CHAPTER 4
SURFACE WATER RESOURCES

4.1 INTRODUCTION

This chapter presents the determination of injuries to surface waters of the Coeur d'Alene River basin. Surface water resources include surface water and suspended, bed, and bank sediments [43 CFR 11.14 (pp)]. The injury determination presented in this chapter focuses on surface water and suspended sediments only. Bed, bank, and floodplain sediments are considered in the following chapter.

Surface water resources of the Coeur d'Alene River basin have been injured as a result of releases of hazardous substances — particularly cadmium, lead, and zinc — from mining and mineral processing operations in the basin. The information presented in this chapter demonstrates the following:

- Sufficient concentrations of hazardous substances exist in pathway resources now, and have in the past, to expose surface water resources to hazardous substances.

- Sufficient concentrations of hazardous substances exist in surface water resources now, and have in the past, to exceed federal, state, and tribal water quality criteria developed for protection of aquatic life. Therefore, surface water resources are injured.

- Exceedences of federal water quality criteria, and therefore, surface water injuries, have been documented from the upper reaches of the South Fork Coeur d'Alene River (downstream of Daisy Gulch), through the mainstem Coeur d'Alene River and Coeur d'Alene Lake, to at least the USGS gauge station at Post Falls Dam on the Spokane River. Surface waters of the mainstem Coeur d'Alene River from the North Fork Coeur d'Alene River confluence to Coeur d'Alene Lake are injured, surface waters of the lateral lakes are injured, and surface waters of Coeur d'Alene Lake are injured.

- Exceedences of federal water quality criteria have also been documented in tributaries of the South Fork Coeur d'Alene River, including Canyon Creek from approximately Burke to the mouth and Gorge Gulch downstream of the Hercules No. 3 adit; the East Fork and mainstem Ninemile Creek from the Interstate-Callahan Mine to the mouth; Grouse Gulch from the Star Mine waste rock dumps to the mouth; Moon Creek from the Charles Dickens Mine/Mill to the mouth; Milo Creek from the Sullivan Adits to the mouth; Portal Gulch downstream of the North Bunker Hill West Mine; Deadwood Gulch/Bunker Creek downstream of the Ontario Mill; Government Gulch from the Senator Stewart Mine to the mouth; East Fork and mainstem Pine Creek from the Constitution Upper Mill to the mouth; Highland Creek from the Highland Surprise Mine/Mill and the Sidney (Red Cloud) Mine/Mill to the mouth; Denver Creek from the Denver Mine to the mouth; and Nabob Creek from the Nabob Mill to the mouth.

- Concentrations of hazardous substances in surface water resources downstream of releases are high enough that surface water serves as a pathway of injury to downstream surface waters.

- Concentrations of hazardous substances in surface water resources of Coeur d'Alene Lake are sufficient to cause adverse effects to phytoplankton

- Concentrations of hazardous substances in surface water resources are sufficient to cause injury to aquatic biological resources (Chapter 7, Fish Resources), and to serve as a pathway of injury to wildlife (Chapter 6, Wildlife Resources) and to aquatic biological resources (Chapter 7, Fish Resources; and Chapter 8, Benthic Macroinvertebrates).

4.2 SURFACE WATER RESOURCES ASSESSED

The Coeur d'Alene River basin extends west from the Idaho-Montana border and includes the North Fork Coeur d'Alene River, South Fork Coeur d'Alene River, and mainstem Coeur d'Alene River watersheds, and Coeur d'Alene Lake (Figures 4-1 and 4-2). In the upper part of the basin, the South Fork Coeur d'Alene River and its tributaries drain approximately 304 square miles (USHUD, 1979). The valleys are narrow; floodplains are less than 1 mile wide. The South Fork Coeur d'Alene River downstream of Wallace is relatively shallow and swift flowing, with a gradient of about 30 feet per mile. The larger tributaries to the South Fork Coeur d'Alene River include Canyon Creek, Ninemile Creek, Placer Creek, Big Creek, Moon Creek, Montgomery Creek, and Pine Creek.

The South Fork Coeur d'Alene River and North Fork Coeur d'Alene River meet near Enaville, Idaho. The North Fork Coeur d'Alene River and its tributaries drain approximately 897 square miles (USHUD, 1979). Tributaries to the North Fork include Shoshone Creek, Prichard Creek, Beaver Creek, and the Little North Fork.

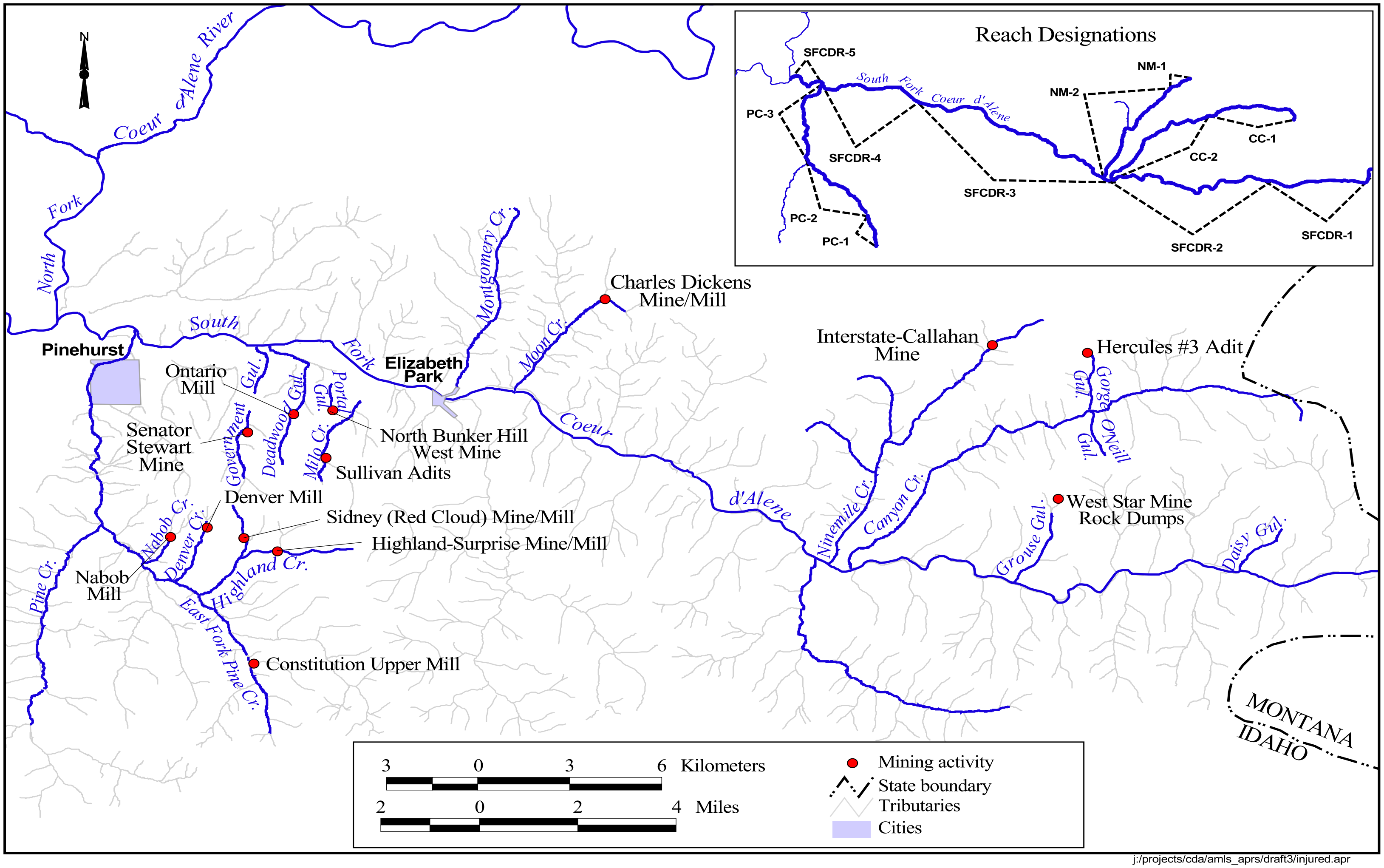

Figure 4-1. South Fork Coeur d'Alene River and tributaries. Mines and mills specifically discussed in the text are shown. Inset shows South Fork Coeur d'Alene River reach designations used in the assessment of injury to surface water resources described in this chapter. See Section 4.4.6 for reach descriptions.

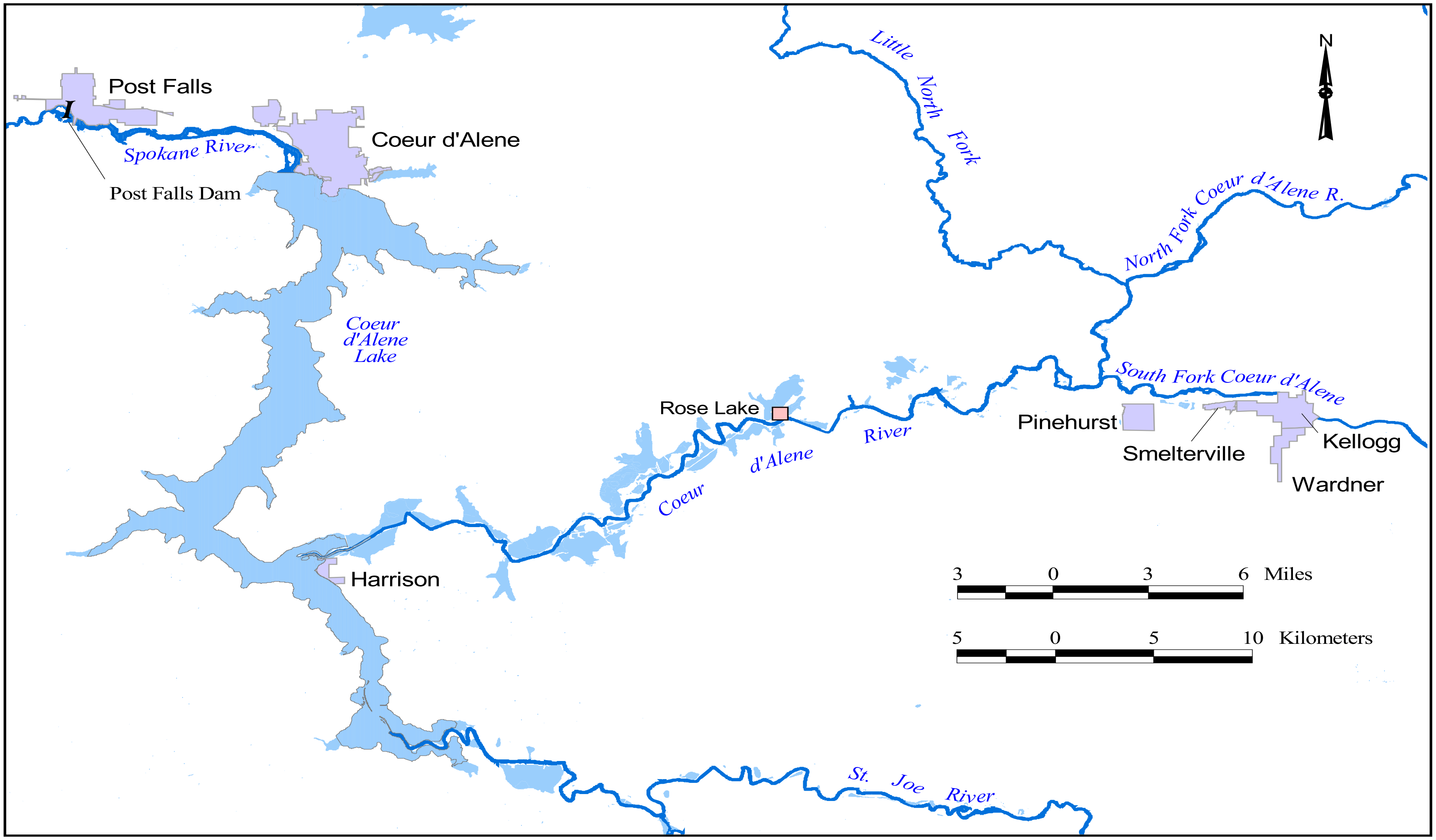

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Figure 4-2. Coeur d'Alene River basin and vicinity, showing the North Fork Coeur d'Alene River, South Fork Coeur d'Alene River, mainstem Coeur d'Alene River, Coeur d'Alene Lake, the upper Spokane River, and the St. Joe River.

The mainstem Coeur d'Alene River area extends from the confluence of the North and South Fork Coeur d'Alene rivers southwest to Coeur d'Alene Lake near Harrison, Idaho. Downstream of the North and South Fork Coeur d'Alene River confluence, the floodplain of the Coeur d'Alene River broadens, averaging 2 to 3 miles. The channel gradient is about 1 foot per mile, and the river is both deeper and slower moving than it is upstream. Many lakes and wetlands border the mainstem channel. The floodplain, lakes, and wetland areas of the lower basin are collectively known as the lateral lakes. The lateral lakes include thousands of acres of marshy wetlands (Bookstrom et al., 1999). The lakes vary from 85 to 640 acres, with a maximum depth of about 50 feet. The Coeur d'Alene River drains approximately 1,475 square miles (USGS, 1997).

Coeur d'Alene Lake is a large natural lake fed mainly by the Coeur d'Alene River and the St. Joe River. The drainage area of Coeur d'Alene Lake is approximately 3,440 square miles (Woods and Beckwith, 1997). Coeur d'Alene Lake discharges to the Spokane River at the north end of the lake. Lake elevation is controlled by the Post Falls Dam on the Spokane River near the Idaho-Washington state line. The normal full pool elevation for the Coeur d'Alene Lake is 2,128 feet msl (WWPC, 1996). At this elevation, the lake's surface area is approximately 50 square miles, mean depth is about 72 feet, and maximum depth is about 209 feet (CLCC, 1996). Operation of the Post Falls Dam also affects the surface water elevation and hydraulics of the lower segments of the mainstem Coeur d'Alene River and lateral lakes.

4.3 INJURY DEFINITIONS

Injury to a surface water resource results from the release of a hazardous substance if one or more of the following changes in the physical or chemical quality of the resource is measured:

- Concentrations and duration of substances in excess of applicable water quality criteria established by section 304(a)(1) of the CWA (Clean Water Act), or by other federal or state laws or regulations that establish such criteria, in surface water that before the discharge or release met the criteria and is a committed use, as that phrase is used in this part, as a habitat for aquatic life, water supply, or recreation [43 CFR § 11.62(b)(1)(iii)].

- Concentrations of substances on bed, bank, or shoreline sediments sufficient to have caused injury as defined . . . to groundwater, air, geologic, or biological resources, when exposed to surface water, suspended sediments, or bed, bank, or shoreline sediments [43 CFR § 11.62(b)(1)(v)].

In this chapter, data confirming exceedences of water quality criteria and concentrations in surface water sufficient that surface water serves as a pathway of injury to downstream surface water resources are presented. In addition, data confirming that surface water causes injury to aquatic biological resources (specifically, phytoplankton) are discussed. Subsequent chapters present data confirming that surface water serves as a pathway of injury to other resources.

4.3.1 Applicable Water Quality Criteria

Applicable water quality criteria include:

- national water quality criteria developed pursuant to section 304(a)(1) of the Clean Water Act
- Coeur d'Alene Tribal water quality criteria
- federal water quality criteria promulgated for the State of Idaho under the National Toxics Rule (NTR), as revised
- State of Idaho water quality criteria.

In accordance with requirements of section 304(a)(1) of the Clean Water Act, the U.S. EPA develops, publishes, and periodically revises national recommended water quality criteria that are generally applicable to the waters of the United States. The criteria address risks to both human health and aquatic life. For the metals addressed in this report, the most stringent 304(a)(1) criteria that apply to waters of the Coeur d'Alene River basin are criteria designed to protect aquatic life. These criteria are generally referred to as aquatic life criteria (ALC).

Federal ALC for metals were originally expressed as total recoverable metal concentrations. The use of total recoverable concentrations was considered to be the simplest, most conservative approach for application to a large number of water bodies of varying water quality. In 1993, based on further scientific review and comment, the U.S. EPA revised its policy on metal criteria. U.S. EPA now recommends the use of dissolved metal concentrations for establishing compliance with ALC, because dissolved metal concentrations more closely approximate the bioavailable fraction of metal in the water column (58 Federal Register 32131, June 8, 1993). The most recent modifications of and corrections to the ALC are contained in U.S. EPA (1999), and it is these criteria that were used to assess injury to surface water in the Coeur d'Alene basin.

In 1992, the U.S. EPA promulgated the NTR, which applied federal water quality criteria to a number of states, including Idaho, that had failed to fully comply with CWA requirements to develop adequately protective criteria for priority toxic pollutants. On February 5, 1993, the NTR criteria became the legally enforceable water quality standards in Idaho for all purposes and programs under the Clean Water Act. Based on the change in U.S. EPA policy for applying metals criteria, the NTR aquatic life criteria for 11 metals, including cadmium, lead, and zinc, were revised in 1995 to express the criteria as dissolved concentrations rather than total recoverable concentrations (60 Federal Register 22228, May 4, 1995). As of April 12, 2000, U.S. EPA withdrew Idaho from the NTR for all aquatic life criteria because the state adopted criteria that are identical to the federal criteria (65 Federal Register 19659, April 12, 2000).

