Screening-Level Evaluation of Contaminants in Sediments from Three Reservoirs and the Estuary of the Klamath River, 2009-2011

Prepared for
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Klamath Dam Removal Water Quality Sub Team
Klamath River Secretarial Determination

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Abstract

The purpose of this report is to inform the Department of Interior Secretarial Determination process regarding the potential for adverse ecological or human health effects from chemical contamination in Klamath Reservoir sediments. It evalautes if the dams are removed and a portion of the accumulated sediments is flushed downstream (Proposed Action or "dams removed") or if the dams remain in place (No Action or "dams in"). The report does not include an evaluation of the physical effects associated with the Proposed Action. This report is only intended to provide a screening-level evaluation to inform the Secretarial Determination. A step-wise process based on the Sediment Evaluation Framework (SEF) was applied that evaluated sediment and elutriate chemistry, laboratory bioassays, bioaccumulation studies, and tissue of fish from the reservoirs. This process generated multiple lines of evidence that were compared to five relevant exposure pathways of biota and human receptors to identify potential adverse effects. The results of this evaluation suggest the Klamath Reservoir sediments can be considered relatively clean, with no chemicals present at levels that would preclude their release into downstream or marine environments. Accordingly Klamath Reservoir sediments are expected to pose no adverse effects, limited effects, or minor effects under the five exposure pathways under the Proposed Action and No Action alternatives. In the future, if there is an affirmative decision, efforts would begin to develop detailed plans for dam removal and permitting processes.

The findings and conclusions in this report represent a collaborative effort between the Water Quality Sub Team, CDM, and Stillwater Sciences in support of the Klamath River Secretarial Determination process. The final report has not been formally disseminated by the agencies involved and should not be construed to present any agency determination or policy.*

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Abbreviations and Acronyms

µg	microgram (10-6 gram)
AET	apparent effect threshold
Ag	Agriculture
A-I	Bird-Individual
ALA	Aquatic Life Acute
ALC	Aquatic Life Chronic
ALI	Aquatic Life Instant
A-P	Bird-Population
ATL	Acceptable Tissue Level
BSAF	Biota-Sediment Accumulation Factor
BSLV	Land Quality Division Sediment Bioaccumulation Screening Level Values
BT	Bioaccumulation Trigger
CA	California
CAR	Carcinogenic
CBP	California Basin Plan
CCC	Criteria Continuous Concentration
CDPH	California Department of Public Health
CHHSL	California Human Health Screening Levels
CMC	Criteria Maximum Concentration
CN	cyanide
COP	California Ocean Plan
COPC	chemicals of potential concern
CR	Copoc 1 Reservoir
CTR	California Toxics Rule
DEQ	Department of Environmental Quality (Oregon)
DET	detected chemical
DL	detection limit
DMMP	Dredged Material Management Program
dw	dry weight
ERED	Environmental Residue-Effects Database
ERL	Effects Range Low
ERM	Effects Range Median
ESA	Endangered Species Act
est	estimated
F	Fish
F-FW	Fish-Freshwater
F-M	Fish-Marine
FPM	floating point method
g	gram
GEC	Gathard Engineering Consultants
H	Human

HCN	free cyanide form
H-G	Human General
HH	human health
HH CTR	Human Health California Toxics Rule
HHSL	Human Health Screening Level
HO	Human Organism
H-S	Human Subsistence
HWO	Human Water and Organism
IG	Iron Gate Reservoir
JC	JC Boyle Reservoir
kg	kilogram (1,000 grams)
KHSA	Klamath Hydro-Settlement Agreement
L	Liter
LC	laboratory control
LC50	sample strength for which 50 percent mortality was experienced
LD	lethal dose
LEL	Lowest Effect Level
LOED	lowest observed adverse effect
MCL	Maximum Contaminant Level
MDL	method detection limit
mg	milligram (10-3 gram)
M-I	Mammal-Individual
ML	Maximum Level
M-P	Mammal-Population
NA	not applicable / no value available
NCRWQCB	North Coast Regional Water Quality Control Board (California)
ND	non-detected
NOAA	National Oceanic and Atmospheric Administration
NOED	no observed adverse effect
NON CAR	Non-carcinogenic
NRWQC	National Recommended Water Quality Criteria
NTR	National Toxics Rule
NTR	National Toxics Rule
ODEQ	Oregon Department of Environmental Quality
OEHHA	Office of Environmental Health hazard Assessment
oz	ounce
PAHs	polycyclic aromatic hydrocarbons
PBDEs	polybrominated diphenyl ethers
PCB	polychlorinated biphenyl
PEC	Probable Effect Concentration
PEL	Probable Effect Level
pg	picogram (10-12 gram)
PNW	SEFPacific Northwest Sediment Evaluation Framework
ppt	parts-per trillion

QC	quality control
RL	reporting limit
RSET	Regional Sediment Evaluation Team
RSL	Regional Screening Levels
RWQC	Recommended Water Quality Criteria
SAP	sampling and analysis plan
SEF	Sediment Evaluation Framework
SEL	Severe Effect Level
SL	Screening Level
SL1	Sediment Screening Level 1
SLV	Screening Level Value
SQO	sediment quality objectives
SQuiRTs	Screening Quick Reference Tables
SVOCs	semi-volatile organic compounds
SWAMP	California Surface Water Ambient Monitoring Program
SWRCB	California State Water Resources Control Board
T20	Chemical concentration representing a 20% probability of observing an effect
T50	Chemical concentration representing a 50% probability of observing an effect
TEC	Threshold Effect Concentration
TEFs	toxic equivalency factors
TEL	Threshold Effect Level
TEQ	toxic equivalency
TIE	Toxicity Identification Evaluation
TOC	total organic carbon
TOT	Total
TOT CAR	Total Carcinogenic
TOT NONCAR	Total Non-carcinogenic
TRV	toxicity reference value
UE	Upper Klamath Estuary
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Service
VOCs	volatile organic compounds
WDNR	Washington State Department of Natural Resources
WDOE	Washington State Department of Ecology
WHO	World Health Organization
WQC	water quality criteria
WQG	Water Quality Guidance
WQST	Water Quality SubTeam
wt	weight
ww	wet weight
yd3	cubic yards

Chapter 1
Introduction

1.1 Site Description and History

The Klamath River originates at the Link River Dam near Upper Klamath Lake, Oregon and flows about 250 miles before emptying into the Pacific Ocean near Klamath, California (**Figure 1**). The Lower Klamath basin is relatively undeveloped and the lower reaches of the Klamath River remain undammed. In contrast, the Upper Klamath Basin supports urbanization, commercial forestry, agriculture and other industry; and the Upper Klamath River is dammed in numerous locations. The four most downstream of these dams, J.C. Boyle, Copco 1, Copco 2, and Iron Gate dams (**Figure 1**), are privately owned by PacifiCorp. Completed in 1918, Copco 1 dam is located in northern California, about 25 miles northeast of Yreka. Copco 2, which forms a small stilling basin below Copco 1, was finished in 1925. In 1958, J.C. Boyle was built in southern Oregon, about 15 miles southwest of Klamath Falls and 30 miles upstream from Copco 1. In 1962, Iron Gate dam was built about 20 miles northeast of Yreka, California, approximately six miles downstream from the Copco 2 dam and 190 miles upstream from the mouth of the Klamath River near Klamath, CA. A small estuary is located at the mouth and extending approximately 2 miles upstream. Multiple ongoing evaluations are being conducted to support a determination by the Secretary of the Department of the Interior (Secretarial Determination) on the Klamath Hydro-Settlement Agreement (KHSA), regarding removal of these four dams in the year 2020.

Estimates of the combined volume of sediment deposits stored within J.C. Boyle, Copco 1 and 2, and Iron Gate Reservoirs range from about 13.1 million cubic yards (yd^3) (BOR 2011a), 14.5 million yd^3 (Eilers and Gubala 2003), to 20.4 million yd^3 (Gathard Engineering Consultants [GEC] 2006). Sediment texture analyses of the current reservoir deposits indicate that the deposits are composed of predominantly fine material (GEC 2006; BOR 2011a).

Model predictions using historic flow conditions indicate that mobilization of reservoir sediment deposits would be most intense during the first year or two following dam removal, when an estimated one-third to two-thirds of the volume would be eroded (BOR 2011a). The amount eroded would depend on the type of water year with higher amounts being eroded if a wet year occurs. These assumptions are supported by modeling performed as part of the Klamath River dam removal study: sediment transport Dam Removal Express Assessment Models (DREAM)-1 simulation, a peer reviewed sediment transport model (BOR 2011a and Stillwater Sciences 2008).

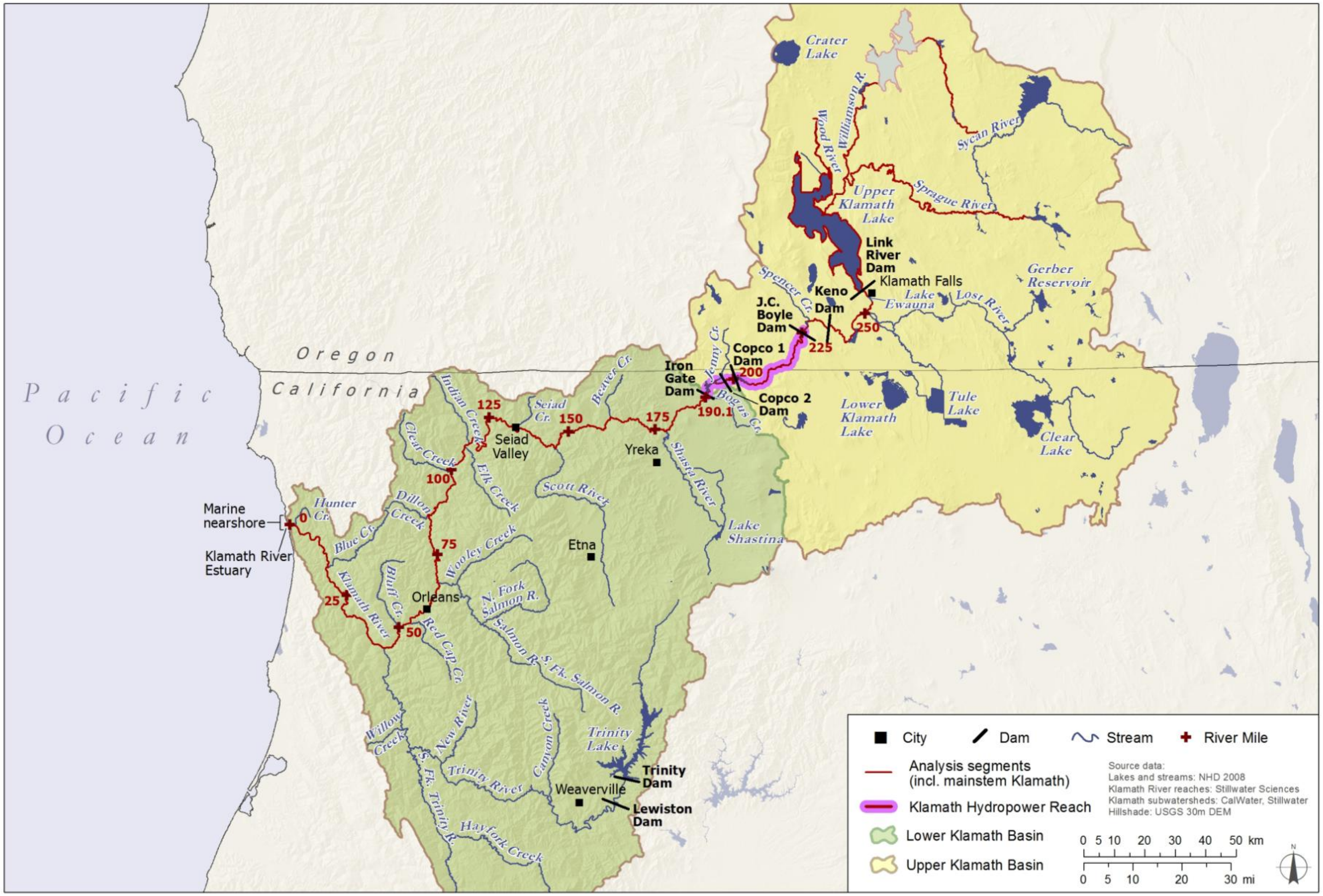

Figure 1
Area of Analysis

The amount of additional sediment delivered to the ocean as the result of dam removal is expected to be less than the average annual amount delivered by the Klamath watershed with the dams in place, because downstream tributary sediment inputs tend to exceed those from the upper basin. Although estimates of long-term average annual sediment discharge to the Klamath Estuary vary considerably, they are generally above the amount estimated to be mobilized under dam removal (BOR 2011a). Minimal long-term deposition of these eroded sediments would occur in the downstream river channel or the Klamath River estuary because the majority of sediment is of small size fraction and would remain in suspension during transport to the Pacific Ocean. Results of multiple modeling runs using DREAM to examine dam removal scenarios also predicted little to no discernable fine sediment deposition due to the overall fine grain nature of the sediments (i.e. silts and clays) and the dominance of the high gradient river channel downstream of Iron Gate Dam (BOR 2011a, Stillwater Sciences 2008).

1.2 Document Objective

The purpose of this report is to inform the Department of Interior Secretarial Determination process regarding the potential for adverse ecological or human health effects from chemical contamination in reservoir sediments if the dams are removed and a portion of the accumulated sediments is flushed downstream (Proposed Action or “dams removed”) or if the dams remain in place (No Action or “dams in”). This report did not include an evaluation of the physical effects (e.g., dissolved oxygen in the water, suspended sediment, siltation/embeddedness, flow alteration, habitat, or other sedimentation and geomorphic impacts) associated with the Proposed Action. These issues are addressed in other studies supporting the Secretarial Determination about whether the Klamath Dams will be removed (Stillwater Sciences, 2011a; BOR 2011a).

Although a considerable amount and breadth of data were collected for this study, this report is not intended to provide a formal Risk Assessment or provide decisions on a formal fish consumption advisory for either the Proposed or No-Action alternatives under the Secretarial Determination. In the future, if there is an affirmative decision, efforts would begin to develop detailed plans for dam removal and permitting processes.

1.3 Project Approach

To assess the potential for sediments behind the Klamath dams to cause adverse chemical or biological effects, the Sediment Evaluation Framework (SEF) was applied, along with chemical analysis of reservoir-collected fish. This process generated multiple lines of evidence that were then compared to several relevant exposure pathways of biota and human receptors to identify potential adverse effects.

1.3.1 SEF Overview

The SEF is a decision making process that was developed by numerous regional state and federal agencies for the Pacific Northwest (RSET, 2009) and is commonly used to determine when sediments from regional dredging projects are chemically and biologically suitable to be discharged into freshwater or marine environments without causing unacceptable adverse impacts. The SEF is consistent with the national dredged material testing guidelines jointly established by the USEPA and USACE (USEPA and USACE, 1991; USEPA and USACE, 1998). The SEF includes additional regionally approved methods and, in particular, region-specific chemical "screening levels" (SLs, discussed below). Although sediments behind the Klamath dams would not be removed by dredging, some portion would nonetheless be discharged (by flushing) into both downstream freshwater areas and ultimately the near shore marine environment. As such, the sediment evaluation and testing approach contained in the SEF is an appropriate framework for evaluating potential chemical and biological effects of released Klamath sediments.

The SEF, as well as the national testing guidelines, follows a tiered evaluation approach in which information is collected and evaluated only so far as is necessary to determine whether adverse effects are likely to occur. This approach is quite different from a typical remediation or cleanup project, where significant risks have already been identified and detailed assessment may be needed to determine cleanup standards necessary to reduce the risks to acceptable levels. In particular, the SEF includes two main "levels" of evaluation.

The SEF Level 1 evaluation involves a comparison of existing or preliminary data to applicable physical, chemical, and/or biological guidelines. When assessment questions can be satisfactorily addressed using Level 1 information and chemicals of concern can be managed sufficiently, sediment and tissue guidelines may be used to determine that no further testing is required. Level 1 concludes by identifying sediments that require no additional testing because they pose little potential for risk, and/or those sediments that do require additional testing because they pose a higher potential for risk associated with sediment exposure. If the preliminary or existing information assessed in Level 1 is insufficient for a regulatory decision, or data are ambiguous, then the project must enter the Level 2 assessment in which new, site-specific data are collected.

The Level 2 process contains two parts:

- Level 2A involves developing a Sampling and Analysis Plan (SAP), collection of new or additional sediment chemical and physical data, and comparison of that data against applicable guidelines (e.g., regional or national screening levels). If the new or additional sediment chemical and physical data are still insufficient for a regulatory decision, or data are ambiguous, then the project transitions into Level 2B.

- Level 2B consists of biological testing (sediment toxicity bioassays and/or bioaccumulation tests) to provide more empirical evidence, beyond simple comparisons to regional or national screening levels, regarding the potential for sediment contamination in the project area to have adverse effects on receptors. Biological evaluations are generally undertaken when: 1) available sediment screening levels are exceeded in Level 2A; 2) when there are no screening levels for chemicals of concern in the sediments; or 3) when uncertainty of data quality affects a decision making process. Laboratory biological tests serve to integrate chemical and biological interactions of sediment contaminants, including bioavailability, by measuring toxic effects on sensitive aquatic organisms:

- Tests involving whole sediment identify potential contamination that could affect bottom-dwelling (benthic) organisms.

- Tests using suspensions/elutriates of sediments (dredged) material are used to assess potential effects to the water column and associated receptors, and to determine numeric and narrative (toxicity) water quality compliance.

- Bioaccumulation testing measures the availability of sediment chemicals to be taken up into the tissues of exposed organisms, and thereby potentially enter the food web. Thus bioaccumulation test results can be used in human or ecological health risk evaluations, if necessary.

1.3.2 SEF Adaptation for the Klamath Process

The Klamath sediment evaluation process was based primarily on the SEF process as shown in **Figure 2**, with some adjustment to help accelerate the associated decisions.

- Existing sediment data collected from J.C. Boyle, Copco 1, and Iron Gate reservoirs and reported by GEC (2006) and Shannon & Wilson, Inc. (2006) were evaluated as part of Level 1. While that evaluation of the sediment data did not indicate a high risk of sediment toxicity (Shannon & Wilson, Inc. 2006, Dillon 2008), it was not sufficient to evaluate all analytes of interest and the spatial coverage was relatively coarse.

- Substantially more data were collected than the SEF's tiered approach strictly calls for between 2009 and 2010. For example, a relatively large number of sediment samples were taken (many individual core samples, and in most cases multiple subsamples from each core). The analyte suite was expanded from the Shannon & Wilson study to include additional chemicals likely to bioaccumulate. This decision transitioned the Klamath River project to include several SEF Level 2B evaluations.

- Full Level 2B testing was conducted on sediments from throughout the reservoirs, concurrent with, and in addition to decisions that might have resulted from Level 2A assessments on their own. These included both biological and elutriate tests.

Additional assessments outside the scope of the SEF were also conducted. To inform the public about potential concerns from eating fish caught from the reservoirs, resident fish collected from the reservoirs were analyzed for bioaccumulative chemicals of concern and results compared to fish tissue advisory levels protective of human health. Additionally, sediment chemistry values were compared to risk-based screening levels designed to be protective of residential exposure to soils (assuming the sediments were available for exposure).

1.3.3 Role of Chemical Screening Levels

The SEF tiered approach was used to help inform details of the evaluations conducted at subsequent levels. In particular, sediment chemistry results, compared against relevant screening levels, were used to identify chemicals to be analyzed in tissue samples for the bioaccumulation tests.

Chemical SLs are presented in the SEF for a variety of compounds routinely found in freshwater or marine sediments. The SLs are derived from regional chemistry and toxicity data from sediment sites in the Pacific Northwest. The regional sediment database includes paired data containing both chemical analytical results and bioassay testing results.

Each SL is derived using at least three different biological endpoints and corresponds to a "no adverse effects level." Different statistical approaches were used to derive marine values (apparent effect threshold – AET- approach) and freshwater values (floating point method - FPM - approach), and as a result, the mathematical models used to derive the SL values are somewhat different in marine and freshwater systems, but both were designed to be consistent with the same narrative definition of no adverse effects levels.

The SLs are designed to be protective of direct toxicity to benthic and epibenthic organisms. To some extent, these SL values also are protective of the invertebrate prey base of salmonid species listed under the Endangered Species Act (ESA). The use of amphipods and chironomids in freshwater bioassays is important as these are common prey species for salmonids.

In addition to freshwater and marine SLs which predict no adverse effects levels, the SEF for marine waters includes "maximum levels" (MLs) that predict potentially significant adverse effects levels. MLs are derived from the same paired data, as the SLs, and reflect concentration associated with adverse effects to all endpoints tested. Both MLs and SLs are developed without considerations to project-specific conditions (e.g., such as mixing and dilution).

In this evaluation of Klamath sediments, SEF regionally-derived MLs and SLs are considered the most applicable to use. They are identified at Step 1 and Steps 2a and 2b in **Figure 2**, and are listed in **Appendix A**.

SLs do not exist for all chemicals found in Klamath reservoir sediments. Under the SEF and national guidance, if no relevant screening value (e.g., SL) exists, or when relevant screening values are exceeded, bioassays need to be conducted to directly measure site-specific toxicity and bioavailability. In this evaluation of Klamath reservoir sediments, biological tests were conducted.

In addition to the SEF process, secondary regional and national chemical screening values were identified and included for additional considerations. These screening levels are identified as Step 2c and 2d criteria in **Figure 2** and are listed in **Appendix A**. These other criteria represent a variety of endpoints and are not necessarily targeted to assess effects related to sediment disposition like SEF Steps 1, 2a and 2b. Exceeding any of these 2c and 2d screening levels alone does not constitute the potential to cause adverse effects. They are provided as additional information for the Secretarial Determination.

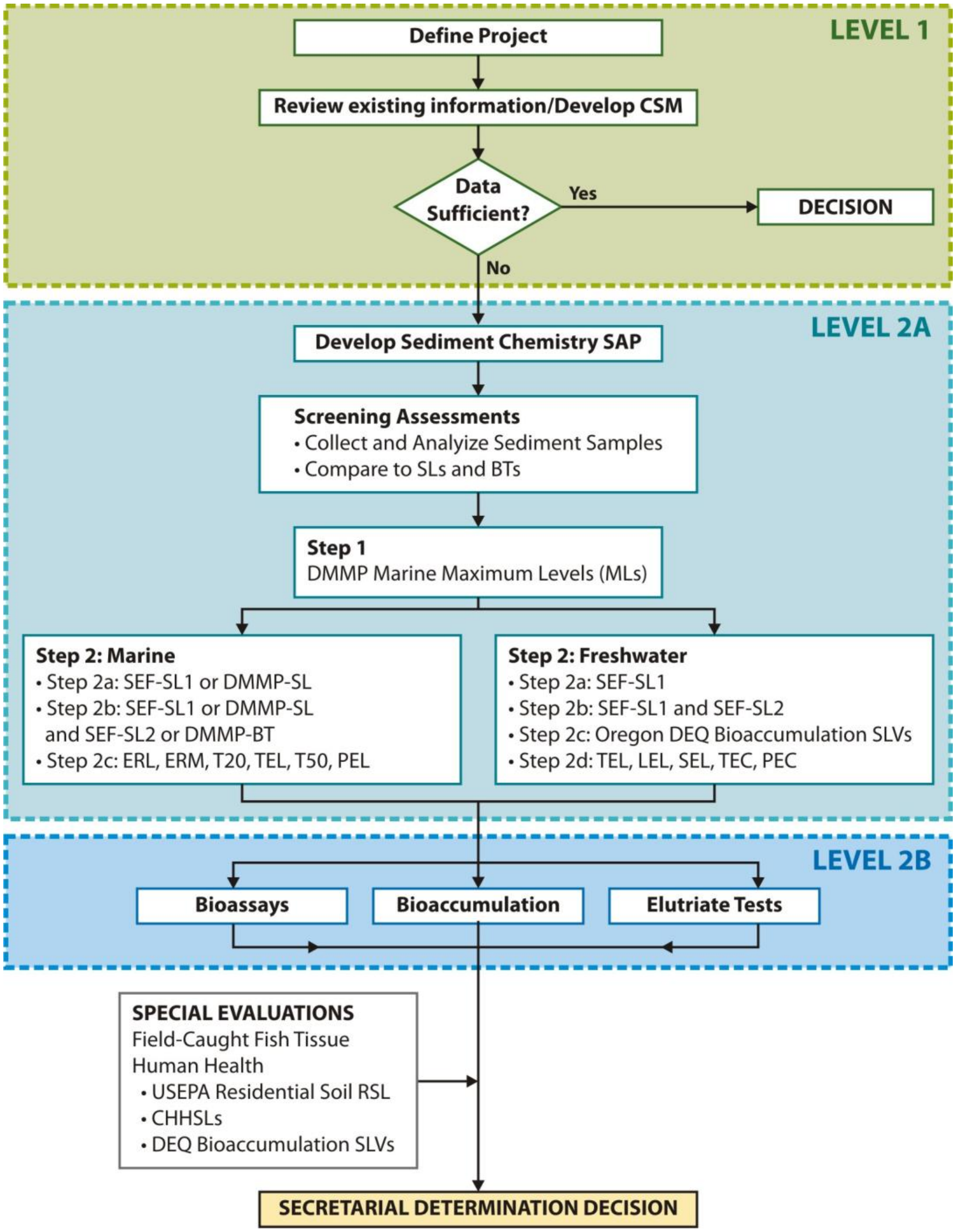

Figure 2
Schematic demonstrating application of the Sediment Evaluation Framework to the Klamath Reservoir contaminant investigation under the Secretarial Determination.

1.4 Lines of Evidence

The evaluation is based upon potential impacts using the following five exposure pathways under either the Proposed Action ”dams removed” or No Action ”dams in” alternatives as specified by the KHSA. For this screening-level study, the term "exposure pathway" is more inclusive then is typically associated with the definition of pathway under ecological risk assessment.

Dams Removed

- Pathway 1 –Short-term water column exposure for aquatic biota and humans from sediments flushed downstream (direct toxicity, not a bioaccumulation issue).
- Pathway 2 –Long-term sediment exposure for riparian biota and humans from reservoir terrace deposits and river bank deposits (terrestrial exposures).
- Pathway 3 –Long-term sediment exposure for aquatic biota and humans from river bed deposits (aquatic exposures).
- Pathway 4 –Long-term sediment exposure for aquatic biota from marine near shore deposits.

Dams In

- Pathway 5 –Long-term sediment exposure for aquatic biota and humans (via fish consumption) to the in-place reservoir sediments.

Figure 3 provides a graphical representation of the five exposure pathways within the Klamath system.

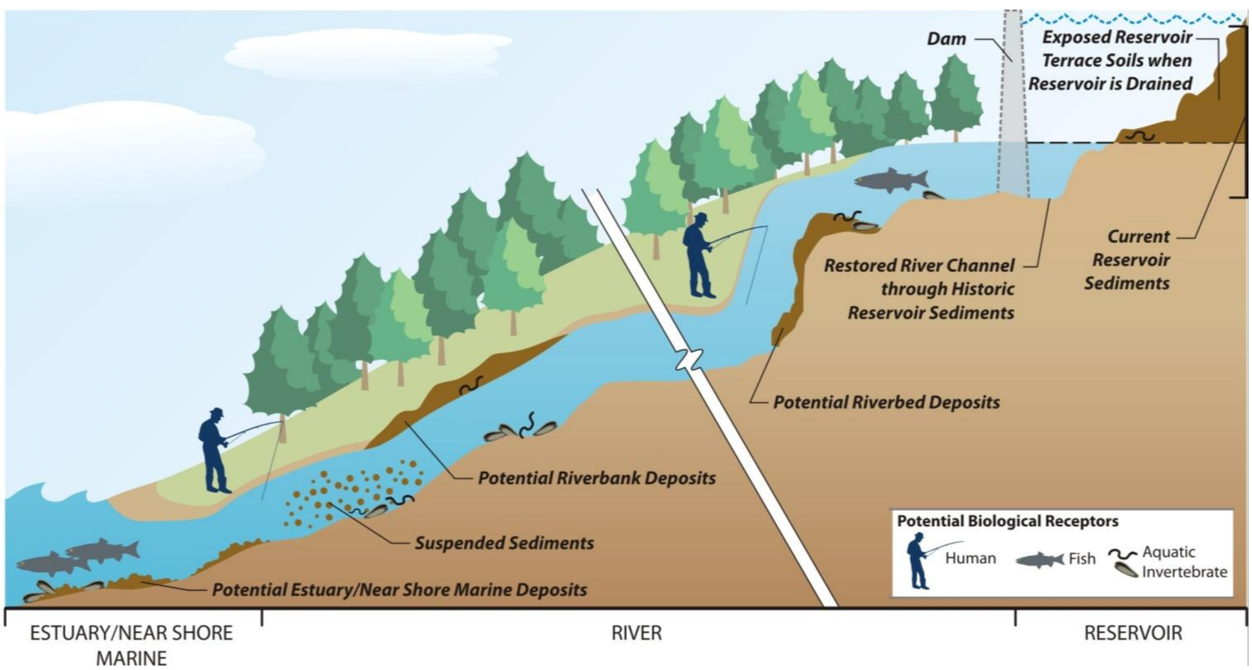

Figure 3
Conceptual pathways of exposure to Klamath Reservoir contaminants evaluated using Multiple Lines of Evidence Approach

Multiple lines of evidence were evaluated for contaminants from J.C. Boyle, Copco 1, and Iron Gate reservoirs and their potential effects downstream and in the estuary and near shore marine area, where applicable. Insufficient sediment was available for sampling in Copco 2 reservoir (BOR, 2011b); therefore, an evaluation of sediments was not completed for Copco 2. The multiple lines of evidence generated by each of these study components are used collectively to evaluate the quality of reservoir sediments and their potential to impact the environment and human health under Proposed Action "dams removed" and No Action "dams in." These lines of evidence are listed in **Table 1** and include the following Level 2A, Level 2B, and special (fish tissue and human health) evaluations:

Level 2A:

A comparison of BOR 2009-2010 sediment chemistry data to freshwater and marine ecological MLs and SLs, as applicable (this includes two independent lines of evidence, items 1 and 2 in **Table 1**).

Calculation of sediment toxic equivalency quotients (TEQs) for dioxin, furan, and dioxin-like polychlorinated biphenyl (PCB) congeners and comparison to ecological TEQ SLs (a single independent line of evidence, item 3 in **Table 1**).

Level 2B:

A comparison of elutriate chemistry results to ecological surface water SLs (a single independent line of evidence, item 4 in **Table 1**).

The results of acute sediment toxicity bioassay for the benthic midge (*Chironomus dilutens*) are evaluated (a single line of evidence, number 5 in **Table 1**).

The results of acute sediment toxicity bioassay for the benthic amphipod (*Hyalella azteca*) are evaluated (a single line of evidence, number 6 in **Table 1**).

The results of elutriate toxicity bioassay for rainbow trout (*Onchorhynchus mykiss*) survival (a single line of evidence, number 7 in **Table 1**).

Calculation of invertebrate (blackworms and Asian clams) biota-sediment accumulation factors (BSAFs) to evaluate bioaccumulation (two independent lines of evidence, numbers 8 and 9 in **Table 1**).

A comparison of chemical concentrations detected in the tissues of invertebrates (blackworms and Asian clams) exposed to reservoir sediments to tissue-based toxicity reference values (TRVs) (two independent lines of evidence, numbers 10 and 11 in **Table 1**).

Table 1. Summary of the Lines of Evidence Included to Evaluate the Potential Sediment-Contaminant Exposure Pathways for the Klamath Secretarial Determination

Line of Evidence	Exposure Pathways				
	1	2	3	4	5
Sediment Evaluation Framework Level 2A Step 1 – Sediment Screening Levels					
1. DMMP Marine MLs				+	
Sediment Evaluation Framework Level 2A Steps 2a, 2b, 2c, 2d – Sediment Screening Levels					
2. Ecological SLs (freshwater and marine)			+	+	+
3. Ecological TEQ SLVs (sediment)			+	+	+
Sediment Evaluation Framework Level 2B – Results of Water Quality Criteria Evaluations and Bioassays					
4. Elutriate WQC (ecological)	+			+	
5. Chironomus Bioassay			+	+	+
6. Hyalella Bioassay			+	+	+
7. Trout Bioassay	+			+	
8. Corbicula Bioaccumulation Study/BSAF(1)			+		+
9. Lumbriculus Bioaccumulation Study/BSAF(1)			+		+
10. Corbicula Tissue TRV			+	+	+
11. Lumbriculus Tissue TRV			+	+	+
Special Evaluations –Human Health in Sediment and Fish Tissue					
12. Perch Tissue TRV (ecological)			+	+	+
13. Bullhead Tissue TRV (ecological)			+	+	+
14. Fish Tissue TEQ (ecological)			+	+	+
15. HHSLs		+	+		+
16. HH TEQ SLVs (sediment)		+	+		+
17. Elutriate WQC (human health)					
18. Perch Tissue TRV (human health)			+		+
19. Bullhead Tissue TRV (human health)			+		+
20. Fish Tissue TEQ (human health)			+		+

+: applicable line of evidence for pathway

Corbicula fluminea =Asian clam (representative bivalve)
Lumbriculus variegatus = blackworm (representative oligochaete)

TEQ: Toxic Equivalency
SLV: Screening Level Value
WQC: Water Quality Criteria
TRV: Toxicity Reference Value
BSAF: Biota-Sediment Accumulation Factor
HHSL: Human Health Screening Level
ML: maximum level
SL: screening level
DMMP: Dredged Material Management Program

Special Evaluations:
A comparison of chemical concentrations detected in tissues of reservoir-collected fish (yellow perch and bullhead) to tissue-based ecological TRVs (two independent lines of evidence, numbers 12 and 13 in **Table 1**).

Fish tissue TEQs for dioxin, furan, and dioxin-like PCB congeners are calculated and compared to ecological TEQ SLs (a single independent line of evidence, item 14 in **Table 1**).

BOR 2009-2010 sediment chemistry data are compared to human health SLs (RSLs, CHHSLs and BSLVs), as applicable (a single independent line of evidence, item 15 in **Table 1**).

Calculation of sediment toxic equivalency quotients (TEQs) for dioxin, furan, and dioxin-like polychlorinated biphenyl (PCB) congeners and comparison to human health TEQ SLs (a single independent line of evidence, item 16 in **Table 1**).

A comparison of elutriate chemistry results to human health surface water WQC (a single independent line of evidence, item 17 in **Table 1**).

A comparison of chemical concentrations detected in tissues of reservoir-collected fish (yellow perch and bullhead) to tissue-based human health TRVs (two independent lines of evidence, numbers 18 and 19 in **Table 1**).

Fish tissue TEQs for dioxin, furan, and dioxin-like PCB congeners are calculated and compared to human health TEQ SLs (a single independent line of evidence, item 20 in **Table 1**).

The results of this evaluation, together with available data from previous studies of the reservoir sediments, are intended to inform the Secretary of any significant concerns related to sediments as they may affect a proposed Action or No Action determination for the associated Secretarial Determination about whether the Klamath River Dams will be removed. The physical, chemical, and biological data collected for this investigation, along with previously- collected data, allows for a detailed screening-level evaluation to be performed. This screening level evaluation follows Steps 2A and 2B of the SEF process (a total of 20 lines of evidence). Decisions on study design or use of data from this study reflect the resolution needed for the issues under consideration for the Secretarial Determination, for which the SEF is well suited. Some such decisions include:

- Some analytes in sediment, including PAH’s and several others, were not detected but had reporting limits that were above the SEF-SL1 screening levels, making the results inconclusive for the Level 2A analysis (**Figure 2**). To accommodate this concern, non-detected chemicals with elevated RLs based on the step-wise comparison of the 2009-2010 sediment data presented **Appendix A** were retained for analysis in macroinvertebrate and/or fish tissues (SEF Level 2B), where bioaccumulation tests could indicate effects from those chemicals potentially in the sediment.

- Analysis of fish tissues was done to evaluate potential human health effects for people who eat fish from the reservoir and for further evaluation of bioaccumulation in the reservoirs. For this analysis, two fish species were evaluated as they were distributed within and across the reservoirs. Both fish are consumed by people as well as wildlife, and represented somewhat different potential exposure routes to chemicals that may be present in the sediments. The species chosen were yellow perch and bullhead. Samples consisted of a single composite of seven fish for each reservoir, which was considered a reasonable approximation of average concentrations for the purposes of the study. Analysis of other species that are caught and consumed from the reservoirs, such as trout and largemouth bass, might be desired for other purposes at a later date. Additional details are provided in Sections 2.3 and 6.1.

- Background concentrations in sediment or tissues are often desired for contaminant studies, to help provide perspective on the relative magnitude of any chemicals detected in the study area. For this study, suitable background areas with similar sediments but without the same potential sources (e.g. urban areas, irrigated agriculture, industry, and hydroelectric development) as the Klamath hydroelectric reservoirs could not be identified. As an alternative, the Klamath River Estuary was sampled because it represents the likely receiving waters for much of the material released from the reservoirs if dams are removed. The lack of suitable background sites complicates the understanding of the relative amount of chemicals in reservoir sediments, but it does not affect analysis against screening levels under the SEF process, or related decisions about sediment release and disposition. Background sites also could help provide insights into potential sources of detected chemicals, but source identification was beyond the scope of this study.

The report is organized to reflect the study design, including the SEF process and special evaluations as follows:

Section 1: Introduction

Section 2: Overview of Data and Information Included in the Evaluation

Section 3: Sediment Chemicals of Potential Concern

Section 4: Evaluation of Elutriate Chemistry and Toxicity Bioassay

Section 5: Sediment Bioassay and Invertebrate Bioaccumulation

Section 6: Fish Tissue

Section 7: Exposure Pathway Evaluation and Conclusions

Section 8: References

Chapter 2
Overview of Data and Information Included in the Evaluation

2.1 Data Collection Approach

As described in Section 1, the data included in this evaluation were collected as part of Level 2 A, Level 2B, and special evaluation assessments, as depicted on **Figure 2**. The SEF is an established, comprehensive federal-state sediment evaluation framework developed for the Pacific Northwest and consistent with USEPA/USACE national sediment testing guidance. The SEF includes comparison of sediment chemistry to screening guidelines to help identify when more comprehensive testing is needed. If screening levels are exceeded, the SEF process calls for biological testing, to provide multiple lines of evidence to evaluate sediment and contaminant exposure pathways relevant to the system being studied. For example, in addition to collecting sediment physical and chemical data, the SEF calls for evaluation of potential toxicity of both suspended sediments (short-term exposure) and sediment deposits (long term exposure).

2.2 Sediment Data

As part of the SEF process Level 1,the potential for toxicity of the sediments trapped behind the reservoirs was investigated using existing data. Shannon & Wilson, Inc. (2006) collected 26 cores from J.C. Boyle, Copco 1, and Iron Gate during 2004–2005, which were analyzed for acid volatile sulfides, metals, pesticides, chlorinated acid herbicides, PCBs, VOCs, SVOCs, cyanide, and dioxins. Herbicides and PCBs were not detected above Puget Sound Dredged Materials Management Program (DMMP) SLs (Shannon & Wilson, Inc. 2006). While cyanide was detected in multiple sediment cores, it was not found in the toxic free cyanide form (HCN or CN^-), which indicated it was not likely to be bioavailable or result in adverse effects to fish and other aquatic biota. Dioxin TEQs were calculated for three sediment samples from J.C. Boyle, Copco 1, and Iron Gate. In the 2004–2005 reservoir samples, calculated concentrations ranged from 2.48 to 4.83 pg/g (picograms per gram or parts per trillion [ppt] expressed as Toxic Equivalent Concentrations), values that were subsequently revised downward to 2.27 to 4.47 pg/g on the basis of updated World Health Organization guidelines (WQST 2010). These levels did not exceed estimated background dioxin concentrations (2-5 ppt) for non-source-impacted sediments throughout the U.S. and specifically in the western U.S. (USEPA 2010). The measured levels exceeded Oregon human health and bioaccumulation thresholds; however, Oregon's human health thresholds are risk-based values for subsistence fishers as well as the general consuming public and are quite restrictive (0.0011–1.1 pg/g dw TEQ) (ODEQ 2007). While the existing sediment data (Shannon & Wilson, Inc. 2006a) did not indicate a high risk of sediment toxicity, it was not sufficient to evaluate all analytes of interest and provided relatively low spatial resolution of chemicals in the reservoirs sediments.

Based on the results provided by the data above and under the guidance of the *Quality Assurance Project Plan Sediment Contaminant Study*, *Klamath River Sediment Sampling Program JC Boyle, Copco-1, Copco-2, and Iron Gate Reservoirs; Klamath River Estuary Revision 2: August 2010* (BOR 2010a), sediment core samples were collected as part of the Secretarial Determination studies to further evaluate sediment quality and the associated potential impacts of the downstream release of sediment deposits currently stored behind the dams. Sediment core samples were collected between 2009 and 2010 at over 30 locations identified on **Figures 4** through **6.** Samples were collected across available sediment depths which resulted in various depth intervals per location. The number of individual samples was 26 at J.C. Boyle, 25 at Copco 1, 24 at Iron Gate, and two at the Klamath Estuary, for a total of 77 samples (BOR 2011b). A total of 501 analytes were quantified across the samples, including metals, PAHs, PCBs, pesticides/ herbicides, phthalates, VOCs, SVOCs, dioxins, furans, and polybrominated diphenyl ethers (PBDEs) (i.e., flame retardants). The results of Level 2A assessment for samples collected in 2009 and 2010 are discussed in **Appendix A**, and summarized in Section 3.

2.3 Tissue Data

Conducted as part of Level 2B of the Secretarial Determination, invertebrates (blackworms and Asian clams) collected from an external location were used for bioaccumulation studies. Blackworms and Asian clams were exposed in the laboratory to sediments collected from each reservoir (Copco 1, Iron Gate, and J.C. Boyle) and the Upper Klamath estuary (refer to Section 2.4), along with laboratory control (LC) samples exposed to their native sediments for approximately one month (28 days). Following these exposures the invertebrates were stored frozen (-80 Deg C) until analysis. Whole body worm and clam soft tissues were composited by taxon and reservoir, and analyzed for a suite of chemicals including metals, dioxins/furans, PCBs, pesticides and PBDEs. Invertebrate tissues were also analyzed for polycyclic aromatic hydrocarbons (PAHs), due to inconclusive results of sediment analysis, in which all sediment PAH detection levels have been greater than their respective SLVs (see Chapter 3) (BOR 2011b). Not all the chemicals were analyzed in each of the invertebrate tissue samples because the amount of available tissue was sometimes limited. When this occurred, a prioritized list was applied with analyses performed in the following order: Dioxins, PAHs, PCBs, organochlorine pesticides, metals, and PBDEs.

Fish collected from the reservoirs were also evaluated as part of the special evaluations conducted for the Secretarial Determination. Prior assessments of contaminants in fish tissue were undertaken as part of separate efforts by the CA Surface Water Ambient Monitoring Program (SWAMP) and PacifiCorp. As part of the SWAMP assessments, sport fish tissue samples were collected in 2007 and 2008 to evaluate accumulated contaminants in nearly 300 lakes statewide in California. Sport fish were sampled to provide information on potential human exposure to selected contaminants and to represent the higher aquatic trophic levels (i.e., the top of the aquatic food web). As part of the assessment, fish tissue samples were collected in Copco 1 and Iron Gate and analyzed for total mercury, selenium, and PCBs (Iron Gate only) (Davis et al. 2010). SWAMP data for Iron Gate and Copco 1 reservoirs identified mercury tissue

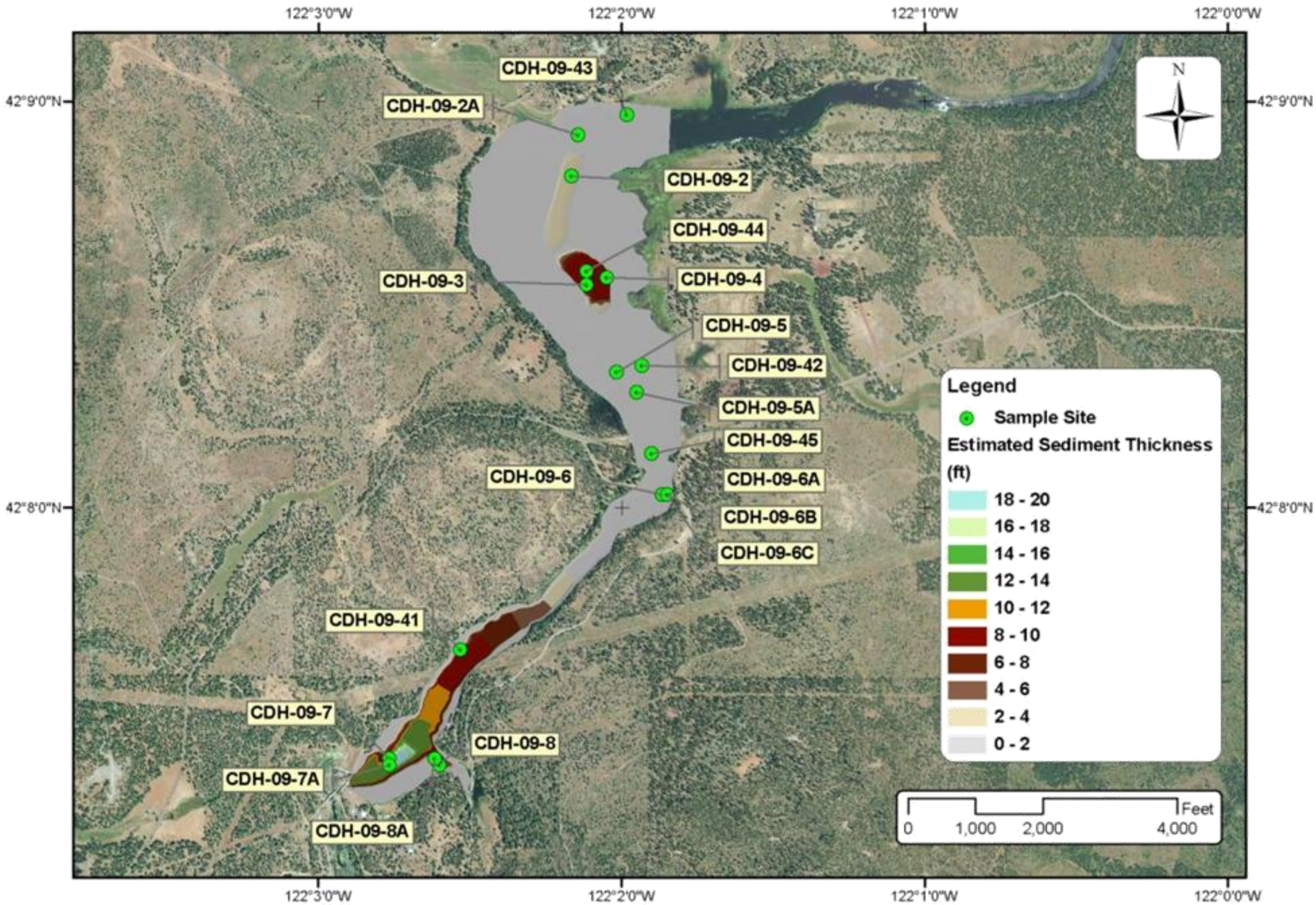

Figure 4
Sediment Sampling Sites for the Klamath River Secretarial Determination– J.C. Boyle Reservoir

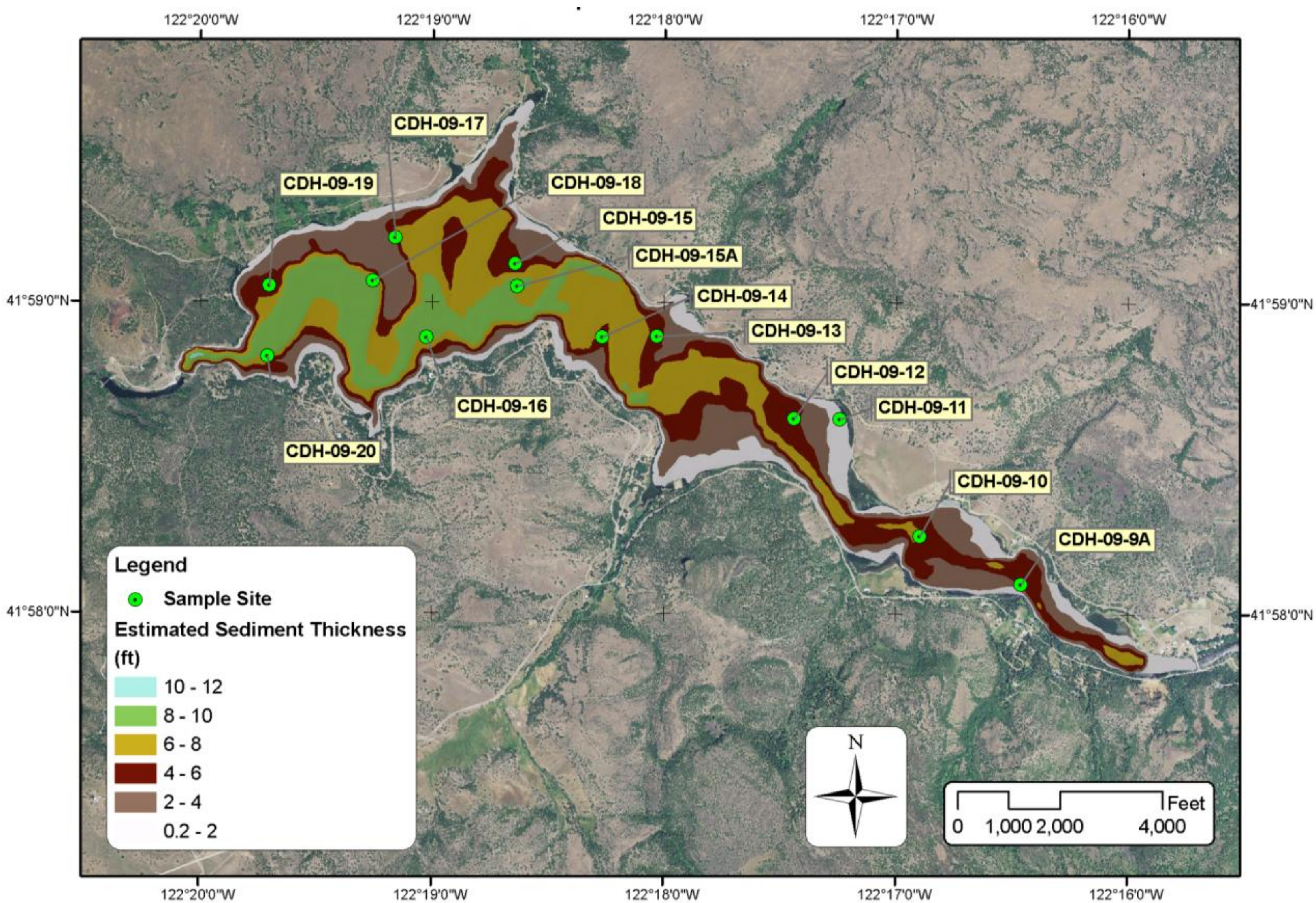

Figure 5
Sediment Sampling Sites for the Klamath River Secretarial Determination– Copco I Reservoir

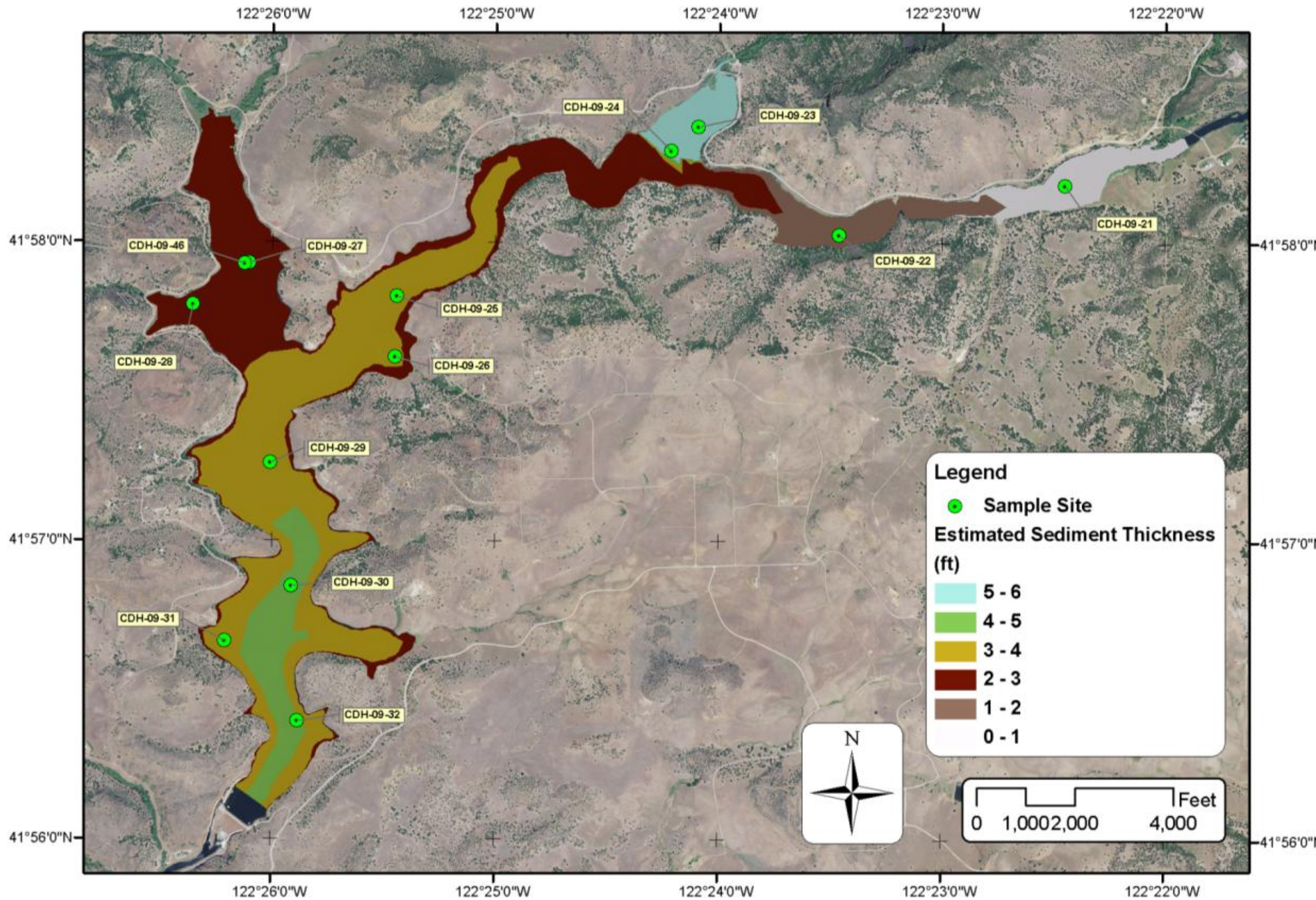

Figure 6
Sediment Sampling Sites for the Klamath River Secretarial Determination– Iron Gate Reservoir

concentrations above the applicable human health criteria. PacifiCorp analyzed metals (i.e., arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, and zinc), organochlorine pesticides, and PCBs in largemouth bass (*Micropterus salmoides*) and black bullhead catfish (*Ameiurus melas*) tissue samples collected from J.C. Boyle, Copco 1, and Iron Gate (PacifiCorp 2004). PacifiCorp reported that, in general, contaminant levels in fish tissue were below both SLs for the protection of human health (EPA 2000) and recommended guidance values for the protection of wildlife (MacDonald 1994). Exceptions found by PacifiCorp included arsenic in samples of largemouth bass from J.C. Boyle, Copco 1, and Iron Gate. Additionally, PacifiCorp indicated that total DDT concentrations in fish tissue samples from J.C. Boyle and Copco 1, and total PCB results in largemouth bass tissue samples collected from J.C. Boyle and Copco 1 exceeded one or more wildlife or human health SLs.

Based on the results provided by the above data, fish were collected as part of the Secretarial Determination studies (**Figure 2)** to further evaluate the potential for chemicals in sediment to bioaccumulate in fish species consumed from the Klamath reservoirs at concentrations above screening levels for human health. Five taxa of resident fish including bullhead *(Ameiurus melas)*, yellow perch (*Perca flavescens*), black crappie (*Poxomis nigromaculatus*), rainbow trout (*Oncorhynchus mykiss*), and largemouth bass (*Micropterus salmoides*) were collected from Copco 1, Iron Gate, and J.C. Boyle reservoirs in September 2010. Of these five taxa, two were selected for submittal to the laboratory for chemical analyses to support this screening level analysis—yellow perch and bullhead. Yellow perch were selected for evaluation because they are common in each of the reservoirs, representative of pelagic fish that reside and forage in the water column, and are an important component of the local fishery for both sport and consumption. Bullhead was selected for this evaluation because it represents benthic fish closely associated with the bottom sediments and is also consumed by people fishing in the reservoirs. Further, both fish species had been collected in sufficient quantities from each reservoir as to provide reasonable representation of the reservoirs, and adequate tissue amounts for laboratory analysis. In combination, selection of these two species was deemed appropriate to support the human health evaluation. One whole body composite sample was prepared by the laboratory using seven specimens per each species-specific composite (bullhead or perch) for each reservoir. Each reservoir was represented by one composite sample for each species (bullhead or perch), with each composite sample prepared by the laboratory using seven fish (whole body). Fish included in each composite were selected from field caught fish to be between seventy-five to one hundred percent of the maximum length fish, thereby ensuring that all fish within a single composite were of approximately the same age. Each composite was analyzed for metals, dioxins/furans, PCBs, pesticides, and PBDEs.

2.4 Elutriate Chemistry Data and Bioassays

Elutriate samples were collected concurrent with the 2009-2010 sediment samples and subject to elutriate chemistry analysis (384 chemicals [**Appendix A**]). Elutriate chemistry results are used as a direct indicator of short term effects from exposure to chemicals potentially released into the water column from suspended solids that would occur during flushing (Pathway 1) if Proposed Action “dams removed” was the selected action. For this study, elutriate test serves as an analog for when sediments and pore water (water found in the interstitial spaces between reservoir sediment particles) are re-suspended. Elutriate samples are from reservoir composite sediment samples are mixed with reservoir water (e.g., one to four dilution) and the resulting supernatant used in the analyses. Standard laboratory elutriate test results do not reflect estimated dilution that would occur if reservoir sediments were re-suspended by flushing under dams-out conditions.

Standard sediment and elutriate toxicity bioassays were conducted using fish and invertebrate national benchmark toxicity species, including rainbow trout (*Onchorhynchus mykiss*), midge (*Chironomus dilutens*), and amphipod (*Hyalella azteca*) (BOR 2010f). The toxicity bioassays studies were conducted as indicators of short- and long-term effects from exposure to deposited sediment.

In the reservoirs, on-thalweg (river channel) and off-thalweg "super composite" samples were used for elutriate chemistry and toxicity tests. Super-composite samples were collected from three reservoirs: Iron Gate, J. C. Boyle, and Copco 1. Each super-composite sample was comprised of subsamples from all on-thalweg cores collected from one reservoir or all off-thalweg cores collected from one reservoir. These super-composites were comprised of sediments collected from a range of core sample depths, which span:

- 0 – 2.9 feet for on-thalweg samples at the J.C. Boyle Reservoir
- 0 – 3.5 feet for off-thalweg samples at the J.C. Boyle Reservoir
- 0 – 9.7 feet for on-thalweg samples at the Copco 1 Reservoir
- 0 – 5.3 feet for off-thalweg samples at the Copco 1 Reservoir
- 0 – 4.8 feet for on-thalweg samples at the Iron Gate Reservoir
- 0 – 7.7 feet for off-thalweg samples at the Iron Gate Reservoir

From the estuary, "area composite" samples from the Upper Estuary and Lower Estuary samples were used for elutriate chemistry and toxicity. These composite samples were comprised of subsamples from multiple-core "area composite" samples collected from the Klamath Estuary, based on three to six core locations distributed within a half-mile. Sample cores span zero to one foot in depth.

Details of the sampling program are described in the *Quality Assurance Project Plan Sediment Contaminant Study, Klamath River Sediment Sampling Program JC Boyle, Copco-1, Copco-2, and Iron Gate Reservoirs; Klamath River Estuary Revision 2: August 2010* (BOR 2010a).

2.5 Data Validation and Database Management

Review, verification, and validation of laboratory sediment chemistry and toxicity, elutriate chemistry, and toxicity data were conducted by BOR following their Environmental Monitoring Branch's Standard Operating Procedures for Quality Assurance (2009-05) (BOR 2010 b-f). Review, verification, and validation of bioaccumulation (i.e., fish and invertebrate tissue) data were undertaken by USGS, USFWS, and USBR. Database construction was undertaken in 2010 and 2011 using Microsoft Office AccessTM (2003) to manage the chemistry, toxicity, and bioaccumulation data, as well as quality control (QC) information, for the aforementioned studies. Verified and validated data were added to the database as they became available and were used in subsequent analyses. Database construction included the following elements:

- Development of consistent chemical classes and individual chemical naming conventions for sediment, elutriate, and tissue datasets;
- Cross-checks on number and type of chemicals analyzed for sediment, elutriate, and tissue data sets;
- Differentiation of QC samples from field or laboratory samples;
- Development of a database convention for analytical non-detects (values reported by the laboratory as "ND"), which assigns a numeric value of less than the laboratory method detection limit (e.g., replaces "ND" with "< 0.01 µg/g" for a chemical having this MDL). For values between the MDL and the reporting limit (RL) a numeric value is provided by the laboratory and qualified with J flag assigned. J flagged values are used for quantitative analyses. However, specific evaluations may have used RLs and their use is specifically defined; and
- Unit conversions were included to maintain a dry weight convention for sediment data and a wet weight convention for tissue data.

Available and appropriate sediment screening levels (SLs) and bioaccumulation triggers (BTs), selected as part of the evaluation (**Appendices A** and **B**), were added to the database in coordination with the Water Quality SubTeam (WQST), a subteam of the Technical Management Team for the Secretarial Determination process. Applicable national and state water quality criteria (for elutriate data applied with consideration of dilution), TRVs for fish and invertebrate tissue, and human health fish tissue screening levels were also identified in coordination with the WQST and were included in the database. The Klamath sediment quality dataset, and a summary of SLs and BTs used in the preliminary evaluation, is available for download at the U.S. Department of Interior's project website (Klamathrestoration.gov).

2.6 Additional Information

While chemicals have been identified in sediments from J.C. Boyle, Copco I, and Iron Gate reservoirs on the Klamath River in California and Oregon (Shannon and Wilson, 2006; BOR 2011b), identification of historical or ongoing contaminant sources is not an objective of this sediment interpretive report. The USGS Forest and Rangeland Ecosystem Science center in Corvallis, Oregon is currently conducting a detailed study of ongoing contaminant sources in the Klamath Basin. Information reviewed for incorporation into this evaluation was limited to the *Upland Contaminant Source Study, Segment of Klamath River in Oregon and Washington* (Shannon and Wilson, 2006b), which includes general information on sites in or near the study area including: 1) reported hazardous waste contamination; 2) use of potentially hazardous materials; 3) industries where hazardous materials are used or transferred; and 4) agricultural use of pesticides and herbicides. No references were found to metal ore mining activities upstream of Iron Gate including in Klamath County. Review of this document did not identify specific sites that are considered ongoing sources of contamination to the reservoirs.

Likewise, toxicity due to cyanotoxins (i.e., toxins in blue-green algae) was not included in this report despite being an acknowledged water quality issue in the Klamath Reservoirs and downstream (Kann and Corum, 2009). This topic was excluded because of uncertainties in the science behind factors controlling the occurrence of cyanobacterial blooms and generation of cyanotoxins, and sampling to characterize the presence and effects of cyanotoxins on invertebrates and fish. Previous and ongoing studies targeting these questions in the basin are better positioned to provide detailed information than could be accomplished through this screening-level evaluation.

Chapter 3
Sediment Chemicals of Potential Concern

To assist with the evaluation of potential impacts from exposure to existing reservoir sediments under No Action ("dams in") and Proposed Action ("dams removed"), the sediment chemistry results for samples collected from the J.C. Boyle, Copco 1, and Iron Gate reservoirs, as well as the Klamath Estuary in 2009-2010 were reviewed to identify ecological and human health chemicals of potential concern (COPCs). A chemical was determined to be a COPC when the detected concentration exceeded a SEF ML or SL, or the detection limit of a non-detected chemical exceeded a SL. The sediment chemistry results were compared to freshwater and marine SLs, and human health screening values as appropriate, to evaluate potential for adverse effects to benthic organisms and humans, respectively, exposed to these sediments.

The hierarchy for freshwater and marine SLs, and human health screening values used to identify sediment COPCs for each reservoir and the estuary under No Action "dams in" (current conditions) and Proposed Action "dams removed" (potential future conditions) is summarized below**,** depicted on **Figure 2,** and detailed in **Appendix A**. **Tables 2** through **4** identify the highest level within the hierarchy at which the maximum detected concentration or the sample-specific RL for a non-detected chemical exceeds its applicable SL(s) leading to the chemical being selected as a COPC.

- Freshwater Screening Level Hierarchy --

  Retain if chemicals were above:

  Step 2a: SEF-SL1 or DMMP-SL
  Step 2b: Step 2a and SEF-SL2 or DMMP-BT

  Chemicals were also retained if they:

  Step 2c: had no SEF and one or more ODEQ bioaccumulative SLVs exceeded
  Step 2d: had no SEF or ODEQ values but one or more values provided in the NOAA SQuiRTs table was exceeded

  Note that although the ODEQ values are only applicable from a regulatory standpoint for J.C. Boyle, they are provided in the table for Copco 1 and Iron Gate when SLs from other sources are unavailable so that relative conditions can be compared among reservoirs.

- Marine Water Screening Level Hierarchy –

  Retain if above:

  Step1: DMMP-MLs
  Step 2a: SEF-SL1 or DMMP-SL
  Step 2b: Step 2a and SEF-SL2 or DMMP-BT

  Chemicals were also retained if they:

  Step 2c: had no SEF or DMMP screening values and one or more values provided in the NOAA SQuiRTs table was exceeded

- Human Health Screening Level Hierarchy –

  Retain if above any of the following:

  USEPA Residential RSLs (total carcinogenic and total non-carcinogenic; or California CHHSLs; or ODEQ bioaccumulation SLVs (human subsistence and human general).

  Note that although the ODEQ values are only applicable from a regulatory standpoint for J.C. Boyle, they are provided in the table for Copco 1 and Iron Gate when SLs from other sources are unavailable so that relative conditions can be compared among reservoirs.

Results of this review and evaluation to identify COPCs are summarized below. Details of chemicals exceeding SLs are presented in Tables A-5 through A-7 of **Appendix A**. The sample-specific reporting limits (RLs) for non-detected chemicals were also evaluated by comparing them to the SLs following the same hierarchy described in **Appendix A** (see also Table A-4). This evaluation resulted in identification of COPCs, which includes the potential presence of these chemicals at values below RLs but above applicable SLs.

3.1 COPCs Under the No Action "Dams In"

The sediment chemistry results for samples collected from the three reservoirs were compared to freshwater sediment SLs (primarily linked to protection of benthic invertebrates) and human health SLs to evaluate the potential for adverse effects to receptors under No Action "dams in." Additionally, the results from laboratory analysis of estuary sediment samples were compared to marine sediment SLs and human health sediment SLs to evaluate the potential for adverse effects to receptors under No Action "dams in." The individual chemicals that are identified as non-detects with elevated sample-specific RLs exceeding applicable SLs are listed in **Appendix C.** The results of the screening process are summarized in **Table 2** (Freshwater Sediment SLs), **Table 3** (Human Health Sediment SLs**)** and **Table 4 (**Marine Sediment SLs). Each table is arranged by reservoir and estuary, detected values followed by elevated RL, and screening level step (1, 2a, 2b, 2c, and 2d) if applicable. Findings for each reservoir are summarized below.

Table 2. Chemicals in 2009-2010 Klamath Reservoir Sediment that Exceed One or More Freshwater Sediment Screening Levels

Chemical	COPC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes[a]	Screening Values Exceeded	Highest of Screening Value Hierarchy Level[b]
J.C. Boyle Reservoir							
Nickel	D	mg/kg	19 - 32	---	114	**SEF-SL1**, SEF-SL2, FWS TEL, FWS LEL, FWS TEC	2b
4,4-DDD	D	ug/kg	3.7	---	9.5	ODEQ Bioacc SLV	2c
4,4-DDE	D	ug/kg	3.4	---	8.7	ODEQ Bioacc SLV	2c
4,4-DDT	D	ug/kg	4.1	---	11	ODEQ Bioacc SLV	2c
Dieldrin	D	ug/kg	3.4	---	1.5 - 9.2	FWS TEL, FWS LEL, FWS TEC, **ODEQ F-FW, ODEQ B-I**, ODEQ B-P, ODEQ M-I, ODEQ M-P	2c
2,3,4,7,8-PECDF	D	pg/g	1.5 - 1.5	---	1.4 - 8.8	**ODEQ F-FW**, ODEQ B-I, **ODEQ M-I**	2c
2,3,7,8-TCDD	D	pg/g	0.19	---	3.7	ODEQ M-I	2c
Iron	D	mg/kg	21,000 - 37,000	---	1.85	FWS LEL	2d
Cadmium	RL	mg/kg	---	0.16 - 0.84	---	SEF-SL1	2a
Aroclor 1221	RL	ug/kg	---	0.24 - 0.49	---	SEF-SL1 (total PCBs)	2a
Aroclor 1232	RL	ug/kg	---	0.16 - 0.24	---	SEF-SL1 (total PCBs)	2a
Aroclor 1242	RL	ug/kg	---	0.045 - 0.24	---	SEF-SL1 (total PCBs)	2a
Aroclor 1248	RL	ug/kg	---	0.045 - 0.24	---	SEF-SL1 (total PCBs)	2a
Aroclor 1254	RL	ug/kg	---	0.045 - 0.24	---	SEF-SL1 (total PCBs)	2a
Aroclor 1260	RL	ug/kg	---	0.045 - 0.24	---	SEF-SL1 (total PCBs)	2a
Bis(2-ethylhexyl)phthalate	RL	ug/kg	---	230 - 1200	---	SEF-SL1	2a
Butyl benzyl phthalate	RL	ug/kg	---	230 - 1200	---	SEF-SL1	2a
Dimethyl phthalate	RL	ug/kg	---	230 - 1200	---	SEF-SL1	2a
Di-n-octyl phthalate	RL	ug/kg	---	230 - 1200	---	SEF-SL1	2a
2-METHYLNAPHTHALENE	RL	ug/kg	---	230 - 1200	---	SEF-SL1	2a
ACENAPHTHENE	RL	ug/kg	---	230 - 1200	---	SEF-SL1	2a
ACENAPHTHYLENE	RL	ug/kg	---	230 - 1200	---	SEF-SL1	2a
BENZO(K)FLUORANTHENE	RL	ug/kg	---	230 - 1200	---	SEF-SL1	2a
DIBENZ(A,H)ANTHRACENE	RL	ug/kg	---	230 - 1200	---	SEF-SL1	2a
DIBENZOFURAN	RL	ug/kg	---	230 - 1200	---	SEF-SL1	2a
FLUORENE	RL	ug/kg	---	230 - 1200	---	SEF-SL1	2a
Chlordane (Technical)	RL	ug/kg	---	4.5 - 24	---	ODEQ Bioacc SLV	2c
Chlordane-Alpha	RL	ug/kg	---	0.9 - 4.9	---	ODEQ Bioacc SLV	2c

Table 2. Chemicals in 2009-2010 Klamath Reservoir Sediment that Exceed One or More Freshwater Sediment Screening Levels

Chemical	COPC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes[a]	Screening Values Exceeded	Highest of Screening Value Hierarchy Level[b]
J.C. Boyle Reservoir con't							
Chlordane-Gamma	RL	ug/kg	---	0.9 - 4.9	---	ODEQ Bioacc SLV	2c
Dieldrin	RL	ug/kg	---	0.9 - 4.9	---	ODEQ Bioacc SLV	2c
BHC-Gamma (HCH-gamma, Lindane)	RL	ug/kg	---	0.9 - 4.9	---	SQuiRTs (TEL, LEL, PEL, TEC)	2d
Endrin	RL	ug/kg	---	0.9 - 4.9	---	SQuiRTs (TEL, LEL, TEC)	2d
Heptachlor	RL	ug/kg	---	0.9 - 4.9	---	SQuiRTs (TEL, LEL, TEC)	2d
Heptachlor Epoxide	RL	ug/kg	---	0.9 - 4.9	---	SQuiRTs (TEL, PEL, TEC)	2d
Toxaphene	RL	ug/kg	---	45 - 240	---	SQuiRTs (TEL)	2d
Copco 1 Reservoir							
Nickel	D	mg/kg	22 - 32	---		SEF - SL1, SEF - SL2	2b
2,3,4,7,8-PECDF	D	pg/g	1.8 - 1.9	---	1.7 - 11.2	**ODEQ F-FW, ODEQ B-I, ODEQ M-I**	2c
Iron	D	mg/kg	21,000 - 24,000	---	1.2	FWS LEL	2d
SILVER	RL	mg/kg	---	1.8 - 2.4	---	SEF-SL1	2a
AROCLOR 1221	RL	ug/kg	---	0.24 - 0.3	---	SEF-SL1 (total PCBs)	2a
AROCLOR 1232	RL	ug/kg	---	0.12 - 0.15	---	SEF-SL1 (total PCBs)	2a
BIS(2-ETHYLHEXYL) PHTHALATE	RL	ug/kg	---	580 - 730	---	SEF-SL1	2a
BUTYL BENZYL PHTHALATE	RL	ug/kg	---	580 - 730	---	SEF-SL1	2a
DIMETHYL PHTHALATE	RL	ug/kg	---	580 - 730	---	SEF-SL1	2a
DI-N-OCTYL PHTHALATE	RL	ug/kg	---	580 - 730	---	SEF-SL1	2a
2-METHYLNAPHTHALENE	RL	ug/kg	---	580 - 730	---	SEF-SL1	2a
ACENAPHTHYLENE	RL	ug/kg	---	580 - 730	---	SEF-SL1	2a
BENZO(K)FLUORANTHENE	RL	ug/kg	---	580 - 730	---	SEF-SL1	2a
DIBENZOFURAN	RL	ug/kg	---	580 - 730	---	SEF-SL1	2a
4,4'-DDE	RL	ug/kg	---	2.4 - 3	---	SQuiRTs (TEL)	2d
4,4'-DDT	RL	ug/kg	---	2.4 - 3	---	SQuiRTs (TEL)	2d
BHC-gamma (HCH-gamma, Lindane)	RL	ug/kg	---	2.4 - 3	---	SQuiRTs (TEL, PEL, TEC)	2d
CHLORDANE (TECHNICAL)	RL	ug/kg	---	12 - 15	---	SQuiRTs (TEL, LEL, PEL, TEC)	2d

Table 2. Chemicals in 2009-2010 Klamath Reservoir Sediment that Exceed One or More Freshwater Sediment Screening Levels

Chemical	COPC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes[(a)]	Screening Values Exceeded	Highest of Screening Value Hierarchy Level[(b)]
Copco 1 Reservoir con't							
DIELDRIN	RL	ug/kg	---	2.4 - 3	---	SQuiRTs (TEL, LEL, TEC)	2d
ENDRIN	RL	ug/kg	---	2.4 - 3	---	SQuiRTs (TEC)	2d
HEPTACHLOR	RL	ug/kg	---	2.4 - 3	---	SQuiRTs (TEL, TEC)	2d
HEPTACHLOR EPOXIDE	RL	ug/kg	---	2.4 - 3	---	SQuiRTs (TEL, PEL, TEC)	2d
TOXAPHENE	RL	ug/kg	---	120 - 150	---	SQuiRTs (TEL)	2d
Iron Gate Reservoir							
Nickel	D	mg/kg	18 - 33	---	118	SEF - SL1, SEF - SL2	2b
2,3,4,7,8-PECDF	D	pg/g	0.74	---	1.1 - 4.4	ODEQ B-I, ODEQ M-I	2c
Iron	D	mg/kg	26,000 - 32,000	---	1.6	FWS LEL	2d
SILVER	RL	mg/kg	---	0.94 - 2.2	---	SEF-SL1	2a
AROCLOR 1221	RL	ug/kg	---	0.067 - 0.3	---	SEF-SL1 (total PCBs)	2a
AROCLOR 1232	RL	ug/kg	---	0.033 - 0.15	---	SEF-SL1 (total PCBs)	2a
BIS(2-ETHYLHEXYL) PHTHALATE	RL	ug/kg	---	170 - 730	---	SEF-SL1	2a
BUTYL BENZYL PHTHALATE	RL	ug/kg	---	170 - 730	---	SEF-SL1	2a
DI-N-OCTYL PHTHALATE	RL	ug/kg	---	170 - 730	---	SEF-SL1	2a
2-METHYLNAPHTHALENE	RL	ug/kg	---	170 - 730	---	SEF-SL1	2a
ACENAPHTHYLENE	RL	ug/kg	---	170 - 730	---	SEF-SL1	2a
BENZO(K)FLUORANTHENE	RL	ug/kg	---	170 - 730	---	SEF-SL1	2a
DIBENZOFURAN	RL	ug/kg	---	170 - 730	---	SEF-SL1	2a
NAPHTHALENE	RL	ug/kg	---	5 - 520	---	SEF-SL1	2a
4,4'-DDE	RL	ug/kg	---	0.67 - 3	---	SQuiRTs (TEL, TEC)	2d
4,4'-DDT	RL	ug/kg	---	0.67 - 3	---	SQuiRTs (TEL)	2d
BHC-gamma (HCH-gamma, Lindane)	RL	ug/kg	---	0.67 - 3	---	SQuiRTs (TEL, PEL, TEC)	2d
CHLORDANE (TECHNICAL)	RL	ug/kg	---	3.3 - 15	---	SQuiRTs (TEL, PEL, LEL, TEC)	2d
DIELDRIN	RL	ug/kg	---	0.67 - 3	---	SQuiRTs (TEL, LEL, TEC)	2d
ENDRIN	RL	ug/kg	---	0.67 - 3	---	SQuiRTs (TEL, TEC)	2d
HEPTACHLOR	RL	ug/kg	---	0.67 - 3	---	SQuiRTs (TEL, TEC)	2d
HEPTACHLOR EPOXIDE	RL	ug/kg	---	0.67 - 3	---	SQuiRTs (TEL, PEL, TEC)	2d
TOXAPHENE	RL	ug/kg	---	33 - 150	---	SQuiRTs (TEL)	2d

Table 2. Chemicals in 2009-2010 Klamath Reservoir Sediment that Exceed One or More Freshwater Sediment Screening Levels

Chemical	COPC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes[a]	Screening Values Exceeded	Highest of Screening Value Hierarchy Level[b]
Lower Klamath							
Chromium	D	mg/kg	96	--	1.0	**SL1-FWS**, SL2-FWS, FWS TEL, FWS LEL, FWS PEL, FWS TEC	2b
Nickel	D	mg/kg	110	--	393	**SL1-FWS**, SL2-FWS, FWS TEL, FWS LEL, FWS PEL, FWS TEC	2b
Iron	D	mg/kg	24,000 - 24,000	--	1.2	FWS LEL	2d
BIS(2-ETHYLHEXYL) PHTHALATE	RL	ug/kg	---	230	---	SEF-SL1	2a
DIMETHYL PHTHALATE	RL	ug/kg	---	230	---	SEF-SL1	2a
DI-N-OCTYL PHTHALATE	RL	ug/kg	---	230	---	SEF-SL1	2a
CHLORDANE (TECHNICAL)	RL	ug/kg	---	4.6	---	SQuiRTs (TEL, TEC)	2d
HEPTACHLOR EPOXIDE	RL	ug/kg	---	0.91	---	SQuiRTs (TEL)	2d
TOXAPHENE	RL	ug/kg	---	46	---	SQuiRTs (TEL)	2d
Upper Klamath							
Chromium	D	mg/kg	96 - 97	---	1.0	**SL1-FWS**, FWS TEL, FWS LEL, FWS PEL, FWS TEC	2a
Bis(2-ethylhexyl)phthalate	D	ug/kg	250	---	1.1	SL1-FWS	2a
DIMETHYL PHTHALATE	RL	ug/kg	---	230	---	SEF-SL1	2a
DI-N-OCTYL PHTHALATE	RL	ug/kg	---	230	---	SEF-SL1	2a
CHLORDANE (TECHNICAL)	RL	ug/kg	---	4.6	---	SQuiRTs (TEL, TEC)	2d
HEPTACHLOR EPOXIDE	RL	ug/kg	---	0.93	---	SQuiRTs (TEL)	2d
TOXAPHENE	RL	ug/kg	---	46	---	SQuiRTs (TEL)	2d

Notes:
Screening Level Hierarchy --
Retain if above:
1) DMMP-MLs
2a) SEF-SL1
2b) SEF-SL1 **AND** SEF-SL2
2c) Chemicals with no SEF and one or more ODEQ bioaccumulative SLVs exceeded
2d) Chemicals with no SEF or ODEQ but one or more SQuiRT exceeded

Units:
metals: mg/kg
pesticides: ug/kg
dioxins and furans: pg/g
SVOCs: ug/kg
phthalates: ug/kg

Table 2. Chemicals in 2009-2010 Klamath Reservoir Sediment that Exceed One or More Freshwater Sediment Screening Levels

Chemical	COPC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes[(a)]	Screening Values Exceeded	Highest of Screening Value Hierarchy Level[(b)]

B-I: Bird individual
B-P: Bird population
F-FW: Fish-freshwater

M-I: Mammal individual
M-P: Mammal population

(a): Ratio of maximum detected concentration to the SL is typically expressed as a Hazard Quotient (HQ). This ratio is presented above for each detected chemical
and is calculated using the maximum detected concentration; the highest and lowest of screening values when multiple are exceeded of same level in screening hierarchy. When more than two screening values are exceeded, the screening levels used for calculation of the ratio (HQ) are in **bold**.
(b): Screening level hierarchy depicted on Figure 2

Based on the information provided in Table A-6 and database query for ambiguous and positive exceedances

Table 3. Chemicals in 2009-2010 Klamath Reservoir Sediment that Exceed One or More Human Health Sediment Screening Levels

Chemical	COPC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes[(1)]	Screening Values Exceeded	Notes
J.C. Boyle Reservoir							
Arsenic	D	mg/kg	4.3 - 15	---	38 - 214	**EPA RSL TOT CAR**, **CHHSL Res**, CHHSL Comm	a
Nickel	D	mg/kg	19 - 32	---	84	**EPA RSL TOT CAR**	a
4,4-DDD	D	ug/kg	3.7	---	11 - 93	ODEQ BSLV H-S, ODEQ BSLV H-G	---
4,4-DDE	D	ug/kg	3.4	---	10 - 85	ODEQ BSLV H-S, ODEQ BSLV H-G	---
4,4-DDT	D	ug/kg	4.1	---	12 - 103	ODEQ BSLV H-S, ODEQ BSLV H-G	---
Dieldrin	D	ug/kg	3.4	---	420 - 3,400	ODEQ BSLV H-S, ODEQ BSLV H-G	---
1,2,3,4,6,7,8-HPCDD	D	pg/g	170 - 180	---	2.1	ODEQ BSLV H-S	---
1,2,3,4,7,8-HXCDD	D	pg/g	1.5 - 1.6	---	4.4	ODEQ BSLV H-S	---
1,2,3,6,7,8-HXCDD	D	pg/g	6.6 - 7.3	---	2.7 - 21	ODEQ BSLV H-S, ODEQ BSLV H-G	---
1,2,3,7,8,9-HXCDD	D	pg/g	3.7	---	1.4 - 11	ODEQ BSLV H-S, ODEQ BSLV H-G	---
1,2,3,4,7,8-HXCDF	D	pg/g	1.7 - 2.1	---	6.2	ODEQ BSLV H-S	
1,2,3,6,7,8-HXCDF	D	pg/g	4.4 - 5.3	---	2.0 - 16	ODEQ BSLV H-S, ODEQ BSLV H-G	---
1,2,3,7,8,9-HXCDF	D	pg/g	0.66 - 0.67	---	0.5 - 1.9	ODEQ BSLV H-S	---
1,2,3,7,8-PECDD	D	pg/g	1.1	---	4.1 - 37	ODEQ BSLV H-S, ODEQ BSLV H-G	---
1,2,3,7,8-PECDF	D	pg/g	0.88 - 1.1	---	3.5	ODEQ BSLV H-S	---
2,3,4,6,7,8-HXCDF	D	pg/g	3 - 3.2	---	1.2 - 9.4	ODEQ BSLV H-S, ODEQ BSLV H-G	---
2,3,4,7,8-PECDF	D	pg/g	1.5	---	50 - 405	ODEQ BSLV H-S, ODEQ BSLV H-G	---
2,3,7,8-TCDD	D	pg/g	0.19	---	19 - 173	ODEQ BSLV H-S, ODEQ BSLV H-G	b
2,3,7,8-TCDF	D	pg/g	0.88 - 0.9	---	1.2 - 9.6	ODEQ BSLV H-S, ODEQ BSLV H-G	---

Table 3. Chemicals in 2009-2010 Klamath Reservoir Sediment that Exceed One or More Human Health Sediment Screening Levels

Chemical	COPC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes(1)	Screening Values Exceeded	Notes
J.C. Boyle Reservoir con't							
Pentachlorophenol	D	ug/kg	34	---	1.1	ODEQ BSLV H-S	b
4,4,'-DDD	RL	ug/kg	---	0.9 - 4.9	---	ODEQ	---
4,4,'-DDE	RL	ug/kg	---	0.9 - 4.9	---	ODEQ	---
4,4,'-DDT	RL	ug/kg	---	0.9 - 4.9	---	ODEQ	---
Aroclor 1221	RL	ug/kg	---	0.24 - 0.49	---	EPA RSL	---
Aroclor 1232	RL	ug/kg	---	0.16 - 0.24	---	EPA RSL	---
Aroclor 1242	RL	ug/kg	---	0.045 - 0.24	---	EPA RSL	---
Aroclor 1248	RL	ug/kg	---	0.045 - 0.24	---	EPA RSL	---
Aroclor 1254	RL	ug/kg	---	0.045 - 0.24	---	EPA RSL	---
Aroclor 1260	RL	ug/kg	---	0.045 - 0.24	---	EPA RSL	---
BHC-Gamma (HCH-gamma, Lindane)	RL	ug/kg	---	0.9 - 4.9	---	CHHSLs	---
Chlordane (Technical)	RL	ug/kg	---	4.5 - 24	---	ODEQ	---
Chlordane-Alpha	RL	ug/kg	---	0.9 - 4.9	---	ODEQ	---
Chlordane-Gamma	RL	ug/kg	---	0.9 - 4.9	---	ODEQ	---
1,2,3-TRICHLOROPROPANE	RL	ug/kg	---	6.7 - 36	---	EPA RSL	---
1,2-DIBROMO-3-CHLOROPROPANE	RL	ug/kg	---	6.7 - 36	---	EPA RSL	---
3,3'-DICHLOROBENZIDINE	RL	ug/kg	---	230 - 1200	---	EPA RSL	---
BENZ(A)ANTHRACENE	RL	ug/kg	---	230 - 1200	---	EPA RSL	---
BENZO(A)PYRENE	RL	ug/kg	---	230 - 1200	---	EPA RSL, CHHSLs	---
BENZO(B)FLUORANTHENE	RL	ug/kg	---	230 - 1200	---	EPA RSL	---
BIS(2-CHLOROETHYL) ETHER	RL	ug/kg	---	230 - 1200	---	EPA RSL	---
DIBENZ(A,H)ANTHRACENE	RL	ug/kg	---	230 - 1200	---	EPA RSL	---
FLUORENE	RL	ug/kg	---	230 - 1200	---	EPA RSL	---
HEXACHLOROBENZENE	RL	ug/kg	---	230 - 1200	---	ODEQ, USEPA RSL	---
INDENO(1,2,3-CD)PYRENE	RL	ug/kg	---	230 - 1200	---	EPA RSL	---
N-NITROSODI-N-PROPYLAMINE	RL	ug/kg	---	230 - 1200	---	EPA RSL	---
TRANS-1,4-DICHLORO-2-BUTENE	RL	ug/kg	---	6.7 - 36	---	EPA RSL	---
1,2-DIBROMOETHANE	RL	ug/kg	---	6.7 - 36	---	EPA RSL	---
Copco 1 Reservoir							
Arsenic	D	mg/kg	6.3 - 13	---	33 - 186	**EPA RSL TOT CAR, CHHSL Res,** CHHSL Comm	---
Nickel	D	mg/kg	22 - 32	---	84	EPA RSL TOT CAR	---
1,2,3,4,6,7,8-HPCDD	D	pg/g	180 - 190	---	---	Yes	c

Table 3. Chemicals in 2009-2010 Klamath Reservoir Sediment that Exceed One or More Human Health Sediment Screening Levels

Chemical	COPC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes[1]	Screening Values Exceeded	Notes
Copco 1 Reservoir con't							
1,2,3,4,6,7,8-HPCDF	D	pg/g	89 - 96	---	---	Yes	c
1,2,3,4,7,8-HXCDD	D	pg/g	1.7 - 1.9	---	---	Yes	c
1,2,3,6,7,8-HXCDD	D	pg/g	8.8 - 9.8	---	---	Yes	c
1,2,3,7,8,9-HXCDD	D	pg/g	4.2 - 4.3	---	---	Yes	c
1,2,3,4,7,8-HXCDF	D	pg/g	2.3 - 2.8	---	---	Yes	c
1,2,3,6,7,8-HXCDF	D	pg/g	3.5 - 5.5	---	---	Yes	c
1,2,3,7,8,9-HXCDF	D	pg/g	1.0	---	---	Yes	c
2,3,4,6,7,8-HXCDF	D	pg/g	3.2 - 3.7	---	---	Yes	c
1,2,3,7,8-PECDD	D	pg/g	1.2 - 1.4	---	---	Yes	c
1,2,3,7,8-PECDF	D	pg/g	0.84	---	---	Yes	c
2,3,4,7,8-PECDF	D	pg/g	1.8 - 1.9	---	---	Yes	c
2,3,7,8-TCDF	D	pg/g	0.99 - 1.2	---	---	Yes	c
AROCLOR 1221	RL	ug/kg	---	0.24 - 0.3	---	EPA RSL	---
AROCLOR 1232	RL	ug/kg	---	0.12 - 0.15	---	EPA RSL	---
BHC-gamma (HCH-gamma, Lindane)	RL	ug/kg	---	2.4 - 3	---	CHHSLs	---
1,2,3-TRICHLOROPROPANE	RL	ug/kg	---	18 - 22	---	EPA RSL	---
1,2-DIBROMO-3-CHLOROPROPANE	RL	ug/kg	---	18 - 22	---	EPA RSL	---
BENZ(A)ANTHRACENE	RL	ug/kg	---	580 - 730	---	EPA RSL	---
BENZO(A)PYRENE	RL	ug/kg	---	580 - 730	---	EPA RSL, CHHSLs	---
BENZO(B)FLUORANTHENE	RL	ug/kg	---	580 - 730	---	EPA RSL	---
BIS(2-CHLOROETHYL) ETHER	RL	ug/kg	---	580 - 730	---	EPA RSL	---
DIBENZ(A,H)ANTHRACENE	RL	ug/kg	---	580 - 730	---	EPA RSL	---
HEXACHLOROBENZENE	RL	ug/kg	---	580 - 730	---	EPA RSL	---
INDENO(1,2,3-CD)PYRENE	RL	ug/kg	---	580 - 730	---	EPA RSL	---
N-NITROSODI-N-PROPYLAMINE	RL	ug/kg	---	580 - 730	---	EPA RSL	---
TRANS-1,4-DICHLORO-2-BUTENE	RL	ug/kg	---	18 - 22	---	EPA RSL	---
Iron Gate Reservoir							
Arsenic	D	mg/kg	7.4 - 10	---	26 - 143	**EPA RSL TOT CAR, CHHSL Res,** CHHSL Comm	---
Nickel	D	mg/kg	18 - 33	---	87	EPA RSL TOT CAR	---
1,2,3,4,7,8-HXCDD	D	pg/g	1.1	---	---	Yes	c
1,2,3,6,7,8-HXCDD	D	pg/g	3.4 - 3.5	---	---	Yes	c

Table 3. Chemicals in 2009-2010 Klamath Reservoir Sediment that Exceed One or More Human Health Sediment Screening Levels

Chemical	COPC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes(1)	Screening Values Exceeded	Notes
Iron Gate Reservoir con't							
1,2,3,7,8,9-HXCDD	D	pg/g	2 - 2.5	---	---	Yes	c
1,2,3,4,7,8-HXCDF	D	pg/g	1.2	---	---	Yes	c
1,2,3,6,7,8-HXCDF	D	pg/g	1.2 - 1.4	---	---	Yes	c
2,3,4,6,7,8-HXCDF	D	pg/g	1.2 - 1.4	---	---	Yes	c
1,2,3,7,8-PECDD	D	pg/g	0.62 - 0.82	---	---	Yes	c
1,2,3,7,8-PECDF	D	pg/g	0.44 - 0.52	---	---	Yes	c
2,3,4,7,8-PECDF	D	pg/g	0.74	---	---	Yes	c
2,3,7,8-TCDF	D	pg/g	0.68	---	---	Yes	c
AROCLOR 1221	RL	ug/kg	---	0.067 - 0.3	---	EPA RSL	---
AROCLOR 1232	RL	ug/kg	---	0.033 - 0.15	---	EPA RSL	---
1,2,3-TRICHLOROPROPANE	RL	ug/kg	---	5 - 22	---	EPA RSL	---
1,2-DIBROMO-3-CHLOROPROPANE	RL	ug/kg	---	5 - 22	---	EPA RSL	---
BENZ(A)ANTHRACENE	RL	ug/kg	---	170 - 730	---	EPA RSL	---
BENZO(A)PYRENE	RL	ug/kg	---	170 - 730	---	EPA RSL, CHHSLs	---
BENZO(B)FLUORANTHENE	RL	ug/kg	---	170 - 730	---	EPA RSL	---
BIS(2-CHLOROETHYL) ETHER	RL	ug/kg	---	170 - 730	---	EPA RSL	---
DIBENZ(A,H)ANTHRACENE	RL	ug/kg	---	170 - 730	---	EPA RSL	---
HEXACHLOROBENZENE	RL	ug/kg	---	170 - 730	---	EPA RSL	---
INDENO(1,2,3-CD)PYRENE	RL	ug/kg	---	170 - 730	---	EPA RSL	---
N-NITROSODI-N-PROPYLAMINE	RL	ug/kg	---	170 - 730	---	EPA RSL	---
TRANS-1,4-DICHLORO-2-BUTENE	RL	ug/kg	---	5 - 22	---	EPA RSL	---
Lower Klamath Estuary							
Arsenic	D	mg/kg	3.2	---	8.2 - 46	**EPA RSL TOT CAR, CHHSL Res,** CHHSL Comm	---
Nickel	D	mg/kg	110	---	289	EPA RSL TOT CAR	---
BHC-gamma (HCH-gamma, Lindane)	RL	ug/kg	---	0.91	---	CHHSLs	---
1,2,3-TRICHLOROPROPANE	RL	ug/kg	---	6.8	---	EPA RSL	---
1,2-DIBROMO-3-CHLOROPROPANE	RL	ug/kg	---	6.8	---	EPA RSL	---
BENZ(A)ANTHRACENE	RL	ug/kg	---	230	---	EPA RSL	---
BENZO(A)PYRENE	RL	ug/kg	---	230	---	EPA RSL, CHHSLs	---
BENZO(B)FLUORANTHENE	RL	ug/kg	---	230	---	EPA RSL	---
BIS(2-CHLOROETHYL) ETHER	RL	ug/kg	---	230	---	EPA RSL	---
DIBENZ(A,H)ANTHRACENE	RL	ug/kg	---	230	---	EPA RSL	---

Table 3. Chemicals in 2009-2010 Klamath Reservoir Sediment that Exceed One or More Human Health Sediment Screening Levels

Chemical	COPC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes[1]	Screening Values Exceeded	Notes
Lower Klamath Estuary con't							
INDENO(1,2,3-CD)PYRENE	RL	ug/kg	---	230	---	EPA RSL	---
N-NITROSODI-N-PROPYLAMINE	RL	ug/kg	---	230	---	EPA RSL	---
Upper Klamath Estuary							
Arsenic	D	mg/kg	2.2	---	5.6 - 31	**EPA RSL TOT CAR, CHHSL Res,** CHHSL Comm	---
Nickel	D	mg/kg	110	---	289	EPA RSL TOT CAR	---
BHC-gamma (HCH-gamma, Lindane)	RL	ug/kg	---	0.93	---	CHHSLs	---
1,2,3-TRICHLOROPROPANE	RL	ug/kg	---	7	---	EPA RSL	---
1,2-DIBROMO-3-CHLOROPROPANE	RL	ug/kg	---	7	---	EPA RSL	---
BENZ(A)ANTHRACENE	RL	ug/kg	---	230	---	EPA RSL	---
BENZO(A)PYRENE	RL	ug/kg	---	230	---	EPA RSL, CHHSLs	---
BENZO(B)FLUORANTHENE	RL	ug/kg	---	230	---	EPA RSL	---
BIS(2-CHLOROETHYL) ETHER	RL	ug/kg	---	230	---	EPA RSL	---
DIBENZ(A,H)ANTHRACENE	RL	ug/kg	---	230	---	EPA RSL	---
INDENO(1,2,3-CD)PYRENE	RL	ug/kg	---	230	---	EPA RSL	---
N-NITROSODI-N-PROPYLAMINE	RL	ug/kg	---	230	---	EPA RSL	---
TRANS-1,4-DICHLORO-2-BUTENE	RL	ug/kg	---	7	---	EPA RSL	---

Notes:
(1): Ratio of maximum detected concentration to the SL is typically expressed as a Hazard Quotient (HQ). This ratio is presented above for each detected chemical and is calculated using the maximum detected concentration; the highest and lowest of screening values when multiple are exceeded of same level in screening hierarchy. When more than two screening values are exceeded, the screening level used for calculation of the ratio (HQ) is in **bold**.

Screening Level Hierarchy for Human Health:
USEPA Residential RSLs (total carcinogenic and total non-carcinogenic), CHHSLs, and ODEQ bioaccumulation SLVs (Human Subsistence and Human General)
(a): no ODEQ values
(b): below USEPA RSLs, CHHSLs
(c): Although ODEQ bioaccumulation SLVs are not applicable in California for regulatory purposes, comparisons of measured concentrations from Copco 1 Reservoir, Iron Gate Reservoir, and Klamath Estuary sediment samples to these SLVs were undertaken due to the lack of other available SLVs for particular chemicals, such as dioxins and furans. This comparison also allowed for direct comparison of sediment quality between all three reservoirs using a common set of SLVs

Table 3. Chemicals in 2009-2010 Klamath Reservoir Sediment that Exceed One or More Human Health Sediment Screening Levels

Chemical	COPC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes(1)	Screening Values Exceeded	Notes

RSL: Residential Screening Level
TOT CAR: Total carcinogen
TOT NON CAR: Total non-carcinogen

Units:
metals: mg/kg
pesticides: ug/kg
dioxins and furans: pg/g
SVOCs: ug/kg

Comm: commercial/industrial
Res: residential

Based on the information provided in Table A-7 and database query for ambiguous and positive exceedances

Table 4. Chemicals in 2009-2010 Klamath Reservoir Sediment that Exceed One or More Marine Sediment Screening Levels

Chemical	COPC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes[(a)]	Screening Values Exceeded	Highest of Screening Value Hierarchy Level[(b)]
J.C. Boyle Reservoir							
Dieldrin	D	ug/kg	3.4	---	1.8	**SEF-SL1**, SEF-SL2, MS ERL, MS T20, MS TEL, MS T50, F-M	2a
2,3,4,7,8-PECDF	D	pg/g	1.5-1.5	---	1.4	ODEQ BSLV	2c
Butyl benzyl phthalate	RL	ug/kg	---	230 - 1200	---	DMMP-ML	1
2,4-DIMETHYLPHENOL	RL	ug/kg	---	230 - 1200	---	DMMP-ML	1
2-METHYLPHENOL	RL	ug/kg	---	230 - 1200	---	DMMP-ML	1
4-METHYLPHENOL	RL	ug/kg	---	230 - 1200	---	DMMP-ML	1
BENZOIC ACID	RL	ug/kg	---	930 - 4800	---	DMMP-ML	1
BENZYL ALCOHOL	RL	ug/kg	---	230 - 1200	---	DMMP-ML	1
HEXACHLOROBENZENE	RL	ug/kg	---	230 - 1200	---	DMMP-ML	1
N-NITROSODIPHENYLAMINE	RL	ug/kg	---	230 - 1200	---	DMMP-ML	1
Aroclor 1232	RL	ug/kg	---	0.16 - 0.24	---	DMMP-SL, SEF-SL1 (total PCBs)	2a
Aroclor 1242	RL	ug/kg	---	0.045 - 0.24	---	DMMP-SL, SEF-SL1 (total PCBs)	2a
Aroclor 1248	RL	ug/kg	---	0.045 - 0.24	---	DMMP-SL, SEF-SL1 (total PCBs)	2a
Aroclor 1254	RL	ug/kg	---	0.045 - 0.24	---	DMMP-SL, SEF-SL1 (total PCBs)	2a
Aroclor 1260	RL	ug/kg	---	0.045 - 0.24	---	DMMP-SL, SEF-SL1 (total PCBs)	2a
Chlordane (Technical)	RL	ug/kg	---	4.5 - 24	---	DMMP-SL, SEF-SL1	2a
Chlordane-Alpha	RL	ug/kg	---	0.9 - 4.9	---	DMMP-SL, SEF-SL1	2a
Chlordane-Gamma	RL	ug/kg	---	0.9 - 4.9	---	DMMP-SL, SEF-SL1	2a
Heptachlor	RL	ug/kg	---	0.9 - 4.9	---	SEF-SL1	2a
Endrin	RL	ug/kg	---	0.9 - 4.9	---	no value	2c
Heptachlor Epoxide	RL	ug/kg	---	0.9 - 4.9	---	SQuiRTs (T20, PEL)	2c
Toxaphene	RL	ug/kg	---	45 - 240	---	SQuiRTs (TEL)	2c
BENZO(B)FLUORANTHENE	RL	ug/kg	---	230 - 1200	---	SQuiRTs (T20, T50)	2c
Butyl benzyl phthalate	RL	ug/kg		230 - 1,200		DMMP-ML	

Table 4. Chemicals in 2009-2010 Klamath Reservoir Sediment that Exceed One or More Marine Sediment Screening Levels

Chemical	COPC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes[(a)]	Screening Values Exceeded	Highest of Screening Value Hierarchy Level[(b)]
Copco 1 Reservoir							
2,4-DIMETHYLPHENOL	RL	ug/kg	---	580 - 730	---	DMMP-ML	1
2-METHYLPHENOL	RL	ug/kg	---	580 - 730	---	DMMP-ML	1
BENZOIC ACID	RL	ug/kg	---	2300 - 2900	---	DMMP-ML	1
HEXACHLOROBENZENE	RL	ug/kg	---	580 - 730	---	DMMP-ML	1
N-NITROSODIPHENYLAMINE	RL	ug/kg	---	580 - 730	---	DMMP-ML	1
AROCLOR 1221	RL	ug/kg	---	0.24 - 0.3	---	DMMP-SL, SEF-SL1 (total PCBs)	2a
AROCLOR 1232	RL	ug/kg	---	0.12 - 0.15	---	DMMP-SL, SEF-SL1 (total PCBs)	2a
CHLORDANE (TECHNICAL)	RL	ug/kg	---	12 - 15	---	DMMP-SL, SEF-SL1	2a
CHLORDANE-ALPHA	RL	ug/kg	---	2.4 - 3	---	SEF-SL1	2a
CHLORDANE-GAMMA	RL	ug/kg	---	2.4 - 3	---	SEF-SL1	2a
DIELDRIN	RL	ug/kg	---	2.4 - 3	---	SEF-SL1	2a
HEPTACHLOR	RL	ug/kg	---	2.4 - 3	---	SEF-SL1	2a
HEPTACHLOR EPOXIDE	RL	ug/kg	---	2.4 - 3	---	SQuiRTs (T20, PEL)	2c
BENZO(B)FLUORANTHENE	RL	ug/kg	---	580 - 730	---	SQuiRTs (T20)	2c
BENZO(G,H,I)PERYLENE	RL	ug/kg	---	580 - 730	---	no value	2c
Iron Gate Reservoir							
1,4-DICHLOROBENZENE	RL	ug/kg	---	5 - 520	---	DMMP-ML	1
2,4-DIMETHYLPHENOL	RL	ug/kg	---	170 - 730	---	DMMP-ML	1
2-METHYLPHENOL	RL	ug/kg	---	170 - 730	---	DMMP-ML	1
BENZOIC ACID	RL	ug/kg	---	670 - 2900	---	DMMP-ML	1
HEXACHLOROBENZENE	RL	ug/kg	---	170 - 730	---	DMMP-ML	1
HEXACHLOROBUTADIENE	RL	ug/kg	---	5 - 520	---	DMMP-ML	1
N-NITROSODIPHENYLAMINE	RL	ug/kg	---	170 - 730	---	DMMP-ML	1
AROCLOR 1221	RL	ug/kg	---	0.067 - 0.3	---	DMMP-SL, SEF-SL1 (total PCBs)	2a
AROCLOR 1232	RL	ug/kg	---	0.033 - 0.15	---	DMMP-SL, SEF-SL1 (total PCBs)	2a
CHLORDANE (TECHNICAL)	RL	ug/kg	---	3.3 - 15	---	DMMP-SL, SEF-SL1	2a
CHLORDANE-ALPHA	RL	ug/kg	---	0.67 - 3	---	SEF-SL1	2a
CHLORDANE-GAMMA	RL	ug/kg	---	0.67 - 3	---	SEF-SL1	2a
DIELDRIN	RL	ug/kg	---	0.67 - 3	---	SEF-SL1	2a
HEPTACHLOR	RL	ug/kg	---	0.67 - 3	---	SEF-SL1	2a

Table 4. Chemicals in 2009-2010 Klamath Reservoir Sediment that Exceed One or More Marine Sediment Screening Levels

Chemical	COPC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes[(a)]	Screening Values Exceeded	Highest of Screening Value Hierarchy Level[(b)]
Iron Gate Reservoir con't							
HEPTACHLOR EPOXIDE	RL	ug/kg	---	0.67 - 3	---	SEF-SL1	2a
1,2,4-TRICHLOROBENZENE	RL	ug/kg	---	5 - 520	---	DMMP-SL, SEF-SL1	2a
1,3-DICHLOROBENZENE	RL	ug/kg	---	5 - 520	---	DMMP-SL	2a
BENZO(B)FLUORANTHENE	RL	ug/kg	---	170 - 730	---	SQuiRTs (T20)	2c
Lower Klamath							
2,4-DIMETHYLPHENOL	RL	ug/kg	---	230	---	DMMP-ML	1
2-METHYLPHENOL	RL	ug/kg	---	230	---	DMMP-ML	1
BENZOIC ACID	RL	ug/kg	---	910	---	DMMP-ML	1
N-NITROSODIPHENYLAMINE	RL	ug/kg	---	230	---	DMMP-ML	1
CHLORDANE (TECHNICAL)	RL	ug/kg	---	4.6	---	SEF-SL1	2a
HEPTACHLOR EPOXIDE	RL	ug/kg	---	0.91	---	SQuiRTs (T20)	2c
TOXAPHENE	RL	ug/kg	---	46	---	SQuiRTs (TEL)	2c
BENZO(B)FLUORANTHENE	RL	ug/kg	---	230	---	SQuiRTs (T20)	2c
Upper Klamath							
2,4-DIMETHYLPHENOL	RL	ug/kg	---	230	---	DMMP-ML	1
2-METHYLPHENOL	RL	ug/kg	---	230	---	DMMP-ML	1
BENZOIC ACID	RL	ug/kg	---	930	---	DMMP-ML	1
N-NITROSODIPHENYLAMINE	RL	ug/kg	---	230	---	DMMP-ML	1
CHLORDANE (TECHNICAL)	RL	ug/kg	---	4.6	---	SEF-SL1	2a
HEPTACHLOR EPOXIDE	RL	ug/kg	---	0.93	---	SQuiRTs (T20)	2c
TOXAPHENE	RL	ug/kg	---	46	---	SQuiRTs (TEL)	2c
BENZO(B)FLUORANTHENE	RL	ug/kg	---	230	---	SQuiRTs (T20)	2c

Notes:
Screening Level Hierarchies for Marine Waters--
Retain if above:
1) DMMP-MLs
2a) SEF-SL1 or DMMP-SL
2b) SEF-SL1 or DMMP-SL **AND** SEF-SL2 or DMMP-BT
2c) Chemicals with no SEF or DMMP and one or more SQuiRTs exceeded

MS: marine sediment
ERL: Effects Range Low
TEL: Threshold Effect Level
PEL: probable effect level

Units:
metals: mg/kg
pesticides: ug/kg
dioxins and furans: pg/g
SVOCs: ug/kg
phthalates: ug/kg

Table 4. Chemicals in 2009-2010 Klamath Reservoir Sediment that Exceed One or More Marine Sediment Screening Levels

Chemical	COPC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes[(a)]	Screening Values Exceeded	Highest of Screening Value Hierarchy Level[(b)]

T20: concentration representing 20% probability of observing effect
T50: concentration representing 50% probability of observing effect

(a): Ratio of maximum detected concentration to the SL is typically expressed as a Hazard Quotient (HQ). This ratio is presented above for each detected chemical and is calculated using the maximum detected concentration; the highest and lowest of screening values when multiple are exceeded of same level in screening hierarchy. When more than two screening values are exceeded, the screening level used for calculation of the ratio (HQ) is in **bold**.
(b): Screening level hierarchy depicted on Figure 2

Based on the information provided in Table A-5 and database query for ambiguous and positive exceedances

3.1.1 J. C. Boyle Reservoir

The number of COPCs for freshwater ecological receptors exposed to sediments from J.C. Boyle is limited. Detected chemicals (designated with "D" in second column of **Table 2**) selected as ecological COPCs are those that have the maximum detected concentration above the SL and include two metals, four pesticides, a single dioxin congener, and a single furan congener (**Table 2**). Of these, only nickel exceeded the SEF SL-1 and SL-2 (Step 2b in **Figure 2**). The remaining seven chemicals, which include a single metal (iron), legacy pesticides and dioxin-like compounds (4,4-DDD, 4,4-DDE, 4,4-DDT, Dieldrin, 2,3,4,7,8-PECDF, and 2,3,7,8-TCDD), did not exceed SEF SLs but exceeded secondary SLs (Steps 2c and 2d in **Figure 2)**. Dieldrin, a commonly detected legacy pesticide, was detected in only one of 14 samples from J.C. Boyle Reservoir

Typically, when one or more dioxins or furans are detected, they are retained as a class of chemicals selected as a COPC and the TEQ is calculated. Although retention of the additional non-detected individual congeners is not indicated in **Tables 2** through **4**, the full World Health Organization (WHO) suite of 17 dioxin and furan congeners was retained as a COPC on the basis of public concern. Evaluation of dioxin and furan TEQs is conducted separately and is presented in Section 3.5.

