Development of Site-Specific Water Quality Criteria for the South Fork Coeur d'Alene River, Idaho

DERIVATION OF ACUTE AND CHRONIC CRITERIA FOR LEAD AND ZINC

Prepared for

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Table of Contents

Tables and Figures

Acronyms

ACR	acute-chronic ratio
ALC	aquatic life criteria
ANCOVA	analysis of covariance
AWQC	ambient water quality criteria
CCC	criterion continuous concentration
CCI	criterion continuous intercept
CI	confidence interval
CMC	criterion maximum concentration
CMI	criterion maximum intercept
EFPC	East Fork of Pine Creek
ELS	early life stage
EPA	U.S. Environmental Protection Agency
FAV	final acute value
FLC	full life cycle
HWC	hatchery Westslope cutthroat trout
IDEQ	Idaho Department of Environmental Quality
IDFG	Idaho Department of Fish and Game
IDHW	Idaho Department of Health and Welfare
LNF	Little North Fork of the South Fork Coeur d'Alene River
LOEC	lowest-observed-effect concentration
MIL	mean individual length
MIW	mean individual weight
NOEC	no-observed-effect concentration
RSP	resident species procedure (EPA 1984a)
RWC	resident Westslope cutthroat trout
SF-8	sampling station upstream of the mouth of Canyon Creek
SF-9	sampling station just downstream of Mullan
SF-10	sampling station just downstream of Shoshone Park
SF-G	sampling station at Golconda district
SMAV	species mean acute value
SF-H	South Fork water supply to Hale Hatchery
South Fork	South Fork Coeur d'Alene River
USGS	U.S. Geological Survey
Windward	Windward Environmental LLC
YOY	young of the year

Acknowledgements

The Windward Environmental (Windward) team members primarily responsible for this work are Frank S. Dillon, Daniel P. Hennessy, D. Michael Johns, and Kathy L. Godtfredsen. Technical staff includes Mr. Garrett D. Gray, Mr. Stefan A. Wodzicki, Joanna M. Florer, and Russell W. Gibson. All reports were edited, prepared for publication, and published by Bejurin J. Cassady.[1]

Throughout the study, the State of Idaho has provided chemical analyses of water samples. In 1996, Barry Pharaoh at the Idaho Department of Health and Welfare (IDHW) laboratory in Boise analyzed zinc samples. Peggy Albertson, chemist principal at the IDHW laboratory in Coeur d'Alene, analyzed all cadmium and lead samples, as well as zinc samples from 1997 to 2001.

All toxicity testing conducted from June 1996 to date has been performed on site in the Silver Valley at the Hale Fish Hatchery, owned by the Shoshone County Sportsman's Association. Mary Von Broeke, Idaho Department of Fish and Game caretaker of the Hale Fish Hatchery, provided assistance over the course of the study, including care of overwintering broodstock from 1999 to 2001.

Geoff Harvey was the Idaho Department of Environmental Quality project officer from 1993-1999. Christopher Mebane was the Idaho Department of Environmental Quality project officer from 2000-2002.

Charles Stephan and Lisa Macchio of EPA provided indispensable advice and review of the criteria derivation process, testing design, and data interpretation.

[1] All members of the Windward team were employed by EVS Consultants through December 1999, then with Windward from January 2000 on, except for Ms. Florer and Mr. Gibson, who were hired in 2000.

1.0 Introduction

The Clean Water Act (40CFR§130-131) and Idaho Code (IDAPA 58.01.02§275) allow for the development and promulgation of site-specific water quality criteria for the protection of aquatic life, when appropriate. The U.S. Environmental Protection Agency (EPA), the State of Idaho, and Hecla Mining Company conducted two meetings in 1993 that resulted in an understanding in principle to develop site-specific criteria for the South Fork Coeur d'Alene River (South Fork) upstream of Canyon Creek (IDEQ 1993). The State's goal in developing site-specific criteria upstream of Canyon Creek was to allow better management, using water quality criteria that are reflective of supported uses (IDEQ 1993).

This report, which is the culmination of five years of site-specific toxicity testing, presents proposed site-specific ambient water quality criteria for lead and zinc. Cadmium was also studied, but because site-specific toxicity test data were similar to those in the national criteria database, site-specific criteria for cadmium were not developed as part of this report. The proposed hardness-dependent maximum and continuous concentrations were based on site-specific toxicity test data and were supported by peer-reviewed scientific literature and supplemental site-specific data. The criteria proposed in this report apply specifically to the segment of the South Fork from Daisy Gulch to Canyon Creek. The process and procedures for developing the data set necessary to determine site-specific water quality criteria for cadmium, lead, and zinc for the South Fork were based on EPA guidance and comments, and ASTM standard test methods that were previously described in detail (EVS 1996a). The process is summarized below in Section 2.

The study process consisted of two phases. Phase 1 was a series of rangefinding tests designed to identify the one or two resident species most sensitive to each metal of interest. The most sensitive species identified in Phase 1 were then used in the second phase testing. The Phase 2 definitive tests were designed to develop more precise toxicity estimates. The high-precision toxicity estimates derived from tests using the most sensitive resident species provide data appropriate to develop hardness-normalized site-specific criteria for the protection of aquatic resources in the South Fork. Results from the site-specific testing program were provided in previous reports (EVS 1996b; EVS 1997; EVS 1998; Windward 2000). These data, along with the testing conducted in 2000 (Windward 2001) provide the basic data set necessary for development of site-specific criteria. This report presents proposed site-specific water quality criteria for lead and zinc.

1.1 Study area and sampling sites

The South Fork was divided into three segments in Idaho's Water Quality Standards and Wastewater Treatment Requirements (IDAPA 58.01.01§110.09): segment P-13 is the reach from the source to Daisy Gulch, segment P-11 is the reach from and including Daisy Gulch to Canyon Creek, and segment P-1 is the reach from Canyon Creek to the mouth. In the agreement among EPA, the State of Idaho, and Hecla Mining Company to develop site-specific criteria, the study area was logically divided at Canyon Creek, a tributary that increases the total metals loading to the South Fork by an order of magnitude (IDEQ 1993).

Above Canyon Creek, the statewide criteria for cadmium, lead, and zinc were sometimes exceeded, although no adverse effects to aquatic life are apparent. Fish populations and community composition of benthic macroinvertebrates were similar to regional reference areas (Hartz 1993; R2 1999). The State's goal for development of site-specific criteria upstream of Canyon Creek was to allow better management with numerical criteria reflective of supported uses (IDEQ 1993).

There are a number of lakes in headwater tributaries of the South Fork, including Stevens Lakes, Lost Lake, Glidden Lakes, and Elsie Lake. Lake water quality was not assessed for this project. Therefore, site-specific criteria were not developed for any lakes in the basin.

Figure 1-1 is a map of the site, including hatchery water sources (SF-H, LNF) and water sampling stations (SF-8, SF-G, SF-9, SF-10) used to support site-specific criteria development.

1.2 Document organization

The remainder of this document is divided into the following sections:

- Section 2 describes the rationale and approach used in developing criteria, including assumptions, steps used to derive criteria, and adherence to or deviation from EPA guidance for developing site-specific criteria. The use and sources of supporting data are presented.
- Section 3 describes the data used for deriving site-specific criteria, including the primary acute and chronic data as well as the supplemental data generated over the course of this study.
- Section 4 details the steps taken in deriving criteria using the approach described in Section 2.
- Section 5 summarizes the proposed hardness-normalized site-specific acute and chronic criteria

The report is supplemented by three appendices: Appendix A summarizes the acute and chronic test data used to derive site-specific criteria, Appendix B contains tabular summaries of the chronic test data used to derive the site-specific lead acute-chronic ratio (ACR), and Appendix C summarizes the results of metals mixture tests. Electronic versions of the acute toxicity test database and chronic toxicity test data summary tables are available on request from Windward.

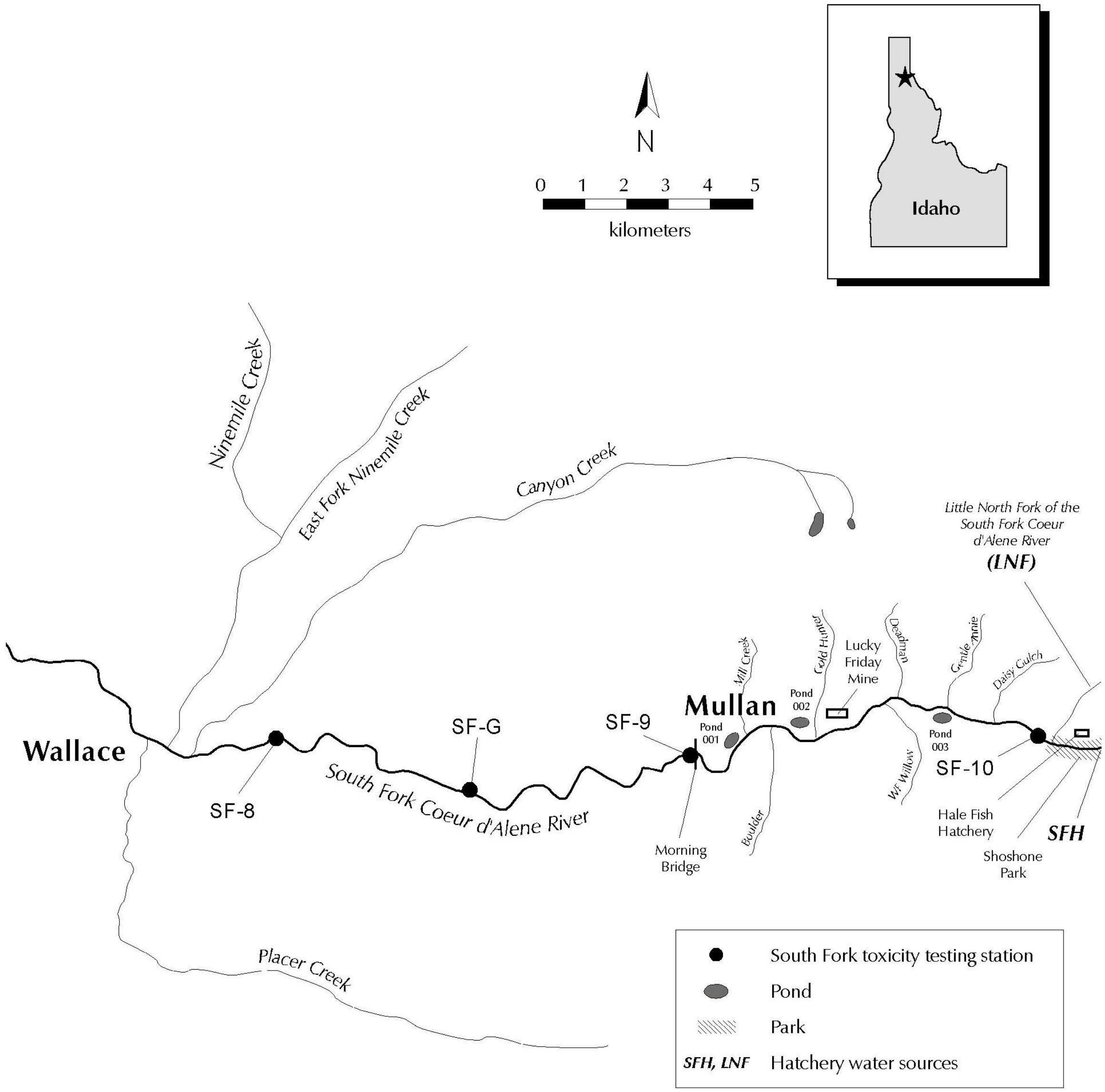

Figure 1-1. Study area, sampling stations, and hatchery water sources

2.0 Rationale and Approach

2.1 Rationale for site-specific criteria development

Federal (40CFR§130-131) and State of Idaho (IDAPA 58.01.02§275) regulations provide for and encourage the review of existing water quality criteria, and, where appropriate, the development of site-specific criteria. Above Canyon Creek, the Idaho acute and chronic criteria for cadmium, lead, and zinc were sometimes exceeded (EVS 1995, MFG 1999). However, biological monitoring data have demonstrated the presence of self-sustaining populations of resident Westslope cutthroat trout (RWC) and benthic macroinvertebrate community composition similar to regional reference areas (Hartz 1993; USGS 1993; R2 1999). This discrepancy between chemical and biological monitoring data supports the case for developing site-specific water quality criteria.

2.2 Approach

Within EPA's dataset for deriving cadmium, lead, or zinc criteria, there are few toxicity data for species resident to the South Fork, and few exposure data from tests conducted in water with quality similar to that found in the South Fork. EPA has published two guidance documents regarding the development of numerical water quality criteria:

- *Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and their Uses* (EPA 1985)
- *Guidelines for Deriving Numerical Aquatic Site-Specific Water Quality Criteria by Modifying National Criteria* (EPA 1984a)

These documents provided the basis for the methods used to derive site-specific criteria for the South Fork. In addition, EPA staff was consulted concerning the technical aspects of the site-specific criteria development process, including the deviation discussed below in Section 2.2.2.

Following a thorough review of available water quality and biological information (EVS 1995), the study design was developed (EVS 1996a). Since EPA's resident species procedure (RSP) addresses organism sensitivity and water quality differences, it was adopted as the foundation for our conceptual approach. The overarching approach for the study design was as follows:

- Identify resident species for testing
- Conduct toxicity tests with rangefinding exposures to identify the most sensitive species
- Conduct definitive toxicity tests with the most sensitive species, including acute and chronic exposures
- Conduct testing across a range of water quality conditions
- Conduct metals mixture testing to verify that proposed site-specific criteria are protective in combination
- Determine acute and chronic site-specific criteria

The approach was a deviation from EPA's RSP (1984a) because the criteria were based on direct results of testing with the most sensitive resident species and were not derived using the final acute value (FAV) equation. A flowchart presenting the process for deriving site-specific criteria is presented in Figure 2-1.