The Coeur d'Alene Tribe has adopted water quality standards for the surface waters of the Coeur d'Alene Reservation. Aquatic life criteria in the tribal standards are based on NTR criteria, and the equations for calculating aquatic life criteria for cadmium, lead, and zinc are identical to those in the NTR. However, if hardness values are below 25 mg/l as $CaCO_3$, the Tribe uses the actual hardness, whereas a hardness of 25 mg/l would be used under the NTR and for section 304(a)(1) of the Clean Water Act (see following section).

For lead, the state criteria, the current recommended 304(a)(1) criteria, the NTR criteria, and the tribal criteria are identical. For cadmium and zinc, the current recommended 304(a)(1) criteria and the identical state criteria are slightly less stringent than the NTR criteria. Therefore, any exceedences of the state criteria are also exceedences of the federal criteria, the NTR criteria, and the tribal criteria.

4.3.2 Calculation of ALC

The toxicity of cadmium, lead, and zinc to aquatic species varies with water hardness. Water hardness is measured as the amount of calcium and magnesium present and is expressed as milligrams of calcium carbonate ($CaCO_3$) per liter. Cadmium, lead, and zinc are more toxic at low hardness values than at high hardness values, and the equations used to calculate freshwater ALC for these metals incorporate water hardness.

The ALC for cadmium, lead, and zinc are expressed in terms of a criterion maximum concentration (acute criterion) and a criterion continuous concentration (chronic criterion). The acute criterion is an estimate of the highest concentration of a substance in surface water to which an aquatic community can be exposed briefly without an unacceptable effect. The chronic criterion is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without an unacceptable effect (63 Federal Register 68364, December 10, 1998).

The acute and chronic criteria are each one of three components that constitute an ALC (U.S. EPA, 1987). The other two parts are the averaging period and the frequency of allowable exceedence. For cadmium, lead, and zinc, the acute averaging period is 1 hour, the chronic averaging period is 4 days, and the frequency of allowable exceedence for both chronic and acute criteria is no more than once every 3 years. For example, the chronic ALC for cadmium at a hardness value of 25 mg/L is a 4-day average concentration of 0.80 µg/L not to be exceeded more than once every three years.

The equations developed by U.S. EPA to calculate freshwater total recoverable metals criteria (µg/L) are:

$$\text{acute criteria} = e^{\left[m_A\left[\ln(\text{hardness})\right]+b_A\right]}$$

$$\text{chronic criteria} = e^{\left[m_C\left[\ln(\text{hardness})\right]+b_C\right]}.$$

The values for the variables m and b for these equations for cadmium, lead, and zinc are presented in Table 4-1.

Table 4-1
Variables m and b for Acute and Chronic ALC

Metal	Acute Criteria		Chronic Criteria	
	m_A	b_A	m_C	b_C
Cadmium	1.128	-3.6867	0.7852	-2.715
Lead	1.273	-1.460	1.273	-4.705
Zinc	0.8473	0.884	0.8473	0.884

The dissolved metals criteria are derived by multiplying the total recoverable metal acute and chronic criteria by a conversion factor. The conversion factors for cadmium and lead are themselves hardness dependent (Table 4-2).

Table 4-2
Equations Used to Convert the Total Acute (CMC) and Chronic (CCC) Criteria to Dissolved Criteria

Metal	CMC Conversion Factor	CCC Conversion Factor
Cadmium	1.136672-[ln(hardness)(0.041838)]	1.101672-[ln(hardness)(0.041838)]
Lead	1.46203-[ln(hardness)(0.145712)]	1. 46203-[ln(hardness)(0.145712)]
Zinc	0.978	0.986
Source: 63 Federal Register 68364, December 10, 1998.		

The equations are applicable for hardness values within the range of 25 to 400 mg/L $CaCO_3$ [40 CFR § 131.36 (c)(4)(i)]. In the past, the U.S. EPA generally recommended that 25 mg/L as $CaCO_3$ be used as a default hardness value in deriving aquatic life criteria for metals when the actual hardness value is below 25 mg/L. However, use of this approach results in criteria that may not be fully protective (62 Federal Register 42175, August 5, 1997). The U.S. EPA now recommends that, for waters with a hardness value less than 25 mg/L, the criteria should be calculated using the actual ambient hardness of the surface water. The Coeur d'Alene Tribal aquatic life criteria for metals are derived based on actual hardness values in surface waters, and the resulting criteria are more stringent than NTR criteria at low hardness values (i.e., below 25 mg/L).

For this assessment, where hardness was less than 25 mg/L, a value of 25 mg/L was used to calculate the ALC. Using this approach, any exceedences of the current recommended 304(a)(1) criteria are also exceedences of the Tribal criteria. No values greater than 400 mg/L were found in the data. Table 4-3 compares current national recommended 304(a)(1) criteria, NTR criteria for the State of Idaho, and Coeur d'Alene Tribal criteria for dissolved cadmium, lead, and zinc at hardness values of 15, 50, and 100 mg/L as $CaCO_3$. The criteria for a hardness of 15 mg/L for the 304(a)(1) Clean Water Act and the NTR are the same as for a hardness of 25 mg/L. At a hardness of 15 mg/L, the Tribe's criteria are lower. Hardness values of 15 mg/L and lower are common in the upper South Fork, upper Ninemile Creek, upper Canyon Creek, and many other streams in the Coeur d'Alene basin (see Section 4.5.2).

Table 4-3
Comparison of Current 304(a)(1) ALC, National Toxics Rule ALC, and Coeur d'Alene Tribal Water Quality Standards

Water Quality Criteria	Hardness = 15 mg/L			Hardness = 50 mg/L			Hardness = 100 mg/L		
	Cd (µg/l)	Pb (µg/l)	Zn (µg/l)	Cd (µg/l)	Pb (µg/l)	Zn (µg/l)	Cd (µg/l)	Pb (µg/l)	Zn (µg/l)
Acute Criteria									
Current Federal 304(a)(1) Criteria; State Criteria	0.95	13.9	36.2	2.01	30.1	65.1	4.27	64.5	117
National Toxics Rule Criteria for Idaho	0.82	13.9	35.4	1.74	30.1	63.6	3.70	64.5	114
Coeur d'Alene Tribal Water Quality Standards	0.47	7.8	23.0	1.74	30.1	63.6	3.70	64.5	114
Chronic Criteria									
Current Federal 304(a)(1) Criteria; State Criteria	0.80	0.54	36.5	1.34	1.18	65.7	2.24	2.52	118
National Toxics Rule Criteria for Idaho	0.37	0.54	32.2	0.62	1.18	58.1	1.03	2.52	104
Coeur d'Alene Tribal Water Quality Standards	0.26	0.30	20.9	0.62	1.18	58.1	1.03	2.52	104

4.3.3 Committed Use Determination

To determine injury, concentrations of hazardous substances are compared to ALC in surface waters with “committed uses” of habitat for aquatic life, water supply, or recreation. A committed use means either a current public use or a planned public use of a natural resource for which there is a documented legal, administrative, budgetary, or financial commitment established before the release of a hazardous substance is detected [43 CFR § 11.14(h)]. The most stringent criterion values or standards apply when surface water is used for more than one committed use [43 CFR §11.62(b)(iii)].

For cadmium, lead, and zinc, the chronic ALC are the most stringent criteria or standards that apply to surface waters of the Coeur d’Alene River basin. The ALC promulgated in the NTR for the State of Idaho apply to all surface waters whose designated uses include cold water biota, warm water biota, and salmonid spawning [40 CFR § 131.36(d)(13)]. Federal ALC are generally applicable to all waters of the United States.

The State of Idaho has classified all surface waters in the Coeur d’Alene River basin for the protection of cold water biota, except the South Fork Coeur d’Alene River downstream of Daisy Gulch, and Canyon Creek and Shields Gulch downstream of mining operations. All surface waters that the state has not specifically classified must support all designated uses, including aquatic life uses.

On July 31, 1997, the U.S. EPA promulgated federal water quality standards for Idaho. The standards added the cold water biota use designation to Canyon Creek downstream of mining operations, to the South Fork Coeur d’Alene River from Daisy Gulch to the mouth, and to Shields Gulch downstream of mining operations. In its final rule, the U.S. EPA indicated that “information and data obtained from the Idaho Division of Environmental Quality support cold water biota as an existing use for the South Fork Coeur d’Alene River.” In designating uses for the surface waters, the U.S. EPA also relied on the rebuttable presumption implicit in the Clean Water Act and U.S. EPA’s regulations at 40 CFR part 131, that in the absence of data to the contrary, “fishable” uses are attainable (62 Federal Register, 42175, July 31, 1997).

Based on state use designations and those added under federal law which apply to state waters, all surface waters within the Coeur d’Alene River basin are currently designated for the protection and support of cold water biota.

4.4 COMPILATION AND ANALYSIS OF EXISTING DATA

To evaluate injury to surface water, existing data were compiled, screened for data quality, and compared to acute and chronic ALC (Ridolfi, 1995, 1999). Sources of data included the U.S. EPA’s Storage and Retrieval of U.S. Waterways Parametric Data (STORET) database, data collected for the Bunker Hill RI/FS and the Coeur d’Alene Basinwide RI/FS by U.S. EPA and its contractors, and data collected by the Idaho Division of Environmental Quality (IDEQ), the U.S. Geological Survey (USGS), the U.S. Bureau of Land Management (U.S. BLM), and the Silver Valley Natural Resource Trustees (SVNRT). The data compiled include hardness and both total recoverable and dissolved concentrations of cadmium, lead, and zinc.

Data retained for use in the injury determination are data obtained from sources that used methods and quality assurance/quality control (QA/QC) protocols that are generally accepted or have been scientifically verified and documented [43 CFR § 11.64(b)]. Data sources used in the injury assessment are summarized in the following sections.

4.4.1 U.S. EPA Data

STORET. STORET is a repository of surface water data collected by U.S. EPA and other federal and state agencies. STORET data used in the injury assessment were collected by or for U.S. EPA and Idaho Department of Health and Welfare (IDHW). Most of the STORET data used in the injury assessment are associated with a long-term U.S. EPA monitoring program in the basin (Hornig et al., 1988) and the Bunker Hill RI/FS (Dames & Moore, 1990). Samples taken as a part of these two programs were collected and analyzed according to standard, accepted U.S. EPA methods and QA/QC protocols.

Coeur d'Alene Basinwide RI/FS data. U.S. EPA has collected surface water quality data as part of the Coeur d'Alene Basinwide RI/FS, primarily in the South Fork Coeur d'Alene River drainage basin (data collection and analysis was ongoing at the time of the preparation of this document). Surface water data, mostly collected during fall 1997 and spring 1998, were available for use in this injury assessment. In addition, samples collected from Coeur d'Alene Lake in 1999 were available. The samples were collected and analyzed according to current standard, accepted U.S. EPA methods and QA/QC protocols.

Bunker Hill RI/FS data. Surface water quality data were collected in 1986 and 1987 at eight stations on the South Fork Coeur d'Alene River for the Bunker Hill RI/FS (Dames & Moore, 1990). Most of the data for these stations were retrieved from STORET. Additional data were compiled from Dames & Moore (1990). The samples were collected and analyzed according to standard, accepted U.S. EPA methods and QA/QC protocols.

4.4.2 IDEQ Data

The IDEQ collected surface water quality data as part of a trace elements monitoring program in the South Fork Coeur d'Alene River drainage (Harvey, 1993). Samples were collected approximately monthly during the 1994, 1995, and 1996 water years. In addition, IDEQ collected water quality data as part of an investigation of point and nonpoint sources of heavy metals to the South Fork Coeur d'Alene River upstream of Canyon Creek (Hartz, 1993). Samples associated with these two programs were collected and analyzed using IDEQ-specified methods and accepted QA/QC protocols.

4.4.3 USGS Data

USGS has collected water quality data, including metal concentrations, in the Coeur d'Alene River basin since the 1960s. Most of the water quality samples were collected in conjunction with water flow measurements at gauging stations. USGS gauging stations have variable periods of records, and some of the older stations are no longer monitored. Data for stations included within the Coeur d'Alene River basin are maintained in the district database by the Idaho District. Most of the USGS data used in the injury assessment were acquired from the district database. In addition, data from recent district water year books were compiled for use in the injury assessment. Samples were collected and analyzed according to standard USGS-specified methods and QA/QC protocols.

4.4.4 U.S. BLM Data

Surface water quality data for the mainstem Coeur d'Alene River and Pine Creek were obtained from the U.S. BLM Coeur d'Alene Office. Data for the mainstem Coeur d'Alene River were obtained as part of a river water quality monitoring program (1991 through 1993) and a draft Preliminary Assessment/Site Investigation conducted during 1992 for U.S. BLM by IDEQ (U.S. BLM, undated). Data for Pine Creek were available in a draft preliminary assessment report (CCJM, 1994). Samples associated with these programs were collected and analyzed using standard, acceptable IDEQ and U.S. BLM-specified methods and QA/QC protocols.

4.4.5 Silver Valley Natural Resource Trustee Data

Surface water quality data were obtained for the Silver Valley Natural Resource Trustees during a 1991 water quality study of the South Fork Coeur d'Alene River and its tributaries (MFG, 1991, 1992). Samples were collected once in the spring (May 1991) and once in the fall (October 1991). Samples were collected and analyzed according to standard, accepted U.S. EPA methods and QA/QC protocols.

4.4.6 Data Analysis

The DOI NRDA regulations stipulate that surface water samples used in assessing injuries meet a specific acceptance criterion:

- The acceptance criterion for injury to the surface water resource is the measurement of concentrations of . . . a hazardous substance in two samples from the resource. The samples must be one of the following types: (A) Two water samples from different locations, separated by a straight-line distance of not less than 100 feet; . . . or (D) Two water samples from the same location collected at different times [43 CFR § 11.62(b)(2)(i)].

The water quality data compiled for the injury determination include numerous stations throughout the Coeur d’Alene River basin. Many of these stations have been sampled repeatedly during different seasons and under a variety of flow conditions. The data used to assess injury meet the acceptance criterion.

Water quality data from the sources identified above were compiled by reach (Table 4-4 and Figures 4-1 and 4-2). For many tributaries to the South Fork Coeur d’Alene River (e.g., Portal Gulch, Moon Creek, Big Creek), surface water data exist only for stations near the mouths of the tributaries. For a number of the tributaries assessed for injury in Table 4-4, no reaches were assigned. In these cases, surface water sampling location identifications were used instead of reach abbreviations. Data from individual reaches and data from the mouths of certain tributaries were compared to federal water quality criteria for determination of injury.

4.5 INJURY DETERMINATION EVALUATION

4.5.1 Pathway Determination

Hazardous substances have been and continue to be transported from mining and mineral processing sources to surface water resources. Pathways of hazardous substances to surface water include groundwater, surface water, and sediments. Resources that serve as a pathway of injury to surface water are, themselves, injured [43 CFR 11.62 (b)(v) and (c)(iv)].

Groundwater. The determination of groundwater as a pathway for contamination of surface water is described in general terms because of the lack of comprehensive data on aquifer properties and groundwater hazardous substance concentrations in the Coeur d’Alene River basin. Groundwater upgradient of surface water resources can be a pathway for transport of heavy metals from mining and mineral processing-related sources to surface water. Mine waters that discharge from adits can transport heavy metals to surface water resources. Groundwater and surface runoff interacting with waste rock can dissolve and transport heavy metals to surface waters. Groundwater and surface runoff interacting with both upland tailings piles and mixed tailings and alluvium in floodplains can also dissolve and transport heavy metals to surface water resources.

Table 4-4
Surface Waters Assessed for Injury in the Coeur d'Alene Basin

Reach Abbreviation/ Location ID	Reach Description	Period of Record[a]
South Fork Coeur d'Alene River		
SFCDR-1	Headwaters to Daisy Gulch	1968-1998
SFCDR-2	Daisy Gulch to Canyon Creek	1971-1995
Tributaries		
SF 223, 317, 318, 319	Grouse Gulch downstream of Star Mine waste rock dumps	1997-1998
SFCDR-3	Canyon Creek to Milo Creek	1971-1998
Tributaries		
CC-1	Headwaters to O'Neill Gulch	1979-1998
CC-2	O'Neill Gulch to mouth	1971-1998
CC 392	Gorge Gulch downstream of Hercules No. 3 adit	1991, 1998
NM-1	Headwaters upstream of Interstate-Callahan Mine[b]	1991-1998
NM-2	Interstate-Callahan Mine to mouth	1971-1998
SFCDR-4	Milo Creek to Pine Creek	1967-1998
Tributaries		
MC 262	Moon Creek downstream of Charles Dickens Mine/Mill	1991-1998
SF 183, 184, 186, 187	Milo Creek downstream of Sullivan adits	1997-1998
SF 104	Portal Creek downstream of North Bunker Hill West Mine	1997
SF 100, 101, 102, 103	Deadwood Gulch/Bunker Creek downstream of Ontario Mill	1997-1998
SF 110	Government Gulch downstream of Senator Stewart Mine	1997-1998
PC-1	East Fork Pine Creek upstream of Constitution Upper Mill[c]	1993-1998
PC-2	Constitution Mine downstream to mouth of East Fork	1993-1998
PC-3	Mainstem Pine Creek from mouth to EF confluence	1972-1998
PC 307, 322, 323	Highland Creek downstream of Highland Surprise Mine/Mill	1993-1998
PC 308, 324	Denver Creek downstream of Denver Mine	1993-1998
PC 310, 326	Nabob Creek downstream of Nabob Mill	1997-1998
SFCDR-5	Pine Creek to North Fork Coeur d'Alene River	1966-1986
Lower Coeur d'Alene River		
CDR-1	Confluence of North and South Forks to Cataldo	1968-1997
CDR-2	Cataldo to Rose Lake	1968-1997
CDR-3	Rose Lake to Harrison	1966-1998
Coeur d'Alene Lake		
CDAL	Coeur d'Alene Lake	1971-1999

a. The period of record is the range of years in which water quality samples were collected and analyzed, and is not continuous for any reach. The period of record used in this injury assessment extends through 1998.
b. Also includes several samples from tributaries to the East Fork of Ninemile Creek downstream of the Interstate-Callahan Mine, which are unexposed to mine wastes.
c. Also includes several samples from tributaries to Pine Creek downstream of the Constitution Upper Mill, which are unexposed to mine wastes.

