAEL-based TRV (mg/kg-bw/day)	Units	1.1	1.1	1.1	1.1	1.1
Risk-Based Screening Levels¹						
Soil Risk-Based Screening Level	mg/kg	NA	NA	NA	NA	NA
Sediment Risk-Based Screening Level	mg/kg	4.7E+00	1.3E-02	3.2E-01	2.7E-01	3.3E-01
Surface Water Risk-Based Screening Level ³	mg/L	2.9E-03	6.3E-03	1.2E-02	1.3E-02	9.0E-03
Dietary Composition						
Plant tissue	fraction	1.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E-02
Invertebrate tissue	fraction	0.0E+00	0.0E+00	7.0E-02	1.4E-01	0.0E+00
Aerial insect tissue	fraction	0.0E+00	1.0E+00	0.0E+00	0.0E+00	0.0E+00
Crustacean tissue	fraction	0.0E+00	0.0E+00	0.0E+00	1.0E-02	4.0E-02
Mammal/Bird tissue	fraction	0.0E+00	0.0E+00	5.0E-02	0.0E+00	6.0E-02
Amphibian tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.0E-02
Reptile tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Fish tissue	fraction	0.0E+00	0.0E+00	8.8E-01	8.5E-01	8.6E-01
Bioaccumulation Factors - Soil, Sediment, and Surface Water						
Plant tissue - Soil	unitless	1.1E+00	1.1E+00	1.1E+00	1.1E+00	1.1E+00
Plant tissue - Sediment	unitless	3.1E+00	3.1E+00	3.1E+00	3.1E+00	3.1E+00
Plant tissue - Surface Water	unitless	5.2E+03	5.2E+03	5.2E+03	5.2E+03	5.2E+03
Terrestrial invertebrate tissue - Soil	unitless	4.6E+00	4.6E+00	4.6E+00	4.6E+00	4.6E+00
Aquatic invertebrate tissue - Sediment	unitless	4.6E+02	4.6E+02	4.6E+02	4.6E+02	4.6E+02
Aquatic invertebrate tissue - Surface Water	unitless	9.8E+02	9.8E+02	9.8E+02	9.8E+02	9.8E+02
Aerial insect tissue - Soil	unitless	4.6E+00	4.6E+00	4.6E+00	4.6E+00	4.6E+00
Aerial insect tissue - Sediment	unitless	4.6E+02	4.6E+02	4.6E+02	4.6E+02	4.6E+02
Aquatic crustacean - Sediment	unitless	6.5E+01	6.5E+01	6.5E+01	6.5E+01	6.5E+01
Aquatic crustacean - Surface Water	unitless	3.5E+03	3.5E+03	3.5E+03	3.5E+03	3.5E+03
Mammal/Bird tissue - Soil or Sediment	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Amphibian tissue - Sediment	unitless	9.2E+01	9.2E+01	9.2E+01	9.2E+01	9.2E+01
Amphibian tissue - Surface Water	unitless	4.9E+01	4.9E+01	4.9E+01	4.9E+01	4.9E+01
Reptile tissue - Soil	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Fish tissue - Sediment	unitless	9.2E+01	9.2E+01	9.2E+01	9.2E+01	9.2E+01
Fish tissue - Surface Water	unitless	3.3E+03	3.3E+03	3.3E+03	3.3E+03	3.3E+03
Exposure Parameters						
Body weight	kg	8.7E-01	9.0E-03	8.0E+00	9.9E+01	1.0E+00
Drinking water rate	L/day	8.8E-02	1.4E-03	6.4E-01	6.2E+00	1.0E-01
Food ingestion rate	kg/day, dw	6.3E-02	1.6E-03	2.4E-01	2.8E+00	4.1E-02
Fraction soil ingested	unitless	9.4E-02	0.0E+00	0.0E+00	2.0E-02	2.0E-02
Site use factor	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Home range	acres	2.7E-01	7.4E+01	8.6E+02	7.0E+05	7.1E+02
Concentrations in Diet Items (Modeled from Soil/Sediment)²						
Plant tissue	mg/kg, dw	1.5E+01	NA	NA	NA	1.0E+00
Invertebrate tissue	mg/kg, dw	NA	NA	1.5E+02	1.3E+02	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	1.8E+01	2.1E+01
Mammal/Bird tissue	mg/kg, dw	NA	NA	3.7E+00	NA	3.7E+00
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA	3.0E+01
Reptile tissue	mg/kg, dw	NA	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	3.0E+01	2.5E+01	3.0E+01
Concentrations in Diet Items (Modeled from Surface Water)²						
Plant tissue	mg/kg, dw	1.5E+01	NA	NA	NA	4.7E+01
Invertebrate tissue	mg/kg, dw	NA	NA	1.2E+01	1.3E+01	NA
Aerial insect tissue	mg/kg, dw	NA	6.2E+00	NA	NA	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	4.5E+01	3.2E+01
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA	4.5E-01
Fish tissue	mg/kg, dw	NA	NA	4.1E+01	4.3E+01	3.0E+01

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 10. PFNA LOAEL Risk-Based Screening Levels

		Aquatic Mammal				
Receptor		Muskrat	Little Brown Bat	River Otter	Harbor Seal	Mink
Media Exposed		Sediment	Sediment	Sediment	Sediment	Sediment
Bioaccessibility Factors						
Soil/Sediment	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Plant tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Prey tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Average Daily Dose - Soil or Sediment (ADD; mg/kg-bw/day)						
Plant tissue	mg/kg-day	1E+00	0E+00	0E+00	0E+00	4E-04
Invertebrate tissue	mg/kg-day	0E+00	0E+00	3E-01	5E-01	0E+00
Aerial insect tissue	mg/kg-day	0E+00	1E+00	0E+00	0E+00	0E+00
Crustacean tissue	mg/kg-day	0E+00	0E+00	0E+00	5E-03	3E-02
Mammal tissue	mg/kg-day	0E+00	0E+00	6E-03	0E+00	9E-03
Bird tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00
Amphibian tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	4E-02
Reptile tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00
Fish tissue	mg/kg-day	0E+00	0E+00	8E-01	6E-01	1E+00
Soil/Sediment	mg/kg-day	3E-02	0E+00	0E+00	2E-04	3E-04
Total (Food + Soil/Sediment)	mg/kg-day	1.1E+00	1.1E+00	1.1E+00	1.1E+00	1.1E+00
Average Daily Dose - Surface Water (ADD; mg/kg-bw/day)						
Plant tissue	mg/kg-day	1.10E+00	0.00E+00	0.00E+00	0.00E+00	1.86E-02
Invertebrate tissue	mg/kg-day	0.00E+00	0.00E+00	2.51E-02	5.02E-02	0.00E+00
Crustacean tissue	mg/kg-day	0.00E+00	0.00E+00	0.00E+00	1.28E-02	5.03E-02
Fish tissue	mg/kg-day	0.00E+00	0.00E+00	1.07E+00	1.04E+00	1.03E+00
Drinking water	mg/kg-day	3.0E-04	1.0E-03	9.8E-04	8.0E-04	8.9E-04
Total (Food + Drinking Water)	mg/kg-day	1.1E+00	1.1E+00	1.1E+00	1.1E+00	1.1E+00
Hazard Quotient (Soil/Sediment Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Hazard Quotient (Surface Water Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00

Appendix F - Wildlife Risk-Based Screening Level Calculations

Table 10. PFNA LOAEL Risk-Based Screening Levels

Notes

1. The risk-based screening level (RBSL) is the concentration in soil, sediment, or surface water where the average daily dose (ADD) is equal to the toxicity reference value (TRV), resulting in a hazard quotient (HQ) of 1.
2. Concentration in diet items is calculated as: $RBSL_{media} \times \text{bioaccumulation factor (BAF or BSAF)}$ where:
 - * the terrestrial plant, invertebrate, or mammal bioaccumulation factor (BAF) is used to calculate terrestrial receptor exposure from concentrations in soil (soil RBSL)
 - * the aquatic plant or invertebrate biota-sediment accumulation factor (BSAF) is used to calculate aquatic receptor exposure from concentrations in sediment (sediment RBSL)
 - * and the aquatic plant or invertebrate BAF is used to calculate aquatic receptor exposure from concentrations in surface water (SW RBSL)
3. The surface water (SW) RBSL incorporates only drinking water ingestion for terrestrial receptors. The aquatic receptor SW RBSL includes drinking water ingestion as well as bioaccumulation in the receptor's dietary items including aquatic plants, invertebrates, and fish.

Risk-Based Screening Level Equations

$$\text{Soil: } \frac{TRV}{\left(\frac{[(FIR * SIR) + (FIR * BAF)] * SUF}{BW} \right)}$$

$$\text{Sediment: } \frac{TRV}{\left(\frac{[(FIR * SIR) + (FIR * BSAF)] * SUF}{BW} \right)}$$

$$\text{Surface water: } \frac{TRV}{\left(\frac{DWR + (FIR * BAF)] * SUF}{BW} \right)}$$

% - percent

BAF - bioaccumulation factor

BSAF - biota-sediment accumulation factor

BW - body weight

DWR - drinking water rate

dw - dry weight

FIR - food ingestion rate

g - gram

L - liters

kg - kilogram

mg/L - milligrams per liter of surface water

mg/kg - milligrams per kilogram of soil or sediment

mg/kg-bw/day - milligrams per kilogram of body weight per day

LOAEL - lowest observed adverse effect level

RBSL - risk-based screening level

SIR - soil ingestion rate

SUF - site use factor

SW - surface water

TRV - toxicity reference value

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 11. PFOS LOAEL Risk-Based Screening Levels

Receptor		Terrestrial Mammal			
		Meadow Vole	Short-Tailed Shrew	Little Brown Bat	Long-Tailed Weasel
Media Exposed		Soil	Soil	Soil	Soil
NOAEL-based TRV (mg/kg-bw/day)	Units	0.17	0.17	0.17	0.17
Risk-Based Screening Levels¹					
Soil Risk-Based Screening Level	mg/kg	5.1E-01	7.9E-02	5.0E-02	2.8E-01
Sediment Risk-Based Screening Level	mg/kg	NA	NA	NA	NA
Surface Water Risk-Based Screening Level ³	mg/L	1.2E+00	1.1E+00	1.0E+00	1.4E+00
Dietary Composition					
Plant tissue	fraction	9.8E-01	1.3E-01	0.0E+00	0.0E+00
Invertebrate tissue	fraction	2.0E-02	8.3E-01	0.0E+00	2.0E-02
Aerial insect tissue	fraction	0.0E+00	4.3E-02	1.0E+00	6.0E-02
Crustacean tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mammal/Bird tissue	fraction	0.0E+00	0.0E+00	0.0E+00	9.2E-01
Amphibian tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Reptile tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Fish tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Bioaccumulation Factors - Soil, Sediment, and Surface Water					
Plant tissue - Soil	unitless	6.6E-01	6.6E-01	6.6E-01	6.6E-01
Plant tissue - Sediment	unitless	6.1E+01	6.1E+01	6.1E+01	6.1E+01
Plant tissue - Surface Water	unitless	1.3E+03	1.3E+03	1.3E+03	1.3E+03
Terrestrial invertebrate tissue - Soil	unitless	1.9E+01	1.9E+01	1.9E+01	1.9E+01
Aquatic invertebrate tissue - Sediment	unitless	1.1E+02	1.1E+02	1.1E+02	1.1E+02
Aquatic invertebrate tissue - Surface Water	unitless	1.5E+03	1.5E+03	1.5E+03	1.5E+03
Aerial insect tissue - Soil	unitless	1.9E+01	1.9E+01	1.9E+01	1.9E+01
Aerial insect tissue - Sediment	unitless	1.1E+02	1.1E+02	1.1E+02	1.1E+02
Aquatic crustacean - Sediment	unitless	2.5E+01	2.5E+01	2.5E+01	2.5E+01
Aquatic crustacean - Surface Water	unitless	5.6E+03	5.6E+03	5.6E+03	5.6E+03
Mammal/Bird tissue - Soil or Sediment	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Amphibian tissue - Sediment	unitless	7.2E+01	7.2E+01	7.2E+01	7.2E+01
Amphibian tissue - Surface Water	unitless	3.3E+03	3.3E+03	3.3E+03	3.3E+03
Reptile tissue - Soil	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Fish tissue - Sediment	unitless	7.2E+01	7.2E+01	7.2E+01	7.2E+01
Fish tissue - Surface Water	unitless	1.3E+04	1.3E+04	1.3E+04	1.3E+04
Exposure Parameters					
Body weight	kg	3.7E-02	1.7E-02	9.0E-03	2.1E-01
Drinking water rate	L/day	5.1E-03	2.5E-03	1.4E-03	2.4E-02
Food ingestion rate	kg/day, dw	1.2E-02	2.2E-03	1.6E-03	1.0E-02
Fraction soil ingested	unitless	2.4E-02	2.4E-02	0.0E+00	2.8E-02
Site use factor	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Home range	acres	6.6E-02	9.6E-01	7.4E+01	2.6E+01
Concentrations in Diet Items (Modeled from Soil/Sediment)²					
Plant tissue	mg/kg, dw	3.4E-01	5.2E-02	NA	NA
Invertebrate tissue	mg/kg, dw	9.5E+00	1.5E+00	NA	5.2E+00
Crustacean tissue	mg/kg, dw	NA	NA	NA	NA
Mammal/Bird tissue	mg/kg, dw	NA	NA	NA	3.2E+00
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA
Reptile tissue	mg/kg, dw	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	NA	NA
Concentrations in Diet Items (Modeled from Surface Water)²					
Plant tissue	mg/kg, dw	NA	NA	NA	NA
Invertebrate tissue	mg/kg, dw	NA	NA	NA	NA
Aerial insect tissue	mg/kg, dw	NA	NA	NA	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	NA
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	NA	NA