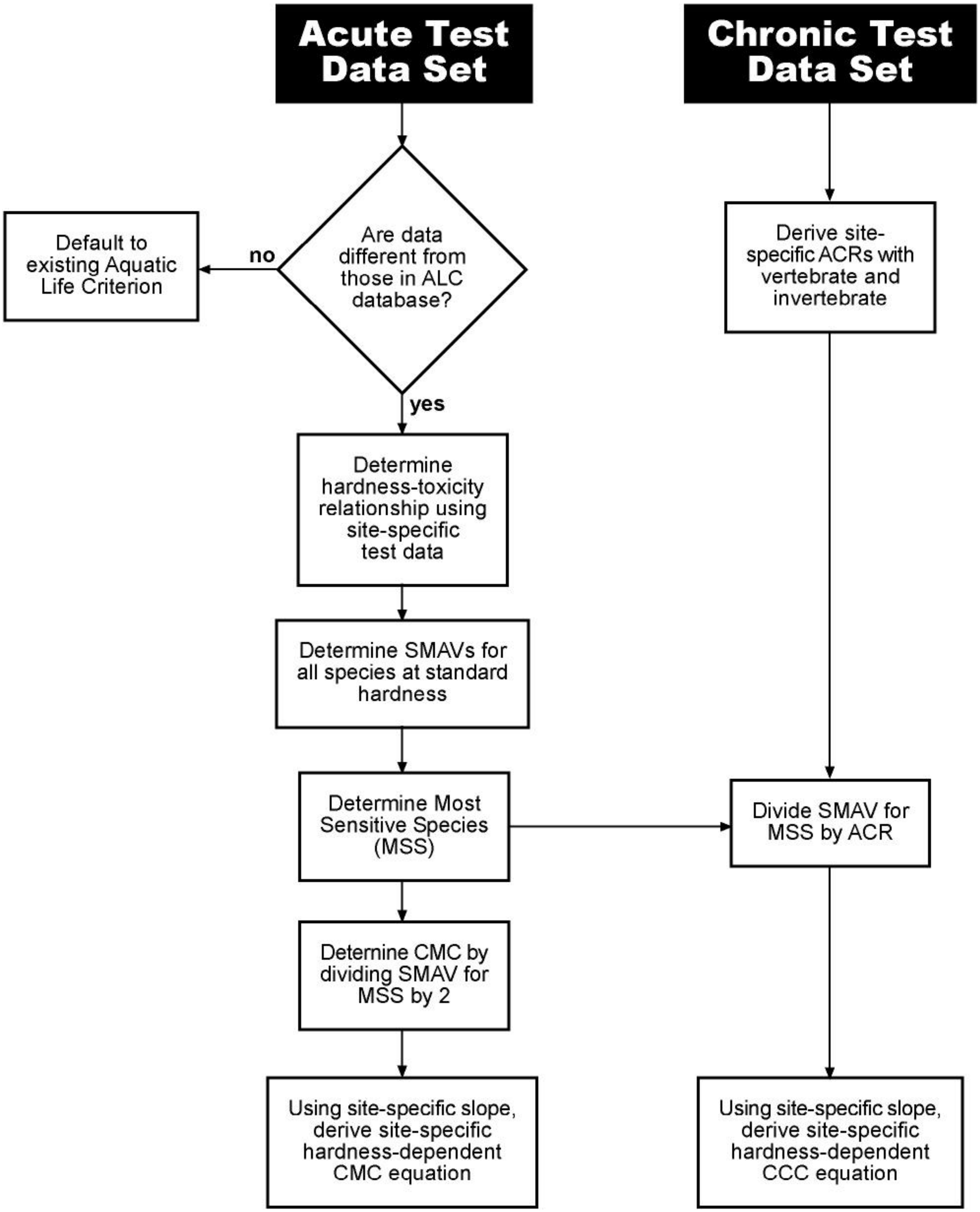

Figure 2-1. Derivation of the site-specific criteria for the South Fork from Daisy Gulch to Canyon Creek

2.2.1 Assumptions

The following were core assumptions that formed the basis of EPA's criteria for divalent trace elements, including cadmium, lead, and zinc. All were considered to be valid assumptions and adopted for developing site-specific criteria for the South Fork.

- Metals concentrations that are protective of the most sensitive resident species in a watershed will be protective of less sensitive aquatic biota at the site. This assumption is typically known as the most sensitive species approach.
- Total hardness (measured as $CaCO_3$) is an acceptable surrogate measure of ionic constituents in water that mitigate metals toxicity (e.g., calcium and magnesium).
- For a given concentration of cadmium, lead, or zinc, increasing water hardness mitigates metal toxicity. The hardness-toxicity relationship can be quantified by determining the regression slope of natural-log-transformed test hardnesses and EC50 data from acceptable acute toxicity tests.
- ACRs are an acceptable way to derive a final chronic value from acute toxicity test data.
- The hardness-toxicity relationship (i.e., regression slope) derived using acute exposures and sensitive species also describes the relationship between hardness and chronic toxicity for that species.

2.2.2 Adherence to and deviations from EPA guidance for deriving site-specific criteria

2.2.2.1 Species selection

EPA guidelines (EPA 1985) specify the suite of aquatic organisms that should ideally be included in the toxicity database for deriving numerical criteria. Table 2-1 compares the organisms identified in the guidance with the resident species used for site-specific criteria development in this study.

A review of the species present in the South Fork and St. Joe River showed that three groups of organisms were not present, would not be expected to be present, or were not present in sufficient numbers to be feasible for use as test organisms:

- A third family in the phylum Chordata
- A planktonic crustacean
- A benthic crustacean

Table 2-1. Comparison of organisms identified specifically in the guidance versus the indigenous species utilized for site-specific criteria development

Organisms Required by EPA Guidelines	Resident Organisms Used to Develop Site-Specific Criteria	
The family Salmonidae in the class Osteichthyes	Westslope cutthroat trout (*Oncorhynchus clarki lewisi*)	
A second family in the class Osteichthyes	Shorthead sculpin (*Cottus confusus*)	
A third family in the phylum chordata	Not applicable[a]	
A planktonic crustacean	Not applicable[a]	
A benthic crustacean	Not applicable[a]	
An insect	Ephemeroptera[b]	Baetidae
		Ephemerillidae
		Heptageniidae
		Leptophlebidae
A family in any order of insect or any phylum not already represented	Gastropoda	Planorbidae
		Physidae
	Plecoptera[b]	Perlodidae
		Chloroperlodidae
	Trichoptera[b]	Hydropsychidae
		Arctopsychidae
	Diptera	Chironomidae
		Simulidae
		Tipulidae
	Coleptera	Dytiscidae

[a] Not expected to be present or not present in sufficient numbers to be feasible for use as test organisms.

[b] In high-gradient streams such as the South Fork, the benthic insect community is the foundation of nutrient cycling and provides the food base for fishes. Therefore, multiple families of these keystone organisms were tested.

Only two families of indigenous resident fish were found in the study area, Salmonidae (RWC and mountain whitefish [*Prosopium williamsoni*]) and Cottidae (shorthead sculpin). The trout and the sculpin were selected for study. Two non-indigenous fish species were also found, brook trout (*Salvelinus fontinalis*) and rainbow trout (*Oncorhynchus mykiss*). The primary objective of the Idaho Department of Fish and Game (IDFG) is to manage the South Fork drainage for wild populations of RWC (Horner 1998). The introduction of non-indigenous competing species has played a significant role in the decline of native RWC in the system (IDFG 2000). Harvest regulations and stockings are managed to attempt to limit these competing, introduced species. Non-indigenous species that can be invasive and compete with indigenous species were not considered resident species for the purposes of inclusion in site-specific criteria development.

Planktonic crustaceans are not adapted to moving water and are not found in high-gradient lotic environments. Based on monitoring data from the Idaho Department of Environmental Quality (IDEQ) (EVS 1995) and the U.S. Geological Survey (USGS 2000), benthic crustaceans such as amphipods and isopods were not present in the

South Fork, nor in areas of similar habitat in the St. Joe, North Fork Coeur d'Alene, and Clearwater rivers.

Although amphibians were present in the South Fork, their numbers precluded their collection for use in testing. A review of relevant toxicological data in EPA's ECOTOX database indicated that amphibians were less sensitive that trout, so criteria protective of trout would be protective of amphibians. Further, the Coeur d'Alene Basin ecological risk assessment concluded that trout were more sensitive than amphibians to cadmium, lead, and zinc (EPA 2000a).

Since the diversity of families specified by EPA guidance (1985) could not be met, species were selected to represent a range of ecologically important fish and macroinvertebrate species typical of high-gradient streams in the intermountain west (Table 2-1).

Subsequent to the selection of species for testing (EVS 1996a,b,c), the ASTM (1997a) standard guide for selection of resident species as test organisms for aquatic toxicity testing was published. ASTM (1997a) states that field-collected organisms should be representative of the organisms that could occur at the study site based on habitat features and historic species records for the region and should not have been previously exposed to contaminants. Therefore, field-collected organisms should be obtained from clean areas well outside the influence of point- and nonpoint sources. Further recommended selection criteria are the ease of organism procurement and laboratory maintenance and handling, availability of existing acute or chronic test procedures, and the potential relative sensitivity of organisms to pollution, including testing sensitive life stages and endpoints. While not available for the species selection process for this project, the ASTM guidelines are fundamentally consistent with the approach used here.

2.2.2.2 Derivation process

The following determinations were made in deriving site-specific criteria; each of these points is in agreement with EPA guidance (EPA 1984a, 1985).

- The most sensitive species approach was accepted as reasonable for determining criteria that are protective of aquatic life.
- Water hardness was recognized as a surrogate for factors mitigating metals toxicity.
- EC50s were used to evaluate species sensitivity.
- Water hardness and EC50 data were natural log-transformed to determine the hardness-toxicity regression slope.
- The intercept of the hardness-dependent criteria equation was based on an estimate of a metal concentration that was protective of the most sensitive species.

- One-half the EC50 of the most sensitive species was considered to be protective from acute effects.
- The chronic value of an acceptable chronic test was the geometric mean of the no-observed-effect concentration (NOEC) and the lowest-observed-effect concentration (LOEC).
- The FAV was divided by the site-specific ACR to determine the criterion continuous concentration (CCC).

Resident species sensitivity was determined by site-specific testing, and rankings of sensitivity were supported by the peer-reviewed literature and site-specific biological monitoring data.[2]

2.2.3 Steps for deriving criteria

The following steps were used to derive site-specific criteria. These steps are discussed in detail in Section 4.

- **Step 1:** Use EC50s to evaluate whether site-specific acute test values for resident species differ from those in EPA's national criteria data sets for cadmium, lead, and zinc. If not, default to EPA aquatic life criteria (ALC).
- **Step 2:** Determine site-specific regression relationship between hardness and toxicity.
- **Step 3:** Determine species mean acute values (SMAVs) for all test species at a standard hardness level and determine the most sensitive resident species.
- **Step 4:** Use the SMAV for the most sensitive species to determine the criterion maximum concentration (CMC).
- **Step 5:** Derive the hardness-dependent CMC equation using the hardness-toxicity slope and the concentration protective of the most sensitive species.
- **Step 6:** Derive the hardness-dependent CCC equation using the hardness-toxicity slope and applying an ACR to the SMAV of the most sensitive species.

[2] Based on the national dataset (EPA 1984b,c and 1987) salmonids were expected to be the most sensitive species to cadmium, lead, and zinc. Although lead rangefinding tests (EVS 1996) initially suggested that *Gyraulus* sp. and *Baetis tricaudatus* were more sensitive than RWC, subsequent testing (Windward 2000) identified RWC as the resident species most sensitive to lead.

3.0 Site-specific Toxicity Test Data

3.1 Test acceptability

Test acceptability was assessed using ASTM (1997b,c,d) and EPA (2000b) test acceptability guidelines. Toxicity test results were presented in detail and thoroughly discussed in the following data reports generated over the course of the study:

- EVS (1996b) presented the results of sampling and preliminary toxicity testing with laboratory and resident species at the University of Washington.
- EVS (1996c) presented the results of acute rangefinding tests with hatchery-raised and resident fish species and resident invertebrate species to determine the resident species most sensitive to cadmium, lead, or zinc.
- EVS (1997) presented the results of early-life-stage (ELS) tests with cadmium, lead, and zinc on hatchery rainbow trout, confirmatory acute tests for lead with selected species, and the attempted collection of an adult RWC broodstock.
- EVS (1998) reported the successful collection of adult RWC and supplemental testing for lead with additional invertebrates.
- Windward (2000) presented the 1999 results for ELS tests with cadmium and lead on hatchery rainbow trout, a full-life-cycle (FLC) test with lead on *Chironomus tentans*, and acute tests using RWC fry and invertebrates.
- Windward (2001) presented the 2000 results for FLC tests with *C. tentans* and acute tests using RWC, hatchery rainbow trout, and *C. tentans.*
- Windward (2002) presented the 2001 test results for acute tests with RWC and newly emerged sculpin.

For the purposes of this report, Table A-1 (Appendix A) provides ranks of acute test quality, with A being highest quality and C being marginal quality. This ranking was primarily assigned on the basis of test conditions. For example, all tests conducted at the University of Washington in 1995 and 1996 were considered C-quality tests because they were not conducted on site. Rangefinding tests conducted in 1996 were considered B-quality tests because limited chemical analyses were conducted on test solutions. Most remaining tests conducted at the Hale Fish Hatchery were considered A-quality tests with exceptions as noted. A-quality tests were those with test solutions measured at least at test initiation and termination and conducted at Hale Fish Hatchery. A-quality tests were used to derive criteria, with the exception of three B-quality invertebrate lead tests included in the regression estimate of the hardness-toxicity relationship.

In addition, two tests conducted with RWC during downstream verification testing conducted in September 2001 were included in this data set because they provided results at the low end of the test hardness range that occurs in the site (i.e., 11.4 mg/L as $CaCO_3$). Tests were conducted in water from the East Fork of Pine Creek (EFPC).

Chronic testing was conducted to derive site-specific ACRs. Testing in 1997 included cadmium, lead, and zinc ELS tests with rainbow trout. Of these three exposures, only the lead ACR was considered an acceptable test (EPA 1998). The concentrations measured in the 1997 cadmium and zinc tests exceeded recommended guidelines for exposure variability. Testing in 1999 included cadmium and lead ELS tests with rainbow trout and a lead FLC test with *C. tentans*. Of the two ELS tests, only the lead test was considered useful for deriving ACRs. The LOEC in the 1999 cadmium ELS exposure was higher than the acute cadmium values for rainbow trout, which would result in an ACR of less than 1.0. The 1999 FLC test was not considered acceptable due to high replicate variability across all endpoints. The 2000 effort included a lead FLC test for which the exposure was acceptable.

3.2 Supporting toxicity test data

Supporting toxicity test data include a mayfly growth test, a Canyon Creek dilution series, the 2000 acclimation experiment, metals mixture exposure tests, and a zinc test using newly emerged sculpin. These data are presented in Table A-1, but were not used to derive numerical criteria. For example, proposed criteria values were normalized based on the results of the August 9, 2000 metals mixture test, in which mortality to RWC was observed. In this case, the hardness-normalized EC50 from the 1996 zinc rangefinding test was higher than hardness-normalized zinc EC50s for RWC from 1999 and 2000 tests. Therefore the 1996 zinc EC50 was not used to estimate a protective concentration. This is reasonable because the fish used in the 1996 test were field-collected, and therefore of unknown age. This report only addresses supporting toxicity test data where it applies to deriving site-specific criteria.

3.3 Database

The data from acceptable tests used to derive site-specific criteria are available in electronic spreadsheet format in addition to data summarized in Appendix A and B. Detailed data tables were presented in the respective data reports.

- Acute toxicity test 96-hour effective mortality database
- Acute toxicity test analytical chemistry database
- Chronic test organism summary tables
- Chronic test analytical chemistry summary tables

Data from acute toxicity tests relating to organism response and analytical chemistry were organized using the categories Test ID and Species. The Test ID is unique for each test within the year. For example "96-F-1" identifies the first fish exposure conducted in 1996. For the organism response data, Species is the second organizing category. For example, four species were tested in the 96-F-1 exposure: shorthead sculpin, field-collected RWC, hatchery rainbow trout, and hatchery cutthroat trout.

4.0 Criterion Derivation

The derivation of criteria for each metal follows the steps presented above in Section 2.4.1. Table 4.1 presents the acute test data used to derive the criteria, including both resident species and surrogate laboratory species values. As was discussed above in Section 2.2.2.1, IDFG does not consider rainbow trout a species native to the South Fork (Horner 1998) and considers them undesirable because they are non-indigenous species that can be invasive and compete with indigenous species (IDFG 2000). Rainbow trout are thus not considered "resident" species for the purposes of inclusion in site-specific criterion development. Rainbow trout were only used in spatial variability and ELS tests as a surrogate species for RWC. Similarly, hatchery cutthroat trout that originated outside of the South Fork basin and cutthroat trout that were field-collected from within the basin but were not of a known age were only used in comparative rangefinding tests to determine the most sensitive species. A broodstock of cutthroat trout captured from the South Fork basin was established at the Hale Fish Hatchery. Only cutthroat trout that were hatched from this captive broodstock, were of a known age, and had no pre-test exposure and potential acclimation to elevated metals were used to establish SMAVs.