CC: Canyon Creek; NM: Ninemile Creek; MC: Moon Creek; PC: Pine Creek.

The groundwater system in the South Fork Coeur d'Alene River basin west of Kellogg is divided into three hydrostratigraphic units: an upper alluvial zone, a middle lacustrine confining zone, and a lower alluvial zone (Dames & Moore, 1991). The upper zone consists of mixed jig and flotation tailings and alluvium underlain by natural alluvium, and reaches thicknesses of 30-40 feet in eastern Smelterville Flats. The alluvium consists of silty to clay sand and gravel with lenses of sand and gravel. Thicknesses of mixed tailings and alluvium are greatest (more than 7 feet) near the CIA and in central Smelterville Flats.

The middle confining zone, which consists of lacustrine silts and clays, retards vertical groundwater flow between the upper and lower zones (Dames & Moore, 1991). The confining zone is believed to end beneath Kellogg between the mouths of Milo and Portal gulches (Dames & Moore, 1991). Thicknesses range from 0 feet near Kellogg to over 50 feet near Smelterville Flats. The composition of the lower zone is similar to the alluvium in the upper zone. The lower zone alluvium is deposited on bedrock of the Belt Supergroup rock. Unlike the upper zones, the lower zone is thickest (>50 feet) near Kellogg and thins westward. East of Kellogg, there is no confining zone, and the upper and lower alluvial units merge into one, unconfined alluvial unit (Dames & Moore, 1991).

Upper zone groundwater flow is largely unconfined, although seasonal and local confinement may occur where overlying tailings are fine grained and in contact with the water table. The saturated thickness of the upper zone ranges from approximately 3 to 40 feet, thickening to the west near the central and western areas of Smelterville (Dames & Moore, 1991). During seasonal high water conditions, the bottom portion of the tailings deposits may become locally saturated (Dames & Moore, 1991). Groundwater elevations in the upper zone fluctuate seasonally and are recharged by precipitation and snowmelt. Groundwater levels are highest in the spring during periods of increased snowmelt and precipitation, and lowest during winter and early spring when precipitation is lowest and snow is not melting (Dames & Moore, 1991).

Groundwater flow in the upper zone is predominantly east to west, with north-south flow near losing and gaining reaches of the South Fork Coeur d'Alene River and near mouths of tributary gulches (Dames & Moore, 1991). Gaining and losing reaches are believed to be associated with variations in valley width. Where the valley widens, the water table falls below the river channel bed surface, and the channel loses water to the upper zone. Where the valley constricts, upper zone groundwater discharges to the river.

Hydraulic conductivity was measured in each of the three groundwater flow zones. Hydraulic conductivity was highest in the upper zone, ranging from 500-10,790 ft/day, and lowest in the confining zone, ranging from 0.00028-0.028 ft/day (Dames & Moore, 1991). Hydraulic conductivity in the lower alluvial aquifer ranged from 100-1,910 ft/day. Transmissivity ranged from 10,002-216,852 ft^2/day in the upper zone and 3,220-80,000 ft^2/day in the lower zone (Dames & Moore, 1991).

In losing sections of stream, surface water can be a pathway to shallow alluvial groundwater. Conversely, in gaining sections of stream, groundwater can be a pathway for contamination of surface water. Surface water/groundwater interactions are evident in gaining and losing sections of the river as seasonal and perennial seeps, and during seasonal flooding and subsequent receding of floodwaters. In losing stream reaches where the valley floor widens, such as in lower Canyon Creek and at Osburn Flats on the South Fork Coeur d'Alene River, water leaves the stream channel and enters the floodplain aquifer (Dames & Moore, 1991). Where the valley constricts, groundwater discharges back to the stream (Dames & Moore, 1991). Hazardous substances leached from the floodplain tailings deposits in these wider reaches of the valley are transferred to the stream with the returning groundwater.

Streams may lose water to groundwater during high flow, and gain water from groundwater during low flow. For example, in the lower Coeur d'Alene River basin, after seasonal flooding and saturation of wetland sediments, groundwater stored in the sediments slowly drains to the river and lakes as the water table lowers during the drier months, and hazardous substances leached from the mixed tailings and alluvium are transferred back to surface waters.

Gaining and losing reaches between Elizabeth Park and Pinehurst on the South Fork Coeur d'Alene River were measured in September 1987 (Dames & Moore, 1991). Between Elizabeth Park and Milo Gulch, the South Fork gained 4.1 ft^3/s. Between Milo Gulch and Deadwood Gulch, the South Fork lost 8.6 ft^3/s. This reach includes the eastern half of the CIA. From the middle of the CIA to Government Gulch, the South Fork gained 3.9 ft^3/s. This indicates that while mill discharge was being applied to the CIA, drainage from at least half of the CIA was being transported to the South Fork. From Smelterville to the Page Ponds, the South Fork lost 2.6 ft^3/s; from the Page Ponds to downstream of Pine Creek, it gained 11.8 ft^3/s. Although the locations of gaining and losing sections of stream probably vary seasonally, the alternating gaining and losing sections in this part of the South Fork indicate that exchange between alluvial groundwater and stream water is extensive and that contaminated groundwater and surface water each are a pathway for contamination of the other.

Metal loadings to Ninemile Creek, Canyon Creek, and the South Fork Coeur d'Alene River confirm that groundwater discharges hazardous substances to surface water. For example, groundwater discharge in Canyon Creek accounts for the majority of zinc (200-300 lb/day) gained in the stream (Box et al., 1997). Near Osburn Flats, groundwater discharges approximately 100-150 lbs of zinc/day to the South Fork, and in western Smelterville Flats, groundwater discharges to surface water between 300 and 600 lbs of zinc/day (Box et al., 1997).

Concentrations of dissolved cadmium, lead, and zinc in groundwater samples collected in Osburn Flats on the South Fork Coeur d'Alene River (Table 4-5) and in lower Canyon Creek (Table 4-6) are presented below. Both areas contain extensive floodplain tailings deposits that are sources of groundwater contamination. The concentrations of dissolved cadmium and zinc in Osburn Flats groundwater are well above acute ALC values, and concentrations of dissolved lead are well above chronic ALC values. As noted above, groundwater in this area discharges to the South Fork in gaining reaches and serves as a pathway for contamination of surface water.

Table 4-5
Dissolved Metals Concentrations in Groundwater from Osburn Flats, South Fork Coeur d'Alene River

Sample ID	Cadmium (µg/L)	Zinc (µg/L)	Lead (µg/L)
GW-TP-4-16-D	139	20,700	23
GW-TP-4-17-T	492	56,300	48
GW-TP-4-18-T	231	26,000	57
Data source: Silver Valley Natural Resource Trustees, 1997, as cited in Ridolfi, 1998.			

Concentrations of metals in the shallow alluvial groundwater in lower Canyon Creek are also extremely elevated. Mean concentrations were 33,900 µg/L of zinc, 260 µg/L of cadmium, and 1,450 µg/L of lead (Houck and Mink, 1994). Houck and Mink concluded that "a significant portion of these metals discharge to the lower portion of Canyon Creek from the ground water system." Table 4-6 presents dissolved zinc concentrations in groundwater in lower Canyon Creek. These data confirm that groundwater concentrations of zinc are extremely elevated in lower Canyon Creek. Where groundwater discharges to the stream, groundwater serves as a pathway for contamination of surface water in the Canyon Creek drainage.

Groundwater draining these and other areas in the South Fork Coeur d'Alene River basin may account for as much as 80% of the dissolved metal loading to the South Fork (Box et al., 1997). In addition to the discharge of contaminated groundwater to streams in floodplains, seepage from adits can contaminate downgradient surface water. Numerous adits and seeps in the South Fork Coeur d'Alene River watershed discharge groundwater directly to surface water resources. The discharge associated with many of these seeps and adits contains heavy metals in concentrations that exceed federal water quality criteria (Tables 2-18 through 2-23, Chapter 2).

Table 4-6
Dissolved Zinc Concentrations in Groundwater,
Lower Canyon Creek, April 1993 and April 1997

Well	Dissolved Zinc (mg/L)			
	Mean	**Minimum**	**Maximum**	**Number of Samples**
WP-1	51.4	22.3	93.4	8
WP-2	17.9	10.6	27.2	7
WP-3	23.2	19.4	28.3	6
WP-4	20.8	17.0	24.1	7
WP-5	16.7	2.6	31.8	6
T-2	21.8	3.9	50.0	7
T-3	29.7	20.9	38.9	6
T-4	58.1	17.3	145	7
T-5	26.4	6.5	44.7	7
T-6	36.0	28.5	43.4	2
T-7	19.2	5.1	46.8	7
CM-1	0.83	0.18	1.6	5
CM-2	9.9	6.5	14.6	3
CM-3	48.3	23.8	79.6	5
CM-4	98.7	37.9	172	6
CM-5	48.1	14.9	89.5	5
CM-6	55.7	14.1	116	5
CM-7	21.1	5.2	39.2	5
CM-8	12.0	5.5	15.6	5
CM-9	5.2	0.85	10.2	5
CM-10	42.7	27.9	54.6	5
CM-11	42.4	15.1	105	5
CM-12	15.7	7.0	27.3	5

Data for wells with more than one measurement are shown.

Data source: MFG, 1998.

Surface Water and Sediments. Surface water carries heavy metals from mining and mineral processing-related sources to downstream surface water resources, including suspended sediments. Surface runoff erodes tailings accumulations and waste rock piles, transporting heavy metals into streams. Surface water remobilizes previously released tailings that are mixed with alluvium in stream beds, banks, and floodplains and transports heavy metal-bearing particulates to downstream surface water resources. Hydrologic processes associated with sediment transport in streams are discussed in Chapter 5.

Data collected in the Coeur d'Alene River basin demonstrate that surface water serves as a pathway to downstream surface water and sediments. Metal loadings data for the South Fork Coeur d'Alene River demonstrate ongoing releases from sources and transport of metals in surface water, resulting in increased metal loads to the river downstream (Ridolfi, 1998). Zinc loads in the South Fork generally increase from the Canyon and Ninemile Creek confluences with the South Fork to the North Fork confluence, with greater loadings and greater variability during high flow than during low flow (Figure 4-3). In both Canyon Creek (Figure 4-4) and Ninemile Creek (Figure 4-5), zinc loads increase with distance downstream of mining-related operations. As in the South Fork, loadings and variability during high flow are greater than during low flow.

The spatial distribution of metals concentrations in Coeur d'Alene Lake bottom sediments also indicates that the Coeur d'Alene River is a source of metals to lake sediments. Sediments near and downgradient of the mouth of the Coeur d'Alene River are enriched in zinc by up to 118 times relative to sediments from the south end of the lake (Table 4-7; see also Chapter 5). The south end of the lake receives surface water primarily from the St. Joe River.

4.5.2 Exceedences of Applicable Water Quality Criteria

In the following sections, measured dissolved concentrations are compared to ALC to determine if stream reaches or locations are injured [43 CFR §11.62 (b)(iii)]. The determination that surface water met the ALC before the release of hazardous substances is presented in Chapter 10.

Analytical detection limits for cadmium, lead, and zinc decreased during the past three decades (the period for which there are surface water data), as laboratory techniques and instrumentation improved. Detection limits for cadmium and lead associated with older data sets frequently exceed acute and chronic criteria, so concentrations near and lower than the criteria were not quantifiable. In some cases, analytical detection limits associated with newer data sets also exceed the criteria, particularly in low hardness waters where the criteria concentrations are also very low. For sample results that were below the detection limit, the detection limit value was compared to the applicable water quality criteria. If the detection limit was greater than the applicable water quality criteria, the result was eliminated from the data set since it is unknown whether the true concentration was greater or less than the criteria.

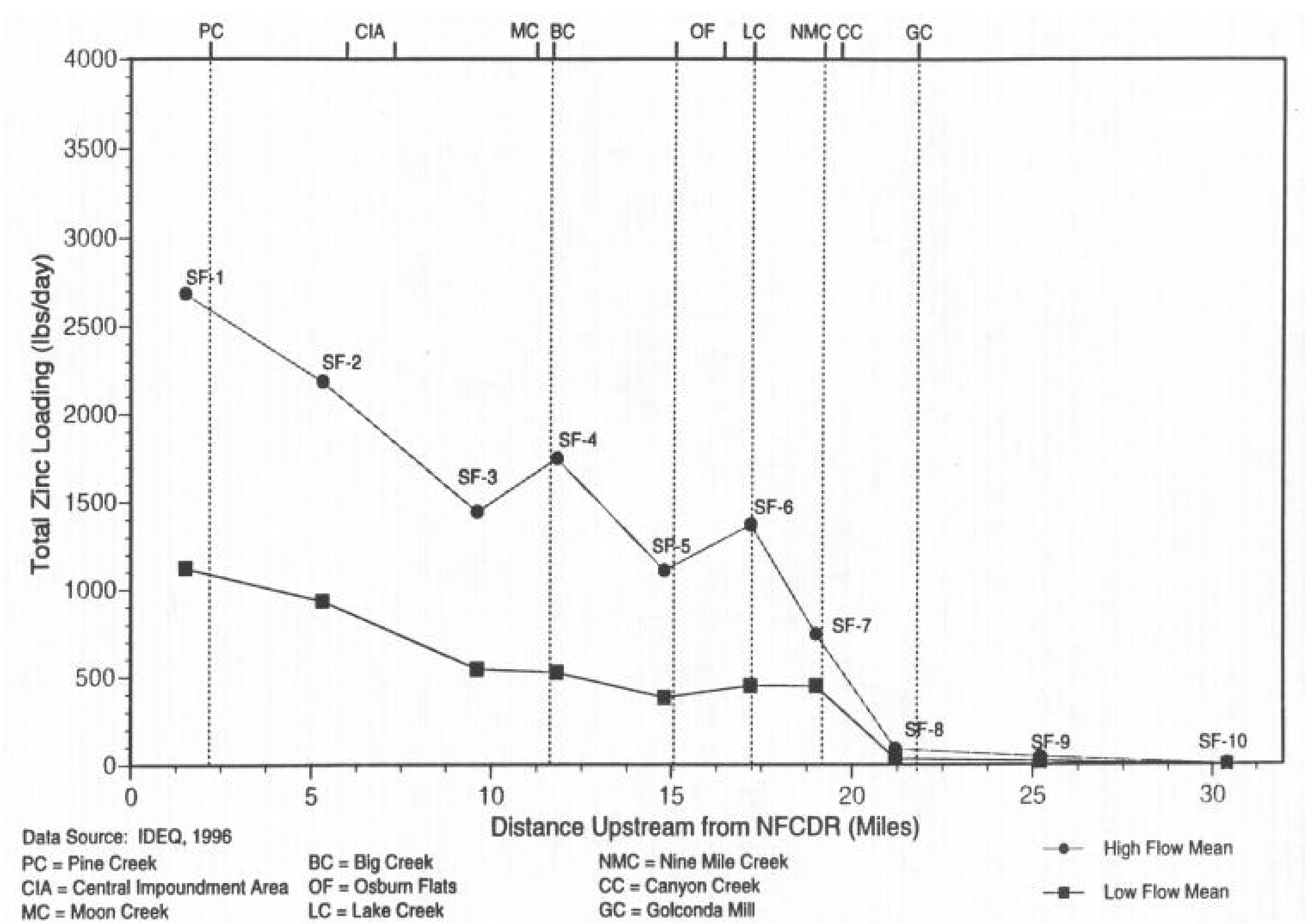

Figure 4-3. Total zinc loading, South Fork Coeur d'Alene River, 1994 water year.
Source: Ridolfi, 1999.