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 11. PFOS LOAEL Risk-Based Screening Levels

Receptor		Terrestrial Mammal			
		Meadow Vole	Short-Tailed Shrew	Little Brown Bat	Long-Tailed Weasel
Media Exposed		Soil	Soil	Soil	Soil
Bioaccessibility Factors					
Soil/Sediment	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Plant tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Prey tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Average Daily Dose - Soil or Sediment (ADD; mg/kg-bw/day)					
Plant tissue	mg/kg-day	1E-01	9E-04	0E+00	0E+00
Invertebrate tissue	mg/kg-day	6E-02	2E-01	0E+00	5E-03
Aerial insect tissue	mg/kg-day	0E+00	8E-03	2E-01	2E-02
Crustacean tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Mammal tissue	mg/kg-day	0E+00	0E+00	0E+00	1E-01
Bird tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Amphibian tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Reptile tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Fish tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Soil/Sediment	mg/kg-day	4E-03	2E-04	0E+00	4E-04
Total (Food + Soil/Sediment)	mg/kg-day	1.7E-01	1.7E-01	1.7E-01	1.7E-01
Average Daily Dose - Surface Water (ADD; mg/kg-bw/day)					
Plant tissue	mg/kg-day	NA	NA	NA	NA
Invertebrate tissue	mg/kg-day	NA	NA	NA	NA
Crustacean tissue	mg/kg-day	NA	NA	NA	NA
Fish tissue	mg/kg-day	NA	NA	NA	NA
Drinking water	mg/kg-day	1.7E-01	1.7E-01	1.7E-01	1.7E-01
Total (Food + Drinking Water)	mg/kg-day	1.7E-01	1.7E-01	1.7E-01	1.7E-01
Hazard Quotient (Soil/Sediment Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Hazard Quotient (Surface Water Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 11. PFOS LOAEL Risk-Based Screening Levels

		Aquatic Mammal				
Receptor		Muskrat	Little Brown Bat	River Otter	Harbor Seal	Mink
Media Exposed		Sediment	Sediment	Sediment	Sediment	Sediment
NOAEL-based TRV (mg/kg-bw/day)	Units	0.17	0.17	0.17	0.17	0.17
Risk-Based Screening Levels¹						
Soil Risk-Based Screening Level	mg/kg	NA	NA	NA	NA	NA
Sediment Risk-Based Screening Level	mg/kg	3.8E-02	8.8E-03	7.7E-02	7.7E-02	6.3E-02
Surface Water Risk-Based Screening Level ³	mg/L	1.8E-03	6.0E-04	4.7E-04	5.1E-04	3.6E-04
Dietary Composition						
Plant tissue	fraction	1.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E-02
Invertebrate tissue	fraction	0.0E+00	0.0E+00	7.0E-02	1.4E-01	0.0E+00
Aerial insect tissue	fraction	0.0E+00	1.0E+00	0.0E+00	0.0E+00	0.0E+00
Crustacean tissue	fraction	0.0E+00	0.0E+00	0.0E+00	1.0E-02	4.0E-02
Mammal/Bird tissue	fraction	0.0E+00	0.0E+00	5.0E-02	0.0E+00	6.0E-02
Amphibian tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.0E-02
Reptile tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Fish tissue	fraction	0.0E+00	0.0E+00	8.8E-01	8.5E-01	8.6E-01
Bioaccumulation Factors - Soil, Sediment, and Surface Water						
Plant tissue - Soil	unitless	6.6E-01	6.6E-01	6.6E-01	6.6E-01	6.6E-01
Plant tissue - Sediment	unitless	6.1E+01	6.1E+01	6.1E+01	6.1E+01	6.1E+01
Plant tissue - Surface Water	unitless	1.3E+03	1.3E+03	1.3E+03	1.3E+03	1.3E+03
Terrestrial invertebrate tissue - Soil	unitless	1.9E+01	1.9E+01	1.9E+01	1.9E+01	1.9E+01
Aquatic invertebrate tissue - Sediment	unitless	1.1E+02	1.1E+02	1.1E+02	1.1E+02	1.1E+02
Aquatic invertebrate tissue - Surface Water	unitless	1.5E+03	1.5E+03	1.5E+03	1.5E+03	1.5E+03
Aerial insect tissue - Soil	unitless	1.9E+01	1.9E+01	1.9E+01	1.9E+01	1.9E+01
Aerial insect tissue - Sediment	unitless	1.1E+02	1.1E+02	1.1E+02	1.1E+02	1.1E+02
Aquatic crustacean - Sediment	unitless	2.5E+01	2.5E+01	2.5E+01	2.5E+01	2.5E+01
Aquatic crustacean - Surface Water	unitless	5.6E+03	5.6E+03	5.6E+03	5.6E+03	5.6E+03
Mammal/Bird tissue - Soil or Sediment	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Amphibian tissue - Sediment	unitless	7.2E+01	7.2E+01	7.2E+01	7.2E+01	7.2E+01
Amphibian tissue - Surface Water	unitless	3.3E+03	3.3E+03	3.3E+03	3.3E+03	3.3E+03
Reptile tissue - Soil	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Fish tissue - Sediment	unitless	7.2E+01	7.2E+01	7.2E+01	7.2E+01	7.2E+01
Fish tissue - Surface Water	unitless	1.3E+04	1.3E+04	1.3E+04	1.3E+04	1.3E+04
Exposure Parameters						
Body weight	kg	8.7E-01	9.0E-03	8.0E+00	9.9E+01	1.0E+00
Drinking water rate	L/day	8.8E-02	1.4E-03	6.4E-01	6.2E+00	1.0E-01
Food ingestion rate	kg/day, dw	6.3E-02	1.6E-03	2.4E-01	2.8E+00	4.1E-02
Fraction soil ingested	unitless	9.4E-02	0.0E+00	0.0E+00	2.0E-02	2.0E-02
Site use factor	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Home range	acres	2.7E-01	7.4E+01	8.6E+02	7.0E+05	7.1E+02
Concentrations in Diet Items (Modeled from Soil/Sediment)²						
Plant tissue	mg/kg, dw	2.3E+00	NA	NA	NA	3.9E+00
Invertebrate tissue	mg/kg, dw	NA	NA	8.2E+00	8.1E+00	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	1.9E+00	1.5E+00
Mammal/Bird tissue	mg/kg, dw	NA	NA	8.8E-01	NA	7.2E-01
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA	4.5E+00
Reptile tissue	mg/kg, dw	NA	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	5.6E+00	5.5E+00	4.5E+00
Concentrations in Diet Items (Modeled from Surface Water)²						
Plant tissue	mg/kg, dw	2.3E+00	NA	NA	NA	4.6E-01
Invertebrate tissue	mg/kg, dw	NA	NA	7.3E-01	7.9E-01	NA
Aerial insect tissue	mg/kg, dw	NA	9.3E-01	NA	NA	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	2.8E+00	2.0E+00
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA	1.2E+00
Fish tissue	mg/kg, dw	NA	NA	6.2E+00	6.7E+00	4.7E+00

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 11. PFOS LOAEL Risk-Based Screening Levels

		Aquatic Mammal				
Receptor		Muskrat	Little Brown Bat	River Otter	Harbor Seal	Mink
Media Exposed		Sediment	Sediment	Sediment	Sediment	Sediment
Bioaccessibility Factors						
Soil/Sediment	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Plant tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Prey tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Average Daily Dose - Soil or Sediment (ADD; mg/kg-bw/day)						
Plant tissue	mg/kg-day	2E-01	0E+00	0E+00	0E+00	2E-03
Invertebrate tissue	mg/kg-day	0E+00	0E+00	2E-02	3E-02	0E+00
Aerial insect tissue	mg/kg-day	0E+00	2E-01	0E+00	0E+00	0E+00
Crustacean tissue	mg/kg-day	0E+00	0E+00	0E+00	5E-04	2E-03
Mammal tissue	mg/kg-day	0E+00	0E+00	1E-03	0E+00	2E-03
Bird tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00
Amphibian tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	5E-03
Reptile tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00
Fish tissue	mg/kg-day	0E+00	0E+00	1E-01	1E-01	2E-01
Soil/Sediment	mg/kg-day	3E-04	0E+00	0E+00	4E-05	5E-05
Total (Food + Soil/Sediment)	mg/kg-day	1.7E-01	1.7E-01	1.7E-01	1.7E-01	1.7E-01
Average Daily Dose - Surface Water (ADD; mg/kg-bw/day)						
Plant tissue	mg/kg-day	1.66E-01	0.00E+00	0.00E+00	0.00E+00	1.85E-04
Invertebrate tissue	mg/kg-day	0.00E+00	0.00E+00	1.53E-03	3.12E-03	0.00E+00
Crustacean tissue	mg/kg-day	0.00E+00	0.00E+00	0.00E+00	8.08E-04	3.18E-03
Fish tissue	mg/kg-day	0.00E+00	0.00E+00	1.64E-01	1.62E-01	1.61E-01
Drinking water	mg/kg-day	1.8E-04	9.6E-05	3.8E-05	3.2E-05	3.5E-05
Total (Food + Drinking Water)	mg/kg-day	1.7E-01	1.7E-01	1.7E-01	1.7E-01	1.7E-01
Hazard Quotient (Soil/Sediment Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Hazard Quotient (Surface Water Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 11. PFOS LOAEL Risk-Based Screening Levels

		Terrestrial Bird			Aquatic Bird		
Receptor		American Goldfinch	House Wren	Red-Tailed Hawk	Red-Winged Blackbird	Tree Swallow	Brown Pelican
Media Exposed		Soil	Soil	Soil	Sediment	Sediment	Sediment
NOAEL-based TRV (mg/kg-bw/day)	Units	0.79	0.79	0.79	0.79	0.79	0.79
Risk-Based Screening Levels¹							
Soil Risk-Based Screening Level	mg/kg	3.8E+00	1.3E-01	8.7E-01	NA	NA	NA
Sediment Risk-Based Screening Level	mg/kg	NA	NA	NA	7.0E-02	1.4E-02	1.4E-01
Surface Water Risk-Based Screening Level ³	mg/L	3.2E+00	3.0E+00	1.4E+01	3.4E-03	9.1E-04	7.5E-04
Dietary Composition							
Plant tissue	fraction	1.0E+00	0.0E+00	0.0E+00	9.2E-01	1.7E-01	0.0E+00
Invertebrate tissue	fraction	0.0E+00	8.5E-01	0.0E+00	7.6E-02	2.6E-01	0.0E+00
Aerial insect tissue	fraction	0.0E+00	1.5E-01	0.0E+00	0.0E+00	5.7E-01	0.0E+00
Crustacean tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mammal/Bird tissue	fraction	0.0E+00	0.0E+00	8.7E-01	0.0E+00	0.0E+00	0.0E+00
Amphibian tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Reptile tissue	fraction	0.0E+00	0.0E+00	1.3E-01	0.0E+00	0.0E+00	0.0E+00
Fish tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00
Bioaccumulation Factors - Soil, Sediment, and Surface Water							
Plant tissue - Soil	unitless	6.6E-01	6.6E-01	6.6E-01	6.6E-01	6.6E-01	6.6E-01
Plant tissue - Sediment	unitless	6.1E+01	6.1E+01	6.1E+01	6.1E+01	6.1E+01	6.1E+01
Plant tissue - Surface Water	unitless	1.3E+03	1.3E+03	1.3E+03	1.3E+03	1.3E+03	1.3E+03
Terrestrial invertebrate tissue - Soil	unitless	1.9E+01	1.9E+01	1.9E+01	1.9E+01	1.9E+01	1.9E+01
Aquatic invertebrate tissue - Sediment	unitless	1.1E+02	1.1E+02	1.1E+02	1.1E+02	1.1E+02	1.1E+02
Aquatic invertebrate tissue - Surface Water	unitless	1.5E+03	1.5E+03	1.5E+03	1.5E+03	1.5E+03	1.5E+03
Aerial insect tissue - Soil	unitless	1.9E+01	1.9E+01	1.9E+01	1.9E+01	1.9E+01	1.9E+01
Aerial insect tissue - Sediment	unitless	1.1E+02	1.1E+02	1.1E+02	1.1E+02	1.1E+02	1.1E+02
Aquatic crustacean - Sediment	unitless	2.5E+01	2.5E+01	2.5E+01	2.5E+01	2.5E+01	2.5E+01
Aquatic crustacean - Surface Water	unitless	5.6E+03	5.6E+03	5.6E+03	5.6E+03	5.6E+03	5.6E+03
Mammal/Bird tissue - Soil or Sediment	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Amphibian tissue - Sediment	unitless	7.2E+01	7.2E+01	7.2E+01	7.2E+01	7.2E+01	7.2E+01
Amphibian tissue - Surface Water	unitless	3.3E+03	3.3E+03	3.3E+03	3.3E+03	3.3E+03	3.3E+03
Reptile tissue - Soil	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Fish tissue - Sediment	unitless	7.2E+01	7.2E+01	7.2E+01	7.2E+01	7.2E+01	7.2E+01
Fish tissue - Surface Water	unitless	1.3E+04	1.3E+04	1.3E+04	1.3E+04	1.3E+04	1.3E+04
Exposure Parameters							
Body weight	kg	1.3E-02	1.1E-02	1.1E+00	5.7E-02	2.0E-02	3.4E+00
Drinking water rate	L/day	3.2E-03	2.8E-03	6.4E-02	8.7E-03	4.3E-03	1.3E-01
Food ingestion rate	kg/day, dw	3.7E-03	3.4E-03	9.0E-02	1.0E-02	1.2E-02	2.7E-01
Fraction soil ingested	unitless	9.3E-02	1.0E-01	0.0E+00	9.3E-02	0.0E+00	2.0E-02
Site use factor	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Home range	acres	1.2E+04	2.3E+00	1.7E+03	1.5E+05	9.5E+03	3.1E+05
Concentrations in Diet Items (Modeled from Soil/Sediment)²							
Plant tissue	mg/kg, dw	2.5E+00	NA	NA	4.3E+00	8.6E-01	NA
Invertebrate tissue	mg/kg, dw	NA	2.5E+00	NA	7.4E+00	1.5E+00	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	NA	NA	NA
Mammal/Bird tissue	mg/kg, dw	NA	NA	1.0E+01	NA	NA	NA
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA	NA	NA
Reptile tissue	mg/kg, dw	NA	NA	1.0E+01	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	NA	NA	NA	1.0E+01
Concentrations in Diet Items (Modeled from Surface Water)²							
Plant tissue	mg/kg, dw	NA	NA	NA	4.5E+00	1.2E+00	NA
Invertebrate tissue	mg/kg, dw	NA	NA	NA	5.3E+00	1.4E+00	NA
Aerial insect tissue	mg/kg, dw	NA	NA	NA	NA	1.4E+00	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	NA	NA	NA
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	NA	NA	NA	1.0E+01