Table 4-1. Species summary of acute toxicity test values used to derive site-specific criteria for cadmium, lead, and zinc

Common Name	*Latin Name* or Family	Test Date	Test Acute Value (µg/L)	Test Hardness (mg/L as $CaCO_3$)
Cadmium				
Caddisfly	*Arctopsyche* sp.	10/22/95	>458	nm
Mayfly	*Rhithrogena* sp.	9/11/96	>50	21
Mayfly	*Baetis tricaudatus*	9/11/96	>73	21
Rainbow trout	*Oncorhynchus mykiss*	10/24/97	0.84	21
Rainbow trout	*Oncorhynchus mykiss*	05/23/99	0.477	7.5
Rainbow trout	*Oncorhynchus mykiss*	05/23/99	1.297	24
Rainbow trout	*Oncorhynchus mykiss*	05/23/99	0.988	30
Rainbow trout	*Oncorhynchus mykiss*	05/23/99	0.967	13.5
Rainbow trout	*Oncorhynchus mykiss*	10/2/99	0.89	32
Rainbow trout	*Oncorhynchus mykiss*	7/26/00	0.831	28.5
Rainbow trout-Sand Point	*Oncorhynchus mykiss*	9/10/96	<0.5	21
Shorthead sculpin	*Cottus confusus*	9/10/96	1.29	21
Snail	*Gyraulus* sp.	9/11/96	>73	21
Stonefly	*Sweltsa* sp.	12/9/95	>5,130	nm
HWC - Sand Point	*Oncorhynchus clarki lewisi*	9/10/96	<0.5	21
RWC	*Oncorhynchus clarki lewisi*	8/26/99	1.41	32
RWC	*Oncorhynchus clarki lewisi*	8/9/00	1.18	30.5
RWC – field-collected	*Oncorhynchus clarki lewisi*	9/10/96	0.93	21

Common Name	*Latin Name* or Family	Test Date	Test Acute Value (µg/L)	Test Hardness (mg/L as $CaCO_3$)
Lead				
Black fly	Simuliidae	9/20/98	>1,035	39
Black fly	Simuliidae	9/20/98	>1,255	22
Caddisfly	*Arctopsyche* sp.	9/20/98	>1,255	22
Crane fly	*Tipula* sp.	9/20/98	>1,035	39
Diving beetle	Dytiscidae	9/20/98	>1,035	39
Mayfly	*Baetis tricaudatus*	7/24/96	596	15
Mayfly	*Baetis tricaudatus*	8/12/96	769	18
Mayfly	*Baetis tricaudatus*	9/28/97	664	20
Mayfly	*Baetis tricaudatus*	9/20/98	463	22
Mayfly	*Baetis tricaudatus*	9/20/98	919.5	39
Mayfly	*Baetis tricaudatus*	9/20/98	1333[a]	67
Mayfly	*Baetis tricaudatus*	9/20/98	>683	84
Mayfly	*Baetis tricaudatus*	4/1/99	>494	nm
Mayfly	*Baetis tricaudatus*	4/19/99	<346	nm
Mayfly	*Baetis tricaudatus*	5/7/99	*580*[b]	13
Mayfly	*Baetis tricaudatus*	5/7/99	*1,090*[b]	19
Mayfly	*Baetis tricaudatus*	5/7/99	*1,250*[b]	33
Mayfly	*Baetis tricaudatus*	5/7/99	*<1,250*[b]	41
Mayfly	*Drunella* sp.	8/24/98	>267.3	19.5
Mayfly	*Epeorus* sp.	4/1/99	>494	nm
Mayfly	*Epeorus* sp.	4/19/99	>346	nm
Mayfly	*Paraleptophlebia* sp.	4/19/99	>346	nm
Mayfly	*Rhithrogena* sp.	7/24/96	>737	15
Mayfly	*Rhithrogena* sp.	8/12/96	>985	18
Mayfly	*Rhithrogena* sp.	8/3/98	429	19
Midge	Chironomidae	9/20/98	>1,035	39
Midge	Chironomidae	9/20/98	>1,255	22
Midge	Chironomidae	9/19/00	9,162.6	34
Midge	Chironomidae	9/26/00	3,323	35.2
Rainbow trout	*Oncorhynchus mykiss*	10/19/97	119.5	20
Rainbow trout	*Oncorhynchus mykiss*	9/27/99	126.6	31.5
Rainbow trout	*Oncorhynchus mykiss*	10/2/99	140.3	32
Rainbow trout	*Oncorhynchus mykiss*	6/17/00	590.32	22.5
Rainbow trout	*Oncorhynchus mykiss*	6/17/00	547.35	29
Rainbow trout	*Oncorhynchus mykiss*	6/17/00	1,164.1	32
Rainbow trout	*Oncorhynchus mykiss*	6/17/00	>843.5	33.5
Rainbow trout	*Oncorhynchus mykiss*	7/26/00	>98.19	28.5
Rainbow trout - Sand Point	*Oncorhynchus mykiss*	9/17/96	179.6	21
Shorthead sculpin (age 1-2)	*Cottus confusus*	9/17/96	>855	21
Snail	*Gyraulus* sp.	8/12/96	561	18
Snail	*Gyraulus* sp.	9/28/97	486	20
Snail	*Gyraulus* sp.	8/3/98	339.9	19
Snail	*Gyraulus* sp.	9/20/98	738	22
Snail	*Gyraulus* sp.	9/20/98	966.8	39
Snail	*Gyraulus* sp.	9/20/98	>952	67
Snail	*Gyraulus* sp.	9/20/98	>683	84
Snail	Physidae	9/20/98	1,117.6	22

Common Name	*Latin Name* or Family	Test Date	Test Acute Value (µg/L)	Test Hardness (mg/L as $CaCO_3$)
Snail	*Gyraulus* sp.	5/7/99	*700*[b]	13
Snail	*Gyraulus* sp.	5/7/99	*>1,250*[b]	19
Snail	*Gyraulus* sp.	5/7/99	*>1,250*[b]	33
Snail	*Gyraulus* sp.	5/7/99	*>1,250*[b]	41
Stonefly	*Sweltsa* sp.	7/24/96	>737	15
Stonefly	*Sweltsa* sp.	8/24/98	>267.3	19.5
Stonefly	*Sweltsa* sp.	4/1/99	>494	nm
HWC - Sand Point	*Oncorhynchus clarki lewisi*	9/17/96	113.6	21
RWC	*Oncorhynchus clarki lewisi*	8/26/99	>123.3	32
RWC	*Oncorhynchus clarki lewisi*	9/21/99	>53.6	31.5
RWC	*Oncorhynchus clarki lewisi*	9/27/99	215.2	32
RWC	*Oncorhynchus clarki lewisi*	8/9/00	>71.8	30.5
RWC	*Oncorhynchus clarki lewisi*	8/16/00	415.41	31.5
RWC	*Oncorhynchus clarki lewisi*	8/16/00	450	56
RWC	*Oncorhynchus clarki lewisi*	8/16/00	>414.3	68
RWC	*Oncorhynchus clarki lewisi*	8/16/00	>409	72.5
RWC	*Oncorhynchus clarki lewisi*	9/9/00	>153	62.5
RWC	*Oncorhynchus clarki lewisi*	9/6/01	50.8	11.4
RWC – field-collected	*Oncorhynchus clarki lewisi*	9/17/96	>855	21
Zinc				
Caddisfly	*Hydropsyche* sp.	7/15/96	>2,926	14
Mayfly	*Baetis tricaudatus*	7/15/96	>2,926	14
Mayfly	*Rhithrogena* sp.	7/15/96	>2,926	14
Rainbow trout	*Oncorhynchus mykiss*	6/8/99	24	9
Rainbow trout	*Oncorhynchus mykiss*	6/8/99	35.8	10
Rainbow trout	*Oncorhynchus mykiss*	6/8/99	116.9	16
Rainbow trout	*Oncorhynchus mykiss*	6/8/99	130.4	24
Rainbow trout	*Oncorhynchus mykiss*	6/28/00	77.5	22.5
Rainbow trout	*Oncorhynchus mykiss*	6/28/00	96.6	29
Rainbow trout	*Oncorhynchus mykiss*	6/28/00	170.5	40
Rainbow trout	*Oncorhynchus mykiss*	6/28/00	203.6	41
Rainbow trout	*Oncorhynchus mykiss*	7/8/00	170.2	30
Rainbow trout	*Oncorhynchus mykiss*	7/8/00	198.9	42
Rainbow trout	*Oncorhynchus mykiss*	7/8/00	278.8	51
Rainbow trout	*Oncorhynchus mykiss*	7/8/00	300.1	55
Rainbow trout	*Oncorhynchus mykiss*	7/26/00	81.7	28.5
Rainbow trout	*Oncorhynchus mykiss*	8/23/00	47.77	35
Rainbow trout	*Oncorhynchus mykiss*	8/23/00	110. 6	66.5
Rainbow trout	*Oncorhynchus mykiss*	8/23/00	137.4	73
Rainbow trout	*Oncorhynchus mykiss*	8/23/00	133.8	75
Rainbow trout-Sand Point	*Oncorhynchus mykiss*	8/13/96	69.3	18
Shorthead sculpin (age 1-2)	*Cottus confusus*	8/13/96	>1,068	18
Snail	*Gyraulus* sp.	7/15/96	>1,303	14
Stonefly	*Sweltsa* sp.	8/12/96	>1,526	18
HWC - Sand Point	*Oncorhynchus clarki lewisi*	8/13/96	124.8	18
RWC	*Oncorhynchus clarki lewisi*	8/26/99	>275.3	32
RWC	*Oncorhynchus clarki lewisi*	9/21/99	208.2	31.5
RWC	*Oncorhynchus clarki lewisi*	8/9/00	196.4	30.5

COMMON NAME	*LATIN NAME* OR FAMILY	TEST DATE	TEST ACUTE VALUE (µg/L)	TEST HARDNESS (mg/L as $CaCO_3$)
RWC	*Oncorhynchus clarki lewisi*	9/12/00	277.7	62.5
RWC	*Oncorhynchus clarki lewisi*	9/9/00	>186	62.5
RWC	*Oncorhynchus clarki lewisi*	9/6/01	75.4	11.4
RWC – field-collected	*Oncorhynchus clarki lewisi*	8/13/96	325	18

[a] Graphical estimate

[b] Based on nominal concentrations

Rainbow trout are not a resident species; they were used as a surrogate species for RWC in testing to assess spatial variability and to develop ACRs.

nm – not measured

Step 1: Use EC50s to evaluate whether site-specific acute test values for resident species differ from those in EPA's National Criteria Data Sets for cadmium, lead, and zinc.

EC50s for the resident species (Table 4-1) were compared to data in EPA's national criteria data sets to evaluate whether the site-specific values were greater than or less than comparable toxicity test values used in the national criteria. The goal of this comparison was to evaluate whether the site-specific test data differed from the test data used to develop ALC.

The site-specific toxicity data indicated that the RWC was a candidate for most sensitive species and is discussed in more detail. For cadmium and zinc, the values obtained by Chapman (as cited in EPA 1984b and 1987) for swim-up and parr of rainbow trout were compared the RWC values; these tests were run in similarly soft water (23 mg/L as $CaCO_3$). No corresponding data were available for lead.

Within the variability of toxicity test data, the cadmium EC50s of RWC overlapped those of similarly aged rainbow trout. Chapman (as cited in EPA 1984b) reported EC50s of 1.3 µg/L and 1.0 µg/L cadmium for swim-up alevin and parr, respectively. The geometric mean of the cadmium EC50s for these two most sensitive life stages was 1.14 µg/L. This value was within the range of EC50s for RWC fry (0.93 to 1.41 µg/L) observed in site-specific testing. The most closely related species to the RWC included in the 2001 national cadmium ALC (EPA 2001) is the rainbow trout. If the three EC50s for RWC listed in Table 4-1 are normalized to a hardness of 50 mg/L using the pooled hardness slope from EPA (2001), they may be compared with the rainbow trout SMAV listed in the 2001 ALC document. These hardness-normalized values are nearly identical: 2.1 µg/L for both RWC and rainbow trout. Because of the similarity of results, no further derivation of site-specific cadmium criteria is included as part of this report.

Zinc EC50s for RWC were compared with those of similarly aged rainbow trout in the national dataset (EPA 1987). Chapman (as cited in EPA 1987) reported EC50s of 93 µg/L and 136 µg/L zinc for swim-up alevin and parr, respectively. The range of site-specific RWC EC50s for zinc was 75.4 to 277 µg/L. Because the range of site-specific acute values was fairly wide compared to the geometric mean of the two most sensitive life stages of rainbow trout in the EPA data set (112 µg/L), site-specific criteria for zinc were pursued. The lack of suitable published lead values for comparison also argued for the development of a site-specific criterion for lead.

Step 2: Determine site-specific regression relationship between hardness and toxicity.

At the core of this analysis was the spatial variability data set. Spatial variability tests were completed for zinc using rainbow trout and for lead using two resident invertebrate species and RWC. Rainbow trout were tested as a surrogate for RWC when RWC were not available, under the assumption that the pattern of acute responses, as a function of water hardness, would be similar for species in the same genus (*Oncorhynchus*).

In addition to the spatial variability data generated with rainbow trout, all acceptable RWC test data were used in the hardness regression analyses so as to include all test data for the resident species. Four RWC EC50s were available for both the lead and zinc analysis.

The 1996 hatchery rainbow and cutthroat trout test data were excluded because these were rangefinding tests with large treatment concentration ranges, and the later hatchery rainbow trout tests were more definitive. For lead, there was a large difference in acute values between the 1999 and 1996 RWC tests (215 µg/L versus >855 µg/L, respectively). Because the 1996 RWC test was a rangefinding exposure, and to ensure protection of the most sensitive resident species, the 1996 RWC test data were excluded from the hardness-toxicity regression analysis.

Lead spatial variability tests were conducted in 1998 with the invertebrates *Baetis tricaudatus* and *Gyraulus* sp., sensitive invertebrate species as determined by testing prior to 1999. However, the 1999 testing revealed for the first time that RWC were more sensitive than these stream invertebrates. Four acceptable RWC tests were included in the analysis because suitable EC50s were calculated and the tests covered a range of hardness (11.4 to 56 mg/L as $CaCO_3$) representative of the conditions in the South Fork upstream of Canyon Creek. Rainbow trout data from the June 17, 2000 spatial variability test were used in the lead regression analysis. In addition to the above lead tests, the analysis included data from three rainbow trout tests conducted in 1997 and 1999, as well as data from three *Baetis* sp. and two *Gyraulus* sp. tests conducted in 1996 and 1997.

Zinc spatial variability tests were conducted solely with rainbow trout. Four acceptable RWC tests were included in the analysis because suitable EC50s were calculated and the tests covered a range of hardness (11.4 to 62.5 mg/L as $CaCO_3$) representative of the conditions in the South Fork upstream of Canyon Creek.

Table 4-2 identifies the lead and zinc test data used for deriving the hardness-toxicity slopes for respective criteria and for the hardness adjustments to the EC50s used in determining SMAVs. Both EC50s and water hardnesses were natural-log-transformed prior to regression to provide consistency with EPA methods for deriving numerical criteria (EPA 1984, 1985). Four groups of data points were used for the lead regression, and two groups of data points were used for the zinc regression. The results of the individual regression lines for lead and zinc are presented in Tables 4-3 and 4-4 respectively.

Analysis of covariance (ANCOVA) was used to determine the pooled slope of the data. The data groups were created using dummy variables constructed to account for group variance. Dummy variables accounted for the fact that the different species or test years may have separate determinant effects on the response (Draper and Smith 1981). The analysis was performed using the regression function of Microsoft Excel®.