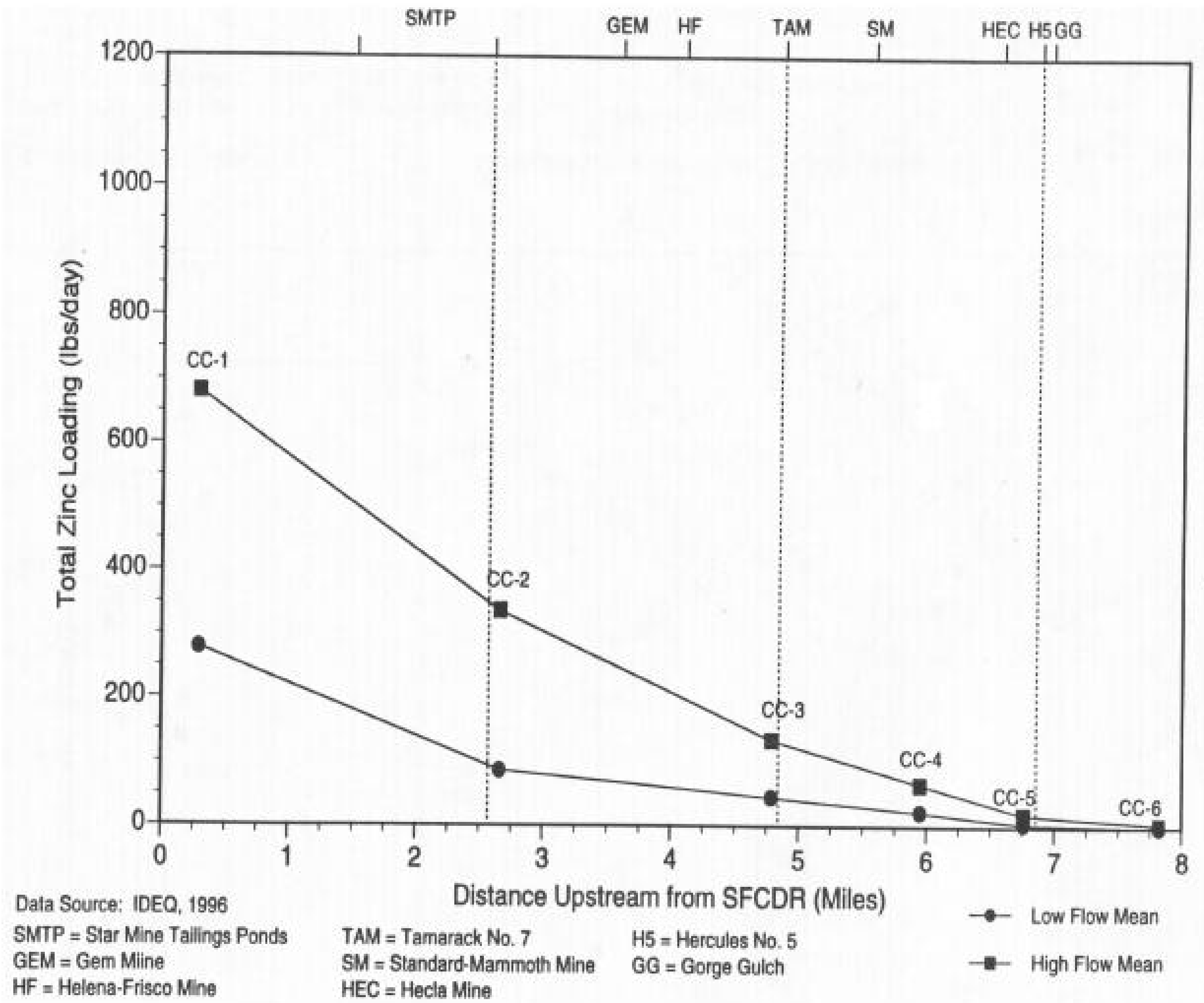

Figure 4-4. Total zinc loading, Canyon Creek, 1994 water year.
Source: Ridolfi, 1999.

For data sets that included both total and dissolved metal concentrations, the data were screened for dissolved concentrations that exceed total concentrations. Any sample for which the dissolved measurement exceeded the total measurement by more than 20% RPD (relative percent difference) was dropped from the data set, unless the dissolved concentration was less than or equal to the ALC. Overall, relatively few data pairs exceed the >20% RPD criterion.

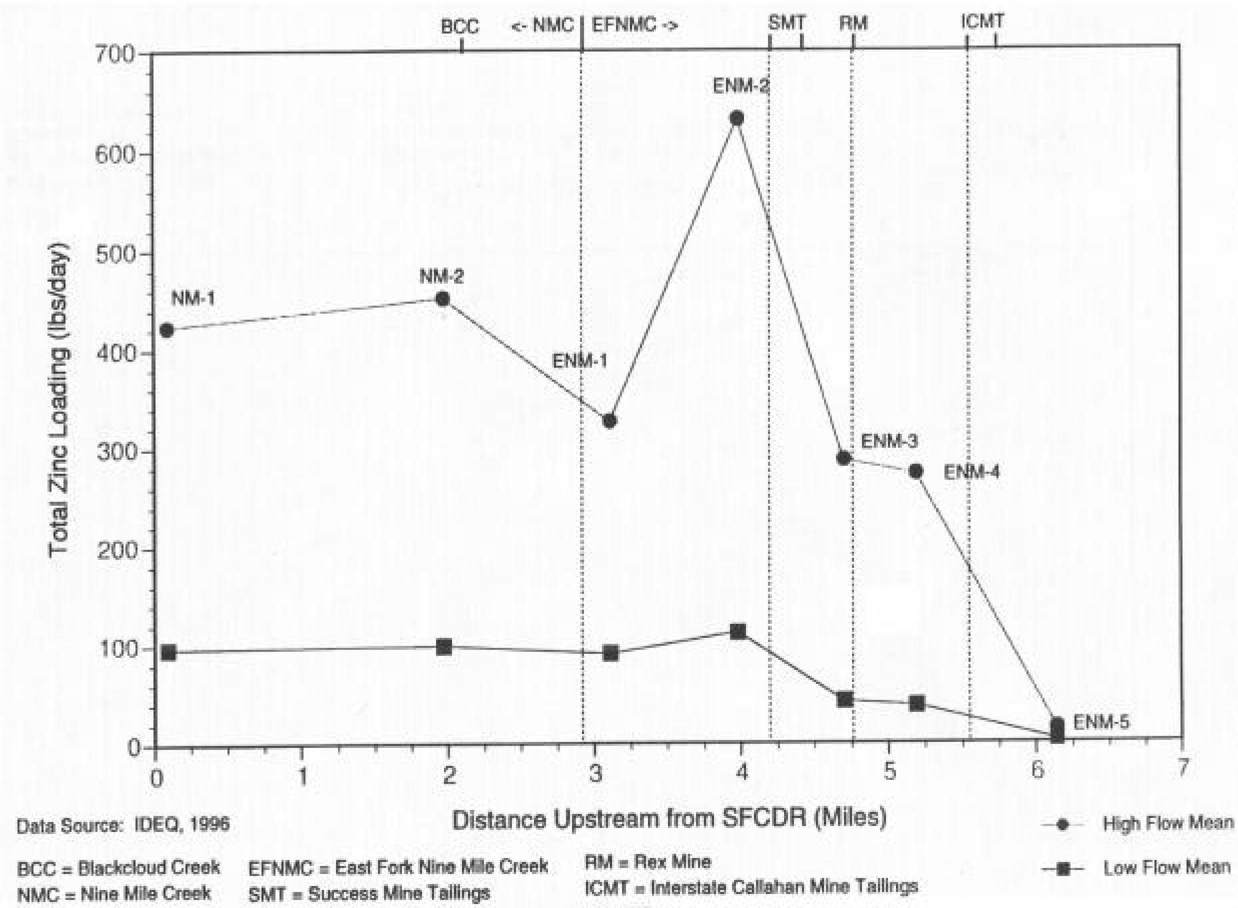

Figure 4-5. Total zinc loading. Ninemile Creek, 1994 water year.
Source: Ridolfi, 1999.

Acute ALC. Acute ALC are 1-hour average concentrations that are not to be exceeded more than once in a 3-year period (U.S. EPA, 1987). The recommended exceedence frequency of 3 years is the U.S. EPA's best scientific judgment of the average amount of time it will take an unstressed system to recover from a pollution event in which exposure to a contaminant exceeds the criterion. A stressed system (e.g., one in which several sources contribute pollutants in a small area) probably requires more time for recovery (U.S. EPA, 1987).

Table 4-7
Minimum, Maximum, Mean, and Median Hazardous Substance Concentrations in Surface and Subsurface Sediments from Coeur d'Alene Lake Near and Downgradient of the Coeur d'Alene River Delta

Element	Surface/ Core Sample[a]	Minimum (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Median (mg/kg)	Unenriched Median[b] (mg/kg)	Enrichment Factor[c]
Arsenic	S	2.4	660	151	120	4.7	26
	C	3.5	845	103	30	12	2.5
Cadmium	S	<0.5	157	62	56	2.8	20
	C	<0.1	137	25	26	0.3	87
Copper	S	9	215	72	70	25	2.8
	C	20	650	91	60	30	2.0
Lead	S	14	7,700	1,900	1,800	24	75
	C	12	27,500	3,200	1,250	33	38
Zinc	S	63	9,100	3,600	3,500	110	32
	C	59	14,000	2,400	2,100	118	18

a. S: surface samples (n = 150); C: subsurface core samples (n = 189).
b. Data from south end of Coeur d'Alene Lake.
c. Enrichment factor = median/unenriched median.

Data source: Horowitz et al., 1995.

Tables 4-8 through 4-10 and Figure 4-6a and b and Figure 4-7a, b, and c summarize acute ALC exceedences. Tables 4-8 through 4-10 and Figure 4-7a, b, and c show acute ALC exceedences for cadmium, lead, and zinc for the South Fork Coeur d'Alene River and tributaries, the mainstem Coeur d'Alene River and Coeur d'Alene Lake for the entire period of record (see Table 4-4). Information in the tables is for the entire reach noted. Figures 4-6a and b show individual locations in the South Fork Coeur d'Alene River basin where one or more acute ALC values were exceeded from 1991 to 1998. Some locations without latitude and longitude designations were not plotted on Figure 4-6. For samples without hardness values, average hardness values from Tables 4-8 through 4-10 were used. Where there was a range of hardness values (e.g., for Highland Creek), the average hardness value was calculated and used. The results characterize acute exceedences of cadmium, lead, and zinc over the seven year period from 1991 to 1998. These figures show the preponderance of acute ALC exceedences in surface waters downstream of mining disturbance. Figures 4-7a, b, and c show the data distribution for cadmium, lead, and zinc relative to mean acute and chronic ALC for each reach of the Coeur d'Alene River, South Fork Coeur d'Alene River, Canyon Creek, Ninemile Creek, Pine Creek, and Coeur d'Alene Lake.

Table 4-8
Acute Criteria for Cadmium — Summary of Exceedences

Stream or Water Body	Reach/ Location ID[a]	Measured Hardness (mg/L as $CaCO_3$) Range (mean)	Measured Concentration (µg/L) Median[b]	Measured Concentration (µg/L) Range	ALC Values[b] (µg/L) Range	No. Exceed	No. Used	(%)	Measured Concentration/ ALC[c] Range
South Fork	SFCDR-1	10.3-40.0 (24.6)	0.25	0.01 U-2.50	0.95-1.58	2 /	38	(5)	0.01-2.33
	SFCDR-2	14.8-96.0 (41.0)	0.80	0.04 U-6.00	0.95 -4.08	9 /	117	(8)	0.03-4.22
	SFCDR-3	22.1-146 (52.5)	7.40	0.20-18.00	0.95-6.42	241 /	253	(95)	0.07-8.10
	SFCDR-4	27.0-270 (102)	10.2	1.20-220.00	1.03-12.5	92 /	97	(95)	0.26-48.2
	SFCDR-5	24.2-271 (89.2)	9.00	1.00 U-390	0.95 -12.5	105 /	111	(95)	0.12-103
South Fork Tributaries									
Grouse Gulch	SF-223	27.0-48.0 (37.5)	8.29	8.20-8.37	1.03-1.92	2 /	2	(100)	4.35-7.95
Moon Creek	MC-262	26.0-60.0 (34.4)	0.70	0.40-1.80	0.99-1.58	1 /	15	(7)	0.32-1.41
Milo Creek	SF-183	71.7[d]	11.4	10.0-24.1	2.97[h]	3 /	3	(100)	3.36-8.11
Portal Creek	SF-104	71.7[d]	3.00	3.00 U	2.97[h]	0 /	1	(0)	1.01
Deadwood Gulch	SF-100-103	71.7[d]	83.9	3.00 U-736	2.97[h]	9 /	12	(75)	1.01-248
Government Gulch	SF-110	71.7[d]	184	40.8-306	2.97[h]	4 /	4	(100)	13.7-103
Canyon Creek	CC-1	2.00-56.0 (13.5)	0.25U	0.04 U-1.00	0.95-2.27	1 /	42[i]	(2)	0.04-1.06
	CC-2	5.00-90.0 (32.9)	5.00	0.25-408	0.95-3.80	295 /	357	(836)	0.19-303
Gorge Gulch	CC-392	17.3[e]	1.30	0.30-.90	0.95[h]	2 /	3	(67)	0.32-2.01
Ninemile Creek	NM-1	5.49-139 (61.1)	0.20	0.04 U-0.46	0.95-6.10	0 /	13	(0)	0.01-0.21
	NM-2	4.36-96.0 (35.8)	23.0	0.20 U-90.00	0.95-4.08	246 /	261	(94)	0.21-62.0
Pine Creek	PC-1	5.43-25.0 (9.86)	0.04	0.01 U-0.20 U	0.95	0 /	8	(0)	0.01-0.21
	PC-2	8.00-48.0 (20.9)	1.30	0.38-10.0	0.95-1.92	4 /	7	(57)	0.40-10.6
	PC-3	3.0-76.0 (14.1)	0.27	0.04-4.00	0.95-3.17	4 /	58	(7)	0.04-4.22

Table 4-8 (cont.)
Acute Criteria for Cadmium — Summary of Exceedences

Stream or Water Body	Reach/ Location ID[a]	Measured Hardness (mg/L as $CaCO_3$) Range (mean)	Measured Concentration (µg/L)		ALC Values (µg/L) Range	No. Exceed	No. Used	(%)	Measured Concentration/ ALC[c] Range
			Median[b]	Range					
Pine Creek Tributaries									
Highland Creek	PC-307	23.8-52.2[f] (38.7)	2.50	1.60-3.50	0.95-2.11	34 /	34	(100)	1.05-2.58
Denver Creek	PC-308	25.9-72.0[g] (44.3)	11.00	7.30-18.30	0.98-2.99	1 /	3	(100)	4.08-10.2
Nabob Creek	PC-310, 326	24.6-233 (173)	4.59	3.00-4.78	0.95-10.6	1 /	3	(33)	0.45-3.17
Coeur d'Alene River	CDR-1	11.9-160 (42.7)	2.80	1.00-120	0.95-7.09	33 /	7	(89)	0.43-66.5
	CDR-2	9.00-137 (46.0)	18.0	1.00-122	0.95-6.00	42 /	45	(93)	1.06-66.0
	CDR-3	12.7-49.8 (28.3)	2.00	0.94-19.0	0.95-2.00	8 /	11	(73)	0.99-16.9
Coeur d'Alene Lake	CDAL	7-76.0 (22.1)	1.00	0.07-2.00	0.95-3.17	21 /	100[i]	(21)	0.07-2.11

a. See Table 4-4 for reach definitions.
b. For values below the detection limit, the detection limit was used to calculate the median.
c. Values below 1 indicate the ALC was not exceeded; values greater than 1 indicate the magnitude of exceedence. If the measured concentration was below detection, the detection limit was divided by the ALC value.
d. Used average hardness for SF 270 in South Fork (n = 15).
e. Used one hardness measurement (17.3) for other two samples with no measured hardness.
f. Used average of existing hardness values (18/34 samples) for samples with no measured hardness.
g. Used average of existing hardness values (16/30 samples) for samples with no measured hardness.
h. Criterion value using noted hardness.
i. Extremely high undetected values not used in calculations.

U = below detection.