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 11. PFOS LOAEL Risk-Based Screening Levels

Receptor		Terrestrial Bird			Aquatic Bird		
		American Goldfinch	House Wren	Red-Tailed Hawk	Red-Winged Blackbird	Tree Swallow	Brown Pelican
Media Exposed		Soil	Soil	Soil	Sediment	Sediment	Sediment
Bioaccessibility Factors							
Soil/Sediment	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Plant tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Prey tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Average Daily Dose - Soil or Sediment (ADD; mg/kg-bw/day)							
Plant tissue	mg/kg-day	7E-01	0E+00	0E+00	7E-01	8E-02	0E+00
Invertebrate tissue	mg/kg-day	0E+00	7E-01	0E+00	1E-01	2E-01	0E+00
Aerial insect tissue	mg/kg-day	0E+00	1E-01	0E+00	0E+00	5E-01	0E+00
Crustacean tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00
Mammal tissue	mg/kg-day	0E+00	0E+00	7E-01	0E+00	0E+00	0E+00
Bird tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00
Amphibian tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00
Reptile tissue	mg/kg-day	0E+00	0E+00	1E-01	0E+00	0E+00	0E+00
Fish tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00	8E-01
Soil/Sediment	mg/kg-day	1E-01	4E-03	0E+00	1E-03	0E+00	2E-04
Total (Food + Soil/Sediment)	mg/kg-day	7.9E-01	7.9E-01	7.9E-01	7.9E-01	7.9E-01	7.9E-01
Average Daily Dose - Surface Water (ADD; mg/kg-bw/day)							
Plant tissue	mg/kg-day	NA	NA	NA	7.19E-01	1.16E-01	0.00E+00
Invertebrate tissue	mg/kg-day	NA	NA	NA	7.02E-02	2.11E-01	0.00E+00
Crustacean tissue	mg/kg-day	NA	NA	NA	0.00E+00	0.00E+00	0.00E+00
Fish tissue	mg/kg-day	NA	NA	NA	0.00E+00	0.00E+00	7.90E-01
Drinking water	mg/kg-day	7.9E-01	7.9E-01	7.9E-01	5.2E-04	2.0E-04	3.0E-05
Total (Food + Drinking Water)	mg/kg-day	7.9E-01	7.9E-01	7.9E-01	7.9E-01	7.9E-01	7.9E-01
Hazard Quotient (Soil/Sediment Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Hazard Quotient (Surface Water Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00

Appendix F - Wildlife Risk-Based Screening Level Calculations

Table 11. PFOS LOAEL Risk-Based Screening Levels

Notes

1. The risk-based screening level (RBSL) is the concentration in soil, sediment, or surface water where the average daily dose (ADD) is equal to the toxicity reference value (TRV), resulting in a hazard quotient (HQ) of 1.
2. Concentration in diet items is calculated as: $RBSL_{media} \times \text{bioaccumulation factor (BAF or BSAF)}$ where:
 - * the terrestrial plant, invertebrate, or mammal bioaccumulation factor (BAF) is used to calculate terrestrial receptor exposure from concentrations in soil (soil RBSL)
 - * the aquatic plant or invertebrate biota-sediment accumulation factor (BSAF) is used to calculate aquatic receptor exposure from concentrations in sediment (sediment RBSL)
 - * and the aquatic plant or invertebrate BAF is used to calculate aquatic receptor exposure from concentrations in surface water (SW RBSL)
3. The surface water (SW) RBSL incorporates only drinking water ingestion for terrestrial receptors. The aquatic receptor SW RBSL includes drinking water ingestion as well as bioaccumulation in the receptor's dietary items including aquatic plants, invertebrates, and fish.

Risk-Based Screening Level Equations

$$\text{Soil: } \frac{TRV}{\left(\frac{[(FIR * SIR) + (FIR * BAF)] * SUF}{BW} \right)}$$

$$\text{Sediment: } \frac{TRV}{\left(\frac{[(FIR * SIR) + (FIR * BSAF)] * SUF}{BW} \right)}$$

$$\text{Surface water: } \frac{TRV}{\left(\frac{DWR + (FIR * BAF)] * SUF}{BW} \right)}$$

% - percent

BAF - bioaccumulation factor

BSAF - biota-sediment accumulation factor

BW - body weight

DWR - drinking water rate

dw - dry weight

FIR - food ingestion rate

g - gram

L - liters

kg - kilogram

mg/L - milligrams per liter of surface water

mg/kg - milligrams per kilogram of soil or sediment

mg/kg-bw/day - milligrams per kilogram of body weight per day

LOAEL - lowest observed adverse effect level

RBSL - risk-based screening level

SIR - soil ingestion rate

SUF - site use factor

SW - surface water

TRV - toxicity reference value

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 12. PFOA LOAEL Risk-Based Screening Levels

Receptor		Terrestrial Mammal			
		Meadow Vole	Short-Tailed Shrew	Little Brown Bat	Long-Tailed Weasel
Media Exposed		Soil	Soil	Soil	Soil
NOAEL-based TRV (mg/kg-bw/day)	Units	0.60	0.60	0.60	0.60
Risk-Based Screening Levels¹					
Soil Risk-Based Screening Level	mg/kg	1.2E+01	2.6E+00	1.7E+00	1.1E+00
Sediment Risk-Based Screening Level	mg/kg	NA	NA	NA	NA
Surface Water Risk-Based Screening Level ³	mg/L	4.4E+00	4.0E+00	3.8E+00	5.2E+00
Dietary Composition					
Plant tissue	fraction	9.8E-01	1.3E-01	0.0E+00	0.0E+00
Invertebrate tissue	fraction	2.0E-02	8.3E-01	0.0E+00	2.0E-02
Aerial insect tissue	fraction	0.0E+00	4.3E-02	1.0E+00	6.0E-02
Crustacean tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mammal/Bird tissue	fraction	0.0E+00	0.0E+00	0.0E+00	9.2E-01
Amphibian tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Reptile tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Fish tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Bioaccumulation Factors - Soil, Sediment, and Surface Water					
Plant tissue - Soil	unitless	1.1E-01	1.1E-01	1.1E-01	1.1E-01
Plant tissue - Sediment	unitless	3.5E+00	3.5E+00	3.5E+00	3.5E+00
Plant tissue - Surface Water	unitless	2.3E+02	2.3E+02	2.3E+02	2.3E+02
Terrestrial invertebrate tissue - Soil	unitless	2.0E+00	2.0E+00	2.0E+00	2.0E+00
Aquatic invertebrate tissue - Sediment	unitless	2.8E+02	2.8E+02	2.8E+02	2.8E+02
Aquatic invertebrate tissue - Surface Water	unitless	3.8E+02	3.8E+02	3.8E+02	3.8E+02
Aerial insect tissue - Soil	unitless	2.0E+00	2.0E+00	2.0E+00	2.0E+00
Aerial insect tissue - Sediment	unitless	2.8E+02	2.8E+02	2.8E+02	2.8E+02
Aquatic crustacean - Sediment	unitless	7.7E+01	7.7E+01	7.7E+01	7.7E+01
Aquatic crustacean - Surface Water	unitless	7.0E+02	7.0E+02	7.0E+02	7.0E+02
Mammal/Bird tissue - Soil or Sediment	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Amphibian tissue - Sediment	unitless	1.7E+01	1.7E+01	1.7E+01	1.7E+01
Amphibian tissue - Surface Water	unitless	8.0E-01	8.0E-01	8.0E-01	8.0E-01
Reptile tissue - Soil	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Fish tissue - Sediment	unitless	1.7E+01	1.7E+01	1.7E+01	1.7E+01
Fish tissue - Surface Water	unitless	8.9E+02	8.9E+02	8.9E+02	8.9E+02
Exposure Parameters					
Body weight	kg	3.7E-02	1.7E-02	9.0E-03	2.1E-01
Drinking water rate	L/day	5.1E-03	2.5E-03	1.4E-03	2.4E-02
Food ingestion rate	kg/day, dw	1.2E-02	2.2E-03	1.6E-03	1.0E-02
Fraction soil ingested	unitless	2.4E-02	2.4E-02	0.0E+00	2.8E-02
Site use factor	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Home range	acres	6.6E-02	9.6E-01	7.4E+01	2.6E+01
Concentrations in Diet Items (Modeled from Soil/Sediment)²					
Plant tissue	mg/kg, dw	1.2E+00	2.8E-01	NA	NA
Invertebrate tissue	mg/kg, dw	2.3E+01	5.2E+00	NA	2.3E+00
Crustacean tissue	mg/kg, dw	NA	NA	NA	NA
Mammal/Bird tissue	mg/kg, dw	NA	NA	NA	1.3E+01
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA
Reptile tissue	mg/kg, dw	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	NA	NA
Concentrations in Diet Items (Modeled from Surface Water)²					
Plant tissue	mg/kg, dw	NA	NA	NA	NA
Invertebrate tissue	mg/kg, dw	NA	NA	NA	NA
Aerial insect tissue	mg/kg, dw	NA	NA	NA	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	NA
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	NA	NA

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 12. PFOA LOAEL Risk-Based Screening Levels

Receptor		Terrestrial Mammal			
		Meadow Vole	Short-Tailed Shrew	Little Brown Bat	Long-Tailed Weasel
Media Exposed		Soil	Soil	Soil	Soil
Bioaccessibility Factors					
Soil/Sediment	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Plant tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Prey tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Average Daily Dose - Soil or Sediment (ADD; mg/kg-bw/day)					
Plant tissue	mg/kg-day	4E-01	5E-03	0E+00	0E+00
Invertebrate tissue	mg/kg-day	1E-01	6E-01	0E+00	2E-03
Aerial insect tissue	mg/kg-day	0E+00	3E-02	6E-01	7E-03
Crustacean tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Mammal tissue	mg/kg-day	0E+00	0E+00	0E+00	6E-01
Bird tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Amphibian tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Reptile tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Fish tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Soil/Sediment	mg/kg-day	9E-02	8E-03	0E+00	2E-03
Total (Food + Soil/Sediment)	mg/kg-day	6.0E-01	6.0E-01	6.0E-01	6.0E-01
Average Daily Dose - Surface Water (ADD; mg/kg-bw/day)					
Plant tissue	mg/kg-day	NA	NA	NA	NA
Invertebrate tissue	mg/kg-day	NA	NA	NA	NA
Crustacean tissue	mg/kg-day	NA	NA	NA	NA
Fish tissue	mg/kg-day	NA	NA	NA	NA
Drinking water	mg/kg-day	6.0E-01	6.0E-01	6.0E-01	6.0E-01
Total (Food + Drinking Water)	mg/kg-day	6.0E-01	6.0E-01	6.0E-01	6.0E-01
Hazard Quotient (Soil/Sediment Exposure)					
	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Hazard Quotient (Surface Water Exposure)					
	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 12. PFOA LOAEL Risk-Based Screening Levels