For lead and zinc, the residuals diagnostic plots indicated that the residuals were sufficiently normal and the variances were stable. An F-test comparing the ANCOVA model to a fully specified model (i.e., one with different intercepts and different slopes for each species) was not statistically different for lead (p=0.64) or zinc (p=0.54). Therefore, it was reasonable to assume for both lead and zinc that there is one pooled slope that is appropriate for all species/test groups. The pooled slope for lead was 0.9402, and was significantly different from zero (p=0.011). The pooled slope for zinc was 0.6624, and was significantly different from zero (p=0.002)

Table 4-2. Test data used in hardness-toxicity regression analysis

Species	Test Date	Acute Value	Water Source	Hardness	Group for ANCOVA
Lead					
Baetis tricaudatus	7/24/96	596.0	LNF	15	Pb-A
Baetis tricaudatus	8/12/96	769.0	LNF	18	Pb-A
Baetis tricaudatus	9/28/97	664.0	LNF	20	Pb-A
Baetis tricaudatus	9/20/98	463	LNF	22	Pb-A
Baetis tricaudatus	9/20/98	919.5	SF-10	39	Pb-A
Baetis tricaudatus	9/20/98	1333[a]	SF-9	67	Pb-A
Gyraulus sp.	8/12/96	561.0	LNF	18	Pb-B
Gyraulus sp.	9/28/97	486.0	LNF	20	Pb-B
Gyraulus sp.	8/3/98	339.9	LNF	19	Pb-B
Gyraulus sp.	9/20/98	738.0	LNF	22	Pb-B
Gyraulus sp.	9/20/98	966.8	SF-10	39	Pb-B
Oncorhynchus mykiss	10/19/97	119.5	LNF	20	Pb-C
Oncorhynchus mykiss	9/27/99	126.6	SF-H	31.5	Pb-C
Oncorhynchus mykiss	10/2/99	140.3	SF-H	32	Pb-C
Oncorhynchus mykiss	6/17/00	590.3	SF-H	22.5	Pb-C
Oncorhynchus mykiss	6/17/00	547.4	SF-9	29	Pb-C
Oncorhynchus mykiss	6/17/00	1,164.1	SF-G	32	Pb-C
Oncorhynchus clarki lewisi	9/27/99	215.2	SFH	32	Pb-D
Oncorhynchus clarki lewisi	8/16/00	450	SF-9	56	Pb-D
Oncorhynchus clarki lewisi	8/16/00	415.4	SFH	31.5	Pb-D
Oncorhynchus clarki lewisi	9/16/01	50.8	EFPC	11.4	Pb-D
Zinc					
Oncorhynchus mykiss	6/8/99	35.8	SF-10	10	Zn-A
Oncorhynchus mykiss	6/8/99	116.9	SF-9	16	Zn-A
Oncorhynchus mykiss	6/8/99	130.4	SF-8	24	Zn-A
Oncorhynchus mykiss	6/28/00	77.5	SF-H	22.5	Zn-A
Oncorhynchus mykiss	6/28/00	96.6	SF-9	29	Zn-A
Oncorhynchus mykiss	6/28/00	170.5	SF-G	40	Zn-A
Oncorhynchus mykiss	6/28/00	203.6	SF-8	41	Zn-A
Oncorhynchus mykiss	7/8/00	170.2	SF-H	30	Zn-A
Oncorhynchus mykiss	7/8/00	198.9	SF-9	42	Zn-A
Oncorhynchus mykiss	7/8/00	278.8	SF-G	51	Zn-A
Oncorhynchus mykiss	7/8/00	300.1	SF-8	55	Zn-A
Oncorhynchus mykiss	8/23/00	47.8	SF-H	35	Zn-A
Oncorhynchus mykiss	8/23/00	110.6	SF-9	66.5	Zn-A
Oncorhynchus mykiss	8/23/00	137.4	SF-G	73	Zn-A
Oncorhynchus mykiss	8/23/00	133.8	SF-8	75	Zn-A
Oncorhynchus mykiss	7/26/00	81.7	SF-H	28.5	Zn-A
Oncorhynchus clarki lewisi	8/26/99	208.2	SF-H	31.5	Zn-B
Oncorhynchus clarki lewisi	8/9/00	196.4	SF-H	30.5	Zn-B
Oncorhynchus clarki lewisi	9/12/00	277.7	SF-9	62.5	Zn-B
Oncorhynchus clarki lewisi	9/16/01	75.4	EFPC	11.4	Zn-B

[a] graphical estimate of EC50

Table 4-3. Individual regression lines for lead

Test Group	N	Slope	Standard Error	Lower 95% Confidence Interval	Upper 95% Confidence Interval	Residual Degrees of Freedom
Baetidae	6	1.273	0.4325	-0.0714	2.4746	4
Planorbidae	5	0.6188	0.2814	-0.2766	0.5142	3
Rainbow trout	6	0.0337	0.1026	-0.2512	0.3186	4
RWC	4	0.6202	0.1546	-0.0450	1.2852	2

Table 4-4. Individual regression lines for zinc

Test Group	N	Slope	Standard Error	Lower 95% Confidence Interval	Upper 95% Confidence Interval	Residual Degrees of Freedom
Rainbow trout	16	0.5623	0.2050	0.1230	1.0033	14
RWC	4	1.2043	0.1949	0.3654	2.0433	2

Step 3: Determine SMAVs for all test species at a standard hardness level and determine the most sensitive resident species.

Site-specific acute values were normalized to a single hardness value using the hardness relationship developed in Step 2. For consistency with EPA's ALC documents, a hardness of 50 mg/L as $CaCO_3$ was used for normalization. Table 4-5 presents the hardness-normalized acute vales for all the resident test species, arranged in order by species and decreasing hardness-normalized acute values. For the purposes of this comparison only, "greater than" values, where the EC50 was higher than the highest concentration tested in a test, are treated as if they were actual acute values.

SMAVs were calculated for each resident species. Table 4-6 presents the SMAVs ranked from highest to lowest. The results of the rangefinding tests using field collected fish of unknown ages were not included in this calculation when more recent results with fish of known ages were available.

Table 4-5. Resident species summary of acute toxicity test values normalized to a hardness of 50 mg/L as $CaCO_3$

Common Name	*Latin Name* or Family	Test Date	Test Acute Values (µg/L)	Test Hardness (mg/L as $CaCO_3$)	Hardness-Normalized Acute Value (µg/L)
Lead					
Black fly	Simuliidae	9/20/98	>1,255	22	2,716
Black fly	Simuliidae	9/20/98	>1,035	39	1,307
Caddisfly	*Arctopsyche* sp.	9/20/98	>1,255	22	2,716
Crane fly	*Tipula* sp.	9/20/98	>1,035	39	1,307
Diving beetle	Dytiscidae	9/20/98	>1,035	39	1,307
Mayfly	*Baetis tricaudatus*	5/7/99	1,090 [a]	19	2,707
Mayfly	*Baetis tricaudatus*	5/7/99	580 [a]	13	2,058

Common Name	*Latin Name* or Family	Test Date	Test Acute Values (µg/L)	Test Hardness (mg/L as $CaCO_3$)	Hardness-Normalized Acute Value (µg/L)
Mayfly	*Baetis tricaudatus*	8/12/96	769	18	2,010
Mayfly	*Baetis tricaudatus*	5/7/99	1,250 [a]	33	1,847
Mayfly	*Baetis tricaudatus*	7/24/96	596	15	1,849
Mayfly	*Baetis tricaudatus*	9/28/97	664	20	1,572
Mayfly	*Baetis tricaudatus*	9/20/98	919.5	39	1,162
Mayfly	*Baetis tricaudatus*	9/20/98	463	22	1,002
Mayfly	*Baetis tricaudatus*	9/20/98	1333 [b]	67	1,012
Mayfly	*Baetis tricaudatus*	9/20/98	>683	84	419
Mayfly	*Drunella* sp.	8/24/98	>267.3	19.5	648
Mayfly	*Rhithrogena* sp.	8/12/96	>985	18	2,574
Mayfly	*Rhithrogena* sp.	7/24/96	>737	15	2,286
Mayfly	*Rhithrogena* sp.	8/3/98	429	19	1,066
Midge	Chironomidae	9/19/00	9,162.6	34	13,167
Midge	Chironomidae	9/26/00	3,323	35.2	4,622
Midge	Chironomidae	9/20/98	>1,255	22	2,716
Midge	Chironomidae	9/20/98	>1,035	39	1,307
Shorthead sculpin	*Cottus confusus*	9/17/96	>855	21	1,933
Snail	*Gyraulus* sp.	5/7/99	>1,250 [a]	19	3,104
Snail	*Gyraulus* sp.	5/7/99	700 [a]	13	2,484
Snail	*Gyraulus* sp.	5/7/99	>1,250 [a]	33	1,848
Snail	*Gyraulus* sp.	9/20/98	738	22	1,597
Snail	*Gyraulus* sp.	5/7/99	>1,250 [a]	41	1,506
Snail	*Gyraulus* sp.	8/12/96	561	18	1,466
Snail	*Gyraulus* sp.	9/20/98	966.8	39	1,221
Snail	*Gyraulus* sp.	9/28/97	486	20	1,150
Snail	*Gyraulus* sp.	8/3/98	339.9	19	844
Snail	*Gyraulus* sp.	9/20/98	>952	67	723
Snail	*Gyraulus* sp.	9/20/98	>683	84	419
Snail	Physidae	9/20/98	1,117.6	22	2,418
Stonefly	*Sweltsa* sp.	7/24/96	>737	15	2,286
Stonefly	*Sweltsa* sp.	8/24/98	>267.3	19.5	648
RWC	*Oncorhynchus clarki lewisi*	8/16/00	415.41	31.5	641
RWC	*Oncorhynchus clarki lewisi*	8/16/00	450	56	405
RWC	*Oncorhynchus clarki lewisi*	9/27/99	215.2	32	327
RWC	*Oncorhynchus clarki lewisi*	8/16/00	>414.3	68	310
RWC	*Oncorhynchus clarki lewisi*	8/16/00	>409	72.5	288
RWC	*Oncorhynchus clarki lewisi*	9/6/01	50.8	11.4	204
RWC	*Oncorhynchus clarki lewisi*	8/26/99	>123.3	32	187
RWC	*Oncorhynchus clarki lewisi*	9/9/00	>153	62.5	124
RWC	*Oncorhynchus clarki lewisi*	8/9/00	>71.8	30.5	114
RWC	*Oncorhynchus clarki lewisi*	9/21/99	>53.6	31.5	83
Zinc					
Caddisfly	*Hydropsyche* sp.	7/15/96	>2,926	14	6,800
Mayfly	*Baetis tricaudatus*	7/15/96	>2,926	14	6,800
Mayfly	*Rhithrogena* sp.	7/15/96	>2,926	14	6,800
Shorthead sculpin (age 1-2)	*Cottus confusus*	8/13/96	>1,068	18	2,101
Snail	*Gyraulus* sp.	7/15/96	>1,303	14	3,028

COMMON NAME	LATIN NAME OR FAMILY	TEST DATE	TEST ACUTE VALUES (µG/L)	TEST HARDNESS (MG/L AS $CaCO_3$)	HARDNESS-NORMALIZED ACUTE VALUE (µG/L)
Stonefly	*Sweltsa* sp.	8/12/96	>1,526	18	3,002
RWC	*Oncorhynchus clarki lewisi*	8/26/99	>275.3	32	370
RWC	*Oncorhynchus clarki lewisi*	9/21/99	208.2	31.5	283
RWC	*Oncorhynchus clarki lewisi*	8/9/00	196.4	30.5	273
RWC	*Oncorhynchus clarki lewisi*	9/12/00	277.7	62.5	240
RWC	*Oncorhynchus clarki lewisi*	9/6/01	75.3	11.4	201
RWC	*Oncorhynchus clarki lewisi*	9/9/00	>186	62.5	160

[a] Based on nominal concentrations

[b] A graphical estimation

Rainbow trout are not a resident species; they were used as a surrogate species for RWC in testing to assess spatial variability and to develop ACRs.

RWC – resident Westslope cutthroat trout

Table 4-6. Ranked hardness-normalized SMAVs

RANK	COMMON NAME	LATIN NAME OR FAMILY	SMAV (µg/L)
Lead			
11	Midge	Chironomidae	3,834
10	Caddisfly	*Arctopsyche* sp.	2,716
9	Shorthead sculpin	*Cottus confusus*	1,933
8	Black fly	Simuliidae	1,884
7	Mayfly	*Rhithrogena* sp.	1,844
6	Mayfly	*Baetis tricaudatus*	1,403
5	Snail	*Gyraulus* sp.	1,370
4	Crane fly Diving beetle	*Tipula* sp. Dytiscidae	1,307
3	Stonefly	*Sweltsa* sp.	1,217
2	Mayfly	*Drunella* sp.	648
1	RWC	*Oncorhynchus clarki lewisi*	226
Zinc			
5	Mayfly Caddisfly	*Baetis tricaudatus* *Rhithrogena* sp. *Hydropsyche* sp.	6,800
4	Snail	*Gyraulus* sp.	3,028
3	Stonefly	*Sweltsa* sp.	3,002
2	Shorthead sculpin	*Cottus confusus*	2,101[a]
1	RWC	*Oncorhynchus clarki lewisi*	245

[a] Data are available for young-of-the-year sculpin, but were not included in this table. See discussion immediately below (third paragraph of Step 3), and in Windward (2002).

The shorthead sculpin SMAV in Table 4-6 for was derived from the rangefinding tests conducted in 1996 using juvenile fish of year class 1-2. The RWC SMAV was derived from ELS tests using swim-up alevins of a known age. A paired test using newly emerged or young-of-the-year (YOY) sculpin and RWC was conducted in 2001 to further evaluate the relative sensitivity of these species to zinc at more closely matched life stages. Details of this test are presented in Windward (2002). Due to unacceptable control mortality (ASTM [1997b,c,d]; EPA [2000]), the tests were not of sufficient quality for inclusion in the criteria development data set. However, the tests do provide useful confirmatory information.

While high control mortality and minimal dose response precluded calculation of EC50s, the data were suggestive regarding relative sensitivity. For sculpin, there was 55% mortality at the highest concentration tested (275 µg Zn/L at a hardness of 38 mg/L as $CaCO_3$). All lower exposures had less than 50% mortality. The EC50 is thus probably at least 275 µg/L. For RWC, there was 65% mortality at 275 µg/L. All lower exposures had less than 50% mortality. The EC50 is thus greater than the highest concentration tested that had less than 50% mortality (175 µg/L), but less than 275 µg/L. The RWC SMAV for zinc, calculated to be 245 µg/L at a hardness of 50 mg/L as $CaCO_3$, becomes 205 µg/L when hardness-normalized to 38 mg/L as $CaCO_3$, the hardness of the side-by-side tests.

Given the uncertainty around the response for the YOY sculpin and RWC, additional analysis was conducted. The differential sensitivity between the YOY sculpin and RWC was analyzed using a two-factor ANOVA model (Windward 2002). This analysis showed that RWC sensitivity to zinc was not significantly different from sculpin sensitivity.

While the side-by-side tests were not definitive, they did not suggest that YOY sculpin were more acutely sensitive to zinc than RWC of a similar age. Newly emerged sculpin may be more sensitive to zinc than were the juvenile (age class 1-2) sculpin tested previously.

Based on the ranking of the SMAVs and the supplementary YOY sculpin/RWC tests, the RWC is the most sensitive resident species to acute toxicity from lead and zinc.

Step 4: Use the SMAV for the most sensitive species to determine the CMC.

For the purpose of determining a CMC, SMAVs for RWC were recalculated using only A-quality test data. Using the hardness-toxicity regression slopes obtained in Step 2, EC50s were normalized to a common water hardness value, representative of site-specific conditions (i.e., 31.5 mg/L hardness). For lead, the hardness-normalized EC50s ranged by over 3 times from lowest to highest. A risk management decision was made to derive a SMAV for calculating a CMC and CCC based on the hardness-normalized EC50s that were less than 2 times higher than the lowest value. This resulted in the use of the lowest two hardness-normalized EC50s. Table 4-7 presents the hardness-normalized acute lead values and the lead SMAV for RWC.