Detected chemicals selected as COPCs for human exposures (**Table 3**) include two metals, four pesticides, a number of dioxin and furan congeners, and pentachlorophenol (wood preservative). There were no exceedances of the USEPA non-carcinogenic residential soil RSL from the 2009-2010 samples. However, samples exceeded the USEPA total carcinogenic RSL for residential soils for arsenic or nickel. The remaining chemicals, which are legacy pesticides (4,4-DDD, 4,4-DDE, 4,4-DDT, Dieldrin), dioxin-like compounds, and pentolchlorophenol exceeded the ODEQ Bioaccumulation SLV for Human–Subsistence and Human-General.

Additionally, multiple chemicals that were not detected were retained as COPCs because their RLs were above the screening levels. Freshwater ecological COPCs retained based on RLs include a single metal, several pesticides, PCB Aroclors, and SVOCs, including PAHs (**Table 2**). It is not certain if these compounds are present in the sediments at concentrations below the RLs. The toxicity and bioaccumulation testing that was conducted helps to reveal if chemicals are present at concentrations that may affect aquatic organisms (refer to Section 5). Human health COPCs retained based on elevated RLs includes several pesticides and PCB Aroclors, PAHs, and a single VOC (**Table 3**).

3.1.2 Copco 1 Reservoir

The number of COPCs for freshwater ecological receptors exposed to sediments is limited for detected chemicals. Detected chemicals selected as ecological COPCs include two metals and a single furan congener (**Table 2**). Of these, only nickel exceeded the SEF SL-1 and SL-2 (Step 2b in Figure 2) . The remaining chemicals, 2,3,4,7,8-PECDF and iron, didn't exceeded SEF SLs, but did exceed other screening values under Steps 2c and 2d in **Figure 2**. COPCs were evaluated using the ODEQ values to assist in the comparison of sediment quality of the reservoirs, particularly with respect to dioxins and furans, since additional SLs are unavailable for these chemicals; ODEQ values are not applicable for regulatory purposes because Copco 1 is located in California

Detected chemicals selected as COPCs for human exposures include two metals and multiple dioxin and furan congeners (**Table 3**). There were no exceedances of the USEPA non-carcinogenic residential soil RSL from the 2009-2010 samples. However, samples exceeded the USEPA total carcinogenic RSL for residential soils for arsenic or nickel. Additionally, multiple dioxin and furan congeners were above ODEQ values.

Chemicals that were not detected were retained as COPCs because their RLs were above the screening levels. Freshwater ecological COPCs based on RLs include a single metal, multiple pesticides, two PCB Aroclors, four phthalates, and four SVOCs, including PAHs (**Table 2**). Human health COPCs based on RLs include two PCB Aroclors, a single pesticide, and multiple SVOCs, including PAHs (**Table 3**).

3.1.3 Iron Gate Reservoir

The number of COPCs for freshwater ecological receptors exposed to sediments is limited for detected chemicals, and includes two metals and a single furan congener (**Table 2**). Of these, only nickel exceeded the SEF SL-1 and SL-2 (Step 2b in Figure 2). The remaining chemicals, 2,3,4,7,8-PECDF and iron, exceeded SLs under Steps 2c and 2d in **Figure 2**.

Similarly, detected chemicals selected as COPCs for human exposures include two metals, and dioxin and furan congeners. There were no exceedances of the USEPA non-carcinogenic residential soil RSL from the 2009-2010 samples. However, samples exceeded the USEPA total carcinogenic RSL for residential soils for arsenic or nickel. Additionally, multiple dioxin and furan congeners were above ODEQ values (**Table 3**).

Chemicals that were not detected were retained as COPCs because their RLs were above the screening levels. Freshwater ecological COPCs based on RLs include a single metal, multiple pesticides and PCB Aroclors, phthalates, and SVOCs, including PAHs (**Table 2**). Human health COPCs based on RLs include two PCB Aroclors and multiple SVOCs, including PAHs (**Table 3**).

3.1.4 Klamath Estuary

In the Upper and Lower Klamath Estuary, there were no detected chemicals retained as marine ecological COPCs at the Klamath Estuary based on a comparison to marine screening levels (**Table 4**). Detected chemicals selected as COPCs for human exposures at the Klamath Estuary included only two metals, arsenic and nickel (**Table 3**). There were no exceedances of the USEPA non-carcinogenic residential soil RSL from the 2009-2010 samples. However, samples exceeded the USEPA total carcinogenic RSL for residential soils for both metals.

Chemicals with elevated RLs were also retained as COPCs. Marine ecological COPCs based on elevated RLs include pesticides and SVOCs, including PAHs, at the Klamath Estuary (**Table 4**). Human health COPCs based on elevated RLs include a single pesticide and multiple SVOCs, including PAHs (**Table 3**).

3.2 COPCs Under the Proposed Action "Dams Removed"

As part of Proposed Action "dams removed," modeling predicts a portion of sediment currently located behind each of the dams would be mobilized, dispersed, and carried to the ocean with minimal deposition downstream and in the estuary due to the sediment being dominated by fine particles and the high velocity of the stream flows that are expected to carry the fine sediment into the ocean (BOR 2011a and Stillwater Sciences 2008). Released sediments would be variably distributed spatially and temporally over the short-term (first one to two years), depending on the flows that actually occur following dam removal (BOR 2011a). Some sediment is likely to be deposited along the bank or the stream bed of the Klamath River. Most of these sediments deposited downstream will ultimately be re-suspended and distributed as suspended material in the marine near shore environment after passing through the estuary (BOR 2011a).

A portion of the reservoir terrace sediments will remain in-place. River terrace and stream bank sediment that remain in place would be more accurately viewed as soils if they are no longer submerged in water, and could lead to exposures by human or terrestrial receptors (which are qualitatively evaluated in Section 7) instead of aquatic organisms.

To evaluate adverse effects to receptors exposed to sediments in the reservoirs under Proposed Action "dams removed," the comparison to both freshwater and human health SLs is applicable under potential future conditions, the results of which are described above for the identification of COPCs under the "dams in" condition. In addition, COPCs were selected by comparing the reservoir sediment chemistry results, including detected concentrations and RLs for non-detected chemicals, to marine SLs. This provides an evaluation of potential adverse effects to the estuary and near shore marine environment, however minimal sediment deposition expected in the estuary, since most of the sediment is expected to be carried out to the ocean. This evaluation assumes that the sediment from the reservoirs would reach the estuary with its current chemical concentrations, which is conservative because it does not account for mixing, dilution, and dispersion of sediments expected to reduce the magnitude and duration of exposure for most forms of aquatic life in the estuary.

3.2.1 J.C. Boyle Reservoir

No detected chemicals exceeded the DMMP MLs at Step 1in **Figure 2**. Only two detected chemicals exceeded marine ecological SLs for exposure to sediments that may be transported and deposited in the marine environment from J.C. Boyle. Detected chemicals selected as marine ecological COPCs under this pathway include Dieldrin, detected in one sample and a single furan congener (**Table 4**). Neither of the detected chemicals exceeded the DMMP MLs at Step 1in **Figure 2**. The detected Dieldrin exceeded the SEF SL-1 and SL-2 at Step 2b in **Figure 2**, while 2,3,4,7,8-PECDF exceeded the ODEQ BSLV at Step 2c. Chemicals that were not detected were retained as ecological COPCs for marine receptors because their RLs were above the screening levels for samples collected from J.C. Boyle. Marine ecological COPCs due to elevated RLs include pesticides and PCB Aroclors, phthalates, and SVOCs, including PAHs (**Table 4**).

3.2.2 Copco 1 Reservoir

No detected chemical was selected as a COPC. COPCs for marine ecological receptors exposed to sediments that may be transported to and deposited in the marine environment from Copco 1. COPCs are limited to chemicals selected due to elevated RLs exceeding SLs (**Table 4**). Chemicals selected as ecological COPCs for marine receptors based on elevated RLs for samples collected from Copco 1 include pesticides, SVOCs, including PAHs, and two PCB Aroclors (**Table 4**).

3.2.3 Iron Gate Reservoir

No detected chemical was selected as a COPC. COPCs for marine ecological receptors exposed to sediments that may be transported to and deposited in the marine environment from Iron Gate. COPCs are limited to chemicals selected due to elevated RLs exceeding SLs (**Table 4**). Chemicals selected as ecological COPCs for marine receptors based on elevated RLs for samples collected from Iron Gate include pesticides, SVOCs, including PAHs, and PCB Aroclors (**Table 4**).

3.3 Sediment COPC Selection Uncertainties

Decisions on study design or use of data from this study reflect the resolution needed for some of the issues under consideration for the Secretarial Determination, for which the SEF is well suited. Some such decisions include:

- Sediment SLs selected for evaluation of sediment quality can influence which chemicals are selected as COPCs and ultimately conclusions regarding sediment quality. Relying on a variety of SLs, and in particularly the most protective SLs, as was done for this evaluation, reduces uncertainties potentially associated with sediment screening. SEF has recently withdrawn the use of SL-2 values. However, this evaluation includes use of SL-2 values because they were recommended for use at the time this evaluation was initiated. In no case did the comparison to SL-2 values affect the selection or elimination of a chemical as a sediment COPC.

- Multiple analytes in sediment were not detected but had reporting limits that were above the SEF screening levels, making the results inconclusive for the Level 2A and human health analyses (**Figure 2**). The individual chemicals that are identified as non-detects with elevated RLs exceeding applicable SLs are listed in **Appendix C.** To accommodate this concern, non-detected chemicals with elevated RLs based on the step-wise comparison of the 2009-2010 sediment data presented **Appendix A** were retained for analysis in macroinvertebrate and/or fish tissues (SEF Level 2B), where bioaccumulation tests could indicate effects from those chemicals potentially in the sediment.

- Background concentrations in sediment or tissues are often desired for contaminant studies, to help provide perspective on the relative magnitude of any chemicals detected in the study area. Many chemicals commonly occur in sediment and other media due to atmospheric deposition (e.g., PCBs, pesticides, and mercury) and natural events (e.g., dioxins from forest fires). Other chemicals, such as arsenic, often naturally occur (especially in the western U.S.) at concentrations exceeding SLs.

For this study, suitable background areas with similar sediments but without the same potential sources (e.g. urban areas, irrigated agriculture, industry, and hydroelectric development) as the Klamath hydroelectric reservoirs could not be identified. The lack of suitable background sites complicates the understanding of the amount number and concentrations of contaminants in reservoir sediments, but it does not affect the analysis of screening levels under the SEF process, or related decisions about sediment release and disposition. Background sites also could provide insight into potential contaminant sources, but source identification was beyond the scope of this study.

- A small number of sediment samples were collected from the estuary to characterize estuary sediment quality, which can lead to some uncertainty associated with selection of sediment COPCs. Only two samples were collected because very few locations were found with fine sediments deposits. The majority of the estuary sediments were comprised of a larger fraction of coarse inorganic sand reflecting the higher water velocities and more dynamic nature of the estuary. The coarse nature of the sediment in the estuary indicates that these sediments have very low organic content to retain chemicals.

- Chemicals in sediment are often distributed heterogeneously. Even with a large number of samples it is often difficult to fully understand the nature and extent of chemical distribution in sediments.

3.4 Sediment COPC Selection Conclusions

Sediment quality of reservoir and estuary sediments does not appear to be notably contaminated based on: (1) comparisons to SLs within the SEF framework and human health criteria, described in Section 2 and provided in **Appendix A**; and (2) the relatively few chemicals detected in sediment from the three reservoirs and the estuary identified as COPCs. No consistent pattern of elevated chemical composition is observed across discrete sampling locations within a reservoir; however, sediment in J.C. Boyle does have marginally higher chemical concentrations and more detected COPCs in sediment when compared to the other reservoirs and the estuary based on ecological and human health SLs. Several chemicals identified as COPCs may occur in reservoir and/or estuary sediments at concentrations similar to local background, but such determinations cannot be confirmed.

3.5 Dioxin and Furan Sediment Evaluation Using TEQs

Some chemicals are known to elicit adverse effects in exposed receptors similar to those associated with exposures to the dioxin 2,3,7,8-TCDD. These chemicals include individual dioxins and furans plus 12 PCB congeners (Van den Berg 1998 and Van den Berg 2006). The 12 PCB congeners associated with dioxin-like effects include the following:

1. 3,3',4,4'-TeCB (PCB-77)
2. 3,4,4',5-TeCB (PCB-81)
3. 2,3,3',4,4'-PeCB (PCB-105)
4. 2,3,4,4',5-PeCB (PCB-114)
5. 2,3',4,4',5-PeCB (PCB-118)
6. 2',3,4,4',5-PeCB (PCB-123)
7. 3,3',4,4',5-PeCB (PCB-126)
8. 2,3,3',4,4',5-HxCB (PCB-156)
9. 2,3,3',4,4',5'-HxCB (PCB-157)
10. 2,3',4,4',5,5'-HxCB (PCB-167)
11. 3,3',4,4',5,5'-HxCB (PCB-169)
12. 2,3,3',4,4',5,5'-HpCB (PCB-189)

To assess the potential effects of these dioxin-like compounds, a TEQ approach is employed where estimated or measured concentrations of relevant dioxin-like congeners are converted to estimated concentrations of the most highly toxic form, 2,3,7,8-TCDD. Conversions are made using toxic equivalency factors (TEFs). TEFs are provided for fish, birds, and mammals (including humans), and are taken from the World Health Organization (WHO; Van den Berg 1998 and Van den Berg 2006). For this evaluation, the 2006 TEFs are used to generate TEQs for mammals and humans, while the 1998 TEFs are used for deriving TEQs for fish and birds. Total TEQs are derived for fish, birds, and mammals (including humans) based on the sum of measured or estimated concentrations of each compound multiplied by the compound-specific TEF:

TEQ = sum (measured or estimated chemical concentration * TEF)

In the preceding sections (Section 3.1-3.4), dioxins and furans were evaluated on an individual congener basis. In this section, dioxins and furans are evaluated using the TEQ approach, the generally recommend approach for evaluating this class of chemicals. The first task was to confirm the TEQ calculations for sediments from three of the four reservoirs targeted for removal (J.C. Boyle, Copco 1, and Iron Gate) and the Klamath Estuary, previously performed, and reported in the document titled *Summary of Klamath Secretarial Determination Preliminary Dioxin Findings* dated August 12, 2010 (DOI 2010).

A second task was to update the TEQ calculations to include the 12 dioxin-like PCB congeners because the 2010 TEQ calculations only included dioxins and furan congeners. To account for dioxin-like PCB congeners, comprehensive TEQ calculations were performed that included dioxins, furans, and dioxin-like PCBs congeners.

The second task also incorporated non-detected results into the analysis using two approaches. Where concentrations for individual congeners were reported as a non-detect, a concentration of one-half of the method detection limit (MDL) for that congener was applied; this is consistent with the DOI 2010 summary where one-half of the reporting limit (RL) was used for non-detects. To be consistent with USEPA’s estimates of background calculations (EPA 2010),TEQ calculations were also calculated setting the concentration of non-detected congeners to zero. Results from these approaches are described below.

3.5.1 Review of 2010 TEQ Calculations for Dioxins and Furans

The review of calculations performed for the *2010 Summary of Klamath Secretarial Determination Preliminary Dioxin Findings* included a review of the spreadsheets that detailed how the TEQs were derived for samples collected from J. C. Boyle, Copco 1, and Iron Gate reservoirs, and the Klamath River estuary in 2009-2010. As part of the TEQ calculation effort, data from the *Sediment Sampling, Geotechnical Testing, and Data Review Report* (Shannon and Wilson 2006) were considered. This 2010 analysis included a "recalculation" of TEQ values for the 2006 Shannon and Wilson data.

The calculations used TEFs from Van den Berg et. al (1998) for fish and birds and Van den Berg et. al (2006) for mammals/ humans. In all the calculations, values for non-detected congeners were set at one half of the detection limit (DL), which in the case of the 2010 calculations the DL was the same as the RL (DOI 2010). The units for the calculations were measured in picograms per gram (pg/g) or parts-per trillion (ppt). The TEQ calculations from the 2010 study did not address dioxin-like PCB chemicals.

The DOI 2010 TEQ results for sediment evaluations were compared to the ODEQ bioaccumulation SLVs for 2,3,7,8-TCDD. SLVs are exposure concentrations that are deemed acceptable for ecological receptors. ODEQ BSLVs include receptor-specific SLVs for both individual organisms and populations. Receptor groups include fish, birds, and mammals. These SLVs are intended only for purposes of screening during ecological risk assessments (ODEQ 1998). The ODEQ BSLVs apply directly to J.C. Boyle because the dam is located in Oregon. These are also provided as a reference for comparison purposes for Copco 1, Iron Gate, and the Klamath Estuary since no specific TEQ screening values are available for California.

Results from the 2010 preliminary TEQ calculations (DOI 2010) are included in **Table 5.** Results are summarized below.

- TEQs ranged from approximately 2 to 7 ppt for J.C. Boyle; 3 to 8 ppt for Copco 1, 2 to 3 ppt for Iron Gate; and were all below 0.2 ppt for the Klamath Estuary (**Table 5**).

- In some cases these values are higher than background TEQ values reported by USEPA for Region 9 (i.e., 2 to 5 ppt), Region 10 (i.e., 4 ppt), and for non-impacted lakes of the United States (i.e., 5.3 ppt) (EPA 2010). The presence of dioxins and trace amounts of furans can be associated with areas with no known source of contamination other than atmospheric deposition. In addition, dioxins can result from forest fires, so there is some background concentration of these compounds expected in most areas.

- J. C. Boyle and Copco 1 TEQs were up to double the background concentrations ranges (EPA 2010). The Iron Gate TEQs were within the background concentration ranges (EPA 2010).

- The J. C. Boyle, Copco 1, and Iron Gate TEQs from the 2009-2010 samples and recalculated TEQs for the Shannon and Wilson (2006) TEQ results exceeded risk-based ODEQ sediment SLVs for fish, mammal-individual, and mammal-population.

Table 5. Comparison of Total TEQs Calculated from Sediments Using 2010 Approach [1, 2]

J.C. Boyle					ODEQ Bioaccumulation SLV for 2,3,7,8-TCDD from Appendix A (pg/g)					Comparison results to ODEQ Bioaccumulation SLV for 2,3,7,8-TCDD
TEFs	**CDH-S-007**	**CDH-S-008**		**S&W 2006 (Recalculated)**	**Fish**	**Bird-Individual**	**Bird-Population**	**Mammal - Individual**	**Mammal - Population**	
2006 WHO Mammal/Human	**7.09**	**6.17**		**3.44**				0.052	1.4	All Exceed Mammal In and Mammal Pop SLVs
1998 Fish TEFs	**5.04**	**4.28**		**2.26**	0.56					All Exceed Fish SLV
1998 Avian TEFs	**6.23**	**5.51**		**2.41**		0.7	3.5			CDH-S-007 & CDH-S-008 Exceed Bird Pop SLV and All Exceed Bird In SLV, S &W 2006 Below Bird Pop SLV
Copco 1										
TEFs	**CDH-S-014**	**CDH-S-015A**		**S&W 2006 (Recalculated)**						
2006 WHO Mammal/Human	**8.04**	**7.93**		**4.47**				0.052	1.4	All Exceed Mammal In and Mammal Pop SLVs
1998 Fish TEFs	**5.83**	**5.86**		**3.14**	0.56					All Exceed Fish SLV
1998 Avian TEFs	**7.51**	**7.16**		**4.45**		0.7	3.5			All Exceed Bird In and Bird Pop SLVs
Iron Gate										
TEFs	**CDH-S-031**	**CDH-S-046**	**CDH-S-029**	**S&W 2006 (Recalculated)**						
2006 WHO Mammal/Human	**3.08**	**3.11**	**3.05**	**2.27**				0.052	1.4	All Exceed Mammal In and Mammal Pop SLVs
1998 Fish TEFs	**2.29**	**2.21**	**2.1**	**1.68**	0.56					All Exceed Fish SLV
1998 Avian TEFs	**2.76**	**2.98**	**3.16**	**1.96**		0.7	3.5			All Exceed Bird In SLV, All Below Bird Pop SLV
Klamath Estuary	**Upper Est.**	**Lower Est.**								
TEFs	**CHA-S-002**	**CHA-S-001**		**S&W 2006 (Recalculated)**						
2006 WHO Mammal/Human	**0.06**	**0.11**		No data from the estuary				0.052	1.4	All Exceed Mammal In SLV, All Below Mammal Pop SLV
1998 Fish TEFs	0.06	0.10			0.56					All Below Fish SLV
1998 Avian TEFs	0.08	0.15				0.7	3.5			All Below Bird In and Bird Pop SLVs

Bold black type indicates one or more exceedances of ODEQ SLV for 2,3,7,8-TCDD for mammals/humans, fish, or birds
[1] Source: August 12, 2010, Klamath Settlement Process, Secretarial Determination, Summary of Klamath Secretarial Determination preliminary dioxin findings
[2] TEQ calculations assume 1/2 detection limit for the non-detected congeners

Acronyms:
WHO - World Health Organization
TEF - toxic equivalency factor
TEQ - toxic equivalent quotient
S&W - Shannon and Wilson
DEQ - Department of Environmental Quality
SLV - Screening Level Value
2,3,7,8-TCDD - 2,3,7,8-tetrachlorodibenzo-*p*-dioxin
pg/g - picogram (10^{-12} gram) per gram
Bird In - Bird Individual
Bird Pop - Bird Population
Mammal In - Mammal Individual
Mammal Pop - Mammal Population

References:
Shannon and Wilson Inc, 2006, Sediment Sampling, Geotechnical Testing, and Data Review Report, Segment of Klamath River, Oregon and California: Shannon & Wilson, Inc., 145 p.

Van den Berg, M., L. Birnbaum, A. T. Bosveld, B. Brunström, P. Cook, M. Feeley, J. P. Giesy, A. Hanberg, R. Hasegawa, S. W. Kennedy, T. Kubiak, J. C. Larsen, F. X. van Leeuwen, A. K. Liem, C. Nolt, R. E. Peterson, L. Poellinger, S. Safe, D. Schrenk, D. Tillitt, M. Tysklind, M. Younes, F. Waern, and T. Zacharewski, 1998, Toxic equivalency factors (TEFs) for PCBs, PCDDs, PCDFs for humans and wildlife: Environmental Health Perspectives, Vol 106, n. 12, pp 775-792.

Van den Berg, M., L.S. Birnbaum, M. Denison, M De Vito, W. Farland, M. Feeley, H. Fiedler, H. Hakansson, A. Hanberg, L. Haws, M. Rose, S. Safe, D. Schrenk, C. Tohyama, A. Tritscher, J. Tuomisto, M. Tysklind, N. Walker, R. E. Peterson, 2006: The 2005 World Health Organization Reevaluation of Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-Like Compounds, Toxicological Sciences, Vol. 93, n. 2, 223–241.

- TEQs for the 2009-2010 reservoir samples exceeded the BSLVs for bird-individual and bird-population except for Iron Gate where the 2009-2010 sample TEQs were below the bird-population BSLV. TEQs for the recalculated Shannon and Wilson results exceeded the bird-individual BSLV but were below the bird-population BSLV except for Copco 1where the recalculated TEQs exceeded ODEQ BSLVs for both bird-individual and bird-population.

- Klamath Estuary TEQs from the 2009-2010 study were below the expected background concentration (EPA 2010) and mammal-population, fish, bird-individual, and bird-population ODEQ SLVs. Both TEQs exceeded the mammal-individual SLV. No estuary TEQs were recalculated from the 2006 Shannon and Wilson study.

- Klamath Estuary TEQs from the 2009-2010 study were below the background concentration range (EPA 2010) and mammal-population, fish, bird-individual, and bird-population ODEQ BSLVs. Both TEQs exceeded the mammal-individual BSLV. No estuary TEQs were recalculated from the 2006 Shannon and Wilson study.

3.5.2 Calculations for Dioxins, Furans, and Dioxin-like PCB Congeners

For this report, the 2010 TEQ calculations for the three reservoirs and the Klamath Estuary were revised to incorporate dioxin-like PCB congeners; therefore TEQ values are slightly higher than the DOI 2010 results.

The calculations used the same TEFs from Van den Berg et. al 1998 for fish and birds and Van den Berg et. al 2006 for mammals/humans as noted above. Separate calculations include the use of one half the MDL for non-detected congeners and a zero value for non-detected congeners. These calculations provide more conservative (i.e., one half MDL) and less conservative (i.e., zero for non-detects) calculations in order to better evaluate TEQs. By calculating both, the influence of non-detected values can also be identified. The units for the calculations are in pg/g.

When the dioxin-like PCB congeners were included, with the assumption that non-detects equal one half of the MDL, the TEQs (**Table 6**) were elevated compared to those calculated in the 2010 preliminary results (**Table 5**). When zero was used for non-detects, the TEQ values (**Table 7**) were slightly lower than the TEQs from the 2010 preliminary results (**Table 5**) except for the avian-associated values. These TEQs were higher than the 2010 preliminary results but lower than the TEQs using one-half the MDL.

The TEQ results incorporating dioxin-like PCB congeners were compared to the ODEQ bioaccumulation SLVs for 2,3,7,8-TCDD. The incorporation of these congeners elevated TEQs. The most apparent differences were for the avian TEQs (**Table 5** through **Table 7**).

A summary of the results and comparisons is provided below.

- Calculated TEQs were highest for Copco 1 sediments regardless of the approach in handling non-detects (one-half the MDL or zero). TEQs were notably lower for Iron Gate sediments than those of J. C. Boyle and Copco 1.

- For the J. C. Boyle, Copco 1, and Iron Gate sediments, one half MDLTEQs for reservoir samples exceeded all the applicable ODEQ BSLVs for fish, bird-individual, bird-population, mammal-individual, and mammal-population (**Table 6**). While TEQs under the assumption of non-detects = zero were slightly lower than the TEQs based on one half the MDL for all the samples, these TEQs (**Table 7**) also exceeded all applicable ODEQ BSLVs except for bird-population SLVs at two Iron Gate locations CDH-S-046 and CDH-S-029.

- TEQs for sediments from the Klamath Estuary based on non-detected values set to one half the MDL (**Table 6**) were slightly higher than the TEQs without the dioxin-like PCB congeners added (**Table 5**). The TEQs were below the BSLVs for mammal-population, fish, avian-individual, and avian-population BSLVs and only exceeded the mammal-individual BSLV (**Table 6**). Under the assumption of non-detects = zero, the TEQs decreased to the point where both samples were below all applicable ODEQ BSLVs (**Table 7**).

3.5.3 Dioxin and Furan TEQ Evaluation Conclusions

TEQs with the dioxins, furans, and PCBs ranged from approximately 4 to 9 ppt for J.C. Boyle; 6 to 10 ppt for Copco 1, 2 to 4 ppt for Iron Gate; and were all below 0.2 ppt for the Klamath Estuary. In some cases these values are slightly higher than background values reported by USEPA for Region 9 (i.e., 2 to 5 ppt), Region 10 (i.e., 4 ppt), and for non-impacted lakes of the United States (i.e., 5.3 ppt) (EPA 2010). These TEQ values indicate the dioxins, furans, and PCBs present in the reservoir sediments have limited potential for adverse effects for either ecological or human receptors exposed to sediment. This would be the case for No Action "dams in." For the Proposed Action "dams removed," exposures would be lessened in the downstream area because the mobilized sediments would be dispersed over a large area and over time and mixed with normal river sediment loads (BOR 2011a). These actions are expected to reduce the chemical concentrations to levels that will no longer be a concern.

One final note is that the presence of dioxins and trace amounts of furans and PCBs can be associated with areas with no known source of contamination other than atmospheric deposition. Dioxins are ubiquitous, resulting from forest fires, so there is some background concentration of these compounds expected in most areas. While J.C. Boyle does have marginally higher chemical concentrations and more detected COPCs in sediment when compared to the other reservoirs and the estuary, this is not necessarily the case with dioxins, furans, and PCBs based on the data.

Table 6. Comparison of Total TEQs [1] including dioxin-like PCB congeners using one-half the MDL for non-detects

J.C. Boyle				ODEQ Bioaccumulation SLV for 2,3,7,8-TCDD from Appendix A (pg/g)					Comparison results to ODEQ Bioaccumulation SLV for 2,3,7,8-TCDD
TEFs	**CDH-S-007**	**CDH-S-008**		**Fish**	**Bird-Individual**	**Bird-Population**	**Mammal - Individual**	**Mammal - Population**	
2006 WHO Mammal/Human	**7.38**	**6.6**					0.052	1.4	All Exceed Mammal In and Mammal Pop SLVs
1998 Fish TEFs	**5.06**	**4.4**		0.56					All Exceed Fish SLV
1998 Avian TEFs	**8.82**	**9**			0.7	3.5			All Exceed Bird In and Bird Pop SLVs
Copco 1									
TEFs	**CDH-S-014**	**CDH-S-015A**							
2006 WHO Mammal/Human	**8.32**	**8.13**					0.052	1.4	All Exceed Mammal In and Mammal Pop SLVs
1998 Fish TEFs	**5.85**	**5.86**		0.56					All Exceed Fish SLV
1998 Avian TEFs	**9.94**	**8.88**			0.7	3.5			All Exceed Bird In and Bird Pop SLVs
Iron Gate									
TEFs	**CDH-S-031**	**CDH-S-046**	**CDH-S-029**						
2006 WHO Mammal/Human	**3.24**	**3.25**	**3.21**				0.052	1.4	All Exceed Mammal In and Mammal Pop SLVs
1998 Fish TEFs	**2.3**	**2.22**	**2.1**	0.56					All Exceed Fish SLV
1998 Avian TEFs	**4.4**	**4.07**	**4.26**		0.7	3.5			All Exceed Bird In and Bird Pop SLVs
Klamath Estuary	**Upper Est.**	**Lower Est.**							
TEFs	**CHA-S-002**	**CHA-S-001**							
2006 WHO Mammal/Human	**0.06**	**0.12**					0.052	1.4	All Exceed Mammal In SLV, All Below Mammal Pop SLV
1998 Fish TEFs	0.06	0.1		0.56					All Below Fish SLV
1998 Avian TEFs	0.1	0.19			0.7	3.5			All Below Bird In and Bird Pop SLVs

Bold black type indicates one or more exceedances of ODEQ SLV for 2,3,7,8-TCDD for mammals/humans, fish, or birds
[1] **TEQ calculations assume 1/2 method detection limit for the non-detected congeners**

Acronyms:
WHO - World Health Organization
TEF - toxic equivalency factor
TEQ - toxic equivalent quotient
DEQ - Department of Environmental Quality
SLV - Screening Level Value
2,3,7,8-TCDD - 2,3,7,8-tetrachlorodibenzo-*p*-dioxin
pg/g - picogram (10^{-12} gram) per gram
Bird In - Bird Individual
Bird Pop - Bird Population
Mammal In - Mammal Individual
Mammal Pop - Mammal Population

References:
Van den Berg, M., L. Birnbaum, A. T. Bosveld, B. Brunström, P. Cook, M. Feeley, J. P. Giesy, A. Hanberg, R. Hasegawa, S. W. Kennedy, T. Kubiak, J. C. Larsen, F. X. van Leeuwen, A. K. Liem, C. Nolt, R. E. Peterson, L. Poellinger, S. Safe, D. Schrenk, D. Tillitt, M. Tysklind, M. Younes, F. Waern, and T. Zacharewski, 1998, Toxic equivalency factors (TEFs) for PCBs, PCDDs, PCDFs for humans and wildlife: Environmental Health Perspectives, Vol 106, n. 12, pp 775-792.

Van den Berg, M., L.S. Birnbaum, M. Denison, M De Vito, W. Farland, M. Feeley, H. Fiedler, H. Hakansson, A. Hanberg, L. Haws, M. Rose, S. Safe, D. Schrenk, C. Tohyama, A. Tritscher, J. Tuomisto, M. Tysklind, N. Walker, R. E. Peterson, 2006: The 2005 World Health Organization Reevaluation of Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-Like Compounds, Toxicological Sciences, Vol. 93, n. 2, 223–241.

Table 7. Comparison of Total TEQs [1] including dioxin-like PCB congeners using zero for non-detects

J.C. Boyle				**ODEQ Bioaccumulation SLV for 2,3,7,8-TCDD from Appendix A (pg/g)**					**Comparison results to ODEQ Bioaccumulation SLV for 2,3,7,8-TCDD**
TEFs	**CDH-S-007**	**CDH-S-008**		**Fish**	**Bird-Individual**	**Bird-Population**	**Mammal - Individual**	**Mammal - Population**	
2006 WHO Mammals/Human	**7**	**5.8**					0.052	1.4	All Exceed Mammal In and Mammal Pop SLVs
1998 Fish TEFs	**4.9**	**3.93**		0.56					All Exceed Fish SLV
1998 Avian TEFs	**8.38**	**8.19**			0.7	3.5			All Exceed Bird In and Bird Pop SLVs
Copco 1									
TEFs	**CDH-S-014**	**CDH-S-015A**							
2006 WHO Mammals/Human	**7.97**	**7.78**					0.052	1.4	All Exceed Mammal In and Mammal Pop SLVs
1998 Fish TEFs	**5.74**	**5.67**		0.56					All Exceed Fish SLV
1998 Avian TEFs	**9.55**	**8.49**			0.7	3.5			All Exceed Bird In and Bird Pop SLVs
Iron Gate									
TEFs	**CDH-S-031**	**CDH-S-046**	**CDH-S-029**						
2006 WHO Mammals/Human	**2.88**	**2.76**	**2.8**				0.052	1.4	All Exceed Mammal In and Mammal Pop SLVs
1998 Fish TEFs	**2**	**1.53**	**1.71**	0.56					All Exceed Fish SLV
1998 Avian TEFs	**3.75**	**3.34**	**3.5**		0.7	3.5			All Exceed Bird In SLV and CDH-S-031 Exceeds Bird Pop SLV, CDH-S-046 & 029 Below the Bird Pop SLV
Klamath Estuary	**Upper Est.**	**Lower Est.**							
TEFs	**CHA-S-002**	**CHA-S-001**							
2006 WHO Mammals/Human	<.01	0.03					0.052	1.4	All Below Mammal In and Mammal Pop SLVs
1998 Fish TEFs	<.01	<.01		0.56					All Below Fish SLV
1998 Avian TEFs	<.01	0.04			0.7	3.5			All Below Bird In and Bird Pop SLVs

Bold black type indicates one or more exceedances of ODEQ SLV for 2,3,7,8-TCDD for mammals/humans, fish, or birds
[1] TEQ calculations assume zero for the non-detected congeners

Acronyms:
WHO - World Health Organization
TEF - toxic equivalency factor
TEQ - toxic equivalent quotient
DEQ - Department of Environmental Quality
SLV - Screening Level Value
2,3,7,8-TCDD - 2,3,7,8-tetrachlorodibenzo-*p*-dioxin
pg/g - picogram (10^{-12} gram) per gram
Bird In - Bird Individual
Bird Pop - Bird Population
Mammal In - Mammal Individual
Mammal Pop - Mammal Population

References:
Van den Berg, M., L. Birnbaum, A. T. Bosveld, B. Brunström, P. Cook, M. Feeley, J. P. Giesy, A. Hanberg, R. Hasegawa, S. W. Kennedy, T. Kubiak, J. C. Larsen, F. X. van Leeuwen, A. K. Liem, C. Nolt, R. E. Peterson, L. Poellinger, S. Safe, D. Schrenk, D. Tillitt, M. Tysklind, M. Younes, F. Waern, and T. Zacharewski, 1998, Toxic equivalency factors (TEFs) for PCBs, PCDDs, PCDFs for humans and wildlife: Environmental Health Perspectives, Vol 106, n. 12, pp 775-792.

Van den Berg, M., L.S. Birnbaum, M. Denison, M De Vito, W. Farland, M. Feeley, H. Fiedler, H. Hakansson, A. Hanberg, L. Haws, M. Rose, S. Safe, D. Schrenk, C. Tohyama, A. Tritscher, J. Tuomisto, M. Tysklind, N. Walker, R. E. Peterson, 2006: The 2005 World Health Organization Reevaluation of Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-Like Compounds, Toxicological Sciences, Vol. 93, n. 2, 223–241.

Chapter 4
Evaluation of Elutriate Chemistry and Toxicity Bioassays

To assist with the evaluation of potential impacts from the reservoir sediments, elutriate chemistry data and the results of elutriate toxicity bioassays were evaluated. These results are used as additional line of evidence to assess the toxicity of sediments. The details of the procedures and results are provided in **Appendix B**. A summary of the results is provided below.

4.1 Elutriate Chemistry

Reservoir sediment samples were used for elutriate chemistry analysis to evaluate the potential toxicity associated with Exposure Pathway 1 (short-term water column exposure) if the Proposed Action "dams removed" is selected. Details of the sampling program are described in the *Quality Assurance Project Plan Sediment Contaminant Study, Klamath River Sediment Sampling Program JC Boyle, Copco-1, Copco-2, and Iron Gate Reservoirs; Klamath River Estuary Revision 2: August 2010* (BOR 2010a) and summarized in Section 2.4.

The elutriate chemistry results were compared to freshwater ecological, marine ecological, and human health water quality criteria to evaluate Exposure Pathway 1 (Proposed Action "dams removed"), which is exposure to chemical contaminants during the short term turbid conditions expected to occur immediately following the removal of the dams. A detailed discussion on the criteria and the results of the comparisons is presented in **Appendix B**. A summary of the results is presented below.

Individual chemicals that exceed any of the freshwater water quality or human health criteria from the elutriate analyses are presented by sediment sampling area in **Tables 8** through **11**. Individual chemicals that could exceed any of the marine water quality criteria from the elutriate analyses are presented in **Tables 12** through **15**. These exceedances are based on full strength elutriate with no accounting for dilution, expected to occur with sediment flushing. Results in all eight tables identify a consistent list of chemicals with concentrations above the water quality criteria in all three reservoirs and the Klamath Estuary, with the exception that the Klamath Estuary had elevated concentrations of chlorides but not ammonia or zinc. The chemicals identified that could exceed freshwater, marine, or human health criteria (without consideration for dilution) included:

- ammonia (reservoirs only)
- phosphorus
- chloride (Estuary only)
- total PCBs
- aluminum
- arsenic
- chromium
- copper
- lead
- mercury
- nickel
- zinc (J.C. Boyle only)

In general, the exceedances of each type of screening criteria (freshwater, marine, or human health) are consistent among reservoirs and between on-thalweg and off-thalweg results. Exceedances identified in estuary samples tend to be fewer compared to those identified in the reservoirs, with the exception of exceedances of human health screening criteria. Note that these exceedances of criteria in the Estuary could be occurring under present conditions when high streamflow results in resuspension of bed material there.

Dilution of mobilized sediments in the downstream areas is expected to occur under the Propose Action "dam removal." Screening level calculations based on modeled hydrology and suspended sediment load estimated the potential dilutions expected with dam removal (**Appendix B**). The estimated dilution has a scale of 48- to 66-fold below Iron Gate Dam (**Appendix B**).

In addition, a dilution factor required to meet the most restrictive exceeded criterion was calculated for each of the chemicals listed above that exceeded any criteria, (refer to Tables B-8, B-9, B-10, and B-11 in **Appendix B**). The reported maximum concentration was divided by the value of the most restrictive exceeded criterion.

The chemical-specific dilution factor was then compared to the estimated dilution factor under the Proposed Action "dams removed" (44- to 66-fold). If the chemical-specific dilution factor is less than 48 to 66, the chemicals will likely be below all criteria in the downstream areas under the Proposed Action.

For the elutriate chemistry results to meet freshwater quality criteria, chloride, chromium, copper, lead and mercury are not a concern based on the estimated dilution factors needed (**Appendix B**, Tables B-9), which are relatively small (< 3) and considerably less than the estimated dilution factor of 48- to 66-fold. Nor is ammonia a concern given the estimated dilution factors needed for the elutriate chemistry results to meet freshwater quality criteria (**Appendix B**, Table B-10**),** which ranges from 0 to 22 is below the estimated dilution factor of 48- to 66-fold below Iron Gate Dam.

Only selected aluminum elutriate results require a higher dilution factor than the estimated factor below Iron Gate Dam of 48- to 66-fold. The dilution factor required for aluminum to meet the freshwater criteria ranges from 8 to 125 with an average value of 44. Given the large volume of the reservoirs and the addition of river flows and tributary inputs during drawdown (BOR 2011a), calculation suggest the actual dilution has the potential to exceed the range of required dilution factors for aluminum to meet its freshwater criteria in the Klamath River and Estuary.

For the elutriate chemistry results to meet human health criteria (**Appendix B**, Tables B-11**)**, the estimated dilution factors are relatively small (< 15) and considerably less than the estimated dilution factor of 48- to 66-fold below Iron Gate Dam. The expected dilution and mixing during drawdown based on the results of the modeling studies (BOR 2011a) is likely to be sufficient for chloride, chromium, nickel and lead to meet the minimum relevant human health criteria.

Table 8. Summary of 2009-2010 Elutriate Chemistry Results for J.C. Boyle Reservoir (Freshwater and Human Health)

Chemical	"Sample" value (ug/L)	Above One or More Fresh Acute Water Quality Criteria	Criteria exceeded	Above One or More Fresh Chronic Water Quality Criteria	Criteria exceeded	Above One or More Human Health Water Quality Criteria	Criteria exceeded
Ammonia as N	12,000	---	---	---	---	---	---
	11,000	---	---	---	---	---	---
Phosphorus, total as P	540	---	---	---	---	---	---
	310	---	---	---	---	---	---
Total PCBs	0.003	---	---	---	---	off-thalweg	CBP HH CTR, NRWQC HWO, NRWQC HO, ODEQ HH HWO, ODEQ HH HO, ODEQ WQC HWO, ODEQ WQC HO
	0.003	---	---	---	---	on-thalweg	CBP HH CTR, NRWQC HWO, NRWQC HO, ODEQ HH HWO, ODEQ HH HO, ODEQ WQC HWO, ODEQ WQC HO
Aluminum	11,000	off-thalweg	NRWQC CMC	off-thalweg	NRWQC CCC	off-thalweg	CDPH MCL, CBP Primary MCL, CBP Secondary MCL, CBP Ag
	4,500	on-thalweg	NRWQC CMC	on-thalweg	NRWQC CCC	on-thalweg	CDPH MCL, CBP Primary MCL, CBP Secondary MCL,
Arsenic	30	---	---	---	---	off-thalweg	CDPH MCL, NRWQC HWO, NRWQC HO, ODEQ HH HWO, ODEQ HH HO, ODEQ WQC HWO, ODEQ WQC HO
	18	---	---	---	---	on-thalweg	CDPH MCL, NRWQC HWO, NRWQC HO, ODEQ HH HWO, ODEQ HH HO, ODEQ WQC HWO, ODEQ WQC HO
Chromium	13	---	---	off-thalweg	CBP CTR, NRWQC CCC, ODEQ WQC	---	---
	5.4	---	---	---	---	---	---
Copper	23	off-thalweg	NRWQC CMC, ODEQ WQC	off-thalweg	CBP CTR, NRWQC CCC, ODEQ WQC	---	---
	12	on-thalweg	NRWQC CMC	on-thalweg	CBP CTR, NRWQC CCC, ODEQ WQC	---	---

Table 8. Summary of 2009-2010 Elutriate Chemistry Results for J.C. Boyle Reservoir (Freshwater and Human Health)

Chemical	"Sample" value (ug/L)	Above One or More Fresh Acute Water Quality Criteria	Criteria exceeded	Above One or More Fresh Chronic Water Quality Criteria	Criteria exceeded	Above One or More Human Health Water Quality Criteria	Criteria exceeded
Lead	6.3	---	---	off-thalweg	CBP CTR, NRWQC CCC, ODEQ WQC	---	---
	3.5	---	---	on-thalweg	CBP CTR, NRWQC CCC, ODEQ WQC	---	---
Mercury	0.027	---	---	off-thalweg	ODEQ WQC	---	---
	0.016	---	---	on-thalweg	ODEQ WQC	---	---
Nickel	8.3	---	---	---	---	---	---
Zinc	30	---	---	---	---	---	---

Notes:

Completed to evaluate toxicity to water dwelling organisms in the Lower Klamath River.

Sediment samples were whole-core composites collected from every on-thalweg and off-thalweg borehole location within a reservoir to provide representative reservoir-wide average sediment composition.

Sediment samples for Klamath Estuary were multiple-core "area composite" samples based on 3 to 6 core locations distributed within a half-mile radius.

“off-thalweg” or “on-thalweg” indicates exceedance of criteria for that sample

Mean hardness from Klamath River at Orleans is 70 mg/L used to calculate hardness adjusted criteria for California reaches of river.

384 analytes were quantified in each of 3 reservoir super-composites on-thalweg and off-thalweg samples.

Freshwater criteria available for 48 analytes.

Ag: Agriculture
ALA: Aquatic Life Acute
ALC: Aquatic Life Chronic
ALI: Aquatic Life Instant
CBP: California Basin Plan
CCC: Criteria Continuous Concentration
CDPH: California Department of Public Health
CMC: Criteria Maximum Concentration
COP: California Ocean Plan
CTR: California Toxics Rule
H: Human
HH CTR: Human Health California Toxics Rule
HO: Human Organism
HWO: Human Water and Organism
ug/L: micrograms per liter
MCL: Maximum Contaminant Level
NRWQC: National Recommended Water Quality Criteria
NTR: National Toxics Rule
ODEQ: Oregon Department of Environmental Quality
WQC: Water Quality Criteria
WQG: Water Quality Guidance

Table 9. Summary of 2009-2010 Elutriate Chemistry Results for Copco 1 Reservoir (Freshwater and Human Health)

Chemical	"Sample" value (ug/L)	Above One or More Fresh Acute Water Quality Criteria	Criteria exceeded	Above One or More Fresh Chronic Water Quality Criteria	Criteria exceeded	Above One or More Human Health Water Quality Criteria	Criteria exceeded
Ammonia as N	8,800	---	---	---	---	---	---
	25,000	---	---	---	---	---	---
Phosphorus, total as P	430	---	---	---	---	---	---
	240	---	---	---	---	---	---
Total PCBs	0.004	---	---	---	---	off-thalweg	CBP HH CTR, NRWQC HWO, NRWQC HO, ODEQ HH HWO, ODEQ HH HO, ODEQ WQC HWO, ODEQ WQC HO
	0.0039	---	---	---	---	on-thalweg	CBP HH CTR, NRWQC HWO, NRWQC HO, ODEQ HH HWO, ODEQ HH HO, ODEQ WQC HWO, ODEQ WQC HO
Aluminum	6,600	off-thalweg	NRWQC CMC	off-thalweg	NRWQC CCC	off-thalweg	CDPH MCL, CBP Primary MCL, CBP Secondary MCL, CBP Ag
	3,600	on-thalweg	NRWQC CMC	on-thalweg	NRWQC CCC	on-thalweg	CDPH MCL, CBP Primary MCL, CBP Secondary MCL
Arsenic	8.9	---	---	---	---	off-thalweg	NRWQC HWO, NRWQC HO, ODEQ HH HWO, ODEQ HH HO, ODEQ WQC HWO, ODEQ WQC HO
	11	---	---	---	---	on-thalweg	CDPH MCL, NRWQC HWO, NRWQC HO, ODEQ HH HWO, ODEQ HH HO, ODEQ WQC HWO, ODEQ WQC HO
Chromium	6.5	---	---	---	---	---	---
	3.6	---	---	---	---	---	---
Copper	12	off-thalweg	NRWQC CMC	off-thalweg	CBP CTR, NRWQC CCC, ODEQ WQC	---	---
	6.9	---	---	on-thalweg	CBP CTR, NRWQC CCC	---	---

Table 9. Summary of 2009-2010 Elutriate Chemistry Results for Copco 1 Reservoir (Freshwater and Human Health)

Chemical	"Sample" value (ug/L)	Above One or More Fresh Acute Water Quality Criteria	Criteria exceeded	Above One or More Fresh Chronic Water Quality Criteria	Criteria exceeded	Above One or More Human Health Water Quality Criteria	Criteria exceeded
Lead	3.6	---	---	off-thalweg	CBP CTR, NRWQC CCC, ODEQ WQC	---	---
	2.2	---	---	on-thalweg	CBP CTR, NRWQC CCC	---	---
Mercury	0.019	---	---	off-thalweg	ODEQ WQC	---	---
	0.017	---	---	on-thalweg	ODEQ WQC	---	---
Nickel	6.2	---	---	---	---	---	---

Notes:
Completed to evaluate toxicity to water dwelling organisms in the Lower Klamath River.
Sediment samples were whole-core composites collected from every on-thalweg and off-thalweg borehole location within a reservoir to provide representative reservoir-wide average sediment composition.
Sediment samples for Klamath Estuary were multiple-core "area composite" samples based on 3 to 6 core locations distributed within a half-mile radius.
"off-thalweg" or "on-thalweg" indicates exceedance of criteria for that sample Mean hardness from Klamath River at Orleans is 70 mg/L used to calculate hardness adjusted criteria for California reaches of river.
384 analytes were quantified in each of 3 reservoir super-composites on-thalweg and off-thalweg samples.
Freshwater criteria available for 48 analytes.

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CTR: California Toxics Rule
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HWO: Human Water and Organism
ug/L: micrograms per liter
MCL: Maximum Contaminant Level
NRWQC: National Recommended Water Quality Criteria
NTR: National Toxics Rule
ODEQ: Oregon Department of Environmental Quality
WQC: Water Quality Criteria
WQG: Water Quality Guidance

Table 10. Summary of 2009-2010 Elutriate Chemistry Results for Iron Gate Reservoir (Freshwater and Human Health)

Chemical	"Sample" value (ug/L)	Above One or More Fresh Acute Water Quality Criteria	Criteria exceeded	Above One or More Fresh Chronic Water Quality Criteria	Criteria exceeded	Above One or More Human Health Water Quality Criteria	Criteria exceeded
Ammonia as N	4,800	---	---	---	---	---	---
	7,200	---	---	---	---	---	---
	10,000	---	---	---	---	---	---
Phosphorus, total as P	130	---	---	---	---	---	---
	310	---	---	---	---	---	---
	330	---	---	---	---	---	---
Total PCBs	0.0017	---	---	---	---	off-thalweg	CBP HH CTR, NRWQC HWO, NRWQC HO, ODEQ HH HWO, ODEQ HH HO, ODEQ WQC HWO, ODEQ WQC HO
	0.0034	---	---	---	---	on-thalweg	CBP HH CTR, NRWQC HWO, NRWQC HO, ODEQ HH HWO, ODEQ HH HO, ODEQ WQC HWO, ODEQ WQC HO
	0.0065	---	---	---	---	on-thalweg	CBP HH CTR, NRWQC HWO, NRWQC HO, ODEQ HH HWO, ODEQ HH HO, ODEQ WQC HWO, ODEQ WQC HO
Aluminum	1,500	off-thalweg	NRWQC CMC	off-thalweg	NRWQC CCC	off-thalweg	CDPH MCL, CBP Primary MCL, CBP Secondary MCL
	2,600	on-thalweg	NRWQC CMC	on-thalweg	NRWQC CCC	on-thalweg	CDPH MCL, CBP Primary MCL, CBP Secondary MCL
	4,700	on-thalweg	NRWQC CMC	on-thalweg	NRWQC CCC	on-thalweg	CDPH MCL, CBP Primary MCL, CBP Secondary MCL

Table 10. Summary of 2009-2010 Elutriate Chemistry Results for Iron Gate Reservoir (Freshwater and Human Health)

Chemical	"Sample" value (ug/L)	Above One or More Fresh Acute Water Quality Criteria	Criteria exceeded	Above One or More Fresh Chronic Water Quality Criteria	Criteria exceeded	Above One or More Human Health Water Quality Criteria	Criteria exceeded
Arsenic	4.8	---	---	---	---	off-thalweg	NRWQC HWO, NRWQC HO, ODEQ HH HWO, ODEQ HH HO, ODEQ WQC HWO, ODEQ WQC HO
	9.4	---	---	---	---	on-thalweg	NRWQC HWO, NRWQC HO, ODEQ HH HWO, ODEQ HH HO, ODEQ WQC HWO, ODEQ WQC HO
	20	---	---	---	---	on-thalweg	CDPH MCL, NRWQC HWO, NRWQC HO, ODEQ HH HWO, ODEQ HH HO, ODEQ WQC HWO, ODEQ WQC HO
Chromium	2.4	---	---	---	---	---	---
	5.5	---	---	---	---	---	---
Copper	4.5	---	---	---	---	---	---
	6.8	---	---	---	---	---	---
	10	---	---	on-thalweg	CBP CTR, NRWQC CCC	---	---
Lead	2.8	---	---	on-thalweg	CBP CTR, NRWQC CCC	---	---
Mercury	0.014	---	---	on-thalweg	ODEQ WQC	---	---
Nickel	5.7	---	---	---	---	---	---

Notes:

Completed to evaluate toxicity to water dwelling organisms in the Lower Klamath River.

Sediment samples were whole-core composites collected from every on-thalweg and off-thalweg borehole location within a reservoir to provide representative reservoir-wide average sediment composition.

Sediment samples for Klamath Estuary were multiple-core "area composite" samples based on 3 to 6 core locations distributed within a half-mile radius.

Mean hardness from Klamath River at Orleans is 70 mg/L used to calculate hardness adjusted criteria for California reaches of river.

384 analytes were quantified in each of 3 reservoir super-composites on-thalweg and off-thalweg samples.

Freshwater criteria available for 48 analytes.

Ag: Agriculture
ALA: Aquatic Life Acute
ALC: Aquatic Life Chronic
ALI: Aquatic Life Instant
CBP: California Basin Plan
CCC: Criteria Continuous Concentration
CDPH: California Department of Public Health
CMC: Criteria Maximum Concentration
COP: California Ocean Plan
CTR: California Toxics Rule
H: Human
HH CTR: Human Health California Toxics Rule
HO: Human Organism
HWO: Human Water and Organism
ug/L: micrograms per liter
MCL: Maximum Contaminant Level
NRWQC: National Recommended Water Quality Criteria
NTR: National Toxics Rule
ODEQ: Oregon Department of Environmental Quality
WQC: Water Quality Criteria
WQG: Water Quality Guidance

Table 11. Summary of 2009-2010 Elutriate Chemistry Results for Klamath River Estuary (Freshwater and Human Health)

Chemical	"Sample" value (ug/L)	Above One or More Fresh Acute Water Quality Criteria	Criteria exceeded	Above One or More Fresh Chronic Water Quality Criteria	Criteria exceeded	Above One or More Human Health Water Quality Criteria	Criteria exceeded
Phosphorus, total as P	60	---	---	---	---	---	---
Chloride	470,000	---	---	X	NRWQC CCC, ODEQ WQC	X	CDPH MCL, CBP secondary MCL, CBP Ag
Total PCBs	0.00016	---	---	---	---	X	NRWQC HWO, NRWQC HO, ODEQ HH HWO, ODEQ HH HO, ODEQ WQC HWO, ODEQ WQC HO
	0.00013	---	---	---	---	X	NRWQC HWO, NRWQC HO, ODEQ HH HWO, ODEQ HH HO, ODEQ WQC HWO, ODEQ WQC HO
Aluminum	770	X	NRWQC CMC	X	NRWQC CCC	X	CBP Secondary MCL
	780	X	NRWQC CMC	X	NRWQC CCC	X	CBP Secondary MCL
Arsenic	6	---	---	---	---	X	NRWQC HWO, NRWQC HO, ODEQ HH HWO, ODEQ HH HO, ODEQ WQC HWO, ODEQ WQC HO
	2.2	---	---	---	---	X	NRWQC HWO, NRWQC HO, ODEQ HH HWO, ODEQ HH HO, ODEQ WQC HWO, ODEQ WQC HO
Chromium	2.8	---	---	---	---	---	---
	5.9	---	---	---	---	---	---
Copper	6.9	---	---	X	CBP CTR, NRWQC CCC	---	---
	7	---	---	X	CBP CTR, NRWQC CCC	---	---

Table 11. Summary of 2009-2010 Elutriate Chemistry Results for Klamath River Estuary (Freshwater and Human Health)

Chemical	"Sample" value (ug/L)	Above One or More Fresh Acute Water Quality Criteria	Criteria exceeded	Above One or More Fresh Chronic Water Quality Criteria	Criteria exceeded	Above One or More Human Health Water Quality Criteria	Criteria exceeded
Mercury	0.023	---	---	X	ODEQ WQC	---	---
Nickel	11	---	---	---	---	---	---
	18	---	---	---	---	X	ODEQ HH HWO, ODEQ WQC HWO

Notes:

Completed to evaluate toxicity to water dwelling organisms in the Lower Klamath River.

Sediment samples were whole-core composites collected from every on-thalweg and off-thalweg borehole location within a reservoir to provide representative reservoir-wide average sediment composition.

Sediment samples for Klamath Estuary were multiple-core "area composite" samples based on 3 to 6 core locations distributed within a half-mile radius.

“off-thalweg” or “on-thalweg” indicates exceedance of criteria for that sample Mean hardness from Klamath River at Orleans is 70 mg/L used to calculate hardness adjusted criteria for California reaches of river.

384 analytes were quantified in each of 3 reservoir super-composites on-thalweg and off-thalweg samples.

Freshwater criteria available for 48 analytes.

Ag: Agriculture
ALA: Aquatic Life Acute
ALC: Aquatic Life Chronic
ALI: Aquatic Life Instant
CBP: California Basin Plan
CCC: Criteria Continuous Concentration
CDPH: California Department of Public Health
CMC: Criteria Maximum Concentration
COP: California Ocean Plan
CTR: California Toxics Rule
H: Human
HH CTR: Human Health California Toxics Rule
HO: Human Organism
HWO: Human Water and Organism
ug/L: micrograms per liter
MCL: Maximum Contaminant Level
NRWQC: National Recommended Water Quality Criteria
NTR: National Toxics Rule
ODEQ: Oregon Department of Environmental Quality
WQC: Water Quality Criteria
WQG: Water Quality Guidance

Table 12. Summary of 2009-2010 Elutriate Chemistry Results for J.C. Boyle Reservoir (Marine)

Chemical	"Sample" value (ug/L)	Above One or More Marine Water Quality Acute Criteria	Criteria exceeded	Above One or More Marine Water Quality Chronic Criteria	Criteria exceeded	Above One or More Marine Water Quality Instant Criteria	Criteria exceeded
Ammonia as N	12,000	off-thalweg	COP ALA	off-thalweg	COP ALC	off-thalweg	COP ALI
	11,000	on-thalweg	COP ALA	on-thalweg	COP ALC	on-thalweg	COP ALI
Phosphorus, total as P	540	---	---	off-thalweg	NRWQC Marine CCC	---	---
	310	---	---	on-thalweg	NRWQC Marine CCC	---	---
Total PCBs	0.003	---	---	---	---	---	---
	0.003	---	---	---	---	---	---
Aluminum	11,000	---	---	---	---	---	---
	4,500	---	---	---	---	---	---
Arsenic	30	---	---	off-thalweg	COP ALC	---	---
	18	---	---	on-thalweg	COP ALC	---	---
Chromium	13	---	---	off-thalweg	COP ALC	---	---
	5.4	---	---	on-thalweg	COP ALC	---	---
Copper	23	off-thalweg	NRWQC Marine CMC, COP ALA	off-thalweg	NRWQC Marine CCC, COP ALC	---	---
	12	on-thalweg	NRWQC Marine CMC	on-thalweg	NRWQC Marine CCC, COP ALC	---	---
Lead	6.3	---	---	off-thalweg	COP ALC	---	---
	3.5	---	---	on-thalweg	COP ALC	---	---
Mercury	0.027	---	---	---	---	---	---
	0.016	---	---	---	---	---	---
Nickel	8.3	---	---	off-thalweg	NRWQC Marine CCC, COP ALC	---	---
Zinc	30	---	---	off-thalweg	COP ALC	---	---

Notes:

Completed to evaluate toxicity to water dwelling organisms in the Lower Klamath River.

Sediment samples were whole-core composites collected from every on-thalweg and off-thalweg borehole location within a reservoir to provide representative reservoir-wide average sediment composition.

Sediment samples for Klamath Estuary were multiple-core "area composite" samples based on 3 to 6 core locations distributed within a half-mile radius.

"off-thalweg" or "on-thalweg" indicates exceedance of criteria for that sample Mean hardness from Klamath River at Orleans is 70 mg/L used to calculate hardness adjusted criteria for California reaches of river.

384 analytes were quantified in each of 3 reservoir super-composites on-thalweg and off-thalweg samples.

Freshwater criteria available for 48 analytes.

Ag: Agriculture
ALA: Aquatic Life Acute
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ALI: Aquatic Life Instant
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CDPH: California Department of Public Health
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COP: California Ocean Plan
CTR: California Toxics Rule
H: Human
HH CTR: Human Health California Toxics Rule
HO: Human Organism
HWO: Human Water and Organism
ug/L: micrograms per liter
MCL: Maximum Contaminant Level
NRWQC: National Recommended Water Quality Criteria
NTR: National Toxics Rule
ODEQ: Oregon Department of Environmental Quality
WQC: Water Quality Criteria
WQG: Water Quality Guidance

Table 13. Summary of 2009-2010 Elutriate Chemistry Results for Copco 1 Reservoir (Marine)

Chemical	"Sample" value (ug/L)	Above One or More Marine Water Quality Acute Criteria	Criteria exceeded	Above One or More Marine Water Quality Chronic Criteria	Criteria exceeded	Above One or More Marine Water Quality Instant Criteria	Criteria exceeded
Ammonia as N	8,800	off-thalweg	COP ALA	off-thalweg	COP ALC	off-thalweg	COP ALI
	25,000	on-thalweg	COP ALA	on-thalweg	COP ALC	on-thalweg	COP ALI
Phosphorus, total as P	430	---	---	off-thalweg	NRWQC Marine CCC	---	---
	240	---	---	on-thalweg	NRWQC Marine CCC	---	---
Total PCBs	0.004	---	---	---	---	---	---
	0.0039	---	---	---	---	---	---
Aluminum	6,600	---	---	---	---	---	---
	3,600	---	---	---	---	---	---
Arsenic	8.9	---	---	off-thalweg	COP ALC	---	---
	11	---	---	on-thalweg	COP ALC	---	---
Chromium	6.5	---	---	off-thalweg	COP ALC	---	---
	3.6	---	---	on-thalweg	COP ALC	---	---
Copper	12	off-thalweg	NRWQC Marine CMC	off-thalweg	NRWQC Marine CCC, COP ALC	---	---
	6.9	on-thalweg	NRWQC Marine CMC	on-thalweg	NRWQC Marine CCC, COP ALC	---	---
Lead	3.6	---	---	off-thalweg	COP ALC	---	---
	2.2	---	---	on-thalweg	COP ALC	---	---
Mercury	0.019	---	---	---	---	---	---
	0.017	---	---	---	---	---	---
Nickel	6.2	---	---	off-thalweg	COP ALC	---	---

Notes:
Completed to evaluate toxicity to water dwelling organisms in the Lower Klamath River.
Sediment samples were whole-core composites collected from every on-thalweg and off-thalweg borehole location within a reservoir to provide representative reservoir-wide average sediment composition.
Sediment samples for Klamath Estuary were multiple-core "area composite" samples based on 3 to 6 core locations distributed within a half-mile radius.
X indicates exceedance of criteria
Mean hardness from Klamath River at Orleans is 70 mg/L used to calculate hardness adjusted criteria for California reaches of river.
384 analytes were quantified in each of 3 reservoir super-composites on-thalweg and off-thalweg samples.
Freshwater criteria available for 48 analytes.

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MCL: Maximum Contaminant Level
NRWQC: National Recommended Water Quality Criteria
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ODEQ: Oregon Department of Environmental Quality
WQC: Water Quality Criteria
WQG: Water Quality Guidance

Table 14. Summary of 2009-2010 Elutriate Chemistry Results for Iron Gate Reservoir (Marine)

Chemical	"Sample" value (ug/L)	Above One or More Marine Water Quality Acute Criteria	Criteria exceeded	Above One or More Marine Water Quality Chronic Criteria	Criteria exceeded	Above One or More Marine Water Quality Instant Criteria	Criteria exceeded
Ammonia as N	4,800	off-thalweg	COP ALA	off-thalweg	COP ALC	---	---
	7,200	on-thalweg	COP ALA	on-thalweg	COP ALC	on-thalweg	COP ALI
	10,000	on-thalweg	COP ALA	on-thalweg	COP ALC	on-thalweg	COP ALI
Phosphorus, total as P	130	---	---	off-thalweg	NRWQC Marine CCC	---	---
	310	---	---	on-thalweg	NRWQC Marine CCC	---	---
	330	---	---	on-thalweg	NRWQC Marine CCC	---	---
Total PCBs	0.0017	---	---	---	---	---	---
	0.0034	---	---	---	---	---	---
	0.0065	---	---	---	---	---	---
Aluminum	1,500	---	---	---	---	---	---
	2,600	---	---	---	---	---	---
	4,700	---	---	---	---	---	---
Arsenic	4.8	---	---	---	---	---	---
	9.4	---	---	on-thalweg	COP ALC	---	---
	20	---	---	on-thalweg	COP ALC	---	---
Chromium	2.4	---	---	on-thalweg	COP ALC	---	---
	5.5	---	---	on-thalweg	COP ALC	---	---
Copper	4.5	---	---	off-thalweg	NRWQC Marine CCC, COP ALC	---	---
	6.8	on-thalweg	NRWQC Marine CMC	on-thalweg	NRWQC Marine CCC, COP ALC	---	---
	10	on-thalweg	NRWQC Marine CMC	on-thalweg	NRWQC Marine CCC, COP ALC	---	---
Lead	2.8	---	---	on-thalweg	COP ALC	---	---
Mercury	0.014	---	---	---	---	---	---
Nickel	5.7	---	---	on-thalweg	COP ALC	---	---

Notes:

Completed to evaluate toxicity to water dwelling organisms in the Lower Klamath River.

Sediment samples were whole-core composites collected from every on-thalweg and off-thalweg borehole location within a reservoir to provide representative reservoir-wide average sediment composition.

Sediment samples for Klamath Estuary were multiple-core "area composite" samples based on 3 to 6 core locations distributed within a half-mile radius.

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Freshwater criteria available for 48 analytes.

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Table 15. Summary of 2009-2010 Elutriate Chemistry Results for Klamath River Estuary (Marine)

Chemical	"Sample" value (ug/L)	Above One or More Marine Water Quality Acute Criteria	Criteria exceeded	Above One or More Marine Water Quality Chronic Criteria	Criteria exceeded	Above One or More Marine Water Quality Instant Criteria	Criteria exceeded
Phosphorus, total as P	60	---	---	X	NRWQC Marine CCC	---	---
Chloride	470,000	---	---	---	---	---	---
Total PCBs	0.00016	---	---	---	---	---	---
	0.00013	---	---	---	---	---	---
Aluminum	770	---	---	---	---	---	---
	780	---	---	---	---	---	---
Arsenic	6	---	---	---	---	---	---
	2.2	---	---	---	---	---	---
Chromium	2.8	---	---	X	COP ALC	---	---
	5.9	---	---	X	COP ALC	---	---
Copper	6.9	X	NRWQC Marine CMC	X	NRWQC Marine CCC, COP ALC	---	---
	7	X	NRWQC Marine CMC	X	NRWQC Marine CCC, COP ALC	---	---
Mercury	0.023	---	---	---	---	---	---
Nickel	11	---	---	X	NRWQC Marine CCC, COP ALC	---	---
	18	---	---	X	NRWQC Marine CCC, COP ALC	---	---

Notes:
Completed to evaluate toxicity to water dwelling organisms in the Lower Klamath River.
Sediment samples were whole-core composites collected from every on-thalweg and off-thalweg borehole location within a reservoir to provide representative reservoir-wide average sediment composition.
Sediment samples for Klamath Estuary were multiple-core "area composite" samples based on 3 to 6 core locations distributed within a half-mile radius.
X indicates exceedance of criteria
Mean hardness from Klamath River at Orleans is 70 mg/L used to calculate hardness adjusted criteria for California reaches of river.
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Concentrations of aluminum, arsenic and total PCBs in the short-term (i.e., less than 2 years following dam removal, when downstream transport of reservoir sediments and pore waters would be the greatest) are estimated to likely require greater dilutions than 48- to 66-fold during drawdown to avoid exceeding the relevant human health criteria (**Appendix B**, Table B-11). The dilution factors for Total PCB average 55, for aluminum the average factor is 79, and the average factor for arsenic is 5000. It should be noted the lower Klamath River and Estuary are not drinking water sources so human exposure to these chemicals will be limited.

The estimated dilution factors needed for the elutriate chemistry results to meet marine criteria are relatively small (< 20) and considerably less than the estimated dilution factor of 48- to 66-fold below Iron Gate Dam. Actual dilution is likely to exceed the range of required dilution factors for ammonia, arsenic, chromium, copper, lead, nickel and zinc to meet marine water quality criteria based on the calculations (**Appendix B**, Table B-8).

Phosphorus concentrations in the short-term (i.e., less than 2 years following dam removal, when downstream transport of reservoir sediments and pore waters would be the greatest) are likely to require the greatest dilutions in order not exceed the marine CCC. Estimated dilution factors range from 600 to 5400. It should be noted these dilution factors are based on national chronic criteria and these conditions following dam removed are expected last less than 2 years (BOR 2011a).

4.2 Elutriate Toxicity Bioassay

The elutriate toxicity bioassay is a standard test that evaluates potential toxicity to aquatic receptors. Acute (96-hour) elutriate toxicity tests were conducted for the rainbow trout (*Onchorhynchus mykiss*) to evaluate toxicity to salmonid fish under potential short-term conditions associated with Exposure Pathway 1 if Proposed Action “dams removed” is selected. Exposure Pathway 1 evaluates the potential effects from exposure to chemical contaminants transferring to the water column during the short term turbid conditions expected to occur immediately following the removal of the dams or episodically in the first year or two.

Rainbow trout were exposed to laboratory control water, site surface water, and four elutriate treatments based on percent elutriate (1%, 10%, 50%, and 100%) created from samples collected from on-thalweg and off-thalweg sample locations from each of the three reservoirs. Of these, the 1% and 10% treatments are considered most representative of field conditions that could occur upon dam removal due to the expectation of substantial mixing and dilution with normal river flows currently located in the hydroelectric reach and downstream of the dams and further dilution with water entering the river from the lower Klamath River tributaries (BOR 2011a). As discussed in Section 4.1, screening level calculations based on modeled hydrology and suspended sediment loads suggest potential dilutions on the scale of 44- to 66-fold (**Appendix B**), which are in the range of the 1-10% dilutions for the elutriate bioassays (10- to 100-fold).

Mean survival following 96-hour exposure to site surface water collected from each reservoir ranges from 92% (Iron Gate) to 100% (J.C. Boyle and Copco 1), suggesting that under current conditions of No Action “dams in”, water column toxicity does not significantly impact survival of salmonid fish. Additionally, acute 96-hour survival tests provided acceptable results (greater than 95% survival) for elutriate samples collected from on-thalweg (i.e., historic river channel) and off-thalweg locations within each reservoir for the 1% and 10% elutriate strengths for each as shown in **Table 16**. A detailed discussion on the results is presented in **Appendix B**.

Mean 96-hour survival was also not significantly different from controls for the 50% elutriate strengths for samples collected from J.C. Boyle and Copco 1 and the 100% elutriate strength for samples collected from J.C. Boyle. However, a statistically significant reduction of mean 96-hour trout survival was identified for exposure to the on-thalweg and off-thalweg samples collected from Copco 1 at 100% elutriate treatment and from Iron Gate at 50% and 100% elutriate treatments. The cause of the observed reduction in survival cannot be determined from available data, but tools such as Toxicity Identification Evaluation (TIE) are available should this need to be determined at a future time. It should also be noted that the laboratory control water for Iron Gate (82%) did not pass the acceptability criterion of 90% mean survival. This failure limits the use of the Iron Gate results, leading to uncertainty regarding conclusions about potential impacts at Iron Gate under Exposure Pathway 1 if Proposed Action “dams removed” is implemented.

LC50 values (elutriate strength for which 50 percent mortality of rainbow trout was experienced) shown in the bottom row of **Table 16** range from >100 percent at J.C. Boyle, 66-68 percent at Copco 1, and 22-32 percent at Iron Gate. Lower LC50 values suggest higher potential toxicity.

Table 16. Summary of 2009-2010 Klamath Reservoir Acute Elutriate Toxicity Results for 96-hour Bioassay

Acute 96-hour survival % bioassay for Rainbow Trout (*Onchorhynchus mykiss*)

Sample type	Location					
	on-thalweg J.C. Boyle Reservoir	off-thalweg J.C. Boyle Reservoir	on-thalweg Copco 1 Reservoir	off-thalweg Copco 1 Reservoir	on-thalweg Iron Gate Reservoir	off-thalweg Iron Gate Reservoir
Mean 96-hr survival						
Laboratory Control Water	100	100	98	98	82(1)	82(1)
Site Surface Water	100	100	100	100	92	92
1% Elutriate	100	100	100	98	98	96
10% Elutriate	100	100	100	100	96	98
50% Elutriate	100	100	94	96	0	0
100% Elutriate	100	94	0	0	38	0
LC50	>100	>100	66	68	32	22

Notes:

Sediment samples were super-composites to provide representative reservoir-wide average sediment composition.

Super-composites are whole-core composite samples that were collected from every on-thalweg and every off-thalweg (non-thalweg) borehole location within a reservoir. Super-composite samples were chosen for analysis of sediment elutriate and for bioassay tests to provide a representative reservoir-wide average sediment composition, and to meet the large sediment and water volume requirements for the elutriate chemistry (Bureau of Reclamation 2010).

Four elutriate strengths (1%, 10%, 50%, and 100%) for super-composite on-thalweg and off-thalweg samples from each reservoir. These were prepared using 4:1 sediment: site surface water slurry.

(1): Control did not pass test acceptability criterion of 90% survival. Each was at 82% survival.

Highlighted: statistically significant reduction in survival compared to site surface water (p=0.05).

These bioassay results suggest for J.C. Boyle Reservoir sediments (LC-50>100 percent), elutriate bioassay results indicate that no further dilution of the 100 percent elutriate strength would be required to prevent water column toxicity to rainbow trout. The sediment and elutriate chemistry may contribute to salmonid toxicity when Copco 1 and Iron Gate reservoirs are being drained if the standardized laboratory conditions for the 50% and 100% elutriate strengths are assumed representative of conditions expected immediately following implementation of Proposed Action “dams removed.” This would also apply to salmonid fish below Copco 1 and Iron Gate under those similar field conditions. However, under Proposed Action “dams removal,” it would be reasonable to expect that sediment and elutriate concentrations would be rapidly dispersed and diluted during drawdown, thereby reducing exposure for salmonid fish. Results suggest a 2- to 4-fold dilution of the 100 percent elutriate strength would be sufficient to prevent water column toxicity to rainbow trout. The estimated dilution factor of about 48- to 66- fold that might occur would be sufficient to eliminate rainbow trout toxicity, and is likely to be high enough to be protective of other fish species that may be more sensitive than rainbow trout. If adverse effects to salmonid fish were to be observed, it would be more likely due to suspended solids and low dissolved oxygen levels rather than acute exposure to chemicals associated with those suspended sediments (Stillwater Sciences 2011).

4.3 Conclusions

The results of the elutriate chemistry indicated low numbers of chemicals present in the sediments that have the potential to adversely affect the downstream environments prior to consideration of physical conditions during removal (e.g., drawdown rate, dilution, and dispersion). The total number is reduced further if dilution is factored in. Only total phosphorus, aluminum, arsenic and total PCBs may potentially exceed criteria in the short-term (i.e., less than 2 years following dam removal, when downstream transport of reservoir sediments and pore waters would be the greatest).

The results of the elutriate toxicity bioassay indicated that salmonid fish are unlikely to experience significant adverse effects when exposed to conditions represented by the 1% and 10% treatments, which are considered likely to be representative of field conditions upon dam removal (refer to the Section 4.2 discussion). Although not expected, salmonid fish exposed to elutriate chemicals from suspended sediments from Copco 1 and Iron Gate could experience adverse effects if the 50% and 100% were representative of field conditions when the Proposed Action “dams removed” was implemented.

Collectively, the elutriate chemistry and elutriate toxicity do not identify a consistent pattern of toxicity by location, representative organism, or conditions. A few differences do exist among the three reservoirs.

A portion of the current reservoir sediments, estimated at one-third to two-thirds, would be released downstream under Proposed Action “dams removed” (BOR 2011a). Released sediments would be distributed spatially and temporally so that no single downstream location would likely to be subject to the magnitude of chemical concentrations that currently exist in the reservoirs, either over a short or long time period. Thus, there would likely to be reduced exposures of aquatic biota currently residing in reservoirs, and marginally increased exposures (likely temporary or short-lived) for aquatic receptors downstream. Thus, data suggest that there would not likely be significant toxicity associated with either No Action “dams in” or Proposed Action “dams removed.”

Chapter 5 Evaluation of Sediment Bioassays and Invertebrate Bioaccumulation

This section presents information related to sediment toxicity and chemical uptake by and accumulation in tissues of aquatic ecological receptors (i.e., representative aquatic invertebrates) exposed to reservoir sediments. A primary focus of this evaluation is to determine if the contaminants present in reservoir sediments are bioavailable, while at relatively low levels, and accumulate to a degree that survival, growth, or reproduction of aquatic organisms represented by selected invertebrate taxa may be adversely affected.

5.1 Approach

The approaches for evaluating chemical concentrations in laboratory reared invertebrates exposed to field collected sediments are described below.

5.1.1 Approach for Evaluating Sediment Toxicity in Invertebrates

Acute (10-day) sediment toxicity tests were conducted for the benthic midge (*Chironomus dilutens*) and the benthic amphipod (*Hyalella azteca*). The same super-composite samples of on-thalweg sediments and off-thalweg sediments from each of the three reservoirs and “area composite” samples from the Klamath Estuary used in the elutriate tests described in Section 4 were used to evaluate the potential sediment toxicity. Again, the use of super- and area-composites provided a reasonably representative average concentration of sediment in the area from which the individual samples were collected and composited (each reservoir and the estuary). This is supported by the low variation in the chemical concentrations detected in sediment samples collected within each reservoir and the estuary.

5.1.2 Approach for Evaluating Bioaccumulation in Invertebrates

The bioaccumulation evaluations are based on the results of controlled studies in which laboratory-reared blackworms (*Lumbriculus variegatus*) and Asian clams (*Corbicula fluminea*) were exposed in the laboratory for 28 days to sediments collected from each of the three reservoirs (i.e., J.C. Boyle, Copco 1, and Iron Gate) and the Upper Klamath Estuary. Blackworms and clams were also exposed to native laboratory control sediments for the same duration. Following these exposures and storage at -80 degrees C, whole body worm and clam soft tissues were analyzed for metals, dioxins/furans, PCBs, pesticides, PBDEs, and polycyclic aromatic hydrocarbons (PAHs). When the amount of invertebrate tissue available for analysis was limited, a prioritized list was applied with analyses performed in the following order: dioxins, PAHs, PCBs, organochlorines, metals, and then PBDEs. Again, chemical concentrations in whole body blackworms and the soft tissue of Asian clams were then screened against tissue concentrations known or predicted to cause ecologically significant impairments to the organisms harboring the chemicals in their tissues. Chemicals with concentrations that exceed selected toxicity reference values (TRVs) are identified as chemicals of potential concern (COPCs). The term COPC is for this purpose used to identify chemicals of potential ecological concern.

Once the laboratory analyses of invertebrate tissues had been completed, quality control and assessment of the data were performed, and the results reported. The assessment of bioavailability and bioaccumulation potential involved the following steps:

- Compilation and summary of the validated tissue data
- Identification of chemicals detected in the tissue samples
- Identification of chemicals with potential to cause impairment
- Development of tissue-based TRVs for selected invertebrate taxa
- Comparison of tissue data to tissue-based TRVs
- Identification of COPCs based on aforementioned comparisons
- Calculation of location specific, taxa specific, and chemical specific biota-sediment accumulation factors (BSAFs) to demonstrate potential chemical uptake and transfer

5.2 Sediment Toxicity Bioassay

No statistically significant difference in survival was identified for reservoir or estuary sediments compared to control sediments for either test organism, with the exception of the survival of midge exposed to on-thalweg sediments from J.C. Boyle as presented in **Table 17**. The mean midge survival for J. C. Boyle was 64% compared to 95% for laboratory controls. Although not statistically significant, the mean midge survival for the off-thalweg sediments (83%) was also lower than control sediments (95%) at J.C. Boyle due to a single replicate that had a substantially lower survival rate than the other four replicates. A detailed discussion on the results is presented in **Appendix B**.

Based on the results of the sediment toxicity bioassay, survival of organisms represented by the amphipod are not statistically different from controls for each reservoir and the estuary under current conditions and are expected to be similar downstream under Proposed Action "dams removed." Further, survival of the organisms represented by the midge living in on-thalweg and off-thalweg sediments of Copco 1, Iron Gate, and in sediments of the Klamath Estuary is not statistically different from controls under current conditions, No Action. Survival is also expected to be similar at down-gradient locations if the Proposed Action is implemented.

Table 17. Summary of Sediment Toxicity Test Results

Acute 10-day survival % bioassay

organism	Location						
	on-thalweg J.C. Boyle Reservoir	off-thalweg J.C. Boyle Reservoir	on-thalweg Copco 1 Reservoir	off-thalweg Copco 1 Reservoir	on-thalweg Iron Gate Reservoir	off-thalweg Iron Gate Reservoir	Klamath Estuary
midge (*Chironomus dilutus*)	X	√	---	---	---	---	---
amphipod (*Hyalella azteca*)	---	---	(1)	(1)	(1)	(1)	---

Notes:

Sediment samples were super-composites to provide representative reservoir-wide average sediment composition

Sediment samples for Klamath Estuary were multiple-core "area composite" samples based on 3 to 6 core locations distributed within a half-mile radius

X: Statistically significant difference (lower) in mean % survival compared to control (p = 0.002) (95% v. 64%)

√: Not statistically significant but worth noting (95% survival of control v. 83% survival)

(1): Control did not pass test acceptability criterion of 80% survival. Each was at 79% survival. Survival of site locations exceed that of controls (84% to 94%).

Highlighted: Have or may have concern for test organism or organisms similar to test organism

---: no concerns for the test organisms

The only result for acute 10-day survival bioassays significantly below the laboratory control was for the midge exposed to on-thalweg sediments at J.C. Boyle (64% mean survival). This reduced survival under No Action "dams in" (current conditions) may be indicative of effects to non-tested organisms represented by the midge. Although not statistically-significant, the reduced survival of the midge (83%) in off-thalweg sediments from J.C. Boyle is also indicative of effects under current conditions.

Under Proposed Action, it would be anticipated that any of the mobilized sediments would be dispersed during downstream movement and diluted with sediments flushed from the other reservoirs as well as those from Klamath River tributaries. These actions will reduce chemical concentrations and the associated toxicity. As a result, the survival of the midge and similar organisms would not be significantly impacted by the sediments originating from J.C. Boyle, under the Proposed Action.

Under the Proposed Action, sediment deposited along the stream bank above the final water level would convert to soil. The same is true for any remaining reservoir sediments that are exposed once the water levels drop. As sediments dry, they may change significantly. For example, with oxidation, the pH may drop, and metals found in the deposits may become more soluble and be prone to leaching. This leachate could have the potential to adversely affect the water quality. This potential impact has not been addressed in this study, but would be temporary, until reaching stable conditions (e.g., erosion and chemical equilibrium with surrounding soil).

The results of the sediment toxicity tests suggest that toxicity to benthic organisms represented by the midge is unlikely under No Action "dams in" (current conditions) for Copco 1, Iron Gate, and the estuary. However, adverse effects may be occurring under No Action “dams in” (current conditions) at J.C. Boyle.

5.3 Chemicals In Invertebrate Tissues

Soft tissues of laboratory reared invertebrates were analyzed for a suite of potentially hazardous and bioaccumulative chemicals, including chemicals identified in the step-wise comparison presented in **Appendix A**. The summary of invertebrate tissue data generated by the analytical laboratory forms the basis of the bioaccumulation evaluations for laboratory reared invertebrates (refer to **Appendix D**, Table D-2). Chemicals analyzed in invertebrates are presented in **Table 18**. This table lists chemicals detected in one or more samples and chemicals not detected in any of the samples for each species.

Table 19 presents the wet weight chemical concentrations detected or estimated in invertebrates for a subset of chemicals for which tissue-based TRVs are available. Chemical concentrations are estimated using the full MDL value for some chemicals that were not detected in tissues because detection limits were sufficiently high to warrant comparisons to relevant tissue-based TRVs. The use of estimated concentrations based on MDLs was limited to potentially toxic and/or bioaccumulative chemicals for which appropriate screening values are available (e.g., Endosulfan I and fluoranthene). This table also presents the laboratory RLs and MDLs. Sample specific MDLs are used for non-detect values.

Chemicals detected in clams that warrant further comparisons to relevant tissue-based TRVs include total arsenic, DDD, DDE, DDT, hexachlorobenzene, lead (not all locations), total mercury, total PBDEs, and total PCBs (**Table 19**). Acenaphthene, benzo(a)pyrene, endosulfan I, endosulfan II, endosulfan sulfate, fluoranthene, lead (not all locations), phenanthrene, and pyrene were not detected in clams and tissue concentrations are estimated for these chemicals using MDLs (**Table 19**).

Chemicals detected in blackworms that warrant further comparisons to relevant tissue-based TRVs include total arsenic, DDD, DDE, DDT (some locations), hexachlorobenzene, lead (not all locations), total mercury, total PBDEs, and total PCBs (**Table 19**). Acenephthene, benzo(a)pyrene, endosulfan I, endosulfan II, endosulfan sulfate, fluoranthene, lead (not all locations), phenanthrene, and pyrene were not detected in blackworms and tissue concentrations are estimated for these chemicals using MDLs (**Table 19**).

Table 18. Chemicals Detected and Not Detected in Laboratory-reared Invertebrate Tissues

Asian Clam		Blackworm	
DET	ND	DET	ND
2,4'-DDD	Acenaphthene	2,4'-DDD	2,4'-DDT
2,4'-DDE	Acenaphthylene	2,4'-DDE	Acenaphthene
2,4'-DDT	alpha-BHC	2-Fluorobiphenyl	Acenaphthylene
2-Fluorobiphenyl	Anthracene	4,4'-DDD	alpha-BHC
4,4'-DDD	BDE (3)	4,4'-DDE	BDE (6)
4,4'-DDE	Benzo(a)anthracene	4,4'-DDT	Benzo(a)anthracene
4,4'-DDT	Benzo(a)pyrene	Aldrin	Benzo(a)pyrene
Aldrin	Benzo(b)fluoranthene	Anthracene	Benzo(b)fluoranthene
Arsenic	Benzo(ghi)perylene	Arsenic	Benzo(ghi)perylene
BDE (8)	Benzo(k)fluoranthene	BDE (5)	Benzo(k)fluoranthene
beta-BHC	Chrysene	beta-BHC	Chrysene
cis-Chlordane	D/F (13)	cis-Chlordane	D/F (5)
cis-Nonachlor	Dibenz(a,h)anthracene	cis-Nonachlor	Dibenz(a,h)anthracene
D/F (2)	Endosulfan I	D/F (10)	Endosulfan I
delta-BHC	Endosulfan sulfate	delta-BHC	Endosulfan II
Dieldrin	Endrin	Dieldrin	Endosulfan sulfate
Endosulfan II	Endrin aldehyde	gamma-BHC (Lindane)	Endrin
gamma-BHC (Lindane)	Endrin ketone	Hexachlorobenzene	Endrin aldehyde
Heptachlor epoxide	Fluoranthene	Lead	Endrin ketone
Hexachlorobenzene	Fluorene	Methoxychlor	Fluoranthene
Lead	Heptachlor	Mirex	Fluorene
Mercury	Indeno(1,2,3-cd)pyrene	Naphthalene	Heptachlor
Mirex	Methoxychlor	Nitrobenzene-d5	Heptachlor epoxide
Nitrobenzene-d5	Naphthalene	OCDD	Indeno(1,2,3-cd)pyrene
OCDD	oxy-Chlordane	OCDF	Mercury
OCDF	PCB congeners (30)	PCB congeners (169)	oxy-Chlordane
PCB congeners (179)	Phenanthrene	Selenium	PCB congeners (40)
Selenium	Pyrene	Terphenyl-d14	Phenanthrene
Terphenyl-d14	Total HpCDF	Total HpCDD	Pyrene
Total HpCDD	Total HxCDD	trans-Chlordane	Total HpCDF
trans-Chlordane	Total HxCDF	trans-Nonachlor	Total HxCDD
trans-Nonachlor	Total PeCDD		Total HxCDF
	Total PeCDF		Total PeCDD
	Total TCDD		Total PeCDF
	Total TCDF		Total TCDD
			Total TCDF

DET - Detected in one or more samples

ND - Not detected in any sample

Table 19. Chemicals Detected or Estimated in Invertebrates for which Tissue-based TRVs Are Available

(Based on wet weight)
(highlighted = chemical NOT DETECTED, result set to MDL for comparison to available TRV)

Species	Sample	Detected Analyte	Result	Units	MDL	RL
Corbicula fluminea	JC-CF	Acenaphthene	21	ug/kg	21	180
Corbicula fluminea	CR-CF	Acenaphthene	21	ug/kg	21	180
Corbicula fluminea	IG-CF	Acenaphthene	21	ug/kg	21	180
Corbicula fluminea	UE-CF	Acenaphthene	22	ug/kg	22	190
Corbicula fluminea	LC-CF-1	Acenaphthene	22	ug/kg	22	190
Corbicula fluminea	LC-CF-2	Acenaphthene	24	ug/kg	24	210
Corbicula fluminea	JC-CF	Arsenic (total)	2.5	mg/kg	0.15	0.2
Corbicula fluminea	IG-CF	Arsenic (total)	0.4	mg/kg	0.15	0.2
Corbicula fluminea	UE-CF	Arsenic (total)	0.55	mg/kg	0.15	0.2
Corbicula fluminea	LC-CF-1	Arsenic (total)	1.4	mg/kg	0.15	0.2
Corbicula fluminea	LC-CF-2	Arsenic (total)	1.7	mg/kg	0.15	0.2
Corbicula fluminea	JC-CF	Benzo(a)pyrene	40	ug/kg	40	180
Corbicula fluminea	CR-CF	Benzo(a)pyrene	40	ug/kg	40	180
Corbicula fluminea	IG-CF	Benzo(a)pyrene	41	ug/kg	41	180
Corbicula fluminea	UE-CF	Benzo(a)pyrene	42	ug/kg	42	190
Corbicula fluminea	LC-CF-1	Benzo(a)pyrene	43	ug/kg	43	190
Corbicula fluminea	LC-CF-2	Benzo(a)pyrene	47	ug/kg	47	210
Corbicula fluminea	JC-CF	DDD	0.58	ug/kg	0.0087	0.078
Corbicula fluminea	IG-CF	DDD	0.6	ug/kg	0.0192	0.072
Corbicula fluminea	UE-CF	DDD	0.88	ug/kg	0.0116	0.08
Corbicula fluminea	LC-CF-1	DDD	1.2	ug/kg	0.0134	0.078
Corbicula fluminea	LC-CF-2	DDD	1.17	ug/kg	0.027	0.078
Corbicula fluminea	JC-CF	DDE	1.854	ug/kg	0.0112	0.078
Corbicula fluminea	IG-CF	DDE	1.967	ug/kg	0.04	0.072
Corbicula fluminea	UE-CF	DDE	3.386	ug/kg	0.0101	0.08
Corbicula fluminea	LC-CF-1	DDE	3.81	ug/kg	0.0115	0.078
Corbicula fluminea	LC-CF-2	DDE	2.79	ug/kg	0.029	0.078
Corbicula fluminea	JC-CF	DDT	0.093	ug/kg	0.0102	0.078
Corbicula fluminea	IG-CF	DDT	0.098	ug/kg	0.03	0.072
Corbicula fluminea	UE-CF	DDT	0.238	ug/kg	0.0159	0.08
Corbicula fluminea	LC-CF-1	DDT	0.247	ug/kg	0.018	0.078
Corbicula fluminea	LC-CF-2	DDT	0.129	ug/kg	0.042	0.078
Corbicula fluminea	JC-CF	Endosulfan I	0.012	ug/kg	0.012	0.039
Corbicula fluminea	IG-CF	Endosulfan I	0.022	ug/kg	0.022	0.036
Corbicula fluminea	UE-CF	Endosulfan I	0.015	ug/kg	0.015	0.04
Corbicula fluminea	LC-CF-1	Endosulfan I	0.015	ug/kg	0.015	0.039
Corbicula fluminea	LC-CF-2	Endosulfan I	0.027	ug/kg	0.027	0.039
Corbicula fluminea	JC-CF	Endosulfan II	0.029	ug/kg	0.022	0.039
Corbicula fluminea	IG-CF	Endosulfan II	0.031	ug/kg	0.031	0.036
Corbicula fluminea	UE-CF	Endosulfan II	0.035	ug/kg	0.035	0.04
Corbicula fluminea	LC-CF-1	Endosulfan II	0.044	ug/kg	0.044	0.044
Corbicula fluminea	LC-CF-2	Endosulfan II	0.081	ug/kg	0.081	0.081

Table 19. Chemicals Detected or Estimated in Invertebrates for which Tissue-based TRVs Are Available

(Based on wet weight)
(highlighted = chemical NOT DETECTED, result set to MDL for comparison to available TRV)

Species	Sample	Detected Analyte	Result	Units	MDL	RL
Corbicula fluminea	JC-CF	Endosulfan sulfate	0.003	ug/kg	0.003	0.039
Corbicula fluminea	IG-CF	Endosulfan sulfate	0.011	ug/kg	0.011	0.036
Corbicula fluminea	UE-CF	Endosulfan sulfate	0.0092	ug/kg	0.0092	0.04
Corbicula fluminea	LC-CF-1	Endosulfan sulfate	0.013	ug/kg	0.013	0.039
Corbicula fluminea	LC-CF-2	Endosulfan sulfate	0.027	ug/kg	0.027	0.039
Corbicula fluminea	JC-CF	Fluoranthene	43	ug/kg	43	180
Corbicula fluminea	CR-CF	Fluoranthene	43	ug/kg	43	180
Corbicula fluminea	IG-CF	Fluoranthene	43	ug/kg	43	180
Corbicula fluminea	UE-CF	Fluoranthene	45	ug/kg	45	190
Corbicula fluminea	LC-CF-1	Fluoranthene	46	ug/kg	46	190
Corbicula fluminea	LC-CF-2	Fluoranthene	50	ug/kg	50	210
Corbicula fluminea	JC-CF	Hexachlorobenzene	0.02	ug/kg	0.00028	0.039
Corbicula fluminea	IG-CF	Hexachlorobenzene	0.019	ug/kg	0.00055	0.036
Corbicula fluminea	UE-CF	Hexachlorobenzene	0.041	ug/kg	0.00019	0.04
Corbicula fluminea	LC-CF-1	Hexachlorobenzene	0.053	ug/kg	0.00016	0.039
Corbicula fluminea	LC-CF-2	Hexachlorobenzene	0.069	ug/kg	0.00037	0.039
Corbicula fluminea	JC-CF	Lead	0.27	mg/kg	0.06	0.1
Corbicula fluminea	IG-CF	Lead	0.06	mg/kg	0.06	0.1
Corbicula fluminea	UE-CF	Lead	0.06	mg/kg	0.06	0.1
Corbicula fluminea	LC-CF-1	Lead	0.065	mg/kg	0.06	0.1
Corbicula fluminea	LC-CF-2	Lead	0.41	mg/kg	0.06	0.1
Corbicula fluminea	JC-CF	Mercury (total)	0.1	mg/kg	0.02	0.04
Corbicula fluminea	IG-CF	Mercury (total)	0.04	mg/kg	0.02	0.04
Corbicula fluminea	UE-CF	Mercury (total)	0.02	mg/kg	0.02	0.04
Corbicula fluminea	LC-CF-1	Mercury (total)	0.09	mg/kg	0.02	0.04
Corbicula fluminea	LC-CF-2	Mercury (total)	0.099	mg/kg	0.02	0.04
Corbicula fluminea	JC-CF	Phenanthrene	15	ug/kg	15	180
Corbicula fluminea	CR-CF	Phenanthrene	16	ug/kg	16	180
Corbicula fluminea	IG-CF	Phenanthrene	16	ug/kg	16	180
Corbicula fluminea	UE-CF	Phenanthrene	16	ug/kg	16	190
Corbicula fluminea	LC-CF-1	Phenanthrene	16	ug/kg	16	190
Corbicula fluminea	LC-CF-2	Phenanthrene	18	ug/kg	18	210
Corbicula fluminea	JC-CF	Pyrene	41	ug/kg	41	180
Corbicula fluminea	CR-CF	Pyrene	41	ug/kg	41	180
Corbicula fluminea	IG-CF	Pyrene	42	ug/kg	42	180
Corbicula fluminea	UE-CF	Pyrene	43	ug/kg	43	190
Corbicula fluminea	LC-CF-1	Pyrene	44	ug/kg	44	190
Corbicula fluminea	LC-CF-2	Pyrene	48	ug/kg	48	210
Corbicula fluminea	JC-CF	Total PBDEs	1037	pg/g	112.39	6292
Corbicula fluminea	IG-CF	Total PBDEs	2247	pg/g	91.05	6292
Corbicula fluminea	UE-CF	Total PBDEs	3096	pg/g	80.56	6292
Corbicula fluminea	LC-CF-2	Total PBDEs	2263	pg/g	71.423	6292
Corbicula fluminea	LC-CF-1	Total PBDEs	4284	pg/g	60.071	6292

Table 19. Chemicals Detected or Estimated in Invertebrates for which Tissue-based TRVs Are Available

(Based on wet weight)
(highlighted = chemical NOT DETECTED, result set to MDL for comparison to available TRV)

Species	Sample	Detected Analyte	Result	Units	MDL	RL
Corbicula fluminea	JC-CF	Total PCBs	17726	pg/g	423.42	3920
Corbicula fluminea	CR-CF	Total PCBs	24871	pg/g	476.07	3990
Corbicula fluminea	IG-CF	Total PCBs	19539	pg/g	238.61	3750
Corbicula fluminea	UE-CF	Total PCBs	23120	pg/g	178.7	3957
Corbicula fluminea	LC-CF-2	Total PCBs	15773	pg/g	168.12	3933
Corbicula fluminea	LC-CF-1	Total PCBs	24390	pg/g	194.4	3949
Lumbriculus variegatus	JC-LV	Acenaphthene	2.3	ug/kg	2.3	20
Lumbriculus variegatus	CR-LV	Acenaphthene	2.3	ug/kg	2.3	20
Lumbriculus variegatus	IG-LV	Acenaphthene	2.2	ug/kg	2.2	19
Lumbriculus variegatus	UE-LV	Acenaphthene	2.3	ug/kg	2.3	20
Lumbriculus variegatus	LC-LV-1	Acenaphthene	4.6	ug/kg	4.6	40
Lumbriculus variegatus	LC-LV-2	Acenaphthene	2.3	ug/kg	2.3	20
Lumbriculus variegatus	LC-LV-3	Acenaphthene	2.3	ug/kg	2.3	20
Lumbriculus variegatus	LC-LV-4	Acenaphthene	12	ug/kg	12	100
Lumbriculus variegatus	JC-LV	Arsenic (total)	1.2	mg/kg	0.15	0.2
Lumbriculus variegatus	CR-LV	Arsenic (total)	0.15	mg/kg	0.15	0.2
Lumbriculus variegatus	IG-LV	Arsenic (total)	0.58	mg/kg	0.15	0.2
Lumbriculus variegatus	UE-LV	Arsenic (total)	0.15	mg/kg	0.15	0.2
Lumbriculus variegatus	LC-LV-2	Arsenic (total)	0.15	mg/kg	0.15	0.2
Lumbriculus variegatus	LC-LV-3	Arsenic (total)	0.15	mg/kg	0.15	0.2
Lumbriculus variegatus	JC-LV	Benzo(a)pyrene	4.4	ug/kg	4.4	20
Lumbriculus variegatus	CR-LV	Benzo(a)pyrene	4.5	ug/kg	4.5	20
Lumbriculus variegatus	IG-LV	Benzo(a)pyrene	4.2	ug/kg	4.2	19
Lumbriculus variegatus	UE-LV	Benzo(a)pyrene	4.5	ug/kg	4.5	20
Lumbriculus variegatus	LC-LV-1	Benzo(a)pyrene	8.9	ug/kg	8.9	40
Lumbriculus variegatus	LC-LV-2	Benzo(a)pyrene	4.3	ug/kg	4.3	20
Lumbriculus variegatus	LC-LV-3	Benzo(a)pyrene	4.4	ug/kg	4.4	20
Lumbriculus variegatus	LC-LV-4	Benzo(a)pyrene	23	ug/kg	23	100
Lumbriculus variegatus	JC-LV	DDD	0.08	ug/kg	0.0072	0.08
Lumbriculus variegatus	CR-LV	DDD	0.315	ug/kg	0.0061	0.08
Lumbriculus variegatus	IG-LV	DDD	0.215	ug/kg	0.006	0.24
Lumbriculus variegatus	LC-LV-2	DDD	0.089	ug/kg	0.025	0.22
Lumbriculus variegatus	LC-LV-3	DDD	0.132	ug/kg	0.132	0.24
Lumbriculus variegatus	JC-LV	DDE	0.634	ug/kg	0.0096	0.08
Lumbriculus variegatus	CR-LV	DDE	1.127	ug/kg	0.0096	0.08
Lumbriculus variegatus	IG-LV	DDE	0.666	ug/kg	0.0105	0.24
Lumbriculus variegatus	LC-LV-2	DDE	0.629	ug/kg	0.036	0.22
Lumbriculus variegatus	LC-LV-3	DDE	0.379	ug/kg	0.111	1.22

Table 19. Chemicals Detected or Estimated in Invertebrates for which Tissue-based TRVs Are Available

(Based on wet weight)

(highlighted = chemical NOT DETECTED, result set to MDL for comparison to available TRV)

Species	Sample	Detected Analyte	Result	Units	MDL	RL
Lumbriculus variegatus	JC-LV	DDT	0.058	ug/kg	0.035	0.08
Lumbriculus variegatus	CR-LV	DDT	0.034	ug/kg	0.034	0.08
Lumbriculus variegatus	IG-LV	DDT	0.0081	ug/kg	0.0081	0.24
Lumbriculus variegatus	LC-LV-2	DDT	0.048	ug/kg	0.048	0.22
Lumbriculus variegatus	LC-LV-3	DDT	0.45	ug/kg	0.45	0.45
Lumbriculus variegatus	JC-LV	Endosulfan I	0.0092	ug/kg	0.0092	0.04
Lumbriculus variegatus	CR-LV	Endosulfan I	0.0079	ug/kg	0.0079	0.04
Lumbriculus variegatus	IG-LV	Endosulfan I	0.007	ug/kg	0.007	0.12
Lumbriculus variegatus	LC-LV-2	Endosulfan I	0.026	ug/kg	0.026	0.11
Lumbriculus variegatus	LC-LV-3	Endosulfan I	0.073	ug/kg	0.073	0.12
Lumbriculus variegatus	JC-LV	Endosulfan II	0.019	ug/kg	0.019	0.04
Lumbriculus variegatus	CR-LV	Endosulfan II	0.027	ug/kg	0.027	0.04
Lumbriculus variegatus	IG-LV	Endosulfan II	0.023	ug/kg	0.023	0.12
Lumbriculus variegatus	LC-LV-2	Endosulfan II	0.068	ug/kg	0.068	0.11
Lumbriculus variegatus	LC-LV-3	Endosulfan II	0.14	ug/kg	0.14	0.14
Lumbriculus variegatus	JC-LV	Endosulfan sulfate	0.009	ug/kg	0.009	0.2
Lumbriculus variegatus	CR-LV	Endosulfan sulfate	0.0089	ug/kg	0.0089	0.2
Lumbriculus variegatus	IG-LV	Endosulfan sulfate	0.0054	ug/kg	0.0054	0.12
Lumbriculus variegatus	LC-LV-2	Endosulfan sulfate	0.048	ug/kg	0.048	0.11
Lumbriculus variegatus	LC-LV-3	Endosulfan sulfate	0.029	ug/kg	0.029	0.61
Lumbriculus variegatus	JC-LV	Fluoranthene	4.7	ug/kg	4.7	20
Lumbriculus variegatus	CR-LV	Fluoranthene	4.8	ug/kg	4.8	20
Lumbriculus variegatus	IG-LV	Fluoranthene	4.5	ug/kg	4.5	19
Lumbriculus variegatus	UE-LV	Fluoranthene	4.8	ug/kg	4.8	20
Lumbriculus variegatus	LC-LV-1	Fluoranthene	9.5	ug/kg	9.5	40
Lumbriculus variegatus	LC-LV-2	Fluoranthene	4.6	ug/kg	4.6	20
Lumbriculus variegatus	LC-LV-3	Fluoranthene	4.7	ug/kg	4.7	20
Lumbriculus variegatus	LC-LV-4	Fluoranthene	24	ug/kg	24	100
Lumbriculus variegatus	JC-LV	Hexachlorobenzene	0.0065	ug/kg	0.00011	0.04
Lumbriculus variegatus	CR-LV	Hexachlorobenzene	0.0058	ug/kg	0.00017	0.04
Lumbriculus variegatus	IG-LV	Hexachlorobenzene	0.0085	ug/kg	0.00029	0.12
Lumbriculus variegatus	LC-LV-2	Hexachlorobenzene	0.022	ug/kg	0.00053	0.11
Lumbriculus variegatus	LC-LV-3	Hexachlorobenzene	0.015	ug/kg	0.0018	0.12
Lumbriculus variegatus	JC-LV	Lead	0.098	mg/kg	0.06	0.1
Lumbriculus variegatus	CR-LV	Lead	0.06	mg/kg	0.06	0.1
Lumbriculus variegatus	IG-LV	Lead	0.11	mg/kg	0.06	0.1
Lumbriculus variegatus	UE-LV	Lead	0.065	mg/kg	0.06	0.1
Lumbriculus variegatus	LC-LV-2	Lead	0.06	mg/kg	0.06	0.1
Lumbriculus variegatus	LC-LV-3	Lead	0.06	mg/kg	0.06	0.1

Table 19. Chemicals Detected or Estimated in Invertebrates for which Tissue-based TRVs Are Available

(Based on wet weight)
(highlighted = chemical NOT DETECTED, result set to MDL for comparison to available TRV)

Species	Sample	Detected Analyte	Result	Units	MDL	RL
Lumbriculus variegatus	JC-LV	Mercury (total)	0.02	mg/kg	0.02	0.04
Lumbriculus variegatus	CR-LV	Mercury (total)	0.02	mg/kg	0.02	0.04
Lumbriculus variegatus	IG-LV	Mercury (total)	0.02	mg/kg	0.02	0.04
Lumbriculus variegatus	UE-LV	Mercury (total)	0.02	mg/kg	0.02	0.04
Lumbriculus variegatus	LC-LV-1	Mercury (total)	0.02	mg/kg	0.02	0.04
Lumbriculus variegatus	LC-LV-2	Mercury (total)	0.02	mg/kg	0.02	0.04
Lumbriculus variegatus	LC-LV-3	Mercury (total)	0.02	mg/kg	0.02	0.04
Lumbriculus variegatus	JC-LV	Phenanthrene	1.7	ug/kg	1.7	20
Lumbriculus variegatus	CR-LV	Phenanthrene	1.7	ug/kg	1.7	20
Lumbriculus variegatus	IG-LV	Phenanthrene	1.6	ug/kg	1.6	19
Lumbriculus variegatus	UE-LV	Phenanthrene	1.7	ug/kg	1.7	20
Lumbriculus variegatus	LC-LV-1	Phenanthrene	3.4	ug/kg	3.4	40
Lumbriculus variegatus	LC-LV-2	Phenanthrene	1.7	ug/kg	1.7	20
Lumbriculus variegatus	LC-LV-3	Phenanthrene	1.7	ug/kg	1.7	20
Lumbriculus variegatus	LC-LV-4	Phenanthrene	8.7	ug/kg	8.7	100
Lumbriculus variegatus	JC-LV	Pyrene	4.5	ug/kg	4.5	20
Lumbriculus variegatus	CR-LV	Pyrene	4.6	ug/kg	4.6	20
Lumbriculus variegatus	IG-LV	Pyrene	4.3	ug/kg	4.3	19
Lumbriculus variegatus	UE-LV	Pyrene	4.6	ug/kg	4.6	20
Lumbriculus variegatus	LC-LV-1	Pyrene	9.1	ug/kg	9.1	40
Lumbriculus variegatus	LC-LV-2	Pyrene	4.4	ug/kg	4.4	20
Lumbriculus variegatus	LC-LV-3	Pyrene	4.5	ug/kg	4.5	20
Lumbriculus variegatus	LC-LV-4	Pyrene	23	ug/kg	23	100
Lumbriculus variegatus	JC-LV	Total PCBs	2352	pg/g	335.12	2041
Lumbriculus variegatus	CR-LV	Total PCBs	4027	pg/g	79.47	1942
Lumbriculus variegatus	IG-LV	Total PCBs	3609	pg/g	70.698	1923
Lumbriculus variegatus	LC-LV-3	Total PCBs	1592	pg/g	259.43	3969
Lumbriculus variegatus	LC-LV-2	Total PCBs	2677	pg/g	224.47	3956
Lumbriculus variegatus	LC-LV-4	Total PCBs	3254	pg/g	139.39	3747
Lumbriculus variegatus	JC-LV	Total PBDEs	319	pg/g	65.21	7779
Lumbriculus variegatus	CR-LV	Total PBDEs	0	pg/g	856.14	62920

Corbicula fluminea =Asian clam (representative bivalve)
Lumbriculus variegatus = blackworm (representative oligochaete)

MDL: method detection limit
RL: sample reporting limit
ug: microgram
kg: kilogram
mg: milligram
pg: picogram
g: gram

Sample ID
JC - J.C. Boyle Reservoir
CR - Copco 1 Reservoir
IG - Iron Gate Reservoir
UE - Upper Klamath Estuary
LC - Laboratory Control Sample

5.4 Tissue-based Toxicity Reference Values for Invertebrates

The next step of the evaluations of invertebrate tissues consisted of compiling and selecting chemical- and species-specific tissue-based Toxicity Reference Values.