		Aquatic Mammal				
Receptor		Muskrat	Little Brown Bat	River Otter	Harbor Seal	Mink
Media Exposed		Sediment	Sediment	Sediment	Sediment	Sediment
NOAEL-based TRV (mg/kg-bw/day)	Units	0.60	0.60	0.60	0.60	0.60
Risk-Based Screening Levels¹						
Soil Risk-Based Screening Level	mg/kg	NA	NA	NA	NA	NA
Sediment Risk-Based Screening Level	mg/kg	2.3E+00	1.2E-02	5.7E-01	3.9E-01	8.0E-01
Surface Water Risk-Based Screening Level ³	mg/L	3.6E-02	8.9E-03	2.4E-02	2.6E-02	1.9E-02
Dietary Composition						
Plant tissue	fraction	1.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E-02
Invertebrate tissue	fraction	0.0E+00	0.0E+00	7.0E-02	1.4E-01	0.0E+00
Aerial insect tissue	fraction	0.0E+00	1.0E+00	0.0E+00	0.0E+00	0.0E+00
Crustacean tissue	fraction	0.0E+00	0.0E+00	0.0E+00	1.0E-02	4.0E-02
Mammal/Bird tissue	fraction	0.0E+00	0.0E+00	5.0E-02	0.0E+00	6.0E-02
Amphibian tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.0E-02
Reptile tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Fish tissue	fraction	0.0E+00	0.0E+00	8.8E-01	8.5E-01	8.6E-01
Bioaccumulation Factors - Soil, Sediment, and Surface Water						
Plant tissue - Soil	unitless	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01
Plant tissue - Sediment	unitless	3.5E+00	3.5E+00	3.5E+00	3.5E+00	3.5E+00
Plant tissue - Surface Water	unitless	2.3E+02	2.3E+02	2.3E+02	2.3E+02	2.3E+02
Terrestrial invertebrate tissue - Soil	unitless	2.0E+00	2.0E+00	2.0E+00	2.0E+00	2.0E+00
Aquatic invertebrate tissue - Sediment	unitless	2.8E+02	2.8E+02	2.8E+02	2.8E+02	2.8E+02
Aquatic invertebrate tissue - Surface Water	unitless	3.8E+02	3.8E+02	3.8E+02	3.8E+02	3.8E+02
Aerial insect tissue - Soil	unitless	2.0E+00	2.0E+00	2.0E+00	2.0E+00	2.0E+00
Aerial insect tissue - Sediment	unitless	2.8E+02	2.8E+02	2.8E+02	2.8E+02	2.8E+02
Aquatic crustacean - Sediment	unitless	7.7E+01	7.7E+01	7.7E+01	7.7E+01	7.7E+01
Aquatic crustacean - Surface Water	unitless	7.0E+02	7.0E+02	7.0E+02	7.0E+02	7.0E+02
Mammal/Bird tissue - Soil or Sediment	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Amphibian tissue - Sediment	unitless	1.7E+01	1.7E+01	1.7E+01	1.7E+01	1.7E+01
Amphibian tissue - Surface Water	unitless	8.0E-01	8.0E-01	8.0E-01	8.0E-01	8.0E-01
Reptile tissue - Soil	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Fish tissue - Sediment	unitless	1.7E+01	1.7E+01	1.7E+01	1.7E+01	1.7E+01
Fish tissue - Surface Water	unitless	8.9E+02	8.9E+02	8.9E+02	8.9E+02	8.9E+02
Exposure Parameters						
Body weight	kg	8.7E-01	9.0E-03	8.0E+00	9.9E+01	1.0E+00
Drinking water rate	L/day	8.8E-02	1.4E-03	6.4E-01	6.2E+00	1.0E-01
Food ingestion rate	kg/day, dw	6.3E-02	1.6E-03	2.4E-01	2.8E+00	4.1E-02
Fraction soil ingested	unitless	9.4E-02	0.0E+00	0.0E+00	2.0E-02	2.0E-02
Site use factor	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Home range	acres	2.7E-01	7.4E+01	8.6E+02	7.0E+05	7.1E+02
Concentrations in Diet Items (Modeled from Soil/Sediment)²						
Plant tissue	mg/kg, dw	8.1E+00	NA	NA	NA	2.8E+00
Invertebrate tissue	mg/kg, dw	NA	NA	1.6E+02	1.1E+02	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	3.0E+01	6.2E+01
Mammal/Bird tissue	mg/kg, dw	NA	NA	6.5E+00	NA	9.1E+00
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA	1.4E+01
Reptile tissue	mg/kg, dw	NA	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	9.6E+00	6.6E+00	1.4E+01
Concentrations in Diet Items (Modeled from Surface Water)²						
Plant tissue	mg/kg, dw	8.3E+00	NA	NA	NA	4.3E+00
Invertebrate tissue	mg/kg, dw	NA	NA	9.3E+00	9.8E+00	NA
Aerial insect tissue	mg/kg, dw	NA	3.4E+00	NA	NA	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	1.8E+01	1.3E+01
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA	1.5E-02
Fish tissue	mg/kg, dw	NA	NA	2.2E+01	2.3E+01	1.7E+01

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 12. PFOA LOAEL Risk-Based Screening Levels

		Aquatic Mammal				
Receptor		Muskrat	Little Brown Bat	River Otter	Harbor Seal	Mink
Media Exposed		Sediment	Sediment	Sediment	Sediment	Sediment
Bioaccessibility Factors						
Soil/Sediment	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Plant tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Prey tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Average Daily Dose - Soil or Sediment (ADD; mg/kg-bw/day)						
Plant tissue	mg/kg-day	6E-01	0E+00	0E+00	0E+00	1E-03
Invertebrate tissue	mg/kg-day	0E+00	0E+00	3E-01	4E-01	0E+00
Aerial insect tissue	mg/kg-day	0E+00	6E-01	0E+00	0E+00	0E+00
Crustacean tissue	mg/kg-day	0E+00	0E+00	0E+00	8E-03	1E-01
Mammal tissue	mg/kg-day	0E+00	0E+00	1E-02	0E+00	2E-02
Bird tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00
Amphibian tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	2E-02
Reptile tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00
Fish tissue	mg/kg-day	0E+00	0E+00	3E-01	2E-01	5E-01
Soil/Sediment	mg/kg-day	2E-02	0E+00	0E+00	2E-04	6E-04
Total (Food + Soil/Sediment)	mg/kg-day	6.0E-01	6.0E-01	6.0E-01	6.0E-01	6.0E-01
Average Daily Dose - Surface Water (ADD; mg/kg-bw/day)						
Plant tissue	mg/kg-day	5.96E-01	0.00E+00	0.00E+00	0.00E+00	1.71E-03
Invertebrate tissue	mg/kg-day	0.00E+00	0.00E+00	1.95E-02	3.88E-02	0.00E+00
Crustacean tissue	mg/kg-day	0.00E+00	0.00E+00	0.00E+00	5.13E-03	2.11E-02
Fish tissue	mg/kg-day	0.00E+00	0.00E+00	5.79E-01	5.54E-01	5.75E-01
Drinking water	mg/kg-day	3.6E-03	1.4E-03	2.0E-03	1.6E-03	1.9E-03
Total (Food + Drinking Water)	mg/kg-day	6.0E-01	6.0E-01	6.0E-01	6.0E-01	6.0E-01
Hazard Quotient (Soil/Sediment Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Hazard Quotient (Surface Water Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00

Appendix F - Wildlife Risk-Based Screening Level Calculations

Table 12. PFOA LOAEL Risk-Based Screening Levels

Notes

1. The risk-based screening level (RBSL) is the concentration in soil, sediment, or surface water where the average daily dose (ADD) is equal to the toxicity reference value (TRV), resulting in a hazard quotient (HQ) of 1.
2. Concentration in diet items is calculated as: $RBSL_{media} \times \text{bioaccumulation factor (BAF or BSAF)}$ where:
 - * the terrestrial plant, invertebrate, or mammal bioaccumulation factor (BAF) is used to calculate terrestrial receptor exposure from concentrations in soil (soil RBSL)
 - * the aquatic plant or invertebrate biota-sediment accumulation factor (BSAF) is used to calculate aquatic receptor exposure from concentrations in sediment (sediment RBSL)
 - * and the aquatic plant or invertebrate BAF is used to calculate aquatic receptor exposure from concentrations in surface water (SW RBSL)
3. The surface water (SW) RBSL incorporates only drinking water ingestion for terrestrial receptors. The aquatic receptor SW RBSL includes drinking water ingestion as well as bioaccumulation in the receptor's dietary items including aquatic plants, invertebrates, and fish.

Risk-Based Screening Level Equations

$$\text{Soil: } \frac{TRV}{\left(\frac{[(FIR * SIR) + (FIR * BAF)] * SUF}{BW} \right)}$$

$$\text{Sediment: } \frac{TRV}{\left(\frac{[(FIR * SIR) + (FIR * BSAF)] * SUF}{BW} \right)}$$

$$\text{Surface water: } \frac{TRV}{\left(\frac{DWR + (FIR * BAF)] * SUF}{BW} \right)}$$

% - percent

BAF - bioaccumulation factor

BSAF - biota-sediment accumulation factor

BW - body weight

DWR - drinking water rate

dw - dry weight

FIR - food ingestion rate

g - gram

L - liters

kg - kilogram

mg/L - milligrams per liter of surface water

mg/kg - milligrams per kilogram of soil or sediment

mg/kg-bw/day - milligrams per kilogram of body weight per day

LOAEL - lowest observed adverse effect level

RBSL - risk-based screening level

SIR - soil ingestion rate

SUF - site use factor

SW - surface water

TRV - toxicity reference value

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 13. PFHxA LOAEL Risk-Based Screening Levels

Receptor		Terrestrial Mammal			
		Meadow Vole	Short-Tailed Shrew	Little Brown Bat	Long-Tailed Weasel
Media Exposed		Soil	Soil	Soil	Soil
NOAEL-based TRV (mg/kg-bw/day)	Units	175	175	175	175
Risk-Based Screening Levels¹					
Soil Risk-Based Screening Level	mg/kg	2.6E+02	7.0E+02	5.3E+02	3.3E+02
Sediment Risk-Based Screening Level	mg/kg	NA	NA	NA	NA
Surface Water Risk-Based Screening Level ³	mg/L	1.3E+03	1.2E+03	1.1E+03	1.5E+03
Dietary Composition					
Plant tissue	fraction	9.8E-01	1.3E-01	0.0E+00	0.0E+00
Invertebrate tissue	fraction	2.0E-02	8.3E-01	0.0E+00	2.0E-02
Aerial insect tissue	fraction	0.0E+00	4.3E-02	1.0E+00	6.0E-02
Crustacean tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mammal/Bird tissue	fraction	0.0E+00	0.0E+00	0.0E+00	9.2E-01
Amphibian tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Reptile tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Fish tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Bioaccumulation Factors - Soil, Sediment, and Surface Water					
Plant tissue - Soil	unitless	2.2E+00	2.2E+00	2.2E+00	2.2E+00
Plant tissue - Sediment	unitless	4.7E+00	4.7E+00	4.7E+00	4.7E+00
Plant tissue - Surface Water	unitless	1.9E+02	1.9E+02	1.9E+02	1.9E+02
Terrestrial invertebrate tissue - Soil	unitless	1.9E+00	1.9E+00	1.9E+00	1.9E+00
Aquatic invertebrate tissue - Sediment	unitless	2.6E+02	2.6E+02	2.6E+02	2.6E+02
Aquatic invertebrate tissue - Surface Water	unitless	2.2E+03	2.2E+03	2.2E+03	2.2E+03
Aerial insect tissue - Soil	unitless	1.9E+00	1.9E+00	1.9E+00	1.9E+00
Aerial insect tissue - Sediment	unitless	2.6E+02	2.6E+02	2.6E+02	2.6E+02
Aquatic crustacean - Sediment	unitless	1.5E+02	1.5E+02	1.5E+02	1.5E+02
Aquatic crustacean - Surface Water	unitless	7.8E+02	7.8E+02	7.8E+02	7.8E+02
Mammal/Bird tissue - Soil or Sediment	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Amphibian tissue - Sediment	unitless	8.6E+01	8.6E+01	8.6E+01	8.6E+01
Amphibian tissue - Surface Water	unitless	2.9E+00	2.9E+00	2.9E+00	2.9E+00
Reptile tissue - Soil	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Fish tissue - Sediment	unitless	8.6E+01	8.6E+01	8.6E+01	8.6E+01
Fish tissue - Surface Water	unitless	3.2E+02	3.2E+02	3.2E+02	3.2E+02
Exposure Parameters					
Body weight	kg	3.7E-02	1.7E-02	9.0E-03	2.1E-01
Drinking water rate	L/day	5.1E-03	2.5E-03	1.4E-03	2.4E-02
Food ingestion rate	kg/day, dw	1.2E-02	2.2E-03	1.6E-03	1.0E-02
Fraction soil ingested	unitless	2.4E-02	2.4E-02	0.0E+00	2.8E-02
Site use factor	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Home range	acres	6.6E-02	9.6E-01	7.4E+01	2.6E+01
Concentrations in Diet Items (Modeled from Soil/Sediment)²					
Plant tissue	mg/kg, dw	5.6E+02	1.5E+03	NA	NA
Invertebrate tissue	mg/kg, dw	4.8E+02	1.3E+03	NA	6.2E+02
Crustacean tissue	mg/kg, dw	NA	NA	NA	NA
Mammal/Bird tissue	mg/kg, dw	NA	NA	NA	3.8E+03
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA
Reptile tissue	mg/kg, dw	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	NA	NA
Concentrations in Diet Items (Modeled from Surface Water)²					
Plant tissue	mg/kg, dw	NA	NA	NA	NA
Invertebrate tissue	mg/kg, dw	NA	NA	NA	NA
Aerial insect tissue	mg/kg, dw	NA	NA	NA	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	NA
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	NA	NA