Table 4-7. Hardness-normalized acute lead values for the most sensitive species

Most Sensitive Species	EC50	Test Hardness	Normalized EC50	SMAV
RWC	50.8	11.4	132.1	
RWC	215.2	32	212	167.4[a]
RWC	450	56	262	
RWC	415.4	31.5	415.4	
Regression slope	0.9402			
Normalized hardness	31.5			

[a] Geometric mean of two lowest EC50s

Because the adjusted RWC EC50s for zinc only varied by 1.25 times from lowest to highest (i.e. were within 25% of each other), the SMAV for zinc was calculated as the geometric mean of the hardness-normalized EC50s of the most sensitive resident species. Table 4-8 presents the hardness-normalized acute zinc values and the zinc SMAV for RWC.

Table 4-8. Hardness-normalized acute zinc values for the most sensitive species

Most Sensitive Species	EC50	Test Hardness	Normalized EC50	SMAV
RWC	75.3	11.4	147.6	
RWC	196.4	30.5	200.9	
RWC	208.2	31.5	208.2	
RWC	277.7	62.5	172.0	181.6
Regression slope	0.6624			
Normalized hardness	31.5			

Based on the SMAVs calculated above, the FAVs are 167.4 µg/L and 181.6 µg/L for lead and zinc respectively.

Prior to the derivation of a hardness-dependent CMC equation, the concentration protective of aquatic life at a specific hardness was determined. EPA methods specify reducing the SMAV for the most sensitive species by a factor of 2. Dividing the SMAV by 2 is intended to extrapolate from a concentration that is expected to be lethal to 50% of a sensitive population to a concentration expected to kill few if any sensitive individuals. The CMC was therefore calculated as one-half the FAV, incorporating the reduction. Therefore, the CMC for lead is 167.4 µg/L ÷ 2 = 83.7µg/L. The CMC for zinc is 181.6 µg/L ÷ 2 = 90.8 µg/L.

Step 5: Derive the hardness-dependent CMC equation using the hardness-toxicity slope and the concentration protective of the most sensitive species.

The CMC equation has two components, the slope and the criterion maximum intercept (CMI). The slope was the same as was derived in Step 2. The intercept was calculated as a function of the natural log (ln) of the hardness-specified CMC and the slope. The hardness values used to derive site-specific CMCs were those used to adjust the SMAVs in Step 4. The intercept equation is:

$$\ln(\text{CMI}) = \ln(\text{hardness-specified CMC}) - [\text{slope} \times \ln(\text{specified hardness})]$$

Once the intercept is determined, the CMC equation is simply:

$$\text{CMC at hardness X} = e[(\text{slope} \times \ln(X)) + \ln(\text{CMI})]$$

Step 6: Derive the hardness-dependent CCC equation using the hardness-toxicity slope and applying an ACR to the SMAV of the most sensitive species.

The derivation of the CCC equation used the same equations as were presented above in Step 5. Instead of a CMI, the intercept was the criterion continuous intercept (CCI). The only difference in derivation was that the CCC is the SMAV divided by the ACR, whereas the CMC was the SMAV divided by 2. Chronic site-specific criteria were determined for zinc and lead. Because chronic testing in 1997 estimated a site-specific ACR similar to the EPA ACR for zinc, the EPA value was applied to the site-specific SMAV. The EPA's final ACR for zinc is 2 (EPA 1996), so the CMC and CCC were the same for zinc.

A site-specific lead ACR was developed using a vertebrate (rainbow trout) and an invertebrate (*C. tentans*). The acceptable site-specific ACRs for lead are summarized in Table 4-9. EPA guidance required that a final site-specific ACR include both vertebrate and invertebrate data points. In 1997, a lead ACR was estimated for rainbow trout as 3.3, based on mean individual weight (EVS 1997). In 1999, a lead ACR was estimated for rainbow trout as 11.02, based on mean individual length (Windward 2000). In 2000, a lead ACR was estimated for *C. tentans* as 50.83, based on 20-day mean individual weight (Windward 2001). The geometric mean of the invertebrate and vertebrate lead ACRs is 17.53. Although not used in the criteria development, these ACR estimates are also supported by mayfly ACR estimates. Subacute lead testing with the mayfly *Baetis tricaudatus* was conducted in 1997 using an early instar growth procedure described by Diamond et al. (1992). A mayfly ACR of 5.2 was estimated based on the growth of early instar mayflies, measured as the number of molts (EVS 1997). This estimate falls within the range of ACR estimates for rainbow trout. ACRs are expected to be lower for the more acutely sensitive species; rainbow trout and mayflies are more acutely sensitive to lead than are chironomid midges (Table 4-6).

Table 4-9. Summary of lead ACRs

Test	Year	Endpoint	NOEC	LOEC	Chronic Value	Acute Value	ACR
ELS	1997	Trout mean individual weight	24	54	36.0	119.5	3.32
ELS	1999	Trout mean individual length	8	18.3	12.1	133.3	11.02
		Geometric mean of trout ACRs					6.05
FLC	2000	*C. tentans* 20-day mean individual weight	56.9	75.1	65.4	3323	50.83
		Site-specific lead ACR[a]					17.53

[a] Geometric mean of invertebrate and invertebrate ACRs

5.0 Proposed Site-Specific Criteria

5.1 Summary of derivation of criteria

Site-specific toxicity test data indicated that the cadmium EC50s for the most sensitive resident species were not different than those for similar laboratory species used in EPA's national data set (Section 4.1). Therefore no site-specific cadmium criteria were derived in this report. Figures 5-1, 5-2, and 5-3 are graphs of the site-specific and Idaho water quality criteria zinc CMCs/CCCs, lead CMCs, and lead CCCs, respectively.

Site-specific hardness-dependent acute and chronic criteria were calculated for lead and zinc. The proposed site-specific CMC equation for dissolved lead is:

$$\text{CMC (dissolved lead) at hardness X} = e^{[(0.9402 \times \ln(X)) + 1.1833]}$$

The proposed site-specific CMC equation for dissolved zinc is:

$$\text{CMC (dissolved zinc) at hardness X} = e^{[(0.6624 \times \ln(X)) +2.2235]}$$

The EPA final ACR for zinc was applied to the hardness-normalized SMAV for the most sensitive resident species. The proposed site-specific CCC equation for dissolved zinc is the same as the CMC equation:

$$\text{CCC (dissolved zinc) at hardness X} = e^{[(0.6624 \times \ln(X)) +2.2235]}$$

As discussed above in Section 4.6, the final site-specific ACR for lead was 17.53. The proposed site-specific CCC equation for dissolved lead is:

$$\text{CCC (dissolved lead) at hardness X} = e^{[(0.9402 \times \ln(X)) - 0.9875]}$$

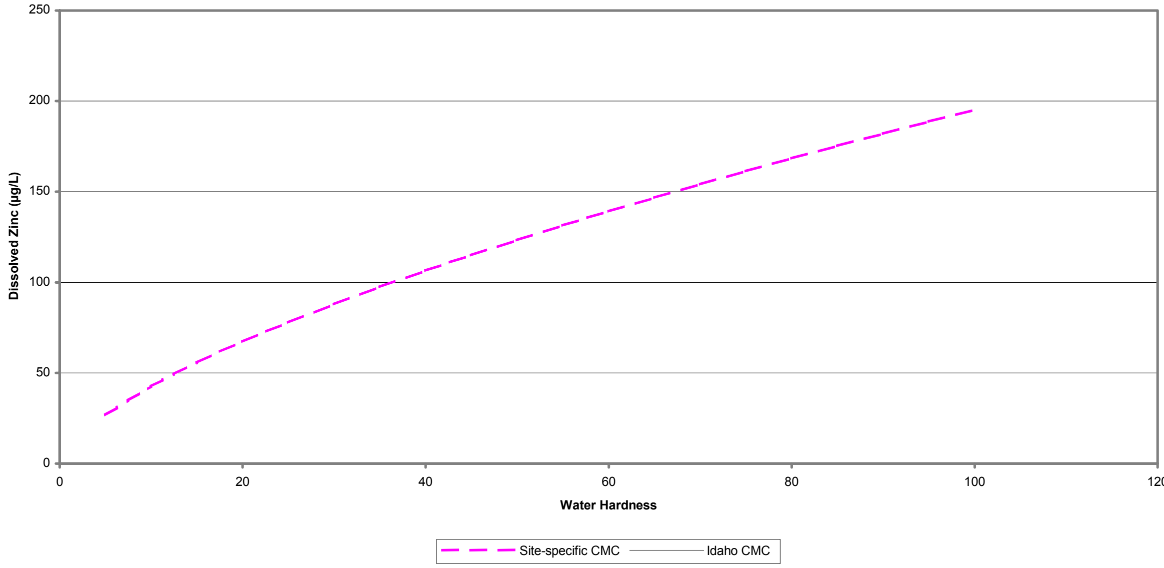

Figure 5-1. Zinc: site-specific CMC (and equivalent CCC) and Idaho CMC

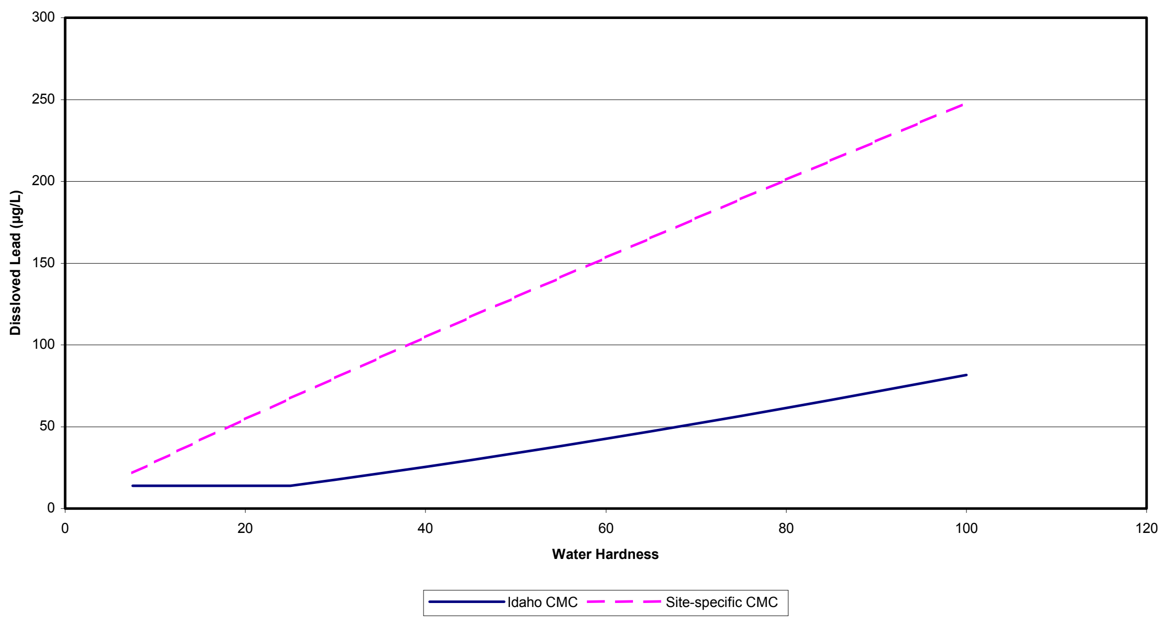

Figure 5-2. Lead: site-specific and Idaho CMC

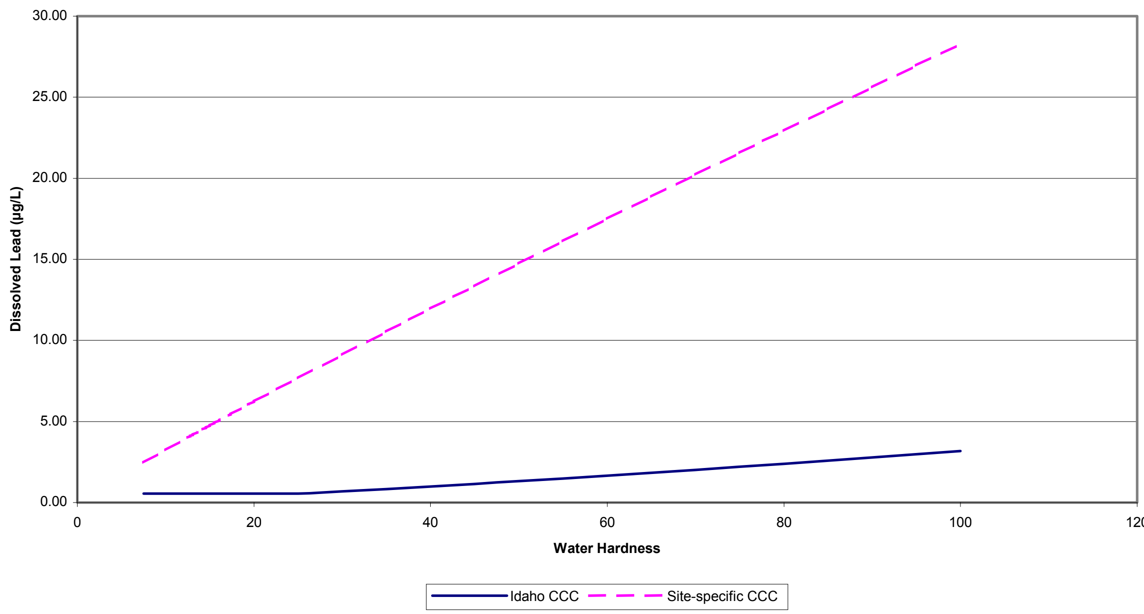

Figure 5-3. Lead: site-specific and Idaho CCC

5.2 Verification testing of metals mixtures

Metals mixture testing was conducted to verify that the proposed lead and zinc criteria were protective of the most sensitive species in combination. Five metals mixture tests were run for the purpose of evaluating the protectiveness of the proposed site-specific criteria for the South Fork Coeur d'Alene above Canyon Creek (Table 5-1). In addition, a test conducted to assess the spatial variability of lead acts effectively as a sixth metals mixture test. A detailed description of the test results is found in Appendix C.

Table 5-1. Summary of metals mixture testing conducted for site-specific criteria validation

Metal Mixture Test ID	Dilution Water	Dilution Water Hardness	Metals Assessed	Test Organism	Test Date
MM1	SFH	28.5	Cd, Pb, Zn	Rainbow trout	7/26/00
MM2	SFH	30.5	Cd, Pb, Zn	RWC	8/9/00
MM3	SF-9	62.5	Pb, Zn	RWC	9/9/00
MM4	SF-9	62.5	Pb, Zn	RWC	9/12/00
MM5	SF-9	67	Cd, Pb, Zn	RWC	9/21/00
MM6	SF-8	72.5	Cd, Pb, Zn	RWC	8/16/00

Of the metal mixture tests discussed in Appendix C, test MM6 provides the most definitive evidence of the protectiveness of the proposed site-specific criteria in combination. The results are summarized in Table 5-2. The test included a series of exposures in which the cadmium concentration was 0.9 µg/L, the zinc concentration was 110% of its proposed site-specific criterion concentration of 158 µg/L, and the lead concentration varied from 44% to 224% of its proposed site-specific criterion concentration of 183 µg/L (Table 5-3). No mortality was seen in any of the exposures.