Table 4-9
Acute Criteria for Lead — Summary of Exceedences

Stream or Water Body	Reach[a]	Measured Hardness ($mg/L\ CaCO_3$) Range (mean)	Measured Concentration (µg/L) Median[b]	Measured Concentration (µg/L) Range	ALC Values[b] (µg/L) Range	No. Exceed / No. Used	(%)	Measured Concentration/ ALC[c] Range
South Fork	SFCDR-1	10.3-40.0 (24.6)	1.50	0.10 U-5.00	13.9-23.5	0 / 37	(0)	0.01-0.36
	SFCDR-2	14.8-96.0 (41.0)	3.00	0.32-45.0	13.9-61.8	1 / 127	(1)	0.02-2.97
	SFCDR-3	22.1-146 (52.5)	10.0	2.00-45.0	13.9-97.3	7 / 267	(3)	0.02-1.35
	SFCDR-4	27.0-270 (102)	10.0	1.00 U-185	15.1-186.8	9 / 110	(8)	0.01-11.3
	SFCDR-5	24.2-271 (89.2)	7.00	0.80 U-420	13.9-187.3	9 / 128	(7)	0.01-27.5
South Fork Tributaries								
Grouse Gulch	SF-223	27.0-48.0 (37.5)	7.82	6.40-9.23	15.2-28.8	0 / 2	(0)	0.32-0.42
Moon Creek	MC-262	26.0-60.0 (34.4)	1.50	0.23-6.00	14.5-36.9	0 / 33	(0)	0.01-0.14
Milo Creek	SF-183	71.7[d]	507	380-533	44.9[h]	4 / 4	(100)	8.47-11.9
Portal Creek	SF-104	71.7[d]	22.0	4.00-25.9	44.9[h]	0 / 3	(0)	0.09-0.58
Deadwood Gulch	SF-100-103	71.7[d]	11.9	1.50 U-191	44.9[h]	2 / 17	(12)	0.03-4.26
Government Gulch	SF-110	71.7[d]	4.80	1.50 U-21.0	44.9[h]	0 / 4	(0)	0.03-0.47
Canyon Creek	CC-1	2.00-56.0 (13.5)	1.50	0.12-3.00	13.9-34.2	0 / 43[i]	(0)	0.01-0.22
	CC-2	5.00-90.0 (32.9)	15.1	1.50 U-578	13.9-57.6	125 / 370	(34)	0.08-28.9
Gorge Gulch	CC-392	17.3[e]	4.00	3.00 U-11.7	13.9[h]	0 / 3	(0)	0.22-0.84
Ninemile Creek	NM-1	5.49-139 (61.1)	0.60	0.10 U-3.95	13.9-92.4	0 / 13	(0)	0.01-0.09
	NM-2	4.36-96.0 (35.8)	44.0	0.20 U-378	13.9-61.8	169 / 263	(64)	0.01-17.5
Pine Creek	PC-1	5.43-25.0 (9.86)	0.10	0.10 U-0.50 U	13.9	0 / 7	(0)	0.01-0.04
	PC-2	8.00-48.0 (20.9)	0.95	0.61-30.9	13.9-28.8	1 / 7	(14)	0.04-2.23
	PC-3	3.0-76.0 (14.1)	1.50	0.20-20.0	13.9-47.8	1 / 63	(2)	0.01-1.44

Table 4-9 (cont.)
Acute Criteria for Lead — Summary of Exceedences

Stream or Water Body	Reach[a]	Measured Hardness (mg/L $CaCO_3$) Range (mean)	Measured Concentration (µg/L) Median[b]	Measured Concentration (µg/L) Range	ALC Values[b] (µg/L) Range	No. Exceed / No. Used	(%)	Measured Concentration/ ALC[c] Range
Pine Creek Tributaries								
Highland Creek	PC-307	23.8-52.2[f] (38.7)	1.50	1.2-4.00	13.9-31.6	0 / 31	(0)	0.05-0.19
Denver Creek	PC-308	25.9-72.0[g] (44.3)	5.00	1.50 U-14.4	14.4-45.1	0 / 29	(0)	0.06-0.45
Nabob Creek	PC-310, 326	24.6-233 (173)	16.2	5.70-16.3	13.9-160	0 / 3	(0)	0.10-0.41
Coeur d'Alene River	CDR-1	11.9-160 (42.7)	5.00	1.00-24.0	13.9-107	1 / 38	(3)	0.02-1.73
	CDR-2	9.00-137 (46.0)	24.0	1.60-770	13.9-90.8	56 / 104	(54)	0.09-27.8
	CDR-3	12.7-49.8 (28.3)	7.35	1.00-100	13.9-30.0	1 / 12	(8)	0.03-7.20
Coeur d'Alene Lake	CDAL	7-76.0 (22.1)	5.00	0.02-12.0	13.9-47.8	0 / 101	(0)	0.001-0.86

a. See Table 4-4 for reach definitions.
b. For values below the detection limit, the detection limit was used to calculate the median.
c. Values below 1 indicate the ALC was not exceeded; values greater than 1 indicate the magnitude of exceedence. If the measured concentration was below detection, the detection limit was divided by the ALC value.
d. Used average hardness for SF 270 in South Fork (n = 15).
e. Used one hardness measurement (17.3) for other two samples with no measured hardness.
f. Used average of existing hardness values (18/34 samples) for samples with no measured hardness.
g. Used average of existing hardness values (16/30 samples) for samples with no measured hardness.
h. Criterion value using noted hardness.
i. Extremely high undetected values not used in calculations.

U = below detection.

Table 4-10
Acute Criteria for Zinc — Summary of Exceedences

Stream or Water Body	Reach[a]	Measured Hardness (mg/L $CaCO_3$) Range (mean)	Measured Concentration (µg/L) Median[b]	Measured Concentration (µg/L) Range	ALC Values[b] (µg/L) Range	No. Exceed / No. Used	(%)	Measured Concentration/ ALC[c] Range
South Fork	SFCDR-1	10.3-40.0 (24.6)	11.0	5.00 U-59.3	36.2-53.9	2 / 25	(8.00)	0.09-1.20
	SFCDR-2	14.8-96.0 (41.0)	108	1.50 U-339	36.2-113	89 / 123	(72)	0.03-5.97
	SFCDR-3	22.1-146 (52.5)	1030	269-2840	36.2-161	267 / 267	(100)	4.44-32.0
	SFCDR-4	27.0-270 (102)	2050	40.0-19000	38.6-272	109 / 110	(99)	0.28-146
	SFCDR-5	24.2-271 (89.2)	1920	3.00 U-23000	36.2-272	127 / 129	(99)	0.01-187
South Fork Tributaries								
Grouse Gulch	SF-223	27.0-48.0 (37.5)	1370	1340-1400	38.7-63.0	2 / 2	(100)	21.3-36.2
Moon Creek	MC-262	26.0-60.0 (34.4)	121	74.0-318	37.4-76.0	18 / 18	(100)	1.33-6.97
Milo Creek	SF-183	71.7[d]	2460	1560-7880	88.4[h]	4 / 4	(100)	17.7-89.1
Portal Creek	SF-104	71.7[d]	440	129-1300	88.4[h]	3 / 3	(100)	1.46-14.7
Deadwood Gulch	SF-100-103	71.7[d]	3980	322-10000	88.4[h]	12 / 12	(100)	3.64-113
Government Gulch	SF-110	71.7[d]	6130	1400-10500	88.4[h]	4 / 4	(100)	15.8-119
Canyon Creek	CC-1	2.00-56.0 (13.5)	16.0	0.30-42.0	36.2-71.7	2 / 45	(44)	0.01-1.16
	CC-2	5.00-90.0 (32.9)	787	29.3-9463	36.2-107	370 / 373	(99)	0.81-199
Gorge Gulch	CC-392	17.3[e]	54.0	12.0 U-172	36.2	2 / 3	(67)	0.33-4.75
Ninemile Creek	NM-1	5.49-139 (61.1)	14.0	4.70-77.0	36.2-155	0 / 12	(0)	0.03-0.86
	NM-2	4.36-96.0 (35.8)	3540	10.0 U-12400	36.2-113	260 / 262	(99)	0.28-246
Pine Creek	PC-1	5.43-25.0 (9.86)	4.70	1.90 U-10.0 U	36.2	0 / 7	(0)	0.05-0.28
	PC-2	8.00-48.0 (20.9)	484	107-3920	36.2-62.9	8 / 8	(100)	2.96-108
	PC-3	3.0-76.0 (14.1)	99.0	20.0 U-402	36.2-92.9	57 / 60	(95)	0.55-11.1

Table 4-10 (cont.)
Acute Criteria for Zinc — Summary of Exceedences

Stream or Water Body	Reach[a]	Measured Hardness ($mg/L\ CaCO_3$) Range (mean)	Measured Concentration (µg/L) Median[b]	Measured Concentration (µg/L) Range	ALC Values[b] (µg/L) Range	No. Exceed	No. Used	(%)	Measured Concentration/ ALC[c] Range
Pine Creek Tributaries									
Highland Creek	PC-307	23.8-52.2[f] (38.7)	949	577-1370	36.2-67.6	34	34	(100)	11.1-23.8
Denver Creek	PC-308	25.9-72.0[g] (44.3)	4150	2850-7410	37.3-88.7	30	30	(100)	47.9-125
Nabob Creek	PC-310, 326	24.6-233 (173)	3420	728-3430	36.2-240	3	3	(100)	14.3-20.1
Coeur d'Alene River	CDR-1	11.9-160 (42.7)	468	20.0-3300	36.2-175	37	38	(97)	0.55-55.1
	CDR-2	9.00-137 (46.0)	1600	69.0-13200	36.2-153	109	109	(100)	1.91-164
	CDR-3	12.7-49.8 (28.3)	346	122-1820	36.2-64.9	12	12	(100)	3.37-44.1
Coeur d'Alene Lake	CDAL	7-76.0 (22.1)	100	2.17-190	36.2-92.9	121	128	(95)	0.06-4.14

a. See Table 4-4 for reach definitions.
b. For values below the detection limit, the detection limit was used to calculate the median.
c. Values below 1 indicate the ALC was not exceeded; values greater than 1 indicate the magnitude of exceedence. If the measured concentration was below detection, the detection limit was divided by the ALC value.
d. Used average hardness for SF 270 in South Fork (n = 15).
e. Used one hardness measurement (17.3) for other two samples with no measured hardness.
f. Used average of existing hardness values (18/34 samples) for samples with no measured hardness.
g. Used average of existing hardness values (16/30 samples) for samples with no measured hardness.
h. Criterion value using noted hardness.

U = below detection.

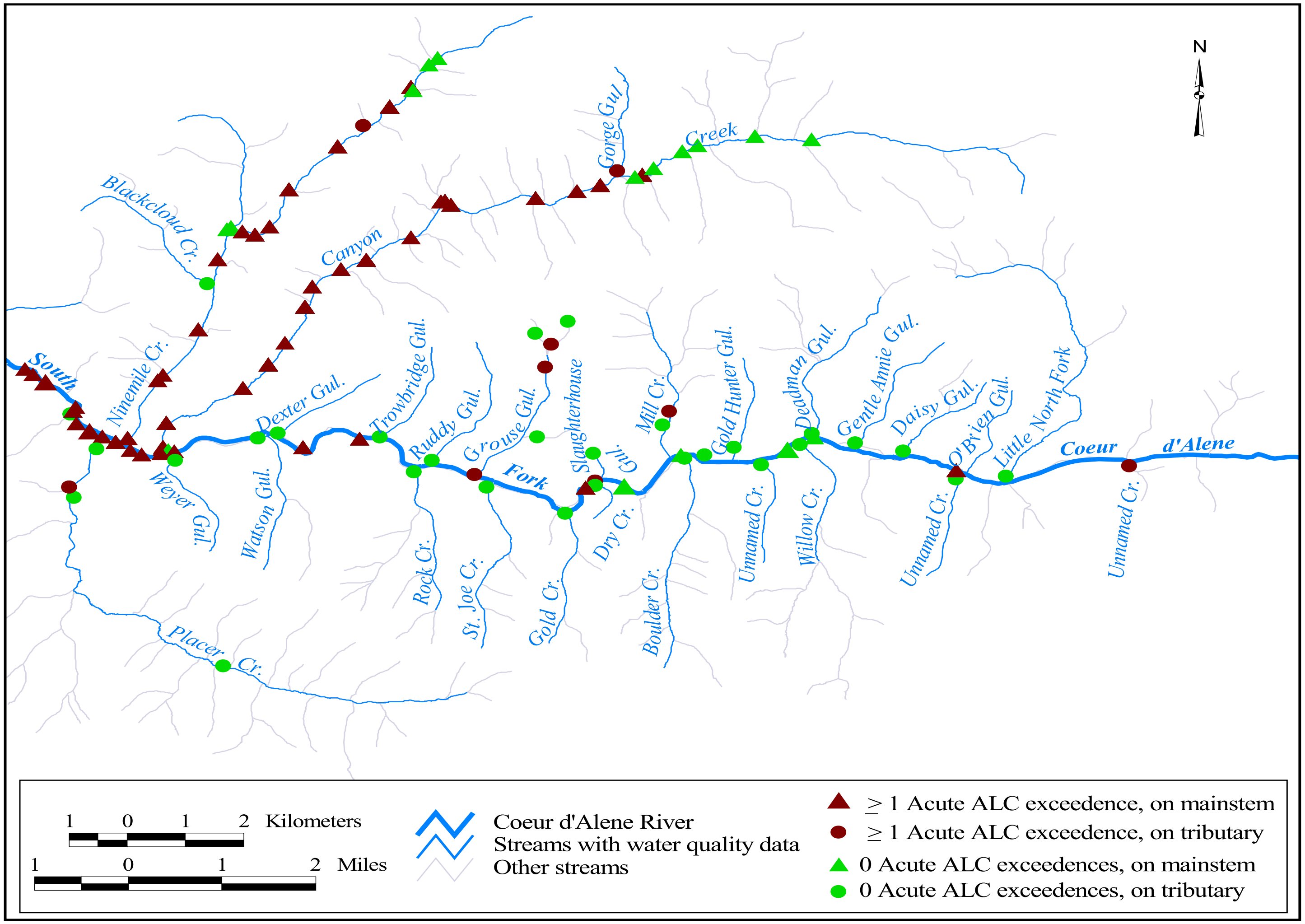

Figure 4-6a. Locations of one or more acute ALC exceedence from 1991 to 1998, South Fork Coeur d'Alene River basin, eastern section. Triangles designate samples collected from mainstem South Fork Coeur d'Alene River, Canyon Creek, and Ninemile Creek sites. Circles designate samples collected from tributaries to each of those mainstems.

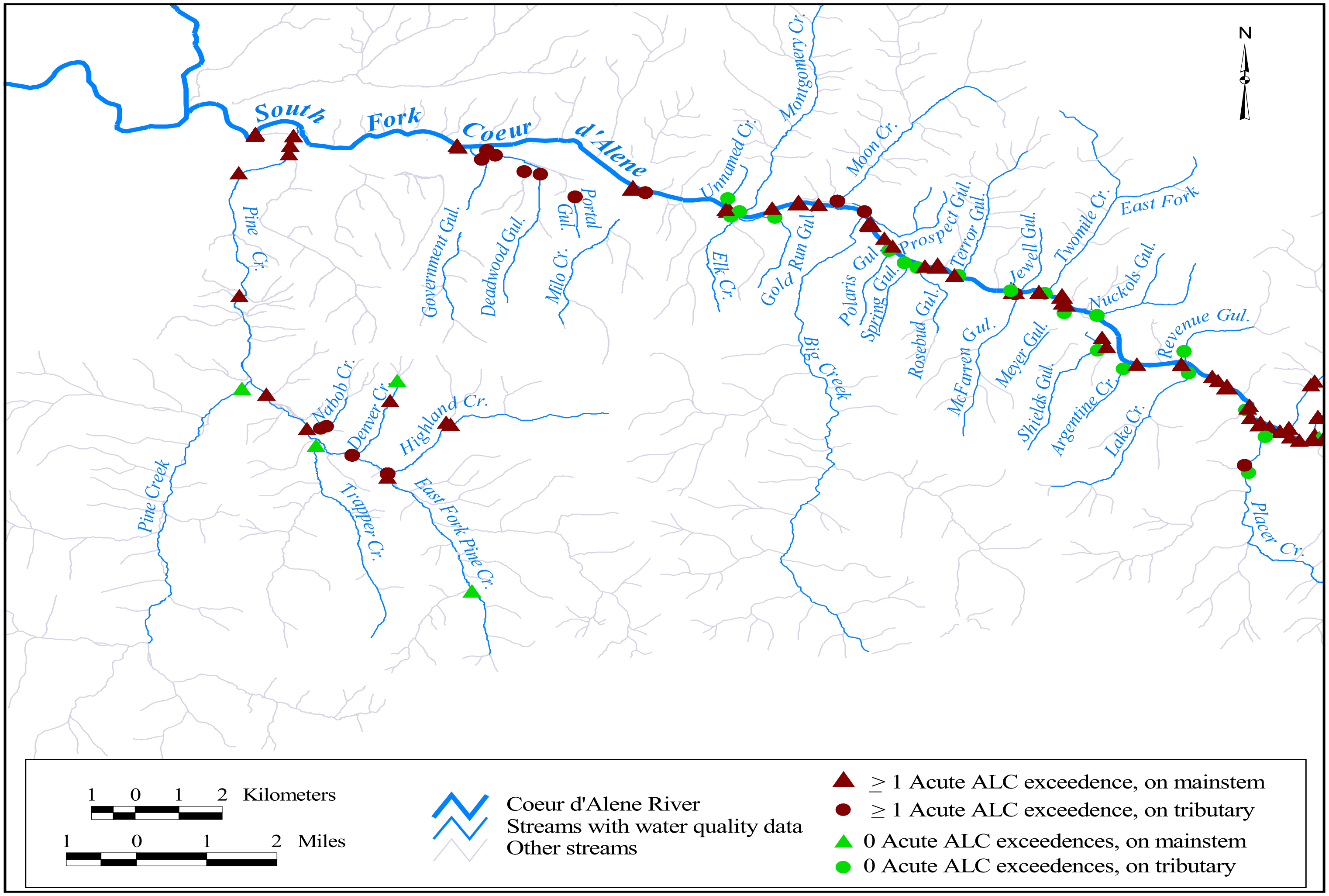

Figure 4-6b. Locations of one or more acute ALC exceedence from 1991 to 1998, South Fork Coeur d'Alene River basin, western section. Triangles designate samples collected from mainstem South Fork Coeur d'Alene River and Pine Creek sites. Circles designate samples collected from tributaries to each of those mainstems.