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 13. PFHxA LOAEL Risk-Based Screening Levels

Receptor		Terrestrial Mammal			
		Meadow Vole	Short-Tailed Shrew	Little Brown Bat	Long-Tailed Weasel
Media Exposed		Soil	Soil	Soil	Soil
Bioaccessibility Factors					
Soil/Sediment	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Plant tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Prey tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Average Daily Dose - Soil or Sediment (ADD; mg/kg-bw/day)					
Plant tissue	mg/kg-day	2E+02	3E+01	0E+00	0E+00
Invertebrate tissue	mg/kg-day	3E+00	1E+02	0E+00	6E-01
Aerial insect tissue	mg/kg-day	0E+00	7E+00	2E+02	2E+00
Crustacean tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Mammal tissue	mg/kg-day	0E+00	0E+00	0E+00	2E+02
Bird tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Amphibian tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Reptile tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Fish tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Soil/Sediment	mg/kg-day	2E+00	2E+00	0E+00	5E-01
Total (Food + Soil/Sediment)	mg/kg-day	1.8E+02	1.8E+02	1.8E+02	1.8E+02
Average Daily Dose - Surface Water (ADD; mg/kg-bw/day)					
Plant tissue	mg/kg-day	NA	NA	NA	NA
Invertebrate tissue	mg/kg-day	NA	NA	NA	NA
Crustacean tissue	mg/kg-day	NA	NA	NA	NA
Fish tissue	mg/kg-day	NA	NA	NA	NA
Drinking water	mg/kg-day	1.8E+02	1.8E+02	1.8E+02	1.8E+02
Total (Food + Drinking Water)	mg/kg-day	1.8E+02	1.8E+02	1.8E+02	1.8E+02
Hazard Quotient (Soil/Sediment Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Hazard Quotient (Surface Water Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 13. PFHxA LOAEL Risk-Based Screening Levels

		Aquatic Mammal				
Receptor		Muskrat	Little Brown Bat	River Otter	Harbor Seal	Mink
Media Exposed		Sediment	Sediment	Sediment	Sediment	Sediment
NOAEL-based TRV (mg/kg-bw/day)	Units	175	175	175	175	175
Risk-Based Screening Levels¹						
Soil Risk-Based Screening Level	mg/kg	NA	NA	NA	NA	NA
Sediment Risk-Based Screening Level	mg/kg	5.1E+02	3.8E+00	6.1E+01	5.5E+01	5.3E+01
Surface Water Risk-Based Screening Level ³	mg/L	1.3E+01	4.4E-01	1.3E+01	1.0E+01	1.4E+01
Dietary Composition						
Plant tissue	fraction	1.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E-02
Invertebrate tissue	fraction	0.0E+00	0.0E+00	7.0E-02	1.4E-01	0.0E+00
Aerial insect tissue	fraction	0.0E+00	1.0E+00	0.0E+00	0.0E+00	0.0E+00
Crustacean tissue	fraction	0.0E+00	0.0E+00	0.0E+00	1.0E-02	4.0E-02
Mammal/Bird tissue	fraction	0.0E+00	0.0E+00	5.0E-02	0.0E+00	6.0E-02
Amphibian tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.0E-02
Reptile tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Fish tissue	fraction	0.0E+00	0.0E+00	8.8E-01	8.5E-01	8.6E-01
Bioaccumulation Factors - Soil, Sediment, and Surface Water						
Plant tissue - Soil	unitless	2.2E+00	2.2E+00	2.2E+00	2.2E+00	2.2E+00
Plant tissue - Sediment	unitless	4.7E+00	4.7E+00	4.7E+00	4.7E+00	4.7E+00
Plant tissue - Surface Water	unitless	1.9E+02	1.9E+02	1.9E+02	1.9E+02	1.9E+02
Terrestrial invertebrate tissue - Soil	unitless	1.9E+00	1.9E+00	1.9E+00	1.9E+00	1.9E+00
Aquatic invertebrate tissue - Sediment	unitless	2.6E+02	2.6E+02	2.6E+02	2.6E+02	2.6E+02
Aquatic invertebrate tissue - Surface Water	unitless	2.2E+03	2.2E+03	2.2E+03	2.2E+03	2.2E+03
Aerial insect tissue - Soil	unitless	1.9E+00	1.9E+00	1.9E+00	1.9E+00	1.9E+00
Aerial insect tissue - Sediment	unitless	2.6E+02	2.6E+02	2.6E+02	2.6E+02	2.6E+02
Aquatic crustacean - Sediment	unitless	1.5E+02	1.5E+02	1.5E+02	1.5E+02	1.5E+02
Aquatic crustacean - Surface Water	unitless	7.8E+02	7.8E+02	7.8E+02	7.8E+02	7.8E+02
Mammal/Bird tissue - Soil or Sediment	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Amphibian tissue - Sediment	unitless	8.6E+01	8.6E+01	8.6E+01	8.6E+01	8.6E+01
Amphibian tissue - Surface Water	unitless	2.9E+00	2.9E+00	2.9E+00	2.9E+00	2.9E+00
Reptile tissue - Soil	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Fish tissue - Sediment	unitless	8.6E+01	8.6E+01	8.6E+01	8.6E+01	8.6E+01
Fish tissue - Surface Water	unitless	3.2E+02	3.2E+02	3.2E+02	3.2E+02	3.2E+02
Exposure Parameters						
Body weight	kg	8.7E-01	9.0E-03	8.0E+00	9.9E+01	1.0E+00
Drinking water rate	L/day	8.8E-02	1.4E-03	6.4E-01	6.2E+00	1.0E-01
Food ingestion rate	kg/day, dw	6.3E-02	1.6E-03	2.4E-01	2.8E+00	4.1E-02
Fraction soil ingested	unitless	9.4E-02	0.0E+00	0.0E+00	2.0E-02	2.0E-02
Site use factor	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Home range	acres	2.7E-01	7.4E+01	8.6E+02	7.0E+05	7.1E+02
Concentrations in Diet Items (Modeled from Soil/Sediment)²						
Plant tissue	mg/kg, dw	2.4E+03	NA	NA	NA	2.5E+02
Invertebrate tissue	mg/kg, dw	NA	NA	1.6E+04	1.4E+04	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	8.5E+03	8.1E+03
Mammal/Bird tissue	mg/kg, dw	NA	NA	7.0E+02	NA	6.0E+02
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA	4.5E+03
Reptile tissue	mg/kg, dw	NA	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	5.3E+03	4.8E+03	4.5E+03
Concentrations in Diet Items (Modeled from Surface Water)²						
Plant tissue	mg/kg, dw	2.4E+03	NA	NA	NA	2.7E+03
Invertebrate tissue	mg/kg, dw	NA	NA	3.0E+04	2.3E+04	NA
Aerial insect tissue	mg/kg, dw	NA	9.8E+02	NA	NA	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	8.1E+03	1.1E+04
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA	4.2E+01
Fish tissue	mg/kg, dw	NA	NA	4.2E+03	3.3E+03	4.5E+03

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 13. PFHxA LOAEL Risk-Based Screening Levels

		Aquatic Mammal				
Receptor		Muskrat	Little Brown Bat	River Otter	Harbor Seal	Mink
Media Exposed		Sediment	Sediment	Sediment	Sediment	Sediment
Bioaccessibility Factors						
Soil/Sediment	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Plant tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Prey tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Average Daily Dose - Soil or Sediment (ADD; mg/kg-bw/day)						
Plant tissue	mg/kg-day	2E+02	0E+00	0E+00	0E+00	1E-01
Invertebrate tissue	mg/kg-day	0E+00	0E+00	3E+01	6E+01	0E+00
Aerial insect tissue	mg/kg-day	0E+00	2E+02	0E+00	0E+00	0E+00
Crustacean tissue	mg/kg-day	0E+00	0E+00	0E+00	2E+00	1E+01
Mammal tissue	mg/kg-day	0E+00	0E+00	1E+00	0E+00	1E+00
Bird tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00
Amphibian tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	5E+00
Reptile tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00
Fish tissue	mg/kg-day	0E+00	0E+00	1E+02	1E+02	2E+02
Soil/Sediment	mg/kg-day	3E+00	0E+00	0E+00	3E-02	4E-02
Total (Food + Soil/Sediment)						
	mg/kg-day	1.8E+02	1.8E+02	1.8E+02	1.8E+02	1.8E+02
Average Daily Dose - Surface Water (ADD; mg/kg-bw/day)						
Plant tissue	mg/kg-day	1.74E+02	0.00E+00	0.00E+00	0.00E+00	1.08E+00
Invertebrate tissue	mg/kg-day	0.00E+00	0.00E+00	6.25E+01	9.25E+01	0.00E+00
Crustacean tissue	mg/kg-day	0.00E+00	0.00E+00	0.00E+00	2.30E+00	1.77E+01
Fish tissue	mg/kg-day	0.00E+00	0.00E+00	1.11E+02	7.96E+01	1.55E+02
Drinking water	mg/kg-day	1.3E+00	7.0E-02	1.1E+00	6.5E-01	1.4E+00
Total (Food + Drinking Water)						
	mg/kg-day	1.8E+02	1.8E+02	1.8E+02	1.8E+02	1.8E+02
Hazard Quotient (Soil/Sediment Exposure)						
	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Hazard Quotient (Surface Water Exposure)						
	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 13. PFHxA LOAEL Risk-Based Screening Levels

Notes

1. The risk-based screening level (RBSL) is the concentration in soil, sediment, or surface water where the average daily dose (ADD) is equal to the toxicity reference value (TRV), resulting in a hazard quotient (HQ) of 1.
2. Concentration in diet items is calculated as: $RBSL_{media} \times \text{bioaccumulation factor (BAF or BSAF)}$ where:
 - * the terrestrial plant, invertebrate, or mammal bioaccumulation factor (BAF) is used to calculate terrestrial receptor exposure from concentrations in soil (soil RBSL)
 - * the aquatic plant or invertebrate biota-sediment accumulation factor (BSAF) is used to calculate aquatic receptor exposure from concentrations in sediment (sediment RBSL)
 - * and the aquatic plant or invertebrate BAF is used to calculate aquatic receptor exposure from concentrations in surface water (SW RBSL)
3. The surface water (SW) RBSL incorporates only drinking water ingestion for terrestrial receptors. The aquatic receptor SW RBSL includes drinking water ingestion as well as bioaccumulation in the receptor's dietary items including aquatic plants, invertebrates, and fish.