Table 5-2. Summary of metals mixture test MM6

Treatment			Hard-ness	Nominal Concentration			Measured Concentrations						Relevant CMC		
							Cd		Pb		Zn				
Test Date	Exposure	Description		Cd	Pb	Zn	T0	T96	T0	T96	T0	T96	Cd [a]	Pb [b]	Zn [b]
8-16-00	1	SF8 Control	72.5	A	A	A	0.9	0.9	4	<3.0	178	173	1.5	183	158
8-16-00	2	Pb-1	72.5	A	125	A	0.9	0.9	104	61	178	173	1.5	183	158
8-16-00	3	Pb-2	72.5	A	250	A	0.9	0.9	198	106	178	173	1.5	183	158
8-16-00	4	Pb-3	72.5	A	500	A	0.9	0.9	314	182	178	173	1.5	183	158
8-16-00	5	Pb-4	72.5	A	1,000	A	0.9	0.9	562	298	178	173	1.5	183	158

A - ambient concentrations

[a] Proposed adoption of EPA 2001 CMC

[b] Site-specific CMC equations from section 5.1

Table 5-3. Metals mixture test MM6 exposures compared to proposed site-specific criteria

Exposure	% Dead	Geo. Means Exposure Concentrations		Site-Specific CMC		Geo. Mean/CMC	
		Pb	Zn	Pb	Zn	Pb	Zn
1	0	<3.0	176	183	158	0.00	1.1
2	0	80	176	183	158	0.44	1.1
3	0	145	176	183	158	0.80	1.1
4	0	239	176	183	158	1.31	1.1
5	0	409	176	183	158	2.24	1.1

This test is supported by the results of test MM3. The results are summarized in Table 5-4.The test included a series of exposures in which zinc varied from 66% to 190% of its proposed site-specific criterion concentration of 143 µg/L, and lead varied from 96% to 184% of its proposed site-specific criterion concentration of 159 µg/L (Table 5-5). No mortality was seen in any of the exposures. As discussed in Appendix C, lead and zinc were not measured at the end of the test (i.e., T96), so the interpretation is based on initial metals concentrations in the test. Therefore, this test has some uncertainty as to the actual exposure concentrations. However, the results are consistent with test MM6 and support the conclusion that the proposed site-specific criteria are protective in combination.

Table 5-4. Summary of metals mixture test MM3

Treatment			Hardness	Nominal Concentration			Measured Concentrations						Relevant CMC		
							Cd		Pb		Zn				
Test Date	Exposure	Description		Cd	Pb	Zn	T0	T96	T0	T96	T0	T96	Cd [a]	Pb [b]	Zn [b]
9-9-00	1	Control	62.5	A	A	A	<0.2	<0.2	4	<3	32	22	1.3	159	143
9-9-00	2	Pb1/Zn0.5	62.5	A	162	78	<0.2	nm	152	nm	88	nm	1.3	159	143
9-9-00	3	Pb1/Zn1.0	62.5	A	162	156	<0.2	nm	255	nm	200	nm	1.3	159	143
9-9-00	4	Pb1/Zn1.5	62.5	A	162	237	<0.2	nm	293	nm	272	nm	1.3	159	143

A - ambient concentrations

nm- not measured

na- not applicable

[a] Proposed adoption of EPA 2001 CMC

[b] Site-specific CMC equations from section 5.1.

Table 5-5. Metals mixture test MM3 exposures compared to proposed site-specific criteria

Test ID	% Dead	Geometric Means/Exposure Concentrations		Site-Specific CMC		Geometric Mean/CMC	
		Pb	Zn	Pb [a]	Zn [a]	Pb	Zn
1	0	4	26.5	159	143	0.03	0.18
2	0	152	88	159	143	0.96	0.61
3	0	255	200	159	143	1.6	1.4
4	0	293	272	159	143	1.84	1.9

[a] Site-specific CMC equations from section 5.1

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Appendix A. Summary of Acute and Chronic Test Data, 1995 – 2001

Windward environmental LLC

Table A-1. Summary of acute test data, 1995 - 2001

Metal Source	Common Name	Species Name	Family	Test Date	Test QA	Acute Value	Confidence Intervals or </> proportion responding	Acute Value normalized to hardness of 50 mg/L	Water Source	Hardness
Cadmium	Caddisfly	Arctopsyche sp.	Hydropsychidae	10/22/1995	C	>458	> 0.3		SF-10	nm
Cadmium	Mayfly	Rhithrogena sp.	Heptageniidae	9/11/1996	B	>50	> 0.14		LNF	21
Cadmium	Mayfly	Baetis tricaudatus	Baetidae	9/11/1996	B	>73	> 0.45		LNF	21
Cadmium	RBT	Oncorhynchus mykiss	Salmonidae	10/24/1997	A	0.84	0.62 - 0.95		LNF	21
Cadmium	RBT	Oncorhynchus mykiss	Salmonidae	05/23/99	A	0.477	nc		LNF	7.5
Cadmium	RBT	Oncorhynchus mykiss	Salmonidae	05/23/99	A	1.297	1.121-1.511		SF-9	24
Cadmium	RBT	Oncorhynchus mykiss	Salmonidae	05/23/99	A	0.988	nc		SF-8	30
Cadmium	RBT	Oncorhynchus mykiss	Salmonidae	05/23/99	A	0.967	0.848-1.111		SF-10	13.5
Cadmium	RBT	Oncorhynchus mykiss	Salmonidae	10/2/1999	A	0.89	0.8-0.98		SFH	32
Cadmium	RBT	Oncorhynchus mykiss	Salmonidae	7/26/2000	A	0.831	0.719-0.945		SFH	28.5
Cadmium	RBT-Sand Point	Oncorhynchus mykiss	Salmonidae	9/10/1996	B	<0.5	<0.86		LNF	21
Cadmium	Shorthead sculpin	Cottus confusus	Cottidae	9/10/1996	B	1.29	0.09-3.65		LNF	21
Cadmium	Snail	Gyraulus sp.	Planorbidae	9/11/1996	B	73	> 0.05		LNF	21
Cadmium	Stonefly	Sweltsa sp.	Chloroperlidae	12/9/1995	C	>5130	> 0.0		SF-10	nm
Cadmium	RWC	Oncorhynchus clarki lewisi	Salmonidae	8/26/1999	A	1.41	1.19-1.76		SFH	32
Cadmium	RWC	Oncorhynchus clarki lewisi	Salmonidae	8/9/2000	A	1.18	1.04-1.32		SFH	30.5
Cadmium	HWC- Sand Point	Oncorhynchus clarki lewisi	Salmonidae	9/10/1996	B	<0.5	<0.71		LNF	21
Cadmium	RWC-field collected	Oncorhynchus clarki lewisi	Salmonidae	9/10/1996	B	0.93	0.52-1.71		LNF	21
Lead	Black fly	Simuliidae	Simuliidae	9/20/1998	A	>1035	> 0.1	1307.4	SF-10	39
Lead	Black fly	Simuliidae	Simuliidae	9/20/1998	A	>1255	> 0.15	2715.6	LNF	22
Lead	Caddisfly	Arctopsyche sp.	Hydropsychidae	9/20/1998	A	>1255	> 0.29	2715.6	LNF	22
Lead	Crane fly	Tipula sp.	Tipulidae	9/20/1998	A	>1035	> 0.25	1307.4	SF-10	39
Lead	Diving beetle	Dytiscidae	Dytiscidae	9/20/1998	A	1035	> 0.0	1307.4	SF-10	39
Lead	Mayfly	Baetis tricaudatus	Baetidae	7/24/1996	B	596	398-1340	1848.7	LNF	15
Lead	Mayfly	Baetis tricaudatus	Baetidae	8/12/1996	B	769	680-869	2009.5	LNF	18
Lead	Mayfly	Baetis tricaudatus	Baetidae	9/28/1997	A	664	368-1315	1571.5	LNF	20
Lead	Mayfly	Baetis tricaudatus	Baetidae	9/20/1998	A	463	234.8-672.5	1001.9	LNF	22
Lead	Mayfly	Baetis tricaudatus	Baetidae	9/20/1998	A	919.5	827.2-1022.2	1161.5	SF-10	39
Lead	Mayfly	Baetis tricaudatus	Baetidae	9/20/1998	A	1333	>0.36	1012.3	SF-9	67
Lead	Mayfly	Baetis tricaudatus	Baetidae	9/20/1998	A	>683	>0.36	419.4	SF-8	84
Lead	Mayfly	Baetis tricaudatus	Baetidae	4/1/1999	B	>494	>0.4		LNF	nm
Lead	Mayfly	Baetis tricaudatus	Baetidae	4/19/1999	B	<346	<0.63		LNF	nm
Lead	Mayfly	Baetis tricaudatus	Baetidae	5/7/1999	B	580	340-940	2058.1	LNF	13

Metal Source	Common Name	Species Name	Family	Test Date	Test QA	Acute Value	Confidence Intervals or </> Proportion Responding	Acute Value Normalized to Hardness of 50 mg/L	Water Source	Hardness
Lead	Mayfly	Baetis tricaudatus	Baetidae	5/7/1999	B	1090	680-1580	2707.2	SF-10	19
Lead	Mayfly	Baetis tricaudatus	Baetidae	5/7/1999	B	1250	>0.4	1847.5	SF-9	33
Lead	Mayfly	Baetis tricaudatus	Baetidae	5/7/1999	B	<1250	<0.6		SF-8	41
Lead	Mayfly	Drunella sp.	Ephemerellidae	8/24/1998	A	>267.3	> 0.17	647.9	LNF	19.5
Lead	Mayfly	Epeorus sp.	Heptageniidae	4/1/1999	B	>494	>0.1		LNF	nm
Lead	Mayfly	Epeorus sp.	Heptageniidae	4/19/1999	B	>346	>0.19		LNF	nm
Lead	Mayfly	Paraleptophlebia sp.	Leptophlebiidae	4/19/1999	B	>346	>0.3		LNF	nm
Lead	Mayfly	Rhithrogena sp.	Heptageniidae	7/24/1996	B	>737	> 0.1	2286.0	LNF	15
Lead	Mayfly	Rhithrogena sp.	Heptageniidae	8/12/1996	B	>985	>0.1	2574.0	LNF	18
Lead	Mayfly	Rhithrogena sp.	Heptageniidae	8/3/1998	A	429	> 0.23	1065.5	LNF	19
Lead	Midge	Chironomidae	Chironomidae	9/20/1998	A	>1035	> 0.1	1307.4	SF-10	39
Lead	Midge	Chironomidae	Chironomidae	9/20/1998	A	>1255	> 0.1	2715.6	LNF	22
Lead	Midge	Chironomidae	Chironomidae	9/19/2000	A	9162.6	2525.2- Infinity	13167.2	SFH	34
Lead	Midge	Chironomidae	Chironomidae	9/26/2000	A	3323	1982.5-8971.3	4622.1	SFH	35.2
Lead	RBT	Oncorhynchus mykiss	Salmonidae	10/19/1997	A	119.5	104.2-138.2	282.8	LNF	20
Lead	RBT	Oncorhynchus mykiss	Salmonidae	9/27/1999	A	126.6	102.2-150.6	195.5	SFH	31.5
Lead	RBT	Oncorhynchus mykiss	Salmonidae	10/2/1999	A	140.3	117.5-163	213.4	SFH	32
Lead	RBT	Oncorhynchus mykiss	Salmonidae	6/17/2000	A	590.32	407.2-1210.3	1250.7	SFH	22.5
Lead	RBT	Oncorhynchus mykiss	Salmonidae	6/17/2000	A	547.35	431.9-744.2	913.5	SF-9	29
Lead	RBT	Oncorhynchus mykiss	Salmonidae	6/17/2000	A	1164.1	694.1-6408.4	1771.0	SF-G	32
Lead	RBT	Oncorhynchus mykiss	Salmonidae	6/17/2000	A	843.5	>0.35	1229.2	SF-8	33.5
Lead	RBT	Oncorhynchus mykiss	Salmonidae	7/26/2000	A	98.19	>0.0	166.6	SFH	28.5
Lead	RBT-Sand Point	Oncorhynchus mykiss	Salmonidae	9/17/1996	B	179.6	107.1-272.7	406.0	LNF	21
Lead	Shorthead sculpin	Cottus confusus	Cottidae	9/17/1996	B	855	> 0.0	1932.8	LNF	21
Lead	Snail	Gyraulus sp.	Planorbidae	8/12/1996	B	561	516-611	1466.0	LNF	18
Lead	Snail	Gyraulus sp.	Planorbidae	9/28/1997	A	486	434-545	1150.2	LNF	20
Lead	Snail	Gyraulus sp.	Planorbidae	8/3/1998	A	339.9	253-603.4	844.2	LNF	19
Lead	Snail	Gyraulus sp.	Planorbidae	9/20/1998	A	738	618.3-866.7	1596.9	LNF	22
Lead	Snail	Gyraulus sp.	Planorbidae	9/20/1998	A	966.8	858.6-1088.6	1221.2	SF-10	39
Lead	Snail	Gyraulus sp.	Planorbidae	9/20/1998	A	>952	> 0.25	723.0	SF-9	67
Lead	Snail	Gyraulus sp.	Planorbidae	9/20/1998	A	>683	>0	419.4	SF-8	84
Lead	Snail	Gyraulus sp.	Planorbidae	5/7/1999	B	700	500-950	2483.9	LNF	13
Lead	Snail	Gyraulus sp.	Planorbidae	5/7/1999	B	>1250	>0.2	3104.5	SF-10	19
Lead	Snail	Gyraulus sp.	Planorbidae	5/7/1999	B	>1250	>0.1	1847.5	SF-9	33
Lead	Snail	Gyraulus sp.	Planorbidae	5/7/1999	B	>1250	>0.2	1506.4	SF-8	41
Lead	Snail	Physidae	Physidae	9/20/1998	A	1117.6	851.7-1917.1	2418.3	LNF	22