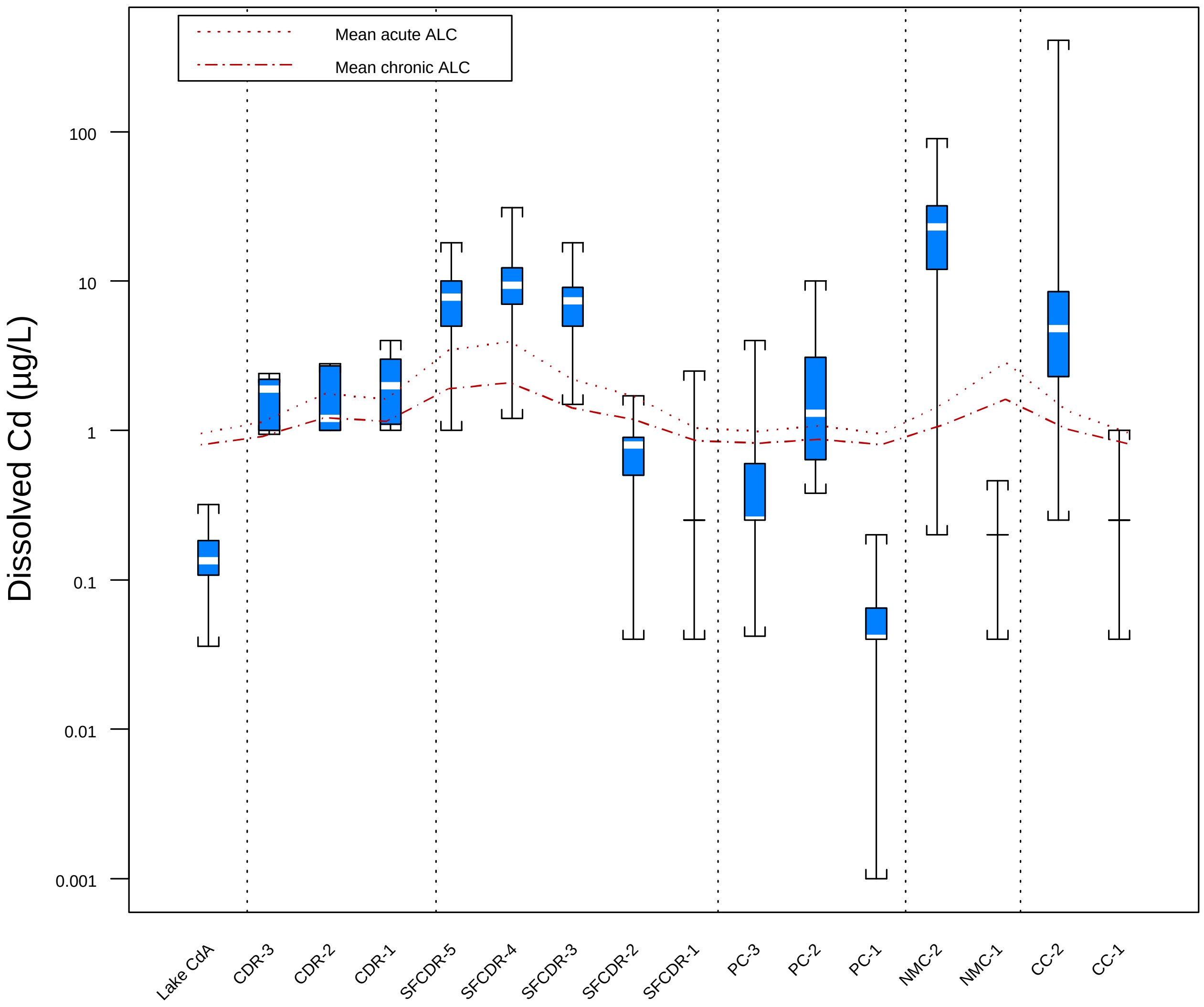

Figure 4-7a. Distribution of cadmium concentrations measured between 1991 and 1999 in reaches of the South Fork Coeur d'Alene River, Canyon Creek, Ninemile Creek, Pine Creek, the mainstem Coeur d'Alene River, and Coeur d'Alene Lake. Box plots show the median (white line in box), interquartile range (box ends), and data range (box whiskers). Dotted and dashed lines are the mean acute and chronic ALC in each reach.

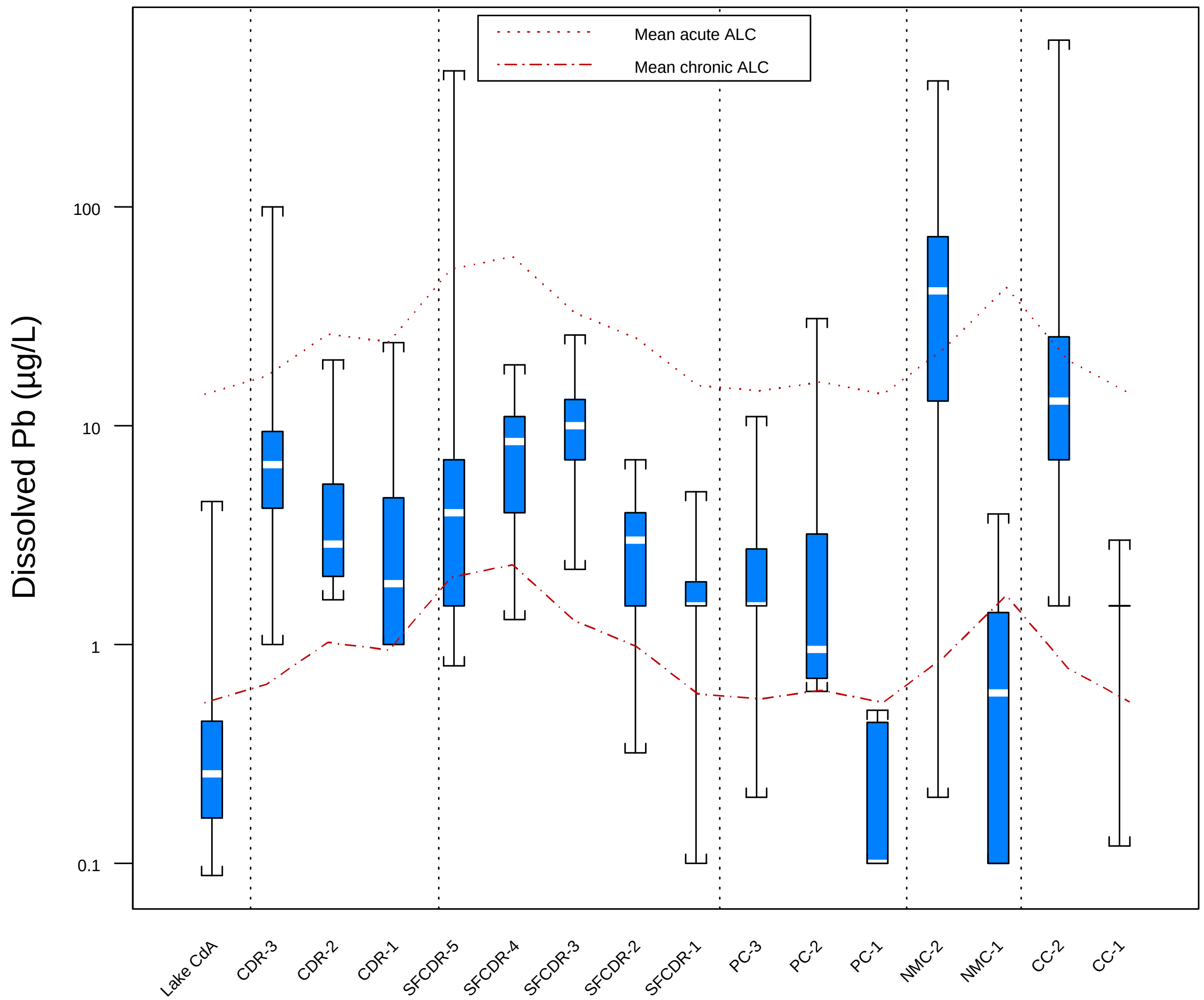

Figure 4-7b. Distribution of lead concentrations measured between 1991 and 1999 in reaches of the South Fork Coeur d'Alene River, Canyon Creek, Ninemile Creek, Pine Creek, the mainstem Coeur d'Alene River, and Coeur d'Alene Lake. Box plots show the median (white line in box), interquartile range (box ends), and data range (box whiskers). Dotted and dashed lines are the mean acute and chronic ALC in each reach.

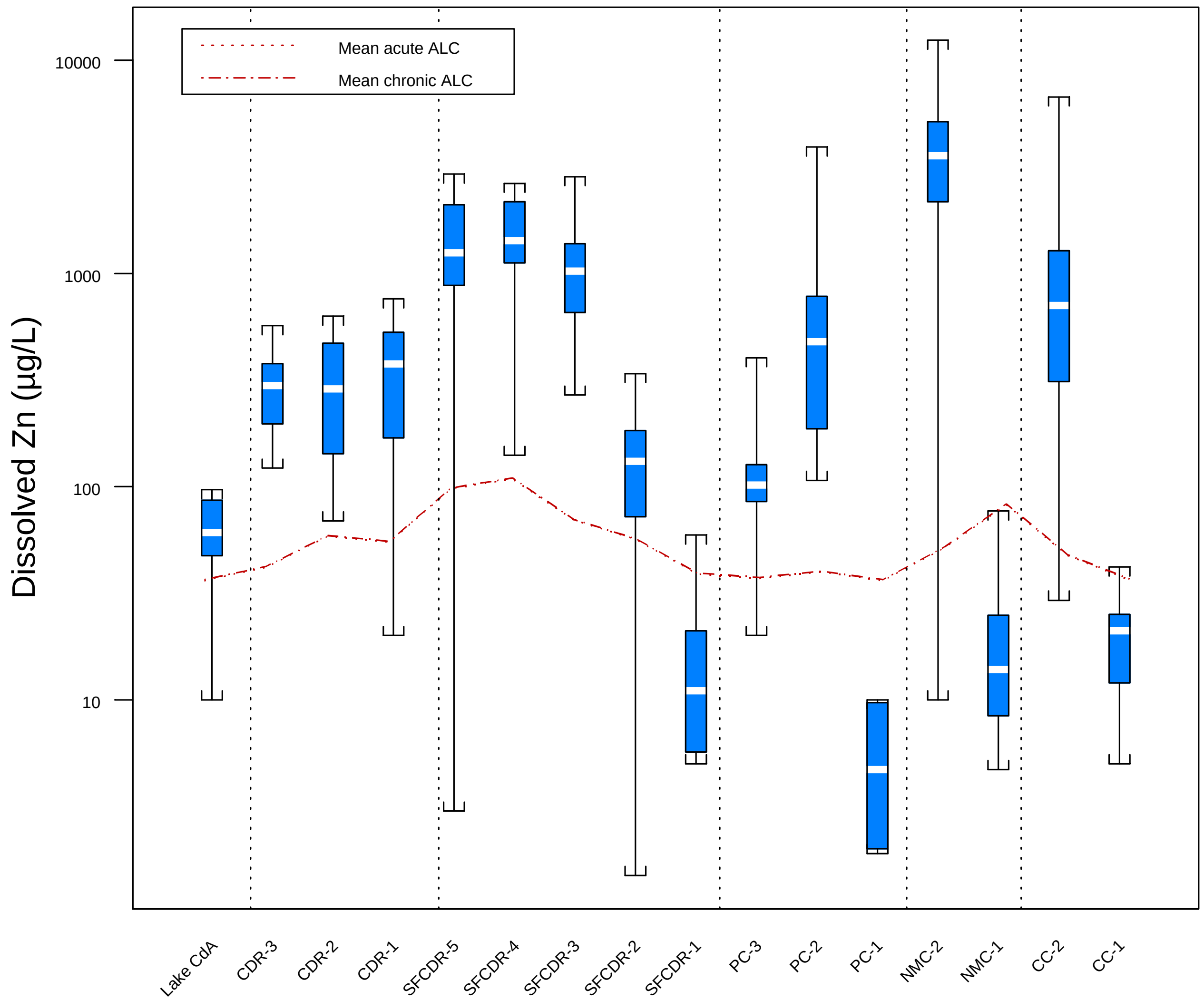

Figure 4-7c. Distribution of zinc concentrations measured between 1991 and 1999 in reaches of the South Fork Coeur d'Alene River, Canyon Creek, Ninemile Creek, Pine Creek, the mainstem Coeur d'Alene River, and Coeur d'Alene Lake. Box plots show the median (white line in box), interquartile range (box ends), and data range (box whiskers). Dashed line is the mean chronic; dotted line (mean acute ALC) overlays it.

Acute ALC have been exceeded repeatedly in the South Fork Coeur d'Alene River downstream of Larson and Daisy Gulch (Reach SFCDR-2), in Canyon Creek downstream of O'Neill Gulch, in Ninemile Creek downstream of the Interstate Callahan Mine, in Pine Creek downstream of the Constitution Mine, in the mainstem Coeur d'Alene River, and in Coeur d'Alene Lake. Exceedences of acute cadmium and zinc criteria have also occurred in the South Fork Coeur d'Alene River upstream of Daisy Gulch (Reach SFCDR-1) and in Canyon Creek upstream of O'Neill Gulch (Reach CC-1), but such exceedences are infrequent relative to the downstream reaches, and the magnitude of the exceedences in these reaches is much lower than in downstream reaches. These upstream reaches and the upper reaches of Ninemile Creek (Reach NM-1) and Pine Creek (Reach PC-1) are upstream of major mining and mineral processing activity.

In addition to acute ALC exceedences in the reaches identified above, acute ALC have been exceeded repeatedly in smaller tributaries in the South Fork basin, including Grouse Gulch, Gorge Gulch, Moon Creek, Milo Creek, Portal Creek, Deadwood Gulch/Bunker Creek, Government Gulch, Highland Creek, Denver Creek, and Nabob Creek (Tables 4-8 through 4-10 and Figures 4-6a and b). Acute ALC values were exceeded in these tributaries during both low flow and high flow conditions. Acute lead and zinc ALC exceedences have also been documented in the lateral lakes, including Killarney Lake, Killarney wetland, and Thompson Lake.

Chronic ALC. Chronic ALC are four-day average concentrations that are not to be exceeded more than once in a 3-year period (U.S. EPA, 1987). Chronic ALC were developed to protect aquatic life from long-term exposures to contaminants and are lower concentrations than acute ALC. Chronic ALC exceedences were evaluated using measured concentrations of dissolved metals in grab samples collected over an approximately 30-year period. For zinc, chronic and acute ALC values are very similar. Therefore, most waters that exceed chronic ALC values for zinc also exceed acute ALC zinc values.

Tables 4-11 through 4-13 summarize chronic ALC exceedences for all data compiled for the assessed reaches. Chronic ALC were exceeded repeatedly in the South Fork Coeur d'Alene River downstream of Larson and Daisy Gulch, in Canyon Creek downstream of O'Neill Gulch, in Ninemile Creek downstream of the Interstate Callahan Mine, and in Pine Creek downstream of the Constitution Mine. Chronic criteria have also been exceeded repeatedly in the mainstem Coeur d'Alene River and in Coeur d'Alene Lake. Exceedences of chronic cadmium, zinc, and particularly lead criteria have also occurred in the South Fork Coeur d'Alene River upstream of Daisy Gulch, in Canyon Creek upstream of O'Neill Gulch, in Ninemile Creek upstream of the Interstate Callahan Mine (lead only), and in East Fork Pine Creek upstream of Constitution Mine (lead only), but exceedences in these upstream reaches are infrequent relative to the downstream reaches, and the magnitude of the exceedences in the upstream reaches is much lower than that in downstream reaches.

Table 4-11
Chronic Criteria for Cadmium — Summary of Exceedences

Stream or Water Body	Reach[a]	Measured Hardness (mg/L $CaCO_3$) Range (mean)	Measured Concentration (µg/L) Median[b]	Measured Concentration (µg/L) Range	ALC Values[b] (µg/L) Range	No. Exceed / No. Used	(%)	Measured Concentration/ ALC[c] Range
South Fork	SFCDR-1	10.3-40.0 (24.6)	0.25	0.01 U-2.50	0.80-1.14	2 / 38	(5)	0.01-2.87
	SFCDR-2	14.8-96.0 (41.0)	0.80	0.04 U-6.00	0.80-2.17	18 / 117	(15)	0.04-5.05
	SFCDR-3	22.1-146 (52.5)	7.40	0.20-18.00	0.80-2.96	251 / 253	(99)	0.12-12.5
	SFCDR-4	27.0-270 (102)	10.2	1.20-220.00	0.85-4.66	92 / 97	(95)	0.51-93.8
	SFCDR-5	24.2-271 (89.2)	9.00	1.00 U-390	0.80-4.67	109 / 111	(98)	0.28-189
South Fork Tributaries								
Grouse Gulch	SF-223	27.0-48.0 (37.5)	8.29	8.20-8.37	0.85-1.30	2 / 2	(100)	6.44-9.65
Moon Creek	MC-262	26.0-60.0 (34.4)	0.70	0.40-1.80	0.83-1.53	4 / 49	(8)	0.44-1.83
Milo Creek	SF-183	71.7[d]	11.4	10.0-24.1	1.75[h]	3 / 3	(100)	5.71-13.8
Portal Creek	SF-104	71.7[d]	3.00	3.00 U	1.75[h]	0 / 1	(0)	1.71
Deadwood Gulch	SF-100-103	71.7[d]	83.9	3.00 U-736	1.75[h]	9 / 12	(75)	1.71-421
Government Gulch	SF-110	71.7[d]	184	40.8-306	1.75[h]	4 / 4	(100)	23.3-175
Canyon Creek	CC-1	2.00-56.0 (13.5)	0.25U	0.04 U-1.00	0.80-1.46	1 / 42[i]	(2)	0.05-1.25
	CC-2	5.00-90.0 (32.9)	5.00	0.25-408	0.80-2.07	299 / 357	(84)	0.25-400
Gorge Gulch	CC-392	17.3[e]	1.30	0.30-1.90	0.80	2 / 3	(67)	0.37-2.37
Ninemile Creek	NM-1	5.49-139 (61.1)	0.20	0.04 U-0.46	0.80-2.86	0 / 13	(0)	0.01-0.25
	NM-2	4.36-96.0 (35.8)	23.0	0.20 U-90.00	0.80-2.17	250 / 261	(96)	0.25-83.9
Pine Creek	PC-1	5.43-25.0 (9.86)	0.04	0.01 U-0.20 U	0.80	0 / 8	(0)	0.01-0.25
	PC-2	8.00-48.0 (20.9)	1.30	0.38-10.0	0.80-1.30	4 / 7	(57)	0.47-12.5
	PC-3	3.0-76.0 (14.1)	0.27	0.04-4.00	0.80-1.83	5 / 58	(9)	0.05-4.99

Table 4-11 (cont.)
Chronic Criteria for Cadmium — Summary of Exceedences

Stream or Water Body	Reach[a]	Measured Hardness ($mg/L\ CaCO_3$) Range (mean)	Measured Concentration (µg/L) Median[b]	Measured Concentration (µg/L) Range	ALC Values[b] (µg/L) Range	No. Exceed / No. Used	(%)	Measured Concentration/ ALC[c] Range
Pine Creek Tributaries								
Highland Creek	PC-307	23.8-52.2[f] (38.7)	2.50	1.60-3.50	0.80-1.38	34 / 34	(100)	1.44-3.32
Denver Creek	PC-308	25.9-72.0[g] (44.3)	11.00	7.30-18.30	0.82-1.76	34 / 34	(100)	5.90-14.6
Nabob Creek	PC-310, 326	24.6-233 (173)	4.59	3.00-4.78	0.80-4.17	3 / 3	(100)	1.10-3.74
Coeur d'Alene River	CDR-1	11.9-160 (42.7)	2.80	1.00-120	0.80-3.17	33 / 37	(89)	0.68-96.4
	CDR-2	9.00-137 (46.0)	18.0	1.00-122	0.80-2.82	42 / 45	(93)	1.25-96.4
	CDR-3	12.7-49.8 (28.3)	2.00	0.94-19.0	0.80-1.34	9 / 11	(82)	1.17-21.1
Coeur d'Alene Lake	CDAL	7-76.0 (22.1)	1.00	0.07-2.00	0.80-1.83	21 / 100[i]	(21)	0.09-2.49

a. See Table 4-4 for reach definitions.
b. For values below the detection limit, the detection limit was used to calculate the median.
c. Values below 1 indicate the ALC was not exceeded; values greater than 1 indicate the magnitude of exceedence. If the measured concentration was below detection, the detection limit was divided by the ALC value.
d. Used average hardness for SF 270 in South Fork (n = 15).
e. Used one hardness measurement (17.3) for other two samples with no measured hardness.
f. Used average of existing hardness values (18/34 samples) for samples with no measured hardness.
g. Used average of existing hardness values (16/30 samples) for samples with no measured hardness.
h. Criterion value using noted hardness.
i. Extremely high undetected values not used in calculations.