Tissue-based TRVs are defined as chemical concentrations in biological tissues associated with no adverse effects (No Effect TRV) or concentrations at which adverse effects begin to be observed (Low Effect TRV). No Effect and Low Effect TRVs are used in this evaluation to determine if chemicals measured or estimated in invertebrate tissues are at concentrations that could impair survival, growth, or reproduction of invertebrates. In contrast to abiotic media-based SLs (e.g., concentrations of chemicals in water, sediment, or soil), tissue-based TRVs are infrequently derived and are only available for a relatively small number of chemicals and species. Chemical- and species-specific No Effect and Low Effect TRVs are compiled as available, but extrapolation between species and/or between chemicals is necessary for several chemicals detected in invertebrate tissues. For example, useful tissue-based TRVs are available for some chemicals of interest such as endosulfan, but not for others such as endosulfan II or endosulfan sulfate. In such cases, the TRVs for endosulfan are assumed acceptable for evaluating endosulfan II and endosulfan sulfate in invertebrate tissues. For some chemicals, TRVs may be available for a species not among those collected but within the same family. Extrapolation of TRVs beyond the family level is not performed for any chemical, and TRVs for surrogate chemicals are limited to similar chemicals such as endosulfan, endosulfan II, and endosulfan sulfate. Finally, in some cases only a Low Effect or No Effect or other single value is available for a given combination of chemical and species. In these cases, the unavailable TRV is estimated from the available data using generally accepted adjustment factors. Although there is no well defined standard, commonly applied adjustment factors used in the derivation of final tissue-based TRVs include the following:

- Low Effect TRV = No Effect TRV * 10
- No Effect TRV = Low Effect TRV / 10
- Low Effect TRV = LC_{50} or LD_{50} or EC_{50}/ 10
- No Effect TRV = LC_{50} or LD_{50} or EC_{50} / 100

Where LC_{50} = lethal concentration to 50% of test organisms

LD_{50} = lethal dose to 50% of test organisms

EC_{50} = effect concentration, observed in 50% of test organisms

Final tissue-based TRVs are preferentially based on survival, growth, or reproduction endpoints. In a few cases, TRVs are based on alternate endpoints that can reasonably be assumed to have potential to adversely affect test organisms in an ecologically significant manner (e.g., behavioral responses that result in feeding impairment).

The source of all tissue-based TRVs is the U.S. Army Corp of Engineers (USACE) Environmental Residue-Effects Database (ERED), accessed online at http://el.erdc.usace.army.mil/ered/. Other potential sources of tissue-based TRVs (such as those derived for the protection of fish and wildlife in San Francisco Bay, based on long-term TMDL targets) were not consulted for this initial screening level assessment, but may be used if further investigation or evaluation is deemed warranted at subsequent stages of the determination process.

Low Effect and No Effect tissue-based TRVs are derived for the two representative invertebrate groups for which whole body tissue data are available, oligochaetes (i.e., worms) and bivalves (i.e., clams and mussels). TRVs for *Lumbriculus* are based on toxicity data for *Lumbriculus* or other aquatic oligochaetes. Selected TRVs for *Corbicula* clams are based on toxicity data for a variety of clams and mussels. Available TRVs for oligochaetes and bivalves for chemicals detected in invertebrate tissues are shown in **Table 20**. Of the chemicals detected (or estimated using MDLs) in worm tissues (**Table 19**), tissue-based TRVs are readily available only for lead, DDD, DDE, total PCBs, and total PBDEs (**Table 20**). Of the chemicals detected (or estimated using MDLs) in clam tissue (**Table 19**), tissue-based TRVs are readily available for acenaphthene, arsenic, DDT, endosulfan I, endosulfan II, endosulfan sulfate, fluoranthene, mercury, phenanthrene, pyrene, and total PCBs (**Table 20**).

Table 20. Invertebrate Tissue-based TRVs

Chemical / Collected Species	Derivation	Study / Source	Test Species	NO EFFECT mg/kg wet wt.	LOW EFFECT mg/kg wet wt.
OLIGOCHAETES					
LEAD					
Lumbriculus	ACCEPT NOED EST. LOED (*10)	Aisemberg J; DE Nahabedian; EA Wider; NRV Guerrero 2005 in USACE ERED	*Lumbriculus*	300	3000
DDE					
Lumbriculus	ACCEPT LOED EST. NOED (/10)	Fisher SW, SW Chordas III, PF Landrum 1999 in USACE ERED	*Lumbriculus*	17.84	178.4
DDD					
Lumbriculus	ACCEPT NOED EST. LOED (*10)	CG Ingersoll, N Wang, JMR Hayward, JR Jones, SB Jones, DS Ireland 2005 in USACE ERED	OLIGOCHAETE (unidentified)	1500	15000
TOTAL PCBS					
Lumbriculus	ACCEPT NOED EST. LOED (*10)	Burton GA Jr, MS Greenberg, CD Rowland, CA Irvine, DR Lavioie, JA Brooker, L Moore, DFN Raymer, RA McWilliam 2005 in USACE ERED	*Lumbriculus*	350	3500
TOTAL PBDEs					
Lumbriculus	ACCEPT NOED EST. LOED (*10)	Leppenen MT, JVK Kukkonen 2004 in USACE ERED	*Lumbriculus*	24.28	242.8
BIVALVES					
MERCURY					
Corbicula	EST. LOED (/10) EST. NOED (/100) FROM LD50	Dillon, T.M.1977 in USACE ERED	MARSH CLAM	0.2	2
DDT					
Corbicula	ACCEPT NOED EST. LOED (*10)	Butler, P.A.1971 in USACE ERED	CLAM, SOFTSHELL	0.88	8.8
TOTAL PCBS					
Corbicula	ACCEPT NOED EST. LOED (*10)	Velduizen-Tsoerkan, M.B., Holwerda, D.A., Zandee, D.I. 1991 in USACE ERED	BLUE MUSSEL	1.4	14
ACENAPHTHENE					
Corbicula	EST. LOED (/10) EST. NOED (/100) FROM ED50	Donkin, P., J. Widdows, S.V. Evans, C.M. Worrall and M. Carr 1989 in USACE ERED	BLUE MUSSEL	0.294	2.94

Table 20. Invertebrate Tissue-based TRVs

Chemical / Collected Species	Derivation	Study / Source	Test Species	NO EFFECT mg/kg wet wt.	LOW EFFECT mg/kg wet wt.
FLUORANTHENE					
Corbicula	ACCEPT LOED EST. NOED (/10)	Eertman, R.H.M., C.L. Groenink, B. Sandee and H. Hummel 1995 in USACE ERED	BLUE MUSSEL	0.022	0.22
PHENANTHRENE					
Corbicula	EST. LOED (/10) EST. NOED (/100) FROM ED50	Donkin, P., J. Widdows, S.V. Evans, C.M. Worrall and M. Carr 1989 in USACE ERED	BLUE MUSSEL	0.307	3.07
PYRENE					
Corbicula	EST. LOED (/10) EST. NOED (/100) FROM ED50	Donkin, P., J. Widdows, S.V. Evans, C.M. Worrall and M. Carr 1989 in USACE ERED	BLUE MUSSEL	1.89	18.9
ENDOSULFAN*					
Corbicula	ACCEPT NOED EST. LOED (*10)	Roberts, D. 1972 in USACE ERED	BLUE MUSSEL	8.1	81
ARSENIC					
Corbicula	ACCEPT NOED EST. LOED (*10)	St-Jean SD, SC Courtenay, RW Parker 2003 in USACE ERED	BLUE MUSSEL	3.6	36

** Endosulfan TRVs assumed applicable to endosulfan II and endosulfan sulfate*

Corbicula fluminea =Asian clam (representative bivalve)
Lumbriculus variegatus = blackworm (representative oligochaete)

mg: milligram
kg: kilogram
wt: weight
TRV: toxicity reference value
USACE: United States Army Corps of Engineers
ERED: Environmental Residue-Effects Database

NOED: no observed adverse effect
LOED: lowest observed adverse effect
est: estimated
LD: lethal dose

5.5 Invertebrate Tissue Screening and Identification of COPCs

Results of the comparisons of tissue-based TRVs to concentrations of chemicals analyzed in blackworms and Asian clams are shown on **Table 21**. Many of these chemicals were not detected in invertebrate tissues, and these are highlighted. As shown on this table, comparisons are made for five chemicals for blackworms (DDD, DDE, lead, total PCBs, and total PBDEs) and for 12 chemicals for bivalves (acenaphthene, arsenic, benzo(a)pyrene, DDT, endosulfan, endosulfan II, endosulfan sulfate, fluoranthene, mercury, phenanthrene, pyrene, and total PCBs). Again, none of the PAHs (e.g., acenphthanene, benzo(a)pyrene, fluoranthene, phenanthrene, and pyrene) were detected in clams, and comparisons are based on estimated tissue concentrations based on MDLs and not on measured concentrations. Tissue-based TRVs are not readily available for the other chemicals detected in worms or clams. For chemicals for which TRVs are available, MDLs remain below applicable TRVs (**Table 21**); therefore, comparisons of estimated tissue concentrations based on MDLs to TRVs are acceptable.

5.5.1 *Lumbriculus* (Blackworm)

No COPCs are identified for oligochaetes represented by blackworms. Tissue-based TRVs are readily available for five of the chemicals detected or estimated (using MDLs) in worm tissue—DDD, DDE, lead, total PCBs, and total PBDEs. None of the concentrations of these chemicals measured in any worm sample exceeded the No Effect TRVs, and in fact many were not detected. Therefore, none of these five chemicals is identified as a COPC for worm tissue.

Oligochaete-based TRVs are unavailable for the other 12 chemicals detected in worm tissue, so no conclusion can be made concerning these chemicals. Of note are two important findings. First, reported concentrations are based on sample-specific MDLs and do not represent confirmed detections for the following chemicals in worm tissue:

- PAHs and DDT from all locations except J.C. Boyle;
- Endosulfan I, endosulfan II, endosulfan sulfate at all locations; and
- Lead from some locations.

Second, in most cases the highest values reported of those based on sample specific MDLs are associated with laboratory control (LC) samples (which provide chemical concentration data for worms and clams exposed to native sediments). The same is true for hexachlorobenzene, where laboratory control samples had the highest concentrations.

Table 21. Invertebrate Residues (wet weight) Compared to Tissue-based TRVs

(highlight = chemical NOT DETECTED, result set to MDL for comparison to available TRV)

								NO EFFECT TRV							LOW EFFECT TRV					
Invertebrate Species	Sample ID	Analyte - Invertebrate	Result	Units	MDL	RL		MARSH CLAM	BLUE MUSSEL	CLAM, SOFTSHELL	FINGERNAIL CLAM	LUMBRICULUS	OLIGOCHAETE		MARSH CLAM	BLUE MUSSEL	CLAM, SOFTSHELL	FINGERNAIL CLAM	LUMBRICULUS	OLIGOCHAETE
Corbicula fluminea	JC-CF	Acenaphthene	21	ug/kg	21	180			294							2940				
Corbicula fluminea	CR-CF	Acenaphthene	21	ug/kg	21	180			294							2940				
Corbicula fluminea	IG-CF	Acenaphthene	21	ug/kg	21	180			294							2940				
Corbicula fluminea	UE-CF	Acenaphthene	22	ug/kg	22	190			294							2940				
Corbicula fluminea	LC-CF-1	Acenaphthene	22	ug/kg	22	190			294							2940				
Corbicula fluminea	LC-CF-2	Acenaphthene	24	ug/kg	24	210			294							2940				
Corbicula fluminea	JC-CF	Arsenic	2.5	mg/kg	0.15	0.2			3.6							36				
Corbicula fluminea	IG-CF	Arsenic	0.4	mg/kg	0.15	0.2			3.6							36				
Corbicula fluminea	UE-CF	Arsenic	0.55	mg/kg	0.15	0.2			3.6							36				
Corbicula fluminea	LC-CF-1	Arsenic	1.4	mg/kg	0.15	0.2			3.6							36				
Corbicula fluminea	LC-CF-2	Arsenic	1.7	mg/kg	0.15	0.2			3.6							36				
Corbicula fluminea	JC-CF	Benzo(a)pyrene	40	ug/kg	40	180					1250							12500		
Corbicula fluminea	CR-CF	Benzo(a)pyrene	40	ug/kg	40	180					1250							12500		
Corbicula fluminea	IG-CF	Benzo(a)pyrene	41	ug/kg	41	180					1250							12500		
Corbicula fluminea	UE-CF	Benzo(a)pyrene	42	ug/kg	42	190					1250							12500		
Corbicula fluminea	LC-CF-1	Benzo(a)pyrene	43	ug/kg	43	190					1250							12500		
Corbicula fluminea	LC-CF-2	Benzo(a)pyrene	47	ug/kg	47	210					1250							12500		
Corbicula fluminea	JC-CF	DDD	0.58	ug/kg	0.0087	0.078		TRV unavailable for bivalve												
Corbicula fluminea	IG-CF	DDD	0.6	ug/kg	0.0192	0.072														
Corbicula fluminea	UE-CF	DDD	0.88	ug/kg	0.0116	0.08														
Corbicula fluminea	LC-CF-1	DDD	1.2	ug/kg	0.0134	0.078														
Corbicula fluminea	LC-CF-2	DDD	1.17	ug/kg	0.027	0.078														
Corbicula fluminea	JC-CF	DDE	1.854	ug/kg	0.0112	0.078		TRV unavailable for bivalve												
Corbicula fluminea	IG-CF	DDE	1.967	ug/kg	0.04	0.072														
Corbicula fluminea	UE-CF	DDE	3.386	ug/kg	0.0101	0.08														
Corbicula fluminea	LC-CF-1	DDE	3.81	ug/kg	0.0115	0.078														
Corbicula fluminea	LC-CF-2	DDE	2.79	ug/kg	0.029	0.078														
Corbicula fluminea	JC-CF	DDT	0.093	ug/kg	0.0102	0.078				880							8800			
Corbicula fluminea	IG-CF	DDT	0.098	ug/kg	0.03	0.072				880							8800			
Corbicula fluminea	UE-CF	DDT	0.238	ug/kg	0.0159	0.08				880							8800			
Corbicula fluminea	LC-CF-1	DDT	0.247	ug/kg	0.018	0.078				880							8800			
Corbicula fluminea	LC-CF-2	DDT	0.129	ug/kg	0.042	0.078				880							8800			
Corbicula fluminea	JC-CF	Endosulfan I	0.012	ug/kg	0.012	0.039			8100							81000				
Corbicula fluminea	IG-CF	Endosulfan I	0.022	ug/kg	0.022	0.036			8100							81000				
Corbicula fluminea	UE-CF	Endosulfan I	0.015	ug/kg	0.015	0.04			8100							81000				
Corbicula fluminea	LC-CF-1	Endosulfan I	0.015	ug/kg	0.015	0.039			8100							81000				
Corbicula fluminea	LC-CF-2	Endosulfan I	0.027	ug/kg	0.027	0.039			8100							81000				

Table 21. Invertebrate Residues (wet weight) Compared to Tissue-based TRVs

(highlight = chemical NOT DETECTED, result set to MDL for comparison to available TRV)

							NO EFFECT TRV						LOW EFFECT TRV					
Invertebrate Species	Sample ID	Analyte - Invertebrate	Result	Units	MDL	RL	MARSH CLAM	BLUE MUSSEL	CLAM, SOFTSHELL	FINGERNAIL CLAM	LUMBRICULUS	OLIGOCHAETE	MARSH CLAM	BLUE MUSSEL	CLAM, SOFTSHELL	FINGERNAIL CLAM	LUMBRICULUS	OLIGOCHAETE
Corbicula fluminea	JC-CF	Endosulfan II	0.029	ug/kg	0.022	0.039		8100						81000				
Corbicula fluminea	IG-CF	Endosulfan II	0.031	ug/kg	0.031	0.036		8100						81000				
Corbicula fluminea	UE-CF	Endosulfan II	0.035	ug/kg	0.035	0.04		8100						81000				
Corbicula fluminea	LC-CF-1	Endosulfan II	0.044	ug/kg	0.044	0.044		8100						81000				
Corbicula fluminea	LC-CF-2	Endosulfan II	0.081	ug/kg	0.081	0.081		8100						81000				
Corbicula fluminea	JC-CF	Endosulfan sulfate	0.003	ug/kg	0.003	0.039		8100						81000				
Corbicula fluminea	IG-CF	Endosulfan sulfate	0.011	ug/kg	0.011	0.036		8100						81000				
Corbicula fluminea	UE-CF	Endosulfan sulfate	0.0092	ug/kg	0.0092	0.04		8100						81000				
Corbicula fluminea	LC-CF-1	Endosulfan sulfate	0.013	ug/kg	0.013	0.039		8100						81000				
Corbicula fluminea	LC-CF-2	Endosulfan sulfate	0.027	ug/kg	0.027	0.039		8100						81000				
Corbicula fluminea	JC-CF	Fluoranthene	**43**	ug/kg	43	180		22						220				
Corbicula fluminea	CR-CF	Fluoranthene	**43**	ug/kg	43	180		22						220				
Corbicula fluminea	IG-CF	Fluoranthene	**43**	ug/kg	43	180		22						220				
Corbicula fluminea	UE-CF	Fluoranthene	**45**	ug/kg	45	190		22						220				
Corbicula fluminea	LC-CF-1	Fluoranthene	**46**	ug/kg	46	190		22						220				
Corbicula fluminea	LC-CF-2	Fluoranthene	**50**	ug/kg	50	210		22						220				
Corbicula fluminea	JC-CF	Hexachlorobenzene	0.02	ug/kg	0.00028	0.039	TRV unavailable for bivalve											
Corbicula fluminea	IG-CF	Hexachlorobenzene	0.019	ug/kg	0.00055	0.036												
Corbicula fluminea	UE-CF	Hexachlorobenzene	0.041	ug/kg	0.00019	0.04												
Corbicula fluminea	LC-CF-1	Hexachlorobenzene	0.053	ug/kg	0.00016	0.039												
Corbicula fluminea	LC-CF-2	Hexachlorobenzene	0.069	ug/kg	0.00037	0.039												
Corbicula fluminea	JC-CF	Lead	0.27	mg/kg	0.06	0.1	TRV unavailable for bivalve											
Corbicula fluminea	IG-CF	Lead	0.06	mg/kg	0.06	0.1												
Corbicula fluminea	UE-CF	Lead	0.06	mg/kg	0.06	0.1												
Corbicula fluminea	LC-CF-1	Lead	0.065	mg/kg	0.06	0.1												
Corbicula fluminea	LC-CF-2	Lead	0.41	mg/kg	0.06	0.1												
Corbicula fluminea	JC-CF	Mercury	0.1	mg/kg	0.02	0.04	0.2						2					
Corbicula fluminea	IG-CF	Mercury	0.04	mg/kg	0.02	0.04	0.2						2					
Corbicula fluminea	UE-CF	Mercury	0.02	mg/kg	0.02	0.04	0.2						2					
Corbicula fluminea	LC-CF-1	Mercury	0.09	mg/kg	0.02	0.04	0.2						2					
Corbicula fluminea	LC-CF-2	Mercury	0.099	mg/kg	0.02	0.04	0.2						2					
Corbicula fluminea	JC-CF	Phenanthrene	15	ug/kg	15	180		307						3070				
Corbicula fluminea	CR-CF	Phenanthrene	16	ug/kg	16	180		307						3070				
Corbicula fluminea	IG-CF	Phenanthrene	16	ug/kg	16	180		307						3070				
Corbicula fluminea	UE-CF	Phenanthrene	16	ug/kg	16	190		307						3070				
Corbicula fluminea	LC-CF-1	Phenanthrene	16	ug/kg	16	190		307						3070				
Corbicula fluminea	LC-CF-2	Phenanthrene	18	ug/kg	18	210		307						3070				
Corbicula fluminea	JC-CF	Pyrene	41	ug/kg	41	180		1890						18900				
Corbicula fluminea	CR-CF	Pyrene	41	ug/kg	41	180		1890						18900				
Corbicula fluminea	IG-CF	Pyrene	42	ug/kg	42	180		1890						18900				

Table 21. Invertebrate Residues (wet weight) Compared to Tissue-based TRVs

(highlight = chemical NOT DETECTED, result set to MDL for comparison to available TRV)

							NO EFFECT TRV						LOW EFFECT TRV					
Invertebrate Species	Sample ID	Analyte - Invertebrate	Result	Units	MDL	RL	MARSH CLAM	BLUE MUSSEL	CLAM, SOFTSHELL	FINGERNAIL CLAM	LUMBRICULUS	OLIGOCHAETE	MARSH CLAM	BLUE MUSSEL	CLAM, SOFTSHELL	FINGERNAIL CLAM	LUMBRICULUS	OLIGOCHAETE
Corbicula fluminea	UE-CF	Pyrene	43	ug/kg	43	190		1890						18900				
Corbicula fluminea	LC-CF-1	Pyrene	44	ug/kg	44	190		1890						18900				
Corbicula fluminea	LC-CF-2	Pyrene	48	ug/kg	48	210		1890						18900				
Corbicula fluminea	JC-CF	Total PBDEs	1037	pg/g	112.39	6292	TRV unavailable for bivalve											
Corbicula fluminea	IG-CF	Total PBDEs	2247	pg/g	91.05	6292												
Corbicula fluminea	UE-CF	Total PBDEs	3096	pg/g	80.56	6292												
Corbicula fluminea	LC-CF-2	Total PBDEs	2263	pg/g	71.423	6292												
Corbicula fluminea	LC-CF-1	Total PBDEs	4284	pg/g	60.071	6292												
Corbicula fluminea	JC-CF	Total PCBs	17,726	pg/g	423.42	3920		1,400,000						14,000,000				
Corbicula fluminea	CR-CF	Total PCBs	24,871	pg/g	476.07	3990		1,400,000						14,000,000				
Corbicula fluminea	IG-CF	Total PCBs	19,539	pg/g	238.61	3749.7		1,400,000						14,000,000				
Corbicula fluminea	UE-CF	Total PCBs	23,120	pg/g	178.7	3957		1,400,000						14,000,000				
Corbicula fluminea	LC-CF-2	Total PCBs	15,773	pg/g	168.12	3933		1,400,000						14,000,000				
Corbicula fluminea	LC-CF-1	Total PCBs	24,390	pg/g	194.4	3949		1,400,000						14,000,000				
Lumbriculus variegatus	JC-LV	Acenaphthene	2.3	ug/kg	2.3	20	TRV unavailable for oligochaete											
Lumbriculus variegatus	CR-LV	Acenaphthene	2.3	ug/kg	2.3	20												
Lumbriculus variegatus	IG-LV	Acenaphthene	2.2	ug/kg	2.2	19												
Lumbriculus variegatus	UE-LV	Acenaphthene	2.3	ug/kg	2.3	20												
Lumbriculus variegatus	LC-LV-1	Acenaphthene	4.6	ug/kg	4.6	40												
Lumbriculus variegatus	LC-LV-2	Acenaphthene	2.3	ug/kg	2.3	20												
Lumbriculus variegatus	LC-LV-3	Acenaphthene	2.3	ug/kg	2.3	20												
Lumbriculus variegatus	LC-LV-4	Acenaphthene	12	ug/kg	12	100												
Lumbriculus variegatus	JC-LV	Arsenic	1.2	mg/kg	0.15	0.2	TRV unavailable for oligochaete											
Lumbriculus variegatus	CR-LV	Arsenic	0.15	mg/kg	0.15	0.2												
Lumbriculus variegatus	IG-LV	Arsenic	0.58	mg/kg	0.15	0.2												
Lumbriculus variegatus	UE-LV	Arsenic	0.15	mg/kg	0.15	0.2												
Lumbriculus variegatus	LC-LV-2	Arsenic	0.15	mg/kg	0.15	0.2												
Lumbriculus variegatus	LC-LV-3	Arsenic	0.15	mg/kg	0.15	0.2												
Lumbriculus variegatus	JC-LV	Benzo(a)pyrene	4.4	ug/kg	4.4	20	TRV unavailable for oligochaete											

Table 21. Invertebrate Residues (wet weight) Compared to Tissue-based TRVs

(highlight = chemical NOT DETECTED, result set to MDL for comparison to available TRV)

							NO EFFECT TRV						LOW EFFECT TRV					
Invertebrate Species	Sample ID	Analyte - Invertebrate	Result	Units	MDL	RL	MARSH CLAM	BLUE MUSSEL	CLAM, SOFTSHELL	FINGERNAIL CLAM	LUMBRICULUS	OLIGOCHAETE	MARSH CLAM	BLUE MUSSEL	CLAM, SOFTSHELL	FINGERNAIL CLAM	LUMBRICULUS	OLIGOCHAETE
Lumbriculus variegatus	CR-LV	Benzo(a)pyrene	4.5	ug/kg	4.5	20												
Lumbriculus variegatus	IG-LV	Benzo(a)pyrene	4.2	ug/kg	4.2	19												
Lumbriculus variegatus	UE-LV	Benzo(a)pyrene	4.5	ug/kg	4.5	20												
Lumbriculus variegatus	LC-LV-1	Benzo(a)pyrene	8.9	ug/kg	8.9	40												
Lumbriculus variegatus	LC-LV-2	Benzo(a)pyrene	4.3	ug/kg	4.3	20												
Lumbriculus variegatus	LC-LV-3	Benzo(a)pyrene	4.4	ug/kg	4.4	20												
Lumbriculus variegatus	LC-LV-4	Benzo(a)pyrene	23	ug/kg	23	100												
Lumbriculus variegatus	JC-LV	DDD	0.08	ug/kg	0.0072	0.08						1500000						15000000
Lumbriculus variegatus	CR-LV	DDD	0.315	ug/kg	0.0061	0.08						1500000						15000000
Lumbriculus variegatus	IG-LV	DDD	0.215	ug/kg	0.006	0.24						1500000						15000000
Lumbriculus variegatus	LC-LV-2	DDD	0.089	ug/kg	0.025	0.22						1500000						15000000
Lumbriculus variegatus	LC-LV-3	DDD	0.132	ug/kg	0.132	0.24						1500000						15000000
Lumbriculus variegatus	JC-LV	DDE	0.634	ug/kg	0.0096	0.08					17840						178400	
Lumbriculus variegatus	CR-LV	DDE	1.127	ug/kg	0.0096	0.08					17840						178400	
Lumbriculus variegatus	IG-LV	DDE	0.666	ug/kg	0.0105	0.24					17840						178400	
Lumbriculus variegatus	LC-LV-2	DDE	0.629	ug/kg	0.036	0.22					17840						178400	
Lumbriculus variegatus	LC-LV-3	DDE	0.379	ug/kg	0.111	1.22					17840						178400	
Lumbriculus variegatus	JC-LV	DDT	0.058	ug/kg	0.035	0.08	TRV unavailable for oligochaete											
Lumbriculus variegatus	CR-LV	DDT	0.034	ug/kg	0.034	0.08												
Lumbriculus variegatus	IG-LV	DDT	0.0081	ug/kg	0.0081	0.24												
Lumbriculus variegatus	LC-LV-2	DDT	0.048	ug/kg	0.048	0.22												
Lumbriculus variegatus	LC-LV-3	DDT	0.45	ug/kg	0.45	0.45												
Lumbriculus variegatus	JC-LV	Endosulfan I	0.0092	ug/kg	0.0092	0.04	TRV unavailable for oligochaete											
Lumbriculus variegatus	CR-LV	Endosulfan I	0.0079	ug/kg	0.0079	0.04												
Lumbriculus variegatus	IG-LV	Endosulfan I	0.007	ug/kg	0.007	0.12												
Lumbriculus variegatus	LC-LV-2	Endosulfan I	0.026	ug/kg	0.026	0.11												
Lumbriculus variegatus	LC-LV-3	Endosulfan I	0.073	ug/kg	0.073	0.12												
Lumbriculus variegatus	JC-LV	Endosulfan II	0.019	ug/kg	0.019	0.04	TRV unavailable for oligochaete											
Lumbriculus variegatus	CR-LV	Endosulfan II	0.027	ug/kg	0.027	0.04												
Lumbriculus variegatus	IG-LV	Endosulfan II	0.023	ug/kg	0.023	0.12												
Lumbriculus variegatus	LC-LV-2	Endosulfan II	0.068	ug/kg	0.068	0.11												
Lumbriculus variegatus	LC-LV-3	Endosulfan II	0.14	ug/kg	0.14	0.14												
Lumbriculus variegatus	JC-LV	Endosulfan sulfate	0.009	ug/kg	0.009	0.2	TRV unavailable for oligochaete											
Lumbriculus variegatus	CR-LV	Endosulfan sulfate	0.0089	ug/kg	0.0089	0.2												
Lumbriculus variegatus	IG-LV	Endosulfan sulfate	0.0054	ug/kg	0.0054	0.12												
Lumbriculus variegatus	LC-LV-2	Endosulfan sulfate	0.048	ug/kg	0.048	0.11												
Lumbriculus variegatus	LC-LV-3	Endosulfan sulfate	0.029	ug/kg	0.029	0.61												

Table 21. Invertebrate Residues (wet weight) Compared to Tissue-based TRVs

(highlight = chemical NOT DETECTED, result set to MDL for comparison to available TRV)

Invertebrate Species	Sample ID	Analyte - Invertebrate	Result	Units	MDL	RL		NO EFFECT TRV							LOW EFFECT TRV					
								MARSH CLAM	BLUE MUSSEL	CLAM, SOFTSHELL	FINGERNAIL CLAM	LUMBRICULUS	OLIGOCHAETE		MARSH CLAM	BLUE MUSSEL	CLAM, SOFTSHELL	FINGERNAIL CLAM	LUMBRICULUS	OLIGOCHAETE
Lumbriculus variegatus	JC-LV	Fluoranthene	4.7	ug/kg	4.7	20		TRV unavailable for oligochaete												
Lumbriculus variegatus	CR-LV	Fluoranthene	4.8	ug/kg	4.8	20														
Lumbriculus variegatus	IG-LV	Fluoranthene	4.5	ug/kg	4.5	19														
Lumbriculus variegatus	UE-LV	Fluoranthene	4.8	ug/kg	4.8	20														
Lumbriculus variegatus	LC-LV-1	Fluoranthene	9.5	ug/kg	9.5	40														
Lumbriculus variegatus	LC-LV-2	Fluoranthene	4.6	ug/kg	4.6	20														
Lumbriculus variegatus	LC-LV-3	Fluoranthene	4.7	ug/kg	4.7	20														
Lumbriculus variegatus	LC-LV-4	Fluoranthene	24	ug/kg	24	100														
Lumbriculus variegatus	JC-LV	Hexachlorobenzene	0.0065	ug/kg	0.00011	0.04		TRV unavailable for oligochaete												
Lumbriculus variegatus	CR-LV	Hexachlorobenzene	0.0058	ug/kg	0.00017	0.04														
Lumbriculus variegatus	IG-LV	Hexachlorobenzene	0.0085	ug/kg	0.00029	0.12														
Lumbriculus variegatus	LC-LV-2	Hexachlorobenzene	0.022	ug/kg	0.00053	0.11														
Lumbriculus variegatus	LC-LV-3	Hexachlorobenzene	0.015	ug/kg	0.0018	0.12														
Lumbriculus variegatus	JC-LV	Lead	0.098	mg/kg	0.06	0.1						300							3000	
Lumbriculus variegatus	CR-LV	Lead	0.06	mg/kg	0.06	0.1						300							3000	
Lumbriculus variegatus	IG-LV	Lead	0.11	mg/kg	0.06	0.1						300							3000	
Lumbriculus variegatus	UE-LV	Lead	0.065	mg/kg	0.06	0.1						300							3000	
Lumbriculus variegatus	LC-LV-2	Lead	0.06	mg/kg	0.06	0.1						300							3000	
Lumbriculus variegatus	LC-LV-3	Lead	0.06	mg/kg	0.06	0.1						300							3000	
Lumbriculus variegatus	JC-LV	Mercury	0.02	mg/kg	0.02	0.04		TRV unavailable for oligochaete												
Lumbriculus variegatus	CR-LV	Mercury	0.02	mg/kg	0.02	0.04														
Lumbriculus variegatus	IG-LV	Mercury	0.02	mg/kg	0.02	0.04														
Lumbriculus variegatus	UE-LV	Mercury	0.02	mg/kg	0.02	0.04														
Lumbriculus variegatus	LC-LV-1	Mercury	0.02	mg/kg	0.02	0.04														
Lumbriculus variegatus	LC-LV-2	Mercury	0.02	mg/kg	0.02	0.04														
Lumbriculus variegatus	LC-LV-3	Mercury	0.02	mg/kg	0.02	0.04														
Lumbriculus variegatus	JC-LV	Phenanthrene	1.7	ug/kg	1.7	20		TRV unavailable for oligochaete												
Lumbriculus variegatus	CR-LV	Phenanthrene	1.7	ug/kg	1.7	20														
Lumbriculus variegatus	IG-LV	Phenanthrene	1.6	ug/kg	1.6	19														
Lumbriculus variegatus	UE-LV	Phenanthrene	1.7	ug/kg	1.7	20														
Lumbriculus variegatus	LC-LV-1	Phenanthrene	3.4	ug/kg	3.4	40														
Lumbriculus variegatus	LC-LV-2	Phenanthrene	1.7	ug/kg	1.7	20														
Lumbriculus variegatus	LC-LV-3	Phenanthrene	1.7	ug/kg	1.7	20														
Lumbriculus variegatus	LC-LV-4	Phenanthrene	8.7	ug/kg	8.7	100														
Lumbriculus variegatus	JC-LV	Pyrene	4.5	ug/kg	4.5	20		TRV unavailable for oligochaete												
Lumbriculus variegatus	CR-LV	Pyrene	4.6	ug/kg	4.6	20														
Lumbriculus variegatus	IG-LV	Pyrene	4.3	ug/kg	4.3	19														
Lumbriculus variegatus	UE-LV	Pyrene	4.6	ug/kg	4.6	20														
Lumbriculus variegatus	LC-LV-1	Pyrene	9.1	ug/kg	9.1	40														

Table 21. Invertebrate Residues (wet weight) Compared to Tissue-based TRVs

(highlight = chemical NOT DETECTED, result set to MDL for comparison to available TRV)

								NO EFFECT TRV						LOW EFFECT TRV					
Invertebrate Species	Sample ID	Analyte - Invertebrate	Result	Units	MDL	RL		MARSH CLAM	BLUE MUSSEL	CLAM, SOFTSHELL	FINGERNAIL CLAM	LUMBRICULUS	OLIGOCHAETE	MARSH CLAM	BLUE MUSSEL	CLAM, SOFTSHELL	FINGERNAIL CLAM	LUMBRICULUS	OLIGOCHAETE
Lumbriculus variegatus	LC-LV-2	Pyrene	4.4	ug/kg	4.4	20													
Lumbriculus variegatus	LC-LV-3	Pyrene	4.5	ug/kg	4.5	20													
Lumbriculus variegatus	LC-LV-4	Pyrene	23	ug/kg	23	100													
Lumbriculus variegatus	JC-LV	Total PCBs	2352	pg/g	335.12	2040.6						350,000,000						3,500,000,000	
Lumbriculus variegatus	CR-LV	Total PCBs	4027	pg/g	79.47	1942.4						350,000,000						3,500,000,000	
Lumbriculus variegatus	IG-LV	Total PCBs	3609	pg/g	70.698	1922.5						350,000,000						3,500,000,000	
Lumbriculus variegatus	LC-LV-3	Total PCBs	1592	pg/g	259.43	3969						350,000,000						3,500,000,000	
Lumbriculus variegatus	LC-LV-2	Total PCBs	2677	pg/g	224.47	3956						350,000,000						3,500,000,000	
Lumbriculus variegatus	LC-LV-4	Total PCBs	3254	pg/g	139.39	3746.8						350,000,000						3,500,000,000	
Lumbriculus variegatus	JC-LV	Total PBDEs	319	pg/g	65.21	7779						24,280,000						242,800,000	
Lumbriculus variegatus	CR-LV	Total PBDEs	0	pg/g	856.14	62920						24,280,000						242,800,000	

Corbicula fluminea =Asian clam (representative bivalve)
Lumbriculus variegatus = blackworm (representative oligochaete)

Bolded values are equal to or exceed No Effect TRV
Boxed values are equal to or exceed Low Effect TRV

MDL: method detection limit
RL: sample reporting limit
TRV: toxicity reference value

ug: microgram
kg: kilogram
mg: milligram
pg: picogram
g: gram

Sample ID
JC - J.C. Boyle Reservoir
CR - Copco 1 Reservoir
IG - Iron Gate Reservoir
UE - Upper Klamath Estuary
LC - Laboratory Control Sample

5.5.2 *Corbicula* (Asian clam)

Tissue-based TRVs are readily available for 12 of the 17 chemicals detected or estimated (using MDLs) in clam tissue. Of these 12 chemicals, only concentrations of fluoranthene (which was not detected but instead is estimated in clams using MDLs) exceed the associated No Effect (but not the Low Effect) TRV.

All MDL-based clam sample results from the three reservoirs as well as the estuary sample and laboratory control samples exceeded the No Effect TRV for fluoranthene but none exceeded the Low Effect TRV. Again, fluoranthene concentrations in clams are not based on actual detections of the chemical but instead are estimated using MDLs. Although it was not detected and adverse effects are unanticipated, fluoranthene is identified as a preliminary COPC for clams and other bivalves represented by Asian clam at this screening level stage of the evaluation.

Bivalve-based TRVs are unavailable for the other five chemicals detected in clam tissue, so no conclusion can be made concerning these five chemicals. For most chemicals, the highest values reported are associated with laboratory control samples (which provide chemical concentration data for clams exposed to native sediments). The following discussion is provided as additional information associated with these five chemicals. No one reservoir appears to be associated with significantly elevated concentrations of these five chemicals in clam tissue compared to the other reservoirs.

- DDD – Three clam samples, concentrations range from 0.58 µg/kg to 0.88 µg/kg. Laboratory controls samples averaged 1.2 µg/kg.

- DDE – Three clam samples, concentrations range from 1.85 µg/kg to 3.39 µg/kg. Laboratory controls samples ranged from 2.79 µg/kg to 3.81 µg/kg.

- Hexachlorobenzene – Three clam samples, concentrations range from 0.019 µg/kg to 0.041 µg/kg. Laboratory controls samples ranged from 0.053 µg/kg to 0.069 µg/kg.

- Lead – Three clam samples, concentrations range from <0.06 mg/kg to 0.27 mg/kg. Lead was not detected in clams but was estimated using MDLs for Iron Gate reservoir and for the Upper Estuary samples. Laboratory controls samples ranged from 0.07 mg/kg to 0.41 mg/kg.

- Total PBDEs – Three clam samples, concentrations range from 1040 pg/g to 3100 pg/g. Laboratory controls samples ranged from 2260 pg/g to 4280 pg/g.

5.6 Invertebrate Bioaccumulation

Bioaccumulation in invertebrates is evaluated in part by calculating Biota-Sediment Accumulation Factors (BSAFs) based on chemical concentrations in field collected sediments and in laboratory reared invertebrate tissues exposed to field collected sediments. BSAFs are calculated for laboratory reared invertebrates exposed to reservoir and Upper Estuary sediment samples, as well as for the laboratory controls. Chemical concentrations are available for both sediment and invertebrate tissues, therefore site-specific BSAFs can be calculated. Calculated BSAFs are used to confirm chemical exposure and to evaluate differences among the reservoirs. BSAFs calculated for invertebrates can be used to describe sediment/invertebrate relationships because laboratory-reared invertebrates were exposed for 28 days to field collected sediment, clean water, and were not fed. Therefore, chemical concentrations in clams and worms reflect exposures to sediment and not to food items or location-specific surface water.

BSAFs are, for this screening level assessment, calculated using two approaches. The first, described below, does not consider the total organic carbon (TOC) content of sediment or the lipid content of invertebrates. Resulting BSAFs using this approach are not normalized for TOC or lipid.

Non-normalized BSAF = Tissue EPC / Sediment EPC

Where

EPC = exposure point concentration

Tissue EPC = reservoir-specific average chemical concentration in soft tissue invertebrate, mg/kg wet weight

Sediment EPC = reservoir-specific average chemical concentration in sediment, mg/kg dry weight

The second method of BSAF derivation is based on TOC normalization of chemical concentrations in sediment and on lipid normalization of chemical concentrations in invertebrates. This approach recognizes that some organic chemicals have an affinity for TOC in sediment and for lipids in biota. For example, biota with high lipid content commonly accumulate higher levels of certain organic chemicals compared to accumulation in leaner or less fatty organisms. Normalized BSAFs are therefore used to evaluate chemical uptake and accumulation without the influence of variable TOC concentrations in sediment or variable lipid concentrations in biological tissues. TOC- and lipid-normalized BSAFs are calculated as follows:

Normalized BSAF = (Tissue EPC/fraction lipid) / (Sediment EPC/fraction TOC)

Where

EPC = exposure point concentration

Tissue EPC = reservoir-specific average chemical concentration in soft tissue invertebrate, mg/kg wet weight

Fraction lipid = percent lipid in whole body organism/100

Sediment EPC = reservoir-specific average chemical concentration in sediment, mg/kg dry weight

Fraction TOC = percent TOC in sediment/100

BSAFs are assumed to be at equilibrium (i.e., steady state) for some chemicals to which laboratory-reared invertebrates are exposed. For other chemicals where uptake and accumulation is expected to be slower, calculated BSAFs are adjusted upwards to estimate steady state conditions reflective of long term exposures. This approach is used to account for the relatively short time period (approximately one month) to which laboratory invertebrates are exposed to reservoir sediments. BSAFs are calculated for all chemicals detected or estimated in invertebrate tissues, regardless of whether or not tissue-based TRVs are available.

Calculated normalized and non-normalized BSAFs for representative invertebrates (blackworm and Asian clam), by group (worm or bivalve), by chemical, and by location, based on the aforementioned equation, are shown in **Table 22**. Also included in this table are mean concentrations of total PCBs and total PBDEs (non-detect values are set to zero for these two classes of chemicals) in sediments used in the calculation of the mean location-specific BSAFs. Two types of BSAFs are considered for laboratory sourced invertebrates exposed in the lab to field collected sediments. These are initial BSAFs based on the 28 day exposure duration and, where appropriate depending on chemical, estimated steady state BSAFs. The latter are based on recommended adjustment factors of 1 (i.e., no adjustment to the initial BSAFs) and 2, where initial BSAFs are doubled to approximate BSAFs under a longer term or steady state exposure. BSAFs are not calculated for worms and clams exposed to laboratory control sediments because sediment chemistry data are lacking for the lab controls. However, it is noted that chemical concentrations in worms and clams exposed to native laboratory sediments are generally similar to and, in some cases, higher than concentrations observed in worms and clams exposed to reservoir sediments.

5.6.1 Clam BSAFs

BSAFs are more or less similar across all three reservoirs, other than arsenic, total PBDEs, and total PCBs. BSAFs for laboratory control animal's native sediments could not be calculated because those sediments were not analyzed for chemical constituents.

Concentrations of some chemicals detected or estimated in clam tissue (e.g., arsenic and lead) from J.C. Boyle reservoir exceed concentrations observed in clams from other locations, resulting in slightly higher BSAFs for this reservoir for these chemicals (**Table 22**). The largest difference is observed for arsenic in clams from J.C. Boyle; therefore, the mean BSAF for arsenic is substantially higher for this reservoir.

Mean BSAFs for total PBDEs vary by location, with the highest BSAFs derived for Iron Gate reservoir (**Table 22**). These results are due to higher PBDE concentrations in clams from this location. In contrast, lower PBDE concentrations in J.C. Boyle reservoir clams appear to account for the lower mean non-normalized BSAF for PBDEs. Substantial differences in mean BSAFs for each of the three reservoirs are noted following normalization for TOC and lipid, with the highest normalized BSAF calculated for Iron Gate and the lowest normalized BSAF calculated for the Upper Klamath Estuary.

Mean BSAFs for total PCBs also vary by location, but less so than mean BSAFs for total PBDEs. The low total PCB concentration in Upper Estuary sediments results in the highest BSAF for total PCBs (**Table 22**).

Table 22. Invertebrate BSAFs, by Reservoir

(highlight = chemical NOT DETECTED, result set to MDL for BSAF calculation)

Invertebrate Species	Sample ID	Analyte - invertebrate Tissue	Invertebrate Tissue Concentration (mg/kg ww)	Mean Invertebrate Tissue Concentration by Reservoir (mg/kg ww)		Mean Sediment Concentration by Reservoir (mg/kg dw)	Reservoir Specific Mean BSAF (non-normalized, ~30d exposure)	Multiplier for Estimating Steady State non-normalized BSAF	Estimated Steady State non-normalized BSAF	Mean Fraction TOC	Mean Fraction Lipid	Reservoir Specific Mean normalized BSAF (steady state)
Corbicula fluminea	JC-CF	Acenaphthene	0.021	0.021	JC BOYLE	3.42	0.006	1	0.006	0.0648	0.0029	0.14
Corbicula fluminea	CR-CF	Acenaphthene	0.021	0.021	COPCO 1	2.57	0.0082	1	0.0082	0.0501	0.0054	0.076
Corbicula fluminea	IG-CF	Acenaphthene	0.021	0.021	IRON GATE	2.31	0.0091	1	0.0091	0.0410	0.0053	0.070
Corbicula fluminea	UE-CF	Acenaphthene	0.022	0.022	UPPER ESTUARY	2.07	0.011	1	0.011	0.0027	0.0063	0.0046
Corbicula fluminea	LC-CF-1	Acenaphthene	0.022	0.023	LAB CONTROL	No Data	Not Calculated	NA	Not Calculated			
Corbicula fluminea	LC-CF-2	Acenaphthene	0.024									
Corbicula fluminea	JC-CF	Arsenic	2.5	2.5	JC BOYLE	47.0	0.05	1	0.05	0.0648	0.0029	1.2
Corbicula fluminea	IG-CF	Arsenic	0.40	No Data	COPCO 1	32.9	No Data	1	No Data			
Corbicula fluminea	UE-CF	Arsenic	0.55	0.40	IRON GATE	35.1	0.011	1	0.011	0.0410	0.0053	0.088
Corbicula fluminea	LC-CF-1	Arsenic	1.4	0.55	UPPER ESTUARY	19.8	0.028	1	0.028	0.0027	0.0063	0.012
Corbicula fluminea	LC-CF-2	Arsenic	1.7	1.55	LAB CONTROL	No Data	Not Calculated	NA	Not Calculated			
Corbicula fluminea	JC-CF	Benzo(a)pyrene	0.040	0.040	JC BOYLE	3.42	0.012	1	0.012	0.0648	0.0029	0.26
Corbicula fluminea	CR-CF	Benzo(a)pyrene	0.040	0.040	COPCO 1	2.57	0.016	1	0.016	0.0501	0.0054	0.14
Corbicula fluminea	IG-CF	Benzo(a)pyrene	0.041	0.041	IRON GATE	2.31	0.018	1	0.018	0.0410	0.0053	0.14
Corbicula fluminea	UE-CF	Benzo(a)pyrene	0.042	0.042	UPPER ESTUARY	2.07	0.020	1	0.020	0.0027	0.0063	0.0087
Corbicula fluminea	LC-CF-1	Benzo(a)pyrene	0.043	0.045	LAB CONTROL	No Data	Not Calculated	NA	Not Calculated			
Corbicula fluminea	LC-CF-2	Benzo(a)pyrene	0.047									
Corbicula fluminea	JC-CF	DDD	0.00058	0.00058	JC BOYLE	0.0666	0.0087	2	0.017	0.0648	0.0029	0.39
Corbicula fluminea	IG-CF	DDD	0.0006	No Data	COPCO 1	0.0618	No Data	2	No Data			
Corbicula fluminea	UE-CF	DDD	0.00088	0.00060	IRON GATE	0.137	0.0044	2	0.0087	0.0410	0.0053	0.068
Corbicula fluminea	LC-CF-1	DDD	0.0012	0.00088	UPPER ESTUARY	0.0498	0.018	2	0.035	0.0027	0.0063	0.015
Corbicula fluminea	LC-CF-2	DDD	0.00117	0.0012	LAB CONTROL	No Data	Not Calculated	NA	Not Calculated			
Corbicula fluminea	JC-CF	DDE	0.001854	0.0019	JC BOYLE	0.0665	0.028	2	0.056	0.0648	0.0029	1.2
Corbicula fluminea	IG-CF	DDE	0.001967	No Data	COPCO 1	0.0618	No Data	2	No Data			
Corbicula fluminea	UE-CF	DDE	0.003386	0.0020	IRON GATE	0.137	0.014	2	0.029	0.0410	0.0053	0.22
Corbicula fluminea	LC-CF-1	DDE	0.00381	0.0034	UPPER ESTUARY	0.0498	0.068	2	0.14	0.0027	0.0063	0.058
Corbicula fluminea	LC-CF-2	DDE	0.00279	0.0033	LAB CONTROL	No Data	Not Calculated	NA	Not Calculated			
Corbicula fluminea	JC-CF	DDT	0.000093	0.0001	JC BOYLE	0.539	0.00017	2	0.0003	0.0648	0.0029	0.0077
Corbicula fluminea	IG-CF	DDT	0.000098	No Data	COPCO 1	0.524	No Data	2	No Data			
Corbicula fluminea	UE-CF	DDT	0.000238	0.0001	IRON GATE	0.479	0.00020	2	0.0004	0.0410	0.0053	0.0032
Corbicula fluminea	LC-CF-1	DDT	0.000247	0.0002	UPPER ESTUARY	0.1344	0.0018	2	0.0035	0.0027	0.0063	0.0015
Corbicula fluminea	LC-CF-2	DDT	0.000129	0.000188	LAB CONTROL	No Data	Not Calculated	NA	Not Calculated			
Corbicula fluminea	JC-CF	Endosulfan I	0.000012	0.000012	JC BOYLE	0.0139	0.00087	1	0.00087	0.0648	0.0029	0.019

Table 22. Invertebrate BSAFs, by Reservoir

(highlight = chemical NOT DETECTED, result set to MDL for BSAF calculation)

Invertebrate Species	Sample ID	Analyte - invertebrate Tissue	Invertebrate Tissue Concentration (mg/kg ww)	Mean Invertebrate Tissue Concentration by Reservoir (mg/kg ww)		Mean Sediment Concentration by Reservoir (mg/kg dw)	Reservoir Specific Mean BSAF (non-normalized, ~30d exposure)	Multiplier for Estimating Steady State non-normalized BSAF	Estimated Steady State non-normalized BSAF	Mean Fraction TOC	Mean Fraction Lipid	Reservoir Specific Mean normalized BSAF (steady state)
Corbicula fluminea	IG-CF	Endosulfan I	0.000022	No Data	COPCO 1	0.0104	No Data	1	No Data			
Corbicula fluminea	UE-CF	Endosulfan I	0.000015	0.000022	IRON GATE	0.0093	0.0024	1	0.0024	0.0410	0.0053	0.018
Corbicula fluminea	LC-CF-1	Endosulfan I	0.000015	0.000015	UPPER ESTUARY	0.00837	0.0018	1	0.0018	0.0027	0.0063	0.00077
Corbicula fluminea	LC-CF-2	Endosulfan I	0.000027	0.000021	LAB CONTROL	No Data	Not Calculated	NA	Not Calculated			
Corbicula fluminea	JC-CF	Endosulfan II	0.000029	0.000029	JC BOYLE	0.0139	0.0021	1	0.0021	0.0648	0.0029	0.047
Corbicula fluminea	IG-CF	Endosulfan II	0.000031	No Data	COPCO 1	0.0104	No Data	1	No Data			
Corbicula fluminea	UE-CF	Endosulfan II	0.000035	0.000031	IRON GATE	0.0093	0.0033	1	0.0033	0.0410	0.0053	0.026
Corbicula fluminea	LC-CF-1	Endosulfan II	0.000044	0.000035	UPPER ESTUARY	0.00837	0.0042	1	0.0042	0.0027	0.0063	0.0018
Corbicula fluminea	LC-CF-2	Endosulfan II	0.000081	0.0000625	LAB CONTROL	No Data	Not Calculated	NA	Not Calculated			
Corbicula fluminea	JC-CF	Endosulfan sulfate	0.000003	0.000003	JC BOYLE	0.0139	0.00022	1	0.00022	0.0648	0.0029	0.0048
Corbicula fluminea	IG-CF	Endosulfan sulfate	0.000011	No Data	COPCO 1	0.0104	No Data	1	No Data			
Corbicula fluminea	UE-CF	Endosulfan sulfate	0.0000092	0.000011	IRON GATE	0.0093	0.0012	1	0.0012	0.0410	0.0053	0.0091
Corbicula fluminea	LC-CF-1	Endosulfan sulfate	0.000013	0.000009	UPPER ESTUARY	0.00837	0.0011	1	0.0011	0.0027	0.0063	0.00047
Corbicula fluminea	LC-CF-2	Endosulfan sulfate	0.000027	0.00002	LAB CONTROL	No Data	Not Calculated	NA	Not Calculated			
Corbicula fluminea	JC-CF	Fluoranthene	0.043	0.043	JC BOYLE	3.42	0.013	1	0.013	0.0648	0.0029	0.28
Corbicula fluminea	CR-CF	Fluoranthene	0.043	0.043	COPCO 1	2.57	0.017	1	0.017	0.0501	0.0054	0.16
Corbicula fluminea	IG-CF	Fluoranthene	0.043	0.043	IRON GATE	2.31	0.019	1	0.019	0.0410	0.0053	0.14
Corbicula fluminea	UE-CF	Fluoranthene	0.045	0.045	UPPER ESTUARY	2.07	0.022	1	0.022	0.0027	0.0063	0.0093
Corbicula fluminea	LC-CF-1	Fluoranthene	0.046	0.048	LAB CONTROL	No Data	Not Calculated	NA	Not Calculated			
Corbicula fluminea	LC-CF-2	Fluoranthene	0.050									
Corbicula fluminea	JC-CF	Hexachlorobenzene	0.00002	0.000020	JC BOYLE	3.42	0.0000059	1	0.0000059	0.0648	0.0029	0.00013
Corbicula fluminea	IG-CF	Hexachlorobenzene	0.000019	No Data	COPCO 1	2.57	No Data	1	No Data			
Corbicula fluminea	UE-CF	Hexachlorobenzene	0.000041	0.000019	IRON GATE	2.31	0.0000082	1	0.0000082	0.0410	0.0053	0.000064
Corbicula fluminea	LC-CF-1	Hexachlorobenzene	0.000053	0.000041	UPPER ESTUARY	2.07	0.000020	1	0.000020	0.0027	0.0063	0.0000085
Corbicula fluminea	LC-CF-2	Hexachlorobenzene	0.000069	0.000061	LAB CONTROL	No Data	Not Calculated	NA	Not Calculated			
Corbicula fluminea	JC-CF	Lead	0.27	0.27	JC BOYLE	42.7	0.01	1	0.01	0.0648	0.0029	0.14
Corbicula fluminea	IG-CF	Lead	0.06	No Data	COPCO 1	33.6	No Data	1	No Data			
Corbicula fluminea	UE-CF	Lead	0.06	0.060	IRON GATE	35.2	0.0017	1	0.0017	0.0410	0.0053	0.013
Corbicula fluminea	LC-CF-1	Lead	0.065	0.060	UPPER ESTUARY	27.0	0.0022	1	0.0022	0.0027	0.0063	0.0010
Corbicula fluminea	LC-CF-2	Lead	0.41	0.24	LAB CONTROL	No Data	Not Calculated	NA	Not Calculated			
Corbicula fluminea	JC-CF	Mercury	0.10	0.10	JC BOYLE	0.883	0.1	2	0.2	0.0648	0.0029	5.1
Corbicula fluminea	IG-CF	Mercury	0.040	No Data	COPCO 1	0.642	No Data	2	No Data			
Corbicula fluminea	UE-CF	Mercury	0.020	0.040	IRON GATE	0.601	0.067	2	0.13	0.0410	0.0053	1.0
Corbicula fluminea	LC-CF-1	Mercury	0.090	0.020	UPPER ESTUARY	0.486	0.041	2	0.082	0.0027	0.0063	0.035
Corbicula fluminea	LC-CF-2	Mercury	0.099	0.09	LAB CONTROL	No Data	Not Calculated	NA	Not Calculated			
Corbicula fluminea	JC-CF	Phenanthrene	0.015	0.015	JC BOYLE	3.42	0.004	1	0.004	0.0648	0.0029	0.10

Table 22. Invertebrate BSAFs, by Reservoir

(highlight = chemical NOT DETECTED, result set to MDL for BSAF calculation)

Invertebrate Species	Sample ID	Analyte - invertebrate Tissue	Invertebrate Tissue Concentration (mg/kg ww)	Mean Invertebrate Tissue Concentration by Reservoir (mg/kg ww)		Mean Sediment Concentration by Reservoir (mg/kg dw)	Reservoir Specific Mean BSAF (non-normalized, ~30d exposure)	Multiplier for Estimating Steady State non-normalized BSAF	Estimated Steady State non-normalized BSAF	Mean Fraction TOC	Mean Fraction Lipid	Reservoir Specific Mean normalized BSAF (steady state)
Corbicula fluminea	CR-CF	Phenanthrene	0.016	0.016	COPCO 1	2.57	0.0062	1	0.0062	0.0501	0.0054	0.058
Corbicula fluminea	IG-CF	Phenanthrene	0.016	0.016	IRON GATE	2.31	0.0069	1	0.0069	0.0410	0.0053	0.054
Corbicula fluminea	UE-CF	Phenanthrene	0.016	0.016	UPPER ESTUARY	2.07	0.0077	1	0.0077	0.0027	0.0063	0.0033
Corbicula fluminea	LC-CF-1	Phenanthrene	0.016	0.017	LAB CONTROL	No Data	Not Calculated	NA	Not Calculated			
Corbicula fluminea	LC-CF-2	Phenanthrene	0.018									
Corbicula fluminea	JC-CF	Pyrene	0.041	0.041	JC BOYLE	3.42	0.012	1	0.012	0.0648	0.0029	0.27
Corbicula fluminea	CR-CF	Pyrene	0.041	0.041	COPCO 1	2.57	0.016	1	0.016	0.0501	0.0054	0.15
Corbicula fluminea	IG-CF	Pyrene	0.042	0.042	IRON GATE	2.31	0.018	1	0.018	0.0410	0.0053	0.14
Corbicula fluminea	UE-CF	Pyrene	0.043	0.043	UPPER ESTUARY	2.07	0.021	1	0.021	0.0027	0.0063	0.0089
Corbicula fluminea	LC-CF-1	Pyrene	0.044	0.046	LAB CONTROL	No Data	Not Calculated	NA	Not Calculated			
Corbicula fluminea	LC-CF-2	Pyrene	0.048									
Corbicula fluminea	JC-CF	Total PBDEs	0.0010	0.0010	JC BOYLE	0.00046	2.3	1	2.3	0.0648	0.0029	50.3
Corbicula fluminea	IG-CF	Total PBDEs	0.0022	No Data	COPCO 1	0.000044	No Data	1	No Data			
Corbicula fluminea	UE-CF	Total PBDEs	0.0031	0.0022	IRON GATE	0.000050	44.6	1	44.6	0.0410	0.0053	345
Corbicula fluminea	LC-CF-2	Total PBDEs	0.0023	0.0031	UPPER ESTUARY	0.00042	7.4	1	7.4	0.0027	0.0063	3.2
Corbicula fluminea	LC-CF-1	Total PBDEs	0.0043	0.0033	LAB CONTROL	No Data	Not Calculated	NA	Not Calculated			
Corbicula fluminea	JC-CF	Total PCBs	0.018	0.018	JC BOYLE	0.0047	3.8	2	7.6	0.0648	0.0029	169
Corbicula fluminea	CR-CF	Total PCBs	0.025	0.024871	COPCO 1	0.0038	6.5	2	13.1	0.0501	0.0054	121
Corbicula fluminea	IG-CF	Total PCBs	0.020	0.019538	IRON GATE	0.0068	2.9	2	5.7	0.0410	0.0053	44.4
Corbicula fluminea	UE-CF	Total PCBs	0.023	0.02312	UPPER ESTUARY	0.0013	17.2	2	34.4	0.0027	0.0063	14.7
Corbicula fluminea	LC-CF-2	Total PCBs	0.016	0.0200815	LAB CONTROL	No Data	Not Calculated	NA	Not Calculated			
Corbicula fluminea	LC-CF-1	Total PCBs	0.024									
Lumbriculus variegatus	JC-LV	Acenaphthene	0.0023	0.0023	JC BOYLE	3.42	0.00067	1	0.00067	0.0648	0.0035	0.012
Lumbriculus variegatus	CR-LV	Acenaphthene	0.0023	0.0023	COPCO 1	2.57	0.00089	1	0.00089	0.0501	0.004	0.011
Lumbriculus variegatus	IG-LV	Acenaphthene	0.0022	0.0022	IRON GATE	2.31	0.00095	1	0.00095	0.0410	0.004	0.010
Lumbriculus variegatus	UE-LV	Acenaphthene	0.0023	0.0023	UPPER ESTUARY	2.07	0.0011	1	0.0011	0.0027	0.007	0.00043
Lumbriculus variegatus	LC-LV-1	Acenaphthene	0.0046	0.0053	LAB CONTROL	No Data	Not Calculated	NA	Not Calculated			
Lumbriculus variegatus	LC-LV-2	Acenaphthene	0.0023									
Lumbriculus variegatus	LC-LV-3	Acenaphthene	0.0023									
Lumbriculus variegatus	LC-LV-4	Acenaphthene	0.012									
Lumbriculus variegatus	JC-LV	Arsenic	1.2	1.2	JC BOYLE	47.0	0.026	1	0.026	0.0648	0.0035	0.47
Lumbriculus variegatus	CR-LV	Arsenic	0.15	0.15	COPCO 1	32.9	0.0046	1	0.0046	0.0501	0.004	0.057
Lumbriculus variegatus	IG-LV	Arsenic	0.58	0.58	IRON GATE	35.1	0.017	1	0.017	0.0410	0.004	0.17
Lumbriculus variegatus	UE-LV	Arsenic	0.15	0.15	UPPER ESTUARY	19.8	0.0076	1	0.0076	0.0027	0.007	0.0029
Lumbriculus variegatus	LC-LV-2	Arsenic	0.15	0.15	LAB CONTROL	No Data	Not Calculated	NA	Not Calculated			
Lumbriculus variegatus	LC-LV-3	Arsenic	0.15									

Table 22. Invertebrate BSAFs, by Reservoir

(highlight = chemical NOT DETECTED, result set to MDL for BSAF calculation)

Invertebrate Species	Sample ID	Analyte - invertebrate Tissue	Invertebrate Tissue Concentration (mg/kg ww)	Mean Invertebrate Tissue Concentration by Reservoir (mg/kg ww)		Mean Sediment Concentration by Reservoir (mg/kg dw)	Reservoir Specific Mean BSAF (non-normalized, ~30d exposure)	Multiplier for Estimating Steady State non-normalized BSAF	Estimated Steady State non-normalized BSAF	Mean Fraction TOC	Mean Fraction Lipid	Reservoir Specific Mean normalized BSAF (steady state)
Lumbriculus variegatus	JC-LV	Benzo(a)pyrene	0.0044	0.0044	JC BOYLE	3.42	0.0013	1	0.0013	0.0648	0.0035	0.024
Lumbriculus variegatus	CR-LV	Benzo(a)pyrene	0.0045	0.0045	COPCO 1	2.57	0.0018	1	0.0018	0.0501	0.004	0.022
Lumbriculus variegatus	IG-LV	Benzo(a)pyrene	0.0042	0.0042	IRON GATE	2.31	0.0018	1	0.0018	0.0410	0.004	0.019
Lumbriculus variegatus	UE-LV	Benzo(a)pyrene	0.0045	0.0045	UPPER ESTUARY	2.07	0.0022	1	0.0022	0.0027	0.007	0.00084
Lumbriculus variegatus	LC-LV-1	Benzo(a)pyrene	0.0089	0.01015	LAB CONTROL	No Data	Not Calculated	NA	Not Calculated			
Lumbriculus variegatus	LC-LV-2	Benzo(a)pyrene	0.0043									
Lumbriculus variegatus	LC-LV-3	Benzo(a)pyrene	0.0044									
Lumbriculus variegatus	LC-LV-4	Benzo(a)pyrene	0.023									
Lumbriculus variegatus	JC-LV	DDD	0.00008	0.000080	JC BOYLE	0.0666	0.0012	1	0.0012	0.0648	0.0035	0.022
Lumbriculus variegatus	CR-LV	DDD	0.000315	0.00032	COPCO 1	0.0618	0.0051	1	0.0051	0.0501	0.004	0.064
Lumbriculus variegatus	IG-LV	DDD	0.000215	0.00022	IRON GATE	0.137	0.0016	1	0.0016	0.0410	0.004	0.016
Lumbriculus variegatus	LC-LV-2	DDD	0.000089	No Data	UPPER ESTUARY	0.0498	No Data	1	No Data			
Lumbriculus variegatus	LC-LV-3	DDD	0.000132	0.00011	LAB CONTROL	No Data	Not Calculated	NA	Not Calculated			
Lumbriculus variegatus	JC-LV	DDE	0.000634	0.000634	JC BOYLE	0.0665	0.0095	1	0.0095	0.0648	0.0035	0.18
Lumbriculus variegatus	CR-LV	DDE	0.001127	0.00113	COPCO 1	0.0618	0.018	1	0.018	0.0501	0.004	0.23
Lumbriculus variegatus	IG-LV	DDE	0.000666	0.00067	IRON GATE	0.137	0.0049	1	0.0049	0.0410	0.004	0.050
Lumbriculus variegatus	LC-LV-2	DDE	0.000629	No Data	UPPER ESTUARY	0.0498	No Data	1	No Data			
Lumbriculus variegatus	LC-LV-3	DDE	0.000379	0.00050	LAB CONTROL	No Data	Not Calculated	NA	Not Calculated			
Lumbriculus variegatus	JC-LV	DDT	0.000058	0.000058	JC BOYLE	0.539	0.00011	1	0.00011	0.0648	0.0035	0.0020
Lumbriculus variegatus	CR-LV	DDT	0.000034	0.00003	COPCO 1	0.524	0.000065	1	0.000065	0.0501	0.004	0.00081
Lumbriculus variegatus	IG-LV	DDT	0.0000081	0.00001	IRON GATE	0.479	0.000017	1	0.000017	0.0410	0.004	0.00017
Lumbriculus variegatus	LC-LV-2	DDT	0.000048	No Data	UPPER ESTUARY	0.134	No Data	1	No Data			
Lumbriculus variegatus	LC-LV-3	DDT	0.00045	0.00025	LAB CONTROL	No Data	Not Calculated	NA	Not Calculated			
Lumbriculus variegatus	JC-LV	Endosulfan I	0.0000092	0.000009	JC BOYLE	0.0139	0.00066	1	0.00066	0.0648	0.0035	0.012
Lumbriculus variegatus	CR-LV	Endosulfan I	0.0000079	0.00001	COPCO 1	0.0104	0.00076	1	0.00076	0.0501	0.004	0.0095
Lumbriculus variegatus	IG-LV	Endosulfan I	0.000007	0.00001	IRON GATE	0.0093	0.00075	1	0.00075	0.0410	0.004	0.0077
Lumbriculus variegatus	LC-LV-2	Endosulfan I	0.000026	No Data	UPPER ESTUARY	0.00837	No Data	1	No Data			
Lumbriculus variegatus	LC-LV-3	Endosulfan I	0.000073	0.00005	LAB CONTROL	No Data	Not Calculated	NA	Not Calculated			
Lumbriculus variegatus	JC-LV	Endosulfan II	0.000019	0.000019	JC BOYLE	0.0139	0.0014	1	0.0014	0.0648	0.0035	0.025
Lumbriculus variegatus	CR-LV	Endosulfan II	0.000027	0.00003	COPCO 1	0.0104	0.0026	1	0.0026	0.0501	0.004	0.032
Lumbriculus variegatus	IG-LV	Endosulfan II	0.000023	0.00002	IRON GATE	0.0093	0.0025	1	0.0025	0.0410	0.004	0.025
Lumbriculus variegatus	LC-LV-2	Endosulfan II	0.000068	No Data	UPPER ESTUARY	0.00837	No Data	1	No Data			
Lumbriculus variegatus	LC-LV-3	Endosulfan II	0.00014	0.00010	LAB CONTROL	No Data	Not Calculated	NA	Not Calculated			
Lumbriculus variegatus	JC-LV	Endosulfan sulfate	0.000009	0.000009	JC BOYLE	0.0139	0.00065	1	0.00065	0.0648	0.0035	0.012
Lumbriculus variegatus	CR-LV	Endosulfan sulfate	0.0000089	0.00001	COPCO 1	0.0104	0.00085	1	0.00085	0.0501	0.004	0.011
Lumbriculus variegatus	IG-LV	Endosulfan sulfate	0.0000054	0.00001	IRON GATE	0.0093	0.00058	1	0.00058	0.0410	0.004	0.0059

Table 22. Invertebrate BSAFs, by Reservoir

(highlight = chemical NOT DETECTED, result set to MDL for BSAF calculation)

Invertebrate Species	Sample ID	Analyte - invertebrate Tissue	Invertebrate Tissue Concentration (mg/kg ww)	Mean Invertebrate Tissue Concentration by Reservoir (mg/kg ww)		Mean Sediment Concentration by Reservoir (mg/kg dw)	Reservoir Specific Mean BSAF (non-normalized, ~30d exposure)	Multiplier for Estimating Steady State non-normalized BSAF	Estimated Steady State non-normalized BSAF	Mean Fraction TOC	Mean Fraction Lipid	Reservoir Specific Mean normalized BSAF (steady state)
Lumbriculus variegatus	LC-LV-2	Endosulfan sulfate	0.000048	No Data	UPPER ESTUARY	0.00837	No Data	1	No Data			
Lumbriculus variegatus	LC-LV-3	Endosulfan sulfate	0.000029	0.00004	LAB CONTROL	No Data	Not Calculated	NA	Not Calculated			
Lumbriculus variegatus	JC-LV	Fluoranthene	0.0047	0.0047	JC BOYLE	3.42	0.0014	1	0.0014	0.0648	0.0035	0.025
Lumbriculus variegatus	CR-LV	Fluoranthene	0.0048	0.0048	COPCO 1	2.57	0.0019	1	0.0019	0.0501	0.004	0.023
Lumbriculus variegatus	IG-LV	Fluoranthene	0.0045	0.0045	IRON GATE	2.31	0.0019	1	0.0019	0.0410	0.004	0.020
Lumbriculus variegatus	UE-LV	Fluoranthene	0.0048	0.0048	UPPER ESTUARY	2.07	0.0023	1	0.0023	0.0027	0.007	0.00089
Lumbriculus variegatus	LC-LV-1	Fluoranthene	0.0095	0.0107	LAB CONTROL	No Data	Not Calculated	NA	Not Calculated			
Lumbriculus variegatus	LC-LV-2	Fluoranthene	0.0046									
Lumbriculus variegatus	LC-LV-3	Fluoranthene	0.0047									
Lumbriculus variegatus	LC-LV-4	Fluoranthene	0.024									
Lumbriculus variegatus	JC-LV	Hexachlorobenzene	0.0000065	0.0000065	JC BOYLE	3.42	0.0000019	1	0.0000019	0.0648	0.0035	0.000035
Lumbriculus variegatus	CR-LV	Hexachlorobenzene	0.0000058	0.0000058	COPCO 1	2.57	0.0000023	1	0.0000023	0.0501	0.004	0.000028
Lumbriculus variegatus	IG-LV	Hexachlorobenzene	0.0000085	0.0000085	IRON GATE	2.31	0.0000037	1	0.0000037	0.0410	0.004	0.000038
Lumbriculus variegatus	LC-LV-2	Hexachlorobenzene	0.000022	No Data	UPPER ESTUARY	2.07	No Data	1	No Data			
Lumbriculus variegatus	LC-LV-3	Hexachlorobenzene	0.000015	0.000019	LAB CONTROL	No Data	Not Calculated	NA	Not Calculated			
Lumbriculus variegatus	JC-LV	Lead	0.098	0.098	JC BOYLE	42.7	0.0023	1	0.0023	0.0648	0.0035	0.042
Lumbriculus variegatus	CR-LV	Lead	0.06	0.060	COPCO 1	33.6	0.0018	1	0.0018	0.0501	0.004	0.022
Lumbriculus variegatus	IG-LV	Lead	0.11	0.11	IRON GATE	35.2	0.0031	1	0.0031	0.0410	0.004	0.032
Lumbriculus variegatus	UE-LV	Lead	0.065	0.065	UPPER ESTUARY	27.0	0.0024	1	0.0024	0.0027	0.007	0.0009
Lumbriculus variegatus	LC-LV-2	Lead	0.06	0.060	LAB CONTROL	No Data	Not Calculated	NA	Not Calculated			
Lumbriculus variegatus	LC-LV-3	Lead	0.06									
Lumbriculus variegatus	JC-LV	Mercury	0.02	0.020	JC BOYLE	0.883	0.023	2	0.045	0.0648	0.0035	0.84
Lumbriculus variegatus	CR-LV	Mercury	0.02	0.020	COPCO 1	0.642	0.031	2	0.062	0.0501	0.004	0.78
Lumbriculus variegatus	IG-LV	Mercury	0.02	0.020	IRON GATE	0.601	0.033	2	0.067	0.0410	0.004	0.68
Lumbriculus variegatus	UE-LV	Mercury	0.02	0.020	UPPER ESTUARY	0.486	0.041	2	0.082	0.0027	0.007	0.032
Lumbriculus variegatus	LC-LV-1	Mercury	0.02	0.020	LAB CONTROL	No Data	Not Calculated	NA	Not Calculated			
Lumbriculus variegatus	LC-LV-2	Mercury	0.02									
Lumbriculus variegatus	LC-LV-3	Mercury	0.02									
Lumbriculus variegatus	JC-LV	Phenanthrene	0.0017	0.0017	JC BOYLE	3.42	0.00050	1	0.00050	0.0648	0.0035	0.0092
Lumbriculus variegatus	CR-LV	Phenanthrene	0.0017	0.0017	COPCO 1	2.57	0.00066	1	0.00066	0.0501	0.004	0.0083
Lumbriculus variegatus	IG-LV	Phenanthrene	0.0016	0.0016	IRON GATE	2.31	0.00069	1	0.00069	0.0410	0.004	0.0071
Lumbriculus variegatus	UE-LV	Phenanthrene	0.0017	0.0017	UPPER ESTUARY	2.07	0.00082	1	0.00082	0.0027	0.007	0.00032
Lumbriculus variegatus	LC-LV-1	Phenanthrene	0.0034	0.003875	LAB CONTROL	No Data	Not Calculated	NA	Not Calculated			
Lumbriculus variegatus	LC-LV-2	Phenanthrene	0.0017									
Lumbriculus variegatus	LC-LV-3	Phenanthrene	0.0017									
Lumbriculus variegatus	LC-LV-4	Phenanthrene	0.0087									
Lumbriculus variegatus	JC-LV	Pyrene	0.0045	0.0045	JC BOYLE	3.42	0.0013	1	0.0013	0.0648	0.0035	0.024

Table 22. Invertebrate BSAFs, by Reservoir

(highlight = chemical NOT DETECTED, result set to MDL for BSAF calculation)

Invertebrate Species	Sample ID	Analyte - invertebrate Tissue	Invertebrate Tissue Concentration (mg/kg ww)	Mean Invertebrate Tissue Concentration by Reservoir (mg/kg ww)		Mean Sediment Concentration by Reservoir (mg/kg dw)	Reservoir Specific Mean BSAF (non-normalized, ~30d exposure)	Multiplier for Estimating Steady State non-normalized BSAF	Estimated Steady State non-normalized BSAF	Mean Fraction TOC	Mean Fraction Lipid	Reservoir Specific Mean normalized BSAF (steady state)
Lumbriculus variegatus	CR-LV	Pyrene	0.0046	0.0046	COPCO 1	2.57	0.0018	1	0.0018	0.0501	0.004	0.022
Lumbriculus variegatus	IG-LV	Pyrene	0.0043	0.0043	IRON GATE	2.31	0.0019	1	0.0019	0.0410	0.004	0.019
Lumbriculus variegatus	UE-LV	Pyrene	0.0046	0.0046	UPPER ESTUARY	2.07	0.0022	1	0.0022	0.0027	0.007	0.00086
Lumbriculus variegatus	LC-LV-1	Pyrene	0.0091	0.01025	LAB CONTROL	No Data	Not Calculated	NA	Not Calculated			
Lumbriculus variegatus	LC-LV-2	Pyrene	0.0044									
Lumbriculus variegatus	LC-LV-3	Pyrene	0.0045									
Lumbriculus variegatus	LC-LV-4	Pyrene	0.023									
Lumbriculus variegatus	JC-LV	Total PCBs	0.0024	0.0024	JC BOYLE	0.0047	0.50	2	1.0	0.0648	0.0035	18.6
Lumbriculus variegatus	CR-LV	Total PCBs	0.0040	0.0040	COPCO 1	0.0038	1.1	2	2.1	0.0501	0.004	26.5
Lumbriculus variegatus	IG-LV	Total PCBs	0.0036	0.0036	IRON GATE	0.0068	0.53	2	1.1	0.0410	0.004	10.9
Lumbriculus variegatus	LC-LV-3	Total PCBs	0.0016	No Data	UPPER ESTUARY	0.0013	No Data	2	No Data			
Lumbriculus variegatus	LC-LV-2	Total PCBs	0.0027	0.0025	LAB CONTROL	No Data	Not Calculated	NA	Not Calculated			
Lumbriculus variegatus	LC-LV-4	Total PCBs	0.0033									
Lumbriculus variegatus	JC-LV	Total PBDEs	0.00032	0.00038	JC BOYLE	0.00046	0.83	1	0.83	0.0648	0.0035	15.4
Lumbriculus variegatus	CR-LV	Total PBDEs	0.00000	0.00086	COPCO 1	0.000044	19.5	1	19.5	0.0501	0.004	244

Corbicula fluminea =Asian clam (representative bivalve)
Lumbriculus variegatus = blackworm (representative oligochaete)

Total PCBs

Sediment Data	ND = 0 mg/kg	records	NDs
CR	0.0038	474	259
IG	0.0068	619	301
JC	0.0047	450	244
UE	0.0013	177	111

Total PBDEs

Sediment Data	ND = 0 mg/kg	records	NDs
CR	0.000044	105	92
IG	0.000050	103	86
JC	0.00046	102	83
UE	0.00042	49	36

Sample ID / Location Code
JC - J.C. Boyle Reservoir
CR - Copco 1 Reservoir
IG - Iron Gate Reservoir
UE - Upper Klamath Estuary
LC - Laboratory Control Sample

mg: milligram
kg: kilogram
ww: wet weight
dw: dry weight
BSAF: biota-sediment transfer factor
NA: not applicable
ND: not detected
TOC: total organic carbon

5.6.2 Worm BSAFs

BSAFs are more or less similar across all three reservoirs, other than arsenic, total PBDEs, and total PCBs, BSAFs for the laboratory control animal's native sediments could not be calculated because those sediments were not analyzed for chemical constituents. Concentrations of most chemicals detected or estimated in worm tissue and sediments are generally similar across reservoir and Upper Estuary samples (**Table 22**). No consistent pattern is noted when comparing chemical concentrations in worms to those measured in clams. The largest difference in BSAFs between locations is observed for arsenic, where the mean non-normalized and normalized BSAF for J.C. Boyle reservoir exceeds those calculated for the other reservoirs or the Upper Estuary.

Mean BSAFs for total PBDEs are calculated only for Copco 1 and J.C. Boyle reservoir (**Table 22**). The mean normalized and non-normalized BSAF is substantially higher for Copco 1 reservoir, based primarily on the lower sediment concentration in Copco 1 reservoir. Worm tissue concentrations of total PBDEs are relatively similar at both reservoirs.

Mean worm BSAFs for total PCBs also vary by location, with the mean non-normalized BSAF for Copco 1 reservoir being about double that calculated for J.C. Boyle and Iron Gate reservoirs (**Table 22**). Total PCB concentrations in worms from all three reservoirs are similar, but the mean sediment concentration is substantially lower for Copco 1 reservoir.

5.6.3 Bioaccumulation Summary – Laboratory Reared Invertebrates

Results of the invertebrate bioaccumulation assessment indicate that although some chemicals have accumulated in laboratory-exposed invertebrates (**Table 18**); no consistent pattern of contaminant distribution is identified among chemicals, media type, or location (**Table 19**). In all cases the differences from one reservoir to another and between reservoirs and laboratory controls are small and likely not ecologically significant.

As expected, data show that invertebrates can accumulate a fairly large number of sediment associated chemicals. Generally, clams accumulated higher concentrations of most chemicals than worms (**Table 19**). These differences in bioaccumulation can be attributed to sediment chemical concentrations because organisms were exposed to clean water, field collected sediments, and were not fed. Therefore, the only potential source of chemicals in invertebrate tissues is field collected sediment.

PAHs were not detected in worms or clams; some metals and pesticides were detected in one or more invertebrate tissue samples. In nearly all cases, the laboratory control samples of worms and clams (exposed to native sediment) were found to have accumulated similar or higher concentrations than samples exposed to field collected sediments. For clams, this is generally true for arsenic (except slightly higher concentrations for J.C. Boyle), DDD, DDE, DDT, lead, mercury, total PBDEs, and total PCBs. For worms, this is also generally true for arsenic, DDT, hexachlorobenzene, mercury, and total PCBs. The few exceptions for worms include slightly higher concentrations of arsenic (J.C. Boyle), DDD (Copco and Iron Gate), DDE (Copco), lead (J.C. Boyle and Iron Gate), and total PCBs (Copco) in one or two reservoir samples compared to the laboratory controls.

5.7 Proposed Action vs. No Action

Under Proposed Action "dams removed", a portion of the current reservoir sediments would be released downstream. At such time, released sediments would be distributed spatially and temporally in such a manner that no single downstream location will be subject to the magnitude of chemical concentrations and volume of sediment currently occurring in the reservoirs (i.e., under the current No Action "dams in"). Further, most of the released sediments based on modeling (BOR 2011a) are expected to be carried to the ocean with minimal deposition downstream and in the estuary if the dams are removed. The marine environment is unlikely to experience ecologically significant increases in contaminant concentrations in near shore sediments because of mixing, dispersion and dilution. It is assumed that sediment toxicity and bioaccumulation in the reservoirs under the current condition, which reflects No Action "dams in," is at maximum levels for aquatic biota linked to the reservoirs. Marginally increased exposures to potentially contaminated sediments compared to current conditions in the river may be experienced by downstream aquatic receptors, but such increases are expected to be minimal, temporary, and probably not ecologically significant given the relatively low concentrations of chemicals in reservoir sediments and biota under the current likely maximum exposure scenario (i.e., No Action "dams in").

Chapter 6
Evaluation of Field Collected Fish Tissue

This section presents and discusses the results of the collection and chemical analyses of field collected fish tissue from the three reservoirs to help evaluate the No Action alternative where fish are continuously exposed to all sources of potential contamination, including surface water, reservoir sediments, and prey. Chemical data for field collected fish therefore provide a ‘snapshot’ of current conditions; i.e., those applicable to No Action “dams in.”

The potential impact of human consumption of fish is also evaluated by comparing field collected whole body fish tissue concentrations to human health screening or advisory levels from a wide variety of sources and encompassing a wide range of exposure-related assumptions. Whole body fish are considered representative of all tissues (e.g., muscle, fat, and skin) to which humans may be exposed via ingestion. The potential effects to ecological (non-human) consumers of fish or invertebrates are not evaluated in the screening level assessment of field collected whole body fish. The evaluations presented in this section are directly linked to the exposure pathways discussed in Section 1 of this report.

6.1 Approach

The approach for evaluating chemical concentrations in field collected fish is described here. Five taxa of resident fish including bullhead (*Ameirus* sp.), yellow perch (*Perca flavescens*), black crappie (*Poxomis nigromaculatus*), rainbow trout (*Oncorhynchus mykiss*), and largemouth bass (*Micropterus salmoides*) were collected from Copco 1, Iron Gate, and JC Boyle reservoirs in 2010. Of these five taxa, two were selected for submittal to the laboratory for chemical analyses—yellow perch and bullhead. Yellow perch were selected because they are common in each of the reservoirs, representative of pelagic fish that reside and forage primarily in the water column, and are an important component of the local fishery for both sport and consumption. Bullheads were selected for this evaluation because they represent benthic (bottom-dwelling) fish closely associated with sediments and are also an important component of the local fishery for sport and consumption. Both fish species are assumed to move about widely in the reservoirs and are therefore potentially broadly exposed to contaminants in sediment or water. In combination, the selection of these two species was deemed appropriate to examine aspects of both human and ecological health evaluations, and to be representative of reservoir conditions.

Whole body composite samples of perch and bullhead from individual reservoirs were submitted to the laboratory. Seven specimens were used to define the species-specific composites for each reservoir. The smallest fish included in each composite were within 75 percent of the maximum length fish included in the composite, thereby ensuring that all fish within a single composite were of approximately the same age. Each composite was analyzed for metals, dioxins/furans, PCBs, pesticides, and polybrominated diphenyl ethers (PBDEs).

Once the laboratory analyses of fish tissue data had been completed, quality control and assessment of the fish data were performed, and the results were reported. The assessment of field collected fish involved the following steps:

- Compilation and summary of the validated fish tissue data
- Identification of chemicals detected in fish tissue samples
- Identification of chemicals with potential to cause impairment
- Identification of tissue-based TRVs for selected fish
- Compilation of human health SLs for cancer and non-cancer effects based on fish ingestion
- Comparison of tissue data to TRVs or SLs

6.2 Chemicals in Fish Tissues

Composite samples representing whole e body field collected fish were analyzed for a suite of potentially hazardous and bioaccumulative chemicals. The summary of fish tissue data generated by the analytical laboratory forms the basis of the evaluations of field collected fish (refer to **Appendix D**, Table D-1). Chemicals analyzed in field collected fish are presented in **Table 23**. This table lists chemicals detected in one or more samples and chemicals not detected in any sample for each species.

Table 24 presents the wet weight chemical concentrations detected or estimated in fish for a subset of chemicals for which tissue-based TRVs were available. Chemical concentrations are estimated using the full MDL value for some chemicals that were not detected in tissues because detection limits were sufficiently high to warrant comparisons to relevant tissue-based TRVs. The use of estimated concentrations based on MDLs was limited to potentially toxic and/or bioaccumulative chemicals for which appropriate screening values are available (e.g., Endrin and 2,3,7,8-TCDD) . This table also presents the laboratory RLs and MDLs. Sample specific MDLs are used for non-detect values.

Chemicals detected in bullhead from one or more locations that warrant comparisons to relevant tissue-based TRVs include arsenic (inorganic), DDE, DDT, Dieldrin, mercury, methylmercury, mirex, selenium, and total PCBs (**Table 24**). Chemicals estimated in bullhead include 2,3,7,8-TCDD, endrin, and for some locations, total arsenic and DDT.

Chemicals detected in perch from one or more locations that warrant comparisons to relevant tissue-based TRVs include arsenic (inorganic), DDE, DDT, Dieldrin, mercury, methylmercury, mirex, selenium, and total PCBs. Chemicals estimated in perch include total arsenic, 2,3,7,8-TCDD, and endrin (**Table 24**).

Table 23. Chemicals Detected and Not Detected in Field Caught Fish Tissues from Klamath Reservoirs, 2010

Bullhead		Yellow Perch	
DET	**ND**	**DET**	**ND**
2,4'-DDD	2,4'-DDT	2,4'-DDD	Acenaphthene
2,4'-DDE	Acenaphthene	2,4'-DDE	Acenaphthylene
2-Fluorobiphenyl	Acenaphthylene	2,4'-DDT	Aldrin
4,4'-DDD	Aldrin	2-Fluorobiphenyl	Anthracene
4,4'-DDE	Anthracene	4,4'-DDD	BDE (4)
4,4'-DDT	BDE (3)	4,4'-DDE	Benzo(a)anthracene
alpha-BHC	Benzo(a)anthracene	4,4'-DDT	Benzo(a)pyrene
Arsenic	Benzo(a)pyrene	alpha-BHC	Benzo(b)fluoranthene
BDE (8)	Benzo(b)fluoranthene	Arsenic	Benzo(ghi)perylene
beta-BHC	Benzo(ghi)perylene	BDE (7)	Benzo(k)fluoranthene
cis-Chlordane	Benzo(k)fluoranthene	beta-BHC	Chrysene
cis-Nonachlor	Chrysene	cis-Chlordane	D/F (14)
D/F (1)	D/F (14)	cis-Nonachlor	Dibenz(a,h)anthracene
delta-BHC	Dibenz(a,h)anthracene	D/F (1)	Endosulfan I
Dieldrin	Endosulfan I	delta-BHC	Endosulfan II
Endosulfan sulfate	Endosulfan II	Dieldrin	Endrin aldehyde
Fluorene	Endrin	Endosulfan sulfate	Endrin ketone
gamma-BHC (Lindane)	Endrin aldehyde	Endrin	Fluoranthene
Heptachlor epoxide	Endrin ketone	gamma-BHC (Lindane)	Fluorene
Hexachlorobenzene	Fluoranthene	Heptachlor	Indeno(1,2,3-cd)pyrene
Lead	Heptachlor	Heptachlor epoxide	Lead
Mercury	Indeno(1,2,3-cd)pyrene	Hexachlorobenzene	OCDF
Methoxychlor	OCDF	Mercury	PCB congeners (24)
Mirex	PCB congeners (28)	Methoxychlor	Phenanthrene
Naphthalene	Phenanthrene	Mirex	Pyrene
Nitrobenzene-d5	Pyrene	Naphthalene	Total HpCDF
OCDD	Total HpCDF	Nitrobenzene-d5	Total HxCDD
oxy-Chlordane	Total HxCDD	OCDD	Total HxCDF
PCB congeners (181)	Total HxCDF	oxy-Chlordane	Total PeCDD
Selenium	Total PeCDD	PCB congeners (185)	Total PeCDF
Total HpCDD	Total PeCDF	Selenium	Total TCDD
trans-Chlordane	Total TCDD	Total HpCDD	Total TCDF
trans-Nonachlor	Total TCDF	trans-Chlordane	
		trans-Nonachlor	

DET - Detected in one or more samples
ND - Not detected in any sample

Table 24. Whole Body Fish Tissue Data (wet weight) from Klamath Reservoirs, 2010

(highlight = chemical NOT DETECTED, result set to MDL for comparison to available TRV)

Species	Sample	Analyte	Result	Units	MDL	RL
Ameiurus sp	JC-BH COMP 1	2,3,7,8-TCDD	0.51	pg/g	0.51	0.97
Ameiurus sp	JC-BH COMP 2	2,3,7,8-TCDD	0.44	pg/g	0.44	0.97
Ameiurus sp	CR-BH COMP 1	2,3,7,8-TCDD	0.41	pg/g	0.41	0.96
Ameiurus sp	IG-BH COMP 1	2,3,7,8-TCDD	0.4	pg/g	0.4	0.96
Ameiurus sp	JC-BH COMP 1	Arsenic (inorganic)	0.029	mg/kg	0.003	0.009
Ameiurus sp	JC-BH COMP 2	Arsenic (inorganic)	0.02	mg/kg	0.005	0.017
Ameiurus sp	JC-BH COMP 2	Arsenic (inorganic)	0.02	mg/kg	0.005	0.018
Ameiurus sp	JC-BH COMP 1	Arsenic (total)	0.17	mg/kg	0.15	0.2
Ameiurus sp	JC-BH COMP 2	Arsenic (total)	0.15	mg/kg	0.15	0.2
Ameiurus sp	CR-BH COMP 1	Arsenic (inorganic)	0.007	mg/kg	0.003	0.009
Ameiurus sp	CR-BH COMP 1	Arsenic (inorganic)	0.022	mg/kg	0.003	0.01
Ameiurus sp	CR-BH COMP 1	Arsenic (total)	0.15	mg/kg	0.15	0.2
Ameiurus sp	IG-BH COMP 1	Arsenic (inorganic)	0.016	mg/kg	0.003	0.01
Ameiurus sp	IG-BH COMP 1	Arsenic (total)	0.15	mg/kg	0.15	0.2
Ameiurus sp	JC-BH COMP 1	DDE	7.144	ug/kg	0.0182	0.076
Ameiurus sp	JC-BH COMP 2	DDE	4.325	ug/kg	0.0084	0.074
Ameiurus sp	CR-BH COMP 1	DDE	6.728	ug/kg	0.0179	0.078
Ameiurus sp	IG-BH COMP 1	DDE	3.726	ug/kg	0.0098	0.078
Ameiurus sp	JC-BH COMP 1	DDT	0.024	ug/kg	0.024	0.076
Ameiurus sp	JC-BH COMP 2	DDT	0.019	ug/kg	0.019	0.074
Ameiurus sp	CR-BH COMP 1	DDT	0.052	ug/kg	0.027	0.078
Ameiurus sp	IG-BH COMP 1	DDT	0.0155	ug/kg	0.0155	0.078
Ameiurus sp	JC-BH COMP 1	Dieldrin	0.072	ug/kg	0.034	0.038
Ameiurus sp	JC-BH COMP 2	Dieldrin	0.048	ug/kg	0.02	0.037
Ameiurus sp	CR-BH COMP 1	Dieldrin	0.064	ug/kg	0.042	0.042
Ameiurus sp	IG-BH COMP 1	Dieldrin	0.077	ug/kg	0.018	0.039
Ameiurus sp	JC-BH COMP 1	Endrin	0.033	ug/kg	0.033	0.038
Ameiurus sp	JC-BH COMP 2	Endrin	0.02	ug/kg	0.02	0.037
Ameiurus sp	CR-BH COMP 1	Endrin	0.038	ug/kg	0.038	0.039
Ameiurus sp	IG-BH COMP 1	Endrin	0.018	ug/kg	0.018	0.039
Ameiurus sp	CR-BH COMP 1	Mercury (methyl)	0.286	mg/kg	0.0009	0.0027
Ameiurus sp	CR-BH COMP 1	Mercury (total)	0.36	mg/kg	0.02	0.04
Ameiurus sp	IG-BH COMP 1	Mercury (methyl)	0.0973	mg/kg	0.001	0.0029
Ameiurus sp	IG-BH COMP 1	Mercury (total)	0.073	mg/kg	0.02	0.04
Ameiurus sp	JC-BH COMP 1	Mercury (methyl)	0.0236	mg/kg	0.001	0.0029
Ameiurus sp	JC-BH COMP 1	Mercury (total)	0.043	mg/kg	0.02	0.04
Ameiurus sp	JC-BH COMP 2	Mercury (methyl)	0.032	mg/kg	0.0014	0.0041
Ameiurus sp	JC-BH COMP 2	Mercury (methyl)	0.034	mg/kg	0.0015	0.0044
Ameiurus sp	JC-BH COMP 2	Mercury (total)	0.037	mg/kg	0.02	0.04

Table 24. Whole Body Fish Tissue Data (wet weight) from Klamath Reservoirs, 2010

(highlight = chemical NOT DETECTED, result set to MDL for comparison to available TRV)

Species	Sample	Analyte	Result	Units	MDL	RL
Ameiurus sp	JC-BH COMP 1	Mirex	0.028	ug/kg	0.0024	0.038
Ameiurus sp	JC-BH COMP 2	Mirex	0.018	ug/kg	0.0021	0.037
Ameiurus sp	CR-BH COMP 1	Mirex	0.033	ug/kg	0.0025	0.039
Ameiurus sp	IG-BH COMP 1	Mirex	0.016	ug/kg	0.002	0.039
Ameiurus sp	JC-BH COMP 1	Selenium	0.14	mg/kg	0.1	0.2
Ameiurus sp	JC-BH COMP 2	Selenium	0.32	mg/kg	0.1	0.2
Ameiurus sp	CR-BH COMP 1	Selenium	0.2	mg/kg	0.1	0.2
Ameiurus sp	IG-BH COMP 1	Selenium	0.14	mg/kg	0.1	0.2
Ameiurus sp	JC-BH COMP 2	Total PCBs	13595	pg/g	77.008	3765.8
Ameiurus sp	JC-BH COMP 1	Total PCBs	17917	pg/g	76.4	3765.8
Ameiurus sp	CR-BH COMP 1	Total PCBs	22615	pg/g	104.84	3765.8
Ameiurus sp	IG-BH COMP 1	Total PCBs	40635	pg/g	98.14	3765.8
Perca flavescens	JC-YP COMP 1	2,3,7,8-TCDD	0.42	pg/g	0.42	0.97
Perca flavescens	CR-YP COMP 1	2,3,7,8-TCDD	0.43	pg/g	0.43	0.96
Perca flavescens	IG-YP COMP 1	2,3,7,8-TCDD	0.35	pg/g	0.35	0.97
Perca flavescens	JC-YP COMP 1	Arsenic (inorganic)	0.01	mg/kg	0.003	0.01
Perca flavescens	JC-YP COMP 1	Arsenic (total)	0.15	mg/kg	0.15	0.2
Perca flavescens	CR-YP COMP 1	Arsenic (inorganic)	0.016	mg/kg	0.005	0.018
Perca flavescens	CR-YP COMP 1	Arsenic (total)	0.15	mg/kg	0.15	0.2
Perca flavescens	IG-YP COMP 1	Arsenic (inorganic)	0.023	mg/kg	0.003	0.01
Perca flavescens	IG-YP COMP 1	Arsenic (total)	0.15	mg/kg	0.15	0.2
Perca flavescens	JC-YP COMP 1	DDE	5.231	ug/kg	0.0069	0.08
Perca flavescens	CR-YP COMP 1	DDE	1.713	ug/kg	0.0047	0.076
Perca flavescens	IG-YP COMP 1	DDE	1.411	ug/kg	0.0055	0.08
Perca flavescens	JC-YP COMP 1	DDT	0.0415	ug/kg	0.0116	0.08
Perca flavescens	CR-YP COMP 1	DDT	0.039	ug/kg	0.0089	0.076
Perca flavescens	IG-YP COMP 1	DDT	0.037	ug/kg	0.0062	0.08
Perca flavescens	JC-YP COMP 1	Dieldrin	0.13	ug/kg	0.0065	0.04
Perca flavescens	CR-YP COMP 1	Dieldrin	0.073	ug/kg	0.0046	0.038
Perca flavescens	IG-YP COMP 1	Dieldrin	0.088	ug/kg	0.004	0.04
Perca flavescens	JC-YP COMP 1	Endrin	0.007	ug/kg	0.007	0.04
Perca flavescens	CR-YP COMP 1	Endrin	0.0047	ug/kg	0.0047	0.038
Perca flavescens	IG-YP COMP 1	Endrin	0.008	ug/kg	0.0036	0.04
Perca flavescens	JC-YP COMP 1	Mercury (methyl)	0.0965	mg/kg	0.001	0.0029
Perca flavescens	JC-YP COMP 1	Mercury (total)	0.1	mg/kg	0.02	0.04
Perca flavescens	CR-YP COMP 1	Mercury (methyl)	0.0727	mg/kg	0.0009	0.0028
Perca flavescens	CR-YP COMP 1	Mercury (total)	0.086	mg/kg	0.02	0.04
Perca flavescens	IG-YP COMP 1	Mercury (methyl)	0.138	mg/kg	0.001	0.0029
Perca flavescens	IG-YP COMP 1	Mercury (total)	0.14	mg/kg	0.02	0.04
Perca flavescens	JC-YP COMP 1	Mirex	0.016	ug/kg	0.0014	0.04
Perca flavescens	CR-YP COMP 1	Mirex	0.0082	ug/kg	0.00099	0.038
Perca flavescens	IG-YP COMP 1	Mirex	0.0048	ug/kg	0.00067	0.04

Table 24. Whole Body Fish Tissue Data (wet weight) from Klamath Reservoirs, 2010

(highlight = chemical NOT DETECTED, result set to MDL for comparison to available TRV)

Species	Sample	Analyte	Result	Units	MDL	RL
Perca flavescens	JC-YP COMP 1	Selenium	0.2	mg/kg	0.1	0.2
Perca flavescens	CR-YP COMP 1	Selenium	0.11	mg/kg	0.1	0.2
Perca flavescens	IG-YP COMP 1	Selenium	0.15	mg/kg	0.1	0.2
Perca flavescens	IG-YP COMP 1	Total PCBs	48196	pg/g	95.057	3765.8
Perca flavescens	CR-YP COMP 1	Total PCBs	7939	pg/g	4082.08	3765.8
Perca flavescens	JC-YP COMP 1	Total PCBs	20302	pg/g	100.78	3765.8

Ameiurus sp. = bullhead (representative Ictalurid)
Perca flavescens = yellow perch (representative Percid)

MDL: method detection limit
RL: sample reporting limit
ug: microgram
kg: kilogram
mg: milligram
pg: picogram
g: gram

Sample ID
JC - J.C. Boyle Reservoir
CR - Copco 1 Reservoir
IG - Iron Gate Reservoir

6.3 Fish Tissue Tissue-based Toxicity Reference Values

The next step of the evaluations of fish tissues consisted of compiling and selecting chemical- and species-specific tissue-based TRVs to determine if chemicals measured or estimated in fish tissues are at concentrations that could impair survival, growth, or reproduction of fish. The same procedure for defining tissue-based TRVs for invertebrates as described in Section 5.4 was used for evaluating fish. No Effect and Low Effect TRVs are again used in this evaluation.

The source of all tissue-based TRVs is the U.S. Army Corp of Engineers (USACE) Environmental Residue-Effects Database (ERED), accessed online at http://el.erdc.usace.army.mil/ered/. Other potential sources of tissue-based TRVs (such as those derived for the protection of fish and wildlife in San Francisco Bay, based on long-term TMDL targets) were not consulted for this initial screening level assessment, but may be used if further investigation or evaluation is deemed warranted at subsequent stages of the determination process.

Low Effect and No Effect tissue-based TRVs are derived for the two fish taxa for which whole body tissue data are available, yellow perch and bullhead. TRVs for yellow perch are based on yellow perch toxicity data, while selected TRVs for bullhead are based on channel catfish data. Selected TRVs for yellow perch and bullhead are shown in **Table 25** for the chemicals detected (or estimated using MDLs) in each species, based on TRV availability. Appropriate (i.e., family-specific) TRVs are available for 2,3,7,8-TCDD and mercury in both taxa and total PCBs in bullhead. For this evaluation, TRVs for 2,3,7,8-TCDD are compared to MDLs associated with the fish tissue results because this chemical was not detected in fish tissue. Comparisons of toxic equivalents (TEQs) calculated for field collected whole body fish to TEQ-based TRVs is conducted as an independent evaluation in subsequent sections of this report. Tissue-based TRVs are unavailable for these two species for the other seven chemicals detected (arsenic, DDD, DDE, Dieldrin, endrin, Mirex, and selenium). **Appendix D** provides a series of spreadsheets identified as Tables D1-D12 containing data from the ERED source from which the final TRVs were selected.

6.4 Fish Tissue Screening and Identification of COPCs

Results of the comparisons of concentrations of chemicals detected or estimated (using MDLs) in whole body fish to tissue-based TRVs are shown in **Table 26**. As shown in this table, such comparisons are made only for mercury and 2,3,7,8-TCDD for both fish taxa, and total PCBs for bullhead only. Tissue based TRVs are not readily available for the other seven chemicals detected or estimated (using MDLs) in bullhead and perch. For some chemicals for which tissue-based TRVs are available, the concentration of the chemical in fish tissue is initially reported as not detected, but the laboratory reporting limit exceeds the selected TRV. This situation results in uncertainty regarding accumulation of the chemical in fish tissue. To ensure that no potentially important chemical is eliminated from further consideration, the MDL is used as a surrogate for

Table 25. Whole Body Fish Tissue-based TRVs

Chemical / Collected Species	**Derivation**	**Study / Source**	**Test Species**	**NO EFFECT mg/kg wet wt.**	**LOW EFFECT mg/kg wet wt.**
2,3,7,8-TCDD					
PERCH	ACCEPT NOED EST. LOED (*10)	Kleeman, J.M., J.R. Olson, S.M. Chen and R.E. Peterson 1986 in USACE ERED	yellow perch	0.000143	0.00143
BULLHEAD	ACCEPT NOED EST. LOED (*10)	Isensee AR, GE Jones 1975 in USACE ERED	channel catfish	0.19	1.9
MERCURY					
PERCH	ACCEPT NOED EST. LOED (*10)	Wiener, J.G., Fitzgerald, W.F., Watras, C.J., Rada, R.G.1990 in USACE ERED	yellow perch	0.135	1.35
BULLHEAD	EST. LOED (/10) EST. NOED (/100)	Birge WJ, JA Black, AG Westerman, JE Hudson 1979 in USACE ERED	channel catfish	0.006	0.0006
TOTAL PCBS					
BULLHEAD	ACCEPT NOED ACCEPT LOED	Hansen, L.G., W.B. Wiekhorst and J. Simon 1976 in USAC ERED	channel catfish	10.9	14.3

mg: milligram
kg: kilogram
wt: weight
TRV: toxicity reference value
USACE: United States Army Corps of Engineers
NOED: no observed adverse effect
LOED: lowest observed adverse effect
est: estimated

Table 26. Residues of Whole Body from Klamath Reservoirs Fish (wet weight) from 2010 Compared to Tissue-based TRVs

(highlight = chemical NOT DETECTED, result set to MDL for comparison to available TRV)

								No Effect TRV			Low Effect TRV	
Fish Species	**Sample ID**	**Analyte - Whole Body Fish**	**Result**	**Units**	**MDL**	**RL**		**BULLHEAD**	**PERCH**		**BULLHEAD**	**PERCH**
Ameiurus sp.	JC-BH COMP 1	2,3,7,8-TCDD	0.51	pg/g	0.51	0.97		190000			1900000	
Ameiurus sp.	JC-BH COMP 2	2,3,7,8-TCDD	0.44	pg/g	0.44	0.97		190000			1900000	
Ameiurus sp.	CR-BH COMP 1	2,3,7,8-TCDD	0.41	pg/g	0.41	0.96		190000			1900000	
Ameiurus sp.	IG-BH COMP 1	2,3,7,8-TCDD	0.4	pg/g	0.4	0.96		190000			1900000	
Ameiurus sp.	JC-BH COMP 1	Arsenic (inorganic)	0.029	mg/kg	0.003	0.009		TRV unavailable for Ictaluridae				
Ameiurus sp.	JC-BH COMP 1	Arsenic (total)	0.17	mg/kg	0.15	0.2						
Ameiurus sp.	JC-BH COMP 2	Arsenic (inorganic)	0.02	mg/kg	0.005	0.017						
Ameiurus sp.	JC-BH COMP 2	Arsenic (inorganic)	0.02	mg/kg	0.005	0.018						
Ameiurus sp.	JC-BH COMP 2	Arsenic (total)	0.15	mg/kg	0.15	0.2						
Ameiurus sp.	CR-BH COMP 1	Arsenic (inorganic)	0.007	mg/kg	0.003	0.009						
Ameiurus sp.	CR-BH COMP 1	Arsenic (inorganic)	0.022	mg/kg	0.003	0.01						
Ameiurus sp.	CR-BH COMP 1	Arsenic (total)	0.15	mg/kg	0.15	0.2						
Ameiurus sp.	IG-BH COMP 1	Arsenic (inorganic)	0.016	mg/kg	0.003	0.01						
Ameiurus sp.	IG-BH COMP 1	Arsenic (total)	0.15	mg/kg	0.15	0.2						
Ameiurus sp.	JC-BH COMP 1	DDE	7.144	ug/kg	0.0182	0.076		TRV unavailable for Ictaluridae				
Ameiurus sp.	JC-BH COMP 2	DDE	4.325	ug/kg	0.0084	0.074						
Ameiurus sp.	CR-BH COMP 1	DDE	6.728	ug/kg	0.0179	0.078						
Ameiurus sp.	IG-BH COMP 1	DDE	3.726	ug/kg	0.0098	0.078						
Ameiurus sp.	JC-BH COMP 1	DDT	0.024	ug/kg	0.024	0.076		TRV unavailable for Ictaluridae				
Ameiurus sp.	JC-BH COMP 2	DDT	0.019	ug/kg	0.019	0.074						
Ameiurus sp.	CR-BH COMP 1	DDT	0.052	ug/kg	0.027	0.078						
Ameiurus sp.	IG-BH COMP 1	DDT	0.0155	ug/kg	0.0155	0.078						
Ameiurus sp.	JC-BH COMP 1	Dieldrin	0.072	ug/kg	0.034	0.038		TRV unavailable for Ictaluridae				
Ameiurus sp.	JC-BH COMP 2	Dieldrin	0.048	ug/kg	0.02	0.037						
Ameiurus sp.	CR-BH COMP 1	Dieldrin	0.064	ug/kg	0.042	0.042						
Ameiurus sp.	IG-BH COMP 1	Dieldrin	0.077	ug/kg	0.018	0.039						
Ameiurus sp.	JC-BH COMP 1	Endrin	0.033	ug/kg	0.033	0.038		TRV unavailable for Ictaluridae				
Ameiurus sp.	JC-BH COMP 2	Endrin	0.02	ug/kg	0.02	0.037						
Ameiurus sp.	CR-BH COMP 1	Endrin	0.038	ug/kg	0.038	0.039						
Ameiurus sp.	IG-BH COMP 1	Endrin	0.018	ug/kg	0.018	0.039						
Ameiurus sp.	JC-BH COMP 1	Mercury (methyl)	**0.0236**	mg/kg	0.001	0.0029		0.0006			0.006	
Ameiurus sp.	JC-BH COMP 1	Mercury (total)	**0.043**	mg/kg	0.02	0.04		0.0006			0.006	
Ameiurus sp.	JC-BH COMP 2	Mercury (methyl)	**0.032**	mg/kg	0.0014	0.0041		0.0006			0.006	
Ameiurus sp.	JC-BH COMP 2	Mercury (methyl)	**0.034**	mg/kg	0.0015	0.0044		0.0006			0.006	
Ameiurus sp.	JC-BH COMP 2	Mercury (total)	**0.037**	mg/kg	0.02	0.04		0.0006			0.006	
Ameiurus sp.	CR-BH COMP 1	Mercury (methyl)	**0.286**	mg/kg	0.0009	0.0027		0.0006			0.006	
Ameiurus sp.	CR-BH COMP 1	Mercury (total)	**0.36**	mg/kg	0.02	0.04		0.0006			0.006	
Ameiurus sp.	IG-BH COMP 1	Mercury (total)	**0.073**	mg/kg	0.02	0.04		0.0006			0.006	
Ameiurus sp.	IG-BH COMP 1	Mercury (methyl)	**0.0973**	mg/kg	0.001	0.0029		0.0006			0.006	
Ameiurus sp.	JC-BH COMP 1	Mirex	0.028	ug/kg	0.0024	0.038		TRV unavailable for Ictaluridae				
Ameiurus sp.	JC-BH COMP 2	Mirex	0.018	ug/kg	0.0021	0.037						
Ameiurus sp.	CR-BH COMP 1	Mirex	0.033	ug/kg	0.0025	0.039						
Ameiurus sp.	IG-BH COMP 1	Mirex	0.016	ug/kg	0.002	0.039						
Ameiurus sp.	JC-BH COMP 1	Selenium	0.14	mg/kg	0.1	0.2		TRV unavailable for Ictaluridae				
Ameiurus sp.	JC-BH COMP 2	Selenium	0.32	mg/kg	0.1	0.2						
Ameiurus sp.	CR-BH COMP 1	Selenium	0.2	mg/kg	0.1	0.2						
Ameiurus sp.	IG-BH COMP 1	Selenium	0.14	mg/kg	0.1	0.2						
Ameiurus sp	CR-BH COMP 1	Total PCBs	22,615	pg/g	104.84	3765.8		10,900,000			14,300,000	

Table 26. Residues of Whole Body from Klamath Reservoirs Fish (wet weight) from 2010 Compared to Tissue-based TRVs

(highlight = chemical NOT DETECTED, result set to MDL for comparison to available TRV)

								No Effect TRV			Low Effect TRV	
Fish Species	**Sample ID**	**Analyte - Whole Body Fish**	**Result**	**Units**	**MDL**	**RL**		**BULLHEAD**	**PERCH**		**BULLHEAD**	**PERCH**
Ameiurus sp	IG-BH COMP 1	Total PCBs	40,635	pg/g	98.14	3765.8		10,900,000			14,300,000	
Ameiurus sp	JC-BH COMP 2	Total PCBs	13,595	pg/g	77.008	3765.8		10,900,000			14,300,000	
Ameiurus sp	JC-BH COMP 1	Total PCBs	17,917	pg/g	76.4	3765.8		10,900,000			14,300,000	
Perca flavescens	JC-YP COMP 1	2,3,7,8-TCDD	0.42	pg/g	0.42	0.97			143			1430
Perca flavescens	CR-YP COMP 1	2,3,7,8-TCDD	0.43	pg/g	0.43	0.96			143			1430
Perca flavescens	IG-YP COMP 1	2,3,7,8-TCDD	0.35	pg/g	0.35	0.97			143			1430
Perca flavescens	JC-YP COMP 1	Arsenic (inorganic)	0.01	mg/kg	0.003	0.01		TRV unavailable for Percidae				
Perca flavescens	JC-YP COMP 1	Arsenic (total)	0.15	mg/kg	0.15	0.2						
Perca flavescens	CR-YP COMP 1	Arsenic (inorganic)	0.016	mg/kg	0.005	0.018						
Perca flavescens	CR-YP COMP 1	Arsenic (total)	0.15	mg/kg	0.15	0.2						
Perca flavescens	IG-YP COMP 1	Arsenic (inorganic)	0.023	mg/kg	0.003	0.01						
Perca flavescens	IG-YP COMP 1	Arsenic (total)	0.15	mg/kg	0.15	0.2						
Perca flavescens	JC-YP COMP 1	DDE	5.231	ug/kg	0.0069	0.08		TRV unavailable for Percidae				
Perca flavescens	CR-YP COMP 1	DDE	1.713	ug/kg	0.0047	0.076						
Perca flavescens	IG-YP COMP 1	DDE	1.411	ug/kg	0.0055	0.08						
Perca flavescens	JC-YP COMP 1	DDT	0.0415	ug/kg	0.0116	0.08		TRV unavailable for Percidae				
Perca flavescens	CR-YP COMP 1	DDT	0.039	ug/kg	0.0089	0.076						
Perca flavescens	IG-YP COMP 1	DDT	0.037	ug/kg	0.0062	0.08						
Perca flavescens	JC-YP COMP 1	Dieldrin	0.13	ug/kg	0.0065	0.04		TRV unavailable for Percidae				
Perca flavescens	CR-YP COMP 1	Dieldrin	0.073	ug/kg	0.0046	0.038						
Perca flavescens	IG-YP COMP 1	Dieldrin	0.088	ug/kg	0.004	0.04						
Perca flavescens	JC-YP COMP 1	Endrin	0.007	ug/kg	0.007	0.04		TRV unavailable for Percidae				
Perca flavescens	CR-YP COMP 1	Endrin	0.0047	ug/kg	0.0047	0.038						
Perca flavescens	IG-YP COMP 1	Endrin	0.008	ug/kg	0.0036	0.04						
Perca flavescens	JC-YP COMP 1	Mercury (methyl)	0.0965	mg/kg	0.001	0.0029			0.135			1.35
Perca flavescens	JC-YP COMP 1	Mercury (total)	0.1	mg/kg	0.02	0.04			0.135			1.35
Perca flavescens	CR-YP COMP 1	Mercury (methyl)	0.0727	mg/kg	0.0009	0.0028			0.135			1.35
Perca flavescens	CR-YP COMP 1	Mercury (total)	0.086	mg/kg	0.02	0.04			0.135			1.35
Perca flavescens	IG-YP COMP 1	Mercury (methyl)	**0.138**	mg/kg	0.001	0.0029			0.135			1.35
Perca flavescens	IG-YP COMP 1	Mercury (total)	**0.14**	mg/kg	0.02	0.04			0.135			1.35
Perca flavescens	JC-YP COMP 1	Mirex	0.016	ug/kg	0.0014	0.04		TRV unavailable for Percidae				
Perca flavescens	CR-YP COMP 1	Mirex	0.0082	ug/kg	0.00099	0.038						
Perca flavescens	IG-YP COMP 1	Mirex	0.0048	ug/kg	0.00067	0.04						
Perca flavescens	JC-YP COMP 1	Selenium	0.2	mg/kg	0.1	0.2		TRV unavailable for Percidae				
Perca flavescens	CR-YP COMP 1	Selenium	0.11	mg/kg	0.1	0.2						
Perca flavescens	IG-YP COMP 1	Selenium	0.15	mg/kg	0.1	0.2						
Perca flavescens	IG-YP COMP 1	Total PCBs	48,196	pg/g	95.057	3765.8		TRV unavailable for Percidae				
Perca flavescens	CR-YP COMP 1	Total PCBs	7,939	pg/g	4082.081	3765.8						
Perca flavescens	JC-YP COMP 1	Total PCBs	20,302	pg/g	100.78	3765.8						

Ameiurus sp. = bullhead (representative Ictalurid)

Perca flavescens = yellow perch (representative Percid)

Bolded values are equal to or exceed No Effect TRV
Boxed values are equal to or exceed Low Effect TRV

Sample ID
JC - J.C. Boyle Reservoir
CR - Copco 1 Reservoir
IG - Iron Gate Reservoir

the non-detected value. Therefore, in these cases the fish is assumed to have accumulated the chemical to the concentration equal to the MDL. This approach may overestimate chemical concentrations in fish, but ensures that all chemicals for which TRVs are available can be evaluated in this initial screening. For chemicals for which TRVs are available, MDLs remain below applicable TRVs, indicating that MDLs are sufficiently low to allow comparisons of tissue chemical concentrations to TRVs (**Table 26**).