Metal Source	Common Name	Species Name	Family	Test Date	Test QA	Acute Value	Confidence Intervals or </> proportion responding	Acute Value normalized to hardness of 50 mg/L	Water Source	Hardness
Lead	Stonefly	Sweltsa sp.	Chloroperlidae	7/24/1996	B	>737	> 0.3	2286.0	LNF	15
Lead	Stonefly	Sweltsa sp.	Chloroperlidae	8/24/1998	A	>267.3	> 0.5	647.9	LNF	19.5
Lead	Stonefly	Sweltsa sp.	Chloroperlidae	4/1/1999	B	>494	>0.2		LNF	nm
Lead	RWC	Oncorhynchus clarki lewisi	Salmonidae	8/26/1999	A	>123.3	>0.25	187.6	SFH	32
Lead	RWC	Oncorhynchus clarki lewisi	Salmonidae	9/21/1999	A	>53.6	>0.0	82.8	SFH	31.5
Lead	RWC	Oncorhynchus clarki lewisi	Salmonidae	9/27/1999	A	215.2	180.1-252.8	327.4	SFH	32
Lead	RWC	Oncorhynchus clarki lewisi	Salmonidae	8/9/2000	A	71.8	>0.0	114.3	SFH	30.5
Lead	RWC	Oncorhynchus clarki lewisi	Salmonidae	8/16/2000	A	415.41	341.8-513.1	641.4	SFH	31.5
Lead	RWC	Oncorhynchus clarki lewisi	Salmonidae	8/16/2000	A	450	nc	404.5	SF-9	56
Lead	RWC	Oncorhynchus clarki lewisi	Salmonidae	8/16/2000	A	>414.3	>0.05	310.3	SF-G	68
Lead	RWC	Oncorhynchus clarki lewisi	Salmonidae	8/16/2000	A	>409	>0.0	288.4	SF-8	72.5
Lead	RWC	Oncorhynchus clarki lewisi	Salmonidae	9/9/2000	A	>153	>0.0	124.0	SF-9	62.5
Lead	RWC	Oncorhynchus clarki lewisi	Salmonidae	9/6/2001	A	50.8	43.1-60	204.0	EFPC	11.4
Lead	RWC	Oncorhynchus clarki lewisi	Salmonidae	9/27/2001	A	>387	nc	>477	St.R	40.5
Lead	RWC	Oncorhynchus clarki lewisi	Salmonidae	8/21/2001	C	>34.64	nc		EFPC	12.3
Lead	HWC- Sand Point	Oncorhynchus clarki lewisi	Salmonidae	9/17/1996	B	113.6	90.2-143.1	256.8	LNF	21
Lead	RWC-field collected	Oncorhynchus clarki lewisi	Salmonidae	9/17/1996	B	>855	> 0.0	1932.8	LNF	21
Zinc	Caddisfly	Hydropsyche sp.	Hydropsychidae	7/15/1996	B	>2926	> 0.31	6799.5	LNF	14
Zinc	Mayfly	Baetis tricaudatus	Baetidae	7/15/1996	B	>2926	> 0.36	6799.5	LNF	14
Zinc	Mayfly	Rhithrogena sp.	Heptageniidae	7/15/1996	B	>2926	> 0.25	6799.5	LNF	14
Zinc	RBT	Oncorhynchus mykiss	Salmonidae	6/8/1999	A	24	nc	74.7	LNF	9
Zinc	RBT	Oncorhynchus mykiss	Salmonidae	6/8/1999	A	35.76	12.15-51.96	103.8	SF-10	10
Zinc	RBT	Oncorhynchus mykiss	Salmonidae	6/8/1999	A	116.9	87.2-161.3	248.7	SF-9	16
Zinc	RBT	Oncorhynchus mykiss	Salmonidae	6/8/1999	A	130.39	112.7-149.4	212.0	SF-8	24
Zinc	RBT	Oncorhynchus mykiss	Salmonidae	6/28/2000	B	77.5	59.4-98.1	131.5	SFH	22.5
Zinc	RBT	Oncorhynchus mykiss	Salmonidae	6/28/2000	B	96.55	81.22-114.78	138.5	SF-9	29
Zinc	RBT	Oncorhynchus mykiss	Salmonidae	6/28/2000	B	170.5	145.2-200.3	197.7	SF-G	40
Zinc	RBT	Oncorhynchus mykiss	Salmonidae	6/28/2000	B	203.6	113.6-387.2	232.2	SF-8	41
Zinc	RBT	Oncorhynchus mykiss	Salmonidae	7/8/2000	A	170.2	135.1-231.8	238.7	SFH	30
Zinc	RBT	Oncorhynchus mykiss	Salmonidae	7/8/2000	A	198.9	164.3-255.2	223.3	SF-9	42
Zinc	RBT	Oncorhynchus mykiss	Salmonidae	7/8/2000	A	278.8	249.2-318.7	275.2	SF-G	51
Zinc	RBT	Oncorhynchus mykiss	Salmonidae	7/8/2000	A	300.1	238.2-433.6	281.7	SF-8	55
Zinc	RBT	Oncorhynchus mykiss	Salmonidae	7/26/2000	A	81.73	71.11-93.93	118.6	SFH	28.5
Zinc	RBT	Oncorhynchus mykiss	Salmonidae	8/23/2000	A	47.77	30.46-65.03	60.5	SFH	35
Zinc	RBT	Oncorhynchus mykiss	Salmonidae	8/23/2000	A	110.56	89.48-138.47	91.5	SF-9	66.5
Zinc	RBT	Oncorhynchus mykiss	Salmonidae	8/23/2000	A	137.41	68.13-168.86	106.9	SF-G	73

Metal Source	Common Name	Species Name	Family	Test Date	Test QA	Acute Value	Confidence Intervals or </> Proportion Responding	Acute Value Normalized to Hardness of 50 mg/L	Water Source	Hardness
Zinc	RBT	Oncorhynchus mykiss	Salmonidae	8/23/2000	A	133.83	20.953-173.48	102.3	SF-8	75
Zinc	RBT-Sand Point	Oncorhynchus mykiss	Salmonidae	8/13/1996	B	69.3	58.8-81.8	136.3	LNF	18
Zinc	Shorthead sculpin	Cottus confusus	Cottidae	8/13/1996	B	>1068	> 0.0	2101.2	LNF	18
Zinc	Shorthead sculpin (YOY)	Cottus confusus	Cottidae	8/21/2001	C	>275	nc		SFH	38.5
Zinc	Snail	Gyraulus sp.	Planorbidae	7/15/1996	B	>1303	1092-1487	3027.9	LNF	14
Zinc	Stonefly	Sweltsa sp.	Chloroperlidae	8/12/1996	B	>1526	> 0.25	3002.3	LNF	18
Zinc	RWC	Oncorhynchus clarki lewisi	Salmonidae	8/26/1999	A	>275.3	>0.35	370.0	SFH	32
Zinc	RWC	Oncorhynchus clarki lewisi	Salmonidae	9/21/1999	A	208.2	177-250.8	282.7	SFH	31.5
Zinc	RWC	Oncorhynchus clarki lewisi	Salmonidae	8/9/2000	A	196.4	169.1-223.8	272.5	SFH	30.5
Zinc	RWC	Oncorhynchus clarki lewisi	Salmonidae	9/9/2000	A	>186	>0.0	160.4	SF-9	62.5
Zinc	RWC	Oncorhynchus clarki lewisi	Salmonidae	9/12/2000	A	277.74	243.2-338.36	239.6	SF-9	62.5
Zinc	RWC	Oncorhynchus clarki lewisi	Salmonidae	9/6/2001	A	75.4	64.6-86.5	200.8	EFPC	11.4
Zinc	RWC	Oncorhynchus clarki lewisi	Salmonidae	8/21/2001	C	>22.23	nc		EFPC	12.8
Zinc	RWC	Oncorhynchus clarki lewisi	Salmonidae	8/21/2001	C	>175	nc		SFH	38.5
Zinc	HWC- Sand Point	Oncorhynchus clarki lewisi	Salmonidae	8/13/1996	B	124.8	54.1-196.9	245.5	LNF	18
Zinc	RWC-field collected	Oncorhynchus clarki lewisi	Salmonidae	8/13/1996	B	325	248-402	639.4	LNF	18
Canyon Creek	RBT	Oncorhynchus mykiss	Salmonidae	10/9/1997	A	2.20%	0-6.3%		LNF	~22
Canyon Creek	HWC- Sand Point	Oncorhynchus clarki lewisi	Salmonidae	10/9/1997	A	<2.2%	<1.0		LNF	~22
Canyon Creek	RBT - LNF reared	Oncorhynchus mykiss	Salmonidae	7/14/2000	A	5.2%	4.4%-6.3%		SFH	~28
Canyon Creek	RBT - SFH reared	Oncorhynchus mykiss	Salmonidae	7/14/2000	A	11.1%	8.8%-14.4%		SFH	~28
CC as Cadmium	RBT - LNF reared	Oncorhynchus mykiss	Salmonidae	7/14/2000	A	0.51	0.4-0.6		SFH	~28
CC as Cadmium	RBT - SFH reared	Oncorhynchus mykiss	Salmonidae	7/14/2000	A	1.01	0.81-1.32		SFH	~28
CC as Zinc	RBT - LNF reared	Oncorhynchus mykiss	Salmonidae	7/14/2000	A	58.3	48.8-70.4		SFH	~28
CC as Zinc	RBT - SFH reared	Oncorhynchus mykiss	Salmonidae	7/14/2000	A	125.3	99.7-162.7		SFH	~28
Pb/Zn as Zn	RWC	Oncorhynchus clarki lewisi	Salmonidae	9/9/2000	A	272	>0.0		SF-9	62.5
Cd/Zn as Zn	RWC	Oncorhynchus clarki lewisi	Salmonidae	9/21/2000	A	479.997	409.8-650.2		SF-9	67
Pb/Cd/Zn as Zn	RWC	Oncorhynchus clarki lewisi	Salmonidae	9/21/2000	A	384.12	349.68-639.72		SF-9	67
Pb/Zn as Zn	RWC	Oncorhynchus clarki lewisi	Salmonidae	9/12/2000	A	315.02	276.47-451.57		SF-9	62.5
LSF (Smelterville) as Cd	RWC	Oncorhynchus clarki lewisi	Salmonidae	9/27/2000	A	2.645	2.3-3.1		St.R	~49
LSF (Smelterville) as Zn	RWC	Oncorhynchus clarki lewisi	Salmonidae	9/27/2000	A	543.96	468.3-642.8		St.R	~49
LSF (Smelterville)	RWC	Oncorhynchus clarki lewisi	Salmonidae	9/27/2000	A	37.24%	32.14-43.87		St.R	~49
LSF (confluence) as Cd	RWC	Oncorhynchus clarki lewisi	Salmonidae	8/27/2001	A	3.7	2.6-4.7		St.R	~96
LSF (confluence) as Pb	RWC	Oncorhynchus clarki lewisi	Salmonidae	8/27/2001	A	nc			St.R	~96

Metal Source	Common Name	Species Name	Family	Test Date	Test QA	Acute Value	Confidence Intervals or </> Proportion Responding	Acute Value Normalized to Hardness of 50 mg/L	Water Source	Hardness
LSF (confluence) as Zn	RWC	Oncorhynchus clarki lewisi	Salmonidae	8/27/2001	A	727.5	478.6-937.4		St.R	~96
LSF (confluence)	RWC	Oncorhynchus clarki lewisi	Salmonidae	8/27/2001	A	53.70%	39.3-67.9		St.R	~96
EPSF as Cd	RWC	Oncorhynchus clarki lewisi	Salmonidae	8/27/2001	A	4.2	3.01-5.8		St.R	~64
EPSF as Pb	RWC	Oncorhynchus clarki lewisi	Salmonidae	8/27/2001	A	nc			St.R	~64
EPSF as Zn	RWC	Oncorhynchus clarki lewisi	Salmonidae	8/27/2001	A	592.8	433.2-809.9		St.R	~64
EPSF	RWC	Oncorhynchus clarki lewisi	Salmonidae	8/27/2001	A	65.30%	46.0-89.2		St.R	~64
Prichard Ck as Pb	RWC	Oncorhynchus clarki lewisi	Salmonidae	9/6/2001	A	37.2	29.02-46.1		PC	13.5
Prichard Ck as Zn	RWC	Oncorhynchus clarki lewisi	Salmonidae	9/6/2001	A	33.6	31.1-37.1		PC	13.5

All values are in µg/l, dissolved (filtered) concentrations
Hardness normalized values estimate values at hardness 50 mg/l by adjusting test hardness with the site-specific hardness-toxicity relationships.
nc - not calculable
nm - not measured
QA signifiers:
A - Test conducted at Hale Hatchery. Test solutions measured at initiation and termination.
B - Test conducted at Hale Hatchery. Test solutions measured at initiation.
C - Test conducted at University of Washington or not meeting test QA/QC specifications.
RBT - Rainbow trout
RWC - Resident Westslope cutthroat trout
HWC - Hatchery Westslope cutthroat trout
Other acronyms are defined at the front of the report.

Table A-2. Summary of all chronic test data, 1997-2000

Metal	Common Name	Species Name	Test Date	Test QA	Duration	Test type	NOEC	LOEC	Chronic Value	Endpoints	Average hardness	Notes
Cadmium	Rainbow trout	*Oncorhynchus mykiss*	8/22/1997	C	69 d	ELS	0.1	1.3	0.36	Survival, Growth (total weight), Growth (total length)	21	1
Cadmium	Rainbow trout	*Oncorhynchus mykiss*	8/22/1997	B	53 d	ELS	0.8	1.6	1.13	Survival	21	2
Cadmium	Rainbow trout	*Oncorhynchus mykiss*	07/23/99	A	62 d	ELS	1.0	2.5	1.58	Survival, growth (same for sum and mean weight, sum and mean length)		
Lead	Rainbow trout	*Oncorhynchus mykiss*	8/22/1997	A	69 d	ELS	24	54	36	Survival, growth (mean wt.)	21	
Lead	Rainbow trout	*Oncorhynchus mykiss*	07/23/99	A	62 d	ELS	8	18	12	Growth (mean length)	26	
Lead	Rainbow trout	*Oncorhynchus mykiss*	07/23/99	A	62 d	ELS	128	300	196	Survival	26	
Lead	Mayfly	*Baetis tricaudatus*	10/18/97	A	10 d	SA	103	160	130	Growth (number of molts)	19	P<0.05
Lead	Mayfly	*Baetis tricaudatus*	10/18/97	A	10 d	SA	3	69	14	Growth (number of molts)	19	P<0.1
Lead	Mayfly	*Baetis tricaudatus*	10/18/97	A	10 d	SA	222	350	279	Survival	19	
Lead	Midge	*Chironomus tentans*	07/21/00	A	55 d	FLC	57	75	65	Growth (21d dry wt.)	32	
Lead	Midge	*Chironomus tentans*	07/21/00	A	55 d	FLC	500	>500	nc	Survival, fecundity, hatching success	32	
Zinc	Rainbow trout	*Oncorhynchus mykiss*	8/22/1997	C	69 d	ELS	2	113	15	Survival, Growth (total weight), Growth (total length)	21	

Grouped by test and chronic values determined for different test endpoints.

Test types: ELS - Early Life Stage; FLC - Full life cycle; SA - Subacute short-term estimate of chronic toxicity

Chronic Value - Geometric mean of NOEC and LOEC

Endpoints - Most sensitive endpoint listed for each test condition shown. When more than one endpoint listed, calculated effects concentrations were equal for those endpoints

nc - not calculable

QA signifiers:

A - Definitive exposure series, desired test duration, and control performance achieved

B - Definitive exposure series and control performance achieved, but desired test duration not achieved

C - Intended test duration and control performance achieved, but exposure series too wide to be definitive

RBT - Rainbow trout

Other acronyms are defined at the front of the report.

Note 1. On Day 53, two intermediate Cd treatments (0.25 µg/l and 0.57 µg/l) overdosed. Overdosed treatments excluded from chronic value calculation.

Note 2. Chronic value calculated including mortality endpoints prior to overdose. For treatments that were not overdosed, mortality did not significantly increase from day 53 and day 68 (P>0.20). Thus, test results interpreted at Day 53 are considered to be usable chronic endpoints.