U = below detection.

Table 4-12
Chronic Criteria for Lead — Summary of Exceedences

Stream or Water Body	Reach[a]	Measured Hardness ($mg/L\ CaCO_3$) Range (mean)	Measured Concentration (µg/L)		ALC Values[b] (µg/L) Range	No. Exceed	No. Used	(%)	Measured Concentration/ ALC[c] Range
			Median[b]	Range					
South Fork	SFCDR-1	10.3-40.0 (24.6)	1.50	0.10 U-5.00	0.54-0.92	8	37	(22)	0.15-9.24
	SFCDR-2	14.8-96.0 (41.0)	3.00	0.32-45.0	0.54-2.41	71	127	(56)	0.59-76.3
	SFCDR-3	22.1-146 (52.5)	10.0	2.00-45.0	0.54-3.79	255	267	(96)	0.53-34.6
	SFCDR-4	27.0-270 (102)	10.0	1.00 U-185	0.59-7.28	83	110	(76)	0.18-289
	SFCDR-5	24.2-271 (89.2)	7.00	0.80 U-420	0.54-7.30	89	128	(70)	0.20-706
South Fork Tributaries									
Grouse Gulch	SF-223	27.0-48.0 (37.5)	7.82	6.40-9.23	0.59-1.12	2	2	(100)	8.22-10.8
Moon Creek	MC-262	26.0-60.0 (34.4)	1.50	0.23-6.00	0.57-1.44	2	33	(6)	0.29-3.50
Milo Creek	SF-183	71.7[d]	507	380-533	1.75[h]	4	4	(100)	217-305
Portal Creek	SF-104	71.7[d]	22.0	4.00-25.9	1.75[h]	3	3	(100)	2.29-14.8
Deadwood Gulch	SF-100-103	71.7[d]	11.9	1.50 U-191	1.75[h]	10	17	(59)	0.86-109
Government Gulch	SF-110	71.7[d]	4.80	1.50 U-21.0	1.75[h]	2	4	(50)	0.86-12.0
Canyon Creek	CC-1	2.00-56.0 (13.5)	1.50	0.12-3.0	0.54-1.33	7	43[i]	(16)	0.22-5.55
	CC-2	5.00-90.0 (32.9)	15.1	1.50 U-578	0.54-2.24	328	370	(89)	1.93-742
Gorge Gulch	CC-392	17.3[e]	4.00	3.00 U-11.7	0.54	2	3	(67)	5.55-21.6
Ninemile Creek	NM-1	5.49-139 (61.1)	0.60	0.10 U-3.95	0.54-3.60	4	13	(31)	0.03-2.40
	NM-2	4.36-96.0 (35.8)	44.0	0.20 U-378	0.54-2.41	245	263	(93)	0.37-450
Pine Creek	PC-1	5.43-25.0 (9.86)	0.10	0.10 U-0.50 U	0.54	0	7	(0)	0.18-0.92
	PC-2	8.00-48.0 (20.9)	0.95	0.61-30.9	0.54-1.12	7	7	(100)	1.13-57.1
	PC-3	3.0-76.0 (14.1)	1.50	0.20-20.0	0.54-1.86	15	63	(24)	0.37-37.0

Table 4-12 (cont.)
Chronic Criteria for Lead — Summary of Exceedences

Stream or Water Body	Reach	Measured Hardness (mg/L $CaCO_3$) Range (mean)	Measured Concentration (µg/L)		ALC Values[a] (µg/L) Range	No. Exceed	No. Used	(%)	Measured Concentration/ ALC[b] Range
			Median[a]	Range					
Pine Creek Tributaries									
Highland Creek	PC-307	23.8-52.2[f] (38.7)	1.50	1.2-4.00	0.54-1.23	15	31	(48)	1.34-4.88
Denver Creek	PC-308	25.9-72.0[g] (44.3)	5.00	1.50 U-14.4	0.56-1.76	28	29	(97)	1.44-11.5
Nabob Creek	PC-310, 326	24.6-233 (173)	16.2	5.70-16.3	0.54-6.22	3	3	(100)	2.60-10.5
Coeur d'Alene River	CDR-1	11.9-160 (42.7)	5.00	1.00-24.0	0.54-4.18	25	38	(66)	0.64-44.4
	CDR-2	9.00-137 (46.0)	24.0	1.60-770	0.54-3.54	98	104	(94)	2.20-714
	CDR-3	12.7-49.8 (28.3)	7.35	1.00-100	0.54-1.17	10	12	(83)	0.86-185
Coeur d'Alene Lake	CDAL	7-76.0 (22.6)	5.00	0.02-12.0	0.54-1.86	16	101	(16)	0.04-22.2

a. See Table 4-4 for reach definitions.
b. For values below the detection limit, the detection limit was used to calculate the median.
c. Values below 1 indicate the ALC was not exceeded; values greater than 1 indicate the magnitude of exceedence. If the measured concentration was below detection, the detection limit was divided by the ALC value.
d. Used average hardness for SF 270 in South Fork (n = 15).
e. Used one hardness measurement (17.3) for other two samples with no measured hardness.
f. Used average of existing hardness values (18/34 samples) for samples with no measured hardness.
g. Used average of existing hardness values (16/30 samples) for samples with no measured hardness.
h. Criterion value using noted hardness.
i. Extremely high undetected values not used in calculations.

U = below detection.

Table 4-13
Chronic Criteria for Zinc — Summary of Exceedences

Stream or Water Body	Reach[a]	Measured Hardness (mg/L $CaCO_3$) Range (mean)	Measured Concentration (µg/L) Median[b]	Measured Concentration (µg/L) Range	ALC Values[b] (µg/L) Range	No. Exceed / No. Used	(%)	Measured Concentration/ ALC[c] Range
South Fork	SFCDR-1	10.3-40.0 (24.6)	11.0	5.00 U-59.3	36.5-54.4	2 / 25	(8)	0.09-1.19
	SFCDR-2	14.8-96.0 (41.0)	108	1.50 U-339	36.5-114	89 / 123	(72)	0.03-5.92
	SFCDR-3	22.1-146 (52.5)	1030	269-2840	36.5-163	267 / 267	(100)	4.41-31.8
	SFCDR-4	27.0-270 (102)	2050	40.0-19000	38.9-274	109 / 110	(99)	0.28-144
	SFCDR-5	24.2-271 (89.2)	1920	3.00 U-23000	36.5-275	127 / 129	(99)	0.01-185
South Fork Tributaries								
Grouse Gulch	SF-223	27.0-48.0 (37.5)	1370	1340-1400	39.0-63.5	2 / 2	(100)	21.1-35.9
Moon Creek	MC-262	26.0-60.0 (34.4)	121	74.0-318	37.7-76.6	18 / 18	(100)	1.32-6.92
Milo Creek	SF-183	71.7[d]	2460	1560-7880	89.1[h]	4 / 4	(100)	17.5-88.4
Portal Creek	SF-104	71.7[d]	440	129-1300	89.1[h]	3 / 3	(100)	1.45-14.6
Deadwood Gulch	SF-100-103	71.7[d]	3980	322-10000	89.1[h]	12 / 12	(100)	3.61-112
Government Gulch	SF-110	71.7[d]	6130	1400-10500	89.1[h]	4 / 4	(100)	15.7-118
Canyon Creek	CC-1	2.00-56.0 (13.5)	16.0	0.30-42.0	36.5-72.3	2 / 45	(4)	0.01-1.15
	CC-2	5.00-90.0 (32.9)	787	29.3-9463	36.5-108.1	370 / 373	(99)	0.80-197
Gorge Gulch	CC-392	17.3[e]	54.0	12.0 U-172	36.5	2 / 3	(67)	0.33-4.71
Ninemile Creek	NM-1	5.49-139 (61.1)	14.0	4.70-77.0	36.5-156	0 / 12	(0)	0.03-0.85
	NM-2	4.36-96.0 (35.8)	3540	10.0 U-12400	36.5-114	260 / 262	(99)	0.27-244
Pine Creek	PC-1	5.43-25.0 (9.86)	4.70	1.90 U-10.0 U	36.5	0 / 7	(0)	0.05-0.27
	PC-2	8.00-48.0 (20.9)	484	107-3920	36.5-63.4	8 / 8	(100)	2.93-107
	PC-3	3.0-76.0 (14.1)	99.0	20.0 U-402	36.5-93.6	57 / 60	(95)	0.55-11.0

Table 4-13 (cont.)
Chronic Criteria for Zinc — Summary of Exceedences

Stream or Water Body	Reach[a]	Measured Hardness ($mg/L\ CaCO_3$) Range (mean)	Measured Concentration (µg/L)		ALC Values[b] (µg/L) Range	No. Exceed / No. Used	(%)	Measured Concentration/ ALC[c] Range
			Median[b]	Range				
Pine Creek Tributaries								
Highland Creek	PC-307	23.8-52.2[f] (38.7)	949	577-1370	36.5-68.1	34 / 34	(100)	10.9-23.6
Denver Creek	PC-308	25.9-72.0[g] (44.3)	4150	2850-7410	37.6-89.4	30 / 30	(100)	47.5-124
Nabob Creek	PC-310, 326	24.6-233 (173)	3420	728-3430	36.5-242	2 / 3	(67)	14.2-20.0
Coeur d'Alene River	CDR-1	11.9-160 (42.7)	468	20.0-3300	36.5-176	37 / 38	(97)	0.55-54.7
	CDR-2	9.00-137 (46.0)	1600	69.0-13200	36.5-154	109 / 109	(100)	1.89-163
	CDR-3	12.7-49.8 (28.3)	346	122-1820	36.5-65.4	12 / 12	(100)	3.34-43.7
Coeur d'Alene Lake	CDAL	7-76.0 (22.8)	100	2.17-190	36.5-93.6	121 / 128	(95)	0.06-4.11

a. See Table 4-4 for reach definitions.
b. For values below the detection limit, the detection limit was used to calculate the median.
c. Values below 1 indicate the ALC was not exceeded; values greater than 1 indicate the magnitude of exceedence. If the measured concentration was below detection, the detection limit was divided by the ALC value.
d. Used average hardness for SF 270 in South Fork (n = 15).
e. Used one hardness measurement (17.3) for other two samples with no measured hardness.
f. Used average of existing hardness values (18/34 samples) for samples with no measured hardness.
g. Used average of existing hardness values (16/30 samples) for samples with no measured hardness.
h. Criterion value using noted hardness.
i. Extremely high undetected values not used in calculations.

U = below detection.

In addition to chronic ALC exceedences in the reaches identified above, chronic ALC have been exceeded in Grouse Gulch, Gorge Gulch, Milo Creek, Portal Creek, Deadwood Gulch/Bunker Creek, Government Gulch, Highland Creek, Denver Creek, and Nabob Creek (Tables 4-11 through 4-13). Chronic ALC values were exceeded in these tributaries during both high and low flow conditions. Chronic lead and zinc ALC exceedences have also been documented in Killarney Lake, Killarney Wetland, and Thompson Lake.

Exceedences of ALC at Specific Locations. In the foregoing evaluation, acute and chronic ALC were summarized by the reaches designated in Table 4-4, or by individual locations for the South Fork, Canyon Creek, Pine Creek tributaries. To assess the effect of combining the data in reaches (rather than examining individual sites), results for individual sampling points in the South Fork Coeur d'Alene River were plotted for both low and high flow periods (fall 1997 and spring 1998, respectively). Sampling during fall 1997 (November 4 through November 12) and spring 1998 (May 7 through May 16) was synoptic. Figures 4-8 through 4-10 show measured dissolved metals concentrations and chronic and acute criteria values during high flow and low flow for sampling sites in all five reaches of the South Fork Coeur d'Alene River.

As seen in Figures 4-7 through 4-9, concentrations of dissolved metals are much lower upstream of Canyon Creek than downstream of Canyon Creek. In reaches upstream of Canyon Creek (SFCDR-1 and 2), concentrations of dissolved cadmium, lead, and zinc are similar during high and low flow conditions. In reaches downstream of Canyon Creek (SFCDR-3, 4, and 5), low flow metal concentrations are much higher than high flow metal concentrations. Dissolved cadmium and zinc concentrations increase with distance downstream, while dissolved lead concentrations decrease with distance downstream of the Canyon Creek confluence. The point very close to the line between SFCDR-2 and 3 during high flow is SF-398, located just upstream of the Canyon Creek confluence. This location was not sampled during low flow in 1997. The point very close to the line between SFCDR-2 and 3 during low flow in 1997 is SF-232, located just downstream of the Canyon Creek confluence. As expected, concentrations from SF-398 and SF-232 are similar to concentrations measured at other upstream and downstream locations, respectively.

In the upper South Fork reaches, dissolved cadmium concentrations did not exceed chronic or acute ALC values for cadmium during low flow in 1997 or high flow in 1998 (Figure 4-8). All concentrations downstream of Canyon Creek exceeded both chronic and acute ALC values for cadmium during both low and high flow times (Figure 4-8).

Dissolved cadmium concentrations show a monotonic increase with distance downstream that is particularly apparent in the three downstream reaches. This pattern holds during both high and low flow synoptic sampling. Dissolved cadmium concentrations are approximately three to four times higher during low flow in 1997 than in high flow in 1998.

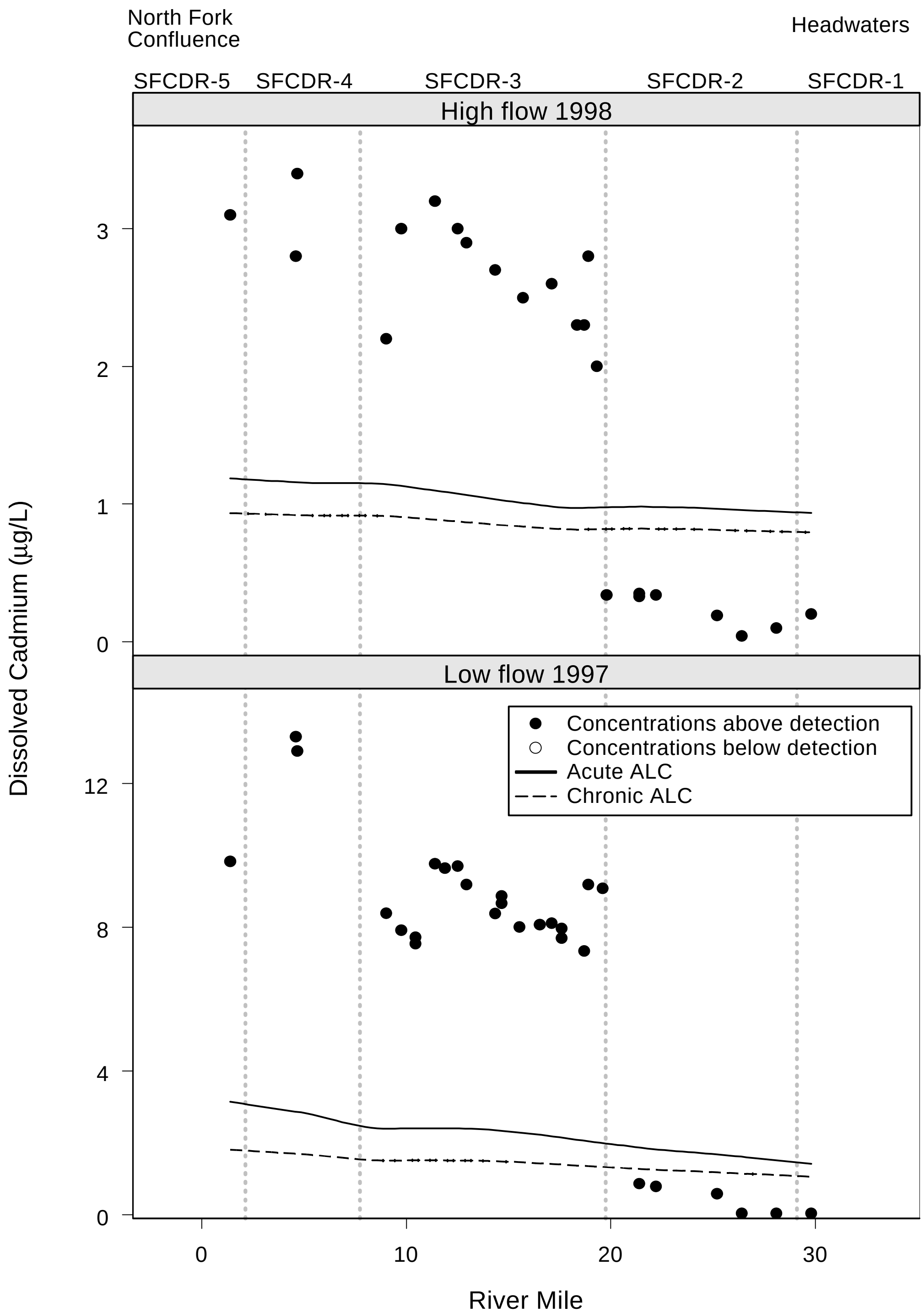

Figure 4-8. Dissolved cadmium concentrations and chronic and acute ALC values during low flow 1997 and high flow 1998 synoptic samplings.