6.4.1 Bullhead

The dioxin 2,3,7,8-TCDD was not detected in bullhead, and concentrations of 2,3,7,8-TCDD in bullhead (**Table 26**) are based on assigning the laboratory MDL to each of the four samples as an estimate of whole body concentrations. Sample-specific MDLs range from 0.4 pg/g to 0.51 pg/g. Assuming a chemical may be present at the full MDL is conservative, and ensures that a chemical is not eliminated from further investigation at this screening level step. Even at the highest MDL (0.51 pg/g or 0.00000051 mg/kg), no sample result approaches the No Effect TRV of 190,000 pg/g (0.19 mg/kg). The dioxin 2,3,7,8-TCDD is therefore not considered a COPC for bullhead tissue based on protection of fish represented by bullhead.

In contrast, each composite bullhead sample from each reservoir contained concentrations of mercury (based on both total mercury and methylmercury) exceeding both the No Effect and Low Effect TRVs (**Table 26**). It is noted that the TRVs for mercury used for this comparison are based on channel catfish data, and channel catfish TRVs for mercury are substantially lower than TRVs for several other fish taxa. It cannot be determined from available data if Ictalurids (i.e., catfish and bullheads) are more sensitive to mercury than fish from other families, or if these findings are an artifact of limited toxicity data. At this screening level stage of the assessment mercury is identified as a COPC for protection of fish represented by bullhead.

Measured concentrations of total PCBs in bullhead substantially exceeded the MDL but remained well below the No Effect TRVs based on channel catfish. Total PCBs are therefore not identified as COPCs for bullhead tissue.

Endrin was not detected in bullhead. Reported concentrations of endrin in bullhead tissues are based on sample specific MDLs and TRVs are not available. Therefore, this chemical cannot be reliably quantified in bullhead samples. Endrin is not identified as a COPC for bullhead.

Although TRVs are unavailable for six other chemicals detected in bullhead samples, and identification of any of these as COPCs is not possible, the following discussion is provided as additional information associated with these chemicals:

- Arsenic – 10 bullhead samples; concentrations range from 0.007 mg/kg to 0.17 mg/kg (total and inorganic sample results)

- DDE – Four bullhead samples; concentrations range from 3.7 ug/kg to 7.1 ug/kg (0.0037 mg/kg to 0.0071 mg/kg).

- DDT – Four bullhead samples; concentrations range from 0.016 ug/kg to 0.052 ug/kg (0.000016 mg/kg to 0.000052 mg/kg).

- Dieldrin – Four bullhead samples; concentrations range from 0.048 ug/kg to 0.077 ug/kg (0.000048 mg/kg to 0.000077 mg/kg).

- Mirex – Four bullhead samples; concentrations range from 0.016 ug/kg to 0.033 ug/kg (0.000016 mg/kg to 0.000033 mg/kg).

- Selenium – Four bullhead samples; concentrations range from 0.14 mg/kg to 0.32 mg/kg.

6.4.2 Yellow Perch

The dioxin 2,3,7,8-TCDD was not detected in perch. Concentrations of 2,3,7,8-TCDD in perch (**Table 26**) are based on assigning the laboratory MDL to each of the three samples. Sample-specific MDLs range from 0.35 pg/g to 0.43 pg/g. Even at the highest MDL (0.43 pg/g or 0.00000043 mg/kg), no sample result approaches the No Effect TRV of 143 pg/g (0.000143 mg/kg). The dioxin 2,3,7,8-TCDD is therefore not considered a COPC for yellow perch tissue based on protection of fish represented by yellow perch.

Two of six whole body yellow perch samples (both from Iron Gate reservoir) contained concentrations of mercury slightly exceeding the No Effect but not the Low Effect TRVs (**Table 26**). Generally, exceedance of a No Effect threshold with no exceedance of a Low Effect threshold indicates low potential for adverse effects. These two mercury concentrations (0.138 and 0.14 mg/kg) detected in whole body yellow perch only slightly exceed the No Effect TRV of 0.135 mg/kg and remains well below the Low Effect TRV of 1.35 mg/kg. At this screening level stage of the assessment, mercury is identified as a COPC for Iron Gate Reservoir for protection of fish represented by yellow perch.

Measured concentrations of total PCBs in whole body yellow perch cannot be compared to tissue-based TRVs because such TRVs are unavailable for percid fish. However, concentrations of total PCBs measured in whole body yellow perch were relatively similar to those measured in bullhead, and those concentrations were well below family-specific TRVs for ictalurids. PCBs are considered unlikely to be retained in whole body yellow perch at concentrations of concern.

Endrin was not detected in yellow perch. Reported concentrations of endrin in yellow perch tissues are based on sample specific MDLs and therefore this chemical cannot be reliably quantified in yellow perch samples. Endrin is not identified as a COPC for yellow perch.

Although TRVs are unavailable for six other chemicals detected in yellow perch samples, and identification of any of these as COPCs is not possible, the following discussion is provided as additional information associated with these chemicals. No one reservoir appears to be associated with significantly elevated concentrations of these six chemicals in whole body fish compared to the other reservoirs.

- Arsenic – Six yellow perch samples (total and inorganic arsenic); concentrations range from 0.01 mg/kg to 0.15 mg/kg, with little difference in concentrations of inorganic arsenic between reservoirs. Total arsenic results based on MDL (not detected).

- DDE – Three yellow perch samples; concentrations range from 1.4 ug/kg to 5.2 ug/kg (0.0014 mg/kg to 0.0052 mg/kg).

- DDT – Three yellow perch samples, concentrations range from 0.037 ug/kg to 0.042 ug/kg (0.000037 mg/kg to 0.000042 mg/kg).

- Dieldrin – Three yellow perch samples, concentrations range from 0.073 ug/kg to 0.13 ug/kg (0.000073 mg/kg to 0.00013 mg/kg).

- Mirex – Three yellow perch samples, concentrations range from 0.0048 ug/kg to 0.016 ug/kg (0.0000048 mg/kg to 0.000016 mg/kg).

- Selenium – Three yellow perch samples, concentrations range from 0.11 mg/kg to 0.2 mg/kg.

6.4.3 Summary of Field Collected Whole Body Fish

Results of chemical analyses of field collected fish (**Table 23**) reveal that no consistent pattern of contaminant distribution is identified among chemicals, media type, or location (**Table 24**). As expected, data reveal that fish can accumulate a fairly large number of sediment associated chemicals. Generally, field collected bullhead have accumulated higher concentrations of chemicals than field collected yellow perch (**Table 24**). These differences in fish bioaccumulation cannot be attributed solely or even primarily to chemicals in sediment because field collected fish are also exposed to chemicals via diet and water ingestion. The relationship between chemical concentrations in sediment and in field collected fish has not been established using the lines of evidence supporting this evaluation. With a few exceptions, where patterns of distribution appear to be observed, in most cases they can be attributed to findings not directly related to sediment contamination. For example, mean sediment concentrations of mercury from the three reservoirs vary little, yet mean whole body bullhead concentrations of mercury, although none are greatly elevated and all may reflect background concentrations for lakes, are nearly four times higher in bullhead from Copco 1 reservoir than those from Iron Gate reservoir (**Table 24**). While total and methyl mercury concentrations in bullhead generally exceed those measured in yellow perch, none exceed 0.36 mg/kg in whole body field collected fish. Also confounding some of the interpretations associated with chemical uptake is the role of regional background conditions. For example, arsenic in the western portion of the nation is, even in uncontaminated areas, known to be elevated relative to some commonly accepted SLs. It is expected that arsenic in fish from uncontaminated locations would also exceed some of these low thresholds. Finally, tissue data for bullhead and perch from the three reservoirs presented in this evaluation support the expectation that most arsenic in fish is present primarily as the less toxic organic form.

6.5 Human Health Evaluation - Fish Consumption

Exceedance or potential exceedance (for non-detected chemicals) of one or more human health screening levels is noted for inorganic arsenic, DDT, Dieldrin, total mercury, total PCBs, and 2,3,7,8-TCDD. The dioxin 2,3,7,8-TCDD was not detected in fish tissue but the laboratory detection limit for this chemical exceeded one or more of the human health screening levels for fish tissue. Maximum fish tissue concentrations of DDE, endrin (not detected, concentrations based on MDL), mirex, and selenium remain below all selected human health screening levels.

Chemicals that were detected or estimated (using full MDLs where results were ND) in composited whole body samples of bullhead and/or yellow perch were compared (using maximum detected concentrations) to multiple screening levels used to assess fish consumption by humans. These chemicals included 2,3,7,8-TCDD (estimated), inorganic arsenic, DDE, DDT, Dieldrin, endrin (estimated), total mercury, mirex, selenium, and total PCBs. Estimated values for 2,3,7,8-TCDD and endrin, based on MDLs, were included in this evaluation because appropriate screening values are available for these two potentially toxic and/or carcinogenic and bioaccumulative chemicals, and because laboratory detection limits exceeded one or more screening levels. Tissue-based TEQs are discussed independently in the following section.

These chemicals (inorganic arsenic, DDE, DDT, Dieldrin, endrin, total mercury, mirex, total PCBs, selenium, and 2,3,7,8-TCDD) were evaluated by comparing maximum whole body concentrations (by species and by reservoir, based on composite fish samples) to the fish consumption screening levels (**Table 27**). For this comparison, MDLs were used for non-detected values. These SLs are provided for both cancer and non-cancer effects, where applicable, and is based on chemical concentrations in fish tissue in mg/kg, wet weight. For this evaluation, whole body concentrations of chemicals are considered representative of consumable tissue concentrations.

The selected human health screening levels (**Table 27**) include those based on a variety of exposure assumptions, including varying ingestion rates (where indicated, ranging from 17.5 to 142.4 grams of fish per day). The higher ingestion rates are (or can be viewed as analogous to) subsistence level consumption, which is not anticipated for humans associated with these reservoirs. Concentrations of several chemicals detected (inorganic arsenic, DDT, Dieldrin, total mercury, total PCBs) or estimated in whole body fish using MDLs (2.3.7.8-TCDD) exceed the most stringent (lowest) screening levels. However, of the detected chemicals, only inorganic arsenic and total PCBs exceed several of the selected human health screening levels. In most cases the degree of exceedance is not large except when comparisons are made to screening levels based on subsistence level consumption rates. Fish tissue data are unavailable for assessing whether or not the concentrations of 2,3,7,8-TCDD (not detected, concentrations based on MDLs), inorganic arsenic, DDE, DDT, Dieldrin, endrin, mercury, mirex, selenium, and total PCBs measured or estimated (using MDLs) in fish collected from the three reservoirs represent regional background conditions. It is expected that fish from locations with no known source of contamination would harbor detectable concentrations of some or all of these chemicals, several of which have been linked to atmospheric deposition.

Table 27. Chemicals in Whole Body Fish (wet weight) from Klamath Reservoirs, 2010 vs. Human Health Screening Levels (Fish Consumption)

Contaminant	Maximum Whole Body Bullhead Concentration by Reservoir (mg/kg ww)			Maximum Whole Body Yellow Perch Concentration by Reservoir (mg/kg ww)				EPA RSL Carcinogenic Target Risk (TR) = 1E-06	EPA RSL Noncancer Hazard Index (HI) = 1	ODEQ Acceptable Tissue Level, Human - Carcinogenic, general/recreational	ODEQ Acceptable Tissue Level, Human -Non-carcinogenic, general/recreational	CA SWAMP	Fish Consumption Guidelines, 32 gm fish/day OEHHA (2008)	Advisory Tissue Levels, 97 gm fish/day OEHHA (2008) 24 oz/wk	ODEQ 2007 Subsistence ATLs (142.4 gm fish/day) in humans	ODEQ ATLs (2007)	EPA HH Screening Level for 17.5 gm fish/day	EPA HH Screening Level for 142.4 gm fish/day	OEHHA HH Screening Values						
Analyte Detected or Estimated (Not detected, based on MDLs) in Whole Body Fish from Table 23	JC BOYLE	COPCO 1	IRON GATE	JC BOYLE	COPCO 1	IRON GATE		Ingestion (mg/kg)	Ingestion (mg/kg)	Ingestion (mg/kg)	Ingestion (mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)						
Arsenic, inorganic	**0.029**	**0.022**	**0.016**	**0.01**	**0.016**	**0.02**	0.0007600	0.0021	0.41	0.0062	1.2	NA	NA	NA	0.00076	NA	0.026	0.00327	1.2						
DDE, p,p'-	0.0071	0.0067	0.0037	0.0052	0.0017	0.0014	0.0093000	0.0093	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA						
DDT	**0.000024**	**0.000052**	**0.000016**	**0.000042**	**0.000039**	**0.000037**	0.0000034	0.0093	0.68	0.027	2.0	0.83	0.021	NA	3.4E-06	NA	0.117	0.0144	0.100						
Dieldrin	**0.000072**	**0.000064**	**0.000077**	**0.00013**	**0.000073**	**0.000088**	7.200E-08	0.0002	0.068	0.00058	0.12	0.024	0.00046	NA	7.2E-08	NA	0.0025	0.000307	0.002						
Endrin	0.000033	0.000038	0.000018	0.0000070	0.0000047	0.0000080	0.1470000	NA	0.41	NA	NA	NA	NA	NA	NA	NA	1.2	0.147	1.0						
Mercury, total	0.043	**0.36**	**0.073**	**0.100**	**0.086**	**0.14**	0.0490000	NA	0.22	NA	0.4	0.12	NA	0.07	0.049	NA	0.4	0.049	0.3						
Mirex	0.000028	0.000033	0.000016	0.000016	0.0000082	0.0000048	0.0001800	0.00018	0.27	NA	NA	NA	NA	NA	NA	NA	0.80	0.098	NA						
PCBs, total	**0.0179**	**0.0226**	**0.0406**	**0.020**	**0.0079**	**0.048**	0.0000006	0.0016	NA	0.0047	0.08	NA	NA	NA	5.7E-07	NA	NA	NA	NA						
Selenium	0.32	0.20	0.14	0.20	0.11	0.15	2.0000000	NA	6.8	NA	20	2.92	7.4	2.5	2.5	NA	20	2.457	2.0						
TCDD, 2,3,7,8	**5.10E-07**	**4.10E-07**	**4.00E-07**	**4.20E-07**	**4.30E-07**	**3.50E-07**	7.60E-09	2.40E-08	1.40E-06	6.20E-08	NA	NA	NA	NA	7.6E-09	NA	NA	NA	NA						

highlight indicates concentration based on MDL
bold tissue values indicate exceedance of one or more screening levels
screening level units = mg/kg wet weight
fish tissue concentrations of arsenic based on inorganic arsenic
fish tissue concentrations of mercury based on total mercury
fish tissue concentrations of 2,3,7,8-TCDD in this table are based on MDLs for 2,3,7,8-TCDD and are not based on calculated TEQs (see Table 28 for TEQ calculations)
EPA RSLs for total PCBs based on RSLs for Aroclor 1254

6.6 Total TEQ Evaluation

To assess the potential effects of these dioxin-like compounds, the same TEQ approach described in Section 3.5 is employed where estimated or measured concentrations of relevant dioxin-like congeners are converted to estimated concentrations of the most highly toxic form, 2,3,7,8-TCDD. Conversions are made using the TEFs provided for fish, birds, and mammals (including humans), and are taken from the World Health Organization (Van den Berg 1998 and Van den Berg 2006). The 2006 TEFs are used to generate TEQs for mammals and humans, while the 1998 TEFs are used for deriving TEQs for fish and birds.

TEQs derived for fish, birds, and mammals (including humans) based on the sum of measured or estimated concentrations multiplied by the compound-specific TEF are shown in **Table 28**. For this screening level effort, total TEQs only include data associated with detections and non-detected values set to zero. This approach prevents gross overestimations of total TEQ, which often result from assigning a value (e.g., half the reporting limit) to non-detected values.

Total TEQs for fish, birds, and mammals are compared to relevant ecological TRVs or human health SLs. Human health SLs used for this evaluation include SLs from two previously identified sources for evaluation of human health concerns related to fish consumption. These SLs are USEPA RSLs for cancer and non-cancer effects and ODEQ ATLs for cancer effects. Total TEQs for fish, birds, and mammals are compared to No Effect and Low Effect tissue-based TRVs for bullhead and yellow perch (**Table 28**), as described previously. For this screening level evaluation, concentrations of chemicals in whole body fish are assumed to represent concentrations in edible fish tissue. The results of these comparisons are summarized below.

All total TEQs for fish, birds, and mammals derived for bullhead and yellow perch samples from all reservoirs remain below both the No Effect and Low Effect TRVs (**Table 28**).

All total TEQs for humans derived for bullhead and yellow perch samples from all reservoirs exceed the human health RSL and ATL for cancer, but none exceeds the human health RSL for non-cancer effects (**Table 28**). The Human Health RSLs and ATLs for cancer effects are calculated to reflect concentrations corresponding to a "one-in-a-million" (1×10^{-6}) cancer risk, and may be difficult or not yet possible to achieve analytically.

The highest TEQs are associated with bullhead from Copco 1 reservoir, with lower concentrations observed in bullhead from J.C. Boyle and Iron Gate reservoirs. The lowest TEQs for bullhead are from J.C. Boyle reservoir. For yellow perch, the highest TEQs are associated with J.C. Boyle, while the lowest TEQs for yellow perch are from Copco 1 reservoir. These findings suggest no consistent pattern can be attributed to reservoir specific TEQ values for fish other than slightly higher values for bullhead from Copco 1, which is consistent with TEQs based on evaluations of these chemicals in sediment, discussed in Section 3.5.

Table 28. TEQ Screening (Sum Dioxin, Furan, PCB) for Fish from Klamath Reservoirs and Invertebrate Tissue Exposed to Klamath Reservoir Sediments, 2009-2010

Fish Total TEQs using WHO 1998 Fish TEFs (from Van den Berg et al. 1998)

								Total TEQ ND = 0	Mean Total TEQ (fish) ND = 0			Residue-based TRVs mg/kg wet weight			
					Total TEQs							No Effect	Low Effect	No Effect	Low Effect
Sample	Taxon	Congeners	Non-detects	Units	ND = MDL	ND = 0	ND = MDL/2	mg/kg	Taxon	mg/kg	Location	Bullhead	Bullhead	Yellow Perch	Yellow Perch
JC-BH COMP 1	Bullhead	29	16	pg/g	3.405	0.022	1.714	2.20E-08	Bullhead	2.78E-08	Copco 1	**1.90E-01**	**1.90E+00**	**1.43E-04**	**1.43E-03**
JC-BH COMP 2	Bullhead	29	17	pg/g	2.557	0.017	1.287	1.74E-08	Yellow Perch	5.76E-09		All < TRV	All < TRV	All < TRV	All < TRV
JC-YP COMP 1	Yellow Perch	29	16	pg/g	2.437	0.020	1.229	1.97E-08	Clam	5.14E-09					
JC-CF	Clam	29	19	pg/g	3.763	0.004	1.884	4.45E-09	Worm	2.09E-08					
JC-LV	Worm	29	19	pg/g	0.546	0.023	0.284	2.25E-08	Bullhead	1.75E-08	Iron Gate				
CR-BH COMP 1	Bullhead	29	15	pg/g	2.286	0.028	1.157	2.78E-08	Yellow Perch	9.15E-09					
CR-YP COMP 1	Yellow Perch	29	18	pg/g	2.573	0.006	1.289	5.76E-09	Clam	3.71E-09					
CR-CF	Clam	29	20	pg/g	3.790	0.005	1.897	5.14E-09	Worm	1.05E-08					
CR-LV	Worm	29	16	pg/g	0.274	0.021	0.148	2.09E-08	Bullhead	1.97E-08	JC Boyle				
IG-BH COMP 1	Bullhead	29	15	pg/g	2.298	0.017	1.158	1.75E-08	Yellow Perch	1.97E-08					
IG-YP COMP 1	Yellow Perch	29	16	pg/g	2.304	0.009	1.157	9.15E-09	Clam	4.45E-09					
IG-CF	Clam	29	19	pg/g	2.656	0.004	1.330	3.71E-09	Worm	2.25E-08					
IG-LV	Worm	29	17	pg/g	0.281	0.011	0.146	1.05E-08	Bullhead	NA	Upper Estuary				
UE-CF	Clam	29	18	pg/g	3.083	0.005	1.544	5.01E-09	Yellow Perch	NA					
UE-LV	Worm	17	15	pg/g	0.391	0.001	0.196	1.21E-09	Clam	1.62E-08					
LC-CF-1	Clam	29	19	pg/g	3.838	0.012	1.925	1.23E-08	Worm	4.92E-08					
LC-CF-2	Clam	29	15	pg/g	3.378	0.020	1.699	2.01E-08	Bullhead	NA	Lab Control				
LC-LV-1	Worm	17	14	pg/g	3.946	0.014	1.980	1.36E-08	Yellow Perch	NA					
LC-LV-2	Worm	29	20	pg/g	0.436	0.001	0.218	7.81E-10	Clam	5.01E-09					
LC-LV-3	Worm	29	18	pg/g	0.515	0.002	0.259	2.38E-09	Worm	1.21E-09					
LC-LV-4	Worm	29	13	pg/g	0.494	0.180	0.337	1.80E-07							

Bird Total TEQs using WHO 1998 Bird TEFs (from Van den Berg et al. 1998)

								Total TEQ ND = 0	Mean Total TEQ (bird) ND = 0			Residue-based TRVs mg/kg wet weight			
					Total TEQs							No Effect	Low Effect	No Effect	Low Effect
Sample	Taxon	Congeners	Non-detects	Units	ND = MDL	ND = 0	ND = MDL/2	mg/kg	Taxon	mg/kg	Location	Bullhead	Bullhead	Yellow Perch	Yellow Perch
JC-BH COMP 1	Bullhead	29	16	pg/g	5.147	0.567	2.857	5.67E-07	Bullhead	6.82E-07	Copco 1	**1.90E-01**	**1.90E+00**	**1.43E-04**	**1.43E-03**
JC-BH COMP 2	Bullhead	29	17	pg/g	4.610	0.537	2.574	5.37E-07	Yellow Perch	2.71E-07		All < TRV	All < TRV	All < TRV	All < TRV
JC-YP COMP 1	Yellow Perch	29	16	pg/g	4.581	0.742	2.662	7.42E-07	Clam	2.26E-07					
JC-CF	Clam	29	19	pg/g	5.351	0.244	2.798	2.44E-07	Worm	3.72E-07					
JC-LV	Worm	29	19	pg/g	0.776	0.025	0.400	2.46E-08	Bullhead	5.49E-07	Iron Gate				
CR-BH COMP 1	Bullhead	29	15	pg/g	4.226	0.682	2.454	6.82E-07	Yellow Perch	3.32E-07					
CR-YP COMP 1	Yellow Perch	29	18	pg/g	4.294	0.271	2.283	2.71E-07	Clam	2.28E-07					
CR-CF	Clam	29	20	pg/g	5.997	0.226	3.111	2.26E-07	Worm	1.48E-07					
CR-LV	Worm	29	16	pg/g	0.722	0.372	0.547	3.72E-07	Bullhead	5.52E-07	JC Boyle				
IG-BH COMP 1	Bullhead	29	15	pg/g	4.230	0.549	2.390	5.49E-07	Yellow Perch	7.42E-07					
IG-YP COMP 1	Yellow Perch	29	16	pg/g	3.783	0.332	2.057	3.32E-07	Clam	2.44E-07					
IG-CF	Clam	29	19	pg/g	4.341	0.228	2.285	2.28E-07	Worm	2.46E-08					

Table 28. TEQ Screening (Sum Dioxin, Furan, PCB) for Fish from Klamath Reservoirs and Invertebrate Tissue Exposed to Klamath Reservoir Sediments, 2009-2010

Fish Total TEQs using WHO 1998 Fish TEFs (from Van den Berg et al. 1998)

								Total TEQ	Mean Total TEQ (fish)			Residue-based TRVs mg/kg wet weight			
					Total TEQs			ND = 0	ND = 0			No Effect	Low Effect	No Effect	Low Effect
Sample	**Taxon**	**Congeners**	**Non-detects**	**Units**	**ND = MDL**	**ND = 0**	**ND = MDL/2**	**mg/kg**	**Taxon**	**mg/kg**	**Location**	**Bullhead**	**Bullhead**	**Yellow Perch**	**Yellow Perch**
IG-LV	Worm	29	17	pg/g	0.648	0.148	0.398	1.48E-07	Bullhead	NA	Upper Estuary				
UE-CF	Clam	29	18	pg/g	4.844	0.305	2.574	3.05E-07	Yellow Perch	NA					
UE-LV	Worm	17	15	pg/g	0.523	0.001	0.262	1.21E-09	Clam	3.72E-07					
LC-CF-1	Clam	29	19	pg/g	5.430	0.469	2.949	4.69E-07	Worm	8.31E-08					
LC-CF-2	Clam	29	15	pg/g	5.397	0.275	2.836	2.75E-07	Bullhead	NA	Lab Control				
LC-LV-1	Worm	17	14	pg/g	5.738	0.013	2.876	1.33E-08	Yellow Perch	NA					
LC-LV-2	Worm	29	20	pg/g	0.808	0.099	0.453	9.93E-08	Clam	3.05E-07					
LC-LV-3	Worm	29	18	pg/g	0.834	0.040	0.437	4.03E-08	Worm	1.21E-09					
LC-LV-4	Worm	29	13	pg/g	0.846	0.179	0.513	1.79E-07							

Human and Mammalian Total TEQs using WHO 2005 Human and Mammalian TEFs (from Van den Berg et al. 2006)

								Total TEQ	Mean Total TEQ (mammal / human)			Residue-based TRVs mg/kg wet weight			
					Total TEQs			ND = 0	ND = 0			No Effect	Low Effect	No Effect	Low Effect
Sample	**Taxon**	**Congeners**	**Non-detects**	**Units**	**ND = MDL**	**ND = 0**	**ND = MDL/2**	**mg/kg**	**Taxon**	**mg/kg**	**Location**	**Bullhead**	**Bullhead**	**Yellow Perch**	**Yellow Perch**
JC-BH COMP 1	Bullhead	29	16	pg/g	3.196	0.344	1.770	3.44E-07	Bullhead	**4.75E-07**	Copco 1	**1.90E-01**	**1.90E+00**	**1.43E-04**	**1.43E-03**
JC-BH COMP 2	Bullhead	29	17	pg/g	2.488	0.275	1.381	2.75E-07	Yellow Perch	**8.28E-08**		All < TRV	All < TRV	All < TRV	All < TRV
JC-YP COMP 1	Yellow Perch	29	16	pg/g	2.423	0.303	1.363	3.03E-07	Clam	2.82E-08					
JC-CF	Clam	29	19	pg/g	3.493	0.026	1.759	2.56E-08	Worm	5.65E-08		**EPA RSL Human Health Screening Level mg/kg wet weight**			
JC-LV	Worm	29	19	pg/g	0.575	0.052	0.313	5.16E-08	Bullhead	**3.86E-07**	Iron Gate				
CR-BH COMP 1	Bullhead	29	15	pg/g	2.420	0.475	1.448	4.75E-07	Yellow Perch	**2.10E-07**		**Cancer**			**Non Cancer**
CR-YP COMP 1	Yellow Perch	29	18	pg/g	2.319	0.083	1.201	8.28E-08	Clam	1.97E-08		**2.40E-08**			**1.40E-06**
CR-CF	Clam	29	20	pg/g	3.527	0.028	1.777	2.82E-08	Worm	2.21E-08		Bullhead & Yellow Perch Exceed for All 3 Reservoirs			All < SL
CR-LV	Worm	29	16	pg/g	0.304	0.056	0.180	5.65E-08	Bullhead	**3.10E-07**	JC Boyle				
IG-BH COMP 1	Bullhead	29	15	pg/g	2.361	0.386	1.373	3.86E-07	Yellow Perch	**3.03E-07**					
IG-YP COMP 1	Yellow Perch	29	16	pg/g	2.192	0.210	1.201	2.10E-07	Clam	2.56E-08		**ODEQ Acceptable tissue level, human wet weight**			**mg/kg**
IG-CF	Clam	29	19	pg/g	2.445	0.020	1.232	1.97E-08	Worm	5.16E-08					

Table 28. TEQ Screening (Sum Dioxin, Furan, PCB) for Fish from Klamath Reservoirs and Invertebrate Tissue Exposed to Klamath Reservoir Sediments, 2009-2010

Fish Total TEQs using WHO 1998 Fish TEFs (from Van den Berg et al. 1998)

Sample	Taxon	Congeners	Non-detects	Units	Total TEQs ND = MDL	ND = 0	ND = MDL/2	Total TEQ ND = 0 mg/kg	Mean Total TEQ (fish) ND = 0 Taxon	mg/kg	Location	Residue-based TRVs mg/kg wet weight No Effect Bullhead	Low Effect Bullhead	No Effect Yellow Perch	Low Effect Yellow Perch
IG-LV	Worm	29	17	pg/g	0.297	0.022	0.160	2.21E-08	Bullhead	NA	Upper Estuary	**Cancer**			**Non Cancer**
UE-CF	Clam	29	18	pg/g	2.772	0.050	1.411	4.99E-08	Yellow Perch	NA		**6.20E-08**			**NA**
UE-LV	Worm	17	15	pg/g	0.347	0.001	0.174	1.43E-09	Clam	1.46E-07		Bullhead Exceed for All 3 Reservoirs Yellow perch exceed for Iron Gate and J.C. Boyle			NA
LC-CF-1	Clam	29	19	pg/g	3.460	0.176	1.818	1.76E-07	Worm	3.41E-08					
LC-CF-2	Clam	29	15	pg/g	2.997	0.116	1.557	1.16E-07	Bullhead	NA	Lab Control				
LC-LV-1	Worm	17	14	pg/g	3.380	0.015	1.697	1.48E-08	Yellow Perch	NA		human health screening levels based on fish consumption, assume whole body fish contaminant concentrations equal to concentrations in edible (muscle/fillet) tissue			
LC-LV-2	Worm	29	20	pg/g	0.434	0.004	0.219	3.56E-09	Clam	4.99E-08					
LC-LV-3	Worm	29	18	pg/g	0.530	0.007	0.268	6.70E-09	Worm	1.43E-09					
LC-LV-4	Worm	29	13	pg/g	0.462	0.111	0.286	1.11E-07							

bold type and bold borders indicate exceedance of TRV

TEQ: toxic equivalency
TEF: toxicity equivalency factor
WHO: World Health Organization
EPA: United States Environmental Protection Agency
ODEQ: Oregon Department of Environmental Quality
ND: not detected

mg: milligram
kg: kilogram
TRV: toxicity reference value
RSL: regional screening level
MDL: method detection limit

pg: picogram
g: gram
NA: not applicable
SL: screening level
RL: sample reporting limit

Sample #
JC - J.C. Boyle Reservoir
CR - Copco 1 Reservoir
IG - Iron Gate Reservoir
UE - Upper Klamath Estuary
LC - Laboratory Control Sample

Chapter 7 Exposure Pathway Evaluation and Conclusions

7.1 Lines of Evidence Included in the Evaluation

The evaluation process for identifying the potential for adverse ecological or human health effects from the reservoir sediments used 20 lines of evidence as described in Section 1.4. The lines of evidence are based on the screening level elements shown in **Figure 2** and the results of various analyses discussed in Chapters 3 through 6. The evaluation is based upon potential impacts using the following five exposure pathways:

- Pathway 1 – Proposed Action - Short-term water column exposure for aquatic biota from sediments flushed downstream (suspended sediments, not a bioaccumulation issue)
- Pathway 2 – Proposed Action - Long-term sediment exposure for riparian biota and humans from reservoir terrace deposits and river bank deposits (terrestrial exposures)
- Pathway 3 – Proposed Action - Long-term sediment exposures for aquatic biota and humans from river bed deposits (aquatic exposures)
- Pathway 4 – Proposed Action - Long-term sediment exposure for aquatic biota from estuary and marine near shore deposits
- Pathway 5 – No Action - Long-term sediment exposure for aquatic biota and humans (via fish consumption) to reservoir sediments

The lines of evidence used to evaluate each pathway are shown in **Table 29**, which presents the same information as Table 1. Various lines of evidence were integrated to draw conclusions regarding potential adverse effects from chemical contamination in reservoir sediments for each of the exposure pathways if the dams are removed (Proposed Action “dams removed”) and a portion of the accumulated sediments are flushed downstream (Pathways 1 through 4), and if the dams remain in place (No Action “dams in”) (Pathway 5).

Table 29. Summary of the Lines of Evidence Used to Evaluate Each Exposure Pathway

Line of Evidence	Exposure Pathways				
	1	2	3	4	5
Sediment Evaluation Framework Level 2A Step 1 – Sediment Screening Levels					
1. DMMP Marine MLs				+	
Sediment Evaluation Framework Level 2A Steps 2a, 2b, 2c, 2d – Sediment Screening Levels					
2. Ecological SLs (freshwater and marine)			+	+	+
3. Ecological TEQ SLVs (sediment)			+	+	+
Sediment Evaluation Framework Level 2B – Results of Water Quality Criteria Evaluations and Bioassays					
4. Elutriate WQC (ecological)	+			+	
5. Chironomus Bioassay			+	+	+
6. Hyalella Bioassay			+	+	+
7. Trout Bioassay	+			+	
8. Corbicula Bioaccumulation Study/BSAF			+		+
9. Lumbriculus Bioaccumulation Study/BSAF			+		+
10. Corbicula Tissue TRV			+	+	+
11. Lumbriculus Tissue TRV			+	+	+
Special Evaluations –Human Health in Sediment and Fish Tissue					
12. Perch Tissue TRV (ecological)			+	+	+
13. Bullhead Tissue TRV (ecological)			+	+	+
14. Fish Tissue TEQ (ecological)			+	+	+
15. HHSLs		+	+		+
16. HH TEQ SLVs (sediment)		+	+		+
17. Elutriate WQC (human health)					
18. Perch Tissue TRV (human health)			+		+
19. Bullhead Tissue TRV (human health)			+		+
20. Fish Tissue TEQ (human health)			+		+

+: applicable line of evidence for exposure pathway

Corbicula fluminea =Asian clam (representative bivalve)
Lumbriculus variegatus = blackworm (representative oligochaete)

TEQ: Toxic Equivalency
SLV: Screening Level Value
WQC: Water Quality Criteria
TRV: Toxicity Reference Value
BSAF: Biota-Sediment Accumulation Factor
HHSL: Human Health Screening Level

7.2 Pathway Evaluation Results and Conclusions

Based on the lines of evidence and in consideration of expected physical processes (e.g., mixing, dilution, and dispersion), the overall conclusions for each of the five exposure pathways are described in this section and summarized on **Figure 7**. This report evaluates potential adverse effects associated with chemical exposure under each pathway and does not evaluate the potential adverse physical effects, such as dissolved oxygen in the water, suspended sediment, siltation/embeddedness, flow alteration, habitat, or other sedimentation and geomorphic impacts. A pathway is termed "incomplete" when the receptor group is unlikely to come in contact sediment-associated contaminants under the given pathway.

	Exposure Pathway	Freshwater biota	Marine biota	Terrestrial biota	Humans
Pathway 1	Short-term exposure to sediments flushed downstream	🟢	🔵	--	--
Pathway 2	Long-term exposure to exposed reservoir terrace and or river bank deposits	--	--	⚫ (1)	🔵 (2)
Pathway 3	Long-term exposure to new river channels and river bed deposits	🔵	--	--	🔵
Pathway 4	Long-term exposure to marine / near shore deposits	--	🔵	--	--
Pathway 5	Long-term exposure to reservoir sediments	🟢	--	--	🟢

⚫	No adverse effects based on lines of evidence
🔵	One or more chemicals present, but at levels unlikely to cause adverse effects based on the lines of evidence
🟢	One or more chemicals present at levels with potential to cause minor or limited adverse effects based on the lines of evidence
🔴	At least one chemical detected at a level with potential for significant adverse effects based on the lines of evidence
--	This exposure pathway is incomplete[3] or insignificant[4] for this receptor group

Note:
This does not include an evaluation of the physical effects (e.g., dissolved oxygen in the water, suspended sediment)
(1) Qualitative evaluation conducted for this exposure pathway
(2) Limited quantitative, along with qualitative evaluations conducted for this exposure pathway
(3) Incomplete - receptor group is unlikely to come in contact with sediment-associated contaminants under this exposure pathway
(4) Insignificant - exposure pathway not considered a major contributor to adverse effects in humans based on best professional judgment

Figure 7
Summary of Conclusions for Exposure Pathways

7.2.1 Exposure Pathway 1

The effects of short-term water column exposure for aquatic (freshwater and marine) biota from sediments flushed downstream under Proposed Action "dams removed" was evaluated. This pathway evaluates the potential effects from exposure to chemical contaminants during the short term turbid conditions expected to occur immediately following the removal of the dams. This exposure pathway is considered incomplete or insignificant due to much reduced frequency and duration of exposure for terrestrial biota and human receptors. Thus, effects to these receptor groups are not evaluated, as identified on **Figure 7**.

The lines of evidence for evaluating potential effects to freshwater and marine biota include the following:

- Comparisons of elutriate chemistry results to freshwater and marine water quality criteria (line of evidence 4 in **Table 29** with results shown in **Tables 8 - 15**); and

- Evaluation of results of the elutriate toxicity bioassay for rainbow trout (line of evidence 7 in **Table 29** with results shown in **Table 16**).

The evaluations of these lines of evidence are discussed below.

Level 2B - Comparisons of elutriate chemistry results to freshwater and marine water quality criteria

Based on estimated range of dilution (48- to 66- fold), the only chemicals that may be an issue in the short-term (i.e., less than 2 years, and episodically) following dam removal are total phosphorus, aluminum, arsenic and total PCBs and only for either marine water quality or human health criteria compliance. Although undiluted elutriate concentrations would initially exceed water quality criteria, the water quality criteria only apply after initial mixing once the dams are removed. Once the dams are removed, mixing, along with dilution and dispersion, will be rapid and substantial as the sediment moves downstream. These actions are expected to reduce the concentration of the sediment and their associated chemicals to levels that are below concern.

These comparisons reveal that several chemical concentrations in undiluted elutriate exceed one or more water quality criteria, including those intended for evaluating surface water exposures for freshwater and marine water column biota. Chemicals that exceed one or more surface water quality criteria include those generally considered to be minimally toxic (e.g., phosphorus and aluminum,) as well as those with potential for contributing to adverse effects (e.g., arsenic, chromium, copper, lead, mercury, nickel, zinc, ammonia, and total PCBs). Exposures to suspended sediment with elevated concentrations of potentially toxic chemicals are of lower concern for aquatic life than exposures to elevated concentrations of dissolved chemicals. The metals with the greatest potential to cause adverse effects in elutriate (e.g., copper, chromium, lead, mercury, nickel and zinc) are, under field conditions, associated with this exposure pathway, expected to bind to particulate matter and therefore are unlikely to contribute substantially to elevated concentrations of the more toxic dissolved forms in the water column.

Level 2B - Evaluation of results of elutriate toxicity bioassay for rainbow trout

Short-term toxicity to fish caused by the mobilized reservoir sediment will not be a concern in the downstream river sections based on the results of the bioassays. The bioassay results suggest for J.C. Boyle Reservoir sediments, with an LC-50 over 100 percent, that no toxicity exists and no water column toxicity to rainbow trout is expected downstream of the dam. LC-50 values between 20 and 70 percent for Copco 1 and Iron Gate sediments suggest water column toxicity exists and may have an adverse effect downstream if not diluted. Only a 2- to 4-fold dilution of the 100 percent elutriate strength would be required to prevent water column toxicity to rainbow trout and comply with the narrative water quality criteria. With the estimated dilution factor of about 48- to 66-fold expected to occur when the dams are removed, this dilution should be sufficient to eliminate rainbow trout toxicity found in the elutriate sediments from both reservoirs, and should also be high enough to be protective of other fish species that may be more sensitive than rainbow trout.

Pathway 1 Conclusions:

Overall, the lines of evidence used to evaluate this pathway suggest short term minor adverse effects for freshwater receptors are possible during the initial period following dam removal (**Figure 7**), most likely at locations immediately below the dams where the concentration of suspended sediments is expected to be the highest. Longer term and more serious adverse effects (e.g., those that might affect populations or communities) are not expected.

It is unlikely that marine ecological receptors would experience adverse effects from short-term exposure to chemicals in the sediments transported to the estuary and near shore areas. The chemical concentrations in the sediments will be diluted by the combining of the sediment loads from the four reservoirs and mixing with the sediment loads from the rest of the watershed including the lower Klamath River tributaries. Because the reservoir sediments are comprised mainly of fine sediments (silt and clay), the sediments will likely remain suspended while traveling downstream, through the estuary and into the ocean due to currents, winds, and wave energy. This would lead to further dilution in the near shore area. As a result of this mixing, dilution, and wide-spread dispersion, short-term toxicity or other adverse effects in the offshore areas where the sediments would eventually settle (and the long-term exposure would occur) is expected to be reduced to levels that are no longer a concern.

7.2.2 Exposure Pathway 2

The effects of potential long-term sediment exposure for terrestrial biota and humans from newly exposed reservoir terraces and river bank deposits (terrestrial exposures) under Proposed Action "dams removal" was evaluated. As part of this pathway, a portion of sediment currently located behind each of the dams would be mobilized, dispersed, and carried downstream. Even though modeling has indicated a minimal amount of deposition will occur along the downstream river bank (BOR 2011 and Stillwater Sciences 2008), the potential adverse effects of these deposited sediments (e.g. onto banks) were evaluated. In addition, some of the sediments remaining in the reservoir footprint would be exposed as the water level drops once the dam is removed. At both river bank and exposed reservoir terraces, terrestrial biota and human receptors could be exposed to the new soils. Under this pathway exposed sediments will be viewed as soils rather than sediments because overlying water will no longer be present. This exposure pathway is incomplete (no exposures would occur) for freshwater and marine biota given the terrestrial association of exposed sediments (soils) that were not expressly studied and, thus, effects to these receptor groups are not evaluated, as identified on **Figure 7**.

Two lines of evidence shown in **Table 29** are directly relevant for evaluating the potential adverse effects of the new soils on human receptors. No lines of evidence are directly relevant for for terrestrial biota. Thus, a limited quantitative evalution for exposure potential for human receptors and a qualitative evaluation for terrestrial biota that might inhabit or use the newly defined soils was performed.

Under this pathway terrestrial biota with some potential for exposure to former sediments are expected to include terrestrial plants, soil-associated invertebrates (e.g., earthworms), birds, small mammals (e.g., rodents), and larger mammals (e.g. deer and humans). Specific receptors are likely to vary depending on type and degree of vegetation and on other habitat-related features as well as potential for recreational use by human receptors. Reservoir sediments were not found to be highly toxic based on comparison to relevant SLs (**Tables 2** and **3**) and exposure to the anticipated small amounts of sediments that would become soil is unlikely to increase potential for adverse effects in terrestrial receptors as these sediments dry and become associated with terrestrial environments.

Although this pathway for terrestrial biota is not quantitatively evaluated with analytical data specifically collected, best professional judgment based on available data are used to conclude adverse effects are not likely to be observed in exposed terrestrial biota (**Figure 7**). This conclusion considers the relatively small amount of sediment anticipated to be deposited and form soil, along with the low toxicity of current reservoir sediments that may become exposed.

The lines of evidence to evaluate potential effects to human receptors include the following:

- Comparison of sediment concentrations to human health SLs (including TEQs) (lines of evidence 15 and 16 in **Table 29** with results shown in **Tables 3, 5, 6,** and **7**)

Special Evaluations - Comparisons of sediment chemical concentrations to human health SLs including comparisons of sediment TEQs to ODEQ Bioaccumulation SLVs

For this analysis, none of the physical or chemical changes that may occur when sediments convert to soils were assumed to impact the chemical concentrations (i.e., the concentrations would remain the same as identified in the sediment). Exposure to humans would most likely be limited to short duration, intermittent recreational use, rather than from residential use or long duration working in the areas of the new soils.

Relatively few chemicals detected in sediment exceeded human health SLs for soil. Several additional chemicals were selected as COPCs due to elevated sample RLs. Results of this evaluation suggest the sediments are not highly toxic.

Only arsenic and nickel were detected in the sediment at levels that exceeded USEPA regional screening levels (RSLs) for residential use or California Human Health Screening Levels (CHHSLs) from the 77 samples collected across all three reservoirs (**Table 3**). The USEPA RSL value that was exceeded was the more stringent total carcinogen RSL. All detected concentrations were below the total non-carcinogen RSLs.

Several pesticides and SVOCs were not detected; yet, the RLs were above at least one of the human health SLs (EPA RSL, CHHLS, and ODEQ SLVs in the case of J.C. Boyle).

Calculated TEQs are at concentrations above ODEQ Bioaccumulation SLVs for mammal individual and mammal population (including humans) in sediments from each of the reservoirs (**Tables 5**, **6**, and **7**). ODEQ Bioaccumulation SLVs are not applicable to water bodies in California; however, they provide a reference for comparison purposes.

As mentioned under Pathway 1, several chemicals may have levels that exceed human health SLs during the initial period of the Proposed Action after dilution has occurred. These levels are not expected to last over the long term under this exposure pathway.

Based on the comparative results and general review of the analytical sediment data, one or two chemicals have been detected at concentrations warranting further investigation, but are at concentrations unlikely to cause adverse effects in exposed human receptors (**Figure 7**). This conclusion considers the relatively small amount of sediment anticipated to be deposited and form soil, along with the low toxicity of current reservoir sediments, and expectations of infrequent human exposures of short duration.

7.2.3 Exposure Pathway 3

The effects of potential long-term sediment exposure for aquatic biota and humans from river bed deposits (aquatic exposures) under Proposed Action "dams removed" were evaluated. This pathway considers two different environments. First to be considered is aquatic life and human receptors exposed to reservoir sediments within the newly formed river channels if the dams were to be removed. Second is aquatic life and human receptors exposed to sediment that would be newly deposited within the river channel downstream of current dams if they were to be removed. These exposure pathways are recognized as being distinct; however, they are evaluated using the same lines of evidence.

As part of this pathway, a portion of sediment currently located behind each of the dams would be mobilized, dispersed, and carried to the ocean with minimal deposition downstream and in the estuary. These assumptions are supported by modeling performed as part of the Klamath River dam removal study: sediment transport Dam Removal Express Assessment Models (DREAM)-1 simulation, a peer reviewed sediment transport model (BOR 2011 and Stillwater Sciences 2008). Results of multiple modeling runs using DREAM to examine dam removal scenarios predicted little to no discernable fine sediment deposition due to the overall fine grain nature of the sediments (i.e. silts and clays) and the dominance of the high gradient river channel downstream of Iron Gate Dam. Deposition of some coarser sediment (i.e. sand) may occur, but sediments of these grain sizes are not typically associated with appreciable contaminant levels due to their lack of organic matter and lower cation exchange capacities.

Some of the remaining reservoir sediments are expect to make up the newly formed river channel within the former reservoirs. In these new channels, erosion will cause deeper sediments to be exposed than under current conditions.

Either exposure pathway (downstream deposits or deeper reservoir sediment) would be incomplete for marine and terrestrial biota. The effects to these receptor groups are not evaluated, as identified on **Figure 7**.

The lines of evidence to evaluate potential effects to freshwater biota include the following:

- Comparisons of sediment concentrations to freshwater sediment ecological SLs, including comparisons of sediment TEQs to ODEQ Bioaccumulation SLVs (lines of evidence 2 and 3 in **Table 29** with results shown in **Tables 2, 5, 6** and **7**);

- Evaluation of results of the sediment toxicity bioassay for the benthic invertebrates (midge and amphipod) (lines of evidence 5 and 6 in **Table 29** with results shown in **Table 17**);

- Calculation of BSAF for invertebrates (focused 28 day laboratory bioaccumulation study) (lines of evidence 8 and 9 in **Table 29** with results shown in **Table 22**);

- Comparisons of tissue-based TRVs to chemical concentrations (including TEQs) in laboratory reared freshwater clams and worms exposed to field collected sediments (lines of evidence 10 and 11 in **Table 29** with results shown in **Tables 21** and **28**); and

- Comparisons of tissue-based TRVs to chemical concentrations (including TEQs) in field collected fish tissue (lines of evidence 12, 13, and 14 in **Table 29** with results shown in **Tables 26** and **28**); this is a conservative line of evidence for riverine fish because exposures would be greatly reduced from those experienced by reservoir fish.

The lines of evidence to evaluate potential effects to human receptors include the following:

- Comparison of sediment concentrations to human health SLs (including TEQs) (lines of evidence 15 and 16 in **Table 29** with results shown in **Tables 3, 5, 6,** and **7**); and

- Comparisons of chemical concentrations in fish to human health SLs for fish based on fish ingestion exposures (lines of evidence 18, 19, and 20 in **Table 29** with results shown in **Table 27** and **28**).

Level 2A -- Comparison of sediment concentrations to freshwater sediment ecological SLs, including comparisons of sediment TEQs to ODEQ Bioaccumulation SLVs

Overall, quality of the sediments collected from the three reservoirs and estuary does not appear to be highly contaminated. From 77 samples across all three reservoirs, only eight chemicals were detected in the sediment at levels that exceeded at least one available screening level (**Table 2**). Of these, only nickel, from all three reservoirs exceeded SEF SL-1 and SL-2 (Step 2b in Figure 2). The remaining seven chemicals exceeded SLs under Steps 2c and 2d in Figure 2 and included iron and some legacy pesticides and dioxin-like compounds (4,4-DDD, 4,4-DDE, 4,4-DDT, Dieldrin, and 2,3,7,8-TCDD found in J.C. Boyle, and 2,3,4,7,8-PECDF.

Several pesticides and semi-volatile organic compounds (SVOCs) were not detected; yet, the reporting limits were above the SLs from Step 2a to Step 2d in **Figure 2**, so other lines of evidence are used to assess these compounds. This issue was addressed in studies under Level 2B.

No consistent pattern of elevated chemical distribution is observed across discrete sampling locations within a reservoir; however, sediment in J.C. Boyle does have marginally higher chemical concentrations and more detected chemicals of potential concern (COPCs) in sediment based on comparison to ecological SLs when compared to the other reservoirs.

There is potential for adverse effects associated with exposure to chemicals in the reservoir sediment without consideration for mixing, dilution, or dispersion. These conditions will apply to the newly formed river channels.

Deposition of sediments downstream and associated exposures by aquatic life are unlikely to cause adverse effects in aquatic biota. This conclusion is based on: 1) frequency and magnitude of exceedance of screening levels; and 2) the expectation of substantial dispersion of sediments prior to deposition. Long term exposures to reservoir sediments transported and deposited downstream under this pathway are expected to be reduced compared to the current exposure potential for “dams in” reservoir sediments because sediments are expected to be mixed, diluted, dispersed, and ultimately carried to the ocean with the majority of the sediments exiting the Klamath River system, as supported by the results of the DREAM-1 simulations described above.

TEQs were calculated for dioxin, furan, and dioxin-like PCBs. The resulting TEQs are only slightly above regional background concentrations and thus have limited potential for adverse effects for both ecological receptors exposed to sediments (EPA 2010). Calculated TEQs are at concentrations above ODEQ Bioaccumulation SLVs (SEF Step 2c) for mammals, fish, and birds in sediments from each of the reservoirs (**Tables 5**, **6**, and **7**). ODEQ Bioaccumulation SLVs are not applicable to water bodies in California; however, they provide a reference for comparison purposes even though the SLVs have very low values. Sources of detected compounds have not been evaluated; however, sources may include atmospheric deposition and regional forest fires.

These TEQs preliminarily suggest that sediment-associated biota exposed to reservoir sediments have potential to be exposed to levels of dioxins and furans with the possibility of adverse affect. These results are based on exposure to reservoir sediments without consideration for mixing, dilution, or dispersion that are expected to occur following dam removal. Therefore, the TEQ results could only be expect to apply to the newly formed river channel. The chemical concentrations in the reservoir sediments and the associated TEQs are expected to be reduced downstream under this pathway because sediments will be mixed and diluted with other sediments from all the reservoirs and watershed, dispersed over a large area and over time, and removed from the river system once the dams are removed, if Proposed Action “dams removed” is implemented. Furthermore, the composition of the food web including invertebrate and fish species colonizing the newly formed riverine sections will be very different from those inhabiting the reservoirs; thus, extrapolation of reservoir results to this pathway provides a conservative estimate of exposure.

Level 2B - Evaluation of results of the sediment toxicity bioassay for the benthic invertebrates (midge and amphipod)

The results of the acute toxicity bioassays for the midge and the amphipod identified no statistically significant difference in survival of either test organism exposed to reservoir sediments compared to control sediments, with the exception of the survival of midge exposed to on-thalweg sediments from the J.C. Boyle (**Tables 17**). Although not statistically significant, the mean midge survival for the off-thalweg sediments at the J.C. Boyle was also lower than control sediments. These results indicate that survival of benthic organisms is not adversely affected by chemical concentrations in sediments at Copco 1 and Iron Gate reservoirs or the estuary. However, the negative response shown by the midge to the test conditions when exposed to the on-thalweg sediment of J.C. Boyle suggests that those sediments at J.C. Boyle may contribute to reduced survival. The cause for the reduction in midge survival may be due to sediment chemistry or other factors or a combination of several factors not discerned by the test. These results are based on exposure to reservoir sediments without consideration for mixing, dilution, or dispersion and would apply to the newly formed river channel if the dams are removed.

No long-term toxic effects are expected to occur in benthic invertebrates and other aquatic life at downstream depositional areas. The sediments expected to be eroded from J.C. Boyle will be subject to mixing with sediments from the other three reservoirs and watershed, dilution, dispersion. These actions should reduce the exposure potential and thus the potential for the detected adverse effects.

Level 2B - Calculation of invertebrate (blackworms and Asian clams) BSAFs to evaluate bioaccumulation (lines of evidence 8 and 9)

The laboratory analytical results and the BSAF calculations indicated: 1) exposure to these sediment chemicals occurs in the reservoirs and 2) reservoir organisms are likely accumulating some sediment chemicals in their tissues (**Table 22**). Laboratory raised invertebrates (blackworms and Asian clams) were exposed to sediment collected from each reservoir and the estuary during a 28-day exposure. Following the exposure, the tissues were analyzed to identify chemicals present in their tissues. Using the results, BSAFs were calculated for each test organism to evaluate bioaccumulation potential. Accumulation of chemicals is not unexpected, and does not necessarily equate to adverse effects but instead confirms exposure.

Level 2B - Comparisons of tissue-based TRVs to chemical concentrations in laboratory reared freshwater clams and worms exposed to field collected sediments

Comparisons of chemical concentrations identified in invertebrate tissue (blackworms and Asian clams) to tissue-based TRVs did not identify the potential for adverse effects, although the 28-day exposures tests for the invertebrates indicate some chemical accumulation is occurring. TRVs for Asian clams (based on toxicity data for bivalves) and TRVs for blackworms (based on toxicity data for oligochaetes) are available for several chemicals detected in invertebrate tissues to indicate if these accumulated chemicals have the potential for adverse effects. Tissue-based TRVs are also referred to as residue-based TRVs, and are identified as such by the USACE ERED database that served as the source of invertebrate (and fish) tissue TRVs used in this evaluation. The lone chemical identified in tissue from invertebrates exposed to reservoir sediment of each reservoir with the potential to be above TRVs was fluoranthene (**Table 21**). Fluoranthene was not detected but its MDLs were above the No Effect TRV, yet were below the Low Effect TRV.

The very low frequency and magnitude of TRV exceedances suggest that reservoir sediments do not contain large amounts of bioaccumulative chemicals based on these results. Invertebrates exposed to former reservoir sediments in the newly formed river channels and in the downstream depositional areas following dam removal under this exposure pathway are not expected to be negatively impacted.

Invertebrate tissue chemical concentrations are the result of 28 day in-laboratory exposures to field collected sediments from the reservoirs and upper estuary. These exposures are relatively short term and may not reflect longer term exposures under field conditions.

Special Evaluations - Comparisons of tissue-based ecological TRVs and TEQs to chemical concentrations in field collected fish tissue

Fish residing in the riverine environment are expected to accumulate sediment-sourced chemicals at a lower rate than those currently residing in the reservoirs. The chemical concentrations found in the reservoir fish tissues are the result of long term continuous exposure to reservoir sediments as well as exposures through prey ingestion and direct contact in water. Fish exposed to former reservoir sediments in newly formed channels would be different species that should move in and out of the area and will probably not be subject to long term exposure. Furthermore, the invertebrate prey species and structure of the food web will be different, making the overall exposure different than currently exist for reservoir fish. The same is true for fish in the downstream depositional areas following dam removal, as well as the reduction in chemical levels in the mobilized reservoir sediments due to mixing, dilution, and dispersion that is expected when the dams are removed.

Concentrations of mercury in bullhead and yellow perch exceed tissue-based TRVs for one or more reservoirs. TRVs for bullhead (based on toxicity data for catfish and bullhead family Ictaluridae) and TRVs for yellow perch (based on toxicity data for perch family Percidae) are available for several chemicals detected in fish tissue. Chemical concentrations identified in fish tissue (perch and bullhead) collected from the three reservoirs were compared to tissue-based ecological TRVs for the three chemical (mercury, dioxin 2,3,7,8-TCDD and total PCBs); however TRVs are not available for the seven other detected chemicals (**Table 26**). There is a level of uncertainty associated with the results of this line of evidence because tissue-based TRVs are unavailable for several of the chemicals detected in fish tissue.

The tissue results were below the TEQ-TRVs for fish and birds, indicating that ecological receptors would not be expected to be negatively affected by exposure to dioxin-like compounds in reservoir fish (**Table 28**). The fish tissue results from species-specific composite samples collected from each of the reservoirs were compared to TEQ-TRVs to evaluate potential adverse effects from exposure to dioxin and dioxin-like chemicals.

Special Evaluations - Comparisons of sediment chemical concentrations to human health SLs including comparisons of sediment TEQs to ODEQ Bioaccumulation SLVs

There is a low potential that the exposed sediments in the new river channels and downstream deposition of eroded sediments will contribute to adverse human effects under this pathway. This conclusion is based on the relatively low concentrations in the sediment chemistry results, the expectation of infrequent and/or short duration exposures to sediments by humans, and minimal amount of downstream deposited sediment under this exposure pathway. Further, human exposures to river sediments are generally considered to be of low concern given the likely behaviors potentially related to exposure (i.e., recreational activities). Finally, mixing, dilution, and transport of the fine grained silt sediments expected when the dams are removed is expected to further reduce both the chemical levels in the mobilized sediments and the resulting exposure potential for humans.

Relatively few chemicals detected in sediment exceeded human health SLs. Several additional chemicals were selected as COPCs due to elevated sample reporting limits. Results of this evaluation suggest the sediments are not highly toxic.

Only arsenic and nickel were detected in the sediment at levels that exceeded USEPA regional screening levels (RSLs) for residential use or California Human Health Screening Levels (CHHSLs) from the 77 samples collected across all three reservoirs (**Table 3**). The USEPA RSL value that was exceeded was the more stringent total carcinogen RSL. All detected concentrations were below the total non-carcinogen RSLs.

Eighteen detected chemicals from J.C. Boyle exceeded ODEQ Bioaccumulation SLVs for humans. These chemicals included legacy pesticides, dioxin-like compounds, and pentachlorophenol (wood preservative). ODEQ SLVs were not applied to chemicals detected in sediments from Copco 1 and Iron Gate because both reservoirs are located in California.

Several pesticides and semi-volatile organic compounds (SVOCs) were not detected; yet, the reporting limits were above at least one of the human health SLs (EPA RSL, CHHLS, or ODEQ SLVs in the case of J.C. Boyle). This issue was addressed in studies under Level 2B.

Calculated TEQs are at concentrations above ODEQ Bioaccumulation SLVs for mammals (including humans) in sediments from each of the reservoirs (**Tables 5**, **6**, and **7**). ODEQ Bioaccumulation SLVs are not applicable to water bodies in California; however, they provide a reference for comparison purposes.

As mentioned under Pathway 1, several chemicals may have levels that exceed human health criteria during the initial period of the Proposed Action after dilution has occurred. These levels are not expected to last over the long term under this exposure pathway.

Special Evaluations - Comparisons of chemical concentrations in fish to human health screening levels for fish, based on fish ingestion exposures and TEQs for mammals/humans

Under this pathway, fish are expected to accumulate chemicals at a lower rate and at lower levels than fish currently living in reservoirs and are unlikely to pose a risk to humans. Fish residing in or using the new river locations through the previous reservoirs and existing downstream stretches, which for migratory salmonids could equal six to eight months of the year, would have reduced sediment exposures relative to fish currently residing in reservoirs because of mixing, dilution, and dispersion of sediments as well as intermittent (riverine) as opposed to continuous (reservoir) exposures. Human health based fish tissue SLs for these chemicals are also sufficiently low that for several of these chemicals (Cancer risk-based values) the SLs are not consistently analytically achievable.

Results of evaluation of this line of evidence suggest that fish tissue concentrations of arsenic, mercury, total PCBs, and dioxins and furans (based on 2,3,7,8-TCDD) exceed human health SLs for fish consumption, for one or more reservoirs (**Table 27**). The dioxin 2,3,7,8-TCDD was not detected in fish tissue but the laboratory detection limit for this chemical exceeded one or more of the human health screening levels for fish tissue.

The fish tissue results from bullhead and perch composite samples collected from each of the reservoirs were compared to TEQ-SLs for humans to evaluate potential adverse effects from exposure to dioxin and dioxin-like chemicals. All total TEQs for humans derived for field collected fish samples from all reservoirs exceed the human health RSL and ATL corresponding to subsistence fish consumption rates, or a “one-in-a-million” (1×10^{-6}) cancer risk, but none exceeds the human health RSL for non-cancer effects (**Table 28**).

Pathway 3 Conclusions:

The multiple lines of evidence used to evaluate this pathway suggest that exposure to chemicals in sediment deposited downstream in the aquatic environment are unlikely to cause adverse long-term effects to freshwater and human receptors (**Figure 7**), since chemical concentrations are generally low and a majority of the sediments will be carried to the ocean and dispersed once the dams are removed under this pathway. Further, mixing, dilution, and dispersion of sediments would also be expected to reduce the magnitude and duration of exposure for most forms of aquatic life and human receptors.

The multiple lines of evidence used to evaluate this pathway also suggest that exposure to chemicals in the newly formed river channel have a low potential to cause adverse long-term effects to freshwater and human receptors (**Figure 7**), since chemical concentrations are generally low, the new riverine environment will provide less time and opportunities for to freshwater and human receptors to be exposed to contaminants.

7.2.4 Exposure Pathway 4

This report evaluated the effects of potential long-term exposure for marine and near shore sediment that would be deposited under Proposed Action “dams removed.” As part of this pathway, a portion of the fine grained sediment currently located behind each of the dams, would be mobilized, dispersed, and carried to the ocean with minimal deposition expected downstream and in the estuary. These sediments are expected to stay in suspension and pass to the near shore area where they would be further dispersed by currents as well as wind and wave action. Minimal sediment deposition is expected to occur in the estuary and near shore environment based on the results of the DREAM-1 simulations referenced above. Terrestrial and human health pathways are considered to be incomplete because of the presumption that no significant bioaccumulation of contaminants will occur offshore to make it into bird, mammal or human diets and, thus, effects to these receptor groups were not evaluated (**Figure 7**).

The lines of evidence to evaluate potential effects to marine biota included the following:

- Comparisons of sediment chemical concentrations to marine ecological SL, including comparison of sediment TEQs to ODEQ Bioaccumulation SLVs (lines of evidence 1, 2, and 3 in **Table 29** with results shown in **Tables 4, 5, 6,** and **7**);

- Comparisons of elutriate chemistry results to marine water quality criteria (line of evidence 4 in **Table 29** with results shown in **Tables 12 - 15**);

- Evaluation of results of the sediment toxicity bioassay for the benthic invertebrates (midge and amphipod) (lines of evidence 5 and 6 in **Table 29** with results shown in **Table 17**);

- Evaluation of results of the elutriate toxicity bioassay for rainbow trout (line of evidence 7 in **Table 29** with results shown in **Table 16**);

- Comparisons of tissue-based TRVs to chemical concentrations in laboratory reared freshwater clams and worms exposed to field collected sediments (lines of evidence 10 and 11 in **Table 29** with results shown in **Table 21**); and

- Comparisons of tissue-based ecological TRVs and TEQs to chemical concentrations in field collected fish tissue (lines of evidence 12, 13, and 14 in **Table 29** with results shown in **Table 26** and **28**)

Level 2A - Comparisons of sediment chemical concentrations to marine sediment SL, including comparisons of sediment TEQs to ODEQ Bioaccumulation SLVs

Overall, quality of the sediments collected from the three reservoirs and estuary does not appear to be highly contaminated. This conclusion is based on comparisons to the marine MLs and SLs,

No Step 1 DMMP MLs were exceeded; and very few chemicals in sediment exceeded marine SLs.

From the samples collected across all three reservoirs and the estuary, only two chemicals were detected in the sediment from one reservoir that exceeded at least one available marine screening level (**Table 4**). From J.C. Boyle, Dieldrin detected in one of 14 samples exceeded the SEF SL-1 (Step 2a in **Figure 2**) and 2,3,4,7,8-PECDF exceeded Step 2c in **Figure 2**.

In all three reservoirs and estuary samples, several legacy pesticides, dioxin-like compounds, and semi-volatile organic compounds (SVOCs) were not detected; yet, the reporting limits were above the SLs from Step 1 to Step 2c in **Figure 2**, so other lines of evidence are used to assess these compounds. This issue was addressed in studies under Level 2B.

No consistent pattern of toxicity or elevated chemical composition is observed across sampling locations.

There is a low probability that sediments with elevated concentrations of the two chemicals detected in J.C. Boyle would remain in the estuary or near shore areas at the same concentrations detected in the reservoir. As the mobilized sediments move downstream they will be subject to mixing with sediments from the other three reservoirs and the watershed, dilution from tributaries, and dispersion by the currents and wind. These actions will reduce the chemicals concentrations to below levels of concern prior to settling in wide spread, long-term depositional areas offshore.

Level 2B - Comparisons of elutriate chemistry results to marine water quality criteria for surface water

Chemicals that exceed marine surface water criteria include those generally considered to be nontoxic (e.g., phosphorus) as well as those with substantial potential for contributing to adverse effects (e.g., copper). Exposures to suspended sediment with elevated concentrations of potentially toxic chemicals are of lower concern for marine receptors than exposures to elevated concentrations of dissolved chemicals. The chemicals with the greatest potential to cause adverse effects in elutriate (e.g., copper) are, under field conditions associated with this exposure pathway, expected to bind to particulate matter and therefore are unlikely to contribute substantially to elevated concentrations of the more toxic dissolved form in the water column.

Further, by the time river water and associated suspended sediments reach the marine environment, the mobilized sediments will have been subject to mixing with sediments from all four reservoirs and the watershed, dilution from tributaries, and dispersion by the currents. These actions will cause a substantial reduction in the amount of sediment suspended in the water column compared to conditions directly below Iron Gate Dam and chemical concentrations are expected to be below levels of concern.

As mentioned under Pathway 1, phosphorus may reach levels that exceed marine water quality criteria during the initial period of the Proposed Action after dilution has occurred. These levels are expected to reduce over the long term under this exposure pathway.

Level 2 B - Evaluation of results of the sediment toxicity bioassay for the benthic invertebrates (midge and amphipod)

Under this pathway, marine organisms are not expected to experience the sediment concentrations, or adverse effects associated with those seen in the undiluted laboratory bioassays. The results of the acute toxicity bioassays for the midge and the amphipod identified no statistically significant difference in survival of either test organism exposed to reservoir or estuary sediments compared to control sediments, with the exception of the survival of midge exposed to on-thalweg sediments from J.C. Boyle. J.C. Boyle sediments will be mixed with sediments from the other reservoirs, diluted with flushing flows during transport downstream, and further mixed and diluted as they are dispersed by the wind and current. These actions are expected to reduce toxicity to below levels of concern in the marine environment.

Level 2B - Evaluation of results of elutriate toxicity bioassay for rainbow trout

Elutriate bioassay results indicate no concern to the estuarine and near shore marine environment from the mobilized reservoir sediments. Although these bioassay tests were conducted in freshwater, the results were applied to estuarine environments to evaluate short-term exposures for estuarine and near shore marine fish. The bioassay results suggest for J.C. Boyle Reservoir sediments, with an LC-50 greater than100 percent, that no toxicity exists and no water column toxicity to rainbow trout is expected downstream of the dam including the estuary and near shore area. The LC-50 values between 20 and 70 percent for Copco 1 and Iron Gate sediments suggest water column toxicity exists and may have an adverse effect downstream if not diluted. Only a 2- to 4-fold dilution of the 100 percent elutriate strength would be sufficient to prevent water column toxicity to rainbow trout. The estimated dilution factor of about 48- to 66-fold is expected to occur when the dams are removed. Additional mixing of the sediments from the other reservoirs and dispersions by the wind and current are expected to reduce toxicity even further. These actions should be sufficient to eliminate the potential rainbow trout toxicity to below levels of concern in the marine environment and should also be high enough to be protective of other fish species that may be more sensitive than rainbow trout.

Level 2B - Comparisons of tissue-based TRVs to chemical concentrations in laboratory reared freshwater clams and worms exposed to field collected sediments

Comparisons of chemical concentrations identified in invertebrate tissue (blackworms and Asian clams) to available tissue-based TRVs did not identify a potential for adverse effects. The lone chemical identified as a Chemical of Potential Concern in tissue from invertebrates collected from each reservoir and the estuary above TRVs was fluoranthene. Fluoranthene was not detected but its MDLs were above the No Effect TRV, yet were below the Low Effect TRV. Under the assumption that marine biota accumulate chemicals in a manner similar to Asian clams and blackworms, then these findings for freshwater organisms suggest that marine biota exposed to reservoir sediments transported downstream are unlikely to suffer measureable adverse effects.

Special Evaluation - Comparisons of tissue-based ecological TRVs and TEQs to chemical concentrations in field collected fish tissue

The chemical levels found in the reservoir fish tissue samples suggest no potential adverse effects to the estuarine and near shore marine area based on comparison to ecological TRVs and TEQs. Fish tissue data suggest that reservoir fish have accumulated low levels of some chemicals, but only mercury was accumulated in bullhead to levels that might be associated with adverse effects. Although fish/sediment relationships have not been well established, it is reasonable to expect lower levels of chemical accumulation in fish residing in or using the estuary and near shore environments, based primarily on reduced exposures to mercury-contaminated sediments. As the mobilized sediments move downstream they will be subject to mixing with sediments from the watershed, dilution from tributaries, and dispersion by the currents and wind. These actions will substantially reduce the chemical concentrations prior to settling in wide spread, long-term depositional areas offshore.

Pathway 4 Conclusions:
Overall, the multiple lines of evidence used to evaluate this pathway suggest that exposure to chemicals in reservoir sediment are unlikely to cause adverse long-term effects to estuary and near shore ecological receptors (**Figure 7**), since sediments from the reservoirs are of a fine grained silt nature and will be carried to the ocean and dispersed once the dams are removed under this pathway. Mixing, dilution, and dispersion of sediments prior to reaching the estuary would also be expected to reduce the magnitude and duration of exposure for most forms of estuary and near shore ecological receptors.

7.2.5 Exposure Pathway 5

This pathway is the evaluation of effects of long-term exposure to reservoir sediment under No Action “dams in.” This exposure pathway would be incomplete or insignificant for terrestrial biota, since all of the sediments in the reservoirs would remain in place and submerged by water in each of the reservoirs. Terrestrial biota that feed on reservoir fish, including birds, are likely to be exposed to any bioaccumulative contaminants but these receptors were not directly evaluated under this study. In addition, this exposure pathway would be incomplete for marine biota, since none of the accumulated reservoir sediments would be transported and deposited in the estuary and near shore marine areas. Conditions in the estuary and near shore areas would remain similar to those conditions identified during the 2009/2010 sampling. Thus, effects to terrestrial and estuarine receptor groups are not evaluated, as identified on **Figure 7**.

To evaluate potential adverse effects under No Action, each of the lines of evidence shown in **Table 29**, with the exception of the Level 2A DMMP MLs and marine SLs (lines of evidence 1 and 2), Level 2B elutriate chemistry ecological (line of evidence 4) and the elutriate toxicity bioassay (line of evidence 7), and Special Evaluations elutriate chemistry human health (line of evidence 17), was evaluated since collectively they represent and assess “current conditions” that would remain relatively unchanged if No Action is selected. These lines of evidence are summarized below.

Level 2A - Comparisons of sediment chemical concentrations to sediment SLs including comparisons of sediment TEQs to ODEQ Bioaccumulation SLVs (lines of evidence 2 – 3)

Overall, quality of the sediments collected from the three reservoirs and estuary exhibits only limited contamination based on comparison to the SLs.

Level 2A Step 1 (DMMP) of the SEF does not apply to this pathway.

From 77 samples across all three reservoirs, only eight chemicals were detected in the sediment at levels that exceeded at least one available screening level (**Table 2**). Of these, only nickel, from all three reservoirs exceeded SEF SL-1 and SL-2 (Step 2b in Figure 2). The remaining seven chemicals exceeded SLs under Steps 2c and 2d in **Figure 2** including iron and some legacy pesticides and dioxin-like compounds (4,4-DDD, 4,4-DDE, 4,4-DDT, Dieldrin, and 2,3,7,8-TCDD only found in J.C. Boyle, and 2,3,4,7,8-PECDF), and Dieldrin was only detected in one sample.

Several pesticides and semi-volatile organic compounds (SVOCs) were not detected; yet, the reporting limits were above the SLs from Step 2a to Step 2d in **Figure 2**, so other lines of evidence are used to assess these compounds. This issue was addressed in studies under Level 2B.

No consistent pattern of elevated chemical distribution is observed across discrete sampling locations within a reservoir; however, sediment in J.C. Boyle does have marginally higher chemical concentrations and more detected chemicals of potential concern (COPCs) in sediment based on comparison to ecological SLs when compared to the other reservoirs.

TEQs were calculated for dioxin, furan, and dioxin-like PCBs. The resulting TEQs are only slightly above regional background concentrations and thus have limited potential for adverse effects for ecological receptors exposed to sediments (EPA 2010). Calculated TEQs are at concentrations above ODEQ Bioaccumulation SLVs (SEF Step 2c) for mammals, fish, and birds in sediments from each of the reservoirs (**Tables 5**, **6**, and **7**). ODEQ Bioaccumulation SLVs are not applicable to water bodies in California; however, they provide a reference for comparison purposes. The sources of compounds detected in reservoir sediments are not known; however, sources may include atmospheric deposition and regional forest fires.

Level 2B - Evaluation of results of the sediment toxicity bioassay for the benthic invertebrates (midge and amphipod; lines of evidence 5 and 6)

The results of the acute toxicity bioassays for the midge and the amphipod identified no statistically significant difference in survival of either test organism exposed to reservoir sediments compared to control sediments, with the exception of the survival of midge exposed to on-thalweg sediments from the J.C. Boyle (**Tables 17**). The mean midge survival for the off-thalweg sediments at the J.C. Boyle was also lower than control sediments, although not statistically significant. These results indicate that survival of benthic organisms is not adversely affected by chemical concentrations in sediments at Copco 1 and Iron Gate reservoirs or the estuary. However, the negative response showed by the midge to the test conditions when exposed to the on-thalweg sediment of J.C. Boyle suggests that those sediments at J.C. Boyle may contribute to reduced survival for benthic organisms under No Action. The cause for the reduction in midge survival may be due to sediment chemistry or other factors or a combination of several factors not discerned by the test.

Level 2B - Calculation of invertebrate (blackworms and Asian clams) BSAFs to evaluate bioaccumulation (lines of evidence 8 and 9)

The laboratory analytical results and the BSAF calculations indicated: 1) exposure to these sediment chemicals occurs in the reservoirs and 2) reservoir organisms are likely accumulating some sediment chemicals in their tissues (**Table 22**). Laboratory raised invertebrates (blackworms and Asian clams) were exposed to sediment collected from each reservoir and the estuary during a 28-day exposure. Following the exposure, the tissues were analyzed to identify chemicals present in their tissues. Using the results, BSAFs were calculated for each test organism to evaluate bioaccumulation potential. Accumulation of chemicals is not unexpected, and does not necessarily equate to adverse effects but instead confirms exposure.

Level 2B - Comparisons of tissue-based TRVs to chemical concentrations in laboratory reared freshwater clams and worms exposed to field collected sediments (lines of evidence 10 and 11)

Comparisons of chemical concentrations identified in invertebrate tissue (blackworms and Asian clams) to tissue-based TRVs did not identify the potential for adverse effects, although the 28-day exposures tests for the invertebrates indicate some chemical accumulation is occurring. TRVs for Asian clams (based on toxicity data for bivalves) and TRVs for blackworms (based on toxicity data for oligochaetes) are available for several chemicals detected in invertebrate tissues to indicate if these accumulated chemicals have the potential for adverse effects. Tissue-based TRVs are also referred to as residue-based TRVs, and are identified as such by the USACE ERED database that served as the source of invertebrate (and fish) tissue TRVs used in this evaluation. The lone chemical identified in tissue from invertebrates exposed to reservoir sediment of each reservoir with the potential to be above TRVs was fluoranthene (**Table 21**). Fluoranthene was not detected but its MDLs were above the No Effect TRV, yet were below the Low Effect TRV.

Special Evaluations - Comparisons of tissue-based ecological TRVs and TEQs to chemical concentrations in field collected fish tissue (lines of evidence 12, 13, and 14)

TRVs for bullhead (based on toxicity data for catfish and bullhead family Ictaluridae) and TRVs for yellow perch (based on toxicity data for perch family Percidae) are available for several chemicals detected in fish tissue. Chemical concentrations identified in fish tissue (perch and bullhead) collected from the three reservoirs were compared to tissue-based ecological TRVs for three chemicals (mercury, dioxin 2,3,7,8-TCDD and total PCBs); however TRVs are not available for the seven other chemicals (**Table 26**). No potential for adverse effects to perch in J.C. Boyle and Copco 1 is expected, since the tissue concentrations were below the tissue-based No Effect and Low Effect TRVs. However, a potential for adverse effects to the perch at Iron Gate was identified for No Action, since mercury was identified in the tissue at concentrations slightly above the No Effect tissue-based TRV. The concentrations, however, were below the Low Effect TRV. A potential for adverse effects was identified for the bullhead in each of the reservoirs based on a comparison of tissue concentrations to tissue-based TRVs. Mercury was the single chemical identified in fish tissue from each reservoir at concentrations above both the No Effect and Low Effect tissue-based TRVs. Concentrations of the remaining chemicals for which TRVs were available were below both TRVs.

The fish tissue results from species-specific composite samples collected from each of the reservoirs were compared to TEQ-TRVs to evaluate potential adverse effects from exposure to dioxin and dioxin-like chemicals. The tissue results were below the TEQ-TRVs for fish and birds, indicating that ecological receptors would not be expected to be negatively affected by exposure to dioxin-like compounds in field caught fish (**Table 28**).

Special Evaluations- Comparisons of sediment chemical concentrations to human health SLs including comparisons of sediment TEQs to ODEQ Bioaccumulation SLVs (lines of evidence 15 and 16)

These two lines of evidence are considered conservative because humans will rarely come in direct contact with the sediments located underwater at the bottom of the reservoirs.

Only arsenic and nickel were detected in the sediment at levels that exceeded USEPA regional screening levels (RSLs) for residential use or California Human Health Screening Levels (CHHSLs) from the 77 samples collected across all three reservoirs (**Table 3**). The USEPA RSL value that was exceeded was the more stringent total carcinogen RSL. All detected concentrations were below the total non-carcinogen RSLs.

Eighteen detected chemicals from J.C. Boyle exceeded ODEQ Bioaccumulation SLVs for humans. These chemicals included legacy pesticides, dioxin-like compounds, and pentachlorophenol (wood preservative). ODEQ SLVs were not applied to chemicals detected in sediments from Copco 1 and Iron Gate because both reservoirs are located in California.

Several pesticides and semi-volatile organic compounds (SVOCs) were not detected; yet, the reporting limits were above at least one of the human health SLs (EPA RSL, CHHLS, or ODEQ SLVs in the case of J.C. Boyle). This issue was addressed in studies under Level 2B.

Calculated TEQs are at concentrations above ODEQ Bioaccumulation SLVs for mammals (including humans) in sediments from each of the reservoirs (**Tables 5**, **6**, and **7**). ODEQ Bioaccumulation SLVs are not applicable to water bodies in California; however, they provide a reference for comparison purposes.

Comparisons of chemical concentrations in fish to human health screening levels, based on fish ingestion exposures and TEQs for mammals/humans (lines of evidence 18 - 20)

The comparison of fish tissue results from samples collected from the three reservoirs to human health SLs and the TEQs for mammals/human receptors suggested a potential for one or more chemicals to have an adverse effects to human receptors from ingestion of fish from each reservoir. Inorganic arsenic, total mercury, and total PCBs exceed several of the selected human health screening levels for both bullhead and perch (**Table 27**). Concentrations of several more detected chemicals (DDT, Dieldrin, total mercury, 2,3,7,8-TCDD) exceed the most stringent (lowest) screening levels based on subsistence level consumption. The dioxin 2,3,7,8-TCDD was not detected in fish tissue but the laboratory detection limit for this chemical exceeded one or more of the human health screening levels for fish tissue. Several of these chemicals have been linked to atmospheric deposition.

The fish tissue results from bullhead and perch composite samples collected from each of the reservoirs were compared to TEQ-SLs for humans to evaluate potential adverse effects from exposure to dioxin and dioxin-like chemicals. All total TEQs for humans derived for field collected fish samples from all reservoirs exceed the human health RSL and ATL for cancer, but none exceeds the human health RSL for non-cancer effects (**Table 28**).

Exposure Pathway 5 Conclusions:

Overall, the results of the evaluation of the applicable lines of evidence for this exposure pathway, suggest that No Action or “dams in” (current conditions) has several chemicals present at levels with the potential to cause minor or limited adverse effects to both freshwater ecological and human receptors (**Figure 7**).

7.5 Final Conclusions

Figure 7 summarizes the evaluation results for the five exposure pathways. The effects range from no effect (black dot) to limited or minor effects from one or more chemicals (green dot). No significant adverse effects were not identified (no red dots).

Sediment quality of reservoir and estuary sediments does not appear to be highly contaminated based on comparisons to SLs and on other lines of evidence. No consistent pattern of elevated chemical composition is observed across discrete sampling locations within the three reservoirs or estuary. No single reservoir is observed to be consistently more or less contaminated based on multiple lines of evidence. Where elevated concentrations of chemicals in sediment are found, the degree of exceedance based on comparisons of measured (i.e., detected) chemical concentrations to SLs is small and in several cases may reflect regional background conditions.

Bioassays (toxicity and bioaccumulation testing using sensitive aquatic organisms) supported the chemistry evaluation's conclusions, confirming only a minor or limited degree of effects, which would be further reduced if sediments are released under a dam removal scenario. In the future, if there is an affirmative, efforts would begin to develop detailed plans for dam removal and permitting processes. Detailed planning for dam removal, together with permitting requirements, would more specifically address the few chemicals identified that exceeded relevant screening values.

Some chemicals also were present in reservoir fish at concentrations that exceeded one or more established screening levels, but that again were below levels that would indicate an unacceptable level of concern for effects on human health or aquatic biota either under current conditions or a dam removal scenario.

As part of the Proposed Action, and applicable to Exposure Pathways 1 through 4, a portion of the fine grained sediment currently located behind each of the dams, would be mobilized, dispersed, and carried to the ocean with minimal deposition downstream and in the estuary if the dams are removed. The sediments are expected to stay in suspension and pass to the near shore area where they would be further dispersed by currents as well as wind and wave action. Minimal sediment deposition is expected to occur in the lower Klamath River, estuary and near shore environment. These actions are expected to reduce the chemicals concentrations and any potential for toxic effects to below levels of concern prior to settling in wide spread, long-term depositional areas offshore.

Based on this information, the lines of evidence used to evaluate Exposure Pathway 1 suggest short term minor adverse effects for freshwater receptors are a possibility during the initial period following dam removal from one or more chemicals, especially at locations immediately below the dams where the concentration of suspended sediments is expected to be the highest. Longer term and more serious adverse effects are not expected. In contrast, no receptors considered as part of Exposure Pathways 2 through 4 are expected to experience adverse effects from Proposed Action, "dams removed."

Exposure Pathway 5 evaluates effects of long-term exposure to reservoir sediment under No Action "dams in." Overall, the results of the evaluation of the applicable lines of evidence for this exposure pathway suggest that No Action (current conditions) may be associated with minor adverse effects to both freshwater ecological and human receptors from one or more chemicals.

Chapter 8
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Appendix A
Sediment Evaluation Framework Level 2A:
Preliminary Assessment: Sediment Data Comparisons to Applicable Screening Levels

A.1 Approach

A.1.1 Sediment Screening Levels

The Sediment Evaluation Framework (SEF) for the Pacific Northwest includes bulk sediment screening levels for standard chemicals of concern and chemicals of special occurrence in marine and freshwater sediments for Idaho, Oregon, and Washington (RSET 2009). SEF screening levels are presented in Tables A-1 and A-2. Similar numeric chemical guidelines for the assessment and characterization of freshwater and marine sediments do not exist for California. The State Water Resources Control Board (SWRCB) is in the process of developing and adopting sediment quality objectives (SQOs) for enclosed bays and estuaries. However, the California SQOs are designed to assess in-place, surficial sediments as opposed to deeper sediment deposits or sediment discharges. As such, the California SQOs are not considered particularly relevant to the Secretarial Determination process.

Some numeric sediment quality guidelines have been established by other regional and state efforts. For example, the interagency state-federal Dredged Material Management Program (DMMP) has issued sediment chemistry screening levels (SL), bioaccumulation thresholds (BT), and maximum levels (ML) for marine sediments in Puget Sound, Washington (Table A-1). The DMMP guidelines do not include numeric values for freshwater sediments. NOAA has compiled Screening Quick Reference Tables (SQuiRTs) that present various guideline values from around the country for organic and inorganic contaminants in a variety of environmental media, including marine and freshwater sediments (Tables A-1 and A-2).

The Oregon Department of Environmental Quality (DEQ) has developed guidance for determining if hazardous substances released to sediment have the potential to bioaccumulate to the point where the contaminants adversely affect either the health of fish or other aquatic organisms, or the health of animals or humans that consume them (Oregon DEQ 2007). The guidelines describe the general processes and protocol used by Oregon DEQ for comparing the measured concentration of contaminants in sediment to risk-based sediment screening level values (SLVs) for humans and relevant classes of wildlife (e.g., freshwater fish, birds, mammals and humans). Oregon DEQ freshwater and human health bioaccumulation SLVs are presented in Table A-2 and Table A-3.

California Human Health Screening Levels (CHHSLs) are concentrations of hazardous chemicals in soil or soil gas that the California Environmental Protection Agency considers to be below thresholds of concern for risks to human health. The presence of a chemical at concentrations in excess of a CHHSL does not indicate that adverse impacts to human health are occurring or will occur but suggests that further evaluation of potential human health concerns is warranted. Finally, the USEPA Regional Screening Levels (RSLs) (formerly Preliminary Remediation Goals [PRGs]) for Chemical Contaminants at Superfund Sites have been developed to assess human health exposure risk for contaminated soils and sediments in various settings (USEPA 1991, 1996, 2002). For the purposes of the exposure pathways evaluated for this project, the Residential Soil

Supporting RSLs represent the most appropriate of these screening levels. As with the other available RSLs (i.e., Industrial Soil, Residential Air, Industrial Air, Residential Tapwater), the Residential Soil Supporting RSLs are based upon human health risk and do not address potential ecological risk. CHHSLs and USEPA RSLs are presented in Table A-3.

The compilation of screening levels presented in Table A-1 through Table A-3 represents an appropriate array of screening tools for different potential effects scenarios to be evaluated under CEQA and NEPA. For example, the SEF freshwater screening values are relevant to assessing potential reservoir and riverine exposures; SEF and DMMP values are relevant for marine and some estuarine evaluations; and the USEPA RSLs have relevance regarding potential direct human exposure to sediments remaining in place following any dam removal. Input on the specific use of the various screening levels to different aspects of the proposed project has been ongoing by the Cooperating Agencies (USEPA, NCRWQCB, Oregon DEQ, USGS, USFWS, NOAA). Screening values have been used in a step-wise manner, to cull the list of potential impact pathways needing evaluation under NEPA and CEQA, or during subsequent permitting actions.

A.1.2 Step-Wise Comparison of Sediment Contaminant Levels to Screening Levels

A.1.2.1 Step 1–Marine Maximum Levels

Step 1 of the step-wise comparison approach is to ascertain whether the Klamath River sediment samples exceed any maximum acceptable contaminant levels for discharge to the aquatic environment. For Step 1, all 77 project reservoir and Klamath River estuary sediment samples collected during 2009–2010 were compared to the DMMP Maximum Levels (MLs) for discharge to Puget Sound. As marine screening levels, the DMMP-MLs provide a benchmark for comparison for the offshore environment adjacent to the Klamath River estuary, which may be the ultimate repository for sediments currently trapped behind the dams and mobilized downstream under a dam removal scenario. As maximum levels, the DMMP-MLs provide the first check on whether the material could be considered unsuitable for unconfined open-water disposal (USACE 2008). DMMP-MLs represent the highest Apparent Effects Threshold (AET) for each contaminant; i.e., each ML is the chemical concentration at which all of the biological indicators used to develop AETs showed significant adverse effects. Under the DMMP, exceedances of the MLs provisionally define the sediment as being unsuitable for unconfined aquatic disposal; additional evaluation (including biological testing) is not needed to reach this conclusion.

A.1.2.2 Step 2–Freshwater and Marine Screening Levels

Step 2 of the step-wise comparison approach is to systematically cull the large list of Klamath River chemicals into a smaller list of chemicals of potential concern (COPCs) using applicable marine and freshwater sediment quality guidelines. Under the SEF, if all chemicals are below the applicable freshwater (SEF-SL1) or marine (DMMP-SL) screening levels, the sediment is considered to pose a very low risk for toxicity and is considered suitable for unconfined aquatic disposal. Again, additional evaluation (including biological testing) is not needed to reach this conclusion. However, if SEF-

SL1s or DMMP-SLs are exceeded, the need for biological testing is indicated. For the Project reservoir and Klamath River estuary sediments, comparisons were made primarily using SEF and DMMP screening levels; however, some chemicals did not have SEF or DMMP values and these were screened using Oregon DEQ Bioaccumulation SLVs or other screening levels included in the SQuiRTs, as follows:

Marine Sediment Screening Level Comparisons

Step 2a–Marine: Chemicals exceeding SEF-SL1 or DMMP-SL.

Step 2b–Marine: Chemicals exceeding SEF-SL1 or DMMP-SL *and* SEF-SL2 or DMMP-BT.

Step 2c–Marine: Chemicals for which there are no SEF or DMMP screening levels, but at least one SQuiRT value is exceeded (ERL, ERM, T20, TEL, T50, PEL; see key in Table A-1 for definitions).

Freshwater Sediment Screening Level Comparisons

Step 2a–Freshwater: Chemicals exceeding SEF-SL1.

Step 2b–Freshwater: Chemicals exceeding SEF-SL1 *and* SEF-SL2.

Step 2c–Freshwater: Chemicals for which there are no SEF guidelines, but at least one Oregon DEQ Bioaccumulation SLV is exceeded (Freshwater-Fish, Bird–Individual, Bird–Population, Mammal–Individual, Mammal–Population).

Step 2d–Freshwater: Chemicals for which there are no SEF or Oregon DEQ guidelines, but at least one SQuiRT value is exceeded needed (TEL, LEL, PEL, SEL, TEC, PEC; see key in Table A-2 for definitions)

A.1.2.3 Human Health Screening Levels

All Klamath River sediment samples were also compared to human health screening values including the USEPA Residential Soil RSLs (total carcinogenic and total non-carcinogenic) and Oregon DEQ bioaccumulation SLVs (Human–Subsistence and Human–General).

Although Oregon DEQ bioaccumulation SLVs are not applicable in California for regulatory purposes, comparisons of measured concentrations from Copco 1 Reservoir, Iron Gate Reservoir, and Klamath Estuary sediment samples to these SLVs were undertaken due to the lack of other available SLVs for particular chemicals, such as dioxins and furans. This comparison also allowed for direct comparison of sediment quality between all three reservoirs using a common set of SLVs.

A.2 Results

A.2.1 Step 1-Marine Maximum Levels

There were no positive exceedances of the 54 applicable DMMP-MLs for the 2009–2010 Project reservoir and Klamath River estuary sites. However, 11 organic compounds analyzed using Method 8270D had laboratory analytical reporting limits (RLs) ranging from 1.1–15.6 times greater than the ML itself (Table A-4), including the following[1]:

- Phthlates–Butyl benzyl phthalate
- Phenols–2,4-Dimethylphenol, 2-Methylphenol
- SVOCs: Chlorinated hydrocarbons–1,2,4-Trichlorobenzene, 1,2-Dichlorobenzene, 1,4-Dichlorobenzene, Hexachlorobenzene, Hexachlorobutadiene
- Other SVOCs–Benzoic Acid, Benzyl Alcohol, N-nitrosodiphenylamine

For these chemicals, the sediment chemistry data alone are not sufficient to determine that the chemicals are present in Klamath River sediments at levels of concern, and therefore these compounds must be retained as possible COPCs at this step (Step 1). Therefore, at this step (Step 1), 43 potential contaminants (i.e., 54 total contaminants possessing DMMP-MLs -11 possible COPCs) present no significant marine toxicity risks and need no further evaluation.

A.2.2 Step 2–Marine and Freshwater Sediment Screening Levels

A.2.2.1 Marine Sediment Screening Levels

Of the 77 total sediment samples analyzed for the 2009–2010 study, only one positively exceeded either the SEF-SL1 or DMMP-SL (Step 2a–Marine). A single sample from J.C. Boyle Reservoir exceeded SEF-SL1 for Dieldrin (Table A-5). Therefore Dieldrin at this one site must be retained as a COPC at this step (Step 2a–Marine). In addition, a suite of 31 organic chemicals, including pesticides/herbicides/insecticides, PAHs, phthalates, SVOCs, and VOCs, had laboratory reporting limits (RLs) above the marine SEF-SL1 or DMMP-SL values (Table A-4). As above, the sediment chemistry data alone are not sufficient to confirm that these compounds are below marine screening levels. Therefore these compounds must be retained as possible COPCs at this step (Step 2a–Marine).

In Step 2b, compounds that exceeded (or may have exceeded) the marine SEF-SL1 or DMMP-SL values are then compared against the marine SEF-SL2 and DMMP-BT values. No samples that exceeded (or may have exceeded) the marine SEF-SL1 or DMMP-SL values also positively exceeded the SEF-SL2 and DMMP-BT values. Twenty-seven of the 31 organic chemicals exceeding SEF-SL1 or DMMP-SL screening

[1] Results for two chemicals (diethyl phthalate, phenol) are shown in the DMMP-ML column in Table A-4, but the range of RLs for these chemicals did not exceed the ML. In some cases the upper end of the range of RLs for these two chemicals was equal to the ML. These two chemicals are included in Table A-4 because results or RLs exceeded another SL.

levels may have also exceeded marine SEF-SL2 and DMMP-BT values, including pesticides/herbicides/insecticides, PAHs, phthalates, SVOCs, and VOCs, which had laboratory reporting limits (RLs) above the marine SEF-SL2 or DMMP-BT values (Table A-4). Therefore, 27 chemicals are retained as possible COPCs at this step (Step 2b–Marine).

For those few chemicals not possessing SEF or DMMP screening levels, screening levels included in the SQuiRTs were considered (Step 2c–Marine). There were no positive exceedances of screening levels included in the SQuiRTs for chemicals not possessing SEF or DMMP screening levels (Table A-4). Two pesticides/herbicides/insecticides (heptachlor epoxide, toxaphene) and one PAH (benzo(b)fluoranthene) possessed RLs greater than the corresponding screening levels (Table A-4) and did not possess SEF or DMMP screening levels. Sample sites for these chemicals included Copco 1, Iron Gate, and J.C. Boyle reservoirs and both Klamath River estuary locations. Therefore, three additional chemicals are retained as possible COPCs at this step (Step 2c–Marine).

Therefore, at this step (Step 2-Marine), 49 potential contaminants (i.e., 83 total contaminants possessing marine SLs - 34 possible COPCs) present no significant marine toxicity risks and need no further evaluation.

A.2.2.2 Freshwater Sediment Screening Levels

No reservoir samples positively exceeded the SEF-SL1 (Step 2a–Freshwater). Both samples in the Klamath River estuary slightly exceeded the SEF-SL1 for chromium, one sample slightly exceeded for bis(2-ethylhexyl) phthalate, and both samples exceeded for nickel (Table A-6). However, 13 chemicals, including metals (i.e., mercury, silver), phthalates, and SVOCs, had RLs above the SEF-SL1 (Table A-4). The sediment chemistry data alone are not sufficient to confirm that these compounds are below the freshwater screening levels; therefore these compounds must be retained as possible COPCs at this step (Step 2a–Freshwater).

In Step 2b, compounds that exceeded (or may have exceeded) the freshwater SEF-SL1 values are compared against the freshwater SEF-SL2 values. Both samples in the Klamath River estuary positively exceeded the SEF-SL2 value for nickel (Table A-6). Additionally, nine of the 13 chemicals exceeding SEF-SL1 values may have exceeded freshwater SEF-SL2 values, including one metal (silver), phthalates, and SVOCs, which had RLs above the SEF-SL2 (Table A-4). Therefore, these compounds are retained as possible COPCs at this step (Step 2b–Freshwater).

For those few chemicals not possessing SEFs, values included in the Oregon DEQ Bioaccumulation SLVs were considered (Step 2c–Freshwater). Six chemicals met this condition, including polychlorinated dioxins and furans (2,3,4,7,8-PECDF, 2,3,7,8-TCDD) and pesticides/herbicides/insecticides (4,4’-DDD, 4,4’-DDE, 4,4’-DDT, and Dieldrin). For 4 of 26 samples collected in J.C. Boyle Reservoir, Oregon, positive exceedances of one or more Oregon DEQ Bioaccumulation SLVs (Step 2c–Freshwater) were observed for each of these compounds (Table A-6). Nine chemicals, including polychlorinated dioxins/furans (2,3,4,7,8-PECDF, 2,3,7,8-TCDD) and pesticides/herbicides/insecticides (4,4’-DDD, 4,4’-DDE, 4,4’-DDT, chlordane-technical, chlordane-alpha, chlordane-gamma, Dieldrin) possessed RLs above the Oregon DEQ bioaccumulation SLVs (Table A-4). These compounds were therefore retained as possible bioaccumulation COPCs at this step (Step 2c–Freshwater).

For those few chemicals not possessing SEF or Oregon DEQ screening levels, screening levels included in the SQuiRTs were considered (Step 2d–Freshwater). There were no positive exceedances of screening levels included in the SQuiRTs for chemicals not possessing SEF or Oregon DEQ screening levels (Table A-6). A suite of four pesticides/herbicides/insecticides (BHC-gamma [HCH-gamma, Lindane], endrin, heptachlor epoxide, toxaphene) possessed RLs that were greater than screening levels included in the SQuiRTs, particularly TELs (Table A-5). Sample sites included Copco 1, Iron Gate, and J.C. Boyle reservoirs and both Klamath River estuary locations. Some exceedances of PELs and TECs were also present for chemicals possessing RLs that were greater than screening level screening levels included in the SQuiRTs (Table A-4).

Therefore, at this step (Step 2-Freshwater), 30 potential contaminants (i.e., 62 total contaminants possessing freshwater SLs - 32 possible COPCs) present no significant freshwater toxicity risks and need no further evaluation.

A.2.3 Human Health Sediment Screening Values

Of the 77 total sediment samples analyzed for the 2009–2010 study, there were no exceedances of the USEPA non-carcinogenic residential soil RSL (Table A-7). However, 47 samples exceeded the USEPA total carcinogenic RSL for residential soils for arsenic or nickel, including J.C. Boyle Reservoir (14 of 26 samples), Copco 1 Reservoir (17 of 25 samples), Iron Gate Reservoir (14 of 24 samples) and the Klamath River Estuary (2 of 2 samples) (Table A-7). Therefore, arsenic and nickel at these stations must be retained for further evaluation as human health COPCs at this step. In addition, 19 chemicals, including PCBs, VOCs, and SVOCs, possessed RLs greater than the USEPA total carcinogenic RSL for residential soils (Table A-4). As above, the sediment chemistry data alone are not sufficient to confirm that these compounds are below human health screening levels. Therefore these compounds must be retained for further evaluation as possible human health COPCs at this step.

Five of 26 samples in J.C. Boyle Reservoir positively exceeded the Oregon DEQ Bioaccumulation SLV for Human–Subsistence for multiple polychlorinated dioxins/furans, pesticides/herbicides/insecticides (4,4’ DDD, 4,4’ DDE, 4,4’ DDT, Dieldrin), and pentachlorophenol. Also, 4 of 26 samples positively exceeded the Oregon DEQ Bioaccumulation SLV for Human–General for these same compounds (except pentachlorophenol) (Table A-7). Therefore these compounds at these stations must be retained for further evaluation as human health COPCs at this step. In addition, multiple polychlorinated dioxins/furans, pesticides/herbicides/insecticides (4,4’ DDD, 4,4’ DDE, 4,4’ DDT, Dieldrin), and hexachlorobenzene possessed RLs greater than the Oregon DEQ Bioaccumulation SLV for Human–Subsistence for and the Human–General screening levels for these same compounds (Table A-4). As above, the sediment chemistry data alone are not sufficient to confirm that these compounds are below human health screening levels. Therefore these compounds must be retained for further evaluation as possible human health COPCs at this step.

Therefore, at this step , 158 potential contaminants (i.e., 190 total contaminants possessing freshwater SLs - 32 possible COPCs) present no significant human health toxicity risks and need no further evaluation.

A.3 Sediment Chemistry Screening Conclusions and Next Steps

The step-wise sediment chemistry screening process summarized above indicates that the sediment deposits in the Klamath River reservoirs are not highly contaminated. There are few positive exceedances of relevant screening values (Tables A-5 through A-7), and therefore little positive indication that significant aquatic toxicity, or ecological or human health risk, would likely result from exposure to the sediments. However, there are multiple chemicals (Table A-4) whose concentrations, or even presence, could not be positively determined due to excessively high laboratory detection limits. Therefore conclusions cannot be reached by screening-level evaluation alone.

Following the framework presented in the SEF, the few compounds that positively exceeded relevant screening levels, as well as the greater number of compounds for which it could not determined whether screening levels were exceeded, must be evaluated further before conclusions about the potential for contaminant-related impacts and risks can be reached. That further evaluation includes elutriate tests, direct laboratory testing of the sediments and elutriates to assess their toxicity to sensitive aquatic organisms (i.e., toxicity bioassays), and direct laboratory testing of the sediments for the bioavailability of the contaminants present (i.e., whether contaminants are available to be taken up by organisms directly exposed to the sediments for extended periods of time, or bioaccumulation assays). Each of these biological testing approaches have been conducted on the same reservoir sediment samples evaluated in the chemistry screening described above. Results of the elutriate and bioassay tests are reported in Appendix B.

Additional important lines of evidence can also be developed outside of the SEF procedures. For example, the presence or absence of contaminants in wild organisms living in the reservoirs can help confirm the real-world relevance of laboratory bioaccumulation test results, and modeling can be used to determine the likely degree of actual exposure to released sediment under different dam removal scenarios. These types of evaluations are reported in Section 5.

A.4 References

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Table A-1. Marine Sediment Screening Levels for the Secretarial Determination Klamath River Sediment Study.