Appendix B. Summary of Acceptable Chronic Test Data for Deriving Site-Specific Lead ACRs

Table B-1. Summary of final endpoint measurements: 1997 lead early-life-stage rainbow trout test

Treatment	TWA Concentration	Replicate	Number Seeded	Count	Percent Survival	Sum Weight	Mean Individual Weight	Sum Length	Mean Individual Length
Control		A	45	33	73.3	13.506	0.409	1,098	33.27
Control		B	45	35	77.8	13.377	0.382	1,145	32.71
Control		C	45	38	84.4	14.85	0.391	1,273	33.50
Pb1	12	A	45	37	82.2	13.088	0.354	1,203	32.51
Pb1		B	45	35	77.8	9.212	0.263	1,021	29.17
Pb1		C	45	41	91.1	14.499	0.354	1,328	32.39
Pb2	24	A	45	37	82.2	13.426	0.363	1,144	30.92
Pb2		B	45	38	84.4	13.256	0.349	1,154	30.37
Pb2		C	45	34	75.6	12.244	0.360	1,116	32.82
Pb3	24	A	45	38	84.4	13.954	0.367	1,261	33.18
Pb3		B	45	33	73.3	12.154	0.368	1,054	31.94
Pb3		C	45	37	82.2	12.786	0.346	1,210	32.70
Pb4	54	A	45	17	37.8	4.406	0.259	468	27.53
Pb4		B	45	9	20.0	2.892	0.321	273	30.33
Pb4		C	45	27	60.0	7.176	0.266	792	29.33
Pb5	143	A	45	1	2.2	0.064	0.064	18	18.00
Pb5		B	45	2	4.4	0.282	0.141	47	23.50
Pb5		C	45	5	11.1	0.59	0.118	112	22.40

Table B-2. Summary of final endpoint measurements: 1999 lead early-life-stage rainbow trout test

Treatment	TWA Concentration	Replicate	Number Seeded	Count	Percent Survival	Sum Weight	Mean Individual Weight	Sum Length	Mean Individual Length
Control		A	60	51	85.0	24.77	0.486	1,855	36.37
Control		B	60	44	73.3	21.91	0.498	1,600	36.36
Control		C	60	45	75.0	20.64	0.459	1,638	36.40
Pb1	8.0	A	60	49	81.7	20.88	0.426	1,727	35.24
Pb1		B	60	50	83.3	21.20	0.424	1,777	35.54
Pb1		C	60	48	80.0	20.46	0.426	1,733	36.10
Pb2	18.3	A	60	53	88.3	21.07	0.397	1,832	34.57
Pb2		B	60	53	88.3	17.93	0.338	1,744	32.91
Pb2		C	60	49	81.7	22.81	0.465	1,770	36.12
Pb3	37.1	A	60	51	85.0	21.94	0.430	1,824	35.76
Pb3		B	60	50	83.3	21.27	0.425	1,761	35.22
Pb3		C	60	50	83.3	20.49	0.410	1,755	35.10
Pb4	87.3	A	60	51	85.0	22.34	0.438	1,775	34.80
Pb4		B	60	49	81.7	18.85	0.385	1,689	34.47
Pb4		C	60	50	83.3	20.38	0.408	1,741	34.82
Pb5	124.7	A	60	27	45.0	12.80	0.474	957	35.44
Pb5		B	60	21	35.0	10.74	0.512	758	36.10
Pb5		C	60	20	33.3	9.77	0.489	721	36.05

Table B-3. Summary of Survival/Growth at day 20: lead full-life-cycle chironomid test, July 21, 2000

Treatment	TWA Concentration	Replicate	Weights: Oven-dried pan (g)	Pan + oven dried organisms (g)	Dried organisms (mg)	No. weighed	Mean individual wt. (mg)	Treatment mean (mg)	Average % survival
Control		A	1.2920	1.3097	0.0177	6	2.950		
		B	1.2859	1.3136	0.0277	9	3.078		
		C	1.2936	1.3077	0.0141	5	2.820	2.949	61.11%
Pb 1	29.2	A	1.2912	1.2959	0.0047	2	2.350		
		B	1.2880	1.3008	0.0128	7	1.829		
		C	1.2893	1.2944	0.0051	2	2.550	2.243	33.33%
Pb2	56.9	A	1.3002	1.3163	0.0161	8	2.013		
		B	1.2971	1.3076	0.0105	4	2.625		
		C	1.2928	1.3139	0.0211	8	2.638	2.425	58.33%
Pb3	75.1	A	1.2966	1.3110	0.0144	6	2.400		
		B	1.2901	1.2997	0.0096	5	1.920		
		C	1.2951	1.3113	0.0162	10	1.620	1.980	58.33%
Pb4	115.4	A	1.2949	1.3098	0.0149	10	1.490		
		B	1.2930	1.2972	0.0042	3	1.400		
		C	1.2947	1.3083	0.0136	9	1.511	1.467	61.11%
Pb5	128	A	1.2958	1.3094	0.0136	9	1.511		
		B	1.2948	1.3017	0.0069	4	1.725		
		C	1.2862	1.2964	0.0102	7	1.457	1.564	61.11%
Pb6	152	A	1.2927	1.3101	0.0174	8	2.175		
		B	1.2870	1.3054	0.0184	11	1.673		
		C	1.2969	1.3078	0.0109	5	2.180	2.009	66.67%

Appendix C. Summary of Metals Mixture Tests

Introduction

Metals mixture testing was conducted to verify that the proposed lead and zinc criteria were protective of the most sensitive species in combination. Five metals mixture tests were run for the purpose of evaluating the protectiveness of the proposed site-specific criteria for the South Fork Coeur d'Alene above Canyon Creek. In addition, a test conducted to assess the spatial variability of lead acts effectively as a sixth metals mixture test. The initial metals mixture test (i.e., MM1) was conducted using rainbow trout. The purpose of the test was to check protocols for test design and set-up. This test was not used to evaluate the protectiveness of the proposed criteria and is not summarized here. Details can be found in Windward (2001). Table C-1 summarizes the metals mixture tests

Table C-1. Summary of metals mixture testing conducted for site-specific criteria validation.

Metal Mixture Test ID	Dilution Water	Dilution Water Hardness	Metals Assessed	Test Organism	Test Date
MM1	SFH	28.5	Cd, Pb, Zn	Rainbow trout	7/26/00
MM2	SFH	30.5	Cd, Pb, Zn	RWC	8/9/00
MM3	SF-9	62.5	Pb, Zn	RWC	9/9/00
MM4	SF-9	62.5	Pb, Zn	RWC	9/12/00
MM5	SF-9	67	Cd, Pb, Zn	RWC	9/21/00
MM6	SF-8	72.5	Cd, Pb, Zn	RWC	8/16/00

Results

The results of the metals mixture tests used for verification purposes are presented in Table C-2 and in the discussion that follows.

Table C-2 Summary of metals mixture tests

Treatment					Nominal Concentration			Measured Concentrations						Relevant CMC		
								Cd		Pb		Zn				
Test	Test Date	Exposure	Description	Hardness	Cd	Pb	Zn	T0	T96	T0	T96	T0	T96	Cd [a]	Pb [b]	Zn [b]
MM2	8/9/2000	1	Site-Specific	30.5	1.2	105	74	1.2	1.3	80	62	158	144	0.62	81	89
MM2	8/9/2000	2	Idaho Criteria	30.5	1.2	18	44	1.3	1.2	140	98	42	36	0.62	81	89
MM3	9/9/2000	3	Pb1/Zn0.5	62.5	A	162	78	<0.2	nm	152	nm	88	nm	1.3	159	143
MM3	9/9/2000	4	Pb1/Zn1.0	62.5	A	162	156	<0.2	nm	255	nm	200	nm	1.3	159	143
MM3	9/9/2000	5	Pb1/Zn1.5	62.5	A	162	237	<0.2	nm	293	nm	272	nm	1.3	159	143
MM4	9/12/2000	6	Pb1/Zn0.5	62.5	A	162	78	<0.2	<0.2	140	94	126	112	1.3	159	143
MM4	9/12/2000	7	Pb1/Zn1.0	62.5	A	162	156	<0.2	<0.2	154	101	226	204	1.3	159	143
MM4	9/12/2000	8	Pb1/Zn1.5	62.5	A	162	237	<0.2	<0.2	164	104	324	307	1.3	159	143
MM5	9/21/2000	9	Pb1/Zn0.5/Cd0.7	67	0.7	179	122	0.6	0.7	107	78	141	123	1.4	170	149
MM5	9/21/2000	10	Pb1/Zn1.0/Cd0.7	67	0.7	179	245	0.6	0.5	90	53	226	204	1.4	170	149
MM5	9/21/2000	11	Pb1/Zn1.5/Cd0.7	67	0.7	179	367	0.8	0.8	117	86	365	330	1.4	170	149
MM6	8-16-00	12	SF8 Control	72.5	A	A	A	0.9	0.9	4	<3.0	178	173	1.5	183	158
MM6	8-16-00	13	Pb-1	72.5	A	125	A	0.9	0.9	104	61	178	173	1.5	183	158
MM6	8-16-00	14	Pb-2	72.5	A	250	A	0.9	0.9	198	106	178	173	1.5	183	158
MM6	8-16-00	15	Pb-3	72.5	A	500	A	0.9	0.9	314	182	178	173	1.5	183	158
MM6	8-16-00	16	Pb-4	72.5	A	1,000	A	0.9	0.9	562	298	178	173	1.5	183	158

A - ambient concentrations

[a] Proposed adoption of EPA 2001 CMC

[b] Site-specific CMC equations from section 5.1.

Metals Mixture Test 2 – MM2

A cadmium-lead-zinc mixture test was started August 9, 2000 using resident Westslope cutthroat trout (RWC). Streamwater from SF-H was collected August 8. The metal mixture exposures consisted of dissolved cadmium, lead, and zinc at proposed site-specific or Idaho criteria. Dissolved cadmium, lead, and zinc measurements in the metal-spiked treatments indicated that nominal concentrations were achieved. Dissolved lead measurements in the Idaho criteria test series were higher than the targeted nominal concentrations; this was due to a mixing error. Dissolved concentrations of cadmium, lead, and zinc measured in the control samples were all below detection.

The variability of all water quality measurements was within acceptable guidelines. Water hardness at test initiation was 30.5 mg/L as $CaCO_3$.

RWC fry averaged 0.18 g per individual. Control survival was greater than 95%. Because less than 50% mortality was observed in all lead-spiked treatments, the dissolved lead EC50 for this test was determined to be greater than the highest treatment concentration (71.8 µg/L). The EC50 for cadmium was 1.18 µg/L (confidence interval [CI]=1.04-1.32 µg/L). The EC50 for zinc was 196.4 µg/L (CI=169.1-223.8 µg/L). Mortality in the metal mixture treatments ranged from 47% to 63%.

Metals Mixture Test 3 – MM3

A lead-zinc mixture test was started September 9, 2000 using RWC. Water from SF-9 was collected September 8. Dissolved lead and zinc measurements in the metal-spiked treatments indicated that nominal concentrations were not achieved. It was found that there had been an error in mixing the zinc solutions. Dissolved concentrations of cadmium measured in the control samples were below detection. Maximum dissolved concentrations of lead and zinc in the control samples were detected at 4.0 µg/L and 32.0 µg/L respectively.

The variability of all water quality measurements was within acceptable guidelines. Water hardness at test initiation was 62.5 mg/L as $CaCO_3$.

RWC fry averaged 0.46 g per individual. Control survival was 100%. No mortalities were observed in any treatments through the duration of the test. Because less than 50% mortality was observed in all treatments, the EC50s for dissolved lead and dissolved zinc for this test were determined to be greater than the highest treatment concentrations, 153.3 µg/L and 186.3 µg/L, respectively. The EC50 for zinc as included in the zinc and lead metal mixture was greater than 272 µg/L.

Metals Mixture Test 4 – MM4

Because of the mixing error noted above in the September 9 test, the test was re-run September 12, 2000. SF-9 water was collected September 11. Dissolved lead and zinc measurements in the metal-spiked treatments indicated that nominal concentrations were achieved. Measurements of the metal mixture series consisting of dissolved lead and zinc indicated that nominal concentrations were achieved. Dissolved concentrations of cadmium and lead measured in the control samples were all below detection, but zinc was measured at 19.1 µg/L.

The variability of all water quality measurements was within acceptable guidelines. Water hardness at test initiation was 62.5 mg/L as $CaCO_3$.

RWC fry averaged 0.66 g per individual. Control survival was 100%. Because less than 50% mortality was observed in all lead-spiked treatments, the dissolved lead EC50 for this test was determined to be greater than the highest treatment concentration, 197.0 µg/L. The EC50 for zinc was 277.74 µg/L (CI=243.2-338.36 µg/L). The EC50 for zinc as included in the lead and zinc metal mixture test series was 315.02 µg/L (CI=276.47-451.57µg/L).

Metals Mixture Test 5 – MM5

A cadmium-lead-zinc mixture test was started September 21, 2000 using RWC. SF-9 water was collected September 20. Dissolved cadmium, lead, and zinc measurements in the metal-spiked treatments indicated that nominal concentrations were achieved. Maximum measured dissolved concentrations of cadmium, lead, and zinc in the control samples were detected at 0.2 µg/L, 4.0 µg/L, and 42.0 µg/L, respectively.

The variability of all water quality measurements was within acceptable guidelines. Water hardness at test initiation was 67.0 mg/L as $CaCO_3$.

RWC fry averaged 0.64 g per individual. Control survival was 100%. The EC50 for zinc as included in the cadmium and zinc metal mixture test series was 479.99 µg/L (CI=409.8-650.2 µg/L). The EC50 for zinc as included in the cadmium, lead, and zinc mixture was 384.12 µg/L (CI=349.68-639.72 µg/L).

Metals Mixture Test 6 – MM6

A lead low-flow spatial variability test was started August 16, 2000. Streamwater was collected August 15. Dissolved lead measurements in the metal-spiked treatments demonstrated that the nominal concentrations were met for SF-H and SF-9 but were not high enough to cause a sufficient response in SF-G and SF-8. Dissolved concentrations for cadmium, lead, and zinc were below detection in SF-H streamwater samples. At SF-9, dissolved cadmium was below detection, but lead and zinc were detected at 4 µg/L and 25 µg/L respectively. At SF-G, cadmium, lead, and zinc were detected at 0.7 µg/L, 5 µg/L, and 142 µg/L respectively. At SF-8, cadmium, lead, and zinc were detected at 0.9 µg/L, 4 µg/L, and 178 µg/L respectively.

The variability of all water quality measurements was within acceptable guidelines. Water hardness increased with distance downstream and ranged from 31.5 mg/L as $CaCO_3$ at SF-H to 72.5 mg/L as $CaCO_3$ at SF-8.

RWC fry averaged 0.20 g per individual. Control survival was 100% in all site waters. A concentration response was observed for metal-spiked series with SF-H streamwater and SF-9 streamwater. No EC50 could be calculated for SF-G and SF-8 because virtually no mortality was observed. No EC50 could be calculated for the SF-9 series because there was no partial response in intermediate treatments. The zinc EC50 in SF-9 water was between the measured treatment concentrations of 284.0 µg/L (no mortality) and 690.0 µg/L (complete mortality); the graphical estimate of the EC50 is approximately 450 µg/L. The EC50 in SF-H water was 415.41 µg/L (CI=341.8-513.1 µg/L).

The exposure series using streamwater from SF stations was used as an appropriate mixture test.

Summary

Table C-3 compares the test results to the proposed site-specific criteria.

Table C-3. Metals mixture test exposures compared to proposed site-specific criteria

			Geometric Means of Exposure Concentrations		Site-Specific CMC		Geometric Mean/CMC	
Test	Exposure	% Dead	Pb	Zn	Pb[a]	Zn[a]	Pb	Zn
MM2	1	46.7	70	151	81.2	88.8	0.87	1.7
MM2	2	63.3	117	39	81.2	88.8	1.45	0.44
MM3	3	0	152	88	159	143	0.96	0.62
MM3	4	0	255	200	159	143	1.61	1.4
MM3	5	0	293	272	159	143	1.84	1.9
MM4	6	0	115	119	159	143	0.72	0.83
MM4	7	10	120	215	159	143	0.75	1.5
MM4	8	50	131	315	159	143	0.93	2.2
MM5	9	0	91	132	170	149	0.54	0.89
MM5	10	0.3	69	269	170	149	0.40	1.8
MM5	11	30	100	347	170	149	0.59	2.33
MM6	12	0	<3.0	176	183	158	0.00	1.1
MM6	13	0	80	176	183	158	0.44	1.1
MM6	14	0	145	176	183	158	0.80	1.1
MM6	15	0	239	176	183	158	1.31	1.1
MM6	16	0	409	176	183	158	2.24	1.1

[a] Site-specific CMC equations from section 5.1

Of the metal mixture tests discussed, test MM6 provides the most definitive evidence of the protectiveness of the proposed site-specific criteria in combination. Tests MM2, MM4, and MM5 did not achieve targeted lead concentrations and could not be used. In addition, MM2 had cadmium at 2 times the proposed criteria in both treatments which may have resulted in observed mortalities and complicated interpretation. Test

MM3 lacked chemical analysis on treatments at the end of the test, which limited its use.

Test MM6 included a series of exposures in which cadmium was at a concentration of 0.9 µg/L, zinc was slightly above (i.e., 110% of) its proposed site-specific criterion of 159 µg/L, and lead varied from 44% to 224% of its proposed site-specific criterion of 183 µg/L). No mortality was seen in any of the exposures.

This test is supported by the results of test MM3.The test included a series of exposures in which zinc varied from 61% to 190% of its proposed site-specific criterion of 143 µg/L, and lead varied from 96% to 184% of its proposed site-specific criterion of 159 µg/L. No mortality was seen in any of the exposures. As discussed, lead and zinc were not measure at the end of the test (i.e., T96) so the interpretation is based on initial metals concentrations in the test. Therefore, this test has some uncertainty as to the actual exposure concentrations; however, the results are consistent with test MM6 and supportive of the conclusion that the proposed site-specific criteria are protective in combination.