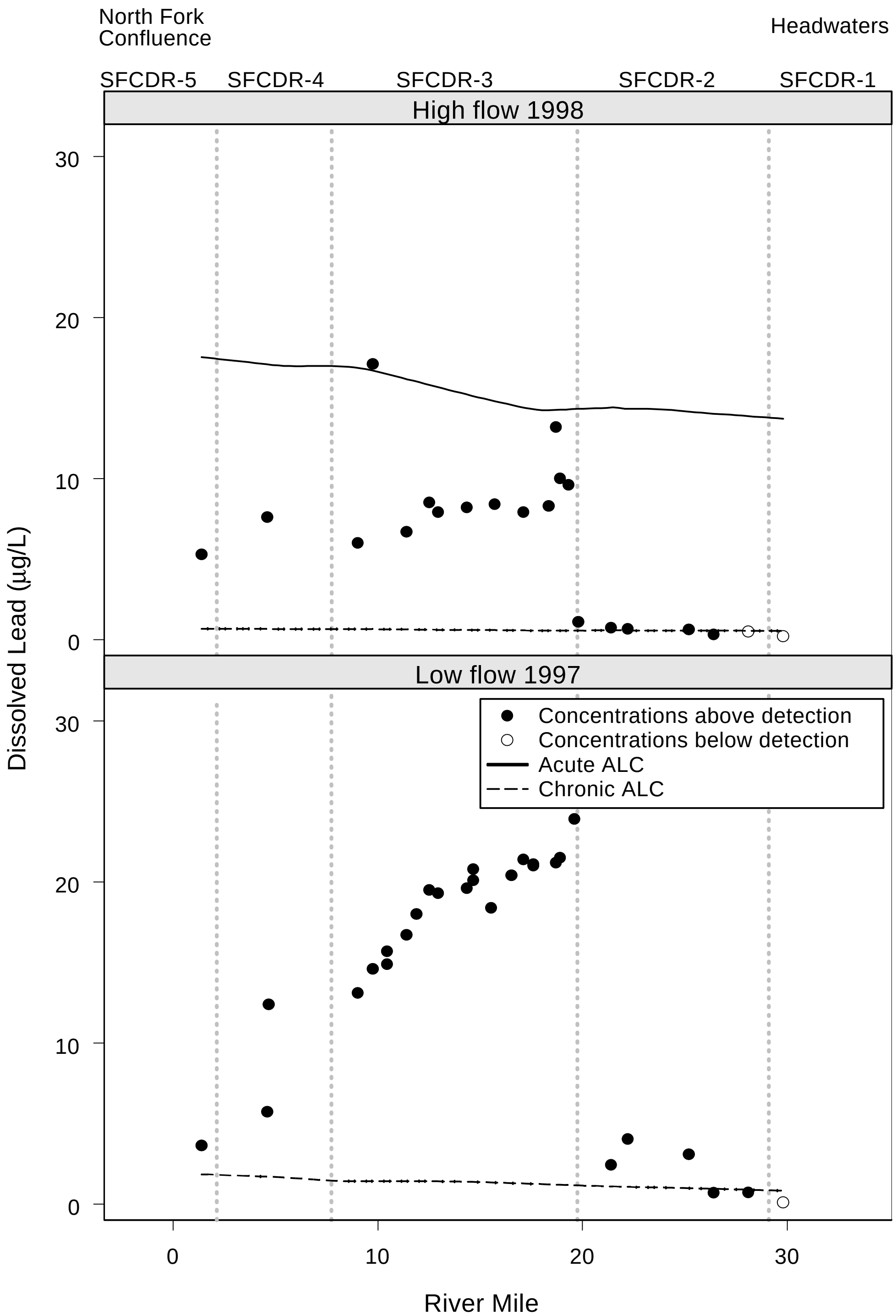

Figure 4-9. Dissolved lead concentrations and chronic and acute ALC values during low flow 1997 and high flow 1998 synoptic samplings.

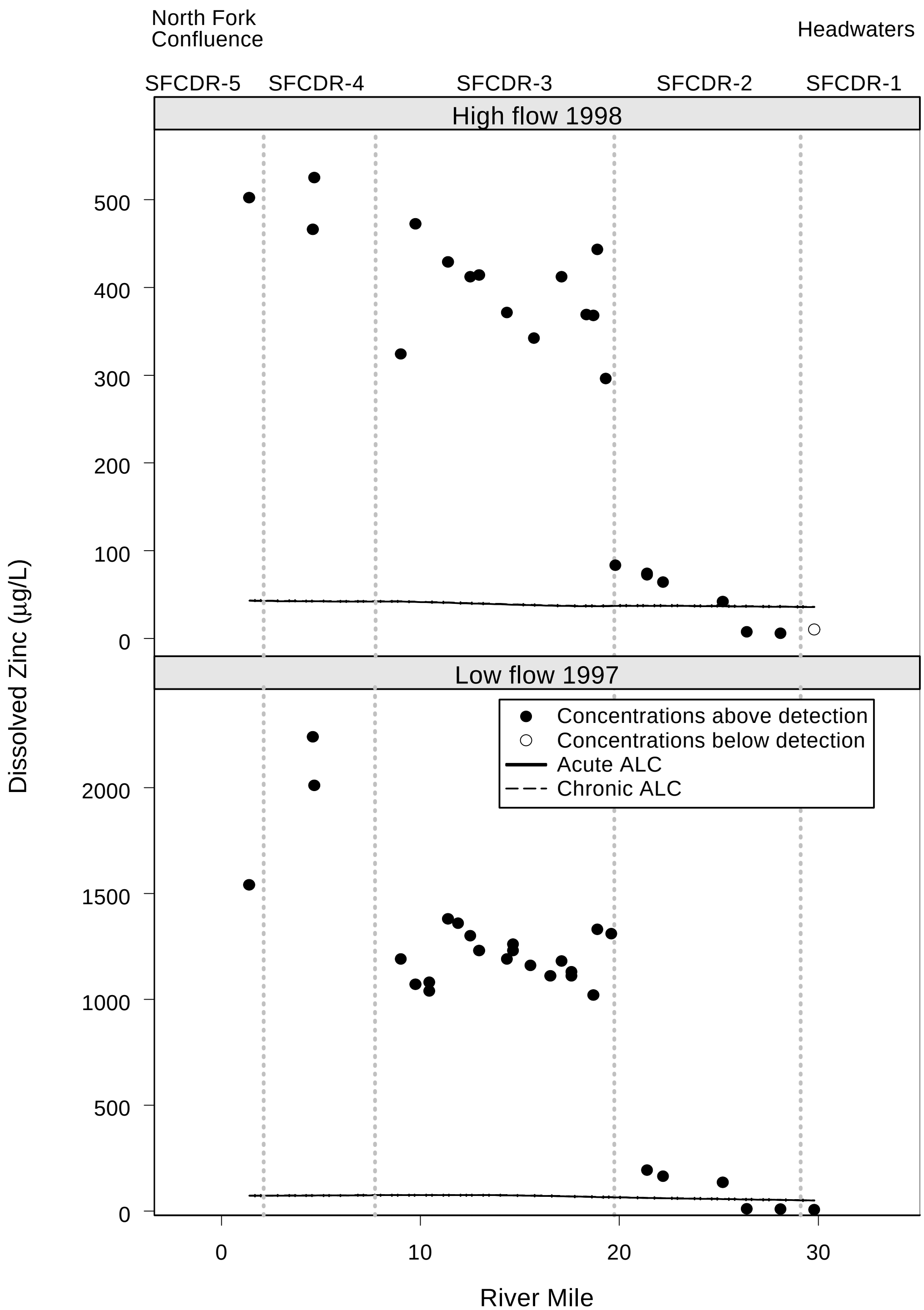

Figure 4-10. Dissolved zinc concentrations and chronic and acute ALC values during low flow 1997 and high flow 1998 synoptic samplings.

Acute ALC values for lead are much higher than chronic ALC values. Only two samples collected during high flow in 1998 exceeded the acute ALC lead value (Figure 4-9). No samples collected during low flow in 1997 exceeded the acute ALC lead value, and the acute ALC for lead is not shown in Figure 4-9. For high flow 1998 (Figure 4-9), only the three most upstream samples did not exceed the chronic ALC value for lead. All three samples are located upstream of Mullan, and two of these samples had concentrations below detection. During the low flow 1997 synoptic sampling, again, lead concentrations from the three most upstream sampling locations did not exceed the chronic ALC value for lead. For SFCDR-2, most of the concentrations exceeded chronic ALC values, but concentrations from the two most upstream sampling points did not.

Concentrations of dissolved lead increase dramatically downstream of the Canyon Creek confluence (upstream end of SFCDR-3). Unlike the profile of dissolved cadmium with distance in the South Fork Coeur d'Alene River, dissolved lead concentrations decrease monotonically with distance downstream of Canyon and Ninemile creek inputs. This pattern is apparent during both low flow 1997 and high flow 1998 synoptic samplings, with the exception of the two points in SFCDR-3 and 4 that exceed the acute ALC value for lead. This decrease with distance downstream is characteristic of a point source of contamination (in this case input from Canyon and Ninemile creeks).

Chronic and acute ALC values for zinc are nearly identical (Figure 4-10). All sampling points downstream of the Canyon Creek confluence exceeded both chronic and acute lead ALC values during both low flow in 1997 and high flow in 1998. Results for SFCDR-2 are similar to those for lead, in that the two most upstream points in the reach (upstream of Mullan) did not exceed ALC values, while all other points in the reach did. The one sampling point in SFCDR-1 did not exceed zinc ALC values during low flow or high flow.

Like dissolved cadmium concentrations, dissolved zinc concentrations show a monotonic increase with distance downstream, especially downstream of the Canyon and Ninemile creek confluences. Dissolved zinc concentrations in the South Fork Coeur d'Alene River downstream of Canyon Creek are higher than zinc ALC values by an order of magnitude or more during both high flow 1998 and low flow 1997. Concentrations in reaches SFCDR-3, 4, and 5 were approximately three to four times higher during low flow than high flow for the synoptic samplings in 1997 and 1998.

This additional analysis confirms that exceedences of acute and chronic cadmium, lead, and zinc criteria occur during both high flow and low flow conditions in all except the upper reaches of the South Fork Coeur d'Alene River, and that repeated exceedences occur at individual locations within the assessed reaches.

Both the acute and chronic ALC have been exceeded in reaches of streams in the South Fork Coeur d'Alene River basin, and at specific locations in the basin, repeatedly during the past 30 years. The duration of exposure is sufficient to trigger the ALC as well. Given the substantial magnitude of the exceedences, as well as the very high percentage of samples that exceed the ALC (Tables 4-8 through 4-13), the measured concentrations clearly meet both the 1-hour and 4-day average concentration standard. Moreover, exceedences are sufficiently frequent (approaching 100% of samples collected between 1967 and 1998) to indicate that the 3-year recovery period clearly is exceeded.

4.5.3 Surface Water as a Pathway of Injury to Other Resources

In addition to the injuries to surface water associated with exceedences of ALC, surface waters in the assessment area are injured because other natural resources have been injured as a result of exposure to contaminated surface water [43 CFR § 11.62 (b)(v)]. For example, as described in Chapter 7, fish are injured by exposure to contaminated surface waters. Chapter 8 demonstrates that benthic invertebrates also are injured as a result of exposure to contaminated surface waters (including suspended and bed sediments).

Studies conducted by the U.S. Geological Survey have also shown that zinc concentrations similar to those measured in Coeur d'Alene Lake cause toxicity (specifically, growth inhibition) in phytoplankton isolated from the lake (see Woods and Beckwith, 1997). In laboratory bioassays conducted in 1994, Kuwabara et al. (as cited in Woods and Beckwith, 1997) observed significant growth reductions in two species of Coeur d'Alene Lake phytoplankton, *Achnanthes minutissima* and *Cyclotella stelligera*, exposed to dissolved zinc concentrations of 19.6 and 39.2 µg/L.[1] Substantial growth reductions were observed even in the lower concentration (19.6 µg Zn/L); this concentrations is less than the median concentration of zinc measured in Coeur d'Alene Lake for the period 1993-1994, as reported by Woods and Beckwith (1997). These data demonstrate that exposure to zinc concentrations that commonly occur in Coeur d'Alene Lake injures phytoplankton, which form the basis of the aquatic food web. Coupled with data on toxicity to fish and invertebrates (Chapters 7 and 8), these studies confirm that surface waters are injured because concentrations of hazardous substances caused injuries to other natural resources.

1. The phytoplankton bioassays were conducted in the presence of EDTA (ethylenediaminetetraacetic acid), an artificial chelating agent designed to mimic the natural complexation of dissolved organic carbon (DOC) in Coeur d'Alene Lake water and hence simulate zinc bioavailability in the lake. However, as pointed out in the Expert Rebuttal Report of Dixon (1999), EDTA has a much higher affinity for zinc than naturally occurring DOC. As such, the bioassays would tend to underestimate the amount of bioavailable zinc in lake water thereby underestimating toxicity.

4.6 SUMMARY

The information presented in this chapter demonstrates the following:

- Sufficient concentrations of hazardous substances exist in pathway resources now, and have in the past, to expose surface water.

- Sufficient concentrations of hazardous substances exist in surface water resources now, and have in the past, to exceed federal, state, and tribal water quality criteria developed for protection of aquatic life. Therefore, surface water resources are injured.

- Methods and protocols for sampling and analysis of surface water varied over time and between agencies. The variability resulting from differences in methods may reduce overall data comparability. However, given the magnitude of ALC exceedences and the frequency of ALC exceedences over time in stream reaches downgradient of mining-related activity, it is unlikely that variability in the data set caused by differences in methods significantly affects the injury assessment results.

- Exceedences of federal water quality criteria, and therefore, surface water injuries, have been documented from the upper reaches of the South Fork Coeur d'Alene River (downstream of Daisy Gulch), through the mainstem Coeur d'Alene River and Coeur d'Alene Lake, to at least the USGS gauge station at Post Falls Dam on the Spokane River. Surface waters of the mainstem Coeur d'Alene River from the North Fork Coeur d'Alene River confluence to Coeur d'Alene Lake are injured, surface waters of the lateral lakes are injured, and surface waters of Coeur d'Alene Lake are injured.

- Exceedences of federal water quality criteria have also been documented in tributaries of the South Fork Coeur d'Alene River, including Canyon Creek from approximately Burke to the mouth and Gorge Gulch downstream of the Hercules No. 3 adit; the East Fork and mainstem Ninemile Creek from the Interstate-Callahan Mine to the mouth; Grouse Gulch from the Star Mine waste rock dumps to the mouth; Moon Creek from the Charles Dickens Mine/Mill to the mouth; Milo Creek from the Sullivan Adits to the mouth; Portal Gulch downstream of the North Bunker Hill West Mine; Deadwood Gulch/Bunker Creek downstream of the Ontario Mill; Government Gulch from the Senator Stewart Mine to the mouth; East Fork and mainstem Pine Creek from the Constitution Upper Mill to the mouth; Highland Creek from the Highland Surprise Mine/Mill and the Sidney (Red Cloud) Mine/Mill to the mouth; Denver Creek from the Denver Mine to the mouth; and Nabob Creek from the Nabob Mill to the mouth.

- Concentrations of hazardous substances in surface water resources of Coeur d’Alene Lake are sufficient to cause adverse effects to phytoplankton

- Concentrations of hazardous substances in surface water resources are sufficient to cause injury to aquatic biological resources (Chapter 7, Fish Resources), and to serve as a pathway of injury to wildlife (Chapter 6, Wildlife Resources) and to aquatic biological resources (Chapter 7, Fish Resources; and Chapter 8, Benthic Macroinvertebrates).

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