Chemical	Units	Pacific Northwest SEF		Puget Sound DMMP			Included in SQuiRTs					
		SL1	SL2	SL	BT	ML	ERL	ERM	T20	TEL	T50	PEL
Metals and AVS												
Antimony	mg/kg	150	150	150		200			0.63		2.4	
Arsenic	mg/kg	57	93	57	507.1	700	8.2	70	7.4	7.24	20	41.6
Cadmium	mg/kg	5.1	6.7	5.1	11.3	14	1.2	9.6	0.38	0.68	1.4	4.21
Chromium	mg/kg	260	270		267		81	370	49	52.3	141	160
Copper	mg/kg	390	390	390	1,027	1,300	34	270	32	18.7	94	108
Lead	mg/kg	450	530	450	975	1,200	46.7	218	30	30.24	94	112
Mercury	mg/kg	0.41	0.59	0.41	1.5	2.3	0.15	0.71	0.14	0.13	0.48	0.7
Nickel	mg/kg			140	370	370	20.9	51.6	15	15.9	47	42.8
Selenium	mg/kg				3							
Silver	mg/kg	6.1	6.1	6.1	6.1	8.4	1	3.7	0.23	0.73	1.1	1.77
Zinc	mg/kg	410	960	410	2,783	3,800	150	410	94	124	245	271
Organics **PAHs**												
Acenaphthene	µg/kg	500	500	500		2,000						
Acenaphthylene	µg/kg	560	1,300	560		1,300						
Anthracene	µg/kg	960	960	960		13,000						
Benz(a)anthracene	µg/kg	1,300	1,600	1,300		5,100						
Benzo(a)pyrene	µg/kg	1,600	1,600	1,600		3,600						
Benzo(b)fluoranthene	µg/kg											
Benzo(g,h,i)perylene	µg/kg	670	720	670		3,200						
Benzo(k)fluoranthene	µg/kg	3,200	3,600	3,200		9,900						
Chrysene	µg/kg	1,400	2,800	1,400		21,000	384	2,800	82	108	650	846
Dibenz(a,h)anthracene	µg/kg	230	230	230		1,900	63.4	260	19	6.22	113	135
Dibenzofuran	µg/kg	540	540	540		1,700						
Fluoranthene	µg/kg	1,700	2,500	1,700	4,600	30,000	600	5,100	119	113	1,034	1,494
Fluorene	µg/kg	540	540	540		3,600	19	540	19	21.2	114	144
Indeno(1,2,3-cd)pyrene	µg/kg	600	690	600		4,400			68		488	

Table A-1. Marine Sediment Screening Levels for the Secretarial Determination Klamath River Sediment Study.

Chemical	Units	Pacific Northwest SEF		Puget Sound DMMP			Included in SQuiRTs					
		SL1	SL2	SL	BT	ML	ERL	ERM	T20	TEL	T50	PEL
Naphthalene	µg/kg	2,100	2,100	2,100		2,400	160	2,100	30	34.6	217	391
Phenanthrene	µg/kg	1,500	1,500	1,500		21,000						
Pyrene	µg/kg	2,600	3,300	2,600	11,980	16,000	665	2,600	125	153	932	1,398
Organics **PCBs**												
Total PCBs	pg/g	130,000	1,000,000	130,000	38,000	3,100,000						
Organics **Pesticides/Herbicides/Insecticides: Organochlorine Pesticides**												
4,4'-DDD	µg/kg			6.9	50	69						
4,4'-DDE	µg/kg			6.9	50	69						
4,4'-DDT	µg/kg			6.9	50	69						
Aldrin	µg/kg	9.5	9.5	10								
BHC-gamma (HCH-gamma, Lindane)	µg/kg			10						0.32		0.99
Chlordane	µg/kg	2.8	4.5	10	37		0.5	6		2.26		4.79
Chlordane (technical)	µg/kg	2.8	4.5	10	37		0.5	6		2.26		4.79
Chlordane-alpha	µg/kg	2.8	4.5	10	37		0.5	6		2.26		4.79
Chlordane-gamma	µg/kg	2.8	4.5	10	37		0.5	6		2.26		4.79
Dieldrin	µg/kg	1.9	3.5	10			0.02	8	0.83	0.72	2.9	4.3
Heptachlor	µg/kg	1.5	2	10								
Heptachlor epoxide	µg/kg								0.6			2.74
Organics **Phthalates**												
Bis(2-ethylhexyl) phthalate	µg/kg	1,300	1,900	1,300		8,300						
Butyl benzyl phthalate	µg/kg	63	900	63		970						
Diethyl phthalate	µg/kg	200	200	200		1,200						
Dimethyl phthalate	µg/kg	71	160	71		1,400						
Di-N-butyl phthalate	µg/kg	1,400	1,400	1,400		5,100						
Di-N-octyl phthalate	µg/kg	6,200	6,200	6,200		6,200						

Table A-1. Marine Sediment Screening Levels for the Secretarial Determination Klamath River Sediment Study.

Chemical	Units	Pacific Northwest SEF		Puget Sound DMMP			Included in SQuiRTs					
		SL1	SL2	SL	BT	ML	ERL	ERM	T20	TEL	T50	PEL
Organics SVOCs: Phenols												
2,4-Dimethylphenol	µg/kg	29	29	29		210						
2-Methylnaphthalene	µg/kg	670	670	670		1,900						
2-Methylphenol	µg/kg	63	63	63		77						
4-Methylphenol	µg/kg	670	670	670		3,600						
Pentachlorophenol	µg/kg	400	690	400	504	690						
Phenol	µg/kg	420	1,200	420		1,200						
Organics VOCs												
Ethylbenzene	µg/kg			10		50						
Tetrachloroethene	µg/kg			57		210						
Total Xylenes	µg/kg			40		160						
Organics SVOCs: Chlorinated hydrocarbons												
1,2,4-Trichlorobenzene	µg/kg	31	51	31		64						
1,2-Dichlorobenzene	µg/kg	35	50	35		110						
1,3-Dichlorobenzene	µg/kg			170								
1,4-Dichlorobenzene	µg/kg	110	110	110		120						
Hexachlorobenzene	µg/kg	22	70	22	168	230						
Hexachlorobutadiene	µg/kg	11	120	29		270						
Hexachloroethane	µg/kg			1,400		14,000						
Trichloroethene	µg/kg			160		1,600						

Table A-1. Marine Sediment Screening Levels for the Secretarial Determination Klamath River Sediment Study.

Chemical	Units	Pacific Northwest SEF		Puget Sound DMMP			Included in SQuiRTs					
		SL1	SL2	SL	BT	ML	ERL	ERM	T20	TEL	T50	PEL
Organics **Other SVOCs**												
Benzoic acid	µg/kg	650	650	650		760						
Benzyl alcohol	µg/kg	57	73	57		870						
N-nitrosodiphenylamine	µg/kg	28	40	28		130						

Screening Level Key:

(blank)= No screening levels apply
SEF= Sediment Evaluation Framework
SL1= Sediment Screening Level 1
SL2= Sediment Screening Level 2
DMMP= Dredged Material Management Program
SL= Screening Level
BT= Bioaccumulation Trigger
ML= Maximum Level
SQuiRTs= Screening Quick Reference Tables
ERL= Effects Range Low
ERM= Effects Range Median
T20= Chemical concentration representing a 20% probability of observing an effect, calculated using individual chemical logistic regression models based on 10-day survival results from marine amphipod tests (*Ampelisca a*. and *Rhepoxynius a.*).
TEL= Threshold Effect Level
T50= Chemical concentration representing a 50% probability of observing an effect, calculated using individual chemical logistic regression models based on 10-day survival results from marine amphipod tests (*Ampelisca a.* and *Rhepoxynius a.*).
PEL= Probable Effect Level

Units Key:

g= gram
kg= kilogram (1,000 grams)
mg= milligram (10^{-3} gram)
ug= microgram (10^{-6} gram)
pg= picogram (10^{-12} gram)

Table A-2. Freshwater Sediment Screening Levels for the Secretarial Determination Klamath River Sediment Study.

Chemical	Units	Pacific Northwest SEF		Included in SQuiRTs						Oregon DEQ Bioaccumulation SLV				
		SL1	SL2	TEL	LEL	PEL	SEL	TEC	PEC	Fish	Bird-Individual	Bird-Population	Mammal-Individual	Mammal-Population
Metals and AVS														
Arsenic	mg/kg	20	51	5.9	6	17	33	9.79	33					
Cadmium	mg/kg	1.1	1.5	0.596	0.6	3.53	10	0.99	4.98					
Chromium	mg/kg	95	100	37.3	26	90	110	43.4	111					
Copper	mg/kg	80	830	35.7	16	197	110	31.6	149					
Lead	mg/kg	340	430	35	31	91.3	250	35.8	128					
Mercury	mg/kg	0.28	0.75	0.174	0.2	0.486	2	0.18	1.06					
Nickel	mg/kg	60	70	18	16	36	75	22.7	48.6					
Silver	mg/kg	2	2.5											
Zinc	mg/kg	130	400	123	120	315	820	121	459					
Organics **PAHs**														
2-Methylnaphthalene	µg/kg	470	560											
Acenaphthene	µg/kg	1,100	1,300											
Acenaphthylene	µg/kg	470	640											
Anthracene	µg/kg	1,200	1,600											
Benz(a)anthracene	µg/kg	4,300	5,800											
Benzo(a)pyrene	µg/kg	3,300	4,800											
Benzo(g,h,i)perylene	µg/kg	4,000	5,200											
Benzo(k)fluoranthene	µg/kg	600	4,000											
Chrysene	µg/kg	5,900	6,400	57.1	340	862	4,600	166	1,290					
Dibenz(a,h)anthracene	µg/kg	800	840	60			1,300	33	135					
Dibenzofuran	µg/kg	400	440											
Fluoranthene	µg/kg	11,000	15,000	111	750	2,355	10,200	423	2,230	37,000			360,000	1,800,000
Fluorene	µg/kg	1,000	3,000	21.2	190	144	1,600	77.4	536					
Indeno(1,2,3-cd)pyrene	µg/kg	4,100	5,300		200		3,200							
Naphthalene	µg/kg	500	1,300	34.6		391		176	561					

Table A-2. Freshwater Sediment Screening Levels for the Secretarial Determination Klamath River Sediment Study.

Chemical	Units	Pacific Northwest SEF		Included in SQuiRTs						Oregon DEQ Bioaccumulation SLV				
		SL1	SL2	TEL	LEL	PEL	SEL	TEC	PEC	Fish	Bird-Individual	Bird-Population	Mammal-Individual	Mammal-Population
Phenanthrene	µg/kg	6,100	7,600											
Pyrene	µg/kg	8,800	16,000	53	490	875	8,500	195	1,520	1,900			18,000,000	90,000,000
Organics PCBs														
Total PCBs	pg/g	60,000	120,000											
Organics Pesticides/Herbicides/Insecticides: Organochlorine Pesticides														
4,4'-DDD	µg/kg									0.39	0.43	1.3	4.9	24
4,4'-DDE	µg/kg									0.39	0.43	1.3	4.9	24
4,4'-DDT	µg/kg									0.39	0.43	1.3	4.9	24
BHC-alpha (HCH-alpha)	µg/kg				6		100							
BHC-beta(HCH-beta)	µg/kg				5		210							
BHC-gamma (HCH-gamma, Lindane)	µg/kg			0.94	3	1.38	10	2.37	4.99					
Chlordane	µg/kg			4.5	7	8.9	60	3.24	17.6	0.5	10	51	28	56
Chlordane (technical)	µg/kg			4.5	7	8.9	60	3.24	17.6	0.5	10	51	28	56
Chlordane-alpha	µg/kg			4.5	7	8.9	60	3.24	17.6	0.5	10	51	28	56
Chlordane-gamma	µg/kg			4.5	7	8.9	60	3.24	17.6	0.5	10	51	28	56
Dieldrin	µg/kg			2.85	2	6.67	910	1.9	61.8	2.2	0.37	1.8	1.2	6.1
Heptachlor	µg/kg			2.67	3	62.4	1,300	2.22	207					
Heptachlor epoxide	µg/kg			0.6	5	2.74	50	2.47	16					

Table A-2. Freshwater Sediment Screening Levels for the Secretarial Determination Klamath River Sediment Study.

Chemical	Units	Pacific Northwest SEF		Included in SQuiRTs						Oregon DEQ Bioaccumulation SLV				
		SL1	SL2	TEL	LEL	PEL	SEL	TEC	PEC	Fish	Bird-Individual	Bird-Population	Mammal-Individual	Mammal-Population
Organics Phthalates														
Bis(2-ethylhexyl) phthalate	µg/kg	220	320											
Butyl benzyl phthalate	µg/kg	260	370											
Dimethyl phthalate	µg/kg	46	440											
Di-N-octyl phthalate	µg/kg	26	45											
Organics SVOCs: Phenols														
Pentachlorophenol	µg/kg									310			330	3,300
Organics SVOCs: Chlorinated hydrocarbons														
Hexachlorobenzene	µg/kg									61,000				
Organics Polychlorinated Dioxins and Furans														
1,2,3,4,6,7,8-HPCDD	pg/g									430,000	530,000	2,700,000	3,900	110,000
1,2,3,4,6,7,8-HPCDF	pg/g									43,000	53,000	270,000	3,900	110,000
1,2,3,4,7,8,9-HPCDF	pg/g									43,000	53,000	270,000	3,900	110,000
1,2,3,4,7,8-HXCDD	pg/g									34	420	2,100	15	420
1,2,3,4,7,8-HXCDF	pg/g									170	210	1,100	15	420
1,2,3,6,7,8-HXCDD	pg/g									1,700	2,100	11,000	15	420
1,2,3,6,7,8-HXCDF	pg/g									34	420	2,100	15	420
1,2,3,7,8,9-HXCDD	pg/g									1,700	210	1,100	15	420
1,2,3,7,8,9-HXCDF	pg/g									34	420	2,100	15	420
1,2,3,7,8-PECDD	pg/g									17	21	110	1.5	42
1,2,3,7,8-PECDF	pg/g									95	59	300	14	400
2,3,4,6,7,8-HXCDF	pg/g									34	420	2,100	15	420

Table A-2. Freshwater Sediment Screening Levels for the Secretarial Determination Klamath River Sediment Study.

Chemical	Units	Pacific Northwest SEF		Included in SQuiRTs						Oregon DEQ Bioaccumulation SLV				
		SL1	SL2	TEL	LEL	PEL	SEL	TEC	PEC	Fish	Bird-Individual	Bird-Population	Mammal-Individual	Mammal-Population
2,3,4,7,8-PECDF	pg/g									1.1	0.7	3.5	0.17	4.7
2,3,7,8-TCDD	pg/g									0.56	0.7	3.5	0.052	1.4
2,3,7,8-TCDF	pg/g									95	5.9	30	4.3	120
OCDD	pg/g									4,300,000	5,300,000	27,000,000	130,000	3,600,000
OCDF	pg/g									4,300,000	5,300,000	27,000,000	130,000	3,600,000

Screening Level Key:

(blank)= No screening levels apply
SEF= Sediment Evaluation Framework
SL1= Sediment Screening Level 1
SL2= Sediment Screening Level 2
SQuiRTs= Screening Quick Reference Tables
TEL= Threshold Effect Level
LEL= Lowest Effect Level
PEL= Probable Effect Level
SEL= Severe Effect Level
TEC= Threshold Effect Concentration
PEC= Probable Effect Concentration
DEQ= Department of Environmental Quality
SLV= Screening Level Value

Units Key:

g= gram
kg= kilogram (1,000 grams)
mg= milligram (10^{-3} gram)
ug= microgram (10^{-6} gram)
pg= picogram (10^{-12} gram)

Table A-3. Human Health Sediment Screening Levels for the Secretarial Determination Klamath River Sediment Study.

Chemical	Units	Oregon DEQ Bioaccumulation SLV		USEPA Regional Screening Levels (RSLs) for Residential Soils[1]		California Human Health Screening Levels (CHHSLs)	
		Human-Subsistence	Human-General	Total Carcinogenic	Total Non-carcinogenic	Residential	Commercial
Conventionals							
Cyanide, WAD	mg/kg				1,600		
Nitrate + nitrite (NO3+NO2)	µg/kg				130,000,000		
Metals and AVS							
Aluminum	mg/kg				77,000		
Antimony	mg/kg				31	30	380
Arsenic	mg/kg			0.39	22	0.07	0.24
Cadmium	mg/kg			1,800	70	1.7	7.5
Chromium	mg/kg					100,000	100,000
Copper	mg/kg				3,100	3,000	38,000
Iron	mg/kg				55,000		
Lead	mg/kg				400	80	320
Mercury	mg/kg				6	18	180
Nickel	mg/kg			0.38	1,500	1,600	16,000
Selenium	mg/kg				390	380	4,800
Silver	mg/kg				390	380	4,800
Zinc	mg/kg				23,000	23,000	100,000
Organics **PAHs**							
2-Methylnaphthalene	µg/kg				310,000		
Acenaphthene	µg/kg				3,400,000		
Anthracene	µg/kg				17,000,000		
Benz(a)anthracene	µg/kg			150			
Benzo(a)pyrene	µg/kg			15		38	130
Benzo(b)fluoranthene	µg/kg			150			

Table A-3. Human Health Sediment Screening Levels for the Secretarial Determination Klamath River Sediment Study.

Chemical	Units	Oregon DEQ Bioaccumulation SLV		USEPA Regional Screening Levels (RSLs) for Residential Soils[1]		California Human Health Screening Levels (CHHSLs)	
		Human-Subsistence	Human-General	Total Carcinogenic	Total Non-carcinogenic	Residential	Commercial
Benzo(k)fluoranthene	µg/kg			1,500			
Chrysene	µg/kg			15,000			
Dibenz(a,h)anthracene	µg/kg			15			
Fluoranthene	µg/kg	62,000	510,000		2,300,000		
Fluorene	µg/kg				2,300,000		
Indeno(1,2,3-cd)pyrene	µg/kg			150			
Naphthalene	µg/kg			3,600	140,000		
Pyrene	µg/kg	47,000	380,000		1,700,000		
Organics **PCBs**							
Aroclor 1016	µg/g			6.3	3.9		
Aroclor 1221	µg/g			0.14			
Aroclor 1232	µg/g			0.14			
Aroclor 1242	µg/g			0.22			
Aroclor 1248	µg/g			0.22			
Aroclor 1254	µg/g			0.22	1.1		
Aroclor 1260	µg/g			0.22			
PCB Congener 105/127	pg/g			34,000			
PCB Congener 114	pg/g			680			
PCB Congener 118/106	pg/g			34,000			
PCB Congener 123	pg/g			34,000			
PCB Congener 126	pg/g			34			
PCB Congener 156	pg/g			6,800			
PCB Congener 157	pg/g			6,800			
PCB Congener 167	pg/g			340,000			

Table A-3. Human Health Sediment Screening Levels for the Secretarial Determination Klamath River Sediment Study.

Chemical	Units	Oregon DEQ Bioaccumulation SLV		USEPA Regional Screening Levels (RSLs) for Residential Soils[1]		California Human Health Screening Levels (CHHSLs)	
		Human-Subsistence	Human-General	Total Carcinogenic	Total Non-carcinogenic	Residential	Commercial
PCB Congener 169	pg/g			340			
PCB Congener 189	pg/g			34,000			
PCB Congener 77	pg/g			34,000			
PCB Congener 81	pg/g			34,000			
Total PCBs	pg/g					89,000	300,000
Organics Pesticides/Herbicides/Insecticides							
4,4'-DDD	µg/kg	0.04	0.33			2,300	9,000
4,4'-DDE	µg/kg	0.04	0.33			1,600	6,300
4,4'-DDT	µg/kg	0.04	0.33			1,600	6,300
Acetochlor	µg/kg				1,200,000		
Alachlor	µg/kg			8,700	610,000		
Aldicarb	µg/kg				61,000		
Aldicarb sulfone	µg/kg				61,000		
Aldrin	µg/kg			29	1,800	33	130
Atrazine	µg/kg			2,100	2,100,000		
Baygon	µg/kg				240,000		
BHC-alpha (HCH-alpha)	µg/kg			77	490,000		
BHC-beta(HCH-beta)	µg/kg			270			
BHC-gamma (HCH-gamma, Lindane)	µg/kg			520	21,000	0.5	2
Bifenthrin	µg/kg				920,000		
Carbaryl	µg/kg				6,100,000		
Carbofuran	µg/kg				310,000		
Chlordane	µg/kg	0.04	0.37	1,600	35,000	430	1,700
Chlordane (technical)	µg/kg	0.04	0.37	1,600	35,000	430	1,700

Table A-3. Human Health Sediment Screening Levels for the Secretarial Determination Klamath River Sediment Study.

Chemical	Units	Oregon DEQ Bioaccumulation SLV		USEPA Regional Screening Levels (RSLs) for Residential Soils[1]		California Human Health Screening Levels (CHHSLs)	
		Human-Subsistence	Human-General	Total Carcinogenic	Total Non-carcinogenic	Residential	Commercial
Chlordane-alpha	µg/kg	0.04	0.37	1,600	35,000	430	1,700
Chlordane-gamma	µg/kg	0.04	0.37	1,600	35,000	430	1,700
Chlorothalonil	µg/kg			160,000	920,000		
Chlorpyrifos	µg/kg				180,000		
Cypermethrin	µg/kg				610,000		
Dalapon	µg/kg				1,800,000		
Dicamba	µg/kg				1,800,000		
Dinoseb	µg/kg				61,000		
Demeton	µg/kg				2,400		
Demeton-o	µg/kg				2,400		
Demeton-s	µg/kg				2,400		
Diazinon	µg/kg				43,000		
Dichlorvos	µg/kg			1,700	31,000		
Dieldrin	µg/kg	0.001	0.0081	30	3,100	35	130
Dimethoate	µg/kg				12,000		
Disulfoton	µg/kg				2,400		
Endosulfan I	µg/kg				370,000		
Endosulfan II	µg/kg				370,000		
Endosulfan sulfate	µg/kg				370,000		
Endrin	µg/kg				18,000	21,000	230,000
Endrin aldehyde	µg/kg				18,000		
Endrin ketone	µg/kg				18,000		
EPTC	µg/kg				2,000,000		
Fenpropathrin	µg/kg				1,500,000		
Heptachlor	µg/kg			110	31,000	130	520

Table A-3. Human Health Sediment Screening Levels for the Secretarial Determination Klamath River Sediment Study.

Chemical	Units	Oregon DEQ Bioaccumulation SLV		USEPA Regional Screening Levels (RSLs) for Residential Soils[1]		California Human Health Screening Levels (CHHSLs)	
		Human-Subsistence	Human-General	Total Carcinogenic	Total Non-carcinogenic	Residential	Commercial
Heptachlor epoxide	µg/kg			53	790		
Malathion	µg/kg				1,200,000		
MCPA (2-methyl-4-chlorophenoxyacetic acid)	µg/kg				31,000		
MCPP	µg/kg				61,000		
Methomyl	µg/kg				1,500,000		
Methoxychlor	µg/kg				310,000	340,000	3,800,000
Methyl parathion	µg/kg				15,000		
Metolachlor	µg/kg				9,200,000		
Metribuzin	µg/kg				1,500,000		
Molinate	µg/kg				120,000		
Oxamyl	µg/kg				1,500,000		
Parathion	µg/kg				370,000		
Pendimethalin	µg/kg				2,400,000		
Permethrin (total)	µg/kg				3,100,000		
Phorate	µg/kg				12,000		
Propachlor	µg/kg				790,000		
Ronnel	µg/kg				3,100,000		
Simazine	µg/kg			4,000	310,000		
Stirophos	µg/kg			20,000	1,800,000		
Terbacil	µg/kg				790,000		
Thiobencarb	µg/kg				610,000		
Toxaphene	µg/kg			440		460	1,800
Tributyl phosphate	µg/kg			53,000	12,000,000		
Trifluralin	µg/kg			63,000	460,000		

Table A-3. Human Health Sediment Screening Levels for the Secretarial Determination Klamath River Sediment Study.

Chemical	Units	Oregon DEQ Bioaccumulation SLV		USEPA Regional Screening Levels (RSLs) for Residential Soils[1]		California Human Health Screening Levels (CHHSLs)	
		Human-Subsistence	Human-General	Total Carcinogenic	Total Non-carcinogenic	Residential	Commercial
Organics Phthalates							
Bis(2-ethylhexyl) phthalate	µg/kg			35,000	1,200,000		
Butyl benzyl phthalate	µg/kg			260,000	12,000,000		
Diethyl phthalate	µg/kg				49,000,000		
Organics VOCs							
1,2,4-Trimethylbenzene	µg/kg				62,000		
1,2-Dibromoethane	µg/kg			34	78,000		
1,3,5-Trimethylbenzene	µg/kg				780,000		
2,4-Dinitrotoluene	µg/kg			1,600	120,000		
2,6-Dinitrotoluene	µg/kg				61,000		
2-Hexanone	µg/kg				210,000		
Acetone	µg/kg				61,000,000		
Allyl chloride	µg/kg			680	1,800		
Benzene	µg/kg			1,100	86,000		
Bromobenzene	µg/kg				300,000		
Bromodichloromethane	µg/kg			270	1,600,000		
Bromoform	µg/kg			61,000	1,200,000		
Bromomethane	µg/kg				7,300		
Carbon disulfide	µg/kg				820,000		
Carbon tetrachloride	µg/kg			610	110,000		
Chlorobenzene	µg/kg				290,000		
Chlorobenzilate	µg/kg			4,400	1,200,000		
Chloroform	µg/kg			290	210,000		

Table A-3. Human Health Sediment Screening Levels for the Secretarial Determination Klamath River Sediment Study.

Chemical	Units	Oregon DEQ Bioaccumulation SLV		USEPA Regional Screening Levels (RSLs) for Residential Soils[1]		California Human Health Screening Levels (CHHSLs)	
		Human-Subsistence	Human-General	Total Carcinogenic	Total Non-carcinogenic	Residential	Commercial
Chloromethane	µg/kg				120,000		
Cyclohexane	µg/kg				7,000,000		
Dibromochloromethane	µg/kg			680	1,200,000		
Dibromomethane	µg/kg				25,000		
Dichlorodifluoromethane	µg/kg				180,000		
Ethyl acetate	µg/kg				70,000,000		
Ethyl ether	µg/kg				16,000,000		
Ethyl methacrylate	µg/kg				7,000,000		
Ethylbenzene	µg/kg			5,400	3,500,000		
Methyl acetate	µg/kg				78,000,000		
Methylene chloride	µg/kg			11,000	1,700,000		
Ortho-xylene	µg/kg				3,800,000		
Pentachloroethane	µg/kg			5,400			
Styrene	µg/kg				6,300,000		
Vinyl chloride	µg/kg			60	74,000		
Organics **SVOCs: Phenols**							
2,4,5-Trichlorophenol	µg/kg				6,100,000		
2,4,6-Trichlorophenol	µg/kg			44,000	61,000		
2,4-Dichlorophenol	µg/kg				180,000		
2,4-Dimethylphenol	µg/kg				1,200,000		
2,4-Dinitrophenol	µg/kg				120,000		
2-Chlorophenol	µg/kg				390,000		
Pentachlorophenol	µg/kg	30	250	3,000	1,400,000	4,400	13,000
Phenol	µg/kg				18,000,000		

Table A-3. Human Health Sediment Screening Levels for the Secretarial Determination Klamath River Sediment Study.

Chemical	Units	Oregon DEQ Bioaccumulation SLV		USEPA Regional Screening Levels (RSLs) for Residential Soils[1]		California Human Health Screening Levels (CHHSLs)	
		Human-Subsistence	Human-General	Total Carcinogenic	Total Non-carcinogenic	Residential	Commercial
Organics SVOCs: Chlorinated Hydrocarbons							
1,1,1,2-Tetrachloroethane	µg/kg			1,900	2,300,000		
1,1,1-Trichloroethane	µg/kg				8,700,000		
1,1,2,2-Tetrachloroethane	µg/kg			560	310,000		
1,1,2-Trichloroethane	µg/kg			1,100	310,000		
1,1-Dichloroethane	µg/kg			3,300	16,000,000		
1,2,3-Trichlorobenzene	µg/kg				49,000		
1,2,3-Trichloropropane	µg/kg			5	5,200		
1,2,4-Trichlorobenzene	µg/kg			22,000	62,000		
1,2-Dibromo-3-chloropropane	µg/kg			5.4	4,900		
1,2-Dichlorobenzene	µg/kg				1,900,000		
1,2-Dichloroethane	µg/kg			430	1,400,000		
1,2-Dichloropropane	µg/kg			890	16,000		
1,3-Dichloropropane	µg/kg				1,600,000		
1,4-Dichlorobenzene	µg/kg			2,400	3,500,000		
3,3'-Dichlorobenzidine	µg/kg			1,100			
Bis(2-chloroethoxy)methane	µg/kg				180,000		
Bis(2-chloroethyl) ether	µg/kg			210			
Hexachlorobenzene	µg/kg	2.3	19	300	49,000		
Hexachlorobutadiene	µg/kg			6,200	61,000		
Hexachlorocyclopentadiene	µg/kg				370,000		
Hexachloroethane	µg/kg			35,000	61,000		
Trans-1,4-dichloro-2-butene	µg/kg			6.9			
Trichlorofluoromethane	µg/kg				790,000		

Table A-3. Human Health Sediment Screening Levels for the Secretarial Determination Klamath River Sediment Study.

Chemical	Units	Oregon DEQ Bioaccumulation SLV		USEPA Regional Screening Levels (RSLs) for Residential Soils[1]		California Human Health Screening Levels (CHHSLs)	
		Human-Subsistence	Human-General	Total Carcinogenic	Total Non-carcinogenic	Residential	Commercial
Organics Other SVOCs							
2-Nitroaniline	µg/kg				610,000		
4-Nitroaniline	µg/kg			24,000	240,000		
Benzoic acid	µg/kg				240,000,000		
Benzyl alcohol	µg/kg				6,100,000		
Dibenzofuran	µg/kg				78,000		
Isophorone	µg/kg			510,000	12,000,000		
Nitrobenzene	µg/kg			4,800	130,000		
N-nitrosodi-n-propylamine	µg/kg			69			
N-nitrosodiphenylamine	µg/kg			99,000			
Pyridine	µg/kg				78,000		
Organics Polychlorinated Dioxins and Furans							
1,2,3,4,6,7,8-HPCDD	pg/g	85	690				
1,2,3,4,6,7,8-HPCDF	pg/g	85	690				
1,2,3,4,7,8,9-HPCDF	pg/g	85	690				
1,2,3,4,7,8-HXCDD	pg/g	0.34	2.7				
1,2,3,4,7,8-HXCDF	pg/g	0.34	2.7				
1,2,3,6,7,8-HXCDD	pg/g	0.34	2.7				
1,2,3,6,7,8-HXCDF	pg/g	0.34	2.7				
1,2,3,7,8,9-HXCDD	pg/g	0.34	2.7				
1,2,3,7,8,9-HXCDF	pg/g	0.34	2.7				
1,2,3,7,8-PECDD	pg/g	0.034	0.27				
1,2,3,7,8-PECDF	pg/g	0.31	2.6				

Table A-3. Human Health Sediment Screening Levels for the Secretarial Determination Klamath River Sediment Study.

Chemical	Units	Oregon DEQ Bioaccumulation SLV		USEPA Regional Screening Levels (RSLs) for Residential Soils[1]		California Human Health Screening Levels (CHHSLs)	
		Human-Subsistence	Human-General	Total Carcinogenic	Total Non-carcinogenic	Residential	Commercial
2,3,4,6,7,8-HXCDF	pg/g	0.34	2.7				
2,3,4,7,8-PECDF	pg/g	0.0037	0.03				
2,3,7,8-TCDD	pg/g	0.0011	0.0091	4.5	72	4.6	19
2,3,7,8-TCDF	pg/g	0.094	0.77				
OCDD	pg/g	2,800	23,000				
OCDF	pg/g	2,800	23,000				
Organics **PBDEs**							
BDE-153	pg/g				16,000,000		
BDE-209	pg/g			690,000,000	430,000,000		
BDE-47	pg/g				7,800,000		
BDE-99	pg/g				7,800,000		

[1] Levels represent totals of ingestion, dermal, and inhalation levels.

Screening Level Key:

(blank)= No screening levels apply
DEQ= Department of Environmental Quality
SLV= Screening Level Value
RSLs= Regional Screening Levels
CHHSLs= California Human Health Screening Levels

Units Key:

g= gram
kg= kilogram (1,000 grams)
mg= milligram (10^{-3} gram)
ug= microgram (10^{-6} gram)
pg= picogram (10^{-12} gram)

Table A-4. Possible Chemicals of Potential Concern (COPCs) Based on Step-wise Comparisons to Sediment Screening Levels

Chemical	Method	Units	Reporting Limit	Freshwater Screening Levels (FWS)													Marine Screening Levels (MS)												Human Health Screening Levels					
				Pacific Northwest SEF		Included in SQuiRTs						Oregon DEQ Bioaccumulation SLV (BSLV)					Pacific Northwest SEF		Puget Sound DMMP			Included in SQuiRTs						Oregon DEQ BSLV	Oregon DEQ BSLV		USEPA RSL		CHHSL	
				SL1	SL2	TEL	LEL	PEL	SEL	TEC	PEC	F	A-I	A-P	M-I	M-P	SL1	SL2	SL	BT	ML	ERL	ERM	T20	TEL	T50	PEL	F	H-S	H-G	TOT CAR	TOT NON CAR	Residential	Commercial
Metals and AVS																																		
Antimony	6020	mg/kg	0.27–1.7														-	-	-		-			0.63		-						-	-	-
Cadmium	6020	mg/kg	0.14–0.84	-	-	0.596	0.6	-	-	-	-						-	-	-	-	-	-	-	0.38	0.68	-	-				-	-	-	-
Mercury	7471A	mg/kg	0.054–0.34	0.28	-	0.174	0.2	-	-	0.18	-						-	-	-	-	-	0.15	-	0.14	0.13	-	-					-	-	-
Silver	6010B	mg/kg	0.68–3.8	2	2.5												-	-	-	-	-	1	3.7	0.23	0.73	1.1	1.77					-	-	-
Organics **PAHs**																																		
2-Methylnaphthalene	8270D	µg/kg	170–1,200	470	560												670	670	670		-											-		
Acenaphthene	8270D	µg/kg	170–1,200	1,100	-	6.71		88.9									500	500	500		-	16	500	19	6.71	116	88.9					-		
Acenaphthylene	8270D	µg/kg	170–1,200	470	640												560	-	560		-													
Anthracene	8270D	µg/kg	170–1,200	1,200	-	46.9	220	245	-	57.2	845						960	960	960		-	85.3	1,100	34	46.9	290	245					-		
Benz(a)anthracene	8270D	µg/kg	170–1,200	-	-	31.7	320	385	-	108	1,05 0						-	-	-		-	261	-	61	74.8	466	693				150			
Benzo(a)pyrene	8270D	µg/kg	170–1,200	-	-	31.9	370	782	-	150	-						-	-	-		-	430	-	69	88.8	520	763				15		38	130
Benzo(b)fluoranthene	8270D	µg/kg	170–1,200																					130		1,107					150			
Benzo(g,h,i)perylene	8270D	µg/kg	170–1,200	-	-												670	720	670		-													
Benzo(k)fluoranthene	8270D	µg/kg	170–1,200	600	-		240		-								-	-	-		-			70		537					-			
Chrysene	8270D	µg/kg	170–1,200	-	-	57.1	340	862	-	166	-						-	-	-		-	384	-	82	108	650	846				-			
Dibenz(a,h)anthracene	8270D	µg/kg	170–1,200	800	840	60			-	33	135						230	230	230		-	63.4	260	19	6.22	113	135				15			
Fluoranthene	8270D	µg/kg	170–1,200	-	-	111	750	-	-	423	-	-			-	-	-	-	-	-	-	600	-	119	113	1,034	-	-	-	-		-		
Fluorene	8270D	µg/kg	170–1,200	1,000	-	21.2	190	144	-	77.4	536						540	540	540		-	19	540	19	21.2	114	144					-		
Indeno(1,2,3-cd)pyrene	8270D	µg/kg	170–1,200	-	-		200		-								600	690	600		-			68		488					150			
Naphthalene	8260C	µg/kg	5–36	-	-	34.6		-		-	-						-	-	-		-	-	-	30	34.6	-	-				-	-		
Naphthalene	8270D	µg/kg	520	500	-	34.6		391		176	-						-	-	-		-	160	-	30	34.6	217	391				-	-		
Pyrene	8270D	µg/kg	170–1,200	-	-	53	490	875	-	195	-	-			-	-	-	-	-	-	-	665	-	125	153	932	-	-	-	-		-		
Organics **PCBs**																																		
Aroclor 1221	8082	µg/g	0.067–0.49																												0.14			
Aroclor 1232	8082	µg/g	0.033–0.24																												0.14			
Aroclor 1242	8082	µg/g	0.033–0.24																												0.22			
Aroclor 1248	8082	µg/g	0.033–0.24																												0.22			
Aroclor 1254	8082	µg/g	0.033–0.24																												0.22	-		
Aroclor 1260	8082	µg/g	0.033–0.24																												0.22			
Organics **Pesticides/Herbicides/Insecticides**																																		
4,4'-DDD	8081A	µg/kg	0.67–4.9			3.54	-	-	-	4.88	-	0.39	0.43	1.3	4.9	-			-	-	-	2	-		1.22		-	0.39	0.04	0.33			-	-
4,4'-DDE	8081A	µg/kg	0.67–4.9			1.42	-	-	-	3.16	-	0.39	0.43	1.3	4.9	-			-	-	-	2.2	-		2.07		-	0.39	0.04	0.33			-	-

Table A-4. Possible Chemicals of Potential Concern (COPCs) Based on Step-wise Comparisons to Sediment Screening Levels

Chemical	Method	Units	Reporting Limit	Freshwater Screening Levels (FWS)													Marine Screening Levels (MS)												Human Health Screening Levels					
				Pacific Northwest SEF		Included in SQuiRTs						Oregon DEQ Bioaccumulation SLV (BSLV)					Pacific Northwest SEF		Puget Sound DMMP			Included in SQuiRTs						Oregon DEQ BSLV	Oregon DEQ BSLV		USEPA RSL		CHHSL	
				SL1	SL2	TEL	LEL	PEL	SEL	TEC	PEC	F	A-I	A-P	M-I	M-P	SL1	SL2	SL	BT	ML	ERL	ERM	T20	TEL	T50	PEL	F	H-S	H-G	TOT CAR	TOT NON CAR	Residential	Commercial
4,4'-DDT	8081A	µg/kg	0.67–4.9			1.19	-	4.77	-	4.16	-	0.39	0.43	1.3	4.9	-			-	-	-	1	-		1.19		4.77	0.39	0.04	0.33			-	-
BHC-gamma (HCH-gamma, Lindane)	8081A	µg/kg	0.67–4.9			0.94	3	1.38	-	2.37	-								-						0.32		0.99				-	-	0.5	2
Chlordane (Technical)	8081A	µg/kg	3.3–24			4.5	7	8.9	-	3.24	17.6	0.5	10	-	-	-	2.8	4.5	10	-		0.5	6		2.26		4.79	0.47	0.04	0.37	-	-	-	-
Chlordane-alpha	8081A	µg/kg	0.67–4.9			4.5	-	-	-	3.24	-	0.5	-	-	-	-	2.8	4.5	-	-		0.5	-		2.26		4.79	0.47	0.04	0.37	-	-	-	-
Chlordane-gamma	8081A	µg/kg	0.67–4.9			4.5	-	-	-	3.24	-	0.5	-	-	-	-	2.8	4.5	-	-		0.5	-		2.26		4.79	0.47	0.04	0.37	-	-	-	-
Dieldrin	8081A	µg/kg	0.67–4.9			2.85	2	-	-	1.9	-	2.2	0.37	1.8	1.2	-	1.9	3.5	-			0.02	-	0.83	0.72	2.9	4.3	2.2	0.001	0.008	-	-	-	-
Endrin	8081A	µg/kg	0.67–4.9			2.67	3	-	-	2.22	-																					-	-	-
Heptachlor	8081A	µg/kg	0.67–4.9														1.5	2	-												-	-	-	-
Heptachlor epoxide	8081A	µg/kg	0.67–4.9			0.6	-	2.74	-	2.47	-													0.6			2.74				-	-		
Toxaphene	8081A	µg/kg	33–240			0.1																			0.1						-		-	-
Organics Phthalates																																		
Bis(2-ethylhexyl) phthalate	8270D	µg/kg	170–1,200	220	320												-	-	-		-										-	-		
Butyl benzyl phthalate	8270D	µg/kg	170–1,200	260	370												63	900	63		970										-	-		
Diethyl phthalate	8270D	µg/kg	170–1,200														200	200	200		1,200											-		
Dimethyl phthalate	8270D	µg/kg	170–1,200	46	440												71	160	71		-													
Di-n-octyl phthalate	8270D	µg/kg	170–1,200	26	45												-	-	-		-													
Organics Polychlorinated Dioxins and Furans																																		
1,2,3,7,8,9-HXCDF	8290A	pg/g	0.026–0.43									-	-	-	-	-												-	0.34	-				
1,2,3,7,8-PECDD	8290A	pg/g	0.046–0.15									-	-	-	-	-												-	0.034	-				
2,3,4,7,8-PECDF	8290A	pg/g	0.024–0.14									-	-	-	-	-												-	0.004	0.03				
2,3,7,8-TCDD	8290A	pg/g	0.028–0.25									-	-	-	0.052	-												-	0.001	0.009	-	-	-	-
2,3,7,8-TCDF	8290A	pg/g	0.043–0.38									-	-	-	-	-												-	0.094	-				
Organics SVOCs																																		
1,2,3-Trichloropropane	8260C	µg/kg	5–36																												5	-		
1,2,4-Trichlorobenzene	8260C	µg/kg	5–36														31	-	31		-										-	-		
1,2,4-Trichlorobenzene	8270D	µg/kg	520														31	51	31		64										-	-		
1,2-Dibromo-3-chloropropane	8260C	µg/kg	5–36																												5.4	-		
1,2-Dichlorobenzene	8260C	µg/kg	5–36														35	-	35		-											-		
1,2-Dichlorobenzene	8270D	µg/kg	520														35	50	35		110											-		
1,3-Dichlorobenzene	8270D	µg/kg	520																170															

Table A-4. Possible Chemicals of Potential Concern (COPCs) Based on Step-wise Comparisons to Sediment Screening Levels

Chemical	Method	Units	Reporting Limit	Freshwater Screening Levels (FWS)													Marine Screening Levels (MS)												Human Health Screening Levels					
				Pacific Northwest SEF		Included in SQuiRTs						Oregon DEQ Bioaccumulation SLV (BSLV)					Pacific Northwest SEF		Puget Sound DMMP			Included in SQuiRTs						Oregon DEQ BSLV	Oregon DEQ BSLV		USEPA RSL		CHHSL	
				SL1	SL2	TEL	LEL	PEL	SEL	TEC	PEC	F	A-I	A-P	M-I	M-P	SL1	SL2	SL	BT	ML	ERL	ERM	T20	TEL	T50	PEL	F	H-S	H-G	TOT CAR	TOT NON CAR	Residential	Commercial
1,4-Dichlorobenzene	8270D	µg/kg	520														110	110	110		120										-	-		
2,4-Dimethylphenol	8270D	µg/kg	170–1,200														29	29	29		210											-		
2-Methylphenol	8270D	µg/kg	170–1,200														63	63	63		77													
3,3'-Dichlorobenzidine	8270D	µg/kg	170–1,200																												1,100			
4-Methylphenol	8270D	µg/kg	170–1,200														670	670	670		-													
Benzoic acid	8270D	µg/kg	670–4,800														650	650	650		760											-		
Benzyl alcohol	8270D	µg/kg	170–1,200														57	73	57		870											-		
Bis(2-chloroethyl) ether	8270D	µg/kg	170–1,200																												210			
Dibenzofuran	8270D	µg/kg	170–1,200	400	440												540	540	540		-											-		
Hexachlorobenzene	8270D	µg/kg	170–1,200									-					22	70	22	168	230							-	2.3	19	300	-		
Hexachlorobutadiene	8260C	µg/kg	5–36														11	-	29		-										-	-		
Hexachlorobutadiene	8270D	µg/kg	520														11	120	29		270										-	-		
N-nitrosodi-n-propylamine	8270D	µg/kg	170–1,200																												69			
N-Nitrosodiphenylamine	8270D	µg/kg	170–1,200														28	40	28		130										-			
Phenol	8270D	µg/kg	170–1,200														420	1,200	420		1,200											-		
Trans-1,4-dichloro-2-butene	8260C	µg/kg	5–36																												6.9			
Organics VOCs																																		
1,2-Dibromoethane	8260C	µg/kg	5–36																												34	-		
Ethylbenzene	8260C	µg/kg	5–36																10		-										-	-		

Screening Level Key:

SEF= Sediment Evaluation Framework
SQuiRTs= Screening Quick Reference Tables
DEQ= Department of Environmental Quality
BSLV= Land Quality Division Sediment Bioaccumulation Screening Level Values
DMMP Dredged Material Management Program
USEPA RSLs= USEPA Regional Screening Levels, Residential Soil
CHHSL= California Human Health Screening Levels
SL1= Sediment Screening Level 1
SL2= Sediment Screening Level 2
TEL= Threshold Effect Level
LEL= Lowest Effect Level
PEL= Probable Effect Level
SEL= Severe Effect Level
TEC= Threshold Effect Concentration

Table A-4. Possible Chemicals of Potential Concern (COPCs) Based on Step-wise Comparisons to Sediment Screening Levels

Chemical	Method	Units	Reporting Limit	Freshwater Screening Levels (FWS)													Marine Screening Levels (MS)												Human Health Screening Levels					
				Pacific Northwest SEF		Included in SQuiRTs						Oregon DEQ Bioaccumulation SLV (BSLV)					Pacific Northwest SEF		Puget Sound DMMP			Included in SQuiRTs						Oregon DEQ BSLV	Oregon DEQ BSLV		USEPA RSL		CHHSL	
				SL1	SL2	TEL	LEL	PEL	SEL	TEC	PEC	F	A-I	A-P	M-I	M-P	SL1	SL2	SL	BT	ML	ERL	ERM	T20	TEL	T50	PEL	F	H-S	H-G	TOT CAR	TOT NON CAR	Residential	Commercial

PEC= Probable Effect Concentration
F= Fish
A-I= Bird-Individual
A-P= Bird-Population
M-I= Mammal-Individual
M-P= Mammal-Population
SL= Screening Level
BT= Bioaccumulation Trigger
ML= Maximum Level
ERL= Effects Range Low
ERM= Effects Range Median
T20= Chemical concentration representing a 20% probability of observing an effect, calculated using individual chemical logistic regression models based on 10-day survival results from marine amphipod tests (Ampelisca a. and Rhepoxynius a.).
TEL= Threshold Effect Level
T50= Chemical concentration representing a 50% probability of observing an effect, calculated using individual chemical logistic regression models based on 10-day survival results from marine amphipod tests (Ampelisca a. and Rhepoxynius a.).
H-S= Human Subsistence
H-G= Human General
TOT CAR= Total Carcinogenic
TOT NONCAR= Total Non-carcinogenic
(blank)= No screening levels apply

Units Key:
g= gram
kg= kilogram (1,000 grams)
mg= milligram (10^{-3} gram)
ug= microgram (10^{-6} gram)
pg= picogram (10^{-12} gram)

Table A-5. Klamath River Sediment Study-Sediment Samples with Values Exceeding One or More Marine Sediment Screening Levels

Chemical	Sample[1]	Measured Value	Units	Marine Screening Levels (MS)											
				PNW SEF		Puget Sound DMMP			Included in SQuiRTs						Oregon DEQ BSLV [2]
				SL1-MS	SL2-MS	SL-MS	BT-MS	ML-MS	MS ERL	MS ERM	MS T20	MS TEL	MS T50	MS PEL	F-M
J.C. Boyle Reservoir															
Metals and AVS															
Arsenic	CDH-S-003(0–3.8)	10	mg/kg	-	-	-	-	-	8.2	-	7.4	7.24	-	-	
Arsenic	CDH-S-004(0–6)	13	mg/kg	-	-	-	-	-	8.2	-	7.4	7.24	-	-	
Arsenic	CDH-S-004(5.8–9)	7.7	mg/kg	-	-	-	-	-	-	-	7.4	7.24	-	-	
Arsenic	CDH-S-005(0.0–0.3)	11	mg/kg	-	-	-	-	-	8.2	-	7.4	7.24	-	-	
Arsenic	CDH-S-006A(0.0–0.3)	11	mg/kg	-	-	-	-	-	8.2	-	7.4	7.24	-	-	
Arsenic	CDH-S-007(0–5)	11	mg/kg	-	-	-	-	-	8.2	-	7.4	7.24	-	-	
Arsenic	CDH-S-007(0–5.1)	11	mg/kg	-	-	-	-	-	8.2	-	7.4	7.24	-	-	
Arsenic	CDH-S-007(12–17)	10	mg/kg	-	-	-	-	-	8.2	-	7.4	7.24	-	-	
Arsenic	CDH-S-007(17–18.7)	9	mg/kg	-	-	-	-	-	8.2	-	7.4	7.24	-	-	
Arsenic	CDH-S-007(4.2–9.2)	11	mg/kg	-	-	-	-	-	8.2	-	7.4	7.24	-	-	
Arsenic	CDH-S-007(9.2–12)	11	mg/kg	-	-	-	-	-	8.2	-	7.4	7.24	-	-	
Arsenic	CDH-S-008(0–1.7)	15	mg/kg	-	-	-	-	-	8.2	-	7.4	7.24	-	-	
Arsenic	CDH-S-043(0.0–2.0)	11	mg/kg	-	-	-	-	-	8.2	-	7.4	7.24	-	-	
Copper	CDH-S-003(0–3.8)	28	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CDH-S-004(0–6)	31	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CDH-S-004(5.8–9)	34	mg/kg	-	-	-	-	-	-	-	32	18.7	-	-	
Copper	CDH-S-005(0.0–0.3)	23	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CDH-S-006A(0.0–0.3)	28	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CDH-S-007(0–5)	28	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CDH-S-007(0–5.1)	22	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CDH-S-007(12–17)	32	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	

Table A-5. Klamath River Sediment Study-Sediment Samples with Values Exceeding One or More Marine Sediment Screening Levels

Chemical	Sample[1]	Measured Value	Units	Marine Screening Levels (MS)											
				PNW SEF		Puget Sound DMMP			Included in SQuiRTs						Oregon DEQ BSLV [2]
				SL1-MS	SL2-MS	SL-MS	BT-MS	ML-MS	MS ERL	MS ERM	MS T20	MS TEL	MS T50	MS PEL	F-M
Copper	CDH-S-007(17–18.7)	25	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CDH-S-007(4.2–9.2)	29	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CDH-S-007(9.2–12)	28	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CDH-S-008(0–1.7)	30	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CDH-S-043(0.0–2.0)	27	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Nickel	CDH-S-002(0–5)	19	mg/kg			-	-	-	-	-	15	15.9	-	-	
Nickel	CDH-S-003(0–3.8)	32	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-004(0–6)	24	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-004(5.8–9)	26	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-005(0.0–0.3)	21	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-006A(0.0–0.3)	25	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-007(0–5)	23	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-007(0–5.1)	25	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-007(12–17)	26	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-007(17–18.7)	21	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-007(4.2–9.2)	23	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-007(9.2–12)	23	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-008(0–1.7)	25	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-043(0.0–2.0)	27	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Organics															
Pesticides/Herbicides/Insecticides															
4,4'-DDD	CDH-S-007(0–5)	3.7	µg/kg			-	-	-	2	-		1.22		-	0.39
4,4'-DDE	CDH-S-007(0–5)	3.4	µg/kg			-	-	-	2.2	-		2.07		-	0.39

Table A-5. Klamath River Sediment Study-Sediment Samples with Values Exceeding One or More Marine Sediment Screening Levels

Chemical	Sample[1]	Measured Value	Units	Marine Screening Levels (MS)											
				PNW SEF		Puget Sound DMMP			Included in SQuiRTs						Oregon DEQ BSLV [2]
				SL1-MS	SL2-MS	SL-MS	BT-MS	ML-MS	MS ERL	MS ERM	MS T20	MS TEL	MS T50	MS PEL	F-M
4,4'-DDT	CDH-S-007(4.2–9.2)	4.1	µg/kg			-	-	-	1	-		1.19		-	0.39
Dieldrin	CDH-S-007(0–5)	3.4	µg/kg	1.9	-	-			0.02	-	0.83	0.72	2.9	-	2.2
Organics															
Polychlorinated Dioxins and Furans															
2,3,4,7,8-PECDF	CDH-S-007(0–18.7)	1.5	pg/g												1.1
2,3,4,7,8-PECDF	CDH-S-008(0–1.7)	1.5	pg/g												1.1
Copco 1 Reservoir															
Metals and AVS															
Arsenic	CDH-S-011(0.0–1.3)	13	mg/kg	-	-	-	-	-	8.2	-	7.4	7.24	-	-	
Arsenic	CDH-S-012(0.0–5.4)	7.3	mg/kg	-	-	-	-	-	-	-	-	7.24	-	-	
Arsenic	CDH-S-013(0.0–5.7)	8.1	mg/kg	-	-	-	-	-	-	-	7.4	7.24	-	-	
Arsenic	CDH-S-015A(0.0–5.0)	9.4	mg/kg	-	-	-	-	-	8.2	-	7.4	7.24	-	-	
Arsenic	CDH-S-015A(5.0–9.7)	8.3	mg/kg	-	-	-	-	-	8.2	-	7.4	7.24	-	-	
Arsenic	CDH-S-016(0.0–5.0)	8.9	mg/kg	-	-	-	-	-	8.2	-	7.4	7.24	-	-	
Arsenic	CDH-S-016(5.0–7.5)	8.8	mg/kg	-	-	-	-	-	8.2	-	7.4	7.24	-	-	
Arsenic	CDH-S-017(0.0–1.2)	8.5	mg/kg	-	-	-	-	-	8.2	-	7.4	7.24	-	-	
Arsenic	CDH-S-018(0.0–5.0)	9.3	mg/kg	-	-	-	-	-	8.2	-	7.4	7.24	-	-	
Arsenic	CDH-S-018(5.0–8.9)	9.1	mg/kg	-	-	-	-	-	8.2	-	7.4	7.24	-	-	
Arsenic	CDH-S-019(0.0–4.8)	9.1	mg/kg	-	-	-	-	-	8.2	-	7.4	7.24	-	-	
Arsenic	CDH-S-020(0.0–5.0)	9.3	mg/kg	-	-	-	-	-	8.2	-	7.4	7.24	-	-	
Arsenic	CDH-S-020(5.0–7.0)	9.9	mg/kg	-	-	-	-	-	8.2	-	7.4	7.24	-	-	
Copper	CDH-S-009A(0.0–4.6)	28	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CDH-S-010(0.0–5.0)	33	mg/kg	-	-	-	-	-	-	-	32	18.7	-	-	

Table A-5. Klamath River Sediment Study-Sediment Samples with Values Exceeding One or More Marine Sediment Screening Levels

Chemical	Sample[1]	Measured Value	Units	Marine Screening Levels (MS)											
				PNW SEF		Puget Sound DMMP			Included in SQuiRTs						Oregon DEQ BSLV [2]
				SL1-MS	SL2-MS	SL-MS	BT-MS	ML-MS	MS ERL	MS ERM	MS T20	MS TEL	MS T50	MS PEL	F-M
Copper	CDH-S-010(5.0–8.0)	27	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CDH-S-011(0.0–1.3)	28	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CDH-S-012(0.0–5.4)	29	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CDH-S-013(0.0–5.7)	35	mg/kg	-	-	-	-	-	34	-	32	18.7	-	-	
Copper	CDH-S-014(0.0–5.3)	31	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CDH-S-015A(0.0–5.0)	30	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CDH-S-015A(5.0–9.7)	29	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CDH-S-016(0.0–5.0)	29	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CDH-S-016(5.0–7.5)	24	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CDH-S-017(0.0–1.2)	28	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CDH-S-018(0.0–5.0)	32	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CDH-S-018(5.0–8.9)	24	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CDH-S-019(0.0–4.8)	24	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CDH-S-020(0.0–5.0)	24	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CDH-S-020(5.0–7.0)	23	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Nickel	CDH-S-009A(0.0–4.6)	28	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-010(0.0–5.0)	32	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-010(5.0–8.0)	24	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-011(0.0–1.3)	25	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-012(0.0–5.4)	26	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-013(0.0–5.7)	30	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-014(0.0–5.3)	28	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-015A(0.0–5.0)	26	mg/kg			-	-	-	20.9	-	15	15.9	-	-	

Table A-5. Klamath River Sediment Study-Sediment Samples with Values Exceeding One or More Marine Sediment Screening Levels

Chemical	Sample[1]	Measured Value	Units	Marine Screening Levels (MS)											
				PNW SEF		Puget Sound DMMP			Included in SQuiRTs						Oregon DEQ BSLV [2]
				SL1-MS	SL2-MS	SL-MS	BT-MS	ML-MS	MS ERL	MS ERM	MS T20	MS TEL	MS T50	MS PEL	F-M
Nickel	CDH-S-015A(5.0–9.7)	26	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-016(0.0–5.0)	26	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-016(5.0–7.5)	23	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-017(0.0–1.2)	24	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-018(0.0–5.0)	28	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-018(5.0–8.9)	23	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-019(0.0–4.8)	22	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-020(0.0–5.0)	23	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-020(5.0–7.0)	23	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Organics															
Polychlorinated Dioxins and Furans															
2,3,4,7,8-PECDF	CDH-S-014(0.0–5.3)	1.9	pg/g												1.1
2,3,4,7,8-PECDF	CDH-S-015A(0.0–9.7)	1.8	pg/g												1.1
Iron Gate Reservoir															
Metals and AVS															
Arsenic	CDH-S-021(0.0–0.5)	9.9	mg/kg	-	-	-	-	-	8.2	-	7.4	7.24	-	-	
Arsenic	CDH-S-022(0.0–1.4)	7.5	mg/kg	-	-	-	-	-	-	-	7.4	7.24	-	-	
Arsenic	CDH-S-023(0.0–5.4)	7.4	mg/kg	-	-	-	-	-	-	-	-	7.24	-	-	
Arsenic	CDH-S-023(5.4–7.7)	8.1	mg/kg	-	-	-	-	-	-	-	7.4	7.24	-	-	
Arsenic	CDH-S-024(0.0–4.1)	8	mg/kg	-	-	-	-	-	-	-	7.4	7.24	-	-	
Arsenic	CDH-S-025(0.0–4.7)	10	mg/kg	-	-	-	-	-	8.2	-	7.4	7.24	-	-	
Arsenic	CDH-S-026(0.0–2.0)	7.5	mg/kg	-	-	-	-	-	-	-	7.4	7.24	-	-	
Arsenic	CDH-S-027(0–1.9)	8.9	mg/kg	-	-	-	-	-	8.2	-	7.4	7.24	-	-	

Table A-5. Klamath River Sediment Study-Sediment Samples with Values Exceeding One or More Marine Sediment Screening Levels

Chemical	Sample[1]	Measured Value	Units	Marine Screening Levels (MS)											
				PNW SEF		Puget Sound DMMP			Included in SQuiRTs						Oregon DEQ BSLV [2]
				SL1-MS	SL2-MS	SL-MS	BT-MS	ML-MS	MS ERL	MS ERM	MS T20	MS TEL	MS T50	MS PEL	F-M
Arsenic	CDH-S-028(0.0–1.0)	7.7	mg/kg	-	-	-	-	-	-	-	7.4	7.24	-	-	
Arsenic	CDH-S-029(0.0–4.8)	7.7	mg/kg	-	-	-	-	-	-	-	7.4	7.24	-	-	
Arsenic	CDH-S-030(0.0–2.9)	8.8	mg/kg	-	-	-	-	-	8.2	-	7.4	7.24	-	-	
Arsenic	CDH-S-031(0.0–4.8)	9.3	mg/kg	-	-	-	-	-	8.2	-	7.4	7.24	-	-	
Arsenic	CDH-S-032(0.0–3.4)	7.7	mg/kg	-	-	-	-	-	-	-	7.4	7.24	-	-	
Arsenic	CDH-S-046(0.0–2.5)	8.4	mg/kg	-	-	-	-	-	8.2	-	7.4	7.24	-	-	
Copper	CDH-S-022(0.0–1.4)	23	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CDH-S-023(0.0–5.4)	30	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CDH-S-023(5.4–7.7)	32	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CDH-S-024(0.0–4.1)	27	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CDH-S-025(0.0–4.7)	31	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CDH-S-026(0.0–2.0)	38	mg/kg	-	-	-	-	-	34	-	32	18.7	-	-	
Copper	CDH-S-027(0–1.9)	27	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CDH-S-028(0.0–1.0)	38	mg/kg	-	-	-	-	-	34	-	32	18.7	-	-	
Copper	CDH-S-029(0.0–4.8)	28	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CDH-S-030(0.0–2.9)	26	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CDH-S-031(0.0–4.8)	37	mg/kg	-	-	-	-	-	34	-	32	18.7	-	-	
Copper	CDH-S-032(0.0–3.4)	28	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CDH-S-046(0.0–2.5)	28	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Nickel	CDH-S-021(0.0–0.5)	18	mg/kg			-	-	-	-	-	15	15.9	-	-	
Nickel	CDH-S-022(0.0–1.4)	19	mg/kg			-	-	-	-	-	15	15.9	-	-	
Nickel	CDH-S-023(0.0–5.4)	27	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-023(5.4–7.7)	28	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-024(0.0–4.1)	31	mg/kg			-	-	-	20.9	-	15	15.9	-	-	

Table A-5. Klamath River Sediment Study-Sediment Samples with Values Exceeding One or More Marine Sediment Screening Levels

Chemical	Sample[1]	Meas ured Value	Units	Marine Screening Levels (MS)											
				PNW SEF		Puget Sound DMMP			Included in SQuiRTs						Oregon DEQ BSLV[2]
				SL1-MS	SL2-MS	SL-MS	BT-MS	ML-MS	MS ERL	MS ERM	MS T20	MS TEL	MS T50	MS PEL	F-M
Nickel	CDH-S-025(0.0–4.7)	28	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-026(0.0–2.0)	33	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-027(0–1.9)	23	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-028(0.0–1.0)	27	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-029(0.0–4.8)	25	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-030(0.0–2.9)	26	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-031(0.0–4.8)	31	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-032(0.0–3.4)	24	mg/kg			-	-	-	20.9	-	15	15.9	-	-	
Nickel	CDH-S-046(0.0–2.5)	20	mg/kg			-	-	-	-	-	15	15.9	-	-	
Klamath River Estuary															
Metals and AVS															
Chromium	CHA-S-001	96	mg/kg	-	-		-		81	-	49	52.3	-	-	
Chromium	CHA-S-002	97	mg/kg	-	-		-		81	-	49	52.3	-	-	
Copper	CHA-S-001	26	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Copper	CHA-S-002	19	mg/kg	-	-	-	-	-	-	-	-	18.7	-	-	
Nickel	CHA-S-001	110	mg/kg			-	-	-	20.9	51.6	15	15.9	47	42.8	
Nickel	CHA-S-002	110	mg/kg			-	-	-	20.9	51.6	15	15.9	47	42.8	

[1] Maps of sample site locations are presented in Section 2.

[2] Although Oregon DEQ bioaccumulation SLVs are not applicable in California for regulatory purposes, comparisons of measured concentrations from Copco 1 Reservoir, Iron Gate Reservoir, and Klamath Estuary sediment samples to these SLVs were undertaken due to the lack of other available SLVs for particular chemicals, such as dioxins and furans. This comparison also allowed for direct comparison of sediment quality between all three reservoirs using a common set of SLVs.

Screening Level Key:

(blank)= No screening levels apply

- = Laboratory value is below screening level

PNW SEF= Pacific Northwest Sediment Evaluation Framework

Table A-5. Klamath River Sediment Study-Sediment Samples with Values Exceeding One or More Marine Sediment Screening Levels

Chemical	Sample[1]	Measured Value	Units	Marine Screening Levels (MS)											
				PNW SEF		Puget Sound DMMP			Included in SQuiRTs						Oregon DEQ BSLV[2]
				SL1-MS	SL2-MS	SL-MS	BT-MS	ML-MS	MS ERL	MS ERM	MS T20	MS TEL	MS T50	MS PEL	F-M

SL1= Sediment Screening Level 1

SL2= Sediment Screening Level 2

DMMP= Dredged Material Management Program

SL= Screening Level

BT= Bioaccumulation Trigger

ML= Maximum Level

SQuiRTs= Screening Quick Reference Tables

ERL= Effects Range Low

ERM= Effects Range Median

T20= Chemical concentration representing a 20% probability of observing an effect, calculated using individual chemical logistic regression models based on 10-day survival results from marine amphipod tests (*Ampelisca a*. and *Rhepoxynius a.*).

TEL= Threshold Effect Level

T50= Chemical concentration representing a 50% probability of observing an effect, calculated using individual chemical logistic regression models based on 10-day survival results from marine amphipod tests (*Ampelisca a.* and *Rhepoxynius a.*).

PEL= Probable Effect Level

DEQ= Department of Environmental Quality

BSLV= Land Quality Division Sediment Bioaccumulation Screening Level Values

F-M= Fish-Marine

Units Key:

g= gram

kg= kilogram (1,000 grams)

mg= milligram (10^{-3} gram)

ug= microgram (10^{-6} gram)

pg= picogram (10^{-12} gram)

Table A-6. Klamath River Sediment Study-Sediment Samples with Values Exceeding One or More Freshwater Sediment Screening Levels

Chemical	Sample[1]	Measured Value	Units	Freshwater Screening Levels (FWS)												
				PNW SEF		Included in SQuiRTs						Oregon DEQ BSLV [2]				
				SL1-FWS	SL2-FWS	FWS TEL	FWS LEL	FWS PEL	FWS SEL	FWS TEC	FWS PEC	F-FW	A-I	A-P	M-I	M-P
J.C. Boyle Reservoir																
Metals and AVS																
Arsenic	CDH-S-003(0–3.8)	10	mg/kg	-	-	5.9	6	-	-	9.79	-					
Arsenic	CDH-S-004(0–6)	13	mg/kg	-	-	5.9	6	-	-	9.79	-					
Arsenic	CDH-S-004(5.8–9)	7.7	mg/kg	-	-	5.9	6	-	-	-	-					
Arsenic	CDH-S-005(0.0–0.3)	11	mg/kg	-	-	5.9	6	-	-	9.79	-					
Arsenic	CDH-S-006A(0.0–0.3)	11	mg/kg	-	-	5.9	6	-	-	9.79	-					
Arsenic	CDH-S-007(0–5)	11	mg/kg	-	-	5.9	6	-	-	9.79	-					
Arsenic	CDH-S-007(0–5.1)	11	mg/kg	-	-	5.9	6	-	-	9.79	-					
Arsenic	CDH-S-007(12–17)	10	mg/kg	-	-	5.9	6	-	-	9.79	-					
Arsenic	CDH-S-007(17–18.7)	9	mg/kg	-	-	5.9	6	-	-	-	-					
Arsenic	CDH-S-007(4.2–9.2)	11	mg/kg	-	-	5.9	6	-	-	9.79	-					
Arsenic	CDH-S-007(9.2–12)	11	mg/kg	-	-	5.9	6	-	-	9.79	-					
Arsenic	CDH-S-008(0–1.7)	15	mg/kg	-	-	5.9	6	-	-	9.79	-					
Arsenic	CDH-S-043(0.0–2.0)	11	mg/kg	-	-	5.9	6	-	-	9.79	-					
Chromium	CDH-S-003(0–3.8)	32	mg/kg	-	-	-	26	-	-	-	-					
Chromium	CDH-S-004(0–6)	32	mg/kg	-	-	-	26	-	-	-	-					
Chromium	CDH-S-004(5.8–9)	32	mg/kg	-	-	-	26	-	-	-	-					
Chromium	CDH-S-006A(0.0–0.3)	30	mg/kg	-	-	-	26	-	-	-	-					
Chromium	CDH-S-007(0–5)	30	mg/kg	-	-	-	26	-	-	-	-					
Chromium	CDH-S-007(0–5.1)	34	mg/kg	-	-	-	26	-	-	-	-					
Chromium	CDH-S-007(12–17)	33	mg/kg	-	-	-	26	-	-	-	-					

Table A-6. Klamath River Sediment Study-Sediment Samples with Values Exceeding One or More Freshwater Sediment Screening Levels

Chemical	Sample[1]	Measured Value	Units	Freshwater Screening Levels (FWS)												
				PNW SEF		Included in SQuiRTs						Oregon DEQ BSLV [2]				
				SL1-FWS	SL2-FWS	FWS TEL	FWS LEL	FWS PEL	FWS SEL	FWS TEC	FWS PEC	F-FW	A-I	A-P	M-I	M-P
Chromium	CDH-S-007(17–18.7)	27	mg/kg	-	-	-	26	-	-	-	-					
Chromium	CDH-S-007(4.2–9.2)	30	mg/kg	-	-	-	26	-	-	-	-					
Chromium	CDH-S-007(9.2–12)	29	mg/kg	-	-	-	26	-	-	-	-					
Chromium	CDH-S-008(0–1.7)	30	mg/kg	-	-	-	26	-	-	-	-					
Chromium	CDH-S-043(0.0–2.0)	38	mg/kg	-	-	37.3	26	-	-	-	-					
Copper	CDH-S-003(0–3.8)	28	mg/kg	-	-	-	16	-	-	-	-					
Copper	CDH-S-004(0–6)	31	mg/kg	-	-	-	16	-	-	-	-					
Copper	CDH-S-004(5.8–9)	34	mg/kg	-	-	-	16	-	-	31.6	-					
Copper	CDH-S-005(0.0–0.3)	23	mg/kg	-	-	-	16	-	-	-	-					
Copper	CDH-S-006A(0.0–0.3)	28	mg/kg	-	-	-	16	-	-	-	-					
Copper	CDH-S-007(0–5)	28	mg/kg	-	-	-	16	-	-	-	-					
Copper	CDH-S-007(0–5.1)	22	mg/kg	-	-	-	16	-	-	-	-					
Copper	CDH-S-007(12–17)	32	mg/kg	-	-	-	16	-	-	31.6	-					
Copper	CDH-S-007(17–18.7)	25	mg/kg	-	-	-	16	-	-	-	-					
Copper	CDH-S-007(4.2–9.2)	29	mg/kg	-	-	-	16	-	-	-	-					
Copper	CDH-S-007(9.2–12)	28	mg/kg	-	-	-	16	-	-	-	-					
Copper	CDH-S-008(0–1.7)	30	mg/kg	-	-	-	16	-	-	-	-					
Copper	CDH-S-043(0.0–2.0)	27	mg/kg	-	-	-	16	-	-	-	-					
Iron	CDH-S-002(0–5)	37,000	mg/kg				20,000		-							
Iron	CDH-S-004(0–6)	21,000	mg/kg				20,000		-							
Iron	CDH-S-004(5.8–9)	26,000	mg/kg				20,000		-							
Iron	CDH-S-007(12–17)	25,000	mg/kg				20,000		-							
Iron	CDH-S-007(17–18.7)	23,000	mg/kg				20,000		-							

Table A-6. Klamath River Sediment Study-Sediment Samples with Values Exceeding One or More Freshwater Sediment Screening Levels

Chemical	Sample[1]	Measured Value	Units	Freshwater Screening Levels (FWS)												
				PNW SEF		Included in SQuiRTs						Oregon DEQ BSLV [2]				
				SL1-FWS	SL2-FWS	FWS TEL	FWS LEL	FWS PEL	FWS SEL	FWS TEC	FWS PEC	F-FW	A-I	A-P	M-I	M-P
Iron	CDH-S-007(9.2–12)	21,000	mg/kg				20,000		-							
Iron	CDH-S-008(0–1.7)	33,000	mg/kg				20,000		-							
Nickel	CDH-S-002(0–5)	19	mg/kg	-	-	18	16	-	-	-	-					
Nickel	CDH-S-003(0–3.8)	32	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-004(0–6)	24	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-004(5.8–9)	26	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-005(0.0–0.3)	21	mg/kg	-	-	18	16	-	-	-	-					
Nickel	CDH-S-006A(0.0–0.3)	25	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-007(0–5)	23	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-007(0–5.1)	25	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-007(12–17)	26	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-007(17–18.7)	21	mg/kg	-	-	18	16	-	-	-	-					
Nickel	CDH-S-007(4.2–9.2)	23	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-007(9.2–12)	23	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-008(0–1.7)	25	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-043(0.0–2.0)	27	mg/kg	-	-	18	16	-	-	22.7	-					
Organics																
Pesticides/Herbicides/Insecticides																
4,4'-DDD	CDH-S-007(0–5)	3.7	µg/kg			3.54	-	-	-	-	-	0.39	0.43	1.3	-	-
4,4'-DDE	CDH-S-007(0–5)	3.4	µg/kg			1.42	-	-	-	3.16	-	0.39	0.43	1.3	-	-
4,4'-DDT	CDH-S-007(4.2–9.2)	4.1	µg/kg			1.19	-	-	-	-	-	0.39	0.43	1.3	-	-
Dieldrin	CDH-S-007(0–5)	3.4	µg/kg			2.85	2	-	-	1.9	-	2.2	0.37	1.8	1.2	-
Organics																

Table A-6. Klamath River Sediment Study-Sediment Samples with Values Exceeding One or More Freshwater Sediment Screening Levels

Chemical	Sample[1]	Measured Value	Units	Freshwater Screening Levels (FWS)												
				PNW SEF		Included in SQuiRTs						Oregon DEQ BSLV [2]				
				SL1-FWS	SL2-FWS	FWS TEL	FWS LEL	FWS PEL	FWS SEL	FWS TEC	FWS PEC	F-FW	A-I	A-P	M-I	M-P
Polychlorinated Dioxins and Furans																
2,3,4,7,8-PECDF	CDH-S-007(0–18.7)	1.5	pg/g									1.1	0.7	-	0.17	-
2,3,4,7,8-PECDF	CDH-S-008(0–1.7)	1.5	pg/g									1.1	0.7	-	0.17	-
2,3,7,8-TCDD	CDH-S-008(0–1.7)	0.19	pg/g									-	-	-	0.05	-
Copco 1 Reservoir																
Metals and AVS																
Arsenic	CDH-S-009A(0.0–4.6)	6.8	mg/kg	-	-	5.9	6	-	-	-	-					
Arsenic	CDH-S-010(0.0–5.0)	6.9	mg/kg	-	-	5.9	6	-	-	-	-					
Arsenic	CDH-S-010(5.0–8.0)	6.9	mg/kg	-	-	5.9	6	-	-	-	-					
Arsenic	CDH-S-011(0.0–1.3)	13	mg/kg	-	-	5.9	6	-	-	9.79	-					
Arsenic	CDH-S-012(0.0–5.4)	7.3	mg/kg	-	-	5.9	6	-	-	-	-					
Arsenic	CDH-S-013(0.0–5.7)	8.1	mg/kg	-	-	5.9	6	-	-	-	-					
Arsenic	CDH-S-014(0.0–5.3)	6.3	mg/kg	-	-	5.9	6	-	-	-	-					
Arsenic	CDH-S-015A(0.0–5.0)	9.4	mg/kg	-	-	5.9	6	-	-	-	-					
Arsenic	CDH-S-015A(5.0–9.7)	8.3	mg/kg	-	-	5.9	6	-	-	-	-					
Arsenic	CDH-S-016(0.0–5.0)	8.9	mg/kg	-	-	5.9	6	-	-	-	-					
Arsenic	CDH-S-016(5.0–7.5)	8.8	mg/kg	-	-	5.9	6	-	-	-	-					
Arsenic	CDH-S-017(0.0–1.2)	8.5	mg/kg	-	-	5.9	6	-	-	-	-					
Arsenic	CDH-S-018(0.0–5.0)	9.3	mg/kg	-	-	5.9	6	-	-	-	-					
Arsenic	CDH-S-018(5.0–8.9)	9.1	mg/kg	-	-	5.9	6	-	-	-	-					
Arsenic	CDH-S-019(0.0–4.8)	9.1	mg/kg	-	-	5.9	6	-	-	-	-					
Arsenic	CDH-S-020(0.0–5.0)	9.3	mg/kg	-	-	5.9	6	-	-	-	-					
Arsenic	CDH-S-020(5.0–7.0)	9.9	mg/kg	-	-	5.9	6	-	-	9.79	-					

Table A-6. Klamath River Sediment Study-Sediment Samples with Values Exceeding One or More Freshwater Sediment Screening Levels

Chemical	Sample[1]	Measured Value	Units	Freshwater Screening Levels (FWS)												
				PNW SEF		Included in SQuiRTs						Oregon DEQ BSLV [2]				
				SL1-FWS	SL2-FWS	FWS TEL	FWS LEL	FWS PEL	FWS SEL	FWS TEC	FWS PEC	F-FW	A-I	A-P	M-I	M-P
Chromium	CDH-S-009A(0.0–4.6)	41	mg/kg	-	-	37.3	26	-	-	-	-					
Chromium	CDH-S-010(0.0–5.0)	41	mg/kg	-	-	37.3	26	-	-	-	-					
Chromium	CDH-S-010(5.0–8.0)	36	mg/kg	-	-	-	26	-	-	-	-					
Chromium	CDH-S-011(0.0–1.3)	35	mg/kg	-	-	-	26	-	-	-	-					
Chromium	CDH-S-012(0.0–5.4)	37	mg/kg	-	-	-	26	-	-	-	-					
Chromium	CDH-S-013(0.0–5.7)	42	mg/kg	-	-	37.3	26	-	-	-	-					
Chromium	CDH-S-014(0.0–5.3)	37	mg/kg	-	-	-	26	-	-	-	-					
Chromium	CDH-S-015A(0.0–5.0)	36	mg/kg	-	-	-	26	-	-	-	-					
Chromium	CDH-S-015A(5.0–9.7)	35	mg/kg	-	-	-	26	-	-	-	-					
Chromium	CDH-S-016(0.0–5.0)	36	mg/kg	-	-	-	26	-	-	-	-					
Chromium	CDH-S-016(5.0–7.5)	34	mg/kg	-	-	-	26	-	-	-	-					
Chromium	CDH-S-017(0.0–1.2)	33	mg/kg	-	-	-	26	-	-	-	-					
Chromium	CDH-S-018(0.0–5.0)	38	mg/kg	-	-	37.3	26	-	-	-	-					
Chromium	CDH-S-018(5.0–8.9)	34	mg/kg	-	-	-	26	-	-	-	-					
Chromium	CDH-S-019(0.0–4.8)	30	mg/kg	-	-	-	26	-	-	-	-					
Chromium	CDH-S-020(0.0–5.0)	31	mg/kg	-	-	-	26	-	-	-	-					
Chromium	CDH-S-020(5.0–7.0)	28	mg/kg	-	-	-	26	-	-	-	-					
Copper	CDH-S-009A(0.0–4.6)	28	mg/kg	-	-	-	16	-	-	-	-					
Copper	CDH-S-010(0.0–5.0)	33	mg/kg	-	-	-	16	-	-	31.6	-					
Copper	CDH-S-010(5.0–8.0)	27	mg/kg	-	-	-	16	-	-	-	-					
Copper	CDH-S-011(0.0–1.3)	28	mg/kg	-	-	-	16	-	-	-	-					
Copper	CDH-S-012(0.0–5.4)	29	mg/kg	-	-	-	16	-	-	-	-					
Copper	CDH-S-013(0.0–5.7)	35	mg/kg	-	-	-	16	-	-	31.6	-					
Copper	CDH-S-014(0.0–5.3)	31	mg/kg	-	-	-	16	-	-	-	-					

Table A-6. Klamath River Sediment Study-Sediment Samples with Values Exceeding One or More Freshwater Sediment Screening Levels

Chemical	Sample[1]	Measured Value	Units	Freshwater Screening Levels (FWS)												
				PNW SEF		Included in SQuiRTs						Oregon DEQ BSLV[2]				
				SL1-FWS	SL2-FWS	FWS TEL	FWS LEL	FWS PEL	FWS SEL	FWS TEC	FWS PEC	F-FW	A-I	A-P	M-I	M-P
Copper	CDH-S-015A(0.0–5.0)	30	mg/kg	-	-	-	16	-	-	-	-					
Copper	CDH-S-015A(5.0–9.7)	29	mg/kg	-	-	-	16	-	-	-	-					
Copper	CDH-S-016(0.0–5.0)	29	mg/kg	-	-	-	16	-	-	-	-					
Copper	CDH-S-016(5.0–7.5)	24	mg/kg	-	-	-	16	-	-	-	-					
Copper	CDH-S-017(0.0–1.2)	28	mg/kg	-	-	-	16	-	-	-	-					
Copper	CDH-S-018(0.0–5.0)	32	mg/kg	-	-	-	16	-	-	31.6	-					
Copper	CDH-S-018(5.0–8.9)	24	mg/kg	-	-	-	16	-	-	-	-					
Copper	CDH-S-019(0.0–4.8)	24	mg/kg	-	-	-	16	-	-	-	-					
Copper	CDH-S-020(0.0–5.0)	24	mg/kg	-	-	-	16	-	-	-	-					
Copper	CDH-S-020(5.0–7.0)	23	mg/kg	-	-	-	16	-	-	-	-					
Iron	CDH-S-010(0.0–5.0)	21,000	mg/kg				20,000		-							
Iron	CDH-S-011(0.0–1.3)	21,000	mg/kg				20,000		-							
Iron	CDH-S-013(0.0–5.7)	21,000	mg/kg				20,000		-							
Iron	CDH-S-014(0.0–5.3)	23,000	mg/kg				20,000		-							
Iron	CDH-S-015A(0.0–5.0)	21,000	mg/kg				20,000		-							
Iron	CDH-S-015A(5.0–9.7)	21,000	mg/kg				20,000		-							
Iron	CDH-S-016(0.0–5.0)	21,000	mg/kg				20,000		-							
Iron	CDH-S-017(0.0–1.2)	24,000	mg/kg				20,000		-							
Iron	CDH-S-018(0.0–5.0)	24,000	mg/kg				20,000		-							
Iron	CDH-S-018(5.0–8.9)	21,000	mg/kg				20,000		-							
Iron	CDH-S-019(0.0–4.8)	22,000	mg/kg				20,000		-							
Iron	CDH-S-020(0.0–5.0)	23,000	mg/kg				20,000		-							
Iron	CDH-S-020(5.0–7.0)	22,000	mg/kg				20,000		-							
Nickel	CDH-S-009A(0.0–4.6)	28	mg/kg	-	-	18	16	-	-	22.7	-					

Table A-6. Klamath River Sediment Study-Sediment Samples with Values Exceeding One or More Freshwater Sediment Screening Levels

Chemical	Sample[1]	Measured Value	Units	Freshwater Screening Levels (FWS)												
				PNW SEF		Included in SQuiRTs						Oregon DEQ BSLV [2]				
				SL1-FWS	SL2-FWS	FWS TEL	FWS LEL	FWS PEL	FWS SEL	FWS TEC	FWS PEC	F-FW	A-I	A-P	M-I	M-P
Nickel	CDH-S-010(0.0–5.0)	32	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-010(5.0–8.0)	24	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-011(0.0–1.3)	25	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-012(0.0–5.4)	26	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-013(0.0–5.7)	30	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-014(0.0–5.3)	28	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-015A(0.0–5.0)	26	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-015A(5.0–9.7)	26	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-016(0.0–5.0)	26	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-016(5.0–7.5)	23	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-017(0.0–1.2)	24	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-018(0.0–5.0)	28	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-018(5.0–8.9)	23	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-019(0.0–4.8)	22	mg/kg	-	-	18	16	-	-	-	-					
Nickel	CDH-S-020(0.0–5.0)	23	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-020(5.0–7.0)	23	mg/kg	-	-	18	16	-	-	22.7	-					
Organics																
Polychlorinated Dioxins and Furans																
2,3,4,7,8-PECDF	CDH-S-014(0.0–5.3)	1.9	pg/g									1.1	0.7	-	0.17	-
2,3,4,7,8-PECDF	CDH-S-015A(0.0–9.7)	1.8	pg/g									1.1	0.7	-	0.17	-
Iron Gate Reservoir																

Table A-6. Klamath River Sediment Study-Sediment Samples with Values Exceeding One or More Freshwater Sediment Screening Levels

Chemical	Sample[1]	Measured Value	Units	Freshwater Screening Levels (FWS)												
				PNW SEF		Included in SQuiRTs						Oregon DEQ BSLV [2]				
				SL1-FWS	SL2-FWS	FWS TEL	FWS LEL	FWS PEL	FWS SEL	FWS TEC	FWS PEC	F-FW	A-I	A-P	M-I	M-P
Metals and AVS																
Arsenic	CDH-S-021(0.0–0.5)	9.9	mg/kg	-	-	5.9	6	-	-	9.79	-					
Arsenic	CDH-S-022(0.0–1.4)	7.5	mg/kg	-	-	5.9	6	-	-	-	-					
Arsenic	CDH-S-023(0.0–5.4)	7.4	mg/kg	-	-	5.9	6	-	-	-	-					
Arsenic	CDH-S-023(5.4–7.7)	8.1	mg/kg	-	-	5.9	6	-	-	-	-					
Arsenic	CDH-S-024(0.0–4.1)	8	mg/kg	-	-	5.9	6	-	-	-	-					
Arsenic	CDH-S-025(0.0–4.7)	10	mg/kg	-	-	5.9	6	-	-	9.79	-					
Arsenic	CDH-S-026(0.0–2.0)	7.5	mg/kg	-	-	5.9	6	-	-	-	-					
Arsenic	CDH-S-027(0–1.9)	8.9	mg/kg	-	-	5.9	6	-	-	-	-					
Arsenic	CDH-S-028(0.0–1.0)	7.7	mg/kg	-	-	5.9	6	-	-	-	-					
Arsenic	CDH-S-029(0.0–4.8)	7.7	mg/kg	-	-	5.9	6	-	-	-	-					
Arsenic	CDH-S-030(0.0–2.9)	8.8	mg/kg	-	-	5.9	6	-	-	-	-					
Arsenic	CDH-S-031(0.0–4.8)	9.3	mg/kg	-	-	5.9	6	-	-	-	-					
Arsenic	CDH-S-032(0.0–3.4)	7.7	mg/kg	-	-	5.9	6	-	-	-	-					
Arsenic	CDH-S-046(0.0–2.5)	8.4	mg/kg	-	-	5.9	6	-	-	-	-					
Chromium	CDH-S-022(0.0–1.4)	29	mg/kg	-	-	-	26	-	-	-	-					
Chromium	CDH-S-023(0.0–5.4)	38	mg/kg	-	-	37.3	26	-	-	-	-					
Chromium	CDH-S-023(5.4–7.7)	40	mg/kg	-	-	37.3	26	-	-	-	-					
Chromium	CDH-S-024(0.0–4.1)	44	mg/kg	-	-	37.3	26	-	-	43.4	-					
Chromium	CDH-S-025(0.0–4.7)	37	mg/kg	-	-	-	26	-	-	-	-					
Chromium	CDH-S-026(0.0–2.0)	42	mg/kg	-	-	37.3	26	-	-	-	-					
Chromium	CDH-S-027(0–1.9)	32	mg/kg	-	-	-	26	-	-	-	-					
Chromium	CDH-S-028(0.0–1.0)	40	mg/kg	-	-	37.3	26	-	-	-	-					
Chromium	CDH-S-029(0.0–4.8)	34	mg/kg	-	-	-	26	-	-	-	-					

Table A-6. Klamath River Sediment Study-Sediment Samples with Values Exceeding One or More Freshwater Sediment Screening Levels

Chemical	Sample[1]	Measured Value	Units	Freshwater Screening Levels (FWS)												
				PNW SEF		Included in SQuiRTs						Oregon DEQ BSLV [2]				
				SL1-FWS	SL2-FWS	FWS TEL	FWS LEL	FWS PEL	FWS SEL	FWS TEC	FWS PEC	F-FW	A-I	A-P	M-I	M-P
Chromium	CDH-S-030(0.0–2.9)	35	mg/kg	-	-	-	26	-	-	-	-					
Chromium	CDH-S-031(0.0–4.8)	48	mg/kg	-	-	37.3	26	-	-	43.4	-					
Chromium	CDH-S-032(0.0–3.4)	35	mg/kg	-	-	-	26	-	-	-	-					
Chromium	CDH-S-046(0.0–2.5)	28	mg/kg	-	-	-	26	-	-	-	-					
Copper	CDH-S-021(0.0–0.5)	17	mg/kg	-	-	-	16	-	-	-	-					
Copper	CDH-S-022(0.0–1.4)	23	mg/kg	-	-	-	16	-	-	-	-					
Copper	CDH-S-023(0.0–5.4)	30	mg/kg	-	-	-	16	-	-	-	-					
Copper	CDH-S-023(5.4–7.7)	32	mg/kg	-	-	-	16	-	-	31.6	-					
Copper	CDH-S-024(0.0–4.1)	27	mg/kg	-	-	-	16	-	-	-	-					
Copper	CDH-S-025(0.0–4.7)	31	mg/kg	-	-	-	16	-	-	-	-					
Copper	CDH-S-026(0.0–2.0)	38	mg/kg	-	-	35.7	16	-	-	31.6	-					
Copper	CDH-S-027(0–1.9)	27	mg/kg	-	-	-	16	-	-	-	-					
Copper	CDH-S-028(0.0–1.0)	38	mg/kg	-	-	35.7	16	-	-	31.6	-					
Copper	CDH-S-029(0.0–4.8)	28	mg/kg	-	-	-	16	-	-	-	-					
Copper	CDH-S-030(0.0–2.9)	26	mg/kg	-	-	-	16	-	-	-	-					
Copper	CDH-S-031(0.0–4.8)	37	mg/kg	-	-	35.7	16	-	-	31.6	-					
Copper	CDH-S-032(0.0–3.4)	28	mg/kg	-	-	-	16	-	-	-	-					
Copper	CDH-S-046(0.0–2.5)	28	mg/kg	-	-	-	16	-	-	-	-					
Iron	CDH-S-022(0.0–1.4)	28,000	mg/kg				20,000		-							
Iron	CDH-S-023(0.0–5.4)	26,000	mg/kg				20,000		-							
Iron	CDH-S-024(0.0–4.1)	30,000	mg/kg				20,000		-							
Iron	CDH-S-025(0.0–4.7)	30,000	mg/kg				20,000		-							
Iron	CDH-S-026(0.0–2.0)	31,000	mg/kg				20,000		-							
Iron	CDH-S-027(0–1.9)	30,000	mg/kg				20,000		-							

Table A-6. Klamath River Sediment Study-Sediment Samples with Values Exceeding One or More Freshwater Sediment Screening Levels

Chemical	Sample[1]	Measured Value	Units	Freshwater Screening Levels (FWS)												
				PNW SEF		Included in SQuiRTs						Oregon DEQ BSLV [2]				
				SL1-FWS	SL2-FWS	FWS TEL	FWS LEL	FWS PEL	FWS SEL	FWS TEC	FWS PEC	F-FW	A-I	A-P	M-I	M-P
Iron	CDH-S-028(0.0–1.0)	30,000	mg/kg				20,000		-							
Iron	CDH-S-029(0.0–4.8)	29,000	mg/kg				20,000		-							
Iron	CDH-S-030(0.0–2.9)	28,000	mg/kg				20,000		-							
Iron	CDH-S-031(0.0–4.8)	27,000	mg/kg				20,000		-							
Iron	CDH-S-032(0.0–3.4)	27,000	mg/kg				20,000		-							
Iron	CDH-S-046(0.0–2.5)	32,000	mg/kg				20,000		-							
Nickel	CDH-S-021(0.0–0.5)	18	mg/kg	-	-	-	16	-	-	-	-					
Nickel	CDH-S-022(0.0–1.4)	19	mg/kg	-	-	18	16	-	-	-	-					
Nickel	CDH-S-023(0.0–5.4)	27	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-023(5.4–7.7)	28	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-024(0.0–4.1)	31	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-025(0.0–4.7)	28	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-026(0.0–2.0)	33	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-027(0–1.9)	23	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-028(0.0–1.0)	27	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-029(0.0–4.8)	25	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-030(0.0–2.9)	26	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-031(0.0–4.8)	31	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-032(0.0–3.4)	24	mg/kg	-	-	18	16	-	-	22.7	-					
Nickel	CDH-S-046(0.0–2.5)	20	mg/kg	-	-	18	16	-	-	-	-					
Organics																
Polychlorinated Dioxins and Furans																
2,3,4,7,8-PECDF	CDH-S-029(0.0–4.8)	0.74	pg/g									-	0.7	-	0.17	-

Table A-6. Klamath River Sediment Study-Sediment Samples with Values Exceeding One or More Freshwater Sediment Screening Levels

Chemical	Sample[1]	Measured Value	Units	Freshwater Screening Levels (FWS)												
				PNW SEF		Included in SQuiRTs						Oregon DEQ BSLV [2]				
				SL1-FWS	SL2-FWS	FWS TEL	FWS LEL	FWS PEL	FWS SEL	FWS TEC	FWS PEC	F-FW	A-I	A-P	M-I	M-P
Klamath River Estuary																
Metals and AVS																
Chromium	CHA-S-001	96	mg/kg	95	-	37.3	26	90	-	43.4	-					
Chromium	CHA-S-002	97	mg/kg	95	-	37.3	26	90	-	43.4	-					
Copper	CHA-S-001	26	mg/kg	-	-	-	16	-	-	-	-					
Copper	CHA-S-002	19	mg/kg	-	-	-	16	-	-	-	-					
Iron	CHA-S-001	24,000	mg/kg				20,000		-							
Iron	CHA-S-002	24,000	mg/kg				20,000		-							
Nickel	CHA-S-001	110	mg/kg	60	70	18	16	36	75	22.7	48.6					
Nickel	CHA-S-002	110	mg/kg	60	70	18	16	36	75	22.7	48.6					
Organics																
Phthalates																
BIS(2-ethylhexyl) phthalate	CHA-S-002	250	µg/kg	220	-											

[1] Maps of sample site locations are presented in Section 2.

[2] Although Oregon DEQ bioaccumulation SLVs are not applicable in California for regulatory purposes, comparisons of measured concentrations from Copco 1 Reservoir, Iron Gate Reservoir, and Klamath Estuary sediment samples to these SLVs were undertaken due to the lack of other available SLVs for particular chemicals, such as dioxins and furans. This comparison also allowed for direct comparison of sediment quality between all three reservoirs using a common set of SLVs.

Screening Level Key:

(blank)=	No screening levels apply
- =	Laboratory value is below screening level
PNW SEF=	Pacific Northwest Sediment Evaluation Framework
SL1=	Sediment Screening Level 1
SL2=	Sediment Screening Level 2
SQuiRTs=	Screening Quick Reference Tables

Table A-6. Klamath River Sediment Study-Sediment Samples with Values Exceeding One or More Freshwater Sediment Screening Levels

Chemical	Sample[1]	Measured Value	Units	Freshwater Screening Levels (FWS)												
				PNW SEF		Included in SQuiRTs						Oregon DEQ BSLV [2]				
				SL1-FWS	SL2-FWS	FWS TEL	FWS LEL	FWS PEL	FWS SEL	FWS TEC	FWS PEC	F-FW	A-I	A-P	M-I	M-P

TEL= Threshold Effect Level
LEL= Lowest Effect Level
PEL= Probable Effect Level
SEL= Severe Effect Level
TEC= Threshold Effect Concentration
PEC= Probable Effect Concentration
DEQ= Department of Environmental Quality
BSLV= Land Quality Division Sediment Bioaccumulation Screening Level Values
F-FW= Fish-Freshwater
A-I= Bird Individual
A-P= Bird Population
M-I= Mammal Individual
M-P= Mammal Population

Units Key:

g= gram
kg= kilogram (1,000 grams)
mg= milligram (10^{-3} gram)
ug= microgram (10^{-6} gram)
pg= picogram (10^{-12} gram)

Table A-7. Klamath River Sediment Study-Sediment Samples with Values Exceeding One or More Human Health Sediment Screening Levels

Chemical	Sample[1]	Measured Value	Units	Human Health Screening Levels: Oregon DEQ BSLV[2] H-S	Oregon DEQ BSLV[2] H-G	USEPA RSL TOT CAR	USEPA RSL TOT NON CAR	CHHSL Residential	CHHSL Commercial
J.C. Boyle Reservoir									
Metals and AVS									
Arsenic	CDH-S-002(0–5)	4.3	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-003(0–3.8)	10	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-004(0–6)	13	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-004(5.8-9)	7.7	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-005(0.0–0.3)	11	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-006A(0.0–0.3)	11	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-007(0–5)	11	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-007(0–5.1)	11	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-007(12–17)	10	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-007(17–18.7)	9	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-007(4.2–9.2)	11	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-007(9.2–12)	11	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-008(0–1.7)	15	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-043(0.0–2.0)	11	mg/kg			0.39	-	0.07	0.24
Nickel	CDH-S-002(0–5)	19	mg/kg			0.38	-	-	-
Nickel	CDH-S-003(0–3.8)	32	mg/kg			0.38	-	-	-
Nickel	CDH-S-004(0–6)	24	mg/kg			0.38	-	-	-
Nickel	CDH-S-004(5.8–9)	26	mg/kg			0.38	-	-	-
Nickel	CDH-S-005(0.0–0.3)	21	mg/kg			0.38	-	-	-
Nickel	CDH-S-006A(0.0–0.3)	25	mg/kg			0.38	-	-	-
Nickel	CDH-S-007(0–5)	23	mg/kg			0.38	-	-	-

Table A-7. Klamath River Sediment Study-Sediment Samples with Values Exceeding One or More Human Health Sediment Screening Levels

Chemical	Sample[1]	Measured Value	Units	Human Health Screening Levels					
				Oregon DEQ BSLV[2]		USEPA RSL		CHHSL	
				H-S	H-G	TOT CAR	TOT NON CAR	Residential	Commercial
Nickel	CDH-S-007(0–5.1)	25	mg/kg			0.38	-	-	-
Nickel	CDH-S-007(12–17)	26	mg/kg			0.38	-	-	-
Nickel	CDH-S-007(17–18.7)	21	mg/kg			0.38	-	-	-
Nickel	CDH-S-007(4.2–9.2)	23	mg/kg			0.38	-	-	-
Nickel	CDH-S-007(9.2–12)	23	mg/kg			0.38	-	-	-
Nickel	CDH-S-008(0–1.7)	25	mg/kg			0.38	-	-	-
Nickel	CDH-S-043(0.0–2.0)	27	mg/kg			0.38	-	-	-
Organics									
Pesticides/Herbicides/Insecticides									
4,4'-DDD	CDH-S-007(0–5)	3.7	µg/kg	0.04	0.33			-	-
4,4'-DDE	CDH-S-007(0–5)	3.4	µg/kg	0.04	0.33			-	-
4,4'-DDT	CDH-S-007(4.2–9.2)	4.1	µg/kg	0.04	0.33			-	-
Dieldrin	CDH-S-007(0–5)	3.4	µg/kg	0	0.01	-	-	-	-
Organics									
Phenols									
Pentachlorophenol	CDH-S-004(0–6)	34	µg/kg	30	-	-	-	-	-
Organics									
Polychlorinated Dioxins and Furans									
1,2,3,4,6,7,8-HPCDD	CDH-S-007(0–18.7)	180	pg/g	85	-				
1,2,3,4,6,7,8-HPCDD	CDH-S-008(0–1.7)	170	pg/g	85	-				
1,2,3,4,7,8-HXCDD	CDH-S-007(0–18.7)	1.6	pg/g	0.34	-				
1,2,3,4,7,8-HXCDD	CDH-S-008(0–1.7)	1.5	pg/g	0.34	-				
1,2,3,4,7,8-HXCDF	CDH-S-007(0–18.7)	2.1	pg/g	0.34	-				

Table A-7. Klamath River Sediment Study-Sediment Samples with Values Exceeding One or More Human Health Sediment Screening Levels

Chemical	Sample[1]	Measured Value	Units	Human Health Screening Levels					
				Oregon DEQ BSLV[2]		USEPA RSL		CHHSL	
				H-S	H-G	TOT CAR	TOT NON CAR	Residential	Commercial
1,2,3,4,7,8-HXCDF	CDH-S-008(0–1.7)	1.7	pg/g	0.34	-				
1,2,3,6,7,8-HXCDD	CDH-S-007(0–18.7)	7.3	pg/g	0.34	2.7				
1,2,3,6,7,8-HXCDD	CDH-S-008(0–1.7)	6.6	pg/g	0.34	2.7				
1,2,3,6,7,8-HXCDF	CDH-S-007(0–18.7)	4.4	pg/g	0.34	2.7				
1,2,3,6,7,8-HXCDF	CDH-S-008(0–1.7)	5.3	pg/g	0.34	2.7				
1,2,3,7,8,9-HXCDD	CDH-S-007(0–18.7)	3.7	pg/g	0.34	2.7				
1,2,3,7,8,9-HXCDD	CDH-S-008(0–1.7)	3.7	pg/g	0.34	2.7				
1,2,3,7,8,9-HXCDF	CDH-S-007(0–18.7)	0.66	pg/g	0.34	-				
1,2,3,7,8,9-HXCDF	CDH-S-008(0–1.7)	0.67	pg/g	0.34	-				
1,2,3,7,8-PECDD	CDH-S-007(0–18.7)	1.1	pg/g	0.03	0.27				
1,2,3,7,8-PECDF	CDH-S-007(0–18.7)	0.88	pg/g	0.31	-				
1,2,3,7,8-PECDF	CDH-S-008(0–1.7)	1.1	pg/g	0.31	-				
2,3,4,6,7,8-HXCDF	CDH-S-007(0–18.7)	3	pg/g	0.34	2.7				
2,3,4,6,7,8-HXCDF	CDH-S-008(0–1.7)	3.2	pg/g	0.34	2.7				
2,3,4,7,8-PECDF	CDH-S-007(0–18.7)	1.5	pg/g	0	0.03				
2,3,4,7,8-PECDF	CDH-S-008(0–1.7)	1.5	pg/g	0	0.03				
2,3,7,8-TCDD	CDH-S-008(0–1.7)	0.19	pg/g	0	0.01	-	-	-	-
2,3,7,8-TCDF	CDH-S-007(0–18.7)	0.9	pg/g	0.09	0.77				
2,3,7,8-TCDF	CDH-S-008(0–1.7)	0.88	pg/g	0.09	0.77				
Copco 1 Reservoir									
Metals and AVS									
Arsenic	CDH-S-009A(0.0–4.6)	6.8	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-010(0.0–5.0)	6.9	mg/kg			0.39	-	0.07	0.24

Table A-7. Klamath River Sediment Study-Sediment Samples with Values Exceeding One or More Human Health Sediment Screening Levels

Chemical	Sample[1]	Measured Value	Units	Human Health Screening Levels					
				Oregon DEQ BSLV[2]		USEPA RSL		CHHSL	
				H-S	H-G	TOT CAR	TOT NON CAR	Residential	Commercial
Arsenic	CDH-S-010(5.0–8.0)	6.9	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-011(0.0–1.3)	13	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-012(0.0–5.4)	7.3	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-013(0.0–5.7)	8.1	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-014(0.0–5.3)	6.3	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-015A(0.0–5.0)	9.4	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-015A(5.0–9.7)	8.3	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-016(0.0–5.0)	8.9	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-016(5.0–7.5)	8.8	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-017(0.0–1.2)	8.5	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-018(0.0–5.0)	9.3	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-018(5.0–8.9)	9.1	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-019(0.0–4.8)	9.1	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-020(0.0–5.0)	9.3	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-020(5.0–7.0)	9.9	mg/kg			0.39	-	0.07	0.24
Nickel	CDH-S-009A(0.0–4.6)	28	mg/kg			0.38	-	-	-
Nickel	CDH-S-010(0.0–5.0)	32	mg/kg			0.38	-	-	-
Nickel	CDH-S-010(5.0–8.0)	24	mg/kg			0.38	-	-	-
Nickel	CDH-S-011(0.0–1.3)	25	mg/kg			0.38	-	-	-
Nickel	CDH-S-012(0.0–5.4)	26	mg/kg			0.38	-	-	-
Nickel	CDH-S-013(0.0–5.7)	30	mg/kg			0.38	-	-	-
Nickel	CDH-S-014(0.0–5.3)	28	mg/kg			0.38	-	-	-
Nickel	CDH-S-015A(0.0–5.0)	26	mg/kg			0.38	-	-	-

Table A-7. Klamath River Sediment Study-Sediment Samples with Values Exceeding One or More Human Health Sediment Screening Levels

Chemical	Sample[1]	Measured Value	Units	Human Health Screening Levels					
				Oregon DEQ BSLV[2]		USEPA RSL		CHHSL	
				H-S	H-G	TOT CAR	TOT NON CAR	Residential	Commercial
Nickel	CDH-S-015A(5.0–9.7)	26	mg/kg			0.38	-	-	-
Nickel	CDH-S-016(0.0–5.0)	26	mg/kg			0.38	-	-	-
Nickel	CDH-S-016(5.0–7.5)	23	mg/kg			0.38	-	-	-
Nickel	CDH-S-017(0.0–1.2)	24	mg/kg			0.38	-	-	-
Nickel	CDH-S-018(0.0–5.0)	28	mg/kg			0.38	-	-	-
Nickel	CDH-S-018(5.0–8.9)	23	mg/kg			0.38	-	-	-
Nickel	CDH-S-019(0.0–4.8)	22	mg/kg			0.38	-	-	-
Nickel	CDH-S-020(0.0–5.0)	23	mg/kg			0.38	-	-	-
Nickel	CDH-S-020(5.0–7.0)	23	mg/kg			0.38	-	-	-
Organics									
Polychlorinated Dioxins and Furans									
1,2,3,4,6,7,8-HPCDD	CDH-S-014(0.0–5.3)	190	pg/g	85	-				
1,2,3,4,6,7,8-HPCDD	CDH-S-015A(0.0–9.7)	180	pg/g	85	-				
1,2,3,4,6,7,8-HPCDF	CDH-S-014(0.0–5.3)	89	pg/g	85	-				
1,2,3,4,6,7,8-HPCDF	CDH-S-015A(0.0–9.7)	96	pg/g	85	-				
1,2,3,4,7,8-HXCDD	CDH-S-014(0.0–5.3)	1.7	pg/g	0.34	-				
1,2,3,4,7,8-HXCDD	CDH-S-015A(0.0–9.7)	1.9	pg/g	0.34	-				
1,2,3,4,7,8-HXCDF	CDH-S-014(0.0–5.3)	2.3	pg/g	0.34	-				
1,2,3,4,7,8-HXCDF	CDH-S-015A(0.0–9.7)	2.8	pg/g	0.34	2.7				
1,2,3,6,7,8-HXCDD	CDH-S-014(0.0–5.3)	8.8	pg/g	0.34	2.7				
1,2,3,6,7,8-HXCDD	CDH-S-015A(0.0–9.7)	9.8	pg/g	0.34	2.7				
1,2,3,6,7,8-HXCDF	CDH-S-014(0.0–5.3)	5.5	pg/g	0.34	2.7				
1,2,3,6,7,8-HXCDF	CDH-S-015A(0.0–9.7)	3.5	pg/g	0.34	2.7				

Table A-7. Klamath River Sediment Study-Sediment Samples with Values Exceeding One or More Human Health Sediment Screening Levels

Chemical	Sample[1]	Measured Value	Units	Human Health Screening Levels					
				Oregon DEQ BSLV[2]		USEPA RSL		CHHSL	
				H-S	H-G	TOT CAR	TOT NON CAR	Residential	Commercial
1,2,3,7,8,9-HXCDD	CDH-S-014(0.0–5.3)	4.3	pg/g	0.34	2.7				
1,2,3,7,8,9-HXCDD	CDH-S-015A(0.0–9.7)	4.2	pg/g	0.34	2.7				
1,2,3,7,8,9-HXCDF	CDH-S-014(0.0–5.3)	1	pg/g	0.34	-				
1,2,3,7,8-PECDD	CDH-S-014(0.0–5.3)	1.2	pg/g	0.03	0.27				
1,2,3,7,8-PECDD	CDH-S-015A(0.0–9.7)	1.4	pg/g	0.03	0.27				
1,2,3,7,8-PECDF	CDH-S-014(0.0–5.3)	0.84	pg/g	0.31	-				
2,3,4,6,7,8-HXCDF	CDH-S-014(0.0–5.3)	3.7	pg/g	0.34	2.7				
2,3,4,6,7,8-HXCDF	CDH-S-015A(0.0–9.7)	3.2	pg/g	0.34	2.7				
2,3,4,7,8-PECDF	CDH-S-014(0.0–5.3)	1.9	pg/g	0	0.03				
2,3,4,7,8-PECDF	CDH-S-015A(0.0–9.7)	1.8	pg/g	0	0.03				
2,3,7,8-TCDF	CDH-S-014(0.0–5.3)	1.2	pg/g	0.09	0.77				
2,3,7,8-TCDF	CDH-S-015A(0.0–9.7)	0.99	pg/g	0.09	0.77				
Iron Gate Reservoir									
Metals and AVS									
Arsenic	CDH-S-021(0.0–0.5)	9.9	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-022(0.0–1.4)	7.5	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-023(0.0–5.4)	7.4	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-023(5.4–7.7)	8.1	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-024(0.0–4.1)	8	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-025(0.0–4.7)	10	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-026(0.0–2.0)	7.5	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-027(0–1.9)	8.9	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-028(0.0–1.0)	7.7	mg/kg			0.39	-	0.07	0.24

Table A-7. Klamath River Sediment Study-Sediment Samples with Values Exceeding One or More Human Health Sediment Screening Levels

Chemical	Sample[1]	Measured Value	Units	Human Health Screening Levels					
				Oregon DEQ BSLV[2]		USEPA RSL		CHHSL	
				H-S	H-G	TOT CAR	TOT NON CAR	Residential	Commercial
Arsenic	CDH-S-029(0.0–4.8)	7.7	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-030(0.0–2.9)	8.8	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-031(0.0–4.8)	9.3	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-032(0.0–3.4)	7.7	mg/kg			0.39	-	0.07	0.24
Arsenic	CDH-S-046(0.0–2.5)	8.4	mg/kg			0.39	-	0.07	0.24
Nickel	CDH-S-021(0.0–0.5)	18	mg/kg			0.38	-	-	-
Nickel	CDH-S-022(0.0–1.4)	19	mg/kg			0.38	-	-	-
Nickel	CDH-S-023(0.0–5.4)	27	mg/kg			0.38	-	-	-
Nickel	CDH-S-023(5.4–7.7)	28	mg/kg			0.38	-	-	-
Nickel	CDH-S-024(0.0–4.1)	31	mg/kg			0.38	-	-	-
Nickel	CDH-S-025(0.0–4.7)	28	mg/kg			0.38	-	-	-
Nickel	CDH-S-026(0.0–2.0)	33	mg/kg			0.38	-	-	-
Nickel	CDH-S-027(0–1.9)	23	mg/kg			0.38	-	-	-
Nickel	CDH-S-028(0.0–1.0)	27	mg/kg			0.38	-	-	-
Nickel	CDH-S-029(0.0–4.8)	25	mg/kg			0.38	-	-	-
Nickel	CDH-S-030(0.0–2.9)	26	mg/kg			0.38	-	-	-
Nickel	CDH-S-031(0.0–4.8)	31	mg/kg			0.38	-	-	-
Nickel	CDH-S-032(0.0–3.4)	24	mg/kg			0.38	-	-	-
Nickel	CDH-S-046(0.0–2.5)	20	mg/kg			0.38	-	-	-
Organics									
Polychlorinated Dioxins and Furans									
1,2,3,4,7,8-HXCDD	CDH-S-031(0.0–4.8)	1.1	pg/g	0.34	-				
1,2,3,4,7,8-HXCDF	CDH-S-031(0.0–4.8)	1.2	pg/g	0.34	-				

Table A-7. Klamath River Sediment Study-Sediment Samples with Values Exceeding One or More Human Health Sediment Screening Levels

Chemical	Sample[1]	Measured Value	Units	Human Health Screening Levels					
				Oregon DEQ BSLV[2]		USEPA RSL		CHHSL	
				H-S	H-G	TOT CAR	TOT NON CAR	Residential	Commercial
1,2,3,6,7,8-HXCDD	CDH-S-029(0.0–4.8)	3.5	pg/g	0.34	2.7				
1,2,3,6,7,8-HXCDD	CDH-S-031(0.0–4.8)	3.4	pg/g	0.34	2.7				
1,2,3,6,7,8-HXCDD	CDH-S-046(0.0–2.5)	3.5	pg/g	0.34	2.7				
1,2,3,6,7,8-HXCDF	CDH-S-029(0.0–4.8)	1.2	pg/g	0.34	-				
1,2,3,6,7,8-HXCDF	CDH-S-031(0.0–4.8)	1.3	pg/g	0.34	-				
1,2,3,6,7,8-HXCDF	CDH-S-046(0.0–2.5)	1.4	pg/g	0.34	-				
1,2,3,7,8,9-HXCDD	CDH-S-029(0.0–4.8)	2	pg/g	0.34	-				
1,2,3,7,8,9-HXCDD	CDH-S-031(0.0–4.8)	2	pg/g	0.34	-				
1,2,3,7,8,9-HXCDD	CDH-S-046(0.0–2.5)	2.5	pg/g	0.34	-				
1,2,3,7,8-PECDD	CDH-S-029(0.0–4.8)	0.68	pg/g	0.03	0.27				
1,2,3,7,8-PECDD	CDH-S-031(0.0–4.8)	0.62	pg/g	0.03	0.27				
1,2,3,7,8-PECDD	CDH-S-046(0.0–2.5)	0.82	pg/g	0.03	0.27				
1,2,3,7,8-PECDF	CDH-S-029(0.0–4.8)	0.44	pg/g	0.31	-				
1,2,3,7,8-PECDF	CDH-S-046(0.0–2.5)	0.52	pg/g	0.31	-				
2,3,4,6,7,8-HXCDF	CDH-S-029(0.0–4.8)	1.2	pg/g	0.34	-				
2,3,4,6,7,8-HXCDF	CDH-S-031(0.0–4.8)	1.2	pg/g	0.34	-				
2,3,4,6,7,8-HXCDF	CDH-S-046(0.0–2.5)	1.4	pg/g	0.34	-				
2,3,4,7,8-PECDF	CDH-S-029(0.0–4.8)	0.74	pg/g	0	0.03				
2,3,7,8-TCDF	CDH-S-031(0.0–4.8)	0.68	pg/g	0.09	-				
2,3,7,8-TCDF	CDH-S-046(0.0–.5)	0.68	pg/g	0.09	-				
Klamath River Estuary									
Metals and AVS									
Arsenic	CHA-S-001	3.2	mg/kg			0.39	-	0.07	0.24

Table A-7. Klamath River Sediment Study-Sediment Samples with Values Exceeding One or More Human Health Sediment Screening Levels

Chemical	Sample[1]	Measured Value	Units	Human Health Screening Levels					
				Oregon DEQ BSLV[2]		USEPA RSL		CHHSL	
				H-S	H-G	TOT CAR	TOT NON CAR	Residential	Commercial
Arsenic	CHA-S-002	2.2	mg/kg			0.39	-	0.07	0.24
Nickel	CHA-S-001	110	mg/kg			0.38	-	-	-
Nickel	CHA-S-002	110	mg/kg			0.38	-	-	-

[1]Maps of sample site locations are presented in Section 2.