Risk-Based Screening Level Equations

$$\text{Soil: } \frac{TRV}{\left(\frac{[(FIR * SIR) + (FIR * BAF)] * SUF}{BW} \right)}$$

$$\text{Sediment: } \frac{TRV}{\left(\frac{[(FIR * SIR) + (FIR * BSAF)] * SUF}{BW} \right)}$$

$$\text{Surface water: } \frac{TRV}{\left(\frac{DWR + (FIR * BAF)] * SUF}{BW} \right)}$$

% - percent

BAF - bioaccumulation factor

BSAF - biota-sediment accumulation factor

BW - body weight

DWR - drinking water rate

dw - dry weight

FIR - food ingestion rate

g - gram

L - liters

kg - kilogram

mg/L - milligrams per liter of surface water

mg/kg - milligrams per kilogram of soil or sediment

mg/kg-bw/day - milligrams per kilogram of body weight per day

LOAEL - lowest observed adverse effect level

RBSL - risk-based screening level

SIR - soil ingestion rate

SUF - site use factor

SW - surface water

TRV - toxicity reference value

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 14. PFBS LOAEL Risk-Based Screening Levels

Receptor		Terrestrial Mammal			
		Meadow Vole	Short-Tailed Shrew	Little Brown Bat	Long-Tailed Weasel
Media Exposed		Soil	Soil	Soil	Soil
NOAEL-based TRV (mg/kg-bw/day)	Units	200	200	200	200
Risk-Based Screening Levels¹					
Soil Risk-Based Screening Level	mg/kg	1.5E+02	5.7E+01	3.6E+01	3.1E+02
Sediment Risk-Based Screening Level	mg/kg	NA	NA	NA	NA
Surface Water Risk-Based Screening Level ³	mg/L	1.5E+03	1.3E+03	1.3E+03	1.7E+03
Dietary Composition					
Plant tissue	fraction	9.8E-01	1.3E-01	0.0E+00	0.0E+00
Invertebrate tissue	fraction	2.0E-02	8.3E-01	0.0E+00	2.0E-02
Aerial insect tissue	fraction	0.0E+00	4.3E-02	1.0E+00	6.0E-02
Crustacean tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mammal/Bird tissue	fraction	0.0E+00	0.0E+00	0.0E+00	9.2E-01
Amphibian tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Reptile tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Fish tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Bioaccumulation Factors - Soil, Sediment, and Surface Water					
Plant tissue - Soil	unitless	3.6E+00	3.6E+00	3.6E+00	3.6E+00
Plant tissue - Sediment	unitless	1.8E+00	1.8E+00	1.8E+00	1.8E+00
Plant tissue - Surface Water	unitless	7.8E+00	7.8E+00	7.8E+00	7.8E+00
Terrestrial invertebrate tissue - Soil	unitless	3.1E+01	3.1E+01	3.1E+01	3.1E+01
Aquatic invertebrate tissue - Sediment	unitless	2.6E+02	2.6E+02	2.6E+02	2.6E+02
Aquatic invertebrate tissue - Surface Water	unitless	3.0E+02	3.0E+02	3.0E+02	3.0E+02
Aerial insect tissue - Soil	unitless	3.1E+01	3.1E+01	3.1E+01	3.1E+01
Aerial insect tissue - Sediment	unitless	2.6E+02	2.6E+02	2.6E+02	2.6E+02
Aquatic crustacean - Sediment	unitless	1.5E+02	1.5E+02	1.5E+02	1.5E+02
Aquatic crustacean - Surface Water	unitless	3.9E+02	3.9E+02	3.9E+02	3.9E+02
Mammal/Bird tissue - Soil or Sediment	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Amphibian tissue - Sediment	unitless	8.6E+01	8.6E+01	8.6E+01	8.6E+01
Amphibian tissue - Surface Water	unitless	1.2E+03	1.2E+03	1.2E+03	1.2E+03
Reptile tissue - Soil	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Fish tissue - Sediment	unitless	8.6E+01	8.6E+01	8.6E+01	8.6E+01
Fish tissue - Surface Water	unitless	9.2E+02	9.2E+02	9.2E+02	9.2E+02
Exposure Parameters					
Body weight	kg	3.7E-02	1.7E-02	9.0E-03	2.1E-01
Drinking water rate	L/day	5.1E-03	2.5E-03	1.4E-03	2.4E-02
Food ingestion rate	kg/day, dw	1.2E-02	2.2E-03	1.6E-03	1.0E-02
Fraction soil ingested	unitless	2.4E-02	2.4E-02	0.0E+00	2.8E-02
Site use factor	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Home range	acres	6.6E-02	9.6E-01	7.4E+01	2.6E+01
Concentrations in Diet Items (Modeled from Soil/Sediment)²					
Plant tissue	mg/kg, dw	5.5E+02	2.0E+02	NA	NA
Invertebrate tissue	mg/kg, dw	4.8E+03	1.8E+03	NA	9.6E+03
Crustacean tissue	mg/kg, dw	NA	NA	NA	NA
Mammal/Bird tissue	mg/kg, dw	NA	NA	NA	3.6E+03
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA
Reptile tissue	mg/kg, dw	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	NA	NA
Concentrations in Diet Items (Modeled from Surface Water)²					
Plant tissue	mg/kg, dw	NA	NA	NA	NA
Invertebrate tissue	mg/kg, dw	NA	NA	NA	NA
Aerial insect tissue	mg/kg, dw	NA	NA	NA	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	NA
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	NA	NA

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 14. PFBS LOAEL Risk-Based Screening Levels

Receptor		Terrestrial Mammal			
		Meadow Vole	Short-Tailed Shrew	Little Brown Bat	Long-Tailed Weasel
Media Exposed		Soil	Soil	Soil	Soil
Bioaccessibility Factors					
Soil/Sediment	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Plant tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Prey tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Average Daily Dose - Soil or Sediment (ADD; mg/kg-bw/day)					
Plant tissue	mg/kg-day	2E+02	3E+00	0E+00	0E+00
Invertebrate tissue	mg/kg-day	3E+01	2E+02	0E+00	9E+00
Aerial insect tissue	mg/kg-day	0E+00	1E+01	2E+02	3E+01
Crustacean tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Mammal tissue	mg/kg-day	0E+00	0E+00	0E+00	2E+02
Bird tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Amphibian tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Reptile tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Fish tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Soil/Sediment	mg/kg-day	1E+00	2E-01	0E+00	4E-01
Total (Food + Soil/Sediment)	mg/kg-day	2.0E+02	2.0E+02	2.0E+02	2.0E+02
Average Daily Dose - Surface Water (ADD; mg/kg-bw/day)					
Plant tissue	mg/kg-day	NA	NA	NA	NA
Invertebrate tissue	mg/kg-day	NA	NA	NA	NA
Crustacean tissue	mg/kg-day	NA	NA	NA	NA
Fish tissue	mg/kg-day	NA	NA	NA	NA
Drinking water	mg/kg-day	2.0E+02	2.0E+02	2.0E+02	2.0E+02
Total (Food + Drinking Water)	mg/kg-day	2.0E+02	2.0E+02	2.0E+02	2.0E+02
Hazard Quotient (Soil/Sediment Exposure)					
	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Hazard Quotient (Surface Water Exposure)					
	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 14. PFBS LOAEL Risk-Based Screening Levels

		Aquatic Mammal				
Receptor		Muskrat	Little Brown Bat	River Otter	Harbor Seal	Mink
Media Exposed		Sediment	Sediment	Sediment	Sediment	Sediment
NOAEL-based TRV (mg/kg-bw/day)	Units	200	200	200	200	200
Risk-Based Screening Levels¹						
Soil Risk-Based Screening Level	mg/kg	NA	NA	NA	NA	NA
Sediment Risk-Based Screening Level	mg/kg	1.5E+03	4.3E+00	7.0E+01	6.3E+01	6.0E+01
Surface Water Risk-Based Screening Level ³	mg/L	3.0E+02	3.8E+00	8.0E+00	8.5E+00	6.0E+00
Dietary Composition						
Plant tissue	fraction	1.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E-02
Invertebrate tissue	fraction	0.0E+00	0.0E+00	7.0E-02	1.4E-01	0.0E+00
Aerial insect tissue	fraction	0.0E+00	1.0E+00	0.0E+00	0.0E+00	0.0E+00
Crustacean tissue	fraction	0.0E+00	0.0E+00	0.0E+00	1.0E-02	4.0E-02
Mammal/Bird tissue	fraction	0.0E+00	0.0E+00	5.0E-02	0.0E+00	6.0E-02
Amphibian tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.0E-02
Reptile tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Fish tissue	fraction	0.0E+00	0.0E+00	8.8E-01	8.5E-01	8.6E-01
Bioaccumulation Factors - Soil, Sediment, and Surface Water						
Plant tissue - Soil	unitless	3.6E+00	3.6E+00	3.6E+00	3.6E+00	3.6E+00
Plant tissue - Sediment	unitless	1.8E+00	1.8E+00	1.8E+00	1.8E+00	1.8E+00
Plant tissue - Surface Water	unitless	7.8E+00	7.8E+00	7.8E+00	7.8E+00	7.8E+00
Terrestrial invertebrate tissue - Soil	unitless	3.1E+01	3.1E+01	3.1E+01	3.1E+01	3.1E+01
Aquatic invertebrate tissue - Sediment	unitless	2.6E+02	2.6E+02	2.6E+02	2.6E+02	2.6E+02
Aquatic invertebrate tissue - Surface Water	unitless	3.0E+02	3.0E+02	3.0E+02	3.0E+02	3.0E+02
Aerial insect tissue - Soil	unitless	3.1E+01	3.1E+01	3.1E+01	3.1E+01	3.1E+01
Aerial insect tissue - Sediment	unitless	2.6E+02	2.6E+02	2.6E+02	2.6E+02	2.6E+02
Aquatic crustacean - Sediment	unitless	1.5E+02	1.5E+02	1.5E+02	1.5E+02	1.5E+02
Aquatic crustacean - Surface Water	unitless	3.9E+02	3.9E+02	3.9E+02	3.9E+02	3.9E+02
Mammal/Bird tissue - Soil or Sediment	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Amphibian tissue - Sediment	unitless	8.6E+01	8.6E+01	8.6E+01	8.6E+01	8.6E+01
Amphibian tissue - Surface Water	unitless	1.2E+03	1.2E+03	1.2E+03	1.2E+03	1.2E+03
Reptile tissue - Soil	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Fish tissue - Sediment	unitless	8.6E+01	8.6E+01	8.6E+01	8.6E+01	8.6E+01
Fish tissue - Surface Water	unitless	9.2E+02	9.2E+02	9.2E+02	9.2E+02	9.2E+02
Exposure Parameters						
Body weight	kg	8.7E-01	9.0E-03	8.0E+00	9.9E+01	1.0E+00
Drinking water rate	L/day	8.8E-02	1.4E-03	6.4E-01	6.2E+00	1.0E-01
Food ingestion rate	kg/day, dw	6.3E-02	1.6E-03	2.4E-01	2.8E+00	4.1E-02
Fraction soil ingested	unitless	9.4E-02	0.0E+00	0.0E+00	2.0E-02	2.0E-02
Site use factor	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Home range	acres	2.7E-01	7.4E+01	8.6E+02	7.0E+05	7.1E+02
Concentrations in Diet Items (Modeled from Soil/Sediment)²						
Plant tissue	mg/kg, dw	2.6E+03	NA	NA	NA	1.1E+02
Invertebrate tissue	mg/kg, dw	NA	NA	1.8E+04	1.7E+04	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	9.7E+03	9.2E+03
Mammal/Bird tissue	mg/kg, dw	NA	NA	8.0E+02	NA	6.9E+02
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA	5.2E+03
Reptile tissue	mg/kg, dw	NA	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	6.1E+03	5.4E+03	5.2E+03
Concentrations in Diet Items (Modeled from Surface Water)²						
Plant tissue	mg/kg, dw	2.4E+03	NA	NA	NA	4.6E+01
Invertebrate tissue	mg/kg, dw	NA	NA	2.4E+03	2.5E+03	NA
Aerial insect tissue	mg/kg, dw	NA	1.1E+03	NA	NA	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	3.3E+03	2.3E+03
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA	7.2E+03
Fish tissue	mg/kg, dw	NA	NA	7.3E+03	7.8E+03	5.5E+03

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 14. PFBS LOAEL Risk-Based Screening Levels

		Aquatic Mammal				
Receptor		Muskrat	Little Brown Bat	River Otter	Harbor Seal	Mink
Media Exposed		Sediment	Sediment	Sediment	Sediment	Sediment
Bioaccessibility Factors						
Soil/Sediment	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Plant tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Prey tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Average Daily Dose - Soil or Sediment (ADD; mg/kg-bw/day)						
Plant tissue	mg/kg-day	2E+02	0E+00	0E+00	0E+00	4E-02
Invertebrate tissue	mg/kg-day	0E+00	0E+00	4E+01	7E+01	0E+00
Aerial insect tissue	mg/kg-day	0E+00	2E+02	0E+00	0E+00	0E+00
Crustacean tissue	mg/kg-day	0E+00	0E+00	0E+00	3E+00	1E+01
Mammal tissue	mg/kg-day	0E+00	0E+00	1E+00	0E+00	2E+00
Bird tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00
Amphibian tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	6E+00
Reptile tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00
Fish tissue	mg/kg-day	0E+00	0E+00	2E+02	1E+02	2E+02
Soil/Sediment	mg/kg-day	1E+01	0E+00	0E+00	4E-02	5E-02
Total (Food + Soil/Sediment)	mg/kg-day	2.0E+02	2.0E+02	2.0E+02	2.0E+02	2.0E+02
Average Daily Dose - Surface Water (ADD; mg/kg-bw/day)						
Plant tissue	mg/kg-day	1.69E+02	0.00E+00	0.00E+00	0.00E+00	1.84E-02
Invertebrate tissue	mg/kg-day	0.00E+00	0.00E+00	5.03E+00	1.01E+01	0.00E+00
Crustacean tissue	mg/kg-day	0.00E+00	0.00E+00	0.00E+00	9.40E-01	3.69E+00
Fish tissue	mg/kg-day	0.00E+00	0.00E+00	1.94E+02	1.88E+02	1.87E+02
Drinking water	mg/kg-day	3.1E+01	6.0E-01	6.5E-01	5.3E-01	5.9E-01
Total (Food + Drinking Water)	mg/kg-day	2.0E+02	2.0E+02	2.0E+02	2.0E+02	2.0E+02
Hazard Quotient (Soil/Sediment Exposure)						
	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Hazard Quotient (Surface Water Exposure)						
	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 14. PFBS LOAEL Risk-Based Screening Levels