[2] Although Oregon DEQ bioaccumulation SLVs are not applicable in California for regulatory purposes, comparisons of measured concentrations from Copco 1 Reservoir, Iron Gate Reservoir, and Klamath Estuary sediment samples to these SLVs were undertaken due to the lack of other available SLVs for particular chemicals, such as dioxins and furans. This comparison also allowed for direct comparison of sediment quality between all three reservoirs using a common set of SLVs.

Screening Level Key:

(blank)= No screening levels apply

- = Laboratory value is below screening level

BSLV= Land Quality Division Sediment Bioaccumulation Screening Level Values

RSL= Regional Screening Levels

CHHSL= California Human Health Screening Levels

H-S= Human – Subsistence

H-G= Human – General

TOT = Total

NON CAR= Non-carcinogenic

CAR= Carcinogenic

Units Key:

g= gram

kg= kilogram (1,000 grams)

mg= milligram (10^{-3} gram)

ug= microgram (10^{-6} gram)

pg= picogram (10^{-12} gram)

Appendix B
Sediment Evaluation Framework Level 2B: Preliminary Assessment: Elutriate Data Comparisons to Applicable Water Quality Criteria and Toxicity Bioassays

B.1 Sediment Toxicity Bioassays

Sediment bioassays can provide additional useful information in the assessment of potential toxicity under the exposure pathways considered for this project. Results from acute (10-day) sediment bioassays for the benthic midge *Chironomus dilutus* and the benthic amphipod *Hyalella azteca*, using super-composite[2] samples of on-thalweg sediments and super-composite samples of off-thalweg sediments in each of the Project reservoirs, indicate generally equal or greater survival in reservoir sediments as compared with laboratory control samples (Table B-1; see raw data in Table B-2 and B-3 and reference toxicity data in Table B-15). The exception is J.C. Boyle Reservoir, which exhibits considerably lower survival for *Chironomus dilutus* in the on-thalweg sample as compared with the laboratory control (64 percent vs. 95 percent). The relatively low survival for *Chironomus dilutus* in the J.C. Boyle Reservoir on-thalweg sample is suggestive of potential toxicity to freshwater benthic organisms. Survival in the off-thalweg sample is similar to the control (91 percent vs. 95 percent), once a statistical outlier from a single replicate is removed from the dataset (see Table B-2). If this replicate is included in the analysis, survival is lower (83 percent) with a large standard deviation (26 percent); due to the latter, survival including all replicates in the off-thalweg test is still not significantly different than the control (95 percent). *Hyalella azteca* survival in the J.C. Boyle Reservoir samples is roughly equivalent to that of the laboratory control (80–81 percent vs. 80 percent) indicating no toxicity. Further, survival results for 28-day bioaccumulation tests using two benthic organisms, *Corbicula fluminea* and *Lumbricula variegates* indicate 100 percent survival for J.C. Boyle with minimal weight change, indicating little to no apparent toxicity over the 28-day period (BES 2010a–2010d).

Overall then, the indication of benthic toxicity to sediments in the project reservoirs is limited to the J.C. Boyle Reservoir on-thalweg sample. While this is of concern under exposure pathways where the dams remain in place, under scenarios where the dams are removed, sediments from all three reservoirs will mix as they move downstream and expose downstream aquatic biota to an "average" sediment composition rather than a reservoir-specific composition. The total volume of erodible sediments in Copco 1 and Iron Gate Reservoirs (2.7 million yd^3 and 2.83 million yd^3, respectively; Wright [2011]) is considerably greater than that of J.C. Boyle Reservoir (0.94 million yd^3; Wright [2011]), diminishing the potential influence of J.C. Boyle Reservoir sediments downstream biota exposure. Finally, fine sediments released during drawdown and dam removal will be transported by large water volumes, and are unlikely to settle along the riverbed (Greimann et al. 2011, Stillwater Sciences 2008); therefore, downstream freshwater benthic organisms are unlikely to experience the same intensity of exposure to reservoir sediments as during the bioassays themselves. Overall, then the freshwater sediment bioassays indicate a low likelihood of acute toxicity to downstream benthic organisms due to sediment release under exposure pathways involving dam removal.

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[2] Super-composite samples were chosen for analysis of sediment elutriate and toxicity studies (i.e., bioassay tests) to provide a representative reservoir-wide average sediment composition, and to meet the large sediment and water volume requirements for the elutriate tests (BOR 2010).

Table B-1. Acute Toxicity Summary Results for Sediment Bioassay, 10-day Survival (%).

	J.C. Boyle Reservoir		Copco 1 Reservoir		Iron Gate Reservoir		Klamath Estuary
	On-thalweg (CDH-E-JBT)	**Off-thalweg (CDH-E-JBN)**	**On-thalweg (CDH-S-CPT)**	**Off-thalweg (CDH-S-CPN)**	**On-thalweg (CDH-S-IGT)**	**Off-thalweg (CDH-S-IGN)**	**CHA-E-002**
Midge (*Chironomus dilutus*)							
Laboratory (control) sediment	95	95	88	88	88	88	81
Sample	64	91([1])	94	88	91	83	89
Amphipod (*Hyalella azteca*)							
Laboratory (control) sediment	80	80	79[(2)]	79[(2)]	79[(2)]	79[(2)]	94
Sample	80	81	84	88	89	94	99

Source: BES (2010a–2010d). Raw data is presented in Table B-2 and B-3, and reference toxicity data in Table B-15.

[1] Statistical outlier removed from the comparison to the laboratory control, based on Grigg's Test (N=8, p<0.05).

[2] Control did not pass test acceptability criterion (80% survival) (EPA/600/R-99/064).

Table B-2. Acute Toxicity Test Results, Raw Data for Sediment Bioassay, 10-day Survival (%) of Midge (*Chironomus dilutus*).[1]

Sample[2]	Replicate	No. Alive	% Survival	Mean % Survival	Standard Deviation	Signif?[3]
J.C. Boyle Reservoir						
Laboratory (Control) Sediment	A	10	100	95	8	n/a
	B	9	90			
	C	10	100			
	D	9	90			
	E	10	100			
	F	10	100			
	G	10	100			
	H	8	80			
CDH-E-JBT	A	10	100	64	24	yes
	B	2	20			
	C	8	80			
	D	6	60			
	E	7	70			
	F	4	40			
	G	7	70			
	H	7	70			
CDH-E-JBN	A	9	90	91	7	no
	B	10	100			
	C[4]	2	20			
	D	9	90			
	E	8	80			
	F	9	90			
	G	10	100			
	H	9	90			

Table B-2. Acute Toxicity Test Results, Raw Data for Sediment Bioassay, 10-day Survival (%) of Midge (*Chironomus dilutus*).[1]

Sample[2]	Replicate	No. Alive	% Survival	Mean % Survival	Standard Deviation	Signif?[3]
Copco Reservoir						
Laboratory (Control) Sediment	A	7	70	88	9	n/a
	B	9	90			
	C	8	80			
	D	9	90			
	E	9	90			
	F	10	100			
	G	9	90			
	H	9	90			
CDH-S-CPT	A	9	90	94	5	no
	B	9	90			
	C	9	90			
	D	10	100			
	E	9	90			
	F	10	100			
	G	9	90			
	H	10	100			
CDH-S-CPN	A	9	90	88	10	no
	B	8	80			
	C	9	90			
	D	9	90			
	E	10	100			
	F	10	100			
	G	8	80			
	H	7	70			
Iron Gate Reservoir						
Laboratory (Control) Sediment	A	7	70	88	9	n/a
	B	9	90			
	C	8	80			
	D	9	90			
	E	9	90			
	F	10	100			
	G	9	90			
	H	9	90			
CDH-S-IGT	A	10	100	91	10	no
	B	9	90			
	C	9	90			
	D	7	70			
	E	10	100			
	F	9	90			
	G	9	90			
	H	10	100			

Table B-2. Acute Toxicity Test Results, Raw Data for Sediment Bioassay, 10-day Survival (%) of Midge (*Chironomus dilutus*).[1]

Sample[2]	Replicate	No. Alive	% Survival	Mean % Survival	Standard Deviation	Signif?[3]
CDH-S-IGN	A	9	90	83	15	no
	B	10	100			
	C	6	60			
	D	7	70			
	E	7	70			
	F	10	100			
	G	8	80			
	H	9	90			
Klamath River Estuary						
Laboratory (Control) Sediment	A	9	90	81	12	n/a
	B	10	100			
	C	8	80			
	D	6	60			
	E	8	80			
	F	7	70			
	G	8	80			
	H	9	90			
CHA-E-002	A	7	70	89	10	No
	B	9	90			
	C	10	100			
	D	10	100			
	E	9	90			
	F	9	90			
	G	8	80			
	H	9	90			

[1] Raw data from BES (2010a–2010d).

[2] Sediment bioassay samples for each reservoir are super-composites of multiple on-thalweg borehole locations ("T" at the end of the sample identifier code) or multiple off-thalweg borehole locations (non-thalweg; "N" at the end of the sample identifier code). An "area composite" sample was collected in the Upper Klamath River Estuary i.e., estuary samples were not segregated according to thalweg/non-thalweg location. Super-composite samples were chosen for analysis of sediment elutriate and toxicity studies (i.e., bioassay tests) to provide a representative reservoir- or estuary-wide average sediment composition, and to meet the large sediment and water volume requirements for the elutriate tests (BOR 2010). Maps of sample site locations are presented in Section 2, Figures 3–5.

[3] "Yes" indicates a statistically significant ($p<0.002$) reduction compared to the laboratory (control) sediment.

[4] Statistical outlier removed from the comparison to the laboratory control, based on Grigg's Test ($N=8$, $p<0.05$).

Table B-3. Acute Toxicity Test Results, Raw Data for Sediment Bioassay, 10-day Survival (%) of Amphipod (*Hyalella azteca*).[1]

Sample[2]	Replicate	No. Alive	% Survival	Mean % Survival	Standard Deviation	Signif?[3]
J.C. Boyle Reservoir						
Laboratory (Control) Sediment	A	9	90	80	17	n/a
	B	10	100			
	C	9	90			
	D	6	60			
	E	7	70			
	F	7	70			
	G	10	100			
	H	6	60			
CDH-E-JBT	A	7	70	80	8	no
	B	9	90			
	C	9	90			
	D	8	80			
	E	7	70			
	F	8	80			
	G	8	80			
	H	8	80			
CDH-E-JBN	A	8	80	81	20	no
	B	9	90			
	C	10	100			
	D	10	100			
	E	5	50			
	F	6	60			
	G	7	70			
	H	10	100			
Copco Reservoir						
Laboratory (Control) Sediment	A	10	100	79[(4)]	18	n/a
	B	7	70			
	C	7	70			
	D	10	100			
	E	10	100			
	F	7	70			
	G	6	60			
	H	6	60			
CDH-S-CPT	A	8	80	84	7	no
	B	7	70			
	C	9	90			
	D	8	80			
	E	9	90			
	F	8	80			
	G	9	90			
	H	9	90			

Table B-3. Acute Toxicity Test Results, Raw Data for Sediment Bioassay, 10-day Survival (%) of Amphipod (*Hyalella azteca*).[1]

Sample[2]	Replicate	No. Alive	% Survival	Mean % Survival	Standard Deviation	Signif?[3]
CDH-S-CPN	A	9	90	88	9	no
	B	9	90			
	C	9	90			
	D	9	90			
	E	10	100			
	F	7	70			
	G	9	90			
	H	8	80			
Iron Gate Reservoir						
Laboratory (Control) Sediment	A	10	100	79[(4)]	18	n/a
	B	7	70			
	C	7	70			
	D	10	100			
	E	10	100			
	F	7	70			
	G	6	60			
	H	6	60			
CDH-S-IGT	A	9	90	89	12	n/a
	B	7	70			
	C	7	70			
	D	10	100			
	E	9	90			
	F	10	100			
	G	10	100			
	H	9	90			
CDH-S-IGN	A	10	100	94	5	n/a
	B	9	90			
	C	9	90			
	D	10	100			
	E	9	90			
	F	10	100			
	G	9	90			
	H	9	90			
Klamath River Estuary						
Laboratory (Control) Sediment	A	10	100	94	14	n/a
	B	10	100			
	C	10	100			
	D	10	100			
	E	10	100			
	F	10	100			
	G	6	60			
	H	9	90			

Table B-3. Acute Toxicity Test Results, Raw Data for Sediment Bioassay, 10-day Survival (%) of Amphipod (*Hyalella azteca*).[1]

Sample[2]	Replicate	No. Alive	% Survival	Mean % Survival	Standard Deviation	Signif?[3]
CHA-E-002	A	9	90	99	4	no
	B	10	100			
	C	10	100			
	D	10	100			
	E	10	100			
	F	10	100			
	G	10	100			
	H	10	100			

[1] Raw data from BES (2010a–2010d)

[2] Sediment bioassay samples for each reservoir are super-composites of multiple on-thalweg borehole locations (“T” at the end of the sample identifier code) or multiple off-thalweg borehole locations (non-thalweg; “N” at the end of the sample identifier code). An "area composite" sample was collected in the Upper Klamath River Estuary i.e., estuary samples were not segregated according to thalweg/non-thalweg location. Super-composite samples were chosen for analysis of sediment elutriate and toxicity studies (i.e., bioassay tests) to provide a representative reservoir- or estuary-wide average sediment composition, and to meet the large sediment and water volume requirements for the elutriate tests (BOR 2010). Maps of sample site locations are presented in Section 2, Figures 3–5.

[3] "Yes" indicates a statistically significant ($p<0.002$) reduction compared to the laboratory (control) sediment.

[4] Control did not pass test acceptability criterion (≥80% survival) (EPA/600/R-99/064)

B.2 Elutriate Chemistry

Elutriate tests can provide additional information regarding the potential toxicity of reservoir sediments mobilized under a dam removal scenario, and in particular to water-dwelling (as opposed to benthic) organisms in the lower Klamath River. For the 2009–2010 Secretarial Determination study, 384 chemicals were quantified in each of three reservoir super-composite[2] on-thalweg and off-thalweg elutriate chemistry samples (BOR 2011a). Of the quantified chemicals, 31 possess relevant marine screening levels (Table B-4), 37 possess relevant freshwater screening levels with a number of other chemicals possessing Oregon DEQ guidance values (Table B-5), and 162 possess relevant human health screening levels (Table B-6). Freshwater quality criteria for certain metals are hardness-dependent (NCRWQCB 2006). Available hardness data from the Klamath River at Orleans (USGS gage no. 11523000) from 1950 through 2003 (n=239) indicates a mean hardness in the river of approximately 70 mg/L. This value is used to calculate hardness-adjusted criteria for cadmium, chromium (III), copper, lead, nickel, zinc, and silver for the applicable California reaches (Table B-7).

Comparisons of elutriate chemistry results to relevant marine criteria indicate that ammonia, phosphorus, arsenic, chromium, copper, lead, nickel and zinc are elevated prior to accounting for dilution (Table B-8). However, since some degree of dilution would occur due to water column averaging, the large volume of water in the reservoirs available for dilution, and the addition of river flows following drawdown, the actual concentrations of metals and ammonia in the river following drawdown would be lower than the measured elutriate values.

The estimated dilution of measured elutriate concentrations required to meet marine water quality criteria can be calculated as follows (USEPA 1998):

$$D_R = \frac{(C_{elutriate} - C_{WQS})}{(C_{WQS} - C_{background})} \qquad \text{Eqn. 1}$$

where:

D_R = dilution of elutriate concentration required to meet water quality criteria;

$C_{elutriate}$ = concentration of chemical in elutriate sample;

C_{WQS} = water quality standard; and,

$C_{background}$ = background levels of chemical [zero as a conservative assumption].

Estimated required dilution factors using Eqn. 1 range from approximately 2 to 7 for all of the metals, and in many cases very small amounts of dilution are required (i.e., dilution factor is less than 1) (Table B-8). Required dilution factors for ammonia are greater; in order to meet the National Recommended Water Quality Criteria (National RWQC) marine criteria continuous concentration (CCC), required dilution factors range from approximately 7 to 40.

A *screening-level estimate* of how much more dilution is likely to occur under a dam removal scenario (as compared with the standard laboratory elutriate mixture) can be developed by scaling the actual suspended sediment concentration (SSC) in the laboratory elutriate samples to the modeled peak suspended sediment concentration (SSC) in the river following drawdown. The latter takes into consideration modeled hydrology and sediment erosion rates following drawdown (Greimann et al. 2011) and provides a rough estimate of future field conditions. The screening-level estimate uses the simplifying assumption that the ratio of chemical concentration to SSC in the laboratory elutriate test is equal to the ratio of chemical concentration to SSC in the river. As a worst case scenario, the peak SSC immediately downstream of Iron Gate Dam, prior to additional mixing and dilution in the river and the marine near shore environment, is estimated, as follows:

$$\left(\frac{C_{elutriate}}{C_{SSC(elutriate)}}\right) = \left(\frac{C_{river\_IGD}}{C_{SSC(river\_IGD)}}\right) \qquad \text{Eqn. 2}$$

where:

$C_{SSC(elutriate)}$ = concentration of SSC in laboratory elutriate sample;

C_{river_IGD} = concentration of chemical in the Klamath River immediately downstream of Iron Gate Dam following drawdown; and,

$C_{SSC(river\_IGD)}$ = peak concentration of SSC in the Klamath River immediately downstream of Iron Gate Dam.

Re-arranging the relationship in Eqn. 2, the expected dilution relative to the elutriate sample (D_E) is estimated as follows:

$$D_E = \left(\frac{C_{elutriate}}{C_{river\_IGD}} \right) = \left(\frac{C_{SSC(elutriate)}}{C_{SSC(river\_IGD)}} \right) \quad \text{Eqn. 3}$$

Laboratory elutriate samples were prepared using a standard 1:4 sediment:water slurry by volume from each reservoir (BES a–d 2010). Assuming an average solids density of 2,600 kg/m^3 (Strauss 2010), $C_{SSC(elutriate)}$ is calculated as follows:

$$C_{SSC(elutriate)} = \frac{1m^3 sediment}{4m^3 water} \times \frac{2{,}600kg}{m^3} \times \frac{10^6 mg}{kg} \times \frac{m^3}{10^3 L} = 650{,}000 \frac{mg}{L}$$

Based upon SSC modeling results for Drawdown Scenario 8 in Greimann et al. (2011), $C_{SSC(river\_IGD)}$ ranges from 9,900 to 13,600 mg/L, depending on water year type.

Therefore, using Eqn. 3, the screening-level estimates of expected dilution under a dam removal scenario (as compared with the standard laboratory elutriate mixture) for the location just downstream of Iron Gate Dam and immediately following drawdown are the following:

$$D_E = \left(\frac{650{,}000 \frac{mg}{L}}{13{,}600 \frac{mg}{L}} \right) = 48 \quad \text{to} \quad D_E = \left(\frac{650{,}000 \frac{mg}{L}}{9{,}900 \frac{mg}{L}} \right) = 66$$

Returning to the ammonia comparison, the range of expected dilution factors for peak SSC concentrations (48 to 60) is generally greater than the 7 to 40 required to meet the National RWQC marine criteria continuous concentration (CCC), indicating that dilution should be sufficient to meet criteria, even under the worst case scenario of peak SSC concentrations immediately downstream of Iron Gate Dam. As with the sediments (see Section B.1), mixing of sediment and pore waters from all three reservoirs as they move downstream will expose downstream aquatic biota to an "average" water column concentration rather than a reservoir- or site-specific concentration. Further, given additional dilution from downstream tributary inputs to the mainstem Klamath River and even greater amounts of dilution in the marine near shore environment itself, actual dilution is anticipated to far exceed the range of required dilution factors for ammonia and metals in the marine environment.

However, phosphorus dilution factors required to meet the National RWQC marine CCC are considerably greater than the range of expected dilution factors, ranging from 1,300 to 5,400 (Table B-8). The Lower Klamath Estuary sample also requires dilution to meet this criterion (dilution factor of approximately 500). In the case of phosphorus, background concentrations in the Klamath River are not zero (ranging 0.1-0.25 TP in the lower river [Asarian et al. 2010]), as conservatively assumed in Eqn. 1; however, background concentrations of phosphorus in the marine environment are expected to be at least an order of magnitude less than background river concentrations such that estimated required dilution factors remain very high (> 1,000). Overall then, phosphorus concentrations in the short-term (i.e., less than 2 years following dam removal, when downstream transport of reservoir sediments and pore waters would be the greatest) may episodically exceed the National RWQC marine CCC.

Comparisons of elutriate chemistry results to relevant freshwater criteria indicate that aluminum, chloride, copper, lead, and mercury are elevated prior to accounting for dilution (Table B-9). The aluminum exceedances are most dramatic, with measured levels (1,500–11,000 ug/L) exceeding criteria (87–750 ug/L) by 1–3 orders of magnitude. The high levels of aluminum measured in the elutriate samples agree with the relatively high levels measured at multiple Klamath River sites during the 2001–2005 SWAMP study (NCRWQCB 2008) including sites downstream of the dams. Consideration of dilution indicates that very small amounts of dilution are necessary for copper, lead and mercury (i.e., required dilution factors are 1 or less), with the exception of the non-thalweg sample in J.C. Boyle Reservoir where a dilution of 2 to 3 is required to meet the minimum criterion for these metals (National RWQC freshwater CCC; Table B-9). For aluminum, required dilution factors range from 16 to 125 for this criterion. Aluminum levels in the Klamath Estuary sediments are also elevated compared to the National RWQC freshwater CCC, requiring a dilution factor of approximately 8 to meet the criterion. However, given the large volume of the reservoirs and the addition of river flows and tributary inputs during drawdown, actual dilution is anticipated to exceed the range of required dilution factors (16-125) for aluminum in the Klamath River.

Freshwater ammonia toxicity to aquatic life is based on ambient pH and water temperature. Ammonia concentrations in some of the 100 percent elutriate samples (Table B-10) exceed pH- and water temperature-based National RWQC for ammonia for the protection of freshwater life (1.1–5.9 mg/L 30-day average for pH 7–8.5 and water temperature 0–14°C [32–57.2ºF] [early life stages of fish present], and 2.1–24.1 mg/L 1-hr average for pH 7–8.5 and all water temperatures [salmonids present] [USEPA 2009]). These acute and chronic ammonia criteria have also been explicitly adopted by the Hoopa Valley Tribe as thresholds for ammonia concentrations for the protection of the COLD beneficial use (HVTEPA 2008). Estimated required dilution factors for ammonia range from 1 to 22, and using an average ammonia concentration for all reservoir samples, the estimated required dilution factor would be 9 for the CCC and 4 for the CMC (Table B-10). Since the range of expected dilution factors for peak SSC concentrations (48 to 60) is generally greater than 1 to 22 (or 9 and 4), dilution should be sufficient to meet criteria, even under the worst case scenario of peak SSC concentrations immediately downstream of Iron Gate Dam. Thus, it is highly unlikely that water concentrations of ammonia at drawdown would exceed 1-hr or 30-day criteria for salmonids and/or early life stages of fish.

Comparisons of elutriate chemistry results to relevant human health criteria indicate that aluminum, arsenic, chloride, chromium, nickel, lead, and total PCBs are elevated prior to accounting for dilution (Table B-11). Small (factor less than 10) to very small (factor less than 1) amounts of dilution are required for chloride, chromium, nickel and lead to meet the minimum relevant human health criteria, such that actual dilution during reservoir drawdown is likely be sufficient to meet criteria. Aluminum and total PCBs may require dilution factors on the order of 100 to meet minimum criteria, while dilution for arsenic may require dilution of approximately 13,000 to meet the minimum criteria (Oregon DEQ human water and organism criterion; Table B-11). Actual dilution during drawdown may be sufficient for these chemicals; episodically, however concentrations of aluminum, arsenic and total PCBs may exceed the relevant criteria in the short-term (i.e., less than 2 years following dam removal, when downstream transport of reservoir sediments and pore waters would be the greatest). For arsenic and total PCBs, National RWQC, which are approximately an order of magnitude less stringent than the Oregon DEQ human water and organism criteria) would still require a dilution factor of roughly 100. Lastly, background concentrations of aluminum and arsenic in the Klamath River may be elevated (Sturdevant 2010, NCRWQCB 2008), such that a conservative assumption of zero concentration used in Eqn. 1 is not accurate. However, if background concentrations for these chemicals already exceed one or more human health criteria, then dilution during dam removal is not particularly relevant (i.e., background concentrations and drawdown concentrations would both exceed criteria).

Table B-4. Marine Water Quality Criteria for the Secretarial Determination Klamath River Sediment Study

Chemical	Units	National RWQC Priority Pollutants		National RWQC Non-priority Pollutants		California Ocean Plan		
		Marine CMC	Marine CCC	Marine CMC	Marine CCC	Aquatic Life Chronic	Aquatic Life Acute	Aquatic Life Instant
Conventionals								
Ammonia as N	µg/L					600	2,400	6,000
Phosphorus, total as P	µg/L				0.1			
Sulfide	µg/L				2			
Metals and AVS								
Arsenic	µg/L	69	36			8	32	80
Cadmium	µg/L	40	8.8			1	4	10
Chromium	µg/L	1,100	50			2	20	
Copper	µg/L	4.8	3.1			3	12	30
Lead	µg/L	210	8.1			2	8	20
Mercury	µg/L	1.8	0.94			0.04	0.16	0.4
Nickel	µg/L	74	8.2			5	20	50
Selenium	µg/L	290	71			15	60	150
Silver	µg/L	1.9				0.7	2.8	7
Zinc	µg/L	90	81			20	80	200
Organics PCBs								
Total PCBs	µg/L		0.03					
Organics Pesticides/Herbicides/Insecticides								
4,4'-DDT	µg/L	0.13	0.001					
Aldrin	µg/L	1.3						
BHC-gamma (HCH-gamma, Lindane)	µg/L	0.16				0.004	0.012	
Chlordane	µg/L	0.09	0.004					
Chlorpyrifos	µg/L			0.011	0.0056			
Demeton	µg/L				0.1			
Diazinon	µg/L			0.82	0.82			
Dieldrin	µg/L	0.71	0.0019					
Endosulfan I	µg/L	0.034	0.0087			0.009	0.018	0.027
Endosulfan II	µg/L	0.034	0.0087					
Endrin	µg/L	0.037	0.0023			0.002	0.004	0.006
Heptachlor	µg/L	0.053	0.0036					
Heptachlor epoxide	µg/L	0.053	0.0036					
Malathion	µg/L				0.1			
Methoxychlor	µg/L				0.03			
Toxaphene	µg/L	0.21	0.0002					
Organics SVOCs: Phenols								
Pentachlorophenol	µg/L	13	7.9			1	10	

Water Quality Criteria Key:

Table B-4. Marine Water Quality Criteria for the Secretarial Determination Klamath River Sediment Study

Chemical	Units	National RWQC Priority Pollutants		National RWQC Non-priority Pollutants		California Ocean Plan		
		Marine CMC	Marine CCC	Marine CMC	Marine CCC	Aquatic Life Chronic	Aquatic Life Acute	Aquatic Life Instant

RWQC= Recommended Water Quality Criteria

CMC= Criteria Maximum Concentration

CCC= Criteria Continuous Concentration

Units Key:

µg= microgram (10^{-6} gram)

L= Liter

Table B-5. Freshwater Quality Criteria for the Secretarial Determination Klamath River Sediment Study

Chemical	Units	California Basin Plan		National RWQC Priority Pollutants		National RWQC Non-priority Pollutants		Oregon DEQ Criteria		Oregon DEQ Guidance Values	
		Aquatic Life CTR	Aquatic Life NTR	Freshwater CMC	Freshwater CCC	Freshwater CMC	Freshwater CCC	Freshwater Acute	Freshwater Chronic	Freshwater Acute	Freshwater Chronic
Conventionals											
Alkalinity	µg/L						20,000		20,000		
Chloride	µg/L					860,000	230,000	860,000	230,000		
Sulfide	µg/L						2		2		
Metals and AVS											
Aluminum	µg/L					750	87				
Antimony	µg/L									9,000	1,600
Arsenic	µg/L	150		340	150			360	190	850	48
Cadmium[1]	µg/L	1.9		2	0.25			3.9	1.1		
Chromium	µg/L	11	150	570	74			1,700	210		
Copper[1]	µg/L	6.9		10.0	6.9			18	12		
Iron	µg/L						1,000		1,000		
Lead[1]	µg/L	2.0		51.8	2.0			82	3.2		
Mercury	µg/L			1.4	0.77			2.4	0.012		
Nickel[1]	µg/L	38.6		350	38.6			1,400	160		
Selenium	µg/L		5		5			260	35		
Silver[1]	µg/L	2.2		3.2				4.1	0.12		
Zinc[1]	µg/L	88.6		88.6	88.6			120	110		
Organics PAHs											
Acenaphthene	µg/L									1,700	520
Fluoranthene	µg/L									3,980	
Naphthalene	µg/L									2,300	620
Organics PCBs											
Total PCBs	µg/L	0.014			0.014			2	0.014		
Organics Carbamate Pesticides											
4,4'-DDD	µg/L	0.001						1.1	0.001	0.06	
4,4'-DDE	µg/L									1,050	
4,4'-DDT	µg/L			1.1	0.001						
Aldrin	µg/L	3		3				3			
BHC-gamma (HCH-gamma, Lindane)	µg/L	0.95		0.95				2	0.08		
Chlordane	µg/L	0.0043		2.4	0.0043			2.4	0.0043		
Chlorpyrifos	µg/L					0.083	0.041	0.083	0.041		
Demeton	µg/L						0.1		0.1		
Diazinon	µg/L					0.17	0.17			0.08	0.05
Dieldrin	µg/L	0.056		0.24	0.056			2.5	0.0019		
Endosulfan I	µg/L		0.056	0.22	0.056			0.22	0.056		
Endosulfan II	µg/L			0.22	0.056						
Endrin	µg/L	0.036		0.086	0.036			0.18	0.0023		

Table B-5. Freshwater Quality Criteria for the Secretarial Determination Klamath River Sediment Study

Chemical	Units	California Basin Plan		National RWQC Priority Pollutants		National RWQC Non-priority Pollutants		Oregon DEQ Criteria		Oregon DEQ Guidance Values	
		Aquatic Life CTR	Aquatic Life NTR	Freshwater CMC	Freshwater CCC	Freshwater CMC	Freshwater CCC	Freshwater Acute	Freshwater Chronic	Freshwater Acute	Freshwater Chronic
Heptachlor	µg/L	0.0038		0.52	0.0038			0.52	0.0038		
Heptachlor epoxide	µg/L			0.52	0.0038						
Malathion	µg/L						0.1		0.1		
Methoxychlor	µg/L						0.03		0.03		
Parathion	µg/L					0.065	0.013	0.065	0.013		
Toxaphene	µg/L	0.0002		0.73	0.0002			0.73	0.0002		
Organics VOCs											
Benzene	µg/L									5,300	
Carbon tetrachloride	µg/L									35,200	
Chloroform	µg/L									28,900	1,240
Ethylbenzene	µg/L									32,000	
Tetrachloroethene	µg/L									5,280	840
Toluene	µg/L									17,500	
Organics SVOCs: Phenols											
2,4,6-Trichlorophenol	µg/L										970
2,4-Dichlorophenol	µg/L									2,020	365
2,4-Dimethylphenol	µg/L									2,120	
2-Chlorophenol	µg/L									4,380	2,000
4-Chloro-3-methylphenol	µg/L									30	
Pentachlorophenol	µg/L			19	15			20	13		
Phenol	µg/L									10,200	2,560
Organics SVOCs: Chlorinated Hydrocarbons											
1,1,2,2-Tetrachloroethane	µg/L										2,400
1,1,2-Trichloroethane	µg/L										9,400
1,2-Dichloroethane	µg/L									118,000	20,000
1,2-Dichloropropane	µg/L									23,000	5,700
Hexachlorobutadiene	µg/L									90	9.3
Hexachlorocyclopentadiene	µg/L									7	5.2
Hexachloroethane	µg/L									980	540
Trichloroethene	µg/L									45,000	21,900
Organics Other SVOCs											
Isophorone	µg/L									117,000	
Nitrobenzene	µg/L									27,000	

Table B-5. Freshwater Quality Criteria for the Secretarial Determination Klamath River Sediment Study

Chemical	Units	California Basin Plan		National RWQC Priority Pollutants		National RWQC Non-priority Pollutants		Oregon DEQ Criteria		Oregon DEQ Guidance Values	
		Aquatic Life CTR	Aquatic Life NTR	Freshwater CMC	Freshwater CCC	Freshwater CMC	Freshwater CCC	Freshwater Acute	Freshwater Chronic	Freshwater Acute	Freshwater Chronic
Organics Polychlorinated Dioxins and Furans											
2,3,7,8-TCDD	µg/L									0.01	0.000038

[1] Hardness adjusted criterion. Criteria are calculated from "GOLDMINE SWRCB 2004 limits.xls" assuming an estimated mean hardness of 70 mg/L as $CaCO_3$ for Klamath River at Orleans (USGS Gage No. 11523000) from 1950–2003 (n=239).

Water Quality Criteria Key:

RWQC= Recommended Water Quality Criteria
DEQ= Department of Environmental Quality
CTR= California Toxics Rule
NTR = National Toxics Rule
CMC= Criteria Maximum Concentration
CCC= Criteria Continuous Concentration

Units Key:

µg = microgram (10^{-6} gram)
L= liter

Table B-6. Human Health Water Quality Criteria for the Secretarial Determination Klamath River Sediment Study

Chemical	Units	California Department of Public Health CCR		California Basin Plan					National RWQC Priority		National RWQC Non-priority		California Ocean Plan		Oregon DEQ HH		Oregon DEQ WQ Criteria	
		MCL	Primary MCL	Secondary MCL	Agriculture	Human Health CTR	Human Health NTR	Human Water and Organism	Human Organism	Human Water and Organism	Human Organism	Human Health NCAR	Human Health CAR	Human Water and Organism	Human Organism	Human Water and Organism	Human Organism	Human Drinking Water
Conventionals																		
Chloride	µg/L	250,000		250,000	106,000													
Metals and AVS																		
Aluminum	µg/L	1,000	1,000	200	5,000													
Antimony	µg/L	6	6			14		5.6	640			1,200		146	45,000	146	45,000	
Arsenic	µg/L	10	50		100			0.018	0.14					0.0022	0.0175	0.0022	0.0175	50
Cadmium	µg/L	5	5		10											10		10
Chromium	µg/L	50	50		100							190,000				170,000	3,433,000	50
Copper	µg/L	1,000	1,300	1,000	200	1,300		1,300						1,300				
Iron	µg/L	300		300	5,000					300				300		300		
Lead	µg/L		15		5,000											50		50
Mercury	µg/L	2	2			0.05										0.144	0.146	2
Nickel	µg/L	100	100		200	610		610	4,600					13.4	100	13.4	100	
Selenium	µg/L	50	50		20			170	4,200					10		10		10
Silver	µg/L	100		100												50		50
Zinc	µg/L	5,000		5,000	2,000			7,400	26,000									
Organics PAHs																		
Acenaphthene	µg/L					1,200		670	990									
Acenaphthylene	µg/L																	
Anthracene	µg/L					9,600		8,300	40,000									
Benz(a)anthracene	µg/L					0.0044		0.0038	0.018									
Benzo(a)pyrene	µg/L	0.2	0.2			0.0044		0.0038	0.018									
Benzo(b)fluoranthene	µg/L					0.0044		0.0038	0.018									
Benzo(g,h,i)perylene	µg/L																	
Benzo(k)fluoranthene	µg/L					0.0044		0.0038	0.018									
Chrysene	µg/L					0.0044		0.0038	0.018									
Dibenz(a,h)anthracene	µg/L					0.0044		0.0038	0.018									
Fluoranthene	µg/L					300		130	140			15		42	54	42	54	
Fluorene	µg/L					1,300		1,100	5,300									
Indeno(1,2,3-cd)pyrene	µg/L					0.0044		0.0038	0.018									
Naphthalene	µg/L																	
Phenanthrene	µg/L																	
Pyrene	µg/L					960		830	4,000									
Organics PCBs																		
Aroclor 1016	µg/L	0.5																
Aroclor 1221	µg/L	0.5																
Aroclor 1232	µg/L	0.5																

Table B-6. Human Health Water Quality Criteria for the Secretarial Determination Klamath River Sediment Study

Chemical	Units	California Department of Public Health CCR		California Basin Plan					National RWQC Priority		National RWQC Non-priority		California Ocean Plan		Oregon DEQ HH		Oregon DEQ WQ Criteria	
		MCL	Primary MCL	Secondary MCL	Agriculture	Human Health CTR	Human Health NTR	Human Water and Organism	Human Organism	Human Water and Organism	Human Organism	Human Health NCAR	Human Health CAR	Human Water and Organism	Human Organism	Human Water and Organism	Human Organism	Human Drinking Water
Aroclor 1242	µg/L	0.5																
Aroclor 1248	µg/L	0.5																
Aroclor 1254	µg/L	0.5																
Aroclor 1260	µg/L	0.5																
Total PCBs	µg/L	0.5	0.5			0.00017		0.000064	0.000064					0.000079	0.000079	0.000079	0.000079	
Organics **Carbamate Pesticides**																		
3-Hydroxycarbofuran	µg/L																	
4,4'-DDD	µg/L					0.00083		0.00031	0.00031				0.00017	0.000024	0.000024	0.000024	0.000024	
4,4'-DDE	µg/L					0.00059		0.00022	0.00022									
4,4'-DDT	µg/L							0.00022	0.00022									
Alachlor	µg/L	2	2															
Aldicarb	µg/L																	
Aldicarb sulfone	µg/L																	
Aldicarb sulfoxide	µg/L																	
Aldrin	µg/L					0.00013		0.000049	0.00005				0.000022	0.000074	0.000079	0.000074	0.000079	
Atrazine	µg/L	1	1															
BHC-alpha (HCH-alpha)	µg/L					0.0039		0.0026	0.0049					0.0092	0.031	0.0092	0.031	
BHC-beta (HCH-beta)	µg/L					0.014		0.0091	0.017					0.0163	0.0547	0.0163	0.0547	
BHC-delta (HCH-delta)	µg/L																	
BHC-gamma (HCH-gamma, Lindane)	µg/L	2	0.2			0.019		0.98	1.8					0.0186	0.0625	0.0186	0.0625	4
Bromacil	µg/L																	
Butachlor	µg/L																	
Carbaryl	µg/L																	
Carbofuran	µg/L	18																
Chlordane	µg/L	0.1	0.1			0.00057		0.0008	0.00081				0.000023	0.00046	0.00048	0.00046	0.00048	
Chlorothalonil	µg/L																	
Dieldrin	µg/L					0.00014		0.000052	0.000054				0.00004	0.000071	0.000076	0.000071	0.000076	
Endosulfan I	µg/L					110		62	89					74	159	74	159	
Endosulfan II	µg/L							62	89									
Endosulfan sulfate	µg/L							62	89									
Endrin	µg/L	2	2			0.76		0.059	0.06					1		1		0.2
Endrin aldehyde	µg/L							0.29	0.3									
Heptachlor	µg/L	0.01	0.01			0.00021		0.000079	0.000079				0.00005	0.00028	0.00029	0.00028	0.00029	
Heptachlor epoxide	µg/L	0.01						0.000039	0.000039				0.00002					
Methomyl	µg/L																	
Methoxychlor	µg/L	30	30							100				100		100		100
Molinate	µg/L	20																

Table B-6. Human Health Water Quality Criteria for the Secretarial Determination Klamath River Sediment Study

Chemical	Units	California Department of Public Health CCR		California Basin Plan					National RWQC Priority		National RWQC Non-priority		California Ocean Plan		Oregon DEQ HH		Oregon DEQ WQ Criteria	
		MCL	Primary MCL	Secondary MCL	Agriculture	Human Health CTR	Human Health NTR	Human Water and Organism	Human Organism	Human Water and Organism	Human Organism	Human Health NCAR	Human Health CAR	Human Water and Organism	Human Organism	Human Water and Organism	Human Organism	Human Drinking Water
Oxamyl	µg/L	50																
Propachlor	µg/L																	
Simazine	µg/L	4	4															
Thiobencarb	µg/L	70																
Toxaphene	µg/L	3	3			0.00073		0.00028	0.00028				0.00021	0.00071	0.00073	0.00071	0.00073	5
Organics **Phthalates**																		
Bis(2-ethylhexyl) phthalate	µg/L							1.2	2.2									
Butyl benzyl phthalate	µg/L							1,500	1,900									
Diethyl phthalate	µg/L							17,000	44,000			33,000		350,000	1,800,000	350,000	1,800,000	
Dimethyl phthalate	µg/L							270,000	1,100,000			820,000		313,000	2,900,000	313,000	2,900,000	
Di-N-butyl phthalate	µg/L							2,000	4,500			3,500						
Organics **VOCs**																		
1,2-Dibromoethane	µg/L		0.05															
1,3,5-Trimethylbenzene	µg/L																	
2,4-Dinitrotoluene	µg/L							0.11	3.4				2.6	0.11	9.1	0.11	9.1	
2,6-Dinitrotoluene	µg/L																	
Benzene	µg/L	1	1			1.2		2.2	51				5.9	0.66	40	0.66	40	
Bromobenzene	µg/L																	
Bromochloromethane	µg/L																	
Bromodichloromethane	µg/L		100			0.56												
Bromoform	µg/L		100			4.3		4.3	140									
Carbon disulfide	µg/L																	
Carbon tetrachloride	µg/L	0.5	0.5				0.25	0.23	1.6				0.9	0.4	6.94	0.4	6.94	
Chlorobenzene	µg/L	70	70				680	130	1,600			570						
Chloroethane	µg/L																	
Chloroform	µg/L		100					5.7	470				130	0.19	15.7	0.19	15.7	
Chloromethane	µg/L																	
Cis-1,2-Dichloroethene	µg/L	6	6															
Dibromochloromethane	µg/L		100			0.41		0.4	13				6.2					
Dibromomethane	µg/L																	
Dichlorodifluoromethane	µg/L																	
Ethylbenzene	µg/L	300	300				3,100	530	2,100			4,100		1,400	3,280	1,400	3,280	
Isopropylbenzene	µg/L																	
Methylene chloride	µg/L							4.6	590									
MTBE	µg/L	13																
N-butylbenzene	µg/L																	
N-propylbenzene	µg/L																	

Table B-6. Human Health Water Quality Criteria for the Secretarial Determination Klamath River Sediment Study

Chemical	Units	California Department of Public Health CCR		California Basin Plan					National RWQC Priority		National RWQC Non-priority		California Ocean Plan		Oregon DEQ HH		Oregon DEQ WQ Criteria	
		MCL	Primary MCL	Secondary MCL	Agriculture	Human Health CTR	Human Health NTR	Human Water and Organism	Human Organism	Human Water and Organism	Human Organism	Human Health NCAR	Human Health CAR	Human Water and Organism	Human Organism	Human Water and Organism	Human Organism	Human Drinking Water
Pentachloroethane	µg/L																	
Sec-butylbenzene	µg/L																	
Styrene	µg/L	100																
Tert-butylbenzene	µg/L																	
Tetrachloroethene	µg/L	5	5				0.8	0.69	3.3				2	0.8	8.85	0.8	8.85	
Toluene	µg/L	150	150			6,800		1,300	15,000			85,000		14,300	424,000	14,300	424,000	
Vinyl chloride	µg/L	0.5	0.5				2	0.025	2.4				36	2	525	2	525	
Organics **SVOCs: Phenols**																		
2,4,5-Trichlorophenol	µg/L									1,800	3,600			2,600		2,600		
2,4,6-Trichlorophenol	µg/L							1.4	2.4				0.29	1.2	3.6	1.2	3.6	
2,4-Dichlorophenol	µg/L							77	290					3,090		3,090		
2,4-Dimethylphenol	µg/L							380	850									
2,4-Dinitrophenol	µg/L							69	5,300			4						
2-Chlorophenol	µg/L							81	150									
2-Nitrophenol	µg/L																	
4,6-Dinitro-2-methylphenol	µg/L							13	280									
4-Chloro-3-methylphenol	µg/L																	
4-Nitrophenol	µg/L																	
Pentachlorophenol	µg/L	1	1			0.28		0.27	3					1,010		1,010		
Phenol	µg/L							10,000	860,000					3,500		3,500		
Organics **SVOCs: Chlorinated Hydrocarbons**																		
1,1,1,2-Tetrachloroethane	µg/L																	
1,1,1-Trichloroethane	µg/L	200	200									540,000				18,400	1,030,000	
1,1,2,2-Tetrachloroethane	µg/L	1	1				0.17	0.17	4				2.3	0.17	10.7	0.17	10.7	
1,1,2-Trichloroethane	µg/L	5	5				0.6	0.59	16				9.4	0.6	41.8	0.6	41.8	
1,1-Dichloroethane	µg/L	5	5															
1,1-Dichloroethene	µg/L	6	6				0.057	330	7,100				0.9					
1,1-Dichloropropene	µg/L																	
1,2,3-Trichlorobenzene	µg/L																	
1,2,3-Trichloropropane	µg/L																	
1,2,4-Trichlorobenzene	µg/L	5	5					35	70									
1,2-Dibromo-3-chloropropane	µg/L		0.2															
1,2-Dichlorobenzene	µg/L	600	600			2,700		420	1,300									
1,2-Dichloroethane	µg/L	0.5	0.5				0.38	0.38	37				28	0.94	243	0.94	243	
1,2-Dichloropropane	µg/L	5	5			0.52		0.5	15									
1,3-Dichlorobenzene	µg/L					400		320	960									
1,3-Dichloropropane	µg/L																	

Table B-6. Human Health Water Quality Criteria for the Secretarial Determination Klamath River Sediment Study

Chemical	Units	California Department of Public Health CCR		California Basin Plan					National RWQC Priority		National RWQC Non-priority		California Ocean Plan		Oregon DEQ HH		Oregon DEQ WQ Criteria	
		MCL	Primary MCL	Secondary MCL	Agriculture	Human Health CTR	Human Health NTR	Human Water and Organism	Human Organism	Human Water and Organism	Human Organism	Human Health NCAR	Human Health CAR	Human Water and Organism	Human Organism	Human Water and Organism	Human Organism	Human Drinking Water
1,4-Dichlorobenzene	µg/L	5	5			400		63	190				18					
2,2-Dichloropropane	µg/L																	
2-Chloronaphthalene	µg/L							1,000	1,600									
2-Chlorotoluene	µg/L																	
3,3'-Dichlorobenzidine	µg/L							0.021	0.028				0.0081					
4-Chlorophenyl phenyl ether	µg/L																	
4-Chlorotoluene	µg/L																	
Bis(2-Chloroethoxy)methane	µg/L																	
Bis(2-Chloroethyl) ether	µg/L							0.03	0.53				0.045	0.03	1.36	0.03	1.36	
Bis(2-Chloroisopropyl) ether	µg/L							1,400	65,000					34.7	4,360	34.7	4,360	
Hexachlorobenzene	µg/L	1						0.00028	0.00029				0.00021	0.00072	0.00074	0.00072	0.00074	
Hexachlorobutadiene	µg/L							0.44	18				14	0.45	50	0.45	50	
Hexachlorocyclopentadiene	µg/L	50						40	1,100			58		206		206		
Hexachloroethane	µg/L							1.4	3.3				2.5	1.9	8.74	1.9	8.74	
Trans-1,2-dichloroethene	µg/L	10	10			700		140	10,000									
Trichloroethene	µg/L	5	5			2.7		2.5	30				27	2.7	80.7	2.7	80.7	
Trichlorofluoromethane	µg/L	150	150															
Organics Other SVOCs																		
Isophorone	µg/L							35	960				730	5,200	520,000	5,200	520,000	
Nitrobenzene	µg/L							17	690			4.9		19,800		19,800		
N-nitrosodi-n-propylamine	µg/L							0.005	0.51									
N-nitrosodiphenylamine	µg/L							3.3	6				2.5	4.9	16.1	4.9	16.1	
Organics Polychlorinated Dioxins and Furans																		
2,3,7,8-TCDD	µg/L	0.00003	0.00003			1.3E-08		5E-09	5.1E-09					1.3E-08	1.4E-08	1.3E-08	1.4E-08	
Organics PBDEs																		
4-Bromophenyl phenyl ether	µg/L																	

Water Quality Criteria Key:

CCR= California Code of Regulations
MCL= Maximum Contaminant Level
RWQC= Recommended Water Quality Criteria
DEQ= Department of Environmental Quality
CTR= California Toxics Rule
NTR = National Toxics Rule
NCAR= Non-carcinogenic
CAR= Carcinogenic

Table B-6. Human Health Water Quality Criteria for the Secretarial Determination Klamath River Sediment Study

Chemical	Units	California Department of Public Health CCR		California Basin Plan					National RWQC Priority		National RWQC Non-priority		California Ocean Plan		Oregon DEQ HH		Oregon DEQ WQ Criteria	
		MCL	Primary MCL	Secondary MCL	Agriculture	Human Health CTR	Human Health NTR	Human Water and Organism	Human Organism	Human Water and Organism	Human Organism	Human Health NCAR	Human Health CAR	Human Water and Organism	Human Organism	Human Water and Organism	Human Organism	Human Drinking Water

Units Key:

µg= microgram (10^{-6} gram)

L= liter

Table B-7. North Coast Basin Plan Hardness-Adjusted Water Quality Criteria for Selected Metals.

	Total Recoverable (ug/l)	
	Criteria Continuous Concentration (CCC)	**Criteria Maximum Concentration(CMC)**
Cadmium	1.9	3.0
Chromium III	150	1300
Copper	6.9	10.0
Lead	2.0	51.8
Nickel	39	350
Zinc	88.6	88.6
	Dissolved Instantaneous Maximum (ug/L)	**Total Recoverable Instantaneous Maximum (ug/L)**
Silver	1.9	2.2

Criteria are calculated from "GOLDMINE SWRCB 2004 limits.xls" assuming an estimated mean hardness of 70 mg/L as $CaCO_3$ for Klamath River at Orleans (USGS gage no. 11523000) from 1950 through 2003 (n=239).

Table B-8. Klamath River Sediment Study-Elutriate Samples with Values Exceeding One or More Marine Water Quality Criteria

Chemical	Sample[1]	Value	Units	Marine Criteria							Dilution required to meet most stringent criterion
				National RWQC Priority		National RWQC Non-priority		California Ocean Plan			
				Marine CMC	Marine CCC	Marine CMC	Marine CCC	Aquatic Life Chronic	Aquatic Life Acute	Aquatic Life Instant	
Conventionals											
Ammonia as N	CDH-E-JBN	12,000	µg/L					600	2,400	6,000	19
Ammonia as N	CDH-E-JBT	11,000	µg/L					600	2,400	6,000	17
Phosphorus, total as P	CDH-E-JBN	540	µg/L				0.1				5,399
Phosphorus, total as P	CDH-E-JBT	310	µg/L				0.1				3,099
Metals and AVS											
Arsenic	CDH-E-JBN	30	µg/L	-	-			8	-	-	2.8
Arsenic	CDH-E-JBT	18	µg/L	-	-			8	-	-	1.3
Chromium	CDH-E-JBN	13	µg/L	-	-			2	-		5.5
Chromium	CDH-E-JBT	5.4	µg/L	-	-			2	-		1.7
Copper	CDH-E-JBN	23	µg/L	4.8	3.1			3	12	-	6.7
Copper	CDH-E-JBT	12	µg/L	4.8	3.1			3	-	-	3.0
Lead	CDH-E-JBN	6.3	µg/L	-	-			2	-	-	2.2
Lead	CDH-E-JBT	3.5	µg/L	-	-			2	-	-	0.8
Nickel	CDH-E-JBN	8.3	µg/L	-	8.2			5	-	-	0.7
Zinc	CDH-E-JBN	30	µg/L	-	-			20	-	-	0.5
Copco 1 Reservoir											
Conventionals											
Ammonia as N	CDH-E-CPN	8,800	µg/L					600	2,400	6,000	13
Ammonia as N	CDH-E-CPT	25,000	µg/L					600	2,400	6,000	40
Phosphorus, total as P	CDH-E-CPN	430	µg/L				0.1				4,299
Phosphorus, total as P	CDH-E-CPT	240	µg/L				0.1				2,399
Metals and AVS											
Arsenic	CDH-E-CPN	8.9	µg/L	-	-			8	-	-	0.1

Arsenic	CDH-E-CPT	11	µg/L	-	-			8	-	-	0.4
Chromium	CDH-E-CPN	6.5	µg/L	-	-			2	-		2.3
Chromium	CDH-E-CPT	3.6	µg/L	-	-			2	-		0.8
Copper	CDH-E-CPN	12	µg/L	4.8	3.1			3	-	-	3.0
Copper	CDH-E-CPT	6.9	µg/L	4.8	3.1			3	-	-	1.3
Lead	CDH-E-CPN	3.6	µg/L	-	-			2	-	-	0.8
Lead	CDH-E-CPT	2.2	µg/L	-	-			2	-	-	0.1
Nickel	CDH-E-CPN	6.2	µg/L	-	-			5	-	-	0.2
Iron Gate Reservoir											
Conventionals											
Ammonia as N	CDH-E-IGN	4,800	µg/L					600	2,400	-	7.0
Ammonia as N	CDH-E-IGT-1	7,200	µg/L					600	2,400	6,000	11
Ammonia as N	CDH-E-IGT-2	10,000	µg/L					600	2,400	6,000	15
Phosphorus, total as P	CDH-E-IGN	130	µg/L				0.1				1,299
Phosphorus, total as P	CDH-E-IGT-1	310	µg/L				0.1				3,099
Phosphorus, total as P	CDH-E-IGT-2	330	µg/L				0.1				3,299
Metals and AVS											
Arsenic	CDH-E-IGT-1	9.4	µg/L	-	-			8	-	-	0.2
Arsenic	CDH-E-IGT-2	20	µg/L	-	-			8	-	-	1.5
Chromium	CDH-E-IGT-1	2.4	µg/L	-	-			2	-		0.2
Chromium	CDH-E-IGT-2	5.5	µg/L	-	-			2	-		1.8
Copper	CDH-E-IGN	4.5	µg/L	-	3.1			3	-	-	0.5
Copper	CDH-E-IGT-1	6.8	µg/L	4.8	3.1			3	-	-	1.3
Copper	CDH-E-IGT-2	10	µg/L	4.8	3.1			3	-	-	2.3
Lead	CDH-E-IGT-2	2.8	µg/L	-	-			2	-	-	0.4
Nickel	CDH-E-IGT-2	5.7	µg/L	-	-			5	-	-	0.1
Klamath River Estuary											
Conventionals											
Phosphorus, total as P	CHA-E-002	60	µg/L				0.1				599
Metals and AVS											
Chromium	CHA-E-001	2.8	µg/L	-	-			2	-		0.4
Chromium	CHA-E-002	5.9	µg/L	-	-			2	-		2.0
Copper	CHA-E-001	6.9	µg/L	4.8	3.1			3	-	-	1.3

Copper	CHA-E-002	7	µg/L	4.8	3.1			3	-	-	1.3
Nickel	CHA-E-001	11	µg/L	-	8.2			5	-	-	1.2
Nickel	CHA-E-002	18	µg/L	-	8.2			5	-	-	2.6

[1] Elutriate samples for each reservoir are super-composites of multiple on-thalweg borehole locations (“T” at the end of the sample identifier code) or multiple off-thalweg borehole locations (non-thalweg; “N” at the end of the sample identifier code). An "area composite" sample was collected in the Upper Klamath River Estuary i.e., estuary samples were not segregated according to thalweg/non-thalweg location. Super-composite samples were chosen for analysis of sediment elutriate and toxicity studies (i.e., bioassay tests) to provide a representative reservoir- or estuary-wide average sediment composition, and to meet the large sediment and water volume requirements for the elutriate tests (BOR 2010). Maps of sample site locations are presented in Section 2, Figures 3–5.

Water Quality Criteria Key:

(blank)= No water quality criteria apply
- = Laboratory value is below water quality criterion screening level
RWQC= Recommended Water Quality Criteria
CMC= Criteria Maximum Concentration
CCC= Criteria Continuous Concentration

Units Key:

µg= microgram (10^{-6} gram)
L= liter

Table B-9. Klamath River Sediment Study-Elutriate Samples with Values Exceeding One or More Freshwater Quality Criteria

Chemical	Sample[1]	Value	Units	Freshwater Criteria										Dilution required to meet most stringent criterion
				California Basin Plan		National RWQC Priority		National RWQC Non-priority		Oregon DEQ WQ Criteria		Oregon DEQ WQ Guidance Values		
				Aquatic Life CTR	Aquatic Life NTR	Freshwater CMC	Freshwater CCC	Freshwater CMC	Freshwater CCC	Freshwater Acute	Freshwater Chronic	Freshwater Acute	Freshwater Chronic	
J.C. Boyle Reservoir														
Metals and AVS														
Aluminum	CDH-E-JBN	11,000	µg/L					750	87					125
Aluminum	CDH-E-JBT	4,500	µg/L					750	87					50
Chromium	CDH-E-JBN	13	µg/L	11	-	-	11			-	11			0.2
Copper[2]	CDH-E-JBN	23	µg/L	6.9		10.0	6.9			18	12			2.3
Copper[2]	CDH-E-JBT	12	µg/L	6.9		10.0	6.9			-	12			0.7
Lead[2]	CDH-E-JBN	6.3	µg/L	2.0		-	2.0			-	3.2			2.1
Lead[2]	CDH-E-JBT	3.5	µg/L	2.0		-	2.0			-	3.2			0.7
Mercury	CDH-E-JBN	0.027	µg/L			-	-			-	0.012			1.3
Mercury	CDH-E-JBT	0.016	µg/L			-	-			-	0.012			0.3
Copco 1 Reservoir														
Metals and AVS														
Aluminum	CDH-E-CPN	6,600	µg/L					750	87					74
Aluminum	CDH-E-CPT	3,600	µg/L					750	87					40
Copper[2]	CDH-E-CPN	12	µg/L	6.9		10.0	6.9			-	12			0.7
Copper[2]	CDH-E-CPT	6.9	µg/L	6.9		-	6.9			-	-			0.0
Lead[2]	CDH-E-CPN	3.6	µg/L	2.0		-	2.0			-	3.2			0.8
Lead[2]	CDH-E-CPT	2.2	µg/L	2.0		-	2.0			-	-			0.1
Mercury	CDH-E-CPN	0.019	µg/L			-	-			-	0.012			0.6
Mercury	CDH-E-CPT	0.017	µg/L			-	-			-	0.012			0.4
Iron Gate Reservoir														
Metals and AVS														
Aluminum	CDH-E-IGN	1,500	µg/L					750	87					16
Aluminum	CDH-E-IGT-1	2,600	µg/L					750	87					28
Aluminum	CDH-E-IGT-2	4,700	µg/L					750	87					53
Copper[2]	CDH-E-IGT-2	10	µg/L	6.9		-	6.9			-	-			0.5
Lead[2]	CDH-E-IGT-2	2.8	µg/L	2.0		-	2.0			-	-			0.4
Mercury	CDH-E-IGT-2	0.014	µg/L			-	-			-	0.012			0.2
Klamath River Estuary														
Conventionals														
Chloride	CHA-E-001	470,000	µg/L					-	230,000	-	230,000			1.0
Metals and AVS														
Aluminum	CHA-E-001	770	µg/L					750	87					7.9
Aluminum	CHA-E-002	780	µg/L					750	87					8.0
Copper[2]	CHA-E-001	6.9	µg/L	6.9		-	6.9			-	-			0.0
Copper[2]	CHA-E-002	7	µg/L	6.9		-	6.9			-	-			0.0
Mercury	CHA-E-002	0.023	µg/L			-	-			-	0.012			0.9

[1] Elutriate samples for each reservoir are super-composites of multiple on-thalweg borehole locations ("T" at the end of the sample identifier code) or multiple off-thalweg borehole locations (non-thalweg; "N" at the end of the sample identifier code). An "area composite" sample was collected in the Upper Klamath River Estuary i.e., estuary samples were not segregated according to thalweg/non-thalweg location. Super-composite samples were chosen for analysis of sediment elutriate and toxicity studies (i.e., bioassay

Table B-9. Klamath River Sediment Study-Elutriate Samples with Values Exceeding One or More Freshwater Quality Criteria

Chemical	Sample[1]	Value	Units	Freshwater Criteria										Dilution required to meet most stringent criterion
				California Basin Plan		National RWQC Priority		National RWQC Non-priority		Oregon DEQ WQ Criteria		Oregon DEQ WQ Guidance Values		
				Aquatic Life CTR	Aquatic Life NTR	Freshwater CMC	Freshwater CCC	Freshwater CMC	Freshwater CCC	Freshwater Acute	Freshwater Chronic	Freshwater Acute	Freshwater Chronic	

tests) to provide a representative reservoir- or estuary-wide average sediment composition, and to meet the large sediment and water volume requirements for the elutriate tests (BOR 2010). Maps of sample site locations are presented in Section 2, Figures 3–5.

[2] Hardness adjusted criteria are required for certain metals (NCRWQCB 2006) and are calculated from "GOLDMINE SWRCB 2004 limits.xls" assuming an estimated mean hardness of 70 mg/L as $CaCO_3$ for Klamath River at Orleans (USGS Gage No. 11523000) from 1950–2003 (n=239).

Water Quality Criteria Key:
(blank)= No water quality criteria apply
- = Laboratory value is below water quality criterion
RWQC= Recommended Water Quality Criteria
DEQ= Department of Environmental Quality
CTR= California Toxics Rule
NTR= National Toxics Rule
CMC= Criteria Maximum Concentration
CCC= Criteria Continuous Concentration

Units Key:
µg= microgram (10^{-6} gram)
L= liter

Table B-10. Measured Ammonia Concentrations in Elutriate Samples and Estimated Ammonia Concentrations in the Water Column at Drawdown.

Location	Site	Ammonia concentration (mg/L) for 100% elutriate sample (1:4 sed:water)	Required dilution to meet minimum ammonia criteria[1]	
			CCC 30-day average (mg N/L)[2]	CMC 1-hour average (mg N/L)[3]
JC Boyle Reservoir	CDH-E-JBT	11	9	4
JC Boyle Reservoir	CDH-E-JBN	12	10	5
Copco1 Reservoir	CDH-E-CPT	25	22	11
Copco1 Reservoir	CDH-E-CPN	8.8	7	3
Iron Gate Reservoir	CDH-E-IGT-1	7.2	6	2
Iron Gate Reservoir	CDH-E-IGT-2	10	8	4
Iron Gate Reservoir	CDH-E-IGN	4.8	3	1
Reservoir Average		*11*	*9*	*4*
Lower Klamath Estuary	CHA-E-001	0.44	0	0
Upper Klamath Estuary	CHA-E-002	0.1	0	0

[1] National recommended water quality ammonia criteria for the protection of freshwater life.

[2] Criteria Chronic Concentration (CCC) ranges 1.1–5.9 mg/L 30-day average for pH 7–8.5 and water temperature 0–14°C (32–57.2ºF) (early life stages of fish present) (USEPA 2009). Minimum CCC value is 1.1 mg/L for pH=8.5.

[3] Criteria Maximum Concentration (CMC) ranges 2.1–24.1 mg/L 1-hr average for pH 7–8.5 and all water temperatures (salmonids present) (USEPA 2009). Minimum CMC value is 2.1 mg/L for pH=8.5.

Table B-11. Klamath River Sediment Study-Elutriate Samples with Values Exceeding One or More Human Health Water Quality Criteria

Chemical	Sample[1]	Value	Units	Human Health Criteria																	Dilution required to meet most stringent criterion
				CCR-CDPH	California Basin Plan				National RWQC Priority		National RWQC Non-priority		California Ocean Plan	Oregon DEQ HH	Oregon DEQ WQ Criteria						
				MCL	Primary MCL	Secondary MCL	Agriculture	Human Health CTR	Human Water and Organism	Human Organism	Human Water and Organism	Human Organism	Human Health NCAR	Human Health CAR	Human Water and Organism	Human Organism	Human Water and Organism	Human Organism	Human Drinking Water		
J.C. Boyle Reservoir																					
Metals and AVS																					
Aluminum	CDH-E-JBN	11,000	µg/L	1,000	1,000	200	5,000														219
Aluminum	CDH-E-JBT	4,500	µg/L	1,000	1,000	200	-														89
Arsenic	CDH-E-JBN	30	µg/L	10	-		-		0.018	0.14					0.0022	0.0175	0.0022	0.0175	-		13,635
Arsenic	CDH-E-JBT	18	µg/L	10	-		-		0.018	0.14					0.0022	0.0175	0.0022	0.0175	-		8,180
Chromium	CDH-E-JBN	13	µg/L	-	-		-						-				-	-	-		12
Chromium	CDH-E-JBT	5.4	µg/L	-	-		-						-				-	-	-		4.4
Lead	CDH-E-JBN	6.3	µg/L		-		-										-		-		0.3
Total PCB	CDH-E-JBN	0.003	µg/L	-	-			0.00017	0.000064	0.000064					0.000079	0.000079	0.000079	0.000079			45
Total PCB	CDH-E-JBT	0.003	µg/L	-	-			0.00017	0.000064	0.000064					0.000079	0.000079	0.000079	0.000079			45

Table B-11. Klamath River Sediment Study-Elutriate Samples with Values Exceeding One or More Human Health Water Quality Criteria

Chemical	Sample[1]	Value	Units	Human Health Criteria																Dilution required to meet most stringent criterion
				CCR-CDPH	California Basin Plan				National RWQC Priority		National RWQC Non-priority		California Ocean Plan	Oregon DEQ HH	Oregon DEQ WQ Criteria					
				MCL	Primary MCL	Secondary MCL	Agriculture	Human Health CTR	Human Water and Organism	Human Organism	Human Water and Organism	Human Organism	Human Health NCAR	Human Health CAR	Human Water and Organism	Human Organism	Human Water and Organism	Human Organism	Human Drinking Water	
Copco 1 Reservoir																				
Metals and AVS																				
Aluminum	CDH-E-CPN	6,600	µg/L	1,000	1,000	200	5,000													131
Aluminum	CDH-E-CPT	3,600	µg/L	1,000	1,000	200	-													71
Arsenic	CDH-E-CPN	8.9	µg/L	-	-		-		0.018	0.14					0.0022	0.0175	0.0022	0.0175	-	4,044
Arsenic	CDH-E-CPT	11	µg/L	10	-		-		0.018	0.14					0.0022	0.0175	0.0022	0.0175	-	4,999
Chromium	CDH-E-CPN	6.5	µg/L	-	-		-						-				-	-	-	5.5
Chromium	CDH-E-CPT	3.6	µg/L	-	-		-						-				-	-	-	2.6
Total PCB	CDH-E-CPN	0.004	µg/L	-	-			0.00017	0.000064	0.000064					0.000079	0.000079	0.000079	0.000079		61
Total PCB	CDH-E-CPT	0.0039	µg/L	-	-			0.00017	0.000064	0.000064					0.000079	0.000079	0.000079	0.000079		59
Iron Gate Reservoir																				
Metals and AVS																				
Aluminum	CDH-E-IGN	1,500	µg/L	1,000	1,000	200	-													29
Aluminum	CDH-E-IGT-1	2,600	µg/L	1,000	1,000	200	-													51
Aluminum	CDH-E-IGT-2	4,700	µg/L	1,000	1,000	200	-													93
Arsenic	CDH-E-IGN	4.8	µg/L	-	-		-		0.018	0.14					0.0022	0.0175	0.0022	0.0175	-	2,180
Arsenic	CDH-E-IGT-1	9.4	µg/L	-	-		-		0.018	0.14					0.0022	0.0175	0.0022	0.0175	-	4,271
Arsenic	CDH-E-IGT-2	20	µg/L	10	-		-		0.018	0.14					0.0022	0.0175	0.0022	0.0175	-	9,089
Chromium	CDH-E-IGN	1.3	µg/L	-	-		-						-				-	-	-	0.3
Chromium	CDH-E-IGT-1	2.4	µg/L	-	-		-						-				-	-	-	1.4
Chromium	CDH-E-IGT-2	5.5	µg/L	-	-		-						-				-	-	-	4.5
Total PCB	CDH-E-IGN	0.0017	µg/L	-	-			0.00017	0.000064	0.000064					0.000079	0.000079	0.000079	0.000079		25
Total PCB	CDH-E-IGT-1	0.0034	µg/L	-	-			0.00017	0.000064	0.000064					0.000079	0.000079	0.000079	0.000079		52
Total PCB	CDH-E-IGT-2	0.0065	µg/L	-	-			0.00017	0.000064	0.000064					0.000079	0.000079	0.000079	0.000079		100
Klamath River Estuary																				
Conventionals																				
Chloride	CHA-E-001	470,000	µg/L	250,000		250,000	106,000													3.4
Metals and AVS																				
Aluminum	CHA-E-001	770	µg/L	-	-	200	-													14
Aluminum	CHA-E-002	780	µg/L	-	-	200	-													14
Arsenic	CHA-E-001	6	µg/L	-	-		-		0.018	0.14					0.0022	0.0175	0.0022	0.0175	-	2,726
Arsenic	CHA-E-002	2.2	µg/L	-	-		-		0.018	0.14					0.0022	0.0175	0.0022	0.0175	-	999
Chromium	CHA-E-001	2.8	µg/L	-	-		-						-				-	-	-	1.8
Chromium	CHA-E-002	5.9	µg/L	-	-		-						-				-	-	-	4.9
Nickel	CHA-E-001	11	µg/L	-	-		-	-	-	-					-	-	-	-		0.1
Nickel	CHA-E-002	18	µg/L	-	-		-	-	-	-					13.4	-	13.4	-		0.8
Total PCB	CHA-E-001	0.00016	µg/L	-	-			-	0.000064	0.000064					0.000079	0.000079	0.000079	0.000079		1.5

Table B-11. Klamath River Sediment Study-Elutriate Samples with Values Exceeding One or More Human Health Water Quality Criteria

Chemical	Sample[1]	Value	Units	Human Health Criteria																Dilution required to meet most stringent criterion
				CCR-CDPH	California Basin Plan				National RWQC Priority		National RWQC Non-priority		California Ocean Plan	Oregon DEQ HH	Oregon DEQ WQ Criteria					
				MCL	Primary MCL	Secondary MCL	Agriculture	Human Health CTR	Human Water and Organism	Human Organism	Human Water and Organism	Human Organism	Human Health NCAR	Human Health CAR	Human Water and Organism	Human Organism	Human Water and Organism	Human Organism	Human Drinking Water	
Total PCB	CHA-E-002	0.00013	µg/L	-	-			-	0.000064	0.000064					0.000079	0.000079	0.000079	0.000079		1.0

[1] Sediment bioassay samples for each reservoir are super-composites of multiple on-thalweg borehole locations (“T” at the end of the sample identifier code) or multiple off-thalweg borehole locations (non-thalweg; “N” at the end of the sample identifier code). An "area composite" sample was collected in the Upper Klamath River Estuary i.e., estuary samples were not segregated according to thalweg/non-thalweg location. Super-composite samples were chosen for analysis of sediment elutriate and toxicity studies (i.e., bioassay tests) to provide a representative reservoir- or estuary-wide average sediment composition, and to meet the large sediment and water volume requirements for the elutriate tests (BOR 2010). Maps of sample site locations are presented in Section 2, Figures 3–5.

Water Quality Criteria Key:

(blank)= No water quality criteria apply

- = Laboratory value is below water quality criterion

CCR= California Code of Regulations

CDPH= California Department of Public Health

MCL= Maximum Contaminant Level

RWQC= Recommended Water Quality Criteria

DEQ= Department of Environmental Quality

CTR= California Toxics Rule

NTR = National Toxics Rule

NCAR= Non-carcinogenic

CAR= Carcinogenic

Units Key:

µg= microgram (10^{-6} gram)

L= Liter

B.3 Elutriate Toxicity Bioassays

Elutriate bioassay results for the Secretarial Determination sediment evaluation process include acute (96-hr) toxicity responses for rainbow trout (*Onchorhynchus mykiss*) run at four elutriate strengths (i.e., 1, 10, 50, 100 percent) for super-composite on-thalweg and off-thalweg samples from each of the Project reservoirs (BOR 2010). Laboratory results indicate that there was no discernable difference in survival between the on-thalweg and off-thalweg samples at any of the elutriate strengths (Table B-12). The estimated LC-50 (elutriate strength for which 50 percent mortality of rainbow trout was experienced) for Iron Gate (22–32 percent) and Copco 1 (66–68 percent) reservoir samples suggests that a 2- to 4-fold dilution of the 100 percent elutriate strength would be required to prevent water column toxicity to rainbow trout. For J.C. Boyle Reservoir sediments (LC-50>100 percent), elutriate bioassay results indicate that no further dilution of the 100 percent elutriate strength would be required to prevent water column toxicity to rainbow trout (Table B-12). Raw data, including toxicity and water chemistry data, for the elutriate bioassays is presented in Tables B-13 through B-15, with reference toxicity data summarized in Table B-16.

Although potential elutriate toxicity to rainbow trout would be eliminated with only minor dilution, consideration of potential impacts to other fish species is necessary; rainbow trout are an indicator species in the laboratory bioassays but their response does not necessarily predict all other possible effects to fish. The Inland Testing Manual (ITM; USEPA 1998) and the Sediment Evaluation Framework (SEF) for the Pacific Northwest (RSET 2009) apply a highly conservative 100-fold safety factor to laboratory LC-50 results in order to ensure there would be no toxicity to any other fish species or life history stages that could be present in the environment, some of which may be more sensitive than the laboratory bioassay species. However, the ITM and SEF approaches assume a single-barge point discharge into a discreet mixing zone of specific size (USEPA 1998, RSET 2009), a standard discharge scenario that is quite different from sediment release that would occur following dam removal. As discussed in Section B.2, even maximum predicted suspended sediment concentrations are expected to be equivalent to 48- to 66-fold dilution. This represents an order of magnitude more dilution than would be sufficient to eliminate rainbow trout toxicity, and thus should also be protective of other fish species that may be more sensitive than rainbow trout.

Table B-12. Toxicity Acute Tests Result Summary for Elutriate Bioassay, 96-hour (4-day), Rainbow Trout (*Onchorhynchus mykiss*).

Sample	J.C. Boyle Reservoir		Copco 1 Reservoir		Iron Gate Reservoir	
	On-thalweg (CDH-E-JBT)	Off-thalweg (CDH-E-JBN)	On-thalweg (CDH-S-CPT)	Off-thalweg (CDH-S-CPN)	On-thalweg (CDH-S-IGT)	Off-thalweg (CDH-S-IGN)
Mean 96-hr Survival (%)						
Laboratory Control Water	100	100	98	98	82(2)	82(2)
Site Surface Water	100	100	100	100	92	92
1% Elutriate[1]	100	100	100	98	98	96
10% Elutriate[1]	100	100	100	100	96	98
50% Elutriate[1]	100	100	94	96	0(3)	0(3)
100% Elutriate[1]	100	94	0(3)	0(3)	38(3)	0(3)
LC-50 (%)						
Elutriate	>100	>100	66	68	32	22
95% CI	n/a	n/a	61–71	63–73	NC	NC
Analysis Method	n/a	n/a	TSK	TSK	Linear	Graphical

Source: BES (2010a–2010d).

[1] Elutriate samples prepared using 4:1 sediment:site surface water slurry.

[2] Control did not pass test acceptability criterion (90% survival) (EPA/600/R-99/064).

[3] Statistically significant reduction compared to Site Surface Water (p=0.05).

Table B-13. Acute Toxicity Test Results, Raw Data for Elutriate Bioassay, 96-hour (4-day), Rainbow trout (*Onchorhynchus mykiss*).[1]

Sample	Replicate	No. Alive	% Survival	Mean % Survival	Standard Deviation	Sample	Replicate	No. Alive	% Survival	Mean % Survival	Standard Deviation
J.C. Boyle Reservoir											
CDH-E-JBT						CDH-E-JBN					
Laboratory Control	A	10	100	100	0	Laboratory Control	A	10	100	100	0
	B	10	100				B	10	100		
	C	10	100				C	10	100		
	D	10	100				D	10	100		
	E	10	100				E	10	100		
Site Surface Water	A	10	100	100	0	Site Surface Water	A	10	100	100	0
	B	10	100				B	10	100		
	C	10	100				C	10	100		
	D	10	100				D	10	100		
	E	10	100				E	10	100		
1% Elutriate	A	10	100	100	0	1% Elutriate	A	10	100	100	0
	B	10	100				B	10	100		
	C	10	100				C	10	100		
	D	10	100				D	10	100		
	E	10	100				E	10	100		
10% Elutriate	A	10	100	100	0	10% Elutriate	A	10	100	100	0
	B	10	100				B	10	100		
	C	10	100				C	10	100		
	D	10	100				D	10	100		
	E	10	100				E	10	100		

Table B-13. Acute Toxicity Test Results, Raw Data for Elutriate Bioassay, 96-hour (4-day), Rainbow trout (*Onchorhynchus mykiss*).[1]

Sample	Replicate	No. Alive	% Survival	Mean % Survival	Standard Deviation	Sample	Replicate	No. Alive	% Survival	Mean % Survival	Standard Deviation
50% Elutriate	A	10	100	100	0	50% Elutriate	A	10	100	100	0
	B	10	100				B	10	100		
	C	10	100				C	10	100		
	D	10	100				D	10	100		
	E	10	100				E	10	100		
100% Elutriate	A	10	100	100	0	100% Elutriate	A	10	100	94	13
	B	10	100				B	10	100		
	C	10	100				C	10	100		
	D	10	100				D	10	100		
	E	10	100				E	7	70		
Copco Reservoir											
CDH-S-CPN						**CDH-S-CPT**					
Laboratory Control	A	9	90	98	4	Laboratory Control	A	9	90	98	4
	B	10	100				B	10	100		
	C	10	100				C	10	100		
	D	10	100				D	10	100		
	E	10	100				E	10	100		
Site Surface Water	A	10	100	100	0	Site Surface Water	A	10	100	100	0
	B	10	100				B	10	100		
	C	10	100				C	10	100		
	D	10	100				D	10	100		
	E	10	100				E	10	100		

Table B-13. Acute Toxicity Test Results, Raw Data for Elutriate Bioassay, 96-hour (4-day), Rainbow trout (*Onchorhynchus mykiss*).[1]

Sample	Replicate	No. Alive	% Survival	Mean % Survival	Standard Deviation	Sample	Replicate	No. Alive	% Survival	Mean % Survival	Standard Deviation
1% Elutriate	A	9	98	98	4	1% Elutriate	A	10	100	100	0
	B	10	100				B	10	100		
	C	10	100				C	10	100		
	D	10	100				D	10	100		
	E	10	100				E	10	100		
10% Elutriate	A	10	100	100	0	10% Elutriate	A	10	100	100	0
	B	10	100				B	10	100		
	C	10	100				C	10	100		
	D	10	100				D	10	100		
	E	10	100				E	10	100		
50% Elutriate	A	9	90	96	5	50% Elutriate	A	10	100	94	9
	B	10	100				B	10	100		
	C	10	100				C	8	80		
	D	9	90				D	9	90		
	E	10	100				E	10	100		
100% Elutriate	A	0	0	0	0	100% Elutriate	A	0	0	0	0
	B	0	0				B	0	0		
	C	0	0				C	0	0		
	D	0	0				D	0	0		
	E	0	0				E	0	0		

Table B-13. Acute Toxicity Test Results, Raw Data for Elutriate Bioassay, 96-hour (4-day), Rainbow trout (*Onchorhynchus mykiss*).[1]

Sample	Replicate	No. Alive	% Survival	Mean % Survival	Standard Deviation	Sample	Replicate	No. Alive	% Survival	Mean % Survival	Standard Deviation
Iron Gate Reservoir											
CDH-S-IGT						**CDH-S-IGN**					
Laboratory Control	A	9	90	82[(2)]	8	Laboratory Control	A	9	90	82[(2)]	8
	B	8	80				B	8	80		
	C	8	80				C	8	80		
	D	7	70				D	7	70		
	E	9	90				E	9	90		
Site Surface Water	A	7	70	92	13	Site Surface Water	A	7	70	92	13
	B	10	100				B	10	100		
	C	10	100				C	10	100		
	D	10	100				D	10	100		
	E	9	90				E	9	90		
1% Elutriate	A	10	100	98	4	1% Elutriate	A	9	90	96	5
	B	10	100				B	10	100		
	C	10	100				C	10	100		
	D	9	90				D	10	100		
	E	10	100				E	9	90		
10% Elutriate	A	10	100	96	5	10% Elutriate	A	10	100	98	4
	B	10	100				B	10	100		
	C	9	90				C	10	100		
	D	10	100				D	10	100		
	E	9	90				E	9	90		

Table B-13. Acute Toxicity Test Results, Raw Data for Elutriate Bioassay, 96-hour (4-day), Rainbow trout (*Onchorhynchus mykiss*).[1]

Sample	Replicate	No. Alive	% Survival	Mean % Survival	Standard Deviation	Sample	Replicate	No. Alive	% Survival	Mean % Survival	Standard Deviation
50% Elutriate	A	0	0	0	0	50% Elutriate	A	0	0	0	0
	B	0	0				B	0	0		
	C	0	0				C	0	0		
	D	0	0				D	0	0		
	E	0	0				E	0	0		
100% Elutriate	A	0	0	38[2]	52	100% Elutriate	A	0	0	0	0
	B	0	0				B	0	0		
	C	9	90				C	0	0		
	D	10	100				D	0	0		
	E	0	0				E	0	0		

[1] Raw data from BES (2010a–2010d)

[2] Control did not pass test acceptability criterion (³ 90% survival) (EPA/600/R-99/064)

Table B-14. Water Chemistry Summary for All Measured Parameters, Elutriate Bioassay, 96-hour (4-day), Rainbow trout (*Onchorhynchus mykiss*).[1]

Parameter	Time of Measurement (hrs)	J.C. Boyle Reservoir		Copco 1 Reservoir		Iron Gate Reservoir	
		CDH-E-JBT	CDH-E-JBN	CDH-S-CPT	CDH-S-CPN	CDH-S-IGT	CDH-S-IGN
Laboratory Control Water							
Hardness(mg/L CaCO3)	0	108	108	100	100	96	96
	96	92	92	106	106	96	96
Alkalinity(mg/L CaCO3)	0	80	80	62	62	60	60
	96	58	58	62	62	54	54
Ammonia(mg/L as N)	0	0.03	0.03	0.05	0.05	ND	ND
	96	0.47	0.47	0.43	0.43	0.45	0.45
Chlorine, total (mg/L)	0	0.03	0.03	0.03	0.03	0.05	0.05
	96	0.03	0.03	ND	ND	0.04	0.04
Conductivity (µS/cm)	0	569	569	606	606	556	556
	96	596	596	606	606	577	577
Salinity(parts per thousand)	0	0.3	0.3	0.3	0.3	0.3	0.3
	96	0.3	0.3	0.3	0.3	0.3	0.3
pH	0	7.8	7.8	8.1	8.1	7.7	7.7
	96	7.4	7.4	7.6	7.6	8.1	8.1
D.O. (mg/L)	0	11.0	11.0	11.3	11.3	11.1	11.1
	96	9.7	9.7	9.6	9.6	10.9	10.9
Water Temperature (Deg C)	0	13.0	13.0	12.1	12.1	13.0	13.0
	96	13.0	13.0	12.7	12.7	13.0	13.0
Site Surface Water							
Hardness (mg/L as CaCO3)	As received	56	56	50	50	60	60
Alkalinity (mg/L as CaCO3)	As received	62	62	66	66	66	66
Ammonia (mg/L as N)	As received	0.46	0.46	0.19	0.19	0.19	0.19
Total chlorine (mg/L)	As received	ND	ND	0.04	0.04	ND	ND
Conductivity (us/cm)	As received	193	193	161	161	161	161
Salinity (ppt)	As received	0.1	0.1	0.1	0.1	0.1	0.1
pH	As received	7.1	7.1	7.4	7.4	6.8	6.8
D.O. (mg/L)	As received	11.0	11.0	12.0	12	10.5	10.5
Water Temperature (Deg C)	As received	9.0	9.0	9.2	9.2	10.0	10.0
Site Surface Water							
pH	0	7.6	7.6	7.9	7.9	7.6	7.6
	96	7.6	7.6	7.7	7.7	8.1	8.1
D.O. (mg/L)	0	11.8	11.8	12.3	12.3	11.8	11.8
	96	9.1	9.1	9.4	9.4	11.1	11.1
Water Temperature (Deg C)	0	12.0	12.0	12.3	12.3	13.0	13.0
	96	13.0	13.0	12.7	12.7	13.0	13.0

Table B-14. Water Chemistry Summary for All Measured Parameters, Elutriate Bioassay, 96-hour (4-day), Rainbow trout (*Onchorhynchus mykiss*).[1]

Parameter	Time of Measurement (hrs)	J.C. Boyle Reservoir		Copco 1 Reservoir		Iron Gate Reservoir	
		CDH-E-JBT	CDH-E-JBN	CDH-S-CPT	CDH-S-CPN	CDH-S-IGT	CDH-S-IGN
1% Elutriate							
pH	0	7.3	7.6	7.9	7.7	7.7	7.7
	96	7.5	7.6	7.6	7.6	8.0	7.9
D.O. (mg/L)	0	8.5	10.8	11.3	11.0	11.0	11.0
	96	9.8	9.6	9.1	9.6	10.5	10.4
Water Temperature (Deg C)	0	13.0	13.0	12.3	12.4	13.0	13.0
	96	13.0	13.0	12.6	12.6	13.0	12.9
10% Elutriate							
pH	0	7.3	7.4	7.7	7.6	7.6	7.6
	96	7.5	7.7	7.7	7.6	7.9	7.9
D.O. (mg/L)	0	7.8	10.6	10.2	9.8	10.9	10.9
	96	9.6	9.7	9.8	10.7	10.6	10.8
Water Temperature (Deg C)	0	13.0	12.6	12.0	12.1	12.5	12.5
	96	13.0	13.0	12.7	12.6	12.9	12.9
50% Elutriate							
pH	0	7.4	7.2	7.7	7.5	7.2	7.2
	96	7.1	7.6	7.9	7.6	7.9	7.3
D.O. (mg/L)	0	8.7	9.3	10.6	7.5	6.0	6.0
	96	9.8	9.8	10.8	10.6	10.9	10.5
Water Temperature (Deg C)	0	12.0	12.0	11.0	11.0	11.9	12.0
	96	13.0	13.0	12.6	12.6	12.9	13.0
100% Elutriate							
Hardness (mg/L CaCO3)	0	50	50	100	100	-	-
	96	90	120	100	100	90	100
Alkalinity (mg/L CaCO3)	0	550	200	250	150	-	-
	96	150	180	250	200	70	100
Ammonia (mg/L as N)	0	7.0	9.0	6.0	6.4	-	-
	96	10.0	9.0	60	28	0.8	0.46
Chlorine, total (mg/L)	0	ND	0.04	ND	ND	-	-
	96	1.7	1.10	0.29	ND	ND	ND
Conductivity (µS/cm)	0	259	220	431	262	297	278
	96	234	189	443	208	235	173
Salinity (parts per thousand)	0	0.1	0.1	0.2	0.1	0.2	0.2
	96	0.1	0.1	0.2	0.1	0.1	0.1
pH Mean Daily ± Std Dev (n=30)		7.6 ± 0.2	7.7 ± 0.2	7.8 ± 0.2	7.7 ± 0.2	7.8 ± 0.3	7.8 ± 0.3
D.O. Mean Daily ± Std Dev (mg/L) (n=30)		10.0 ± 0.8	10.2 ± 1.1	10.4 ± 0.7	10.4 ± 0.7	10.7 ± 0.3	10.7 ± 0.3

Table B-14. Water Chemistry Summary for All Measured Parameters, Elutriate Bioassay, 96-hour (4-day), Rainbow trout (*Onchorhynchus mykiss*).[1]

Parameter	Time of Measurement (hrs)	J.C. Boyle Reservoir		Copco 1 Reservoir		Iron Gate Reservoir	
		CDH-E-JBT	CDH-E-JBN	CDH-S-CPT	CDH-S-CPN	CDH-S-IGT	CDH-S-IGN
Water Temperature Mean Daily ± Std Dev (Deg C) (n=30)		12.5 ± 0.3	12.5 ± 0.3	12.5 ± 0.3	12.5 ± 0.3	12.9 ± 0.4	12.9 ± 0.4

[1] Raw data from BES (2010a–2010d)

Key:

ND= Indicates the measurement was "non-detect" or below the detection limit (0.03 mg/L for Cl).

- = Indicates no measurement was taken.

Table B-15. Water Chemistry Summary for Ammonia (mg/L as N), Elutriate Bioassay, 96-hour (4-day), Rainbow trout *(Onchorhynchus mykiss*).[1]

Sample	Time of Measurement (hrs)	J.C. Boyle Reservoir		Copco 1 Reservoir		Iron Gate Reservoir	
		On-thalweg (CDH-E-JBT)	Off-thalweg (CDH-E-JBN)	On-thalweg (CDH-S-CPT)	Off-thalweg (CDH-S-CPN)	On-thalweg (CDH-S-IGT)	Off-thalweg (CDH-S-IGN)
Laboratory Control Water	0	0.03	0.03	0.05	0.05	ND	ND
	96	0.47	0.47	0.43	0.43	0.45	0.45
Site Surface Water	As received	0.46	0.46	0.19	0.19	0.19	0.19
100% Elutriate	0	7	9	6	6.4	-	-
	96	10	9	60	28	0.8	0.46

Source: BOR 2010

[1] Raw data from BES (2010a–2010d)

Key:

ND= Indicates the measurement was "non-detect" or below the detection limit (0.03 mg/L for Cl).

- = Indicates no measurement was taken.

Table B-16. Acute Toxicity Test Results Summary, Reference Toxicant Test, 96-hour (4-day).[1]

	Amphipod (*Hyalella azteca*)	Midge (*Chironomus dilutus*)	Rainbow Trout (*Onchorhynchus mykiss*)
Reference Toxicant	KCl	KCl	SDS
Mean LC-50 (mg/L)	319	4.61	19.3
2SD of LC-50 (mg/L)	191	0.2	7.9
Number of Tests	25	2	36
Test Dates	4/23/2004 to 8/24/2010	11/27/2009, 12/08/2009	8/7/2008 to 9/13/2010

[1] Raw data from BES (2010a–2010d)

B.4 References

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Appendix C
Summary of COPC Selection Process and Evaluation of Reporting Limits Associated with Non-Detected Chemicals

Appendix C: Summary of COC Selection Process and Evaluation of Reporting Limits Associated with Non-Detected Chemicals

	Units	range RL	total # results	Marine exceeded	Marine notes	Hierarchy Freshwater Exceeded	Freshwater Notes	HH Exceeded	HH Notes
JC Boyle									
Antimony	mg/kg	0.31 - 1.7	14	No		No	no ESL	No	
Cadmium	mg/kg	0.16 - 0.84	14	No		Yes	SEF-SL1	No	
Mercury	mg/kg	0.063 - 0.34	14	No		No		No	
Silver	mg/kg	0.79 - 3.8	14	No		No		No	
4,4,'-DDD	ug/kg	0.9 - 4.9	13	No		Yes	ODEQ Bioacc SLV	Yes	ODEQ
4,4,'-DDE	ug/kg	0.9 - 4.9	13	No		Yes	ODEQ Bioacc SLV	Yes	ODEQ
4,4,'-DDT	ug/kg	0.9 - 4.9	13	No		Yes	ODEQ Bioacc SLV	Yes	ODEQ
Aroclor 1221	mg/kg	0.24 - 0.49	13	No		Yes	SEF-SL1 (total PCBs)	Yes	EPA RSL
Aroclor 1232	mg/kg	0.16 - 0.24	9	Yes	DMMP-SL, SEF-SL1 (total PCBs)	Yes	SEF-SL1 (total PCBs)	Yes	EPA RSL
Aroclor 1242	mg/kg	0.045 - 0.24	14	Yes	DMMP-SL, SEF-SL1 (total PCBs)	Yes	SEF-SL1 (total PCBs)	Yes	EPA RSL
Aroclor 1248	mg/kg	0.045 - 0.24	14	Yes	DMMP-SL, SEF-SL1 (total PCBs)	Yes	SEF-SL1 (total PCBs)	Yes	EPA RSL
Aroclor 1254	mg/kg	0.045 - 0.24	14	Yes	DMMP-SL, SEF-SL1 (total PCBs)	Yes	SEF-SL1 (total PCBs)	Yes	EPA RSL
Aroclor 1260	mg/kg	0.045 - 0.24	14	Yes	DMMP-SL, SEF-SL1 (total PCBs)	Yes	SEF-SL1 (total PCBs)	Yes	EPA RSL
BHC-Gamma (HCH-gamma, Lindane)	ug/kg	0.9 - 4.9	14	No		Yes	Squirts	Yes	CHHSLs
Chlordane (Technical)	ug/kg	4.5 - 24	14	Yes	DMMP-SL, SEF-SL1	Yes	ODEQ Bioacc SLV	Yes	ODEQ
Chlordane-Alpha	ug/kg	0.9 - 4.9	14	Yes	DMMP-SL, SEF-SL1	Yes	ODEQ Bioacc SLV	Yes	ODEQ
Chlordane-Gamma	ug/kg	0.9 - 4.9	14	Yes	DMMP-SL, SEF-SL1	Yes	ODEQ Bioacc SLV	Yes	ODEQ
Dieldrin	ug/kg	0.9 - 4.9	13	Yes	SEF-SL1	Yes	ODEQ Bioacc SLV	Yes	ODEQ
Endrin	ug/kg	0.9 - 4.9	14	Yes	Squirts	Yes	Squirts	No	
Heptachlor	ug/kg	0.9 - 4.9	14	Yes	SEF-SL1	Yes	Squirts	No	
Heptachlor Epoxide	ug/kg	0.9 - 4.9	14	Yes	Squirts	Yes	Squirts	No	
Toxaphene	ug/kg	45 - 240	14	Yes	Squirts	Yes	Squirts	No	
Bis(2-ethylhexyl)phthalate	ug/kg	230 - 1200	14	No		Yes	SEF-SL1	No	
Butyl benzyl phthalate	ug/kg	230 - 1200	14	Yes	DMMP-ML	Yes	SEF-SL1	No	
Diethyl phthalate	ug/kg	230 - 1200	14	No		No	no ESL	No	
Dimethyl phthalate	ug/kg	230 - 1200	14	No		Yes	SEF-SL1	No	no ESL
Di-n-octyl phthalate	ug/kg	230 - 1200	14	No		Yes	SEF-SL1	No	no ESL
1,2,3,7,8-PECDD	pg/g	0.91	1	No	no ESL	No		No	no ESL
2,3,7,8-TCDD	pg/g	0.3	1	No	no ESL	No		No	no ESL
1,2,3-TRICHLOROPROPANE	ug/kg	6.7 - 36	16	No	no ESL	No	no ESL	Yes	EPA RSL
1,2,4-TRICHLOROBENZENE	ug/kg	6.7 - 36	16	No		No	no ESL	No	
1,2-DIBROMO-3-CHLOROPROPANE	ug/kg	6.7 - 36	16	No	no ESL	No	no ESL	Yes	EPA RSL
1,2-DICHLOROBENZENE	ug/kg	6.7 - 36	16	No		No	no ESL	No	
2,4-DIMETHYLPHENOL	ug/kg	230 - 1200	14	Yes	DMMP-ML	No	no ESL	No	
2-METHYLNAPHTHALENE	ug/kg	230 - 1200	14	No		Yes	SEF-SL1	No	
2-METHYLPHENOL	ug/kg	230 - 1200	14	Yes	DMMP-ML	No	no ESL	No	no ESL
3,3'-DICHLOROBENZIDINE	ug/kg	230 - 1200	14	No	no ESL	No	no ESL	Yes	EPA RSL
4-METHYLPHENOL	ug/kg	230 - 1200	14	Yes	DMMP-ML	No	no ESL	No	no ESL
ACENAPHTHENE	ug/kg	230 - 1200	14	No		Yes	SEF-SL1	No	
ACENAPHTHYLENE	ug/kg	230 - 1200	14	No		Yes	SEF-SL1	No	no ESL
ANTHRACENE	ug/kg	230 - 1200	14	No		No		No	
BENZ(A)ANTHRACENE	ug/kg	230 - 1200	14	No		No		Yes	EPA RSL
BENZO(A)PYRENE	ug/kg	230 - 1200	14	No		No		Yes	EPA RSL, CHHSLs
BENZO(B)FLUORANTHENE	ug/kg	230 - 1200	14	Yes	Squirts	No	no ESL	Yes	EPA RSL
BENZO(G,H,I)PERYLENE	ug/kg	230 - 1200	14	No		No		No	no ESL
BENZO(K)FLUORANTHENE	ug/kg	230 - 1200	14	No		Yes	SEF-SL1	No	
BENZOIC ACID	ug/kg	930 - 4800	14	Yes	DMMP-ML	No	no ESL	No	
BENZYL ALCOHOL	ug/kg	230 - 1200	14	Yes	DMMP-ML	No	no ESL	No	
BIS(2-CHLOROETHYL) ETHER	ug/kg	230 - 1200	14	No	no ESL	No	no ESL	Yes	EPA RSL
CHRYSENE	ug/kg	230 - 1200	14	No		No		No	

Appendix C: Summary of COC Selection Process and Evaluation of Reporting Limits Associated with Non-Detected Chemicals

						Hierarchy			
	Units	range RL	total # results	Marine exceeded	Marine notes	Freshwater Exceeded	Freshwater Notes	HH Exceeded	HH Notes
DIBENZ(A,H)ANTHRACENE	ug/kg	230 - 1200	14	No		Yes	SEF-SL1	Yes	EPA RSL
DIBENZOFURAN	ug/kg	230 - 1200	14	No		Yes	SEF-SL1	No	
FLUORANTHENE	ug/kg	230 - 1200	14	No		No		No	
FLUORENE	ug/kg	230 - 1200	14	No		Yes	SEF-SL1	Yes	EPA RSL
HEXACHLOROBENZENE	ug/kg	230 - 1200	14	Yes	DMMP-ML	No	no ESL	Yes	ODEQ, EPA RSL
HEXACHLOROBUTADIENE	ug/kg	6.7 - 36	16	No		No	no ESL	No	
INDENO(1,2,3-CD)PYRENE	ug/kg	230 - 1200	14	No		No		Yes	EPA RSL
NAPHTHALENE	ug/kg	6.7 - 36	16	No		No		No	
N-NITROSODI-N-PROPYLAMINE	ug/kg	230 - 1200	14	No	no ESL	No		Yes	EPA RSL
N-NITROSODIPHENYLAMINE	ug/kg	230 - 1200	14	Yes	DMMP-ML	No		No	
PHENOL	ug/kg	230 - 1200	14	No		No		No	
PYRENE	ug/kg	230 - 1200	14	No		No		No	
TRANS-1,4-DICHLORO-2-BUTENE	ug/kg	6.7 - 36	16	No	no ESL	No		Yes	EPA RSL
1,2-DIBROMOETHANE	ug/kg	6.7 - 36	16	No	no ESL	No		Yes	EPA RSL
ETHYLBENZENE	ug/kg	6.7 - 36	16	No		No		No	
Copco 1									
ANTIMONY	mg/kg	0.72 - 0.95	17	No		No	no ESL	No	
CADMIUM	mg/kg	0.36 - 0.48	17	No		No		No	
MERCURY	mg/kg	0.14 - 0.19	17	No		No		No	
SILVER	mg/kg	1.8 - 2.4	17	No		Yes	SEF-SL1	No	
AROCLOR 1221	mg/kg	0.24 - 0.3	17	Yes	DMMP-SL, SEF-SL1 (total PCBs)	Yes	SEF-SL1 (total PCBs)	Yes	EPA RSL
AROCLOR 1232	mg/kg	0.12 - 0.15	17	Yes	DMMP-SL, SEF-SL1 (total PCBs)	Yes	SEF-SL1 (total PCBs)	Yes	EPA RSL
4,4'-DDD	ug/kg	2.4 - 3	17	No		No		No	
4,4'-DDE	ug/kg	2.4 - 3	17	No		Yes	Squirts	No	
4,4'-DDT	ug/kg	2.4 - 3	17	No		Yes	Squirts	No	
BHC-gamma (HCH-gamma, Lindane)	ug/kg	2.4 - 3	17	No		Yes	Squirts	Yes	CHHSLs
CHLORDANE (TECHNICAL)	ug/kg	12 - 15	17	Yes	DMMP-SL, SEF-SL1	Yes	Squirts	No	
CHLORDANE-ALPHA	ug/kg	2.4 - 3	17	Yes	SEF-SL1	No		No	
CHLORDANE-GAMMA	ug/kg	2.4 - 3	17	Yes	SEF-SL1	No		No	
DIELDRIN	ug/kg	2.4 - 3	17	Yes	SEF-SL1	Yes	Squirts	No	
ENDRIN	ug/kg	2.4 - 3	17	No	no ESL	Yes	Squirts	No	
HEPTACHLOR	ug/kg	2.4 - 3	17	Yes	SEF-SL1	Yes	Squirts	No	
HEPTACHLOR EPOXIDE	ug/kg	2.4 - 3	17	Yes	Squirts	Yes	Squirts	No	
TOXAPHENE	ug/kg	120 - 150	17	Yes	Squirts	Yes	Squirts	No	
BIS(2-ETHYLHEXYL) PHTHALATE	ug/kg	580 - 730	17	No		Yes	SEF-SL1	No	
BUTYL BENZYL PHTHALATE	ug/kg	580 - 730	17	No		Yes	SEF-SL1	No	
DIETHYL PHTHALATE	ug/kg	580 - 730	17	No		No	no ESL	No	
DIMETHYL PHTHALATE	ug/kg	580 - 730	17	No		Yes	SEF-SL1	No	no ESL
DI-N-OCTYL PHTHALATE	ug/kg	580 - 730	17	No		Yes	SEF-SL1	No	no ESL

Appendix C: Summary of COC Selection Process and Evaluation of Reporting Limits Associated with Non-Detected Chemicals

	Units	range RL	total # results	Marine exceeded	Marine notes	Hierarchy Freshwater Exceeded	Freshwater Notes	HH Exceeded	HH Notes
1,2,3,7,8,9-HXCDF	pg/g	0.43	1	No		No	no ESL	No	no ESL
1,2,3,7,8-PECDF	pg/g	0.47	1	No		No	no ESL	No	no ESL
2,3,7,8-TCDD	pg/g	0.17 - 0.25	2	No	no ESL	No	no ESL	No	
1,2,3-TRICHLOROPROPANE	ug/kg	18 - 22	17	No	no ESL	No	no ESL	Yes	EPA RSL
1,2-DIBROMO-3-CHLOROPROPANE	ug/kg	18 - 22	17	No	no ESL	No	no ESL	Yes	EPA RSL
2,4-DIMETHYLPHENOL	ug/kg	580 - 730	17	Yes	DMMP-ML	No	no ESL	No	
2-METHYLNAPHTHALENE	ug/kg	580 - 730	17	No		Yes	SEF-SL1	No	
2-METHYLPHENOL	ug/kg	580 - 730	17	Yes	DMMP-ML	No	no ESL	No	no ESL
ACENAPHTHENE	ug/kg	580 - 730	17	No		No		No	
ACENAPHTHYLENE	ug/kg	580 - 730	17	No		Yes	SEF-SL1	No	no ESL
ANTHRACENE	ug/kg	580 - 730	17	No		No		No	
BENZ(A)ANTHRACENE	ug/kg	580 - 730	17	No		No		Yes	EPA RSL
BENZO(A)PYRENE	ug/kg	580 - 730	17	No		No		Yes	EPA RSL, CHHSLs
BENZO(B)FLUORANTHENE	ug/kg	580 - 730	17	Yes	Squirts	No	no ESL	Yes	EPA RSL
BENZO(G,H,I)PERYLENE	ug/kg	580 - 730	17	Yes	Squirts	No		No	no ESL
BENZO(K)FLUORANTHENE	ug/kg	580 - 730	17	No		Yes	SEF-SL1	No	
BENZOIC ACID	ug/kg	2300 - 2900	17	Yes	DMMP-ML	No	no ESL	No	
BENZYL ALCOHOL	ug/kg	580 - 730	17	No		No	no ESL	No	
BIS(2-CHLOROETHYL) ETHER	ug/kg	580 - 730	17	No	no ESL	No	no ESL	Yes	EPA RSL
CHRYSENE	ug/kg	580 - 730	17	No		No		No	
DIBENZ(A,H)ANTHRACENE	ug/kg	580 - 730	17	No		No		Yes	EPA RSL
DIBENZOFURAN	ug/kg	580 - 730	17	No		Yes	SEF-SL1	No	
FLUORANTHENE	ug/kg	580 - 730	17	No		No		No	
FLUORENE	ug/kg	580 - 730	17	No		No		No	
HEXACHLOROBENZENE	ug/kg	580 - 730	17	Yes	DMMP-ML	No		Yes	EPA RSL
HEXACHLOROBUTADIENE	ug/kg	18 - 22	17	No		No		No	
INDENO(1,2,3-CD)PYRENE	ug/kg	580 - 730	17	No		No		Yes	EPA RSL
N-NITROSODI-N-PROPYLAMINE	ug/kg	580 - 730	17	No	no ESL	No	no ESL	Yes	EPA RSL
N-NITROSODIPHENYLAMINE	ug/kg	580 - 730	17	Yes	DMMP-ML	No	no ESL	No	
PHENOL	ug/kg	580 - 730	17	No		No	no ESL	No	
PYRENE	ug/kg	580 - 730	17	No		No		No	
TRANS-1,4-DICHLORO-2-BUTENE	ug/kg	18 - 22	17	No	no ESL	No	no ESL	Yes	EPA RSL
ETHYLBENZENE	ug/kg	18 - 22	17	No		No	no ESL	No	
Iron Gate									
ANTIMONY	mg/kg	0.38 - 0.89	14	No		No	no ESL	No	
CADMIUM	mg/kg	0.19 - 0.45	14	No		No		No	
MERCURY	mg/kg	0.075 - 0.18	14	No		No		No	
SILVER	mg/kg	0.94 - 2.2	14	No		Yes	SEF-SL1	No	
AROCLOR 1221	mg/kg	0.067 - 0.3	14	Yes	DMMP-SL, SEF-SL1 (total PCBs)	Yes	SEF-SL1 (total PCBs)	Yes	EPA RSL
AROCLOR 1232	mg/kg	0.033 - 0.15	14	Yes	DMMP-SL, SEF-SL1 (total PCBs)	Yes	SEF-SL1 (total PCBs)	Yes	EPA RSL
4,4'-DDD	ug/kg	0.67 - 3	15	No		No		No	
4,4'-DDE	ug/kg	0.67 - 3	15	No		Yes	Squirts	No	
4,4'-DDT	ug/kg	0.67 - 3	15	No		Yes	Squirts	No	
BHC-gamma (HCH-gamma, Lindane)	ug/kg	0.67 - 3	15	No		Yes	Squirts	No	
CHLORDANE (TECHNICAL)	ug/kg	3.3 - 15	15	Yes	DMMP-SL, SEF-SL1	Yes	Squirts	No	
CHLORDANE-ALPHA	ug/kg	0.67 - 3	15	Yes	SEF-SL1	No		No	
CHLORDANE-GAMMA	ug/kg	0.67 - 3	15	Yes	SEF-SL1	No		No	
DIELDRIN	ug/kg	0.67 - 3	15	Yes	SEF-SL1	Yes	Squirts	No	

Appendix C: Summary of COC Selection Process and Evaluation of Reporting Limits Associated with Non-Detected Chemicals

				Hierarchy					
	Units	range RL	total # results	Marine exceeded	Marine notes	Freshwater Exceeded	Freshwater Notes	HH Exceeded	HH Notes
ENDRIN	ug/kg	0.67 - 3	15	No	no ESL	Yes	Squirts	No	
HEPTACHLOR	ug/kg	0.67 - 3	15	Yes	SEF-SL1	Yes	Squirts	No	
HEPTACHLOR EPOXIDE	ug/kg	0.67 - 3	15	Yes	SEF-SL1	Yes	Squirts	No	
TOXAPHENE	ug/kg	33 - 150	15	No	no ESL	Yes	Squirts	No	
BIS(2-ETHYLHEXYL) PHTHALATE	ug/kg	170 - 730	15	No		Yes	SEF-SL1	No	
BUTYL BENZYL PHTHALATE	ug/kg	170 - 730	15	No		Yes	SEF-SL1	No	
DIETHYL PHTHALATE	ug/kg	170 - 730	15	No		No	no ESL	No	
DIMETHYL PHTHALATE	ug/kg	170 - 730	15	No		Yes	SEF-SL1	No	no ESL
DI-N-BUTYL PHTHALATE	ug/kg	170 - 730	15	No		No	no ESL	No	no ESL
DI-N-OCTYL PHTHALATE	ug/kg	170 - 730	15	No		Yes	SEF-SL1	No	no ESL
1,2,3,4,7,8-HXCDD	pg/g	0.78 - 1.2	2	No	no ESL	No	no ESL	No	no ESL
1,2,3,4,7,8-HXCDF	pg/g	0.22 - 1.1	5	No	no ESL	No	no ESL	No	no ESL
1,2,3,7,8-PECDF	pg/g	0.34 - 0.72	3	No	no ESL	No	no ESL	No	no ESL
2,3,4,7,8-PECDF	pg/g	0.71 - 0.72	2	No	no ESL	No	no ESL	No	no ESL
2,3,7,8-TCDD	pg/g	0.17 - 0.21	3	No	no ESL	No	no ESL	No	
2,3,7,8-TCDF	pg/g	0.72	1	No	no ESL	No	no ESL	No	no ESL
1,2,3-TRICHLOROPROPANE	ug/kg	5 - 22	14	No	no ESL	No	no ESL	Yes	EPA RSL
1,2,4-TRICHLOROBENZENE	ug/kg	5 - 520	15	Yes	DMMP-SL, SEF-SL1	No	no ESL	No	
1,2-DIBROMO-3-CHLOROPROPANE	ug/kg	5 - 22	14	No	no ESL	No	no ESL	Yes	EPA RSL
1,2-DICHLOROBENZENE	ug/kg	5 - 22	15	No		No	no ESL	No	
1,3-DICHLOROBENZENE	ug/kg	5 - 520	15	Yes	DMMP-SL	No	no ESL	No	no ESL
1,4-DICHLOROBENZENE	ug/kg	5 - 520	15	Yes	DMMP-ML	No	no ESL	No	no ESL
2,4-DIMETHYLPHENOL	ug/kg	170 - 730	15	Yes	DMMP-ML	No	no ESL	No	
2-METHYLNAPHTHALENE	ug/kg	170 - 730	15	No		Yes	SEF-SL1	No	
2-METHYLPHENOL	ug/kg	170 - 730	15	Yes	DMMP-ML	No	no ESL	No	no ESL
4-METHYLPHENOL	ug/kg	170 - 730	15	No		No	no ESL	No	no ESL
ACENAPHTHENE	ug/kg	170 - 730	15	No		No		No	
ACENAPHTHYLENE	ug/kg	170 - 730	15	No		Yes	SEF-SL1	No	no ESL
ANTHRACENE	ug/kg	170 - 730	15	No		No		No	
BENZ(A)ANTHRACENE	ug/kg	170 - 730	15	No		No		Yes	EPA RSL
BENZO(A)PYRENE	ug/kg	170 - 730	15	No		No		Yes	EPA RSL, CHHSLs
BENZO(B)FLUORANTHENE	ug/kg	170 - 730	15	Yes	Squirts	No	no ESL	Yes	EPA RSL
BENZO(G,H,I)PERYLENE	ug/kg	170 - 730	15	No		No		No	no ESL
BENZO(K)FLUORANTHENE	ug/kg	170 - 730	15	No		Yes	SEF-SL1	No	
BENZOIC ACID	ug/kg	670 - 2900	15	Yes	DMMP-ML	No	no ESL	No	
BENZYL ALCOHOL	ug/kg	170 - 730	15	No		No	no ESL	No	
BIS(2-CHLOROETHYL) ETHER	ug/kg	170 - 730	15	No	no ESL	No	no ESL	Yes	EPA RSL
CHRYSENE	ug/kg	170 - 730	15	No		No		No	
DIBENZ(A,H)ANTHRACENE	ug/kg	170 - 730	15	No		No		Yes	EPA RSL
DIBENZOFURAN	ug/kg	170 - 730	15	No		Yes	SEF-SL1	No	
FLUORANTHENE	ug/kg	170 - 730	15	No		No		No	
FLUORENE	ug/kg	170 - 730	15	No		No		No	
HEXACHLOROBENZENE	ug/kg	170 - 730	15	Yes	DMMP-ML	No	no ESL	Yes	EPA RSL
HEXACHLOROBUTADIENE	ug/kg	5 - 520	15	Yes	DMMP-ML	No	no ESL	No	
INDENO(1,2,3-CD)PYRENE	ug/kg	170 - 730	15	No		No		Yes	EPA RSL
NAPHTHALENE	ug/kg	5 - 520	15	No		Yes	SEF-SL1	No	
N-NITROSODI-N-PROPYLAMINE	ug/kg	170 - 730	15	No	no ESL	No	no ESL	Yes	EPA RSL
N-NITROSODIPHENYLAMINE	ug/kg	170 - 730	15	Yes	DMMP-ML	No	no ESL	No	
PHENOL	ug/kg	170 - 730	15	No		No	no ESL	No	
PYRENE	ug/kg	170 - 730	15	No		No		No	
TRANS-1,4-DICHLORO-2-BUTENE	ug/kg	5 - 22	14	No	no ESL	No	no ESL	Yes	EPA RSL
ETHYLBENZENE	ug/kg	5 - 22	14	No	no ESL	No	no ESL	No	

Appendix C: Summary of COC Selection Process and Evaluation of Reporting Limits Associated with Non-Detected Chemicals

				Hierarchy					
	Units	range RL	total # results	Marine exceeded	Marine notes	Freshwater Exceeded	Freshwater Notes	HH Exceeded	HH Notes
Lower Klamath Estuary									
SILVER	mg/kg	0.75	1	No		No		No	
4,4'-DDD	ug/kg	0.91	1	No		No		No	
4,4'-DDE	ug/kg	0.91	1	No		No		No	
4,4'-DDT	ug/kg	0.91	1	No		No		No	
BHC-gamma (HCH-gamma, Lindane)	ug/kg	0.91	1	No		No		Yes	CHHSLs
CHLORDANE (TECHNICAL)	ug/kg	4.6	1	Yes	SEF-SL1	Yes	Squirts	No	
CHLORDANE-ALPHA	ug/kg	0.91	1	No		No		No	
CHLORDANE-GAMMA	ug/kg	0.91	1	No		No		No	
DIELDRIN	ug/kg	0.91	1	No		No		No	
HEPTACHLOR EPOXIDE	ug/kg	0.91	1	Yes	Squirts	Yes	Squirts	No	
TOXAPHENE	ug/kg	46	1	Yes	Squirts	Yes	Squirts	No	
BIS(2-ETHYLHEXYL) PHTHALATE	ug/kg	230	1	No		Yes	SEF-SL1	No	
BUTYL BENZYL PHTHALATE	ug/kg	230	1	No		No		No	
DIETHYL PHTHALATE	ug/kg	230	1	No		No		No	
DIMETHYL PHTHALATE	ug/kg	230	1	No		Yes	SEF-SL1	No	no ESL
DI-N-OCTYL PHTHALATE	ug/kg	230	1	No		Yes	SEF-SL1	No	no ESL
1,2,3,7,8-PECDD	pg/g	0.048	1	No	no ESL	No	no ESL	No	no ESL
2,3,4,7,8-PECDF	pg/g	0.037	1	No	no ESL	No	no ESL	No	no ESL
2,3,7,8-TCDD	pg/g	0.072	1	No	no ESL	No	no ESL	No	
2,3,7,8-TCDF	pg/g	0.1	1	No	no ESL	No	no ESL	No	no ESL
1,2,3-TRICHLOROPROPANE	ug/kg	6.8	1	No	no ESL	No	no ESL	Yes	EPA RSL
1,2-DIBROMO-3-CHLOROPROPANE	ug/kg	6.8	1	No	no ESL	No	no ESL	Yes	EPA RSL
2,4-DIMETHYLPHENOL	ug/kg	230	1	Yes	DMMP-ML	No	no ESL	No	
2-METHYLPHENOL	ug/kg	230	1	Yes	DMMP-ML	No	no ESL	No	no ESL
ACENAPHTHENE	ug/kg	230	1	No		No		No	
ANTHRACENE	ug/kg	230	1	No		No		No	
BENZ(A)ANTHRACENE	ug/kg	230	1	No		No		Yes	EPA RSL
BENZO(A)PYRENE	ug/kg	230	1	No		No		Yes	EPA RSL, CHHSLs
BENZO(B)FLUORANTHENE	ug/kg	230	1	Yes	Squirts	No	no ESL	Yes	EPA RSL
BENZO(K)FLUORANTHENE	ug/kg	230	1	No		No		No	
BENZOIC ACID	ug/kg	910	1	Yes	DMMP-ML	No	no ESL	No	
BENZYL ALCOHOL	ug/kg	230	1	No		No	no ESL	No	
BIS(2-CHLOROETHYL) ETHER	ug/kg	230	1	No	no ESL	No	no ESL	Yes	EPA RSL
CHRYSENE	ug/kg	230	1	No		No		No	
DIBENZ(A,H)ANTHRACENE	ug/kg	230	1	No		No		Yes	EPA RSL
FLUORANTHENE	ug/kg	230	1	No		No		No	
FLUORENE	ug/kg	230	1	No		No		No	
HEXACHLOROBENZENE	ug/kg	230	1	No		No	no ESL	No	
INDENO(1,2,3-CD)PYRENE	ug/kg	230	1	No		No		Yes	EPA RSL
N-NITROSODI-N-PROPYLAMINE	ug/kg	230	1	No		No	no ESL	Yes	EPA RSL
N-NITROSODIPHENYLAMINE	ug/kg	230	1	Yes	DMMP-ML	No	no ESL	No	
PYRENE	ug/kg	230	1	No		No		No	

Appendix C: Summary of COC Selection Process and Evaluation of Reporting Limits Associated with Non-Detected Chemicals

	Units	range RL	total # results	Marine exceeded	Marine notes	Hierarchy Freshwater Exceeded	Freshwater Notes	HH Exceeded	HH Notes
Upper Klamath Estuary									
SILVER	mg/kg	0.68	1	No		No		No	
4,4'-DDD	ug/kg	0.93	1	No		No		No	
4,4'-DDE	ug/kg	0.93	1	No		No		No	
4,4'-DDT	ug/kg	0.93	1	No		No		No	
BHC-gamma (HCH-gamma, Lindane)	ug/kg	0.93	1	No		No		Yes	CHHSLs
CHLORDANE (TECHNICAL)	ug/kg	4.6	1	Yes	SEF-SL1	Yes	Squirts	No	
CHLORDANE-ALPHA	ug/kg	0.93	1	No		No		No	
CHLORDANE-GAMMA	ug/kg	0.93	1	No		No		No	
DIELDRIN	ug/kg	0.93	1	No		No		No	
HEPTACHLOR EPOXIDE	ug/kg	0.93	1	Yes	Squirts	Yes	Squirts	No	
TOXAPHENE	ug/kg	46	1	Yes	Squirts	Yes	Squirts	No	
BUTYL BENZYL PHTHALATE	ug/kg	230	1	No		No		No	
DIETHYL PHTHALATE	ug/kg	230	1	No		No	no ESL	No	
DIMETHYL PHTHALATE	ug/kg	230	1	No		Yes	SEF-SL1	No	no ESL
DI-N-OCTYL PHTHALATE	ug/kg	230	1	No		Yes	SEF-SL1	No	no ESL
1,2,3,7,8-PECDD	pg/g	0.046	1	No	no ESL	No	no ESL	No	no ESL
2,3,4,7,8-PECDF	pg/g	0.024	1	No	no ESL	No	no ESL	No	no ESL
2,3,7,8-TCDD	pg/g	0.028	1	No	no ESL	No	no ESL	No	
1,2,3-TRICHLOROPROPANE	ug/kg	7	1	No	no ESL	No	no ESL	Yes	EPA RSL
1,2-DIBROMO-3-CHLOROPROPANE	ug/kg	7	1	No	no ESL	No	no ESL	Yes	EPA RSL
2,4-DIMETHYLPHENOL	ug/kg	230	1	Yes	DMMP-ML	No	no ESL	No	
2-METHYLPHENOL	ug/kg	230	1	Yes	DMMP-ML	No	no ESL	No	no ESL
ACENAPHTHENE	ug/kg	230	1	No		No		No	
ANTHRACENE	ug/kg	230	1	No		No		No	
BENZ(A)ANTHRACENE	ug/kg	230	1	No		No		Yes	EPA RSL
BENZO(A)PYRENE	ug/kg	230	1	No		No		Yes	EPA RSL, CHHSLs
BENZO(B)FLUORANTHENE	ug/kg	230	1	Yes	Squirts	No	no ESL	Yes	EPA RSL
BENZO(K)FLUORANTHENE	ug/kg	230	1	No		No		No	
BENZOIC ACID	ug/kg	930	1	Yes	DMMP-ML	No	no ESL	No	
BENZYL ALCOHOL	ug/kg	230	1	No		No	no ESL	No	
BIS(2-CHLOROETHYL) ETHER	ug/kg	230	1	No		No	no ESL	Yes	EPA RSL
CHRYSENE	ug/kg	230	1	No		No		No	
DIBENZ(A,H)ANTHRACENE	ug/kg	230	1	No		No		Yes	EPA RSL
FLUORANTHENE	ug/kg	230	1	No		No		No	
FLUORENE	ug/kg	230	1	No		No		No	
HEXACHLOROBENZENE	ug/kg	230	1	No		No	no ESL	No	
INDENO(1,2,3-CD)PYRENE	ug/kg	230	1	No		No		Yes	EPA RSL
N-NITROSODI-N-PROPYLAMINE	ug/kg	230	1	No	no ESL	No	no ESL	Yes	EPA RSL
N-NITROSODIPHENYLAMINE	ug/kg	230	1	Yes	DMMP-ML	No	no ESL	No	
PYRENE	ug/kg	230	1	No		No		No	
TRANS-1,4-DICHLORO-2-BUTENE	ug/kg	7	1	No	no ESL	No	no ESL	Yes	EPA RSL

Units:
metals: mg/kg
pesticides: ug/kg
dioxins and furans: pg/g
SVOCs: ug/kg
phthalates: ug/kg
PCBs: mg/kg

(shaded) : exceeds marine screening levels
BOLD : exceeds freshwater screening levels
underline : exceeds human health screening levels

ODEQ bioaccumulation values only applicable for J.C. Boyle Reservoir

Appendix C: Summary of COC Selection Process and Evaluation of Reporting Limits Associated with Non-Detected Chemicals

	Units	Sample Reporting Limits																
JC Boyle																		
Antimony	mg/kg	0.31	0.74	0.8	0.84	0.97	0.97	0.99	1	1	1	1.1	1.2	1.5	1.7			
Cadmium	mg/kg	0.16	0.37	0.4	0.42	0.48	0.49	0.49	0.5	0.51	0.51	0.56	0.59	0.77	0.84			
Mercury	mg/kg	0.063	0.15	0.16	0.17	0.19	0.19	0.2	0.2	0.2	0.2	0.23	0.24	0.31	0.34			
Silver	mg/kg	0.79	1.9	2	2.1	2.4	2.4	2.5	2.5	2.5	2.5	2.8	3	3	3.8			
4,4,'-DDD	ug/kg	0.9	2.4	2.5	2.6	2.8	3.1	3.2	3.3	3.4	3.8	3.9	4.8	4.9				
4,4,'-DDE	ug/kg	0.9	2.4	2.5	2.6	2.8	3.1	3.2	3.3	3.4	3.8	3.9	4.8	4.9				
4,4,'-DDT	ug/kg	0.9	2.4	2.5	2.6	2.8	3.1	3.2	3.2	3.3	3.8	3.9	4.8	4.9				
Aroclor 1221	mg/kg	0.24	0.25	0.26	0.28	0.31	0.32	0.32	0.33	0.34	0.38	0.39	0.48	0.49				
Aroclor 1232	mg/kg	0.16	0.16	0.16	0.16	0.17	0.19	0.19	0.24	0.24								
Aroclor 1242	mg/kg	0.045	0.12	0.13	0.13	0.14	0.16	0.16	0.16	0.16	0.17	0.19	0.19	0.24	0.24			
Aroclor 1248	mg/kg	0.045	0.12	0.13	0.13	0.14	0.16	0.16	0.16	0.16	0.17	0.19	0.19	0.24	0.24			
Aroclor 1254	mg/kg	0.045	0.12	0.13	0.13	0.14	0.16	0.16	0.16	0.16	0.17	0.19	0.19	0.24	0.24			
Aroclor 1260	mg/kg	0.045	0.12	0.13	0.13	0.14	0.16	0.16	0.16	0.16	0.17	0.19	0.19	0.24	0.24			
BHC-Gamma (HCH-gamma, Lindane)	ug/kg	0.9	2.4	2.5	2.6	2.8	3.1	3.2	3.2	3.3	3.4	3.8	3.9	4.8	4.9			
Chlordane (Technical)	ug/kg	4.5	12	13	13	14	16	16	16	16	17	19	19	24	24			
Chlordane-Alpha	ug/kg	0.9	2.4	2.5	2.6	2.8	3.1	3.2	3.2	3.3	3.4	3.8	3.9	4.8	4.9			
Chlordane-Gamma	ug/kg	0.9	2.4	2.5	2.6	2.8	3.1	3.2	3.2	3.3	3.4	3.8	3.9	4.8	4.9			
Dieldrin	ug/kg	0.9	2.4	2.5	2.6	2.8	3.1	3.2	3.3	3.4	3.8	3.9	4.8	4.9				
Endrin	ug/kg	0.9	2.4	2.5	2.6	2.8	3.1	3.2	3.2	3.3	3.4	3.8	3.9	4.8	4.9			
Heptachlor	ug/kg	0.9	2.4	2.5	2.6	2.8	3.1	3.2	3.2	3.3	3.4	3.8	3.9	4.8	4.9			
Heptachlor Epoxide	ug/kg	0.9	2.4	2.5	2.6	2.8	3.1	3.2	3.2	3.3	3.4	3.8	3.9	4.8	4.9			
Toxaphene	ug/kg	45	120	130	130	140	160	160	160	160	170	190	190	240	240			
Bis(2-ethylhexyl)phthalate	ug/kg	230	510	610	680	720	770	790	800	810	830	920	950	1200	1200			
Butyl benzyl phthalate	ug/kg	230	510	610	680	720	770	790	800	810	830	920	950	1200	1200			
Diethyl phthalate	ug/kg	230	510	610	680	720	770	790	800	810	830	920	950	1200	1200			
Dimethyl phthalate	ug/kg	230	510	610	680	720	770	790	800	810	830	920	950	1200	1200			
Di-n-octyl phthalate	ug/kg	230	510	610	680	720	770	790	800	810	830	920	950	1200	1200			
1,2,3,7,8-PECDD	pg/g	0.91																
2,3,7,8-TCDD	pg/g	0.3																
1,2,3-TRICHLOROPROPANE	ug/kg	6.7	18	19	19	19	22	23	23	24	24	24	26	27	28	30	36	
1,2,4-TRICHLOROBENZENE	ug/kg	6.7	18	19	19	19	22	23	23	24	24	24	26	27	28	30	36	
1,2-DIBROMO-3-CHLOROPROPANE	ug/kg	6.7	18	19	19	19	22	23	23	24	24	24	26	27	28	30	36	
1,2-DICHLOROBENZENE	ug/kg	6.7	18	19	19	19	22	23	23	24	24	24	26	27	28	30	36	
2,4-DIMETHYLPHENOL	ug/kg	230	510	610	680	720	770	790	800	810	830	920	950	1200	1200			
2-METHYLNAPHTHALENE	ug/kg	230	510	610	680	720	770	790	800	810	830	920	950	1200	1200			
2-METHYLPHENOL	ug/kg	230	510	610	680	720	770	790	800	810	830	920	950	1200	1200			
3,3'-DICHLOROBENZIDINE	ug/kg	230	510	610	680	720	770	790	800	810	830	920	950	1200	1200			
4-METHYLPHENOL	ug/kg	230	510	610	680	720	770	790	800	810	830	920	950	1200	1200			
ACENAPHTHENE	ug/kg	230	510	610	680	720	770	790	800	810	830	920	950	1200	1200			
ACENAPHTHYLENE	ug/kg	230	510	610	680	720	770	790	800	810	830	920	950	1200	1200			
ANTHRACENE	ug/kg	230	510	610	680	720	770	790	800	810	830	920	950	1200	1200			
BENZ(A)ANTHRACENE	ug/kg	230	510	610	680	720	770	790	800	810	830	920	950	1200	1200			
BENZO(A)PYRENE	ug/kg	230	510	610	680	720	770	790	800	810	830	920	950	1200	1200			
BENZO(B)FLUORANTHENE	ug/kg	230	510	610	680	720	770	790	800	810	830	920	950	1200	1200			
BENZO(G,H,I)PERYLENE	ug/kg	230	510	610	680	720	770	790	800	810	830	920	950	1200	1200			
BENZO(K)FLUORANTHENE	ug/kg	230	510	610	680	720	770	790	800	810	830	920	950	1200	1200			
BENZOIC ACID	ug/kg	930	2000	2400	2700	2900	3100	3200	3200	3200	3300	3700	3800	4800	4800			
BENZYL ALCOHOL	ug/kg	230	510	610	680	720	770	790	800	810	830	920	950	1200	1200			
BIS(2-CHLOROETHYL) ETHER	ug/kg	230	510	610	680	720	770	790	800	810	830	920	950	1200	1200			
CHRYSENE	ug/kg	230	510	610	680	720	770	790	800	810	830	920	950	1200	1200			

Appendix C: Summary of COC Selection Process and Evaluation of Reporting Limits Associated with Non-Detected Chemicals

	Units	Sample Reporting Limits																
DIBENZ(A,H)ANTHRACENE	ug/kg	230	510	610	680	720	770	790	800	810	830	920	950	1200	1200			
DIBENZOFURAN	ug/kg	230	510	610	680	720	770	790	800	810	830	920	950	1200	1200			
FLUORANTHENE	ug/kg	230	510	610	680	720	770	790	800	810	830	920	950	1200	1200			
FLUORENE	ug/kg	230	510	610	680	720	770	790	800	810	830	920	950	1200	1200			
HEXACHLOROBENZENE	ug/kg	230	510	610	680	720	770	790	800	810	830	920	950	1200	1200			
HEXACHLOROBUTADIENE	ug/kg	6.7	18	19	19	19	22	23	23	24	24	24	26	27	28	30	36	
INDENO(1,2,3-CD)PYRENE	ug/kg	230	510	610	680	720	770	790	800	810	830	920	950	1200	1200			
NAPHTHALENE	ug/kg	6.7	18	19	19	19	22	23	23	24	24	24	26	27	28	30	36	
N-NITROSODI-N-PROPYLAMINE	ug/kg	230	510	610	680	720	770	790	800	810	830	920	950	1200	1200			
N-NITROSODIPHENYLAMINE	ug/kg	230	510	610	680	720	770	790	800	810	830	920	950	1200	1200			
PHENOL	ug/kg	230	510	610	680	720	770	790	800	810	830	920	950	1200	1200			
PYRENE	ug/kg	230	510	610	680	720	770	790	800	810	830	920	950	1200	1200			
TRANS-1,4-DICHLORO-2-BUTENE	ug/kg	6.7	18	19	19	19	22	23	23	24	24	24	26	27	28	30	36	
1,2-DIBROMOETHANE	ug/kg	6.7	18	19	19	19	22	23	23	24	24	24	26	27	28	30	36	
ETHYLBENZENE	ug/kg	6.7	18	19	19	19	22	23	23	24	24	24	26	27	28	30	36	
Copco 1																		
ANTIMONY	mg/kg	0.72	0.72	0.75	0.76	0.78	0.78	0.78	0.8	0.81	0.81	0.82	0.83	0.86	0.87	0.89	0.91	0.95
CADMIUM	mg/kg	0.36	0.36	0.37	0.38	0.39	0.39	0.39	0.4	0.4	0.41	0.41	0.41	0.43	0.44	0.45	0.46	0.48
MERCURY	mg/kg	0.14	0.14	0.15	0.15	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.17	0.17	0.17	0.18	0.18	0.19
SILVER	mg/kg	1.8	1.8	1.9	1.9	1.9	2	2	2	2	2	2	2.1	2.2	2.2	2.2	2.3	2.4
AROCLOR 1221	mg/kg	0.24	0.24	0.24	0.25	0.25	0.25	0.25	0.26	0.26	0.27	0.27	0.27	0.28	0.28	0.28	0.29	0.3
AROCLOR 1232	mg/kg	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.14	0.14	0.14	0.14	0.14	0.15
4,4'-DDD	ug/kg	2.4	2.4	2.4	2.5	2.5	2.5	2.5	2.6	2.6	2.7	2.7	2.7	2.8	2.8	2.8	2.9	3
4,4'-DDE	ug/kg	2.4	2.4	2.4	2.5	2.5	2.5	2.5	2.6	2.6	2.7	2.7	2.7	2.8	2.8	2.8	2.9	3
4,4'-DDT	ug/kg	2.4	2.4	2.4	2.5	2.5	2.5	2.5	2.6	2.6	2.7	2.7	2.7	2.8	2.8	2.8	2.9	3
BHC-gamma (HCH-gamma, Lindane)	ug/kg	2.4	2.4	2.4	2.5	2.5	2.5	2.5	2.6	2.6	2.7	2.7	2.7	2.8	2.8	2.8	2.9	3
CHLORDANE (TECHNICAL)	ug/kg	12	12	12	12	13	13	13	13	13	13	13	14	14	14	14	14	15
CHLORDANE-ALPHA	ug/kg	2.4	2.4	2.4	2.5	2.5	2.5	2.5	2.6	2.6	2.7	2.7	2.7	2.8	2.8	2.8	2.9	3
CHLORDANE-GAMMA	ug/kg	2.4	2.4	2.4	2.5	2.5	2.5	2.5	2.6	2.6	2.7	2.7	2.7	2.8	2.8	2.8	2.9	3
DIELDRIN	ug/kg	2.4	2.4	2.4	2.5	2.5	2.5	2.5	2.6	2.6	2.7	2.7	2.7	2.8	2.8	2.8	2.9	3
ENDRIN	ug/kg	2.4	2.4	2.4	2.5	2.5	2.5	2.5	2.6	2.6	2.7	2.7	2.7	2.8	2.8	2.8	2.9	3
HEPTACHLOR	ug/kg	2.4	2.4	2.4	2.5	2.5	2.5	2.5	2.6	2.6	2.7	2.7	2.7	2.8	2.8	2.8	2.9	3
HEPTACHLOR EPOXIDE	ug/kg	2.4	2.4	2.4	2.5	2.5	2.5	2.5	2.6	2.6	2.7	2.7	2.7	2.8	2.8	2.8	2.9	3
TOXAPHENE	ug/kg	120	120	120	120	130	130	130	130	130	130	130	140	140	140	140	140	150
BIS(2-ETHYLHEXYL) PHTHALATE	ug/kg	580	580	590	620	620	620	620	620	650	650	660	680	700	700	710	710	730
BUTYL BENZYL PHTHALATE	ug/kg	580	580	590	620	620	620	620	620	650	650	660	680	700	700	710	710	730
DIETHYL PHTHALATE	ug/kg	580	580	590	620	620	620	620	620	650	650	660	680	700	700	710	710	730
DIMETHYL PHTHALATE	ug/kg	580	580	590	620	620	620	620	620	650	650	660	680	700	700	710	710	730
DI-N-OCTYL PHTHALATE	ug/kg	580	580	590	620	620	620	620	620	650	650	660	680	700	700	710	710	730

Appendix C: Summary of COC Selection Process and Evaluation of Reporting Limits Associated with Non-Detected Chemicals

	Units	Sample Reporting Limits																
1,2,3,7,8,9-HXCDF	pg/g	0.43																
1,2,3,7,8-PECDF	pg/g	0.47																
2,3,7,8-TCDD	pg/g	0.17	0.25															
1,2,3-TRICHLOROPROPANE	ug/kg	18	18	18	19	19	19	19	19	20	20	20	20	21	21	21	21	22
1,2-DIBROMO-3-CHLOROPROPANE	ug/kg	18	18	18	19	19	19	19	19	20	20	20	20	21	21	21	21	22
2,4-DIMETHYLPHENOL	ug/kg	580	580	590	620	620	620	620	620	650	650	660	680	700	700	710	710	730
2-METHYLNAPHTHALENE	ug/kg	**580**	**580**	**590**	**620**	**620**	**620**	**620**	**620**	**650**	**650**	**660**	**680**	**700**	**700**	**710**	**710**	**730**
2-METHYLPHENOL	ug/kg	580	580	590	620	620	620	620	620	650	650	660	680	700	700	710	710	730
ACENAPHTHENE	ug/kg	580	580	590	620	620	620	620	620	650	650	660	680	700	700	710	710	730
ACENAPHTHYLENE	ug/kg	**580**	**580**	**590**	**620**	**620**	**620**	**620**	**620**	**650**	**650**	**660**	**680**	**700**	**700**	**710**	**710**	**730**
ANTHRACENE	ug/kg	580	580	590	620	620	620	620	620	650	650	660	680	700	700	710	710	730
BENZ(A)ANTHRACENE	ug/kg	580	580	590	620	620	620	620	620	650	650	660	680	700	700	710	710	730
BENZO(A)PYRENE	ug/kg	580	580	590	620	620	620	620	620	650	650	660	680	700	700	710	710	730
BENZO(B)FLUORANTHENE	ug/kg	580	580	590	620	620	620	620	620	650	650	660	680	700	700	710	710	730
BENZO(G,H,I)PERYLENE	ug/kg	580	580	590	620	620	620	620	620	650	650	660	680	700	700	710	710	730
BENZO(K)FLUORANTHENE	ug/kg	580	580	590	**620**	**620**	**620**	**620**	**620**	**650**	**650**	**660**	**680**	**700**	**700**	**710**	**710**	**730**
BENZOIC ACID	ug/kg	2300	2300	2400	2500	2500	2500	2500	2500	2600	2600	2700	2700	2800	2800	2800	2900	2900
BENZYL ALCOHOL	ug/kg	580	580	590	620	620	620	620	620	650	650	660	680	700	700	710	710	730
BIS(2-CHLOROETHYL) ETHER	ug/kg	580	580	590	620	620	620	620	620	650	650	660	680	700	700	710	710	730
CHRYSENE	ug/kg	580	580	590	620	620	620	620	620	650	650	660	680	700	700	710	710	730
DIBENZ(A,H)ANTHRACENE	ug/kg	580	580	590	620	620	620	620	620	650	650	660	680	700	700	710	710	730
DIBENZOFURAN	ug/kg	**580**	**580**	**590**	**620**	**620**	**620**	**620**	**620**	**650**	**650**	**660**	**680**	**700**	**700**	**710**	**710**	**730**
FLUORANTHENE	ug/kg	580	580	590	620	620	620	620	620	650	650	660	680	700	700	710	710	730
FLUORENE	ug/kg	580	580	590	620	620	620	620	620	650	650	660	680	700	700	710	710	730
HEXACHLOROBENZENE	ug/kg	580	580	590	620	620	620	620	620	650	650	660	680	700	700	710	710	730
HEXACHLOROBUTADIENE	ug/kg	18	18	18	19	19	19	19	19	20	20	20	20	21	21	21	21	22
INDENO(1,2,3-CD)PYRENE	ug/kg	580	580	590	620	620	620	620	620	650	650	660	680	700	700	710	710	730
N-NITROSODI-N-PROPYLAMINE	ug/kg	580	580	590	620	620	620	620	620	650	650	660	680	700	700	710	710	730
N-NITROSODIPHENYLAMINE	ug/kg	580	580	590	620	620	620	620	620	650	650	660	680	700	700	710	710	730
PHENOL	ug/kg	580	580	590	620	620	620	620	620	650	650	660	680	700	700	710	710	730
PYRENE	ug/kg	580	580	590	620	620	620	620	620	650	650	660	680	700	700	710	710	730
TRANS-1,4-DICHLORO-2-BUTENE	ug/kg	18	18	18	19	19	19	19	19	20	20	20	20	21	21	21	21	22
ETHYLBENZENE	ug/kg	18	18	18	19	19	19	19	19	20	20	20	20	21	21	21	21	22
Iron Gate																		
ANTIMONY	mg/kg	0.38	0.42	0.45	0.54	0.62	0.71	0.75	0.78	0.81	0.84	0.85	0.87	0.87	0.89			
CADMIUM	mg/kg	0.19	0.21	0.23	0.27	0.31	0.35	0.37	0.39	0.4	0.42	0.42	0.43	0.43	0.45			
MERCURY	mg/kg	0.075	0.083	0.091	0.11	0.12	0.14	0.15	0.16	0.16	0.17	0.17	0.17	0.17	0.18			
SILVER	mg/kg	0.94	1	1.1	1.4	1.5	1.8	1.9	2	2	**2.1**	**2.1**	**2.2**	**2.2**	**2.2**			
AROCLOR 1221	mg/kg	**0.067**	**0.12**	**0.13**	**0.15**	**0.19**	**0.2**	**0.24**	**0.25**	**0.25**	**0.26**	**0.26**	**0.28**	**0.29**	**0.3**			
AROCLOR 1232	mg/kg	0.033	**0.062**	**0.066**	**0.075**	**0.096**	**0.098**	**0.12**	**0.12**	**0.13**	**0.13**	**0.13**	**0.14**	**0.14**	**0.15**			
4,4'-DDD	ug/kg	0.67	1.2	1.3	1.5	1.7	1.9	2.1	2.4	2.5	2.5	2.6	2.6	2.8	2.9	3		
4,4'-DDE	ug/kg	0.67	1.2	1.3	**1.5**	**1.7**	**1.9**	**2.1**	**2.4**	**2.5**	**2.5**	**2.6**	**2.6**	**2.8**	**2.9**	**3**		
4,4'-DDT	ug/kg	0.67	**1.2**	**1.3**	**1.5**	**1.7**	**1.9**	**2.1**	**2.4**	**2.5**	**2.5**	**2.6**	**2.6**	**2.8**	**2.9**	**3**		
BHC-gamma (HCH-gamma, Lindane)	ug/kg	0.67	**1.2**	**1.3**	**1.5**	**1.7**	**1.9**	**2.1**	**2.4**	**2.5**	**2.5**	**2.6**	**2.6**	**2.8**	**2.9**	**3**		
CHLORDANE (TECHNICAL)	ug/kg	**3.3**	**6.2**	**6.6**	**7.5**	**8.5**	**9.6**	**10**	**12**	**12**	**13**	**13**	**13**	**14**	**14**	**15**		
CHLORDANE-ALPHA	ug/kg	0.67	1.2	1.3	1.5	1.7	1.9	2.1	2.4	2.5	2.5	2.6	2.6	2.8	2.9	3		
CHLORDANE-GAMMA	ug/kg	0.67	1.2	1.3	1.5	1.7	1.9	2.1	2.4	2.5	2.5	2.6	2.6	2.8	2.9	3		
DIELDRIN	ug/kg	0.67	1.2	1.3	1.5	1.7	1.9	**2.1**	**2.4**	**2.5**	**2.5**	**2.6**	**2.6**	**2.8**	**2.9**	**3**		

Appendix C: Summary of COC Selection Process and Evaluation of Reporting Limits Associated with Non-Detected Chemicals

	Units	Sample Reporting Limits																
ENDRIN	ug/kg	0.67	1.2	1.3	1.5	1.7	1.9	2.1	2.4	2.5	2.5	2.6	2.6	2.8	2.9	3		
HEPTACHLOR	ug/kg	0.67	1.2	1.3	1.5	1.7	1.9	2.1	2.4	2.5	2.5	2.6	2.6	2.8	2.9	3		
HEPTACHLOR EPOXIDE	ug/kg	0.67	1.2	1.3	1.5	1.7	1.9	2.1	2.4	2.5	2.5	2.6	2.6	2.8	2.9	3		
TOXAPHENE	ug/kg	33	62	66	75	85	96	100	120	120	130	130	130	140	140	150		
BIS(2-ETHYLHEXYL) PHTHALATE	ug/kg	170	310	330	370	420	470	520	590	600	630	630	640	700	710	730		
BUTYL BENZYL PHTHALATE	ug/kg	170	310	330	370	420	470	520	590	600	630	630	640	700	710	730		
DIETHYL PHTHALATE	ug/kg	170	310	330	370	420	470	520	590	600	630	630	640	700	710	730		
DIMETHYL PHTHALATE	ug/kg	170	310	330	370	420	470	520	590	600	630	630	640	700	710	730		
DI-N-BUTYL PHTHALATE	ug/kg	170	310	330	370	420	470	520	590	600	630	630	640	700	710	730		
DI-N-OCTYL PHTHALATE	ug/kg	170	310	330	370	420	470	520	590	600	630	630	640	700	710	730		
1,2,3,4,7,8-HXCDD	pg/g	0.78	1.2															
1,2,3,4,7,8-HXCDF	pg/g	0.96	1.1	0.22	0.3	0.81												
1,2,3,7,8-PECDF	pg/g	0.34	0.71	0.72														
2,3,4,7,8-PECDF	pg/g	0.71	0.72															
2,3,7,8-TCDD	pg/g	0.17	0.18	0.21														
2,3,7,8-TCDF	pg/g	0.72																
1,2,3-TRICHLOROPROPANE	ug/kg	5	9.3	9.9	11	14	15	18	19	19	19	19	21	21	22			
1,2,4-TRICHLOROBENZENE	ug/kg	5	9.3	9.9	11	14	15	18	19	19	19	19	21	21	22	520		
1,2-DIBROMO-3-CHLOROPROPANE	ug/kg	5	9.3	9.9	11	14	15	18	19	19	19	19	21	21	22			
1,2-DICHLOROBENZENE	ug/kg	5	9.3	9.9	11	14	15	18	19	19	19	19	21	21	22	520		
1,3-DICHLOROBENZENE	ug/kg	5	9.3	9.9	11	14	15	18	19	19	19	19	21	21	22	520		
1,4-DICHLOROBENZENE	ug/kg	5	9.3	9.9	11	14	15	18	19	19	19	19	21	21	22	520		
2,4-DIMETHYLPHENOL	ug/kg	170	310	330	370	420	470	520	590	600	630	630	640	700	710	730		
2-METHYLNAPHTHALENE	ug/kg	170	310	330	370	420	470	520	590	600	630	630	640	700	710	730		
2-METHYLPHENOL	ug/kg	170	310	330	370	420	470	520	590	600	630	630	640	700	710	730		
4-METHYLPHENOL	ug/kg	170	310	330	370	420	470	520	590	600	630	630	640	700	710	730		
ACENAPHTHENE	ug/kg	170	310	330	370	420	470	520	590	600	630	630	640	700	710	730		
ACENAPHTHYLENE	ug/kg	170	310	330	370	420	470	520	590	600	630	630	640	700	710	730		
ANTHRACENE	ug/kg	170	310	330	370	420	470	520	590	600	630	630	640	700	710	730		
BENZ(A)ANTHRACENE	ug/kg	170	310	330	370	420	470	520	590	600	630	630	640	700	710	730		
BENZO(A)PYRENE	ug/kg	170	310	330	370	420	470	520	590	600	630	630	640	700	710	730		
BENZO(B)FLUORANTHENE	ug/kg	170	310	330	370	420	470	520	590	600	630	630	640	700	710	730		
BENZO(G,H,I)PERYLENE	ug/kg	170	310	330	370	420	470	520	590	600	630	630	640	700	710	730		
BENZO(K)FLUORANTHENE	ug/kg	170	310	330	370	420	470	520	590	600	630	630	640	700	710	730		
BENZOIC ACID	ug/kg	670	1200	1300	1500	1700	1900	2100	2400	2400	2500	2500	2600	2800	2900	2900		
BENZYL ALCOHOL	ug/kg	170	310	330	370	420	470	520	590	600	630	630	640	700	710	730		
BIS(2-CHLOROETHYL) ETHER	ug/kg	170	310	330	370	420	470	520	590	600	630	630	640	700	710	730		
CHRYSENE	ug/kg	170	310	330	370	420	470	520	590	600	630	630	640	700	710	730		
DIBENZ(A,H)ANTHRACENE	ug/kg	170	310	330	370	420	470	520	590	600	630	630	640	700	710	730		
DIBENZOFURAN	ug/kg	170	310	330	370	420	470	520	590	600	630	630	640	700	710	730		
FLUORANTHENE	ug/kg	170	310	330	370	420	470	520	590	600	630	630	640	700	710	730		
FLUORENE	ug/kg	170	310	330	370	420	470	520	590	600	630	630	640	700	710	730		
HEXACHLOROBENZENE	ug/kg	170	310	330	370	420	470	520	590	600	630	630	640	700	710	730		
HEXACHLOROBUTADIENE	ug/kg	5	9.3	9.9	11	14	15	18	19	19	19	19	21	21	22	520		
INDENO(1,2,3-CD)PYRENE	ug/kg	170	310	330	370	420	470	520	590	600	630	630	640	700	710	730		
NAPHTHALENE	ug/kg	5	9.3	9.9	11	14	15	18	19	19	19	19	21	21	22	520		
N-NITROSODI-N-PROPYLAMINE	ug/kg	170	310	330	370	420	470	520	590	600	630	630	640	700	710	730		
N-NITROSODIPHENYLAMINE	ug/kg	170	310	330	370	420	470	520	590	600	630	630	640	700	710	730		
PHENOL	ug/kg	170	310	330	370	420	470	520	590	600	630	630	640	700	710	730		
PYRENE	ug/kg	170	310	330	370	420	470	520	590	600	630	630	640	700	710	730		
TRANS-1,4-DICHLORO-2-BUTENE	ug/kg	5	9.3	9.9	11	14	15	18	19	19	19	19	21	21	22			
ETHYLBENZENE	ug/kg	5	9.3	9.9	11	14	15	18	19	19	19	19	21	21	22			

	Units	Sample Reporting Limits																
Lower Klamath Estuary																		
SILVER	mg/kg	0.75																
4,4'-DDD	ug/kg	0.91																
4,4'-DDE	ug/kg	0.91																
4,4'-DDT	ug/kg	0.91																
BHC-gamma (HCH-gamma, Lindane)	ug/kg	0.91																
CHLORDANE (TECHNICAL)	ug/kg	**4.6**																
CHLORDANE-ALPHA	ug/kg	0.91																
CHLORDANE-GAMMA	ug/kg	0.91																
DIELDRIN	ug/kg	0.91																
HEPTACHLOR EPOXIDE	ug/kg	**0.91**																
TOXAPHENE	ug/kg	**46**																
BIS(2-ETHYLHEXYL) PHTHALATE	ug/kg	**230**																
BUTYL BENZYL PHTHALATE	ug/kg	230																
DIETHYL PHTHALATE	ug/kg	230																
DIMETHYL PHTHALATE	ug/kg	**230**																
DI-N-OCTYL PHTHALATE	ug/kg	**230**																
1,2,3,7,8-PECDD	pg/g	0.048																
2,3,4,7,8-PECDF	pg/g	0.037																
2,3,7,8-TCDD	pg/g	0.072																
2,3,7,8-TCDF	pg/g	0.1																
1,2,3-TRICHLOROPROPANE	ug/kg	6.8																
1,2-DIBROMO-3-CHLOROPROPANE	ug/kg	6.8																
2,4-DIMETHYLPHENOL	ug/kg	230																
2-METHYLPHENOL	ug/kg	230																
ACENAPHTHENE	ug/kg	230																
ANTHRACENE	ug/kg	230																
BENZ(A)ANTHRACENE	ug/kg	230																
BENZO(A)PYRENE	ug/kg	230																
BENZO(B)FLUORANTHENE	ug/kg	230																
BENZO(K)FLUORANTHENE	ug/kg	230																
BENZOIC ACID	ug/kg	910																
BENZYL ALCOHOL	ug/kg	230																
BIS(2-CHLOROETHYL) ETHER	ug/kg	230																
CHRYSENE	ug/kg	230																
DIBENZ(A,H)ANTHRACENE	ug/kg	230																
FLUORANTHENE	ug/kg	230																
FLUORENE	ug/kg	230																
HEXACHLOROBENZENE	ug/kg	230																
INDENO(1,2,3-CD)PYRENE	ug/kg	230																
N-NITROSODI-N-PROPYLAMINE	ug/kg	230																
N-NITROSODIPHENYLAMINE	ug/kg	230																
PYRENE	ug/kg	230																

	Units	Sample Reporting Limits																
Upper Klamath Estuary																		
SILVER	mg/kg	0.68																
4,4'-DDD	ug/kg	0.93																
4,4'-DDE	ug/kg	0.93																
4,4'-DDT	ug/kg	0.93																
BHC-gamma (HCH-gamma, Lindane)	ug/kg	0.93																
CHLORDANE (TECHNICAL)	ug/kg	4.6																
CHLORDANE-ALPHA	ug/kg	0.93																
CHLORDANE-GAMMA	ug/kg	0.93																
DIELDRIN	ug/kg	0.93																
HEPTACHLOR EPOXIDE	ug/kg	0.93																
TOXAPHENE	ug/kg	**46**																
BUTYL BENZYL PHTHALATE	ug/kg	230																
DIETHYL PHTHALATE	ug/kg	230																
DIMETHYL PHTHALATE	ug/kg	**230**																
DI-N-OCTYL PHTHALATE	ug/kg	**230**																
1,2,3,7,8-PECDD	pg/g	0.046																
2,3,4,7,8-PECDF	pg/g	0.024																
2,3,7,8-TCDD	pg/g	0.028																
1,2,3-TRICHLOROPROPANE	ug/kg	7																
1,2-DIBROMO-3-CHLOROPROPANE	ug/kg	7																
2,4-DIMETHYLPHENOL	ug/kg	230																
2-METHYLPHENOL	ug/kg	230																
ACENAPHTHENE	ug/kg	230																
ANTHRACENE	ug/kg	230																
BENZ(A)ANTHRACENE	ug/kg	230																
BENZO(A)PYRENE	ug/kg	230																
BENZO(B)FLUORANTHENE	ug/kg	230																
BENZO(K)FLUORANTHENE	ug/kg	230																
BENZOIC ACID	ug/kg	930																
BENZYL ALCOHOL	ug/kg	230																
BIS(2-CHLOROETHYL) ETHER	ug/kg	230																
CHRYSENE	ug/kg	230																
DIBENZ(A,H)ANTHRACENE	ug/kg	230																
FLUORANTHENE	ug/kg	230																
FLUORENE	ug/kg	230																
HEXACHLOROBENZENE	ug/kg	230																
INDENO(1,2,3-CD)PYRENE	ug/kg	230																
N-NITROSODI-N-PROPYLAMINE	ug/kg	230																
N-NITROSODIPHENYLAMINE	ug/kg	230																
PYRENE	ug/kg	230																
TRANS-1,4-DICHLORO-2-BUTENE	ug/kg	7																

Units:
metals: mg/kg
pesticides: ug/kg
dioxins and furans: pg/g
SVOCs: ug/kg
phthalates: ug/kg
PCBs: mg/kg

Appendix D
Summary of the Fish and Invertebrate Tissue Data

APPENDIX D. TABLE D1
FISH TISSUE DATA SORTED BY CHEMICAL

"Total PBDEs" are the simple sum of all the "BDE xxx" values for each sample
"Total PCBs" are the simple sum of all the "PCB xxx" values for each sample

								NOEL			LOEL		
Species	Sample	Analyte	Bound	Result	Units	MDL	RL	BULLHEAD	PERCH	BASS	BULLHEAD	PERCH	BASS
Ameiurus spp	IG-BH COMP 1	2,3,7,8-TCDD	<	0.4	pg/g	0.4	0.96	190000	143	1000	1900000	1430	16000
Ameiurus spp	CR-BH COMP 1	2,3,7,8-TCDD	<	0.41	pg/g	0.41	0.96	190000	143	1000	1900000	1430	16000
Ameiurus spp	JC-BH COMP 2	2,3,7,8-TCDD	<	0.44	pg/g	0.44	0.97	190000	143	1000	1900000	1430	16000
Ameiurus spp	JC-BH COMP 1	2,3,7,8-TCDD	<	0.51	pg/g	0.51	0.97	190000	143	1000	1900000	1430	16000
Ameiurus spp	CR-BH COMP 1	Arsenic	=	0.007	mg/kg	0.003	0.009			1.8			2.24
Ameiurus spp	IG-BH COMP 1	Arsenic	=	0.016	mg/kg	0.003	0.01			1.8			2.24
Ameiurus spp	JC-BH COMP 2	Arsenic	=	0.02	mg/kg	0.005	0.017			1.8			2.24
Ameiurus spp	JC-BH COMP 2	Arsenic	=	0.02	mg/kg	0.005	0.018			1.8			2.24
Ameiurus spp	CR-BH COMP 1	Arsenic	=	0.022	mg/kg	0.003	0.01			1.8			2.24
Ameiurus spp	JC-BH COMP 1	Arsenic	=	0.029	mg/kg	0.003	0.009			1.8			2.24
Ameiurus spp	CR-BH COMP 1	Arsenic	=	0.032	mg/kg	0.003	0.009			1.8			2.24
Ameiurus spp	CR-BH COMP 1	Arsenic	=	0.057	mg/kg	0.003	0.009			1.8			2.24
Ameiurus spp	CR-BH COMP 1	Arsenic	=	0.061	mg/kg	0.003	0.009			1.8			2.24
Ameiurus spp	JC-BH COMP 2	Arsenic	=	0.084	mg/kg	0.005	0.017			1.8			2.24
Ameiurus spp	JC-BH COMP 2	Arsenic	=	0.121	mg/kg	0.005	0.017			1.8			2.24
Ameiurus spp	JC-BH COMP 2	Arsenic	=	0.141	mg/kg	0.005	0.018			1.8			2.24
Ameiurus spp	CR-BH COMP 1	Arsenic	<	0.15	mg/kg	0.15	0.2			1.8			2.24
Ameiurus spp	IG-BH COMP 1	Arsenic	<	0.15	mg/kg	0.15	0.2			1.8			2.24
Ameiurus spp	JC-BH COMP 2	Arsenic	<	0.15	mg/kg	0.15	0.2			1.8			2.24
Ameiurus spp	JC-BH COMP 1	Arsenic	=	0.17	mg/kg	0.15	0.2			1.8			2.24
Ameiurus spp	IG-BH COMP 1	Arsenic	=	20.1	mg/kg	0.15	0.2			1.8			2.24
Ameiurus spp	IG-BH COMP 1	DDE	=	3.726	ug/kg	0.0098	0.078			40000			75000
Ameiurus spp	JC-BH COMP 2	DDE	=	4.325	ug/kg	0.0084	0.074			40000			75000
Ameiurus spp	CR-BH COMP 1	DDE	=	6.728	ug/kg	0.0179	0.078			40000			75000
Ameiurus spp	JC-BH COMP 1	DDE	=	7.144	ug/kg	0.0182	0.076			40000			75000
Ameiurus spp	IG-BH COMP 1	DDT	=	0.0155	ug/kg	0.0155	0.078			4200			42000
Ameiurus spp	JC-BH COMP 2	DDT	=	0.019	ug/kg	0.019	0.074			4200			42000
Ameiurus spp	JC-BH COMP 1	DDT	=	0.024	ug/kg	0.024	0.076			4200			42000
Ameiurus spp	CR-BH COMP 1	DDT	=	0.052	ug/kg	0.027	0.078			4200			42000
Ameiurus spp	JC-BH COMP 2	Dieldrin	=	0.048	ug/kg	0.02	0.037			3700			37000
Ameiurus spp	CR-BH COMP 1	Dieldrin	=	0.064	ug/kg	0.042	0.042			3700			37000
Ameiurus spp	JC-BH COMP 1	Dieldrin	=	0.072	ug/kg	0.034	0.038			3700			37000
Ameiurus spp	IG-BH COMP 1	Dieldrin	=	0.077	ug/kg	0.018	0.039			3700			37000
Ameiurus spp	IG-BH COMP 1	Endrin	<	0.018	ug/kg	0.018	0.039			80			300
Ameiurus spp	JC-BH COMP 2	Endrin	<	0.02	ug/kg	0.02	0.037			80			300
Ameiurus spp	JC-BH COMP 1	Endrin	<	0.033	ug/kg	0.033	0.038			80			300
Ameiurus spp	CR-BH COMP 1	Endrin	<	0.038	ug/kg	0.038	0.039			80			300
Ameiurus spp	JC-BH COMP 1	Mercury	=	0.0236	mg/kg	0.001	0.0029	0.0006	0.135	5.4	0.006	1.35	54
Ameiurus spp	JC-BH COMP 2	Mercury	=	0.032	mg/kg	0.0014	0.0041	0.0006	0.135	5.4	0.006	1.35	54
Ameiurus spp	JC-BH COMP 2	Mercury	=	0.034	mg/kg	0.0015	0.0044	0.0006	0.135	5.4	0.006	1.35	54
Ameiurus spp	JC-BH COMP 2	Mercury	=	0.037	mg/kg	0.02	0.04	0.0006	0.135	5.4	0.006	1.35	54
Ameiurus spp	JC-BH COMP 1	Mercury	=	0.043	mg/kg	0.02	0.04	0.0006	0.135	5.4	0.006	1.35	54
Ameiurus spp	IG-BH COMP 1	Mercury	=	0.073	mg/kg	0.02	0.04	0.0006	0.135	5.4	0.006	1.35	54
Ameiurus spp	IG-BH COMP 1	Mercury	=	0.0973	mg/kg	0.001	0.0029	0.0006	0.135	5.4	0.006	1.35	54
Ameiurus spp	CR-BH COMP 1	Mercury	=	0.286	mg/kg	0.0009	0.0027	0.0006	0.135	5.4	0.006	1.35	54
Ameiurus spp	CR-BH COMP 1	Mercury	=	0.36	mg/kg	0.02	0.04	0.0006	0.135	5.4	0.006	1.35	54
Ameiurus spp	IG-BH COMP 1	Mercury	=	0.851	mg/kg	0.02	0.04	0.0006	0.135	5.4	0.006	1.35	54
Ameiurus spp	JC-BH COMP 2	Mercury	=	0.8871	mg/kg	0.0014	0.0042	0.0006	0.135	5.4	0.006	1.35	54
Ameiurus spp	JC-BH COMP 2	Mercury	=	0.8968	mg/kg	0.0014	0.0043	0.0006	0.135	5.4	0.006	1.35	54
Ameiurus spp	IG-BH COMP 1	Mercury	=	1.12	mg/kg	0.02	0.04	0.0006	0.135	5.4	0.006	1.35	54
Ameiurus spp	IG-BH COMP 1	Mirex	=	0.016	ug/kg	0.002	0.039			20			200
Ameiurus spp	JC-BH COMP 2	Mirex	=	0.018	ug/kg	0.0021	0.037			20			200
Ameiurus spp	JC-BH COMP 1	Mirex	=	0.028	ug/kg	0.0024	0.038			20			200
Ameiurus spp	CR-BH COMP 1	Mirex	=	0.033	ug/kg	0.0025	0.039			20			200
Ameiurus spp	IG-BH COMP 1	Selenium	=	0.14	mg/kg	0.1	0.2			0.66			0.68
Ameiurus spp	JC-BH COMP 1	Selenium	=	0.14	mg/kg	0.1	0.2			0.66			0.68
Ameiurus spp	CR-BH COMP 1	Selenium	=	0.2	mg/kg	0.1	0.2			0.66			0.68
Ameiurus spp	JC-BH COMP 2	Selenium	=	0.32	mg/kg	0.1	0.2			0.66			0.68
Ameiurus spp	IG-BH COMP 1	Selenium	=	21.4	mg/kg	0.1	0.2			0.66			0.68
Ameiurus spp	IG-BH COMP 1	Selenium	=	21.5	mg/kg	0.1	0.2			0.66			0.68
Ameiurus spp	JC-BH COMP 2	Total PCBs	=	13626.1	pg/g	77.008	3765.8	2172000		1.8E+07	1.4E+07		1.8E+08
Ameiurus spp	JC-BH COMP 1	Total PCBs	=	17944.1	pg/g	76.4	3765.8	2172000		1.8E+07	1.4E+07		1.8E+08
Ameiurus spp	CR-BH COMP 1	Total PCBs	=	22663.9	pg/g	104.84	3765.8	2172000		1.8E+07	1.4E+07		1.8E+08
Ameiurus spp	IG-BH COMP 1	Total PCBs	=	40672.9	pg/g	98.14	3765.8	2172000		1.8E+07	1.4E+07		1.8E+08
Perca flavescens	IG-YP COMP 1	2,3,7,8-TCDD	<	0.35	pg/g	0.35	0.97	190000	143	1000	1900000	1430	16000
Perca flavescens	JC-YP COMP 1	2,3,7,8-TCDD	<	0.42	pg/g	0.42	0.97	190000	143	1000	1900000	1430	16000
Perca flavescens	CR-YP COMP 1	2,3,7,8-TCDD	<	0.43	pg/g	0.43	0.96	190000	143	1000	1900000	1430	16000
Perca flavescens	JC-YP COMP 1	Arsenic	=	0.01	mg/kg	0.003	0.01			1.8			2.24
Perca flavescens	CR-YP COMP 1	Arsenic	=	0.016	mg/kg	0.005	0.018			1.8			2.24
Perca flavescens	IG-YP COMP 1	Arsenic	=	0.023	mg/kg	0.003	0.01			1.8			2.24
Perca flavescens	CR-YP COMP 1	Arsenic	<	0.15	mg/kg	0.15	0.2			1.8			2.24
Perca flavescens	IG-YP COMP 1	Arsenic	<	0.15	mg/kg	0.15	0.2			1.8			2.24
Perca flavescens	JC-YP COMP 1	Arsenic	<	0.15	mg/kg	0.15	0.2			1.8			2.24
Perca flavescens	IG-YP COMP 1	DDE	=	1.411	ug/kg	0.0055	0.08			40000			75000
Perca flavescens	CR-YP COMP 1	DDE	=	1.713	ug/kg	0.0047	0.076			40000			75000
Perca flavescens	JC-YP COMP 1	DDE	=	5.231	ug/kg	0.0069	0.08			40000			75000
Perca flavescens	IG-YP COMP 1	DDT	=	0.037	ug/kg	0.0062	0.08			4200			42000
Perca flavescens	CR-YP COMP 1	DDT	=	0.039	ug/kg	0.0089	0.076			4200			42000
Perca flavescens	JC-YP COMP 1	DDT	=	0.0415	ug/kg	0.0116	0.08			4200			42000
Perca flavescens	CR-YP COMP 1	Dieldrin	=	0.073	ug/kg	0.0046	0.038			3700			37000
Perca flavescens	IG-YP COMP 1	Dieldrin	=	0.088	ug/kg	0.004	0.04			3700			37000
Perca flavescens	JC-YP COMP 1	Dieldrin	=	0.13	ug/kg	0.0065	0.04			3700			37000
Perca flavescens	CR-YP COMP 1	Endrin	<	0.0047	ug/kg	0.0047	0.038			80			300
Perca flavescens	JC-YP COMP 1	Endrin	<	0.007	ug/kg	0.007	0.04			80			300
Perca flavescens	IG-YP COMP 1	Endrin	=	0.008	ug/kg	0.0036	0.04			80			300
Perca flavescens	CR-YP COMP 1	Mercury	=	0.0727	mg/kg	0.0009	0.0028	0.0006	0.135	5.4	0.006	1.35	54
Perca flavescens	CR-YP COMP 1	Mercury	=	0.086	mg/kg	0.02	0.04	0.0006	0.135	5.4	0.006	1.35	54
Perca flavescens	JC-YP COMP 1	Mercury	=	0.0965	mg/kg	0.001	0.0029	0.0006	0.135	5.4	0.006	1.35	54
Perca flavescens	JC-YP COMP 1	Mercury	=	0.1	mg/kg	0.02	0.04	0.0006	0.135	5.4	0.006	1.35	54
Perca flavescens	IG-YP COMP 1	Mercury	=	0.138	mg/kg	0.001	0.0029	0.0006	0.135	5.4	0.006	1.35	54
Perca flavescens	IG-YP COMP 1	Mercury	=	0.14	mg/kg	0.02	0.04	0.0006	0.135	5.4	0.006	1.35	54
Perca flavescens	IG-YP COMP 1	Mirex	=	0.0048	ug/kg	0.00067	0.04			20			200
Perca flavescens	CR-YP COMP 1	Mirex	=	0.0082	ug/kg	0.00099	0.038			20			200
Perca flavescens	JC-YP COMP 1	Mirex	=	0.016	ug/kg	0.0014	0.04			20			200
Perca flavescens	CR-YP COMP 1	Selenium	=	0.11	mg/kg	0.1	0.2			0.66			0.68
Perca flavescens	IG-YP COMP 1	Selenium	=	0.15	mg/kg	0.1	0.2			0.66			0.68
Perca flavescens	JC-YP COMP 1	Selenium	=	0.2	mg/kg	0.1	0.2			0.66			0.68
Perca flavescens	CR-YP COMP 1	Total PCBs	=	11970.5	pg/g	4082.08	3765.8	2172000		1.8E+07	1.4E+07		1.8E+08
Perca flavescens	JC-YP COMP 1	Total PCBs	=	20345	pg/g	100.78	3765.8	2172000		1.8E+07	1.4E+07		1.8E+08
Perca flavescens	IG-YP COMP 1	Total PCBs	=	48233.4	pg/g	95.057	3765.8	2172000		1.8E+07	1.4E+07		1.8E+08

APPENDIX D. TABLE D2
INVERTEBRATE TISSUE DATA SORTED BY CHEMICAL

"Total PBDEs" are the simple sum of all the "BDE xxx" values for each sample
"Total PCBs" are the simple sum of all the "PCB xxx" values for each sample

								CANDIDATE TRVS											
								NOEL						LOEL					
Species	Sample	Analyte	Bound	Result	Units	MDL	RL	MARSH CLAM	BLUE MUSSEL	CLAM, SOFTSHELL	FINGERNAIL CLAM	LUMBRICULUS	OLIGOCHAETE	MARSH CLAM	BLUE MUSSEL	CLAM, SOFTSHELL	FINGERNAIL CLAM	LUMBRICULUS	OLIGOCHAETE
Corbicula fluminea	CR-CF	Acenaphthene	<	21	ug/kg	21	180		294						2940				
Corbicula fluminea	IG-CF	Acenaphthene	<	21	ug/kg	21	180		294						2940				
Corbicula fluminea	JC-CF	Acenaphthene	<	21	ug/kg	21	180		294						2940				
Corbicula fluminea	LC-CF-1	Acenaphthene	<	22	ug/kg	22	190		294						2940				
Corbicula fluminea	UE-CF	Acenaphthene	<	22	ug/kg	22	190		294						2940				
Corbicula fluminea	LC-CF-2	Acenaphthene	<	24	ug/kg	24	210		294						2940				
Corbicula fluminea	JC-CF	Acenaphthene	=	189	ug/kg	24	210		294						2940				
Corbicula fluminea	JC-CF	Acenaphthene	=	208	ug/kg	23	200		294						2940				
Corbicula fluminea	IG-CF	Arsenic	=	0.4	mg/kg	0.15	0.2		3.6						36				
Corbicula fluminea	UE-CF	Arsenic	=	0.55	mg/kg	0.15	0.2		3.6						36				
Corbicula fluminea	LC-CF-1	Arsenic	=	1.4	mg/kg	0.15	0.2		3.6						36				
Corbicula fluminea	LC-CF-2	Arsenic	=	1.7	mg/kg	0.15	0.2		3.6						36				
Corbicula fluminea	JC-CF	Arsenic	=	2.5	mg/kg	0.15	0.2		3.6						36				
Corbicula fluminea	JC-CF	Arsenic	=	22.5	mg/kg	0.15	0.2		3.6						36				
Corbicula fluminea	JC-CF	Arsenic	=	23	mg/kg	0.15	0.2		3.6						36				
Corbicula fluminea	CR-CF	Benzo(a)pyrene	<	40	ug/kg	40	180				1250						12500		
Corbicula fluminea	JC-CF	Benzo(a)pyrene	<	40	ug/kg	40	180				1250						12500		
Corbicula fluminea	IG-CF	Benzo(a)pyrene	<	41	ug/kg	41	180				1250						12500		
Corbicula fluminea	UE-CF	Benzo(a)pyrene	<	42	ug/kg	42	190				1250						12500		
Corbicula fluminea	LC-CF-1	Benzo(a)pyrene	<	43	ug/kg	43	190				1250						12500		
Corbicula fluminea	LC-CF-2	Benzo(a)pyrene	<	47	ug/kg	47	210				1250						12500		
Corbicula fluminea	JC-CF	Benzo(a)pyrene	=	209	ug/kg	46	210				1250						12500		
Corbicula fluminea	JC-CF	Benzo(a)pyrene	=	224	ug/kg	45	200				1250						12500		
Corbicula fluminea	JC-CF	DDD	=	0.58	ug/kg	0.009	0.078						2E+06						2E+07
Corbicula fluminea	IG-CF	DDD	=	0.6	ug/kg	0.019	0.072						2E+06						2E+07
Corbicula fluminea	UE-CF	DDD	=	0.88	ug/kg	0.012	0.08						2E+06						2E+07
Corbicula fluminea	LC-CF-2	DDD	=	1.17	ug/kg	0.027	0.078						2E+06						2E+07
Corbicula fluminea	LC-CF-1	DDD	=	1.2	ug/kg	0.013	0.078						2E+06						2E+07
Corbicula fluminea	JC-CF	DDE	=	1.854	ug/kg	0.011	0.078					17840						2E+05	
Corbicula fluminea	IG-CF	DDE	=	1.967	ug/kg	0.04	0.072					17840						2E+05	
Corbicula fluminea	LC-CF-2	DDE	=	2.79	ug/kg	0.029	0.078					17840						2E+05	
Corbicula fluminea	UE-CF	DDE	=	3.386	ug/kg	0.01	0.08					17840						2E+05	
Corbicula fluminea	LC-CF-1	DDE	=	3.81	ug/kg	0.012	0.078					17840						2E+05	
Corbicula fluminea	JC-CF	DDT	=	0.093	ug/kg	0.01	0.078			880						8800			
Corbicula fluminea	IG-CF	DDT	=	0.098	ug/kg	0.03	0.072			880						8800			
Corbicula fluminea	LC-CF-2	DDT	=	0.129	ug/kg	0.042	0.078			880						8800			
Corbicula fluminea	UE-CF	DDT	=	0.238	ug/kg	0.016	0.08			880						8800			
Corbicula fluminea	LC-CF-1	DDT	=	0.247	ug/kg	0.018	0.078			880						8800			
Corbicula fluminea	JC-CF	Endosulfan I	<	0.012	ug/kg	0.012	0.039		8100						81000				
Corbicula fluminea	LC-CF-1	Endosulfan I	<	0.015	ug/kg	0.015	0.039		8100						81000				
Corbicula fluminea	UE-CF	Endosulfan I	<	0.015	ug/kg	0.015	0.04		8100						81000				
Corbicula fluminea	IG-CF	Endosulfan I	<	0.022	ug/kg	0.022	0.036		8100						81000				
Corbicula fluminea	LC-CF-2	Endosulfan I	<	0.027	ug/kg	0.027	0.039		8100						81000				
Corbicula fluminea	JC-CF	Endosulfan II	=	0.029	ug/kg	0.022	0.039		8100						81000				
Corbicula fluminea	IG-CF	Endosulfan II	<	0.031	ug/kg	0.031	0.036		8100						81000				
Corbicula fluminea	UE-CF	Endosulfan II	<	0.035	ug/kg	0.035	0.04		8100						81000				
Corbicula fluminea	LC-CF-1	Endosulfan II	<	0.044	ug/kg	0.044	0.044		8100						81000				
Corbicula fluminea	LC-CF-2	Endosulfan II	<	0.081	ug/kg	0.081	0.081		8100						81000				
Corbicula fluminea	JC-CF	Endosulfan sulfate	<	0.003	ug/kg	0.003	0.039		8100						81000				
Corbicula fluminea	UE-CF	Endosulfan sulfate	<	0.0092	ug/kg	0.009	0.04		8100						81000				
Corbicula fluminea	IG-CF	Endosulfan sulfate	<	0.011	ug/kg	0.011	0.036		8100						81000				
Corbicula fluminea	LC-CF-1	Endosulfan sulfate	<	0.013	ug/kg	0.013	0.039		8100						81000				
Corbicula fluminea	LC-CF-2	Endosulfan sulfate	<	0.027	ug/kg	0.027	0.039		8100						81000				
Corbicula fluminea	CR-CF	Fluoranthene	<	43	ug/kg	43	180		22						220				
Corbicula fluminea	IG-CF	Fluoranthene	<	43	ug/kg	43	180		22						220				
Corbicula fluminea	JC-CF	Fluoranthene	<	43	ug/kg	43	180		22						220				
Corbicula fluminea	UE-CF	Fluoranthene	<	45	ug/kg	45	190		22						220				
Corbicula fluminea	LC-CF-1	Fluoranthene	<	46	ug/kg	46	190		22						220				
Corbicula fluminea	LC-CF-2	Fluoranthene	<	50	ug/kg	50	210		22						220				
Corbicula fluminea	JC-CF	Fluoranthene	=	209	ug/kg	49	210		22						220				
Corbicula fluminea	JC-CF	Fluoranthene	=	226	ug/kg	48	200		22						220				
Corbicula fluminea	IG-CF	Hexachlorobenzen	=	0.019	ug/kg	6E-04	0.036		3.1						31				
Corbicula fluminea	JC-CF	Hexachlorobenzen	=	0.02	ug/kg	3E-04	0.039		3.1						31				
Corbicula fluminea	UE-CF	Hexachlorobenzen	=	0.041	ug/kg	2E-04	0.04		3.1						31				
Corbicula fluminea	LC-CF-1	Hexachlorobenzen	=	0.053	ug/kg	2E-04	0.039		3.1						31				
Corbicula fluminea	LC-CF-2	Hexachlorobenzen	=	0.069	ug/kg	4E-04	0.039		3.1						31				
Corbicula fluminea	IG-CF	Lead	<	0.06	mg/kg	0.06	0.1					300						3000	
Corbicula fluminea	UE-CF	Lead	<	0.06	mg/kg	0.06	0.1					300						3000	
Corbicula fluminea	LC-CF-1	Lead	=	0.065	mg/kg	0.06	0.1					300						3000	
Corbicula fluminea	JC-CF	Lead	=	0.27	mg/kg	0.06	0.1					300						3000	
Corbicula fluminea	LC-CF-2	Lead	=	0.41	mg/kg	0.06	0.1					300						3000	
Corbicula fluminea	JC-CF	Lead	=	20.1	mg/kg	0.06	0.1					300						3000	
Corbicula fluminea	JC-CF	Lead	=	20.5	mg/kg	0.06	0.1					300						3000	
Corbicula fluminea	UE-CF	Mercury	<	0.02	mg/kg	0.02	0.04	0.2						2					
Corbicula fluminea	IG-CF	Mercury	=	0.04	mg/kg	0.02	0.04	0.2						2					
Corbicula fluminea	LC-CF-1	Mercury	=	0.09	mg/kg	0.02	0.04	0.2						2					
Corbicula fluminea	LC-CF-2	Mercury	=	0.099	mg/kg	0.02	0.04	0.2						2					
Corbicula fluminea	JC-CF	Mercury	=	0.1	mg/kg	0.02	0.04	0.2						2					
Corbicula fluminea	JC-CF	Mercury	=	1.29	mg/kg	0.02	0.04	0.2						2					
Corbicula fluminea	JC-CF	Mercury	=	1.36	mg/kg	0.02	0.04	0.2						2					
Corbicula fluminea	JC-CF	Phenanthrene	<	15	ug/kg	15	180		307						3070				
Corbicula fluminea	CR-CF	Phenanthrene	<	16	ug/kg	16	180		307						3070				
Corbicula fluminea	IG-CF	Phenanthrene	<	16	ug/kg	16	180		307						3070				
Corbicula fluminea	LC-CF-1	Phenanthrene	<	16	ug/kg	16	190		307						3070				
Corbicula fluminea	UE-CF	Phenanthrene	<	16	ug/kg	16	190		307						3070				
Corbicula fluminea	LC-CF-2	Phenanthrene	<	18	ug/kg	18	210		307						3070				
Corbicula fluminea	JC-CF	Phenanthrene	=	206	ug/kg	18	210		307						3070				
Corbicula fluminea	JC-CF	Phenanthrene	=	224	ug/kg	17	200		307						3070				
Corbicula fluminea	CR-CF	Pyrene	<	41	ug/kg	41	180		1890						18900				
Corbicula fluminea	JC-CF	Pyrene	<	41	ug/kg	41	180		1890						18900				
Corbicula fluminea	IG-CF	Pyrene	<	42	ug/kg	42	180		1890						18900				
Corbicula fluminea	UE-CF	Pyrene	<	43	ug/kg	43	190		1890						18900				
Corbicula fluminea	LC-CF-1	Pyrene	<	44	ug/kg	44	190		1890						18900				
Corbicula fluminea	LC-CF-2	Pyrene	<	48	ug/kg	48	210		1890						18900				
Corbicula fluminea	JC-CF	Pyrene	=	215	ug/kg	47	210		1890						18900				
Corbicula fluminea	JC-CF	Pyrene	=	225	ug/kg	46	200		1890						18900				
Corbicula fluminea	JC-CF	Total PBDEs	=	1148.15	pg/g	112.4	6292					2E+07						2E+08	
Corbicula fluminea	LC-CF-2	Total PBDEs	=	2332.77	pg/g	71.42	6292					2E+07						2E+08	
Corbicula fluminea	IG-CF	Total PBDEs	=	2336.31	pg/g	91.05	6292					2E+07						2E+08	
Corbicula fluminea	UE-CF	Total PBDEs	=	3174.85	pg/g	80.56	6292					2E+07						2E+08	
Corbicula fluminea	LC-CF-1	Total PBDEs	=	4342.72	pg/g	60.07	6292					2E+07						2E+08	
Corbicula fluminea	LC-CF-2	Total PCBs	=	15859.2	pg/g	168.1	3933		1E+06			4E+08			1E+07			4E+09	
Corbicula fluminea	JC-CF	Total PCBs	=	17951.6	pg/g	423.4	3920		1E+06			4E+08			1E+07			4E+09	

APPENDIX D. TABLE D2
INVERTEBRATE TISSUE DATA SORTED BY CHEMICAL

"Total PBDEs" are the simple sum of all the "BDE xxx" values for each sample
"Total PCBs" are the simple sum of all the "PCB xxx" values for each sample

								CANDIDATE TRVS											
								NOEL						LOEL					
Species	Sample	Analyte	Bound	Result	Units	MDL	RL	MARSH CLAM	BLUE MUSSEL	CLAM, SOFTSHELL	FINGERNAIL CLAM	LUMBRICULUS	OLIGOCHAETE	MARSH CLAM	BLUE MUSSEL	CLAM, SOFTSHELL	FINGERNAIL CLAM	LUMBRICULUS	OLIGOCHAETE
Corbicula fluminea	IG-CF	Total PCBs	=	19642.4	pg/g	238.6	3750		1E+06			4E+08			1E+07			4E+09	
Corbicula fluminea	UE-CF	Total PCBs	=	23206.7	pg/g	178.7	3957		1E+06			4E+08			1E+07			4E+09	
Corbicula fluminea	LC-CF-1	Total PCBs	=	24477.7	pg/g	194.4	3949		1E+06			4E+08			1E+07			4E+09	
Corbicula fluminea	CR-CF	Total PCBs	=	25128.3	pg/g	476.1	3990		1E+06			4E+08			1E+07			4E+09	
Lumbriculus variegatu	IG-LV	Acenaphthene	<	2.2	ug/kg	2.2	19		294						2940				
Lumbriculus variegatu	CR-LV	Acenaphthene	<	2.3	ug/kg	2.3	20		294						2940				
Lumbriculus variegatu	JC-LV	Acenaphthene	<	2.3	ug/kg	2.3	20		294						2940				
Lumbriculus variegatu	LC-LV-2	Acenaphthene	<	2.3	ug/kg	2.3	20		294						2940				
Lumbriculus variegatu	LC-LV-3	Acenaphthene	<	2.3	ug/kg	2.3	20		294						2940				
Lumbriculus variegatu	UE-LV	Acenaphthene	<	2.3	ug/kg	2.3	20		294						2940				
Lumbriculus variegatu	LC-LV-1	Acenaphthene	<	4.6	ug/kg	4.6	40		294						2940				
Lumbriculus variegatu	LC-LV-4	Acenaphthene	<	12	ug/kg	12	100		294						2940				
Lumbriculus variegatu	CR-LV	Arsenic	<	0.15	mg/kg	0.15	0.2		3.6						36				
Lumbriculus variegatu	LC-LV-2	Arsenic	<	0.15	mg/kg	0.15	0.2		3.6						36				
Lumbriculus variegatu	LC-LV-3	Arsenic	<	0.15	mg/kg	0.15	0.2		3.6						36				
Lumbriculus variegatu	UE-LV	Arsenic	<	0.15	mg/kg	0.15	0.2		3.6						36				
Lumbriculus variegatu	IG-LV	Arsenic	=	0.58	mg/kg	0.15	0.2		3.6						36				
Lumbriculus variegatu	JC-LV	Arsenic	=	1.2	mg/kg	0.15	0.2		3.6						36				
Lumbriculus variegatu	IG-LV	Benzo(a)pyrene	<	4.2	ug/kg	4.2	19				1250						12500		
Lumbriculus variegatu	LC-LV-2	Benzo(a)pyrene	<	4.3	ug/kg	4.3	20				1250						12500		
Lumbriculus variegatu	JC-LV	Benzo(a)pyrene	<	4.4	ug/kg	4.4	20				1250						12500		
Lumbriculus variegatu	LC-LV-3	Benzo(a)pyrene	<	4.4	ug/kg	4.4	20				1250						12500		
Lumbriculus variegatu	CR-LV	Benzo(a)pyrene	<	4.5	ug/kg	4.5	20				1250						12500		
Lumbriculus variegatu	UE-LV	Benzo(a)pyrene	<	4.5	ug/kg	4.5	20				1250						12500		
Lumbriculus variegatu	LC-LV-1	Benzo(a)pyrene	<	8.9	ug/kg	8.9	40				1250						12500		
Lumbriculus variegatu	LC-LV-4	Benzo(a)pyrene	<	23	ug/kg	23	100				1250						12500		
Lumbriculus variegatu	JC-LV	DDD	=	0.08	ug/kg	0.007	0.08						2E+06						2E+07
Lumbriculus variegatu	LC-LV-2	DDD	=	0.089	ug/kg	0.025	0.22						2E+06						2E+07
Lumbriculus variegatu	LC-LV-3	DDD	=	0.132	ug/kg	0.132	0.24						2E+06						2E+07
Lumbriculus variegatu	IG-LV	DDD	=	0.215	ug/kg	0.006	0.24						2E+06						2E+07
Lumbriculus variegatu	CR-LV	DDD	=	0.315	ug/kg	0.006	0.08						2E+06						2E+07
Lumbriculus variegatu	LC-LV-3	DDE	=	0.379	ug/kg	0.111	1.22					17840						2E+05	
Lumbriculus variegatu	LC-LV-2	DDE	=	0.629	ug/kg	0.036	0.22					17840						2E+05	
Lumbriculus variegatu	JC-LV	DDE	=	0.634	ug/kg	0.01	0.08					17840						2E+05	
Lumbriculus variegatu	IG-LV	DDE	=	0.666	ug/kg	0.011	0.24					17840						2E+05	
Lumbriculus variegatu	CR-LV	DDE	=	1.127	ug/kg	0.01	0.08					17840						2E+05	
Lumbriculus variegatu	IG-LV	DDT	=	0.0081	ug/kg	0.008	0.24			880						8800			
Lumbriculus variegatu	CR-LV	DDT	=	0.034	ug/kg	0.034	0.08			880						8800			
Lumbriculus variegatu	LC-LV-2	DDT	=	0.048	ug/kg	0.048	0.22			880						8800			
Lumbriculus variegatu	JC-LV	DDT	=	0.058	ug/kg	0.035	0.08			880						8800			
Lumbriculus variegatu	LC-LV-3	DDT	=	0.45	ug/kg	0.45	0.45			880						8800			
Lumbriculus variegatu	IG-LV	Endosulfan I	<	0.007	ug/kg	0.007	0.12		8100						81000				
Lumbriculus variegatu	CR-LV	Endosulfan I	<	0.0079	ug/kg	0.008	0.04		8100						81000				
Lumbriculus variegatu	JC-LV	Endosulfan I	<	0.0092	ug/kg	0.009	0.04		8100						81000				
Lumbriculus variegatu	LC-LV-2	Endosulfan I	<	0.026	ug/kg	0.026	0.11		8100						81000				
Lumbriculus variegatu	LC-LV-3	Endosulfan I	<	0.073	ug/kg	0.073	0.12		8100						81000				
Lumbriculus variegatu	JC-LV	Endosulfan II	<	0.019	ug/kg	0.019	0.04		8100						81000				
Lumbriculus variegatu	IG-LV	Endosulfan II	<	0.023	ug/kg	0.023	0.12		8100						81000				
Lumbriculus variegatu	CR-LV	Endosulfan II	<	0.027	ug/kg	0.027	0.04		8100						81000				
Lumbriculus variegatu	LC-LV-2	Endosulfan II	<	0.068	ug/kg	0.068	0.11		8100						81000				
Lumbriculus variegatu	LC-LV-3	Endosulfan II	<	0.14	ug/kg	0.14	0.14		8100						81000				
Lumbriculus variegatu	IG-LV	Endosulfan sulfate	<	0.0054	ug/kg	0.005	0.12		8100						81000				
Lumbriculus variegatu	CR-LV	Endosulfan sulfate	<	0.0089	ug/kg	0.009	0.2		8100						81000				
Lumbriculus variegatu	JC-LV	Endosulfan sulfate	<	0.009	ug/kg	0.009	0.2		8100						81000				
Lumbriculus variegatu	LC-LV-3	Endosulfan sulfate	<	0.029	ug/kg	0.029	0.61		8100						81000				
Lumbriculus variegatu	LC-LV-2	Endosulfan sulfate	<	0.048	ug/kg	0.048	0.11		8100						81000				
Lumbriculus variegatu	IG-LV	Fluoranthene	<	4.5	ug/kg	4.5	19		22						220				
Lumbriculus variegatu	LC-LV-2	Fluoranthene	<	4.6	ug/kg	4.6	20		22						220				
Lumbriculus variegatu	JC-LV	Fluoranthene	<	4.7	ug/kg	4.7	20		22						220				
Lumbriculus variegatu	LC-LV-3	Fluoranthene	<	4.7	ug/kg	4.7	20		22						220				
Lumbriculus variegatu	CR-LV	Fluoranthene	<	4.8	ug/kg	4.8	20		22						220				
Lumbriculus variegatu	UE-LV	Fluoranthene	<	4.8	ug/kg	4.8	20		22						220				
Lumbriculus variegatu	LC-LV-1	Fluoranthene	<	9.5	ug/kg	9.5	40		22						220				
Lumbriculus variegatu	LC-LV-4	Fluoranthene	<	24	ug/kg	24	100		22						220				
Lumbriculus variegatu	CR-LV	Hexachlorobenzen	=	0.0058	ug/kg	2E-04	0.04		3.1						31				
Lumbriculus variegatu	JC-LV	Hexachlorobenzen	=	0.0065	ug/kg	1E-04	0.04		3.1						31				
Lumbriculus variegatu	IG-LV	Hexachlorobenzen	=	0.0085	ug/kg	3E-04	0.12		3.1						31				
Lumbriculus variegatu	LC-LV-3	Hexachlorobenzen	=	0.015	ug/kg	0.002	0.12		3.1						31				
Lumbriculus variegatu	LC-LV-2	Hexachlorobenzen	=	0.022	ug/kg	5E-04	0.11		3.1						31				
Lumbriculus variegatu	CR-LV	Lead	<	0.06	mg/kg	0.06	0.1					300						3000	
Lumbriculus variegatu	LC-LV-2	Lead	<	0.06	mg/kg	0.06	0.1					300						3000	
Lumbriculus variegatu	LC-LV-3	Lead	<	0.06	mg/kg	0.06	0.1					300						3000	
Lumbriculus variegatu	UE-LV	Lead	=	0.065	mg/kg	0.06	0.1					300						3000	
Lumbriculus variegatu	JC-LV	Lead	=	0.098	mg/kg	0.06	0.1					300						3000	
Lumbriculus variegatu	IG-LV	Lead	=	0.11	mg/kg	0.06	0.1					300						3000	
Lumbriculus variegatu	CR-LV	Mercury	<	0.02	mg/kg	0.02	0.04	0.2						2					
Lumbriculus variegatu	IG-LV	Mercury	<	0.02	mg/kg	0.02	0.04	0.2						2					
Lumbriculus variegatu	JC-LV	Mercury	<	0.02	mg/kg	0.02	0.04	0.2						2					
Lumbriculus variegatu	LC-LV-1	Mercury	<	0.02	mg/kg	0.02	0.04	0.2						2					
Lumbriculus variegatu	LC-LV-2	Mercury	<	0.02	mg/kg	0.02	0.04	0.2						2					
Lumbriculus variegatu	LC-LV-3	Mercury	<	0.02	mg/kg	0.02	0.04	0.2						2					
Lumbriculus variegatu	UE-LV	Mercury	<	0.02	mg/kg	0.02	0.04	0.2						2					
Lumbriculus variegatu	IG-LV	Phenanthrene	<	1.6	ug/kg	1.6	19		307						3070				
Lumbriculus variegatu	CR-LV	Phenanthrene	<	1.7	ug/kg	1.7	20		307						3070				
Lumbriculus variegatu	JC-LV	Phenanthrene	<	1.7	ug/kg	1.7	20		307						3070				
Lumbriculus variegatu	LC-LV-2	Phenanthrene	<	1.7	ug/kg	1.7	20		307						3070				
Lumbriculus variegatu	LC-LV-3	Phenanthrene	<	1.7	ug/kg	1.7	20		307						3070				
Lumbriculus variegatu	UE-LV	Phenanthrene	<	1.7	ug/kg	1.7	20		307						3070				
Lumbriculus variegatu	LC-LV-1	Phenanthrene	<	3.4	ug/kg	3.4	40		307						3070				
Lumbriculus variegatu	LC-LV-4	Phenanthrene	<	8.7	ug/kg	8.7	100		307						3070				
Lumbriculus variegatu	IG-LV	Pyrene	<	4.3	ug/kg	4.3	19		1890						18900				
Lumbriculus variegatu	LC-LV-2	Pyrene	<	4.4	ug/kg	4.4	20		1890						18900				
Lumbriculus variegatu	JC-LV	Pyrene	<	4.5	ug/kg	4.5	20		1890						18900				
Lumbriculus variegatu	LC-LV-3	Pyrene	<	4.5	ug/kg	4.5	20		1890						18900				
Lumbriculus variegatu	CR-LV	Pyrene	<	4.6	ug/kg	4.6	20		1890						18900				
Lumbriculus variegatu	UE-LV	Pyrene	<	4.6	ug/kg	4.6	20		1890						18900				
Lumbriculus variegatu	LC-LV-1	Pyrene	<	9.1	ug/kg	9.1	40		1890						18900				
Lumbriculus variegatu	LC-LV-4	Pyrene	<	23	ug/kg	23	100		1890						18900				
Lumbriculus variegatu	LC-LV-3	Total PCBs	=	1794.24	pg/g	259.4	3969		1E+06			4E+08			1E+07			4E+09	
Lumbriculus variegatu	JC-LV	Total PCBs	=	2642.26	pg/g	335.1	2041		1E+06			4E+08			1E+07			4E+09	
Lumbriculus variegatu	LC-LV-2	Total PCBs	=	2819.74	pg/g	224.5	3956		1E+06			4E+08			1E+07			4E+09	
Lumbriculus variegatu	LC-LV-4	Total PCBs	=	3323.93	pg/g	139.4	3747		1E+06			4E+08			1E+07			4E+09	
Lumbriculus variegatu	IG-LV	Total PCBs	=	3653.91	pg/g	70.7	1923		1E+06			4E+08			1E+07			4E+09	

APPENDIX D. TABLE D2
INVERTEBRATE TISSUE DATA SORTED BY CHEMICAL

"Total PBDEs" are the simple sum of all the "BDE xxx" values for each sample
"Total PCBs" are the simple sum of all the "PCB xxx" values for each sample

								CANDIDATE TRVS											
								NOEL						LOEL					
Species	Sample	Analyte	Bound	Result	Units	MDL	RL	MARSH CLAM	BLUE MUSSEL	CLAM, SOFTSHELL	FINGERNAIL CLAM	LUMBRICULUS	OLIGOCHAETE	MARSH CLAM	BLUE MUSSEL	CLAM, SOFTSHELL	FINGERNAIL CLAM	LUMBRICULUS	OLIGOCHAETE
Lumbriculus variegatu	CR-LV	Total PCBs	=	4070.99	pg/g	79.47	1942		1E+06			4E+08			1E+07			4E+09	
Lumbriculus variegatu	JC-LV	Total PBDEs	=	383.24	pg/g	65.21	7779					2E+07						2E+08	
Lumbriculus variegatu	CR-LV	Total PBDEs	=	856.14	pg/g	856.1	62920					2E+07						2E+08	

APPENDIX D. TABLE D3

Whole Body Fish Tissue / Residue-based TRVs

REPRESENTATIVE FISH

		Derivation	NO EFFECT mg/kg wet	LOW EFFECT mg/kg wet
2,3,7,8-TCDD				
	PERCH	ACCEPT NOED EST. LOED (*10)	0.000143	0.00143
	BULLHEAD	ACCEPT NOED EST. LOED (*10)	0.19	1.9
	BASS	ACCEPT NOED EST. LOED (/10) FROM	0.001	0.016
MERCURY				
	PERCH	ACCEPT NOED EST. LOED (*10)	0.135	1.35
	BULLHEAD	EST. LOED (/10) EST. NOED (/100)	0.006	0.0006
	BASS	ACCEPT NOED EST. LOED (*10)	5.4	54
TOTAL PCBS				
	BULLHEAD	ACCEPT NOED AND LOED	10.9	14.3
	BASS	ACCEPT NOED EST. LOED (*10)	17.5	175
AROCLOR 1242				
	BULLHEAD	ACCEPT NOED EST. LOED (*10)	2.172	21.72
DDE				
	BASS	ACCEPT NOED AND LOED	40	75
DDT				
	BASS	ACCEPT LOED EST. NOED (/10)	4.2	42
CHLORPYRIFOS				
	BASS	ACCEPT NOED AND LOED	0.42	2.06
DIELDRIN				
	BASS	ACCEPT LOED EST. NOED (/10)	3.7	37
ENDRIN				
	BASS	ACCEPT NOED AND LOED	0.08	0.3
FENVALERATE				
	BASS	EST. LOED (/10) AND EST. NOED (/100) FROM LD50	0.067	0.0067
LINDANE				
	BASS	EST. LOED (/20) AND EST. NOED (/200) FROM LD100	0.0008	0.00008
MIREX				
	BASS	ACCEPT NOED EST. LOED (*10)	0.02	0.2
SELENIUM				
	BASS	ACCEPT NOED AND LOED	0.66	0.68
ARSENIC				
	BASS	ACCEPT NOED AND LOED	1.8	2.24

APPENDIX D. TABLE D3

Invertebrate Tissue / Residue-based TRVs

			NO EFFECT mg/kg wet	LOW EFFECT mg/kg wet
OLIGOCHAETES				
LEAD		**Derivation**		
	LUMRICULUS	**ACCEPT NOED EST. LOED (*10)**	300	3000
TOTAL PCBS				
	LUMRICULUS	**ACCEPT NOED EST. LOED (*10)**	350	3500
DDE				
	LUMRICULUS	**ACCEPT LOED EST. NOED (/10)**	17.84	178.4
DDD				
	OLIGOCHAETE	**ACCEPT NOED EST. LOED (*10)**	1500	15000
PBDE				
	LUMRICULUS	**ACCEPT NOED EST. LOED (*10)**	24.28	242.8
BIVALVES				
CADMIIUM				
	CORBICULA	**ACCEPT NOED EST. LOED (*10)**	20	200
BENZO(A)PYRENE				
	FINGERNAIL CLAM	**ACCEPT NOED EST. LOED (*10)**	1.25	12.5
MERCURY				
	MARSH CLAM	**EST. LOED (/10) EST. NOED (/100) FROM**	0.2	2
DDT				
	CLAM, SOFTSHELL	**ACCEPT NOED EST. LOED (*10)**	0.88	8.8
PCBS				
	BLUE MUSSEL	**ACCEPT NOED EST. LOED (*10)**	1.4	14
1-				
	BLUE MUSSEL	**EST. LOED (/10) EST. NOED (/100) FROM**	0.216	2.16
ACENAPHTHENE				
	BLUE MUSSEL	**EST. LOED (/10) EST. NOED (/100) FROM**	0.294	2.94
BIPHENYL				
	BLUE MUSSEL	**EST. LOED (/10) EST. NOED (/100) FROM**	0.156	1.56
DEHP				
	BLUE MUSSEL	**ACCEPT NOED EST. LOED (*10)**	123	1230
DIBENZOTHIOPHENE				
	BLUE MUSSEL	**EST. LOED (/10) EST. NOED (/100) FROM**	0.142	1.42
DIISODECYLPHTHALATE				
	BLUE MUSSEL	**ACCEPT NOED EST. LOED (*10)**	133	1330
FLUORANTHENE				
	BLUE MUSSEL	**ACCEPT LOED EST. NOED (/10)**	0.022	0.22
OCTANE				
	BLUE MUSSEL	**EST. LOED (/10) EST. NOED (/100) FROM**	0.246	2.46
PCP				
	BLUE MUSSEL	**ACCEPT LOED EST. NOED (/10)**	0.23	2.3
PERCHLOROBENZENE				
	BLUE MUSSEL	**ACCEPT NOED EST. LOED (*10)**	0.0031	0.031
PHENANTHRENE				
	BLUE MUSSEL	**EST. LOED (/10) EST. NOED (/100) FROM**	0.307	3.07
PYRENE				
	BLUE MUSSEL	**EST. LOED (/10) EST. NOED (/100) FROM**	1.89	18.9
ENDOSULFAN				
	BLUE MUSSEL	**ACCEPT NOED EST. LOED (*10)**	8.1	81
LINDANE				
	BLUE MUSSEL	**ACCEPT LOED EST. NOED (/10)**	0.00136	0.0136
ARSENIC				
	BLUE MUSSEL	**ACCEPT NOED EST. LOED (*10)**	3.6	36

APPENDIX D. TABLE D4
CANDIDATE TRVS YELLOW PERCH

YELLOW PERCH

2,3,7,8-TCDD	Year	Author	Publication Source	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Feeding Behavior	Comments
	1986	Kleeman, J.M., J.R. Olson, S.M. Chen and R.E. Peterson	Toxicol Appl Pharmacol 083:402-411.	1746-01-6	0.000143	MG/KG	6	Mortality	NOED	Ingestion	Whole Body	Immature	Carnivore-aquatic insects, fish, inverts	No Effect On Mortality. Residue measured at end of exposure period.
	1986	Kleeman, J.M., J.R. Olson, S.M. Chen and R.E. Peterson	Toxicol Appl Pharmacol 083:402-411.	1746-01-6	0.000143	MG/KG	6	Morphology	NOED	Ingestion	Whole Body	Immature	Carnivore-aquatic insects, fish, inverts	No Effect On Fin Necrosis Or Hemorrhage. Residue measured at end of exposure period.
	1986	Kleeman, J.M., J.R. Olson, S.M. Chen and R.E. Peterson	Toxicol Appl Pharmacol 083:402-411.	1746-01-6	0.000143	MG/KG	6	Growth	NOED	Ingestion	Whole Body	Immature	Carnivore-aquatic insects, fish, inverts	No Effect On Growth. Residue measured at end of exposure period.
	1988	Kleeman, J.M., J.R. Olson and R.E. Peterson	Fundam. Appl. Toxicol. 10:206-213.	1746-01-6	0.001	MG/KG	20	Mortality	NOED	Injection	Whole Body	NA	Carnivore-aquatic insects, fish, inverts	No significant increase in mortality.
	1988	Kleeman, J.M., J.R. Olson and R.E. Peterson	Fundam. Appl. Toxicol. 10:206-213.	1746-01-6	0.003	MG/KG	20	Mortality	LD50	Injection	Whole Body	NA	Carnivore-aquatic insects, fish, inverts	80 Day LD50 For Mortality
	1988	Kleeman, J.M., J.R. Olson and R.E. Peterson	Fundam. Appl. Toxicol. 10:206-213.	1746-01-6	0.005	MG/KG	20	Growth	LOED	Injection	Whole Body	NA	Carnivore-aquatic insects, fish, inverts	Significant Reduction In Body Weight
	1988	Kleeman, J.M., J.R. Olson and R.E. Peterson	Fundam. Appl. Toxicol. 10:206-213.	1746-01-6	0.025	MG/KG	20	Morphology	LOED	Injection	Whole Body	NA	Carnivore-aquatic insects, fish, inverts	Fin necrosis, cutaneous hemorrhage.

Mercury	Year	Author	Publication Source	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Feeding Behavior	Comments
	1990	Wiener, J.G., Fitzgerald, W.F., Watras, C.J., Rada, R.G.	Environ Tox & Chem 09:909-918	7439-97-6	0.135	MG/KG	60	Growth	NOED	Combined	Whole Body	Adult	Carnivore-aquatic insects, fish, inverts	Controlled Field Study; Two Years But Only 1-year Old Fish Analyzed; Basin Treated By Reducing Ph From About 6 To 5.6

APPENDIX D. TABLE D5
CANDIDATE TRVS BULLHEAD

BLACK BULLHEAD

2,3,7,8-TCDD	Year	Author	Publication Source	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Feeding Behavior	Comments
	1988	Kleeman, J.M., J.R. Olson and R.E. Peterson	Fundam. Appl. Toxicol. 10:206-213.	1746-01-6	0.001	MG/KG	20	Mortality	NOED	Injection	Whole Body	NA	Aquatic invertebrates, including aquatic insects and their larvae	No significant increase in mortality.
	1988	Kleeman, J.M., J.R. Olson and R.E. Peterson	Fundam. Appl. Toxicol. 10:206-213.	1746-01-6	0.025	MG/KG	20	Morphology	LOED	Injection	Whole Body	NA	Aquatic invertebrates, including aquatic insects and their larvae	Fin Necrosis
	1988	Kleeman, J.M., J.R. Olson and R.E. Peterson	Fundam. Appl. Toxicol. 10:206-213.	1746-01-6	0.005	MG/KG	20	Mortality	LD50	Injection	Whole Body	NA	Aquatic invertebrates, including aquatic insects and their larvae	80 Day LD50 For Mortality

CHANNEL CATFISH

2,3,7,8-TCDD	Year	Author	Publication Source	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Feeding Behavior	Comments
	1978	Yockim, R.S., Isensee, A.R., Jones, G.E.	Chemosphere 07:215-220	1746-01-6	0.0044	MG/KG	1	Mortality	LD100	Absorption	Whole Body	NA	Omnivore	Model ecosystem exposure. 100% Mortality in 20 days.. Radiolabelled TCDD added to sediment and leached into water.
	1975	Isensee, A.R. and G.E. Jones	Environ Sci Tech 09:668-672	1746-01-6	0.14	MG/KG	3	Mortality	NOED	Combined	Whole Body	Adult	Omnivore	No effect on survival. Model ecosystem.
	1975	Isensee AR, GE Jones	Environ Sci Tech 09:668-672	1746-01-6	0.19	MG/KG	3	Mortality	NOED	Absorption	Whole Body	Juvenile	Omnivore	

TOTAL PCBS	Download	r	Publication Source	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Feeding Behavior	Comments
	1976	Hansen, L.G., W.B. Wiekhorst and J. Simon	J Fish Res Bd Can 33:1343-1352.	1336-36-3	10.9	MG/KG	3	Mortality	NOED	Ingestion	Whole Body	Immature	Omnivore	No Effect On Mortality
	1976	Hansen, L.G., W.B. Wiekhorst and J. Simon	J Fish Res Bd Can 33:1343-1352.	1336-36-3	10.9	MG/KG	3	Cellular	NOED	Ingestion	Whole Body	Immature	Omnivore	No evidence of histopathology in liver, brain, kidney, reproductive tract, gills, gastrointestinal system, or muscle.

APPENDIX D. TABLE D5
CANDIDATE TRVS BULLHEAD

	1976	Hansen, L.G., W.B. Wiekhorst and J. Simon	J Fish Res Bd Can 33:1343-1352.	1336-36-3	14.3	MG/KG	3	Mortality	NOED	Ingestion	Whole Body	Immature	Omnivore	No Effect On Mortality
	1976	Hansen, L.G., W.B. Wiekhorst and J. Simon	J Fish Res Bd Can 33:1343-1352.	1336-36-3	14.3	MG/KG	3	Growth	LOED	Ingestion	Whole Body	Immature	Omnivore	40% Reduction in body weight. Increased liver/body weight ratio.
	1976	Hansen, L.G., W.B. Wiekhorst and J. Simon	J Fish Res Bd Can 33:1343-1352.	1336-36-3	14.3	MG/KG	3	Cellular	NOED	Ingestion	Whole Body	Immature	Omnivore	No evidence of histopathology in liver, brain, kidney, reproductive tract, gills, gastrointestinal system, or muscle. Residue in whole body minus offal.
	1983	Fingerman, S. and E.C. Short, Jr.	Bull Environ Contam Toxicol 30:147-151	1336-36-3	100	MG/KG	1	Biochemical	NOED	Injection	Whole Body	Immature	Omnivore	No effect on 5-HT, norephinephrine, and dopamine levels in brain.

MERCURY

Download

Ref ID	Year	Author	Publication Source	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Feeding Behavior	Comments
JA33	1979	Birge WJ, JA Black, AG Westerman, JE	The Biogeochemistry of Mercury, pg 629-655	7439-97-6	0.06	MG/KG	3	Mortality	LD50	Water	Whole Body	Embryo	Omnivore	Duration = 4d posthatch

AROCLOR 1242

Download

		or	Publication Source	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Feeding Behavior	Comments
	1976	Hansen LG, WB Wiekhurst, J Simon	J Fish Res Board Can 33:1343-1352	53469-21-9	2.172	MG/KG	2	Physiological	NOED	Ingestion	Whole Body	Fingerling	Omnivore	Kidney Weight Whole Body Minus Stomach and Contents Fed 20 Ug/g dose at 3% body wt, 1x per day. Day 84, 12 control fish died due to pump/drain failure. Feeding of experimentals disrupted days 140-196 - all fed control food for this duration.
	1976	Hansen LG, WB Wiekhurst, J Simon	J Fish Res Board Can 33:1343-1352	53469-21-9	2.172	MG/KG	2	Mortality	NOED	Ingestion	Whole Body	Fingerling	Omnivore	Whole Body Minus Stomach and Contents Fed 20 Ug/g dose at 3% body wt, 1x per day. Day 84, 12 control fish died due to pump/drain failure. Feeding of experimentals disrupted days 140-196 - all fed control food for this duration.
	1976	Hansen LG, WB Wiekhurst, J Simon	J Fish Res Board Can 33:1343-1352	53469-21-9	2.172	MG/KG	2	Morphology	NOED	Ingestion	Whole Body	Fingerling	Omnivore	Tissue Pathologies Whole Body Minus Stomach and Contents Fed 20 Ug/g dose at 3% body wt, 1x per day. Day 84, 12 control fish died due to pump/drain failure. Feeding of experimentals disrupted days 140-196 - all fed control food for this duration.
	1976	Hansen LG, WB Wiekhurst, J Simon	J Fish Res Board Can 33:1343-1352	53469-21-9	2.172	MG/KG	2	Physiological	ED120	Ingestion	Whole Body	Fingerling	Omnivore	Liver Weight Increase Whole Body Minus Stomach and Contents Fed 20 Ug/g dose at 3% body wt, 1x per day. Day 84, 12 control fish died due to pump/drain failure. Feeding of experimentals disrupted days 140-196 - all fed control food for this duration.
	1976	Hansen LG, WB Wiekhurst, J Simon	J Fish Res Board Can 33:1343-1352	53469-21-9	2.172	MG/KG	2	Physiological	NOED	Ingestion	Whole Body	Fingerling	Omnivore	Brain Weight Whole Body Minus Stomach and Contents Fed 20 Ug/g dose at 3% body wt, 1x per day. Day 84, 12 control fish died due to pump/drain failure. Feeding of experimentals disrupted days 140-196 - all fed control food for this duration.

APPENDIX D. TABLE D6
CANDIDATE TRVS LARGEMOUTH BASS

LARGEMOUTH BASS

2,3,7,8-TCDD	Year	Author	Publication Source	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Feeding Behavior	Comments
	1988	Kleeman, J.M., J.R. Olson and R.E. Peterson	Fundam. Appl. Toxicol. 10:206-213.	1746-01-6	0.011	MG/KG	20	Mortality	LD50	Injection	Whole Body	NA	Omnivorous; other fish, small animals	80 Day LD50 For Mortality
	1988	Kleeman, J.M., J.R. Olson and R.E. Peterson	Fundam. Appl. Toxicol. 10:206-213.	1746-01-6	0.025	MG/KG	20	Morphology	LOED	Injection	Whole Body	NA	Omnivorous; other fish, small animals	Fin Necrosis, Hyperpigmentation
	1988	Kleeman, J.M., J.R. Olson and R.E. Peterson	Fundam. Appl. Toxicol. 10:206-213.	1746-01-6	0.001	MG/KG	20	Mortality	NOED	Injection	Whole Body	NA	Omnivorous; other fish, small animals	No significant increase in mortality.

Mercury	Year	Author	Publication Source	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Feeding Behavior	Comments
	2002	Friedmann, A., E. Costain, D. MacLatchy, W. Stansley and E.	Ecotoxicol Environ Saf 52:117-122	7439-97-6	5.4	MG/KG	15	Physiological	NOED	Combined	Whole Body	Adult	Omnivorous; other fish, small animals	Minimum of 15 replicates per measurement type at each of three lakes. Condition factor, GSI, serum cortisol, interenal nucelar diameter, testosterone showed no differences between fish with 0.3 or 5.4 mg/kg body burdens.
	2002	Friedmann, A., E. Costain, D. MacLatchy, W. Stansley and E.	Ecotoxicol Environ Saf 52:117-122	7439-97-6	1.23	MG/KG	15	Physiological	IP-100	Combined	Whole Body	Adult	Omnivorous; other fish, small animals	Minimum of 15 replicates per measurement type at each of three lakes. Endpoint is % increase of 11-ketotestosterone which was a doubling between fish with 0.3 and fish with 1.23 or 5.4 mg/kg BB of Hg. Same induction percentage for both BB.
	2002	Friedmann, A., E. Costain, D. MacLatchy, W. Stansley and E.	Ecotoxicol Environ Saf 52:117-122	7439-97-6	5.4	MG/KG	15	Physiological	ED30	Combined	Whole Body	Adult	Omnivorous; other fish, small animals	Minimum of 15 replicates per measurement type at each of three lakes. Endpoint is % reduction of LSI between fish with 0.3 and 5.4 mg/kg BB of Hg.

SELENIUM	Year	Author	Publication Source	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Feeding Behavior	Comments
	1982	Lemly, A.D.	Aquat Toxicol 02:235-252.	7782-49-2	3.1	MG/KG	3	Mortality	NOED	Absorption	Whole Body	Immature	Omnivorous; other fish, small animals	No mortality at 20 or 30 degrees C in soft or hard water.

APPENDIX D. TABLE D6
CANDIDATE TRVS LARGEMOUTH BASS

DDE	Year	Author	Publication Source	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Feeding Behavior	Comments
	2007	Johnson KG, JK Muller, B Price, A Ware, MS Sepulveda, CJ Borgert, TS Gross	Environ Tox & Chem 26(5):927-934	72-55-9	40	MG/KG	2	Reproduction	NOED	Ingestion	Whole Body	Adult	Omnivorous; other fish, small animals	Estradiol in female fish
	2007	Johnson KG, JK Muller, B Price, A Ware, MS Sepulveda, CJ Borgert, TS Gross	Environ Tox & Chem 26(5):927-934	72-55-9	40	MG/KG	2	Reproduction	NOED	Ingestion	Whole Body	Adult	Omnivorous; other fish, small animals	11-Ketotestosterone in male fish
	2007	Johnson KG, JK Muller, B Price, A Ware, MS Sepulveda, CJ Borgert, TS Gross	Environ Tox & Chem 26(5):927-934	72-55-9	40	MG/KG	2	Reproduction	NOED	Ingestion	Whole Body	Adult	Omnivorous; other fish, small animals	11-ketotestosterone in female fish
	2007	Johnson KG, JK Muller, B Price, A Ware, MS Sepulveda, CJ Borgert, TS Gross	Environ Tox & Chem 26(5):927-934	72-55-9	75	MG/KG	2	Reproduction	IP479	Ingestion	Whole Body	Adult	Omnivorous; other fish, small animals	Estradiol in male fish **Caution: high variability-outliers
	2007	Johnson KG, JK Muller, B Price, A Ware, MS Sepulveda, CJ Borgert, TS Gross	Environ Tox & Chem 26(5):927-934	72-55-9	40	MG/KG	2	Reproduction	NOED	Ingestion	Whole Body	Adult	Omnivorous; other fish, small animals	11-Ketotestosterone in male fish **Caution: high variability-outliers
	2007	Johnson KG, JK Muller, B Price, A Ware, MS Sepulveda, CJ Borgert, TS Gross	Environ Tox & Chem 26(5):927-934	72-55-9	40	MG/KG	2	Reproduction	ED37	Ingestion	Whole Body	Adult	Omnivorous; other fish, small animals	Estradiol in female fish **Trend for dose response decr. at all conc.