		Terrestrial Bird			Aquatic Bird		
Receptor		American Goldfinch	House Wren	Red-Tailed Hawk	Red-Winged Blackbird	Tree Swallow	Brown Pelican
Media Exposed		Soil	Soil	Soil	Sediment	Sediment	Sediment
NOAEL-based TRV (mg/kg-bw/day)	Units	153	153	153	153	153	153
Risk-Based Screening Levels¹							
Soil Risk-Based Screening Level	mg/kg	1.5E+02	1.5E+01	1.7E+02	NA	NA	NA
Sediment Risk-Based Screening Level	mg/kg	NA	NA	NA	4.0E+01	1.2E+00	2.2E+01
Surface Water Risk-Based Screening Level ³	mg/L	6.2E+02	5.8E+02	2.7E+03	2.9E+01	1.1E+00	2.1E+00
Dietary Composition							
Plant tissue	fraction	1.0E+00	0.0E+00	0.0E+00	9.2E-01	1.7E-01	0.0E+00
Invertebrate tissue	fraction	0.0E+00	8.5E-01	0.0E+00	7.6E-02	2.6E-01	0.0E+00
Aerial insect tissue	fraction	0.0E+00	1.5E-01	0.0E+00	0.0E+00	5.7E-01	0.0E+00
Crustacean tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mammal/Bird tissue	fraction	0.0E+00	0.0E+00	8.7E-01	0.0E+00	0.0E+00	0.0E+00
Amphibian tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Reptile tissue	fraction	0.0E+00	0.0E+00	1.3E-01	0.0E+00	0.0E+00	0.0E+00
Fish tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00
Bioaccumulation Factors - Soil, Sediment, and Surface Water							
Plant tissue - Soil	unitless	3.6E+00	3.6E+00	3.6E+00	3.6E+00	3.6E+00	3.6E+00
Plant tissue - Sediment	unitless	1.8E+00	1.8E+00	1.8E+00	1.8E+00	1.8E+00	1.8E+00
Plant tissue - Surface Water	unitless	7.8E+00	7.8E+00	7.8E+00	7.8E+00	7.8E+00	7.8E+00
Terrestrial invertebrate tissue - Soil	unitless	3.1E+01	3.1E+01	3.1E+01	3.1E+01	3.1E+01	3.1E+01
Aquatic invertebrate tissue - Sediment	unitless	2.6E+02	2.6E+02	2.6E+02	2.6E+02	2.6E+02	2.6E+02
Aquatic invertebrate tissue - Surface Water	unitless	3.0E+02	3.0E+02	3.0E+02	3.0E+02	3.0E+02	3.0E+02
Aerial insect tissue - Soil	unitless	3.1E+01	3.1E+01	3.1E+01	3.1E+01	3.1E+01	3.1E+01
Aerial insect tissue - Sediment	unitless	2.6E+02	2.6E+02	2.6E+02	2.6E+02	2.6E+02	2.6E+02
Aquatic crustacean - Sediment	unitless	1.5E+02	1.5E+02	1.5E+02	1.5E+02	1.5E+02	1.5E+02
Aquatic crustacean - Surface Water	unitless	3.9E+02	3.9E+02	3.9E+02	3.9E+02	3.9E+02	3.9E+02
Mammal/Bird tissue - Soil or Sediment	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Amphibian tissue - Sediment	unitless	8.6E+01	8.6E+01	8.6E+01	8.6E+01	8.6E+01	8.6E+01
Amphibian tissue - Surface Water	unitless	1.2E+03	1.2E+03	1.2E+03	1.2E+03	1.2E+03	1.2E+03
Reptile tissue - Soil	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Fish tissue - Sediment	unitless	8.6E+01	8.6E+01	8.6E+01	8.6E+01	8.6E+01	8.6E+01
Fish tissue - Surface Water	unitless	9.2E+02	9.2E+02	9.2E+02	9.2E+02	9.2E+02	9.2E+02
Exposure Parameters							
Body weight	kg	1.3E-02	1.1E-02	1.1E+00	5.7E-02	2.0E-02	3.4E+00
Drinking water rate	L/day	3.2E-03	2.8E-03	6.4E-02	8.7E-03	4.3E-03	1.3E-01
Food ingestion rate	kg/day, dw	3.7E-03	3.4E-03	9.0E-02	1.0E-02	1.2E-02	2.7E-01
Fraction soil ingested	unitless	9.3E-02	1.0E-01	0.0E+00	9.3E-02	0.0E+00	2.0E-02
Site use factor	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Home range	acres	1.2E+04	2.3E+00	1.7E+03	1.5E+05	9.5E+03	3.1E+05
Concentrations in Diet Items (Modeled from Soil/Sediment)²							
Plant tissue	mg/kg, dw	5.4E+02	NA	NA	7.3E+01	2.2E+00	NA
Invertebrate tissue	mg/kg, dw	NA	4.8E+02	NA	1.1E+04	3.2E+02	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	NA	NA	NA
Mammal/Bird tissue	mg/kg, dw	NA	NA	1.9E+03	NA	NA	NA
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA	NA	NA
Reptile tissue	mg/kg, dw	NA	NA	1.9E+03	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	NA	NA	NA	1.9E+03
Concentrations in Diet Items (Modeled from Surface Water)²							
Plant tissue	mg/kg, dw	NA	NA	NA	2.2E+02	8.3E+00	NA
Invertebrate tissue	mg/kg, dw	NA	NA	NA	8.5E+03	3.2E+02	NA
Aerial insect tissue	mg/kg, dw	NA	NA	NA	NA	3.2E+02	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	NA	NA	NA
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	NA	NA	NA	1.9E+03

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 14. PFBS LOAEL Risk-Based Screening Levels

Receptor		Terrestrial Bird			Aquatic Bird		
		American Goldfinch	House Wren	Red-Tailed Hawk	Red-Winged Blackbird	Tree Swallow	Brown Pelican
Media Exposed		Soil	Soil	Soil	Sediment	Sediment	Sediment
Bioaccessibility Factors							
Soil/Sediment	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Plant tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Prey tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Average Daily Dose - Soil or Sediment (ADD; mg/kg-bw/day)							
Plant tissue	mg/kg-day	1E+02	0E+00	0E+00	1E+01	2E-01	0E+00
Invertebrate tissue	mg/kg-day	0E+00	1E+02	0E+00	1E+02	5E+01	0E+00
Aerial insect tissue	mg/kg-day	0E+00	2E+01	0E+00	0E+00	1E+02	0E+00
Crustacean tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00
Mammal tissue	mg/kg-day	0E+00	0E+00	1E+02	0E+00	0E+00	0E+00
Bird tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00
Amphibian tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00
Reptile tissue	mg/kg-day	0E+00	0E+00	2E+01	0E+00	0E+00	0E+00
Fish tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00	2E+02
Soil/Sediment	mg/kg-day	4E+00	5E-01	0E+00	7E-01	0E+00	4E-02
Total (Food + Soil/Sediment)	mg/kg-day	1.5E+02	1.5E+02	1.5E+02	1.5E+02	1.5E+02	1.5E+02
Average Daily Dose - Surface Water (ADD; mg/kg-bw/day)							
Plant tissue	mg/kg-day	NA	NA	NA	3.57E+01	8.04E-01	0.00E+00
Invertebrate tissue	mg/kg-day	NA	NA	NA	1.13E+02	4.76E+01	0.00E+00
Crustacean tissue	mg/kg-day	NA	NA	NA	0.00E+00	0.00E+00	0.00E+00
Fish tissue	mg/kg-day	NA	NA	NA	0.00E+00	0.00E+00	1.53E+02
Drinking water	mg/kg-day	1.5E+02	1.5E+02	1.5E+02	4.3E+00	2.3E-01	8.3E-02
Total (Food + Drinking Water)	mg/kg-day	1.5E+02	1.5E+02	1.5E+02	1.5E+02	1.5E+02	1.5E+02
Hazard Quotient (Soil/Sediment Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Hazard Quotient (Surface Water Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00

Appendix F - Wildlife Risk-Based Screening Level Calculations

Table 14. PFBS LOAEL Risk-Based Screening Levels

Notes

1. The risk-based screening level (RBSL) is the concentration in soil, sediment, or surface water where the average daily dose (ADD) is equal to the toxicity reference value (TRV), resulting in a hazard quotient (HQ) of 1.
2. Concentration in diet items is calculated as: $RBSL_{media} \times \text{bioaccumulation factor (BAF or BSAF)}$ where:
 - * the terrestrial plant, invertebrate, or mammal bioaccumulation factor (BAF) is used to calculate terrestrial receptor exposure from concentrations in soil (soil RBSL)
 - * the aquatic plant or invertebrate biota-sediment accumulation factor (BSAF) is used to calculate aquatic receptor exposure from concentrations in sediment (sediment RBSL)
 - * and the aquatic plant or invertebrate BAF is used to calculate aquatic receptor exposure from concentrations in surface water (SW RBSL)
3. The surface water (SW) RBSL incorporates only drinking water ingestion for terrestrial receptors. The aquatic receptor SW RBSL includes drinking water ingestion as well as bioaccumulation in the receptor's dietary items including aquatic plants, invertebrates, and fish.

Risk-Based Screening Level Equations

$$\text{Soil: } \frac{TRV}{\left(\frac{[(FIR * SIR) + (FIR * BAF)] * SUF}{BW} \right)}$$

$$\text{Sediment: } \frac{TRV}{\left(\frac{[(FIR * SIR) + (FIR * BSAF)] * SUF}{BW} \right)}$$

$$\text{Surface water: } \frac{TRV}{\left(\frac{DWR + (FIR * BAF)] * SUF}{BW} \right)}$$

% - percent

BAF - bioaccumulation factor

BSAF - biota-sediment accumulation factor

BW - body weight

DWR - drinking water rate

dw - dry weight

FIR - food ingestion rate

g - gram

L - liters

kg - kilogram

mg/L - milligrams per liter of surface water

mg/kg - milligrams per kilogram of soil or sediment

mg/kg-bw/day - milligrams per kilogram of body weight per day

LOAEL - lowest observed adverse effect level

RBSL - risk-based screening level

SIR - soil ingestion rate

SUF - site use factor

SW - surface water

TRV - toxicity reference value

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 15. PFBA LOAEL Risk-Based Screening Levels

Receptor		Terrestrial Mammal			
		Meadow Vole	Short-Tailed Shrew	Little Brown Bat	Long-Tailed Weasel
Media Exposed		Soil	Soil	Soil	Soil
NOAEL-based TRV (mg/kg-bw/day)	Units	175	175	175	175
Risk-Based Screening Levels¹					
Soil Risk-Based Screening Level	mg/kg	7.0E+01	1.9E+02	1.4E+02	3.2E+02
Sediment Risk-Based Screening Level	mg/kg	NA	NA	NA	NA
Surface Water Risk-Based Screening Level ³	mg/L	1.3E+03	1.2E+03	1.1E+03	1.5E+03
Dietary Composition					
Plant tissue	fraction	9.8E-01	1.3E-01	0.0E+00	0.0E+00
Invertebrate tissue	fraction	2.0E-02	8.3E-01	0.0E+00	2.0E-02
Aerial insect tissue	fraction	0.0E+00	4.3E-02	1.0E+00	6.0E-02
Crustacean tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Mammal/Bird tissue	fraction	0.0E+00	0.0E+00	0.0E+00	9.2E-01
Amphibian tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Reptile tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Fish tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Bioaccumulation Factors - Soil, Sediment, and Surface Water					
Plant tissue - Soil	unitless	8.0E+00	8.0E+00	8.0E+00	8.0E+00
Plant tissue - Sediment	unitless	6.2E+00	6.2E+00	6.2E+00	6.2E+00
Plant tissue - Surface Water	unitless	1.9E+01	1.9E+01	1.9E+01	1.9E+01
Terrestrial invertebrate tissue - Soil	unitless	7.1E+00	7.1E+00	7.1E+00	7.1E+00
Aquatic invertebrate tissue - Sediment	unitless	2.6E+02	2.6E+02	2.6E+02	2.6E+02
Aquatic invertebrate tissue - Surface Water	unitless	3.0E+02	3.0E+02	3.0E+02	3.0E+02
Aerial insect tissue - Soil	unitless	7.1E+00	7.1E+00	7.1E+00	7.1E+00
Aerial insect tissue - Sediment	unitless	2.6E+02	2.6E+02	2.6E+02	2.6E+02
Aquatic crustacean - Sediment	unitless	1.5E+02	1.5E+02	1.5E+02	1.5E+02
Aquatic crustacean - Surface Water	unitless	3.9E+02	3.9E+02	3.9E+02	3.9E+02
Mammal/Bird tissue - Soil or Sediment	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Amphibian tissue - Sediment	unitless	8.6E+01	8.6E+01	8.6E+01	8.6E+01
Amphibian tissue - Surface Water	unitless	2.9E+00	2.9E+00	2.9E+00	2.9E+00
Reptile tissue - Soil	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Fish tissue - Sediment	unitless	8.6E+01	8.6E+01	8.6E+01	8.6E+01
Fish tissue - Surface Water	unitless	3.2E+03	3.2E+03	3.2E+03	3.2E+03
Exposure Parameters					
Body weight	kg	3.7E-02	1.7E-02	9.0E-03	2.1E-01
Drinking water rate	L/day	5.1E-03	2.5E-03	1.4E-03	2.4E-02
Food ingestion rate	kg/day, dw	1.2E-02	2.2E-03	1.6E-03	1.0E-02
Fraction soil ingested	unitless	2.4E-02	2.4E-02	0.0E+00	2.8E-02
Site use factor	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Home range	acres	6.6E-02	9.6E-01	7.4E+01	2.6E+01
Concentrations in Diet Items (Modeled from Soil/Sediment)²					
Plant tissue	mg/kg, dw	5.6E+02	1.5E+03	NA	NA
Invertebrate tissue	mg/kg, dw	5.0E+02	1.3E+03	NA	2.3E+03
Crustacean tissue	mg/kg, dw	NA	NA	NA	NA
Mammal/Bird tissue	mg/kg, dw	NA	NA	NA	3.6E+03
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA
Reptile tissue	mg/kg, dw	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	NA	NA
Concentrations in Diet Items (Modeled from Surface Water)²					
Plant tissue	mg/kg, dw	NA	NA	NA	NA
Invertebrate tissue	mg/kg, dw	NA	NA	NA	NA
Aerial insect tissue	mg/kg, dw	NA	NA	NA	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	NA
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	NA	NA