APPENDIX D. TABLE D6
CANDIDATE TRVS LARGEMOUTH BASS

	2007	Johnson KG, JK Muller, B Price, A Ware, MS Sepulveda, CJ Borgert, TS Gross	Environ Tox & Chem 26(5):927-934	72-55-9	40	MG/KG	2	Reproduction	NOED	Ingestion	Whole Body	Adult	Omnivorous; other fish, small animals	11-Ketotestosteronein female fish **Trend for dose response decr. at all conc.
	2007	Johnson KG, JK Muller, B Price, A Ware, MS Sepulveda, CJ Borgert, TS Gross	Environ Tox & Chem 26(5):927-934	72-55-9	40	MG/KG	2	Reproduction	NOED	Ingestion	Whole Body	Adult	Omnivorous; other fish, small animals	Estradiol in male fish

APPENDIX D. TABLE D7
CANDIDATE TRVS SURROGATE FISH SPECIES

BLUEGILL

DIOXIN

	Download	r	Publication Source	Analyte Name	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Feeding Behavior	Comments
	1988	Kleeman, J.M., J.R. Olson and R.E. Peterson	Fundam. Appl. Toxicol. 10:206-213.	TCDD	1746-01-6	0.001	MG/KG	20	Mortality	NOED	Injection	Whole Body	NA	Carnivore-aquatic insects, fish, inverts	No significant increase in mortality.
	1988	Kleeman, J.M., J.R. Olson and R.E. Peterson	Fundam. Appl. Toxicol. 10:206-213.	2,3,7,8-TCDD	1746-01-6	0.001	MG/KG	20	Mortality	NOED	Injection	Whole Body	NA	Carnivore-aquatic insects, fish, inverts	No significant increase in mortality.
	1993	Cook PM , RJ Erickson, RL Spehar, SP Bradbury, GT Ankley	EPA 600/R-93/055	TCDD	1746-01-6	0.016	MG/KG		Mortality	LD50	Injection		Juvenile	Carnivore-aquatic insects, fish, inverts	Kleeman et al 1988
	1988	Kleeman, J.M., J.R. Olson and R.E. Peterson	Fundam. Appl. Toxicol. 10:206-213.	TCDD	1746-01-6	0.016	MG/KG	20	Mortality	LD50	Injection	Whole Body	NA	Carnivore-aquatic insects, fish, inverts	80 Day LD50 For Mortality
	1993	Cook PM , RJ Erickson, RL Spehar, SP Bradbury, GT Ankley	EPA 600/R-93/055	2,3,7,8-TCDD	1746-01-6	0.016	MG/KG		Mortality	LD50	Injection		Juvenile	Carnivore-aquatic insects, fish, inverts	Kleeman et al 1988
	1988	Kleeman, J.M., J.R. Olson and R.E. Peterson	Fundam. Appl. Toxicol. 10:206-213.	2,3,7,8-TCDD	1746-01-6	0.016	MG/KG	20	Mortality	LD50	Injection	Whole Body	NA	Carnivore-aquatic insects, fish, inverts	80 Day LD50 For Mortality
	1988	Kleeman, J.M., J.R. Olson and R.E. Peterson	Fundam. Appl. Toxicol. 10:206-213.	TCDD	1746-01-6	0.025	MG/KG	20	Morphology	LOED	Injection	Whole Body	NA	Carnivore-aquatic insects, fish, inverts	Fin necrosis, cutaneous hemorrhage.
	1988	Kleeman, J.M., J.R. Olson and R.E. Peterson	Fundam. Appl. Toxicol. 10:206-213.	TCDD	1746-01-6	0.025	MG/KG	20	Growth	LOED	Injection	Whole Body	NA	Carnivore-aquatic insects, fish, inverts	Significant Reduction In Body Weight
	1988	Kleeman, J.M., J.R. Olson and R.E. Peterson	Fundam. Appl. Toxicol. 10:206-213.	2,3,7,8-TCDD	1746-01-6	0.025	MG/KG	20	Growth	LOED	Injection	Whole Body	NA	Carnivore-aquatic insects, fish, inverts	Significant Reduction In Body Weight

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BLUEGILL	1988	Kleeman, J.M., J.R. Olson and R.E. Peterson	Fundam. Appl. Toxicol. 10:206-213.	2,3,7,8-TCDD	1746-01-6	0.025	MG/KG	20	Morphology	LOED	Injection	Whole Body	NA	Carnivore-aquatic insects, fish, inverts	Fin necrosis, cutaneous hemorrhage.

PESTICIDE

	Download	r	Publication Source	Analyte Name	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Feeding Behavior	Comments
	1967	Gakstatter, J.H. and C.M. Weiss	Trans Am Fish Soc 096:301-307.	4,4`-DDT	50-29-3	4.2	MG/KG	5	Behavior	LOED	Absorption	Whole Body	Immature	Carnivore-aquatic insects, fish, inverts	Severe symptoms of poisoning including loss of equilibrium and convulsions.
	1972	Macek, K.J., D.F. Walsh, J.W. Hogan, and D.D. Holz	Trans Am Fish Soc 003:420-427	Chlorpyrifos	2921-88-2	0.2	MG/KG	2	Biochemical	ED60	Combined	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	60% Inhibition of acetylcholinesterase activity. Mesocosm study, 2 applications 30 days apart. Residue measured at 7 days.
	1972	Macek, K.J., D.F. Walsh, J.W. Hogan, and D.D. Holz	Trans Am Fish Soc 003:420-427	Chlorpyrifos	2921-88-2	0.42	MG/KG	2	Mortality	NOED	Combined	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	No significant increase in mortality. Mesocosm study, 2 applications 30 days apart. Residue measured at 35 days.
	1972	Macek, K.J., D.F. Walsh, J.W. Hogan, and D.D. Holz	Trans Am Fish Soc 003:420-427	Chlorpyrifos	2921-88-2	0.42	MG/KG	2	Behavior	NOED	Combined	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	No changes in swimming behavior. Mesocosm study, 2 applications 30 days apart. Residue measured at 35 days.
	1972	Macek, K.J., D.F. Walsh, J.W. Hogan, and D.D. Holz	Trans Am Fish Soc 003:420-427	Chlorpyrifos	2921-88-2	2.06	MG/KG	2	Behavior	LOED	Combined	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	Erratic swimming, loss of equilibrium after applications. Mesocosm study, 2 applications 30 days apart. Residue measured at 3 days.
	1972	Macek, K.J., D.F. Walsh, J.W. Hogan, and D.D. Holz	Trans Am Fish Soc 003:420-427	Chlorpyrifos	2921-88-2	2.06	MG/KG	2	Mortality	LOED	Combined	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	55% Increased mortality. Mesocosm study, 2 applications 30 days apart. Residue measured at 3 days.
	1972	Macek, K.J., D.F. Walsh, J.W. Hogan, and D.D. Holz	Trans Am Fish Soc 003:420-427	Chlorpyrifos	2921-88-2	2.12	MG/KG	2	Biochemical	ED90	Combined	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	90% Inhibition of acetylcholinesterase activity. Mesocosm study, 2 applications 30 days apart. Residue measured at 7 days.
	1967	Gakstatter, J.H. and C.M. Weiss	Trans Am Fish Soc 096:301-307.	Dieldrin	60-57-1	3.7	MG/KG	5	Behavior	LOED	Absorption	Whole Body	Immature	Carnivore-aquatic insects, fish, inverts	Severe symptoms of poisoning including loss of equilibrium and convulsions.

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	1970	Bennett, H.J. and J.W. Day Jr.	Pesticides Monitoring Journal, 3(4):201-203.	Endrin	72-20-8	0.04	MG/KG	1	Mortality	NOED	Absorption	Muscle	NA	Carnivore-aquatic insects, fish, inverts	No increase in mortality.
	1970	Bennett, H.J. and J.W. Day Jr.	Pesticides Monitoring Journal, 3(4):201-203.	Endrin	72-20-8	0.08	MG/KG	1	Mortality	NOED	Absorption	Whole Body	NA	Carnivore-aquatic insects, fish, inverts	No increase in mortality.
	1970	Bennett, H.J. and J.W. Day Jr.	Pesticides Monitoring Journal, 3(4):201-203.	Endrin	72-20-8	0.12	MG/KG	1	Mortality	LOED	Absorption	Muscle	NA	Carnivore-aquatic insects, fish, inverts	Increase in mortality.
	1970	Bennett, H.J. and J.W. Day Jr.	Pesticides Monitoring Journal, 3(4):201-203.	Endrin	72-20-8	0.3	MG/KG	1	Mortality	LOED	Absorption	Whole Body	NA	Carnivore-aquatic insects, fish, inverts	Increase in mortality.
	1970	Bennett, H.J. and J.W. Day Jr.	Pesticides Monitoring Journal, 3(4):201-203.	Endrin	72-20-8	0.5	MG/KG	1	Mortality	NOED	Absorption	Gastrointestinal Tract	NA	Carnivore-aquatic insects, fish, inverts	No increase in mortality.
	1970	Bennett, H.J. and J.W. Day Jr.	Pesticides Monitoring Journal, 3(4):201-203.	Endrin	72-20-8	0.7	MG/KG	1	Mortality	LOED	Absorption	Gastrointestinal Tract	NA	Carnivore-aquatic insects, fish, inverts	Increase in mortality.
	1970	Bennett, H.J. and J.W. Day Jr.	Pesticides Monitoring Journal, 3(4):201-203.	Endrin	72-20-8	0.8	MG/KG	1	Mortality	NOED	Absorption	Liver	NA	Carnivore-aquatic insects, fish, inverts	No increase in mortality.
	1970	Bennett, H.J. and J.W. Day Jr.	Pesticides Monitoring Journal, 3(4):201-203.	Endrin	72-20-8	1	MG/KG	1	Mortality	LOED	Absorption	Liver	NA	Carnivore-aquatic insects, fish, inverts	Increase in mortality.
	1987	Bradbury, S.P., D.M. Symonik, J.R. Coats, and G.J. Atchison.	Bull Environ Contam Toxicol 38:727-735	Fenvalerate	51630-58-1	0.67	MG/KG	10	Mortality	LD50	Injection	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	50% Mortality after i.p. injection of .67 mg/kg.
	1976	Macek KJ, KS Buxton, SK Derr, JW Dean, S Sauter	EPA 600/3-76/046 49pp.	Lindane	58-89-9	0.016	MG/KG	2	Reproduction	ED10	Water	Muscle	Juvenile	Carnivore-aquatic insects, fish, inverts	% hatchability. Caution: lack of spawning in control conc.; not statistically validated
	1976	Macek KJ, KS Buxton, SK Derr, JW Dean, S Sauter	EPA 600/3-76/046 49pp.	Lindane	58-89-9	0.016	MG/KG	2	Mortality	LD100	Water	Muscle	Juvenile	Carnivore-aquatic insects, fish, inverts	F1 fry survival @90 d
	1976	Macek KJ, KS Buxton, SK Derr, JW Dean, S Sauter	EPA 600/3-76/046 49pp.	Lindane	58-89-9	0.025	MG/KG	2	Mortality	LD88	Water	Muscle	Juvenile	Carnivore-aquatic insects, fish, inverts	F1 fry survival @90 d

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	1976	Macek KJ, KS Buxton, SK Derr, JW Dean, S Sauter	EPA 600/3-76/046 49pp.	Lindane	58-89-9	0.025	MG/KG	2	Reproduction	ED12	Water	Muscle	Juvenile	Carnivore-aquatic insects, fish, inverts	% hatchability. Caution: lack of spawning in control conc.; not statistically validated
	1976	Macek KJ, KS Buxton, SK Derr, JW Dean, S Sauter	EPA 600/3-76/046 49pp.	Lindane	58-89-9	0.062	MG/KG	2	Mortality	LD41	Water	Muscle	Juvenile	Carnivore-aquatic insects, fish, inverts	F1 fry survival @90 d
	1976	Macek KJ, KS Buxton, SK Derr, JW Dean, S Sauter	EPA 600/3-76/046 49pp.	Lindane	58-89-9	0.062	MG/KG	2	Reproduction	ED35	Water	Muscle	Juvenile	Carnivore-aquatic insects, fish, inverts	% hatchability. Caution: lack of spawning in control conc.; not statistically validated
	1976	Macek KJ, KS Buxton, SK Derr, JW Dean, S Sauter	EPA 600/3-76/046 49pp.	Lindane	58-89-9	0.196	MG/KG	2	Mortality	LD86	Water	Muscle	Juvenile	Carnivore-aquatic insects, fish, inverts	F1 fry survival @90 d
	1976	Macek KJ, KS Buxton, SK Derr, JW Dean, S Sauter	EPA 600/3-76/046 49pp.	Lindane	58-89-9	0.196	MG/KG	2	Reproduction	ED30	Water	Muscle	Juvenile	Carnivore-aquatic insects, fish, inverts	% hatchability. Caution: lack of spawning in control conc.; not statistically validated
	1976	Macek KJ, KS Buxton, SK Derr, JW Dean, S Sauter	EPA 600/3-76/046 49pp.	Lindane	58-89-9	0.196	MG/KG	2	Reproduction	ED70	Water	Muscle	Juvenile	Carnivore-aquatic insects, fish, inverts	% hatchability. Caution: lack of spawning in control conc.; not statistically validated
	1976	Macek, K.J., K.S. Buxton, S.K. Derr, J.W. Dean and S. Sauter	U.S. EPA 600/3-76-046, ORD, Duluth, MN. 50 pp.	Lindane	58-89-9	0.297	MG/KG	1	Mortality	NOED	Absorption	Muscle	Immature	Carnivore-aquatic insects, fish, inverts	No Effect On Survival
	1976	Macek, K.J., K.S. Buxton, S.K. Derr, J.W. Dean and S. Sauter	U.S. EPA 600/3-76-046, ORD, Duluth, MN. 50 pp.	Lindane	58-89-9	0.297	MG/KG	1	Growth	NOED	Absorption	Muscle	Immature	Carnivore-aquatic insects, fish, inverts	No Effect On Growth
	1967	Gakstatter, J.H. and C.M. Weiss	Trans Am Fish Soc 096:301-307.	Lindane	58-89-9	1.5	MG/KG	5	Behavior	NOED	Absorption	Whole Body	Immature	Carnivore-aquatic insects, fish, inverts	No symptoms of poisoning.
	1974	Hyde, K.M., S. Stokes, J.F. Fowler, J.B. Graves, and F.L. Bonner.	Trans Am Fish Soc 002a:366-369	Mirex	2385-85-5	0.02	MG/KG	1	Growth	NOED	Absorption	Whole Body	NA	Carnivore-aquatic insects, fish, inverts	No significant difference in weight or length. Fish raised in outdoor ponds treated with Mirex bait. Fish were fed commercial feed.

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CANDIDATE TRVS SURROGATE FISH SPECIES

	1968	van Valin, C.C., Andrews, A.K., Eller, L.L.	Trans Am Fish Soc 097:185-196.	Mirex	2385-85-5	10	MG/KG	1	Growth	NOED	Combined	Whole Body	Immature	Carnivore-aquatic insects, fish, inverts	No significant difference in weight gain.
	1968	van Valin, C.C., Andrews, A.K., Eller, L.L.	Trans Am Fish Soc 097:185-196.	Mirex	2385-85-5	14	MG/KG	1	Mortality	NOED	Combined	Whole Body	Immature	Carnivore-aquatic insects, fish, inverts	No significant increase in mortality.
	1968	van Valin, C.C., Andrews, A.K., Eller, L.L.	Trans Am Fish Soc 097:185-196.	Mirex	2385-85-5	14	MG/KG	1	Morphology	NOED	Combined	Whole Body	Immature	Carnivore-aquatic insects, fish, inverts	No morphological changes.
	1968	van Valin, C.C., Andrews, A.K., Eller, L.L.	Trans Am Fish Soc 097:185-196.	Mirex	2385-85-5	14	MG/KG	1	Growth	LOED	Combined	Whole Body	Immature	Carnivore-aquatic insects, fish, inverts	34% Reduction in weight gain probably due to reduced food intake. Residue at 100 days.
	1968	van Valin, C.C., Andrews, A.K., Eller, L.L.	Trans Am Fish Soc 097:185-196.	Mirex	2385-85-5	30	MG/KG	1	Mortality	NOED	Combined	Whole Body	Immature	Carnivore-aquatic insects, fish, inverts	No increase in mortality. Mirex bait added to outdoor ponds
	1968	van Valin, C.C., Andrews, A.K., Eller, L.L.	Trans Am Fish Soc 097:185-196.	Mirex	2385-85-5	30	MG/KG	1	Cellular	NOED	Combined	Whole Body	Immature	Carnivore-aquatic insects, fish, inverts	No evidence of histopathology. Mirex bait added to outdoor ponds
BLUEGILL	1968	van Valin, C.C., Andrews, A.K., Eller, L.L.	Trans Am Fish Soc 097:185-196.	Mirex	2385-85-5	30	MG/KG	1	Reproduction	NOED	Combined	Whole Body	Immature	Carnivore-aquatic insects, fish, inverts	No apparent effect on reproductive success (no measurements given). Mirex bait added to outdoor ponds

ARSENIC

	Download	r	Publication Source	Analyte Name	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Feeding Behavior	Comments
	1980	Barrows, M.E., S.R. Petrocelli, K.J. Macek and J.J. Carroll	p. 379-392 in Haque, R., ed. Dynamics, Exposure and Hazard Assessment of Toxic Chemicals	Arsenic	7440-38-2	0.52	MG/KG	5	Mortality	NOED	Absorption	Whole Body	Immature	Carnivore-aquatic insects, fish, inverts	No Effect On Mortality
	1966	Gilderhus, P.A.	Trans Am Fish Soc 095:289-296	Arsenic	7440-38-2	0.53	MG/KG	1	Reproduction	NOED	Combined	Whole Body	Adult	Carnivore-aquatic insects, fish, inverts	Normal ovary and oocyte development. Weekly applications of sodium arsenite herbicide in artificial pond.
	1966	Gilderhus, P.A.	Trans Am Fish Soc 095:289-296	Arsenic	7440-38-2	1.72	MG/KG	1	Cellular	LOED	Combined	Whole Body	Adult	Carnivore-aquatic insects, fish, inverts	Histopathology of ovary, gill, and liver. Weekly applications of sodium arsenite herbicide in artificial pond.
	1966	Gilderhus, P.A.	Trans Am Fish Soc 095:289-296	Arsenic	7440-38-2	1.72	MG/KG	1	Reproduction	LOED	Combined	Whole Body	Adult	Carnivore-aquatic insects, fish, inverts	Abnormal ovary and oocyte development. Weekly applications of sodium arsenite herbicide in artificial pond.

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CANDIDATE TRVS SURROGATE FISH SPECIES

	1966	Gilderhus, P.A.	Trans Am Fish Soc 095:289-296	Arsenic	7440-38-2	1.8	MG/KG	1	Mortality	NOED	Combined	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	No increase in mortality. Weekly application of sodium arsenite herbicide in artificial pond.
	1966	Gilderhus, P.A.	Trans Am Fish Soc 095:289-296	Arsenic	7440-38-2	1.8	MG/KG	1	Growth	NOED	Combined	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	No difference in weight gain. Weekly application of sodium arsenite herbicide in artificial pond.
	1966	Gilderhus, P.A.	Trans Am Fish Soc 095:289-296	Arsenic	7440-38-2	2.24	MG/KG	1	Growth	LOED	Combined	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	Decrease in weight gain. One application of sodium arsenite herbicide in artificial pond.
	1966	Gilderhus, P.A.	Trans Am Fish Soc 095:289-296	Arsenic	7440-38-2	2.24	MG/KG	1	Mortality	LOED	Combined	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	Increase in mortality. One application of sodium arsenite herbicide in artificial pond.
	1966	Gilderhus, P.A.	Trans Am Fish Soc 095:289-296	Arsenic	7440-38-2	5.5	MG/KG	1	Growth	NOED	Combined	Whole Body	Adult	Carnivore-aquatic insects, fish, inverts	No difference in weight. Monthly applications of sodium arsenite herbicide in artificial pond.
	1966	Gilderhus, P.A.	Trans Am Fish Soc 095:289-296	Arsenic	7440-38-2	5.5	MG/KG	1	Mortality	NOED	Combined	Whole Body	Adult	Carnivore-aquatic insects, fish, inverts	No increase in mortality. Monthly applications of sodium arsenite herbicide in artificial pond.
	1966	Gilderhus, P.A.	Trans Am Fish Soc 095:289-296	Arsenic	7440-38-2	11.6	MG/KG	1	Growth	LOED	Combined	Whole Body	Adult	Carnivore-aquatic insects, fish, inverts	Decrease in weight. Weekly appplications of sodium arsenite herbicide in artificial pond.
	1966	Gilderhus, P.A.	Trans Am Fish Soc 095:289-296	Arsenic	7440-38-2	11.6	MG/KG	1	Mortality	LOED	Combined	Whole Body	Adult	Carnivore-aquatic insects, fish, inverts	Increased mortality. Weekly appplications of sodium arsenite herbicide in artificial pond.
	1966	Gilderhus, P.A.	Trans Am Fish Soc 095:289-296	Arsenic	7440-38-2	11.6	MG/KG	1	Cellular	NA	Combined	Whole Body	Adult	Carnivore-aquatic insects, fish, inverts	Acute heart damage. Weekly applications of sodium arsenite herbicide in artificial pond.
BLUEGILL	1966	Gilderhus, P.A.	Trans Am Fish Soc 095:289-296	Arsenic	7440-38-2	11.6	MG/KG	1	Biochemical	NOED	Combined	Whole Body	Adult	Carnivore-aquatic insects, fish, inverts	No difference in hematocrit. Weekly applications of sodium arsenite herbicide in artificial pond.

SELENIUM

	Download	r	Publication Source	Analyte Name	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Feeding Behavior	Comments
	1993	Cleveland L, EE Little, DR Buckler, and RH Wiedmeye	Aquat Toxicol	Selenium	7782-49-2	0.5	MG/KG		Mortality	NOED	Ingestion	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	Condition Index
	1986	Gillespie RB, PC Baumann	Trans Am Fish Soc 115:208-213	Selenium	7782-49-2	0.62	MG/KG	2	Reproductio n	NOED	Water	Whole Body	Adult	Carnivore-aquatic insects, fish, inverts	Larval Abnormalities, RxR cross, Residues measured in the Larvae. Exp_concentration at Roxboro
	1993	Cleveland L, EE Little, DR Buckler, and RH Wiedmeye	Aquat Toxicol	Selenium	7782-49-2	0.66	MG/KG		Mortality	NOED	Ingestion	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	Condition Index
	2003	Hamilton SJ	Ecotoxicol Environ Saf 56:201-210	Selenium	7782-49-2	0.66	MG/KG		Growth	NOED	NS	Whole Body	NS	Carnivore-aquatic insects, fish, inverts	Review paper Cleveland et al 1993
	1993	Cleveland L, EE Little, DR Buckler, and RH Wiedmeye	Aquat Toxicol	Selenium	7782-49-2	0.68	MG/KG		Mortality	LD20	Water	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	

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	1993	Cleveland L, EE Little, DR Buckler, and RH Wiedmeye	Aquat Toxicol	Selenium	7782-49-2	0.8	MG/KG		Mortality	LD40	Water	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	
	1993	Cleveland L, EE Little, DR Buckler, and RH Wiedmeye	Aquat Toxicol	Selenium	7782-49-2	0.8	MG/KG		Survival	NOED	Water	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	
	2004	SJ Hamilton	Sci Total Environ 326:1-31	Selenium	7782-49-2	0.86	MG/KG	0	Mortality	NS	Ingestion	Whole Body	NS	Carnivore-aquatic insects, fish, inverts	fish wt = 0.2g REF: Cleveland et al 1993
	1993	Cleveland L, EE Little, DR Buckler, and RH Wiedmeye	Aquat Toxicol	Selenium	7782-49-2	0.9	MG/KG		Mortality	LD21	Ingestion	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	
	1993	Cleveland L, EE Little, DR Buckler, and RH Wiedmeye	Aquat Toxicol	Selenium	7782-49-2	0.9	MG/KG		Physiological	NOED	Ingestion	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	Condition Index
	2003	Hamilton SJ	Ecotoxicol Environ Saf 56:201-210	Selenium	7782-49-2	0.92	MG/KG		Growth	LOED	NS	Whole Body	NS	Carnivore-aquatic insects, fish, inverts	Review paper Cleveland et al 1993
	1993	Cleveland L, EE Little, DR Buckler, and RH Wiedmeye	Aquat Toxicol	Selenium	7782-49-2	0.98	MG/KG		Mortality	LD18	Ingestion	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	
	1993	Cleveland L, EE Little, DR Buckler, and RH Wiedmeye	Aquat Toxicol	Selenium	7782-49-2	1.04	MG/KG		Mortality	LD47	Water	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	
	2004	SJ Hamilton	Sci Total Environ 326:1-31	Selenium	7782-49-2	1.1	MG/KG	0	Mortality	NS	Ingestion	Whole Body	NS	Carnivore-aquatic insects, fish, inverts	fish wt = 2.4g REF: Lemly 1993
	1993	Lemly, A.D.	Aquat Toxicol 27:133-158	Selenium	7782-49-2	1.2	MG/KG	3	Growth	NOED	Combined	Whole Body	Immature	Carnivore-aquatic insects, fish, inverts	No difference in body weight to length ratio. Exposure at 20 degrees C. Concurrent epxosure to 5 ug inorganic Se/L in water and 5.1 ug Seleno-L-Methionine/g in food.
	1993	Lemly, A.D.	Aquat Toxicol 27:133-158	Selenium	7782-49-2	1.2	MG/KG	3	Physiological	LOED	Combined	Whole Body	Immature	Carnivore-aquatic insects, fish, inverts	Increased oxygen consumption. Exposure at 20 degrees C. Concurrent exposure to 5 ug inorganic Se/L in water and 5.1 ug Seleno-L-Methionine/g in food.

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CANDIDATE TRVS SURROGATE FISH SPECIES

	1993	Lemly, A.D.	Aquat Toxicol 27:133-158	Selenium	7782-49-2	1.2	MG/KG	3	Physiological	LOED	Combined	Whole Body	Immature	Carnivore-aquatic insects, fish, inverts	Increased oxygen consumption and lipid depletion. Exposure at 4 degrees C. Concurrent epxosure to 5 ug inorganic Se/L in water and 5.1 ug Seleno-L-Methionine/g in food.
	1993	Lemly, A.D.	Aquat Toxicol 27:133-158	Selenium	7782-49-2	1.2	MG/KG	3	Biochemical	LOED	Combined	Whole Body	Immature	Carnivore-aquatic insects, fish, inverts	Decreased hemoglobin and red blood cells. Exposure at 4 or 20 degrees C. Concurrent epxosure to 5 ug inorganic Se/L in water and 5.1 ug Seleno-L-Methionine/g in food.
	1993	Lemly, A.D.	Aquat Toxicol 27:133-158	Selenium	7782-49-2	1.2	MG/KG	3	Growth	LOED	Combined	Whole Body	Immature	Carnivore-aquatic insects, fish, inverts	Reduced weight to length ratio. Exposure at 4 degrees C. Concurrent epxosure to 5 ug inorganic Se/L in water and 5.1 ug Seleno-L-Methionine/g in food.
	1993	Lemly, A.D.	Aquat Toxicol 27:133-158	Selenium	7782-49-2	1.2	MG/KG	3	Cellular	LOED	Combined	Whole Body	Immature	Carnivore-aquatic insects, fish, inverts	Swelling and distortion in gill tissue. Exposure at 4 or 20 degrees C. Concurrent exposure to 5 ug inorganic Se/L in water and 5.1 ug Seleno-L-Methionine/g in food.
	1993	Lemly, A.D.	Aquat Toxicol 27:133-158	Selenium	7782-49-2	1.2	MG/KG	3	Behavior	LOED	Combined	Whole Body	Immature	Carnivore-aquatic insects, fish, inverts	Decrease in feeding activity. Exposure at 4 degrees C. Concurrent epxosure to 5 ug inorganic Se/L in water and 5.1 ug Seleno-L-Methionine/g in food.
	1993	Cleveland L, EE Little, DR Buckler, and RH Wiedmeye	Aquat Toxicol	Selenium	7782-49-2	1.42	MG/KG		Mortality	LD55	Water	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	
	1993	Cleveland L, EE Little, DR Buckler, and RH Wiedmeye	Aquat Toxicol	Selenium	7782-49-2	1.58	MG/KG		Physiological	ED7	Ingestion	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	Condition Index
	1993	Lemly, A.D.	Aquat Toxicol 27:133-158	Selenium	7782-49-2	1.6	MG/KG	3	Mortality	LOED	Combined	Whole Body	Immature	Carnivore-aquatic insects, fish, inverts	35% Increase in mortality. Exposure at 4 degrees C. Concurrent epxosure to 5 ug inorganic Se/L in water and 5.1 ug Seleno-L-Methionine/g in food.
	1993	Lemly, A.D.	Aquat Toxicol 27:133-158	Selenium	7782-49-2	1.6	MG/KG	3	Mortality	NOED	Combined	Whole Body	Immature	Carnivore-aquatic insects, fish, inverts	No increase in mortality. Exposure at 20 degrees C. Concurrent epxosure to 5 ug inorganic Se/L in water and 5.1 ug Seleno-L-Methionine/g in food.
	1993	Lemly, A.D.	Aquat Toxicol 27:133-158	Selenium	7782-49-2	1.6	MG/KG	3	Cellular	NOED	Combined	Whole Body	Immature	Carnivore-aquatic insects, fish, inverts	No changes in liver, kidney, heart or spleen tissue. Exposure at 4 C. Concurrent epxosure to 5 ug inorganic Se/L in water and 5.1 ug Seleno-L-Methionine/g in food.
	1993	Cleveland L, EE Little, DR Buckler, and RH Wiedmeye	Aquat Toxicol	Selenium	7782-49-2	2.2	MG/KG		Mortality	NOED	Ingestion	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	Condition Index

APPENDIX D. TABLE D7
CANDIDATE TRVS SURROGATE FISH SPECIES

	1993	Cleveland L, EE Little, DR Buckler, and RH Wiedmeye	Aquat Toxicol	Selenium	7782-49-2	2.2	MG/KG		Physiological	ED13	Ingestion	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	Condition Index
	1993	Cleveland L, EE Little, DR Buckler, and RH Wiedmeye	Aquat Toxicol	Selenium	7782-49-2	2.38	MG/KG		Mortality	LD15	Ingestion	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	
	1980	Barrows, M.E., S.R. Petrocelli, K.J. Macek and J.J. Carroll	p. 379-392 in Haque, R., ed. Dynamics, Exposure and Hazard Assessment of Toxic Chemicals	Selenium	7782-49-2	2.4	MG/KG	5	Mortality	NOED	Absorption	Whole Body	Immature	Carnivore-aquatic insects, fish, inverts	No Effect On Mortality
	1993	Cleveland L, EE Little, DR Buckler, and RH Wiedmeye	Aquat Toxicol	Selenium	7782-49-2	2.7	MG/KG		Physiological	ED7	Ingestion	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	Condition Index
	1993	Cleveland L, EE Little, DR Buckler, and RH Wiedmeye	Aquat Toxicol	Selenium	7782-49-2	2.96	MG/KG		Physiological	ED14	Water	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	Condition index
	1993	Cleveland L, EE Little, DR Buckler, and RH Wiedmeye	Aquat Toxicol	Selenium	7782-49-2	2.96	MG/KG		Physiological	ED14	Water	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	Condition index
	1993	Cleveland L, EE Little, DR Buckler, and RH Wiedmeye	Aquat Toxicol	Selenium	7782-49-2	2.96	MG/KG		Mortality	LD88	Water	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	
	1993	Coyle JJ, DR Buckler, CG Ingersoll, JF Fairchild, and TW May	Environ Tox & Chem 12:551-565	Selenium	7782-49-2	3.24	MG/KG	2	Physiological	NOED	Combined	Whole Body	Adult	Carnivore-aquatic insects, fish, inverts	No effect, GSI; Results support field observations that food chain accumulation of Se can severely reduce reproductive success of bluegills; there was diferential uptake into reproductive organs

APPENDIX D. TABLE D7
CANDIDATE TRVS SURROGATE FISH SPECIES

	1993	Coyle JJ, DR Buckler, CG Ingersoll, JF Fairchild, and TW May	Environ Tox & Chem 12:551-565	Selenium	7782-49-2	3.24	MG/KG	2	Physiological	NOED	Combined	Whole Body	Adult	Carnivore-aquatic insects, fish, inverts	No effect, condition factor; Results support field observations that food chain accumulation of Se can severely reduce reproductive success of bluegills; there was diferential uptake into reproductive organs
	1993	Coyle JJ, DR Buckler, CG Ingersoll, JF Fairchild, and TW May	Environ Tox & Chem 12:551-565	Selenium	7782-49-2	3.24	MG/KG	2	Growth	NOED	Combined	Whole Body	Adult	Carnivore-aquatic insects, fish, inverts	No effect, length & weight; Results support field observations that food chain accumulation of Se can severely reduce reproductive success of bluegills; there was diferential uptake into reproductive organs
	1993	Coyle JJ, DR Buckler, CG Ingersoll, JF Fairchild, and TW May	Environ Tox & Chem 12:551-565	Selenium	7782-49-2	3.6	MG/KG	2	Survival	NOED	Combined	Whole Body	Adult	Carnivore-aquatic insects, fish, inverts	Results support field observations that food chain accumulation of Se can severely reduce reproductive success of bluegills; there was diferential uptake into reproductive organs
	1993	Coyle JJ, DR Buckler, CG Ingersoll, JF Fairchild, and TW May	Environ Tox & Chem 12:551-565	Selenium	7782-49-2	3.6	MG/KG	2	Reproductio n	NOED	Combined	Whole Body	Adult	Carnivore-aquatic insects, fish, inverts	No effect, % hatch; Results support field observations that food chain accumulation of Se can severely reduce reproductive success of bluegills; there was diferential uptake into reproductive organs
	1993	Coyle JJ, DR Buckler, CG Ingersoll, JF Fairchild, and TW May	Environ Tox & Chem 12:551-565	Selenium	7782-49-2	3.6	MG/KG	2	Reproductio n	NOED	Combined	Whole Body	Adult	Carnivore-aquatic insects, fish, inverts	No effect, spawning frequency; Results support field observations that food chain accumulation of Se can severely reduce reproductive success of bluegills; there was diferential uptake into reproductive organs
	1993	Coyle JJ, DR Buckler, CG Ingersoll, JF Fairchild, and TW May	Environ Tox & Chem 12:551-565	Selenium	7782-49-2	3.6	MG/KG	2	Physiological	NOED	Combined	Whole Body	Adult	Carnivore-aquatic insects, fish, inverts	No effect, condition factor; Results support field observations that food chain accumulation of Se can severely reduce reproductive success of bluegills; there was diferential uptake into reproductive organs

APPENDIX D. TABLE D7
CANDIDATE TRVS SURROGATE FISH SPECIES

	1993	Coyle JJ, DR Buckler, CG Ingersoll, JF Fairchild, and TW May	Environ Tox & Chem 12:551-565	Selenium	7782-49-2	3.6	MG/KG	2	Growth	NOED	Combined	Whole Body	Adult	Carnivore-aquatic insects, fish, inverts	No effect, length & weight; Results support field observations that food chain accumulation of Se can severely reduce reproductive success of bluegills; there was diferential uptake into reproductive organs
	1993	Coyle JJ, DR Buckler, CG Ingersoll, JF Fairchild, and TW May	Environ Tox & Chem 12:551-565	Selenium	7782-49-2	3.6	MG/KG	2	Mortality	LD92	Combined	Whole Body	Adult	Carnivore-aquatic insects, fish, inverts	Reduced survival of newly hatched larvae; Results support field observations that food chain accumulation of Se can severely reduce reproductive success of bluegills; there was diferential uptake into reproductive organs
	1993	Coyle JJ, DR Buckler, CG Ingersoll, JF Fairchild, and TW May	Environ Tox & Chem 12:551-565	Selenium	7782-49-2	3.6	MG/KG	2	Reproduction	NOED	Combined	Whole Body	Adult	Carnivore-aquatic insects, fish, inverts	No effect, # eggs/spawn; Results support field observations that food chain accumulation of Se can severely reduce reproductive success of bluegills; there was diferential uptake into reproductive organs
	2004	SJ Hamilton	Sci Total Environ 326:1-31	Selenium	7782-49-2	3.8	MG/KG	0	Reproduction	NS	Ingestion	Whole Body	Adult	Carnivore-aquatic insects, fish, inverts	fish wt = 2.4g REF: Coyle et al 1993
	1992	Hermanutz, R.O., Allen, K.N., Roush, T.H., and S.F. Hedtke	Environ Tox & Chem 11: 217-224	Selenium	7782-49-2	4.6	MG/KG	6	Reproduction	NA	Combined	Whole Body	Adult	Carnivore-aquatic insects, fish, inverts	Measurable But Not Statistically Significant Reduced Survival Of Embryos And Larvae
	1992	Hermanutz, R.O., Allen, K.N., Roush, T.H., and S.F. Hedtke	Environ Tox & Chem 11: 217-224	Selenium	7782-49-2	4.6	MG/KG	6	Growth	NA	Combined	Whole Body	Adult	Carnivore-aquatic insects, fish, inverts	
	1992	Hermanutz, R.O., Allen, K.N., Roush, T.H., and S.F. Hedtke	Environ Tox & Chem 11: 217-224	Selenium	7782-49-2	4.6	MG/KG	6	Mortality	LOED	Combined	Whole Body	Adult	Carnivore-aquatic insects, fish, inverts	
	1992	Hermanutz, R.O., Allen, K.N., Roush, T.H., and S.F. Hedtke	Environ Tox & Chem 11: 217-224	Selenium	7782-49-2	4.6	MG/KG	6	Reproduction	NA	Combined	Whole Body	Adult	Carnivore-aquatic insects, fish, inverts	Measurable But Not Statistically Significant Reduced Survival Of Embryos And Larvae
	1982	Lemly, A.D.	Aquat Toxicol 02:235-252.	Selenium	7782-49-2	4.7	MG/KG	3	Mortality	NOED	Absorption	Whole Body	Immature	Carnivore-aquatic insects, fish, inverts	No mortality at 20 or 30 degrees C in soft or hard water.

APPENDIX D. TABLE D7
CANDIDATE TRVS SURROGATE FISH SPECIES

	Year	Author	Publication Source	Analyte Name	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Feeding Behavior	Comments
	2004	SJ Hamilton	Sci Total Environ 326:1-31	Selenium	7782-49-2	5	MG/KG	0	Mortality	NS	Ingestion	Whole Body	NS	Carnivore-aquatic insects, fish, inverts	fish wt = 0.3 g REF: Bryson et al 1984
	1986	Gillespie RB, PC Baumann	Trans Am Fish Soc 115:208-213	Selenium	7782-49-2	5.64	MG/KG	3	Reproductio n	ED88	Water	Whole Body	Adult	Carnivore-aquatic insects, fish, inverts	Larval Abnormalities,HxH cross Exp_concentration recorded from Hyco Reservoir. Residues measured in Larvae. 1983
	1986	Gillespie RB, PC Baumann	Trans Am Fish Soc 115:208-213	Selenium	7782-49-2	5.64	MG/KG	2	Reproductio n	ED100	Water	Whole Body	Adult	Carnivore-aquatic insects, fish, inverts	Larval Abnormalities,HxH cross Residue measured in Larvae Exp_concentration recorded from Hyco Reservoir. 1982
BLUEGILL	2002	Hamilton SJ	Aquat Toxicol 57:85-100	Selenium	7782-49-2	25	MG/KG		Mortality	NS	Ingestion	Whole body	NS	Carnivore-aquatic insects, fish, inverts	zooplankton; Bryson et al 1984

PCB

Download

		r	Publication Source	Analyte Name	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Feeding Behavior	Comments
GREEN SUNFISH	1980	Barrows, M.E., S.R. Petrocelli, K.J. Macek and J.J. Carroll	p. 379-392 in Haque, R., ed. Dynamics, Exposure and Hazard Assessment of Toxic Chemicals	PCBz	608-93-5	17.5	MG/KG	5	Mortality	NOED	Absorption	Whole Body	Immature	Carnivore-aquatic insects, fish, inverts	No Effect On Mortality

DDT

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	Year	Author	Publication Source	Analyte Name	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Feeding Behavior	Comments
GREEN SUNFISH	1971	Hamelink, J.L., R.C. Waybrant, and R.C. Ball.	Trans Am Fish Soc 100:207-214.	4,4`-DDT	50-29-3	24	MG/KG	1	Mortality	LOED	Combined	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	Lethal body burden. Fish exposed in outdoor artificial pool.

ARSENIC

	Year	Author	Publication Source	Analyte Name	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Feeding Behavior	Comments
	1976	Sorensen EMB	Bull Environ Contam Toxicol 15:756-761	Arsenic	7440-38-2	0.002	MG/KG	1	Mortality	LT50	Water	Whole Body	NA	Carnivore-aquatic insects, fish, inverts	Large fish
	1976	Sorensen EMB	Bull Environ Contam Toxicol 15:756-761	Arsenic	7440-38-2	0.008	MG/KG	1	Mortality	LT50	Water	Whole Body	NA	Carnivore-aquatic insects, fish, inverts	small fish
	1976	Sorensen EMB	Bull Environ Contam Toxicol 15:756-761	Arsenic	7440-38-2	116.3	MG/KG	1	Growth	NOED	Water	Whole Body	NA	Carnivore-aquatic insects, fish, inverts	Weight and Length

APPENDIX D. TABLE D7
CANDIDATE TRVS SURROGATE FISH SPECIES

	1976	Sorensen EMB	Bull Environ Contam Toxicol 15:756-761	Arsenic	7440-38-2	108.2	MG/KG	1	Mortality	NOED	Water	Whole Body	NA	Carnivore-aquatic insects, fish, inverts	Large fish
	1976	Sorensen EMB	Bull Environ Contam Toxicol 15:756-761	Arsenic	7440-38-2	116.3	MG/KG	1	Mortality	NOED	Water	Whole Body	NA	Carnivore-aquatic insects, fish, inverts	Large fish
	1976	Sorensen EMB	Bull Environ Contam Toxicol 15:756-761	Arsenic	7440-38-2	116.3	MG/KG	1	Physiological	NOED	Water	Whole Body	NA	Carnivore-aquatic insects, fish, inverts	Condition formula: k(TL)=(W x 10^5)/L^3
PUMPKINSEED	1976	Sorensen EMB	Bull Environ Contam Toxicol 15:756-761	Arsenic	7440-38-2	116.3	MG/KG	1	Physiological	NOED	Water	Whole Body	NA	Carnivore-aquatic insects, fish, inverts	Condition formula: k(TL)=(W x 10^5)/L^3

DDT

	Download	r	Publication Source	Analyte Name	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Feeding Behavior	Comments
WALLEYE	1971	Hamelink, J.L., R.C. Waybrant, and R.C. Ball.	Trans Am Fish Soc 100:207-214.	4,4`-DDT	50-29-3	24	MG/KG	1	Mortality	LOED	Combined	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	Lethal body burden. Fish exposed in outdoor artificial pool.

MERCURY

	Download	r	Publication Source	Analyte Name	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Feeding Behavior	Comments
	1996	Friedmann, A.S., M.C. Watzin, T. Brinck-Johnsen and J.C. Leiter	Aquat Toxicol 35:265-278	Mercury	7439-97-6	0.25	MG/KG	22	Biochemical	LOED	Ingestion	Whole Body	Immature	Carnivorous; largely on various minnows, occasionally young whitefish	Reduced plasma cortisol levels
	1996	Friedmann, A.S., M.C. Watzin, T. Brinck-Johnsen and J.C. Leiter	Aquat Toxicol 35:265-278	Mercury	7439-97-6	0.25	MG/KG	22	Cellular	LOED	Ingestion	Whole Body	Immature	Carnivorous; largely on various minnows, occasionally young whitefish	Multifocal Cell Atrophy in testes.
	1996	Friedmann, A.S., M.C. Watzin, T. Brinck-Johnsen and J.C. Leiter	Aquat Toxicol 35:265-278	Mercury	7439-97-6	0.25	MG/KG	22	Development	LOED	Ingestion	Whole Body	Immature	Carnivorous; largely on various minnows, occasionally young whitefish	Impaired testicular development. Significantly decreased ratio of gonad weight to total weight in males.

APPENDIX D. TABLE D7
CANDIDATE TRVS SURROGATE FISH SPECIES

	1996	Friedmann, A.S., M.C. Watzin, T. Brinck-Johnsen and J.C. Leiter	Aquat Toxicol 35:265-278	Mercury	7439-97-6	0.25	MG/KG	22	Growth	NOED	Ingestion	Whole Body	Immature	Carnivorous; largely on various minnows, occasionally young whitefish	No Effect On Length Or Weight
	1996	Friedmann, A.S., M.C. Watzin, T. Brinck-Johnsen and J.C. Leiter	Aquat Toxicol 35:265-278	Mercury	7439-97-6	2.37	MG/KG	22	Mortality	NOED	Ingestion	Whole Body	Immature	Carnivorous; largely on various minnows, occasionally young whitefish	No Statistically Significant Increase In Mortality
	1996	Friedmann, A.S., M.C. Watzin, T. Brinck-Johnsen and J.C. Leiter	Aquat Toxicol 35:265-278	Mercury	7439-97-6	2.37	MG/KG	22	Growth	LOED	Ingestion	Whole Body	Immature	Carnivorous; largely on various minnows, occasionally young whitefish	Significant Reduction In Length And Weight Of Males, But Not Females
	1996	Friedmann, A.S., M.C. Watzin, T. Brinck-Johnsen and J.C. Leiter	Aquat Toxicol 35:265-278	Mercury	7439-97-6	2.37	MG/KG	22	Cellular	NOED	Ingestion	Whole Body	Immature	Carnivorous; largely on various minnows, occasionally young whitefish	No evidence of histopathology in ovaries.
	1996	Friedmann, A.S., M.C. Watzin, T. Brinck-Johnsen and J.C. Leiter	Aquat Toxicol 35:265-278	Mercury	7439-97-6	2.37	MG/KG	22	Development	NOED	Ingestion	Whole Body	Immature	Carnivorous; largely on various minnows, occasionally young whitefish	No significant difference in ratio of gonad weight to total weight in females.

APPENDIX D. TABLE D8
CANDIDATE TRVS *LUMBRICULUS*

LUMBRICULUS

LEAD

	Download	thor	Publication Source	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Feeding Behavior	Comments
	2005	Aisemberg J; DE Nahabedian; EA Wider; NRV Guerrero	Toxicology 210:45-53	7439-92-1	10	MG/KG	10	Mortality	NOED	Water	Whole Body	Adult	Feeds on small animals in substrata	
	2005	Aisemberg J; DE Nahabedian; EA Wider; NRV Guerrero	Toxicology 210:45-53	7439-92-1	30	MG/KG	10	Mortality	NOED	Water	Whole Body	Adult	Feeds on small animals in substrata	
	2005	Aisemberg J; DE Nahabedian; EA Wider; NRV Guerrero	Toxicology 210:45-53	7439-92-1	60	MG/KG	10	Mortality	NOED	Water	Whole Body	Adult	Feeds on small animals in substrata	
	2005	Aisemberg J; DE Nahabedian; EA Wider; NRV Guerrero	Toxicology 210:45-53	7439-92-1	170	MG/KG	10	Mortality	NOED	Water	Whole Body	Adult	Feeds on small animals in substrata	
	2005	Aisemberg J; DE Nahabedian; EA Wider; NRV Guerrero	Toxicology 210:45-53	7439-92-1	220	MG/KG	10	Mortality	NOED	Water	Whole Body	Adult	Feeds on small animals in substrata	
	2005	Aisemberg J; DE Nahabedian; EA Wider; NRV Guerrero	Toxicology 210:45-53	7439-92-1	300	MG/KG	10	Mortality	NOED	Water	Whole Body	Adult	Feeds on small animals in substrata	

TOTAL PCBS

	Download	thor	Publication Source	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Feeding Behavior	Comments
	2005	Burton GA Jr, MS Greenberg, CD Rowland, CA Irvine, DR Lavioie, JA Brooker, L Moore, DFN Raymer, RA McWilliam	Environ Pollut 134:133-144	1336-36-3	10	MG/KG	3	Survival	NOED	Combined	Whole Body	Adult	Feeds on small animals in substrata	Difficult to ascertain the experimental design because the paper is presenting multiple experiments from 1991 to present
	2005	Burton GA Jr, MS Greenberg, CD Rowland, CA Irvine, DR Lavioie, JA Brooker, L Moore, DFN Raymer, RA McWilliam	Environ Pollut 134:133-144	1336-36-3	125	MG/KG	3	Survival	NOED	Combined	Whole Body	Adult	Feeds on small animals in substrata	Difficult to ascertain the experimental design because the paper is presenting multiple experiments from 1991 to present

APPENDIX D. TABLE D8
CANDIDATE TRVS *LUMBRICULUS*

	2005	Burton GA Jr, MS Greenberg, CD Rowland, CA Irvine, DR Lavioie, JA Brooker, L Moore, DFN Raymer, RA McWilliam	Environ Pollut 134:133-144	1336-36-3	210	MG/KG	3	Survival	NOED	Combined	Whole Body	Adult	Feeds on small animals in substrata	Difficult to ascertain the experimental design because the paper is presenting multiple experiments from 1991 to present
	2005	Burton GA Jr, MS Greenberg, CD Rowland, CA Irvine, DR Lavioie, JA Brooker, L Moore, DFN Raymer, RA McWilliam	Environ Pollut 134:133-144	1336-36-3	260	MG/KG	3	Survival	NOED	Combined	Whole Body	Adult	Feeds on small animals in substrata	Difficult to ascertain the experimental design because the paper is presenting multiple experiments from 1991 to present
	2005	Burton GA Jr, MS Greenberg, CD Rowland, CA Irvine, DR Lavioie, JA Brooker, L Moore, DFN Raymer, RA McWilliam	Environ Pollut 134:133-144	1336-36-3	350	MG/KG	3	Survival	NOED	Combined	Whole Body	Adult	Feeds on small animals in substrata	Difficult to ascertain the experimental design because the paper is presenting multiple experiments from 1991 to present

DDE Download

	Year	Author	Publication Source	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Feeding Behavior	Comments
	1999	Fisher SW, SW Chordas III, PF Landrum	Aquat Toxicol 45:115-126	72-55-9	178.4	MG/KG	3	Mortality	LD38	Ingestion	Whole Body	Adult	Feeds on small animals in substrata	
	1999	Fisher SW, SW Chordas III, PF Landrum	Aquat Toxicol 45:115-126	72-55-9	178.4	MG/KG	3	Growth	ED29	Ingestion	Whole Body	Adult	Feeds on small animals in substrata	mean decrease in Biomass
	1999	Fisher SW, SW Chordas III, PF Landrum	Aquat Toxicol 45:115-126	72-55-9	330.1	MG/KG	3	Growth	ED35	Ingestion	Whole Body	Adult	Feeds on small animals in substrata	mean decrease in Biomass
	1999	Fisher SW, SW Chordas III, PF Landrum	Aquat Toxicol 45:115-126	72-55-9	330.1	MG/KG	3	Mortality	LD94	Ingestion	Whole Body	Adult	Feeds on small animals in substrata	

PBDE **Download**

	Year	Author	Publication Source	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Feeding Behavior	Comments
	2004	Leppenen MT, JVK Kukkonen	Environ Tox & Chem 23(1):166-172	32534-81-9	22.02	MG/KG	3	Growth	NOED	Ingestion	Whole Body	Adult	Feeds on small animals in substrata	Weight - residue given in lipid weight- Lake Hoyiainen sediment
	2004	Leppenen MT, JVK Kukkonen	Environ Tox & Chem 23(1):166-172	32534-81-9	22.02	MG/KG	3	Behavior	NOED	Ingestion	Whole Body	Adult	Feeds on small animals in substrata	Feeding behavior - residue given in lipid weight- Lake Hoyiainen sediment

APPENDIX D. TABLE D8
CANDIDATE TRVS *LUMBRICULUS*

	2004	Leppenen MT, JVK Kukkonen	Environ Tox & Chem 23(1):166-172	32534-81-9	24.28	MG/KG	3	Mortality	NOED	Ingestion	Whole Body	Adult	Feeds on small animals in substrata	Residue given in lipid weight- Lake Kuorinka sediment
	2004	Leppenen MT, JVK Kukkonen	Environ Tox & Chem 23(1):166-172	32534-81-9	24.28	MG/KG	3	Growth	NOED	Ingestion	Whole Body	Adult	Feeds on small animals in substrata	Weight- Residue given in lipid weight- Lake Kuorinka sediment
	2004	Leppenen MT, JVK Kukkonen	Environ Tox & Chem 23(1):166-172	32534-81-9	24.28	MG/KG	3	Behavior	NOED	Ingestion	Whole Body	Adult	Feeds on small animals in substrata	feeding Behavior- Residue given in lipid weight- Lake Kuorinka sediment

APPENDIX D. TABLE D9
CANDIDATE TRVS *CORBICULA*

CORBICULA
CADMIIUM

	Year	Author	Publication Source	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Feeding Behavior	Comments
	2001	Barfield, M.L., J.L. Farris, M.C. Black	J Toxicol Environ Health, Part A 63:495-510	7440-43-9	20	MG/KG	1	Mortality	NOED	Water	Whole Body	NS	Filter feeders; phytoplankton, detritus, bacteria, small zooplankters	Cellulase Enzyme Activity
	2001	Barfield, M.L., J.L. Farris, M.C. Black	J Toxicol Environ Health, Part A 63:495-510	7440-43-9	25	MG/KG	1	Biochemical	IP134	Water	Whole Body	NS	Filter feeders; phytoplankton, detritus, bacteria, small zooplankters	Cellulase Enzyme Activity

APPENDIX D. TABLE D10
CANDIDATE TRVS SURROGATE INVERTEBRATE TAXA

OLIGOCHAETE
DDD

Download

	Year	Author	Publication Source	Species Scientific Name	Species Common Name	Analyte Name	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Habitat	Species Feeding Behavior	Comments
	2005	CG Ingersoll, N Wang, JMR Hayward, JR Jones, SB Jones, DS Ireland	Environ Tox & Chem 24:2853-2870	Oligocheata	Oligochaete	4,4`-DDD	72-54-8	1500	MG/KG	7	NA	NOED	Combined	Whole Body	Adult			abundance, field assessment

GREATER EUROPEAN PEA CLAM
BENZO(A)PYRENE

	Download	hor	Publication Source	Species Scientific Name	Species Common Name	Analyte Name	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Habitat	Species Feeding Behavior	Comments
	1999	Heinonen J, JVK Kukkonen, IJ Holopainen	Ecol App 9(2):475-481	Pisidium amnicum	Clam	Benzo[a]pyrene	50-32-8	0.001	MG/KG	1	Mortality	NOED	Water	Whole Body	Adult	Not Specified	Not Specified	21 ug/l TCP and 4 ng/l BaP Uninfected, 4 degrees C
	1999	Heinonen J, JVK Kukkonen, IJ Holopainen	Ecol App 9(2):475-481	Pisidium amnicum	Clam	Benzo[a]pyrene	50-32-8	0.016	MG/KG	1	Mortality	NOED	Water	Whole Body	Adult	Not Specified	Not Specified	21 ug/l TCP and 4 ng/l BaP Infected with Palaeorchis crassus, 20 degrees C
	1999	Heinonen J, JVK Kukkonen, IJ Holopainen	Ecol App 9(2):475-481	Pisidium amnicum	Clam	Benzo[a]pyrene	50-32-8	0.016	MG/KG	1	Mortality	NOED	Water	Whole Body	Adult	Not Specified	Not Specified	21 ug/l TCP and 4 ng/l BaP Infected with Phyllodistomum elongatum, 4 degrees C
	1999	Heinonen J, JVK Kukkonen, IJ Holopainen	Ecol App 9(2):475-481	Pisidium amnicum	Clam	Benzo[a]pyrene	50-32-8	0.024	MG/KG	1	Mortality	NOED	Water	Whole Body	Adult	Not Specified	Not Specified	21 ug/l TCP and 4 ng/l BaP Infected with Bunodera luciopercae, 4 degrees C
	1999	Heinonen J, JVK Kukkonen, IJ Holopainen	Ecol App 9(2):475-481	Pisidium amnicum	Clam	Benzo[a]pyrene	50-32-8	0.024	MG/KG	1	Mortality	NOED	Water	Whole Body	Adult	Not Specified	Not Specified	21 ug/l TCP and 4 ng/l BaP, Uninfected, 20 degrees C
	1999	Heinonen J, JVK Kukkonen, IJ Holopainen	Ecol App 9(2):475-481	Pisidium amnicum	Clam	Benzo[a]pyrene	50-32-8	0.028	MG/KG	1	Mortality	NOED	Water	Whole Body	Adult	Not Specified	Not Specified	21 ug/l TCP and 4 ng/l BaP Infected with Bunodera luciopercae, 20 degrees C

CLAM, FINGERNAIL
BENZO(A)PYRENE

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	Year	Author	Publication Source	Species Scientific Name	Species Common Name	Analyte Name	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Habitat	Species Feeding Behavior	Comments
	1997	Borchert, J., L. Karbe and J. Westendorf	Bull Environ Contam Toxicol 58:158-165	Sphaerium corneum	Clam - Fingernail	Benzo[a]pyrene	50-32-8	1.25	MG/KG	5	Mortality	NOED	Combined	Whole Body	Adult	Not Specified	Not Specified	No Effect On Survival. Residue measured at end of exposure period.

CLAM, MARSH
MERCURY

	Download	hor	Publication Source	Species Scientific Name	Species Common Name	Analyte Name	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Habitat	Species Feeding Behavior	Comments

APPENDIX D. TABLE D10
CANDIDATE TRVS SURROGATE INVERTEBRATE TAXA

	1977	Dillon, T.M.	Arch Environ Contam Toxicol 06:249-255	Rangia cuneata	Clam - Marsh	Mercury	7439-97-6	20	MG/KG	3	Mortality	LD50	Absorption	Whole Body	Adult	North Chesapeake Bay to Texas in freshwater to	Filter feeder; plankton, bacteria, fine detrital particles	50% Mortality
	1977	Dillon, T.M.	Arch Environ Contam Toxicol 06:249-255	Rangia cuneata	Clam - Marsh	Mercury	7439-97-6	20	MG/KG	3	Mortality	LD50	Absorption	Whole Body	Adult	North Chesapeake Bay to Texas in freshwater to	Filter feeder; plankton, bacteria, fine detrital particles	50% Mortality in clams that had been pre-exposed to 1 ppb Hg for 2 weeks prior to test.
	1977	Dillon, T.M.	Arch Environ Contam Toxicol 06:249-255	Rangia cuneata	Clam - Marsh	Mercury	7439-97-6	73.1	MG/KG	1	Mortality	LOED	Absorption	Whole Body	Adult	North Chesapeake Bay to Texas in freshwater to	Filter feeder; plankton, bacteria, fine detrital particles	Lethal Body Burden. Initial water concentration of 10 mg Hg/L. At 96 hr, 0.176 mg Hg/L.

CLAM, SOFTSHELL
MERCURY

	Download	hor	Publication Source	Species Scientific Name	Species Common Name	Analyte Name	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Habitat	Species Feeding Behavior	Comments
	2001	Gorbi, G., M.G. Corradi, M. Invidia, M. Bassi	Ecotoxicol Environ Saf 48:36-42	Mya arenaria	Clam - Soft Shell	Mercury	7439-97-6	25	MG/KG	3	Biochemical	LOED	Water	Whole Body	NS	Coastal Maine to Maryland, tidal flats to depths around 20 - 30 ft.	Filter selectively; zooplankton, bacteria, decomposing fragments of large organisms.	Decrease in phagocytic activity in Hemocytes
	2001	Gorbi, G., M.G. Corradi, M. Invidia, M. Bassi	Ecotoxicol Environ Saf 48:36-42	Mya arenaria	Clam - Soft Shell	Mercury	7439-97-6	50	MG/KG	3	Biochemical	LOED	Water	Whole Body	NS	Coastal Maine to Maryland, tidal flats to depths around 20 - 30 ft.	Filter selectively; zooplankton, bacteria, decomposing fragments of large organisms.	Decrease in phagocytic activity in Hemocytes

CLAM, SOFTSHELL
DDT

Download

	Year	Author	Publication Source	Species Scientific Name	Species Common Name	Analyte Name	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Habitat	Species Feeding Behavior	Comments
	1971	Butler, P.A.	Proc. Royal Soc. London, Series B 177:321-329.	Mya arenaria	Clam - Soft Shell	4,4`-DDT	50-29-3	0.88	MG/KG	1	Behavior	NOED	Combined	Whole Body	Adult	Coastal Maine to Maryland, tidal flats to depths around 20 - 30 ft.	Filter selectively; zooplankton, bacteria, decomposing fragments of large organisms.	No Effect On Feeding Activity Assume wet weight

MUSSELL, MYTILUS
PCBS

Download

	Download	hor	Publication Source	Species Scientific Name	Species Common Name	Analyte Name	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Habitat	Species Feeding Behavior	Comments
	1991	Velduizen-Tsoerkan, M.B., Holwerda, D.A., Zandee, D.I.	Arch Environ Contam Toxicol 20:259-265	Mytilus edulis	Mussel	PCBs	1336-36-3	0.6	MG/KG	2	Physiological	NOED	Combined	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	No significant difference in ability to survive anoxic stress after exposure period. Measured as anoxic survival time.
	1991	Velduizen-Tsoerkan, M.B., Holwerda, D.A., Zandee, D.I.	Arch Environ Contam Toxicol 20:259-265	Mytilus edulis	Mussel	PCBs	1336-36-3	1.4	MG/KG	2	Physiological	LOED	Combined	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Significant decrease in ability to survive anoxic stress after exposure period. Measured as anoxic survival time.
	1991	Velduizen-Tsoerkan, M.B., Holwerda, D.A., Zandee, D.I.	Arch Environ Contam Toxicol 20:259-265	Mytilus edulis	Mussel	PCBs	1336-36-3	1.4	MG/KG	2	Physiological	NOED	Combined	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	No Significant Changes In Adenylate Energy Charge Or Glycogen Content

APPENDIX D. TABLE D10
CANDIDATE TRVS SURROGATE INVERTEBRATE TAXA

MUSSELL, MYTILUS

PAH/SVOC

Ref ID	Download	hor	Publication Source	Species Scientific Name	Species Common Name	Analyte Name	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Habitat	Species Feeding Behavior	Comments
	1989	Donkin, P., J. Widdows, S.V. Evans, C.M. Worrall and M. Carr	Aquat Toxicol 14:277-294.	Mytilus edulis	Mussel	1-chloronaphthalene	90-13-1	21.6	MG/KG	2	Behavior	ED50	Absorption	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	50% Reduction In Feeding Rate Assume wet weight.
	1989	Donkin, P., J. Widdows, S.V. Evans, C.M. Worrall and M. Carr	Aquat Toxicol 14:277-294.	Mytilus edulis	Mussel	Acenaphthene	83-32-9	29.4	MG/KG	2	Behavior	ED50	Absorption	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	50% Reduction In Feeding Rate Assume wet weight.
	2002	Durand, F, LD Peters, DR Livingstone	Mar Environ Res 54:271-274	Mytilus edulis	Mussel	Benzo[a]pyrene	50-32-8	0.0000078	MG/KG	6	Biochemical	IP20	Water	Mantle	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	animal experiences dry period "tidal", single dose of 1ppb BaP in water Effect: MDA induction
	2002	Durand, F, LD Peters, DR Livingstone	Mar Environ Res 54:271-274	Mytilus edulis	Mussel	Benzo[a]pyrene	50-32-8	0.0000174	MG/KG	6	Biochemical	IP67	Water	Mantle	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	animal continually submersed in water "subtidal", single dose of 1ppb BaP in water Effect: MDA induction
	2002	Durand, F, LD Peters, DR Livingstone	Mar Environ Res 54:271-274	Mytilus edulis	Mussel	Benzo[a]pyrene	50-32-8	0.0000247	MG/KG	6	Biochemical	IP40	Water	Mantle	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	animal experiences dry period "tidal", single dose of 1ppb BaP in water Effect: MDA induction
	2002	Durand, F, LD Peters, DR Livingstone	Mar Environ Res 54:271-274	Mytilus edulis	Mussel	Benzo[a]pyrene	50-32-8	0.0000272	MG/KG	6	Biochemical	NOED	Water	Mantle	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	animal continually submersed in water "subtidal", single dose of 1ppb BaP in water Effect: MDA induction
	2002	Durand, F, LD Peters, DR Livingstone	Mar Environ Res 54:271-274	Mytilus edulis	Mussel	Benzo[a]pyrene	50-32-8	0.0000297	MG/KG	6	Biochemical	IP47	Water	Mantle	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	animal continually submersed in water "subtidal", single dose of 1ppb BaP in water Effect: MDA induction
	2002	Durand, F, LD Peters, DR Livingstone	Mar Environ Res 54:271-274	Mytilus edulis	Mussel	Benzo[a]pyrene	50-32-8	0.0000302	MG/KG	6	Biochemical	IP313	Water	Mantle	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	animal experiences dry period "tidal", single dose of 1ppb BaP in water Effect: MDA induction Greater than 100% increase
	2002	Durand, F, LD Peters, DR Livingstone	Mar Environ Res 54:271-274	Mytilus edulis	Mussel	Benzo[a]pyrene	50-32-8	0.0000365	MG/KG	6	Biochemical	IP193	Water	Mantle	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	animal experiences dry period "tidal", single dose of 1ppb BaP in water Effect: MDA induction Greater than 100% increase
	2002	Durand, F, LD Peters, DR Livingstone	Mar Environ Res 54:271-274	Mytilus edulis	Mussel	Benzo[a]pyrene	50-32-8	0.000436	MG/KG	6	Biochemical	IP67	Water	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	animal continually submersed in water "subtidal", single dose of 1ppb BaP in water Effect: MDA induction
	2002	Durand, F, LD Peters, DR Livingstone	Mar Environ Res 54:271-274	Mytilus edulis	Mussel	Benzo[a]pyrene	50-32-8	0.000564	MG/KG	6	Biochemical	IP47	Water	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	animal continually submersed in water "subtidal", single dose of 1ppb BaP in water Effect: MDA induction

APPENDIX D. TABLE D10
CANDIDATE TRVS SURROGATE INVERTEBRATE TAXA

	2002	Durand, F, LD Peters, DR Livingstone	Mar Environ Res 54:271-274	Mytilus edulis	Mussel	Benzo[a]pyrene	50-32-8	0.000618	MG/KG	6	Biochemical	NOED	Water	Soft Tissue	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	animal continually submersed in water "subtidal", single dose of 1ppb BaP in water Effect: MDA induction
	2002	Durand, F, LD Peters, DR Livingstone	Mar Environ Res 54:271-274	Mytilus edulis	Mussel	Benzo[a]pyrene	50-32-8	0.00062	MG/KG	6	Biochemical	IP193	Water	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	animal experiences dry period "tidal", single dose of 1ppb BaP in water Effect: MDA induction Greater than 100% increase
	2002	Durand, F, LD Peters, DR Livingstone	Mar Environ Res 54:271-274	Mytilus edulis	Mussel	Benzo[a]pyrene	50-32-8	0.000707	MG/KG	6	Biochemical	IP313	Water	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	animal experiences dry period "tidal", single dose of 1ppb BaP in water Effect: MDA induction Greater than 100% increase
	2002	Durand, F, LD Peters, DR Livingstone	Mar Environ Res 54:271-274	Mytilus edulis	Mussel	Benzo[a]pyrene	50-32-8	0.000764	MG/KG	6	Biochemical	IP40	Water	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	animal experiences dry period "tidal", single dose of 1ppb BaP in water Effect: MDA induction
	2002	Durand, F, LD Peters, DR Livingstone	Mar Environ Res 54:271-274	Mytilus edulis	Mussel	Benzo[a]pyrene	50-32-8	0.000811	MG/KG	6	Biochemical	IP20	Water	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	animal experiences dry period "tidal", single dose of 1ppb BaP in water Effect: MDA induction
	1995	Eertman, R.H.M., C.L. Groenink, B. Sandee and H. Hummel	Mar. Environ. Res. 39:169-173.	Mytilus edulis	Mussel	Benzo[a]pyrene	50-32-8	0.161	MG/KG	1	Biochemical	LOED	Absorption	Whole Body	NA	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Elevated Activity Of Superoxide Dimutase (SOD), a hormetic effect.
	1995	Eertman, R.H.M., C.L. Groenink, B. Sandee and H. Hummel	Mar. Environ. Res. 39:169-173.	Mytilus edulis	Mussel	Benzo[a]pyrene	50-32-8	0.3	MG/KG	1	Reproduction	LOED	Absorption	Whole Body	NA	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Abnormal Gametogenesis
	1995	Eertman, R.H.M., C.L. Groenink, B. Sandee and H. Hummel	Mar. Environ. Res. 39:169-173.	Mytilus edulis	Mussel	Benzo[a]pyrene	50-32-8	3.2	MG/KG	1	Physiological	ED50	Absorption	Whole Body	NA	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	50% Reduction In Clearance Rate (calculated)
	1995	Eertman, R.H.M., C.L. Groenink, B. Sandee and H. Hummel	Mar. Environ. Res. 39:169-173.	Mytilus edulis	Mussel	Benzo[a]pyrene	50-32-8	3.2	MG/KG	1	Biochemical	LOED	Absorption	Whole Body	NA	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Inhibition Of Superoxide Dimutase (SOD) And Catalase Activity
	1995	Eertman, R.H.M., C.L. Groenink, B. Sandee and H. Hummel	Mar. Environ. Res. 39:169-173.	Mytilus edulis	Mussel	Benzo[a]pyrene	50-32-8	3.2	MG/KG	1	Physiological	LOED	Absorption	Whole Body	NA	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Reduced tolerance to aerial exposure.
	2000	Okay OS, P Donkin, LD Peters, DR Livingstone	Environ Pollut 110:103-113	Mytilus edulis	Mussel	Benzo[a]pyrene	50-32-8	16.1	MG/KG	4	Cellular	ED50	Ingestion	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Eertman et al 1995
	2003	Skarpheoinsdottir H, G Ericson, L Dalla Zuanna, M Gilek	Aquat Toxicol 62:165-177	Mytilus edulis	Mussel	Benzo[a]pyrene	50-32-8	24	MG/KG	3	Cellular	IP400	Water	Gill	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	DNA Adducts. NOEC for DNA adduct formation in digestive gland = <1mg/g. NOEC scope for growth for exposed mussels

APPENDIX D. TABLE D10
CANDIDATE TRVS SURROGATE INVERTEBRATE TAXA

	2000	Okay OS, P Donkin, LD Peters, DR Livingstone	Environ Pollut 110:103-113	Mytilus edulis	Mussel	Benzo[a]pyrene	50-32-8	25	MG/KG	4	Biochemical	IP125	Ingestion	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	BaP measured in whole body minus the digestive tract Effect is benzo[a]pyrene hydroxylase activity high algae density
	2000	Okay OS, P Donkin, LD Peters, DR Livingstone	Environ Pollut 110:103-113	Mytilus edulis	Mussel	Benzo[a]pyrene	50-32-8	25	MG/KG	4	Biochemical	IP133	Ingestion	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	BaP measured in whole body minus the digestive tract Effect is NADPH-cytochrome c reductase activity low algae density
	2000	Okay OS, P Donkin, LD Peters, DR Livingstone	Environ Pollut 110:103-113	Mytilus edulis	Mussel	Benzo[a]pyrene	50-32-8	30	MG/KG	4	Biochemical	IP200	Ingestion	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	BaP measured in whole body minus the digestive tract Effect is NADPH-cytochrome c reductase activity high algae density
	2000	Okay OS, P Donkin, LD Peters, DR Livingstone	Environ Pollut 110:103-113	Mytilus edulis	Mussel	Benzo[a]pyrene	50-32-8	30	MG/KG	4	Biochemical	IP120	Ingestion	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	BaP measured in whole body minus the digestive tract Effect is NADPH-cytochrome c reductase activity high algae density
	2003	Skarpheoinsdottir H, G Ericson, L Dalla Zuanna, M Gilek	Aquat Toxicol 62:165-177	Mytilus edulis	Mussel	Benzo[a]pyrene	50-32-8	90.548	MG/KG	3	Cellular	IP215	Water	Gill	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	NOEC for DNA adduct formation in digestive gland = <1mg/g
	2003	Skarpheoinsdottir H, G Ericson, L Dalla Zuanna, M Gilek	Aquat Toxicol 62:165-177	Mytilus edulis	Mussel	Benzo[a]pyrene	50-32-8	90.548	MG/KG	3	Cellular	IP374	Water	Gill	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	DNA Adducts. NOEC for DNA adduct formation in digestive gland = <1mg/g
	2000	Okay OS, P Donkin, LD Peters, DR Livingstone	Environ Pollut 110:103-113	Mytilus edulis	Mussel	Benzo[a]pyrene	50-32-8	140	MG/KG	4	Cellular	ED50	Ingestion	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	BaP measured in whole body minus the digestive tract Effect is blood cell lysosomal stability as measured by blood cell neutral dye retention time
	2000	Okay OS, P Donkin, LD Peters, DR Livingstone	Environ Pollut 110:103-113	Mytilus edulis	Mussel	Benzo[a]pyrene	50-32-8	140	MG/KG	4	Cellular	ED50	Ingestion	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	BaP measured in whole body minus the digestive tract Effect is blood cell lysosomal stability as measured by blood cell neutral dye retention time
	2003	Skarpheoinsdottir H, G Ericson, L Dalla Zuanna, M Gilek	Aquat Toxicol 62:165-177	Mytilus edulis	Mussel	Benzo[a]pyrene	50-32-8	147.714	MG/KG	3	Cellular	IP328	Water	Gill	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	DNA Adducts. NOEC for DNA adduct formation in digestive gland = <1mg/g
	1989	Donkin, P., J. Widdows, S.V. Evans, C.M. Worrall and M. Carr	Aquat Toxicol 14:277-294.	Mytilus edulis	Mussel	Biphenyl	92-52-4	15.6	MG/KG	2	Behavior	ED50	Absorption	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	50% Reduction In Feeding Rate Assume wet weight.
	1980	Zaroogian, G.E.	Mar Biol 58:275-284.	Mytilus edulis	Mussel	DEHP	117-81-7	9.7	MG/KG	0	NA	NOED	Water	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Mean BCF for DEHP = 2497
	1980	Zaroogian, G.E.	Mar Biol 58:275-284.	Mytilus edulis	Mussel	DEHP	117-81-7	110.6	MG/KG	0	NA	NOED	Water	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Mean BCF for DEHP = 2497

APPENDIX D. TABLE D10
CANDIDATE TRVS SURROGATE INVERTEBRATE TAXA

	1982	Brown, D. and R.S. Thompson	Chemosphere 11:427-435.	Mytilus edulis	Mussel	DEHP	117-81-7	123	MG/KG	5	Behavior	NOED	Absorption	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	No Effect On Feeding Activity. Residue measured at end of exposure period.
	1982	Brown, D. and R.S. Thompson	Chemosphere 11:427-435.	Mytilus edulis	Mussel	DEHP	117-81-7	123	MG/KG	5	Mortality	NOED	Absorption	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	No Effect On Mortality. Residue measured at end of exposure period.
	1989	Donkin, P., J. Widdows, S.V. Evans, C.M. Worrall and M. Carr	Aquat Toxicol 14:277-294.	Mytilus edulis	Mussel	Dibenzothiophene	132-65-0	14.2	MG/KG	2	Behavior	ED50	Absorption	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	50% Reduction In Feeding Rate Assume wet weight.
	1980	Zaroogian, G.E.	Mar Biol 58:275-284.	Mytilus edulis	Mussel	Diisodecylphthalate	26761-40-0	17.5	MG/KG	0	NA	NOED	Water	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Mean BCF for DIDP = 3488
	1980	Zaroogian, G.E.	Mar Biol 58:275-284.	Mytilus edulis	Mussel	Diisodecylphthalate	26761-40-0	125	MG/KG	0	NA	NOED	Water	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Mean BCF for DIDP = 3488 1/2 t = 3.5 d
	1982	Brown, D. and R.S. Thompson	Chemosphere 11:427-435.	Mytilus edulis	Mussel	Diisodecylphthalate	26761-40-0	133	MG/KG	5	Behavior	NOED	Absorption	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	No Effect On Feeding Activity. Residue measured at end of exposure period.
	1982	Brown, D. and R.S. Thompson	Chemosphere 11:427-435.	Mytilus edulis	Mussel	Diisodecylphthalate	26761-40-0	133	MG/KG	5	Mortality	NOED	Absorption	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	No Effect On Mortality. Residue measured at end of exposure period.
	1995	Eertman, R.H.M., C.L. Groenink, B. Sandee and H. Hummel	Mar. Environ. Res. 39:169-173.	Mytilus edulis	Mussel	Fluoranthene	206-44-0	0.112	MG/KG	1	Biochemical	NA	Absorption	Whole Body	NA	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Elevated Activity Of Superoxide Dimutase (SOD), a hormetic effect.
	1995	Eertman, R.H.M., C.L. Groenink, B. Sandee and H. Hummel	Mar. Environ. Res. 39:169-173.	Mytilus edulis	Mussel	Fluoranthene	206-44-0	0.22	MG/KG	1	Reproduction	LOED	Absorption	Whole Body	NA	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Abnormal Gametogenesis
	1995	Eertman, R.H.M., C.L. Groenink, B. Sandee and H. Hummel	Mar. Environ. Res. 39:169-173.	Mytilus edulis	Mussel	Fluoranthene	206-44-0	1.5	MG/KG	1	Biochemical	LOED	Absorption	Whole Body	NA	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Inhibition Of Superoxide Dimutase (SOD) And Catalase Activity
	1995	Eertman, R.H.M., C.L. Groenink, B. Sandee and H. Hummel	Mar. Environ. Res. 39:169-173.	Mytilus edulis	Mussel	Fluoranthene	206-44-0	1.5	MG/KG	1	Physiological	LOED	Absorption	Whole Body	NA	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Reduced tolerance to aerial exposure.
	2000	Okay OS, P Donkin, LD Peters, DR Livingstone	Environ Pollut 110:103-113	Mytilus edulis	Mussel	Fluoranthene	206-44-0	1.9	MG/KG	4	Cellular	ED50	Ingestion	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Eertman et al 1995

APPENDIX D. TABLE D10
CANDIDATE TRVS SURROGATE INVERTEBRATE TAXA

	1995	Eertman, R.H.M., C.L. Groenink, B. Sandee and H. Hummel	Mar. Environ. Res. 39:169-173.	Mytilus edulis	Mussel	Fluoranthene	206-44-0	1.9	MG/KG	1	Physiological	ED50	Absorption	Whole Body	NA	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	50% Reduction In Clearance Rate (calculated)
	1989	Donkin, P., J. Widdows, S.V. Evans, C.M. Worrall and M. Carr	Aquat Toxicol 14:277-294.	Mytilus edulis	Mussel	Fluoranthene	206-44-0	627	MG/KG	2	Behavior	ED50	Absorption	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	50% Reduction In Feeding Rate Assume wet weight.
	1989	Donkin, P., J. Widdows, S.V. Evans, C.M. Worrall and M. Carr	Aquat Toxicol 14:277-294.	Mytilus edulis	Mussel	Octane	111-65-9	24.6	MG/KG	2	Behavior	ED50	Absorption	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	50% Reduction In Feeding Rate Assume wet weight.
	2006	Meador J	Human & Ecol. Risk Assessment 12:1018-1073	Mytilus edulis	Mussel	PCP	87-86-5	2.3	MG/KG		Physiological	LOED				Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	***CRITICAL BODY RESIDUE (LOER) Refer to Table 6.
	1992	Wang, W.X., Widdows, J., Page, D.S.	Mar. Environ. Res. 34: 327-331	Mytilus edulis	Mussel	PCP	87-86-5	2.34	MG/KG	1	Physiological	LOED	Absorption	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Significant increase in anoxic rate of metabolism. 30% Decrease in anoxic survival time (anoxia tolerance).
	1992	Wang, W.X., Widdows, J., Page, D.S.	Mar. Environ. Res. 34: 327-331	Mytilus edulis	Mussel	PCP	87-86-5	9.9	MG/KG	1	Physiological	ED50	Absorption	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Significant increase in anoxic rate of metabolism. 50% Decrease in anoxic survival time (anoxia tolerance).
	1992	Wang, W.X., Widdows, J., Page, D.S.	Mar. Environ. Res. 34: 327-331	Mytilus edulis	Mussel	PCP	87-86-5	29.4	MG/KG	1	Physiological	ED64	Absorption	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Significant increase in anoxic rate of metabolism. 64% Decrease in anoxic survival time (anoxia tolerance).
	1994	Hermsen, W., Sims,L. and M. Crane	Mar. Environ. Res. 38:61-69.	Mytilus edulis	Mussel	Perchlorobenzene	118-74-1	0.0031	MG/KG	3	Behavior	NOED	Combined	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	No significant effect on clearance (feeding) rate. Residue <3.1 ug/kg.
	1989	Donkin, P., J. Widdows, S.V. Evans, C.M. Worrall and M. Carr	Aquat Toxicol 14:277-294.	Mytilus edulis	Mussel	Phenanthrene	85-01-8	30.7	MG/KG	2	Behavior	ED50	Absorption	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	50% Reduction In Feeding Rate Assume wet weight
	1989	Donkin, P., J. Widdows, S.V. Evans, C.M. Worrall and M. Carr	Aquat Toxicol 14:277-294.	Mytilus edulis	Mussel	Pyrene	129-00-0	189	MG/KG	2	Behavior	ED50	Absorption	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	50% Reduction In Feeding Rate, Exp_conc = >0.04 mg/L. Assume wet weight.

MUSSELL, MYTILUS

PESTICIDE

	Download	hor	Publication Source	Species Scientific Name	Species Common Name	Analyte Name	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Habitat	Species Feeding Behavior	Comments
	1972	Roberts, D.	Mar Biol 16, 119-125 (1972)	Mytilus edulis	Mussel	Endosulfan	115-29-7	8.1	MG/KG	2	Mortality	NOED	Combined	Whole Body	Mature	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	

	1994	Hermsen, W., Sims,L. and M. Crane	Mar. Environ. Res. 38:61-69.	Mytilus edulis	Mussel	Lindane	58-89-9	0.0136	MG/KG	3	Behavior	LOED	Combined	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	20% Reduction in clearance (feeding) rate.

MUSSELL, MYTILUS

ARSENIC

	Download	hor	Publication Source	Species Scientific Name	Species Common Name	Analyte Name	CAS No	Conc_Wet	Conc_Units	No. Reps	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Habitat	Species Feeding Behavior	Comments
	2003	St-Jean SD, SC Courtenay, RW Parker	Water Qual Res J Can 38(4):647-666	Mytilus edulis	Mussel	Arsenic	7440-38-2	3.6	MG/KG	1	Mortality	NOED	Combined	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	
	2003	St-Jean SD, SC Courtenay, RW Parker	Water Qual Res J Can 38(4):647-666	Mytilus edulis	Mussel	Arsenic	7440-38-2	3.6	MG/KG	1	Growth	NOED	Combined	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Length - Growth in test animals increased in direct proportion to proximity to pulpmill effluent plume which was deemed to reflect not the contaminants, but the increased amounts of nutrients.

APPENDIX D. TABLE D11
TRV SUMMARY FISH

2,3,7,8-TCDD	Year	Author	Publication Source	Conc_Wet	Conc_Units	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Feeding Behavior	Comments	Proposed Use
YELLOW PERCH	1986	Kleeman, J.M., J.R. Olson, S.M. Chen and R.E. Peterson	Toxicol Appl Pharmacol 083:402-411.	0.000143	MG/KG	Mortality	NOED	Ingestion	Whole Body	Immature	Carnivore-aquatic insects, fish, inverts	No Effect On Mortality. Residue measured at end of exposure period.	ACCEPT NOED EST. LOED (*10)
BLACK BULLHEAD	1988	Kleeman, J.M., J.R. Olson and R.E. Peterson	Fundam. Appl. Toxicol. 10:206-213.	0.001	MG/KG	Mortality	NOED	Injection	Whole Body	NA	Aquatic invertebrates, including aquatic insects and their larvae	No significant increase in mortality.	REJECT
BLACK BULLHEAD	1988	Kleeman, J.M., J.R. Olson and R.E. Peterson	Fundam. Appl. Toxicol. 10:206-213.	0.025	MG/KG	Morphology	LOED	Injection	Whole Body	NA	Aquatic invertebrates, including aquatic insects and their larvae	Fin Necrosis	REJECT
CHANNEL CATFISH	1975	Isensee AR, GE Jones	Environ Sci Tech 09:668-672	0.19	MG/KG	Mortality	NOED	Absorption	Whole Body	Juvenile	Omnivore		ACCEPT NOED EST. LOED (*10)
LARGEMOUTH BASS	1988	Kleeman, J.M., J.R. Olson and R.E. Peterson	Fundam. Appl. Toxicol. 10:206-213.	0.025	MG/KG	Morphology	LOED	Injection	Whole Body	NA	Omnivorous; other fish, small animals	Fin Necrosis, Hyperpigmentation	REJECT
LARGEMOUTH BASS	1988	Kleeman, J.M., J.R. Olson and R.E. Peterson	Fundam. Appl. Toxicol. 10:206-213.	0.001	MG/KG	Mortality	NOED	Injection	Whole Body	NA	Omnivorous; other fish, small animals	No significant increase in mortality.	ACCEPT NOED
BLUEGILL	1988	Kleeman, J.M., J.R. Olson and R.E. Peterson	Fundam. Appl. Toxicol. 10:206-213.	0.001	MG/KG	Mortality	NOED	Injection	Whole Body	NA	Carnivore-aquatic insects, fish, inverts	No significant increase in mortality.	REJECT
BLUEGILL	1993	Cook PM , RJ Erickson, RL Spehar, SP Bradbury, GT Ankley	EPA 600/R-93/055	0.016	MG/KG	Mortality	LD50	Injection		Juvenile	Carnivore-aquatic insects, fish, inverts	Kleeman et al 1988	ACCEPT EST. LOED (/10)

Mercury													
YELLOW PERCH	1990	Wiener, J.G., Fitzgerald, W.F., Watras, C.J., Rada, R.G.	Environ Tox & Chem 09:909-918	0.135	MG/KG	Growth	NOED	Combined	Whole Body	Adult	Carnivore-aquatic insects, fish, inverts	Controlled Field Study; Two Years But Only 1-year Old Fish Analyzed; Basin Treated By Reducing Ph From About 6 To 5.6	ACCEPT NOED EST. LOED (*10)
CHANNEL CATFISH	1979	Birge WJ, JA Black, AG Westerman, JE Hudson	The Biogeochemistry of Mercury, pg 629-655	0.06	MG/KG	Mortality	LD50	Water	Whole Body	Embryo	Omnivore	Duration = 4d posthatch	ACCEPT EST. LOED (/10) EST. NOED (/100)
LARGEMOUTH BASS	2002	Friedmann, A., E. Costain, D. MacLatchy, W. Stansley and E. Washuta	Ecotoxicol Environ Saf 52:117-122	5.4	MG/KG	Physiological	NOED	Combined	Whole Body	Adult	Omnivorous; other fish, small animals	Minimum of 15 replicates per measurement type at each of three lakes. Condition factor, GSI, serum cortisol, interenal nucelar diameter, testosterone showed no differences between fish with 0.3 or 5.4 mg/kg body burdens.	ACCEPT NOED EST. LOED (*10)
WALLEYE	1996	Friedmann, A.S., M.C. Watzin, T. Brinck-Johnsen and J.C. Leiter	Aquat Toxicol 35:265-278	2.37	MG/KG	Mortality	NOED	Ingestion	Whole Body	Immature	Carnivorous; largely on various minnows, occasionally young whitefish	No Statistically Significant Increase In Mortality	REJECT

TOTAL PCBS													
CHANNEL CATFISH	1976	Hansen, L.G., W.B. Wiekhorst and J. Simon	J Fish Res Bd Can 33:1343-1352.	10.9	MG/KG	Mortality	NOED	Ingestion	Whole Body	Immature	Omnivore	No Effect On Mortality	ACCEPT NOED
CHANNEL CATFISH	1976	Hansen, L.G., W.B. Wiekhorst and J. Simon	J Fish Res Bd Can 33:1343-1352.	14.3	MG/KG	Growth	LOED	Ingestion	Whole Body	Immature	Omnivore	40% Reduction in body weight. Increased liver/body weight ratio.	ACCEPT LOED

APPENDIX D. TABLE D11
TRV SUMMARY FISH

BLUEGILL	1980	Barrows, M.E., S.R. Petrocelli, K.J. Macek and J.J. Carroll	p. 379-392 in Haque, R., ed. Dynamics, Exposure and Hazard Assessment of Toxic	17.5	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	Carnivore-aquatic insects, fish, inverts	No Effect On Mortality	**ACCEPT NOED EST. LOED (*10)**
AROCLOR 1242													
CHANNEL CATFISH	1976	Hansen LG, WB Wiekhurst, J Simon	J Fish Res Board Can 33:1343-1352	2.172	MG/KG	Mortality	NOED	Ingestion	Whole Body	Fingerling	Omnivore	Whole Body Minus Stomach and Contents Fed 20 Ug/g dose at 3% body wt, 1x per day. Day 84, 12 control fish died due to pump/drain failure. Feeding of experimentals disrupted days 140-196 - all fed control food for this duration.	**ACCEPT NOED EST. LOED (*10)**
DDE													
LARGEMOUTH BASS	2007	Johnson KG, JK Muller, B Price, A Ware, MS Sepulveda, CJ Borgert, TS Gross	Environ Tox & Chem 26(5):927-934	40	MG/KG	Reproduction	NOED	Ingestion	Whole Body	Adult	Omnivorous; other fish, small animals	Estradiol in female fish	**ACCEPT NOED**
LARGEMOUTH BASS	2007	Johnson KG, JK Muller, B Price, A Ware, MS Sepulveda, CJ Borgert, TS Gross	Environ Tox & Chem 26(5):927-934	75	MG/KG	Reproduction	IP479	Ingestion	Whole Body	Adult	Omnivorous; other fish, small animals	Estradiol in male fish **Caution: high variability-outliers	**ACCEPT LOED**
DDT													
BLUEGILL	1967	Gakstatter, J.H. and C.M. Weiss	Trans Am Fish Soc 096:301-307.	4.2	MG/KG	Behavior	LOED	Absorption	Whole Body	Immature	Carnivore-aquatic insects, fish, inverts	Severe symptoms of poisoning including loss of equilibrium and convulsions.	**ACCEPT LOED EST. NOED (/10)**
GREEN SUNFISH	1971	Hamelink, J.L., R.C. Waybrant, and R.C. Ball.	Trans Am Fish Soc 100:207-214.	24	MG/KG	Mortality	LOED	Combined	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	Lethal body burden. Fish exposed in outdoor artificial pool.	**REJECT**
PUMPKINSEED	1971	Hamelink, J.L., R.C. Waybrant, and R.C. Ball.	Trans Am Fish Soc 100:207-214.	24	MG/KG	Mortality	LOED	Combined	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	Lethal body burden. Fish exposed in outdoor artificial pool.	**REJECT**
CHLORPYRIFOS													
BLUEGILL	1972	Macek, K.J., D.F. Walsh, J.W. Hogan, and D.D. Holz	Trans Am Fish Soc 003:420-427	0.42	MG/KG	Mortality	NOED	Combined	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	No significant increase in mortality. Mesocosm study, 2 applications 30 days apart. Residue measured at 35 days.	**ACCEPT NOED**
BLUEGILL	1972	Macek, K.J., D.F. Walsh, J.W. Hogan, and D.D. Holz	Trans Am Fish Soc 003:420-427	2.06	MG/KG	Mortality	LOED	Combined	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	55% Increased mortality. Mesocosm study, 2 applications 30 days apart. Residue measured at 3 days.	**ACCEPT LOED**
DIELDRIN													
BLUEGILL	1967	Gakstatter, J.H. and C.M. Weiss	Trans Am Fish Soc 096:301-307.	3.7	MG/KG	Behavior	LOED	Absorption	Whole Body	Immature	Carnivore-aquatic insects, fish, inverts	Severe symptoms of poisoning including loss of equilibrium and convulsions.	**ACCEPT LOED EST. NOED (/10)**
ENDRIN													
BLUEGILL	1970	Bennett, H.J. and J.W. Day Jr.	Pesticides Monitoring Journal, 3(4):201-203.	0.08	MG/KG	Mortality	NOED	Absorption	Whole Body	NA	Carnivore-aquatic insects, fish, inverts	No increase in mortality.	**ACCEPT NOED**
BLUEGILL	1970	Bennett, H.J. and J.W. Day Jr.	Pesticides Monitoring Journal, 3(4):201-203.	0.3	MG/KG	Mortality	LOED	Absorption	Whole Body	NA	Carnivore-aquatic insects, fish, inverts	Increase in mortality.	**ACCEPT LOED**

APPENDIX D. TABLE D11
TRV SUMMARY FISH

FENVALERATE													
BLUEGILL	1987	Bradbury, S.P., D.M. Symonik, J.R. Coats, and G.J. Atchison.	Bull Environ Contam Toxicol 38:727-735	0.67	MG/KG	Mortality	LD50	Injection	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	50% Mortality after i.p. injection of .67 mg/kg.	**ACCEPT EST. LOED (/10) EST. NOED (/100)**
LINDANE													
BLUEGILL	1976	Macek KJ, KS Buxton, SK Derr, JW Dean, S Sauter	EPA 600/3-76/046 49pp.	0.016	MG/KG	Mortality	LD100	Water	Muscle	Juvenile	Carnivore-aquatic insects, fish, inverts	F1 fry survival @90 d	**ACCEPT EST. LOED (/20) EST. NOED (/200)**
BLUEGILL	1976	Macek, K.J., K.S. Buxton, S.K. Derr, J.W. Dean and S. Sauter	U.S. EPA 600/3-76-046, ORD, Duluth, MN. 50 pp.	0.297	MG/KG	Growth	NOED	Absorption	Muscle	Immature	Carnivore-aquatic insects, fish, inverts	No Effect On Growth	**REJECT**
MIREX													
BLUEGILL	1974	Hyde, K.M., S. Stokes, J.F. Fowler, J.B. Graves, and F.L. Bonner.	Trans Am Fish Soc 002a:366-369	0.02	MG/KG	Growth	NOED	Absorption	Whole Body	NA	Carnivore-aquatic insects, fish, inverts	No significant difference in weight or length. Fish raised in outdoor ponds treated with Mirex bait. Fish were fed commercial feed.	**ACCEPT NOED EST. LOED (*10)**
BLUEGILL	1968	van Valin, C.C., Andrews, A.K., Eller, L.L.	Trans Am Fish Soc 097:185-196.	14	MG/KG	Growth	LOED	Combined	Whole Body	Immature	Carnivore-aquatic insects, fish, inverts	34% Reduction in weight gain probably due to reduced food intake. Residue at 100 days.	**REJECT**
BLUEGILL	1968	van Valin, C.C., Andrews, A.K., Eller, L.L.	Trans Am Fish Soc 097:185-196.	30	MG/KG	Mortality	NOED	Combined	Whole Body	Immature	Carnivore-aquatic insects, fish, inverts	No increase in mortality. Mirex bait added to outdoor ponds	**REJECT**
SELENIUM													
LARGEMOUTH BASS	1982	Lemly, A.D.	Aquat Toxicol 02:235-252.	3.1	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	Omnivorous; other fish, small animals	No mortality at 20 or 30 degrees C in soft or hard water.	**REJECT**
BLUEGILL	1993	Cleveland L, EE Little, DR Buckler, and RH Wiedmeyer	Aquat Toxicol	0.66	MG/KG	Mortality	NOED	Ingestion	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	Condition Index	**ACCEPT NOED**
BLUEGILL	2003	Hamilton SJ	Ecotoxicol Environ Saf 56:201-210	0.66	MG/KG	Growth	NOED	NS	Whole Body	NS	Carnivore-aquatic insects, fish, inverts	Review paper Cleveland et al 1993	**REJECT**
BLUEGILL	1993	Cleveland L, EE Little, DR Buckler, and RH Wiedmeyer	Aquat Toxicol	0.68	MG/KG	Mortality	LD20	Water	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts		**ACCEPT LOED**
ARSENIC													
GREEN SUNFISH	1976	Sorensen EMB	Bull Environ Contam Toxicol 15:756-761	0.002	MG/KG	Mortality	LT50	Water	Whole Body	NA	Carnivore-aquatic insects, fish, inverts	Large fish	**REJECT - PENDING REVIEW**
BLUEGILL	1966	Gilderhus, P.A.	Trans Am Fish Soc 095:289-296	1.8	MG/KG	Mortality	NOED	Combined	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	No increase in mortality. Weekly application of sodium arsenite herbicide in artificial pond.	**ACCEPT NOED**
BLUEGILL	1966	Gilderhus, P.A.	Trans Am Fish Soc 095:289-296	1.8	MG/KG	Growth	NOED	Combined	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	No difference in weight gain. Weekly application of sodium arsenite herbicide in artificial pond.	
BLUEGILL	1966	Gilderhus, P.A.	Trans Am Fish Soc 095:289-296	2.24	MG/KG	Growth	LOED	Combined	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	Decrease in weight gain. One application of sodium arsenite herbicide in artificial pond.	**ACCEPT LOED**
BLUEGILL	1966	Gilderhus, P.A.	Trans Am Fish Soc 095:289-296	2.24	MG/KG	Mortality	LOED	Combined	Whole Body	Juvenile	Carnivore-aquatic insects, fish, inverts	Increase in mortality. One application of sodium arsenite herbicide in artificial pond.	

yellow perch or surrogate percid
bullhead or surrogate ictalurid
largemouth bass or surrogate centrarchid

APPENDIX D. TABLE D12
TRV SUMMARY INVERTEBRATES

OLIGOCHAETES													
LEAD													
	Year	Author	Publication Source	Conc_Wet	Conc_Units	Effect Class	Toxicity Measure	Exposure Route	Species Body Part	Species Start Lifestage	Species Feeding Behavior	Comments	Proposed Use
LUMRICULUS	2005	Aisemberg J; DE Nahabedian; EA Wider; NRV Guerrero	Toxicology 210:45-53	300	MG/KG	Mortality	NOED	Water	Whole Body	Adult	Feeds on small animals in substrata		ACCEPT NOED EST. LOED (*10)
TOTAL PCBS													
LUMRICULUS	2005	Burton GA Jr, MS Greenberg, CD Rowland, CA Irvine, DR Lavioie, JA Brooker, L Moore, DFN Raymer, RA McWilliam	Environ Pollut 134:133-144	350	MG/KG	Survival	NOED	Combined	Whole Body	Adult	Feeds on small animals in substrata	Difficult to ascertain the experimental design because the paper is presenting multiple experiments from 1991 to present	ACCEPT NOED EST. LOED (*10)
DDE													
LUMRICULUS	1999	Fisher SW, SW Chordas III, PF Landrum	Aquat Toxicol 45:115-126	178.4	MG/KG	Mortality	LD38	Ingestion	Whole Body	Adult	Feeds on small animals in substrata		ACCEPT LOED EST. NOED (/10)
LUMRICULUS	1999	Fisher SW, SW Chordas III, PF Landrum	Aquat Toxicol 45:115-126	178.4	MG/KG	Growth	ED29	Ingestion	Whole Body	Adult	Feeds on small animals in substrata	mean decrease in Biomass	
DDD													
OLIGOCHAETE	2005	CG Ingersoll, N Wang, JMR Hayward, JR Jones, SB Jones, DS Ireland	Environ Tox & Chem 24:2853-2870	1500	MG/KG	NA	NOED	Combined	Whole Body	Adult		abundance, field assessment	ACCEPT NOED EST. LOED (*10)
PBDE													
LUMRICULUS	2004	Leppenen MT, JVK Kukkonen	Environ Tox & Chem 23(1):166-172	24.28	MG/KG	Mortality	NOED	Ingestion	Whole Body	Adult	Feeds on small animals in substrata	Residue given in lipid weight- Lake Kuorinka sediment	ACCEPT NOED EST. LOED (*10)
LUMRICULUS	2004	Leppenen MT, JVK Kukkonen	Environ Tox & Chem 23(1):166-172	24.28	MG/KG	Growth	NOED	Ingestion	Whole Body	Adult	Feeds on small animals in substrata	Weight- Residue given in lipid weight- Lake Kuorinka sediment	
BIVALVES													
CADMIIUM													
CORBICULA	2001	Barfield, M.L., J.L. Farris, M.C. Black	J Toxicol Environ Health, Part A 63:495-510	20	MG/KG	Mortality	NOED	Water	Whole Body	NS	Filter feeders; phytoplankton, detritus, bacteria, small zooplankters	Cellulase Enzyme Activity	ACCEPT NOED EST. LOED (*10)
BENZO(A)PYRENE													
GREATER EUROPEAN PEA CLAM	1999	Heinonen J, JVK Kukkonen, IJ Holopainen	Ecol App 9(2):475-481	0.028	MG/KG	Mortality	NOED	Water	Whole Body	Adult	Not Specified	21 ug/l TCP and 4 ng/l BaP Infected with Bunodera luciopercae, 20 degrees C	REJECT
FINGERNAIL CLAM	1997	Borchert, J., L. Karbe and J. Westendorf	Bull Environ Contam Toxicol 58:158-165	1.25	MG/KG	Mortality	NOED	Combined	Whole Body	Adult	Not Specified	No Effect On Survival. Residue measured at end of exposure period.	ACCEPT NOED EST. LOED (*10)

APPENDIX D. TABLE D12
TRV SUMMARY INVERTEBRATES

MERCURY													
MARSH CLAM	1977	Dillon, T.M.	Arch Environ Contam Toxicol 06:249-255	20	MG/KG	Mortality	LD50	Absorption	Whole Body	Adult	Filter feeder; plankton, bacteria, fine detrital particles	50% Mortality in clams that had been pre-exposed to 1 ppb Hg for 2 weeks prior to test.	**ACCEPT EST. LOED (/10) EST. NOED (/100)**
SOFTSHELL CLAM	2001	Gorbi, G., M.G. Corradi, M. Invidia, M. Bassi	Ecotoxicol Environ Saf 48:36-42	25	MG/KG	Biochemical	LOED	Water	Whole Body	NS	Filter selectively; zooplankton, bacteria, decomposing fragments of large organisms.	Decrease in phagocytic activity in Hemocytes	**REJECT**
DDT													
CLAM, SOFTSHELL	1971	Butler, P.A.	Proc. Royal Soc. London, Series B 177:321-329.	0.88	MG/KG	Behavior	NOED	Combined	Whole Body	Adult	Filter selectively; zooplankton, bacteria, decomposing fragments of large organisms.	No Effect On Feeding Activity Assume wet weight	**ACCEPT NOED EST. LOED (*10)**
PCBS													
BLUE MUSSEL	1991	Velduizen-Tsoerkan, M.B., Holwerda, D.A., Zandee, D.I.	Arch Environ Contam Toxicol 20:259-265	1.4	MG/KG	Physiologica l	NOED	Combined	Whole Body	Adult	Filter plankton, diatoms, bottom vegetation	No Significant Changes In Adenylate Energy Charge Or Glycogen Content	**ACCEPT NOED EST. LOED (*10)**
1-													
BLUE MUSSEL	1989	Donkin, P., J. Widdows, S.V. Evans, C.M. Worrall and M. Carr	Aquat Toxicol 14:277-294.	21.6	MG/KG	Behavior	ED50	Absorption	Whole Body	Adult	Filter plankton, diatoms, bottom vegetation	50% Reduction In Feeding Rate Assume wet weight.	**ACCEPT EST. LOED (/10) EST. NOED (/100)**
ACENAPHTHENE													
BLUE MUSSEL	1989	Donkin, P., J. Widdows, S.V. Evans, C.M. Worrall and M. Carr	Aquat Toxicol 14:277-294.	29.4	MG/KG	Behavior	ED50	Absorption	Whole Body	Adult	Filter plankton, diatoms, bottom vegetation	50% Reduction In Feeding Rate Assume wet weight.	**ACCEPT EST. LOED (/10) EST. NOED (/100)**
BIPHENYL													
BLUE MUSSEL	1989	Donkin, P., J. Widdows, S.V. Evans, C.M. Worrall and M. Carr	Aquat Toxicol 14:277-294.	15.6	MG/KG	Behavior	ED50	Absorption	Whole Body	Adult	Filter plankton, diatoms, bottom vegetation	50% Reduction In Feeding Rate Assume wet weight.	**ACCEPT EST. LOED (/10) EST. NOED (/100)**
DEHP													
BLUE MUSSEL	1982	Brown, D. and R.S. Thompson	Chemospher e 11:427-435.	123	MG/KG	Mortality	NOED	Absorption	Whole Body	Adult	Filter plankton, diatoms, bottom vegetation	No Effect On Mortality. Residue measured at end of exposure period.	**ACCEPT NOED EST. LOED (*10)**
DIBENZOTHIOPHENE													
BLUE MUSSEL	1989	Donkin, P., J. Widdows, S.V. Evans, C.M. Worrall and M. Carr	Aquat Toxicol 14:277-294.	14.2	MG/KG	Behavior	ED50	Absorption	Whole Body	Adult	Filter plankton, diatoms, bottom vegetation	50% Reduction In Feeding Rate Assume wet weight.	**ACCEPT EST. LOED (/10) EST. NOED (/100)**
DIISODECYLPHTHALATE													
BLUE MUSSEL	1982	Brown, D. and R.S. Thompson	Chemospher e 11:427-435.	133	MG/KG	Mortality	NOED	Absorption	Whole Body	Adult	Filter plankton, diatoms, bottom vegetation	No Effect On Mortality. Residue measured at end of exposure period.	**ACCEPT NOED EST. LOED (*10)**

APPENDIX D. TABLE D12
TRV SUMMARY INVERTEBRATES

FLUORANTHENE													
BLUE MUSSEL	1995	Eertman, R.H.M., C.L. Groenink, B. Sandee and H. Hummel	Mar. Environ. Res. 39:169-173.	0.22	MG/KG	Reproduction	LOED	Absorption	Whole Body	NA	Filter plankton, diatoms, bottom vegetation	Abnormal Gametogenesis	**ACCEPT LOED EST. NOED (/10)**
OCTANE													
BLUE MUSSEL	1989	Donkin, P., J. Widdows, S.V. Evans, C.M. Worrall and M. Carr	Aquat Toxicol 14:277-294.	24.6	MG/KG	Behavior	ED50	Absorption	Whole Body	Adult	Filter plankton, diatoms, bottom vegetation	50% Reduction In Feeding Rate Assume wet weight.	**ACCEPT EST. LOED (/10) EST. NOED (/100)**
PCP													
BLUE MUSSEL	2006	Meador J	Human & Ecol. Risk Assessment 12:1018-1073	2.3	MG/KG	Physiological	LOED				Filter plankton, diatoms, bottom vegetation	***CRITICAL BODY RESIDUE (LOER) Refer to Table 6.	**ACCEPT LOED EST. NOED (/10)**
PERCHLOROBENZENE													
BLUE MUSSEL	1994	Hermsen, W., Sims,L. and M. Crane	Mar. Environ. Res. 38:61-69.	0.0031	MG/KG	Behavior	NOED	Combined	Whole Body	Adult	Filter plankton, diatoms, bottom vegetation	No significant effect on clearance (feeding) rate. Residue <3.1 ug/kg.	**ACCEPT NOED EST. LOED (*10)**
PHENANTHRENE													
BLUE MUSSEL	1989	Donkin, P., J. Widdows, S.V. Evans, C.M. Worrall and M. Carr	Aquat Toxicol 14:277-294.	30.7	MG/KG	Behavior	ED50	Absorption	Whole Body	Adult	Filter plankton, diatoms, bottom vegetation	50% Reduction In Feeding Rate Assume wet weight	**ACCEPT EST. LOED (/10) EST. NOED (/100)**
PYRENE													
BLUE MUSSEL	1989	Donkin, P., J. Widdows, S.V. Evans, C.M. Worrall and M. Carr	Aquat Toxicol 14:277-294.	189	MG/KG	Behavior	ED50	Absorption	Whole Body	Adult	Filter plankton, diatoms, bottom vegetation	50% Reduction In Feeding Rate, Exp_conc = >0.04 mg/L. Assume wet weight.	**ACCEPT EST. LOED (/10) EST. NOED (/100)**
ENDOSULFAN													
BLUE MUSSEL	1972	Roberts, D.	Mar Biol 16, 119-125 (1972)	8.1	MG/KG	Mortality	NOED	Combined	Whole Body	Mature	Filter plankton, diatoms, bottom vegetation		**ACCEPT NOED EST. LOED (*10)**
LINDANE													
BLUE MUSSEL	1994	Hermsen, W., Sims,L. and M. Crane	Mar. Environ. Res. 38:61-69.	0.0136	MG/KG	Behavior	LOED	Combined	Whole Body	Adult	Filter plankton, diatoms, bottom vegetation	20% Reduction in clearance (feeding) rate.	**ACCEPT LOED EST. NOED (/10)**
ARSENIC													
BLUE MUSSEL	2003	St-Jean SD, SC Courtenay, RW Parker	Water Qual Res J Can 38(4):647-666	3.6	MG/KG	Mortality	NOED	Combined	Whole Body	Adult	Filter plankton, diatoms, bottom vegetation		**ACCEPT NOED EST. LOED (*10)**
BLUE MUSSEL	2003	St-Jean SD, SC Courtenay, RW Parker	Water Qual Res J Can 38(4):647-666	3.6	MG/KG	Growth	NOED	Combined	Whole Body	Adult	Filter plankton, diatoms, bottom vegetation	Length - Growth in test animals increased in direct proportion to proximity to pulpmill effluent plume which was deemed to reflect not the contaminants, but the increased amounts of nutrients.	