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 15. PFBA LOAEL Risk-Based Screening Levels

Receptor		Terrestrial Mammal			
		Meadow Vole	Short-Tailed Shrew	Little Brown Bat	Long-Tailed Weasel
Media Exposed		Soil	Soil	Soil	Soil
Bioaccessibility Factors					
Soil/Sediment	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Plant tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Prey tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Average Daily Dose - Soil or Sediment (ADD; mg/kg-bw/day)					
Plant tissue	mg/kg-day	2E+02	3E+01	0E+00	0E+00
Invertebrate tissue	mg/kg-day	3E+00	1E+02	0E+00	2E+00
Aerial insect tissue	mg/kg-day	0E+00	7E+00	2E+02	7E+00
Crustacean tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Mammal tissue	mg/kg-day	0E+00	0E+00	0E+00	2E+02
Bird tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Amphibian tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Reptile tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Fish tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00
Soil/Sediment	mg/kg-day	5E-01	6E-01	0E+00	4E-01
Total (Food + Soil/Sediment)	mg/kg-day	1.8E+02	1.8E+02	1.8E+02	1.8E+02
Average Daily Dose - Surface Water (ADD; mg/kg-bw/day)					
Plant tissue	mg/kg-day	NA	NA	NA	NA
Invertebrate tissue	mg/kg-day	NA	NA	NA	NA
Crustacean tissue	mg/kg-day	NA	NA	NA	NA
Fish tissue	mg/kg-day	NA	NA	NA	NA
Drinking water	mg/kg-day	1.8E+02	1.8E+02	1.8E+02	1.8E+02
Total (Food + Drinking Water)	mg/kg-day	1.8E+02	1.8E+02	1.8E+02	1.8E+02
Hazard Quotient (Soil/Sediment Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Hazard Quotient (Surface Water Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 15. PFBA LOAEL Risk-Based Screening Levels

		Aquatic Mammal				
Receptor		Muskrat	Little Brown Bat	River Otter	Harbor Seal	Mink
Media Exposed		Sediment	Sediment	Sediment	Sediment	Sediment
NOAEL-based TRV (mg/kg-bw/day)	Units	175	175	175	175	175
Risk-Based Screening Levels¹						
Soil Risk-Based Screening Level	mg/kg	NA	NA	NA	NA	NA
Sediment Risk-Based Screening Level	mg/kg	3.8E+02	3.8E+00	6.1E+01	5.5E+01	5.3E+01
Surface Water Risk-Based Screening Level ³	mg/L	1.2E+02	3.3E+00	2.1E+00	2.2E+00	1.6E+00
Dietary Composition						
Plant tissue	fraction	1.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E-02
Invertebrate tissue	fraction	0.0E+00	0.0E+00	7.0E-02	1.4E-01	0.0E+00
Aerial insect tissue	fraction	0.0E+00	1.0E+00	0.0E+00	0.0E+00	0.0E+00
Crustacean tissue	fraction	0.0E+00	0.0E+00	0.0E+00	1.0E-02	4.0E-02
Mammal/Bird tissue	fraction	0.0E+00	0.0E+00	5.0E-02	0.0E+00	6.0E-02
Amphibian tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.0E-02
Reptile tissue	fraction	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Fish tissue	fraction	0.0E+00	0.0E+00	8.8E-01	8.5E-01	8.6E-01
Bioaccumulation Factors - Soil, Sediment, and Surface Water						
Plant tissue - Soil	unitless	8.0E+00	8.0E+00	8.0E+00	8.0E+00	8.0E+00
Plant tissue - Sediment	unitless	6.2E+00	6.2E+00	6.2E+00	6.2E+00	6.2E+00
Plant tissue - Surface Water	unitless	1.9E+01	1.9E+01	1.9E+01	1.9E+01	1.9E+01
Terrestrial invertebrate tissue - Soil	unitless	7.1E+00	7.1E+00	7.1E+00	7.1E+00	7.1E+00
Aquatic invertebrate tissue - Sediment	unitless	2.6E+02	2.6E+02	2.6E+02	2.6E+02	2.6E+02
Aquatic invertebrate tissue - Surface Water	unitless	3.0E+02	3.0E+02	3.0E+02	3.0E+02	3.0E+02
Aerial insect tissue - Soil	unitless	7.1E+00	7.1E+00	7.1E+00	7.1E+00	7.1E+00
Aerial insect tissue - Sediment	unitless	2.6E+02	2.6E+02	2.6E+02	2.6E+02	2.6E+02
Aquatic crustacean - Sediment	unitless	1.5E+02	1.5E+02	1.5E+02	1.5E+02	1.5E+02
Aquatic crustacean - Surface Water	unitless	3.9E+02	3.9E+02	3.9E+02	3.9E+02	3.9E+02
Mammal/Bird tissue - Soil or Sediment	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Amphibian tissue - Sediment	unitless	8.6E+01	8.6E+01	8.6E+01	8.6E+01	8.6E+01
Amphibian tissue - Surface Water	unitless	2.9E+00	2.9E+00	2.9E+00	2.9E+00	2.9E+00
Reptile tissue - Soil	unitless	1.1E+01	1.1E+01	1.1E+01	1.1E+01	1.1E+01
Fish tissue - Sediment	unitless	8.6E+01	8.6E+01	8.6E+01	8.6E+01	8.6E+01
Fish tissue - Surface Water	unitless	3.2E+03	3.2E+03	3.2E+03	3.2E+03	3.2E+03
Exposure Parameters						
Body weight	kg	8.7E-01	9.0E-03	8.0E+00	9.9E+01	1.0E+00
Drinking water rate	L/day	8.8E-02	1.4E-03	6.4E-01	6.2E+00	1.0E-01
Food ingestion rate	kg/day, dw	6.3E-02	1.6E-03	2.4E-01	2.8E+00	4.1E-02
Fraction soil ingested	unitless	9.4E-02	0.0E+00	0.0E+00	2.0E-02	2.0E-02
Site use factor	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Home range	acres	2.7E-01	7.4E+01	8.6E+02	7.0E+05	7.1E+02
Concentrations in Diet Items (Modeled from Soil/Sediment)²						
Plant tissue	mg/kg, dw	2.4E+03	NA	NA	NA	3.3E+02
Invertebrate tissue	mg/kg, dw	NA	NA	1.6E+04	1.4E+04	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	8.5E+03	8.1E+03
Mammal/Bird tissue	mg/kg, dw	NA	NA	7.0E+02	NA	6.0E+02
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA	4.5E+03
Reptile tissue	mg/kg, dw	NA	NA	NA	NA	NA
Fish tissue	mg/kg, dw	NA	NA	5.3E+03	4.8E+03	4.5E+03
Concentrations in Diet Items (Modeled from Surface Water)²						
Plant tissue	mg/kg, dw	2.3E+03	NA	NA	NA	3.1E+01
Invertebrate tissue	mg/kg, dw	NA	NA	6.1E+02	6.6E+02	NA
Aerial insect tissue	mg/kg, dw	NA	9.8E+02	NA	NA	NA
Crustacean tissue	mg/kg, dw	NA	NA	NA	8.7E+02	6.2E+02
Amphibian tissue	mg/kg, dw	NA	NA	NA	NA	4.7E+00
Fish tissue	mg/kg, dw	NA	NA	6.6E+03	7.1E+03	5.1E+03

Appendix F - Wildlife Risk-Based Screening Level Calculations
Table 15. PFBA LOAEL Risk-Based Screening Levels

		Aquatic Mammal				
Receptor		Muskrat	Little Brown Bat	River Otter	Harbor Seal	Mink
Media Exposed		Sediment	Sediment	Sediment	Sediment	Sediment
Bioaccessibility Factors						
Soil/Sediment	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Plant tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Prey tissue	percent	1.0E+02	1.0E+02	1.0E+02	1.0E+02	1.0E+02
Average Daily Dose - Soil or Sediment (ADD; mg/kg-bw/day)						
Plant tissue	mg/kg-day	2E+02	0E+00	0E+00	0E+00	1E-01
Invertebrate tissue	mg/kg-day	0E+00	0E+00	3E+01	6E+01	0E+00
Aerial insect tissue	mg/kg-day	0E+00	2E+02	0E+00	0E+00	0E+00
Crustacean tissue	mg/kg-day	0E+00	0E+00	0E+00	2E+00	1E+01
Mammal tissue	mg/kg-day	0E+00	0E+00	1E+00	0E+00	1E+00
Bird tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00
Amphibian tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	5E+00
Reptile tissue	mg/kg-day	0E+00	0E+00	0E+00	0E+00	0E+00
Fish tissue	mg/kg-day	0E+00	0E+00	1E+02	1E+02	2E+02
Soil/Sediment	mg/kg-day	3E+00	0E+00	0E+00	3E-02	4E-02
Total (Food + Soil/Sediment)	mg/kg-day	1.8E+02	1.8E+02	1.8E+02	1.8E+02	1.8E+02
Average Daily Dose - Surface Water (ADD; mg/kg-bw/day)						
Plant tissue	mg/kg-day	1.63E+02	0.00E+00	0.00E+00	0.00E+00	1.23E-02
Invertebrate tissue	mg/kg-day	0.00E+00	0.00E+00	1.29E+00	2.64E+00	0.00E+00
Crustacean tissue	mg/kg-day	0.00E+00	0.00E+00	0.00E+00	2.45E-01	9.81E-01
Fish tissue	mg/kg-day	0.00E+00	0.00E+00	1.74E+02	1.72E+02	1.74E+02
Drinking water	mg/kg-day	1.2E+01	5.2E-01	1.6E-01	1.4E-01	1.6E-01
Total (Food + Drinking Water)	mg/kg-day	1.8E+02	1.7E+02	1.8E+02	1.8E+02	1.8E+02
Hazard Quotient (Soil/Sediment Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Hazard Quotient (Surface Water Exposure)	unitless	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00

Appendix F - Wildlife Risk-Based Screening Level Calculations

Table 15. PFBA LOAEL Risk-Based Screening Levels

Notes

1. The risk-based screening level (RBSL) is the concentration in soil, sediment, or surface water where the average daily dose (ADD) is equal to the toxicity reference value (TRV), resulting in a hazard quotient (HQ) of 1.
2. Concentration in diet items is calculated as: $RBSL_{media} \times \text{bioaccumulation factor (BAF or BSAF)}$ where:
 - * the terrestrial plant, invertebrate, or mammal bioaccumulation factor (BAF) is used to calculate terrestrial receptor exposure from concentrations in soil (soil RBSL)
 - * the aquatic plant or invertebrate biota-sediment accumulation factor (BSAF) is used to calculate aquatic receptor exposure from concentrations in sediment (sediment RBSL)
 - * and the aquatic plant or invertebrate BAF is used to calculate aquatic receptor exposure from concentrations in surface water (SW RBSL)
3. The surface water (SW) RBSL incorporates only drinking water ingestion for terrestrial receptors. The aquatic receptor SW RBSL includes drinking water ingestion as well as bioaccumulation in the receptor's dietary items including aquatic plants, invertebrates, and fish.

Risk-Based Screening Level Equations

$$\text{Soil: } \frac{TRV}{\left(\frac{[(FIR * SIR) + (FIR * BAF)] * SUF}{BW} \right)}$$

$$\text{Sediment: } \frac{TRV}{\left(\frac{[(FIR * SIR) + (FIR * BSAF)] * SUF}{BW} \right)}$$

$$\text{Surface water: } \frac{TRV}{\left(\frac{DWR + (FIR * BAF)] * SUF}{BW} \right)}$$

% - percent

BAF - bioaccumulation factor

BSAF - biota-sediment accumulation factor

BW - body weight

DWR - drinking water rate

dw - dry weight

FIR - food ingestion rate

g - gram

L - liters

kg - kilogram

mg/L - milligrams per liter of surface water

mg/kg - milligrams per kilogram of soil or sediment

mg/kg-bw/day - milligrams per kilogram of body weight per day

LOAEL - lowest observed adverse effect level

RBSL - risk-based screening level

SIR - soil ingestion rate

SUF - site use factor

SW - surface water

TRV - toxicity reference value