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# Distribution Of Heavy Metal Loadings To The South Fork Couer d'Alene River In Northern Idaho

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# DISTRIBUTION OF HEAVY METAL LOADINGS TO THE SOUTH FORK COEUR D'ALENE RIVER IN NORTHERN IDAHO

Final Report
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for the
National Network for Environmental Management Studies
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**ABSTRACT**

The purpose of this study is to determine the current distribution of metals loadings to the South Fork Coeur d'Alene River in northern Idaho. Water quality and flow data obtained from EPA Region 10 for September 1986 and September 1987 are used to determine loadings during the low-flow season. Data from May of 1988 are used to determine loadings for the high-flow season.

Total and dissolved loads of arsenic, cadmium, copper, lead, mercury, and zinc are calculated for the river and tributary streams. For the point-source discharges, loadings are calculated using average flow rates and metals concentrations as recorded on monthly NPDES discharge monitoring reports. Diagrams of the South Fork River basin showing sample locations and total metals loadings for cadmium, lead, and zinc are compiled.

Because most of the point sources of metals to the South Fork have been effectively controlled, water quality degradation in the basin is in large part a result of non-point sources and remobilization of floodplain and river bed sediment. Tailings are dispersed throughout the floodplain and continue to degrade the waters by their availability to leaching and erosion. Impacts to the river are greatest during high flows which result in an increase in contaminant loads to the river. Water quality also becomes critical for aquatic life during low-flow periods when metal concentrations peak.

**DISTRIBUTION OF HEAVY METAL LOADINGS TO THE SOUTH FORK COEUR D'ALENE RIVER IN NORTHERN IDAHO**

## 1.0 INTRODUCTION

This study examines the distribution of heavy metals loadings to the South Fork Coeur d'Alene River in northern Idaho under low- and high-flow conditions. Water quality and flow data obtained from EPA Region 10 for the September 1986 through May 1988 time period are examined to evaluate the primary sources of heavy metal pollutants to the river.

The study area encompasses the drainage basin of the South Fork Coeur d'Alene River from above the town of Mullan to downstream of the confluence of the South Fork and the main stem of the Coeur d'Alene River at Cataldo. The study area is shown on Figure 1. The South Fork Coeur d'Alene River has its headwaters in the Bitterroot Mountain Range on the continental divide near the Idaho-Montana border and lies entirely within Shoshone County, Idaho. The South Fork drains an area of about 300 square miles and flows westward for approximately 30 miles to its confluence with the North Fork. From this confluence near Cataldo, the Coeur d'Alene River flows an additional 35 miles into Lake Coeur d'Alene.

The study area includes the cities of Wallace, Osburn, Kellogg, Wardner, Smelterville, and Pinehurst. Mineral production is the primary industry in the area, which is known as the Coeur d'Alene Mining District. For over a century, metals such as gold, silver, lead, copper, zinc, cadmium, and antimony have been extracted from numerous mines and processed at various mills in the area. Metals refining has occurred at various facilities located in the drainage basin of the South Fork, including a lead smelter; zinc plant; cadmium, silver, and antimony refineries; and a phosphoric acid and phosphate fertilizer plant.

The South Fork Coeur d'Alene River has had a history of water quality problems due to metals pollution from mineral production activities. Since the passage of the Clean Water Act, discharge limits have been imposed on point dischargers of pollution to the river. Following a long-term monitoring program, EPA determined (Hornig et al., 1988) that in 1986, the low-flow metals loadings to the river were primarily a result of non-permitted sources. The objective of this study was to examine data that was most recently collected by U.S. EPA, U.S. Geological Survey, and Dames & Moore to evaluate the current heavy metal loadings to the South Fork Coeur d'Alene River.

The author wishes to acknowledge the support and direction provided by David Frank of U.S. EPA's Region 10 Environmental Services Division and by Richard Horner of the University of Washington Department of Civil Engineering. The author also acknowledges the

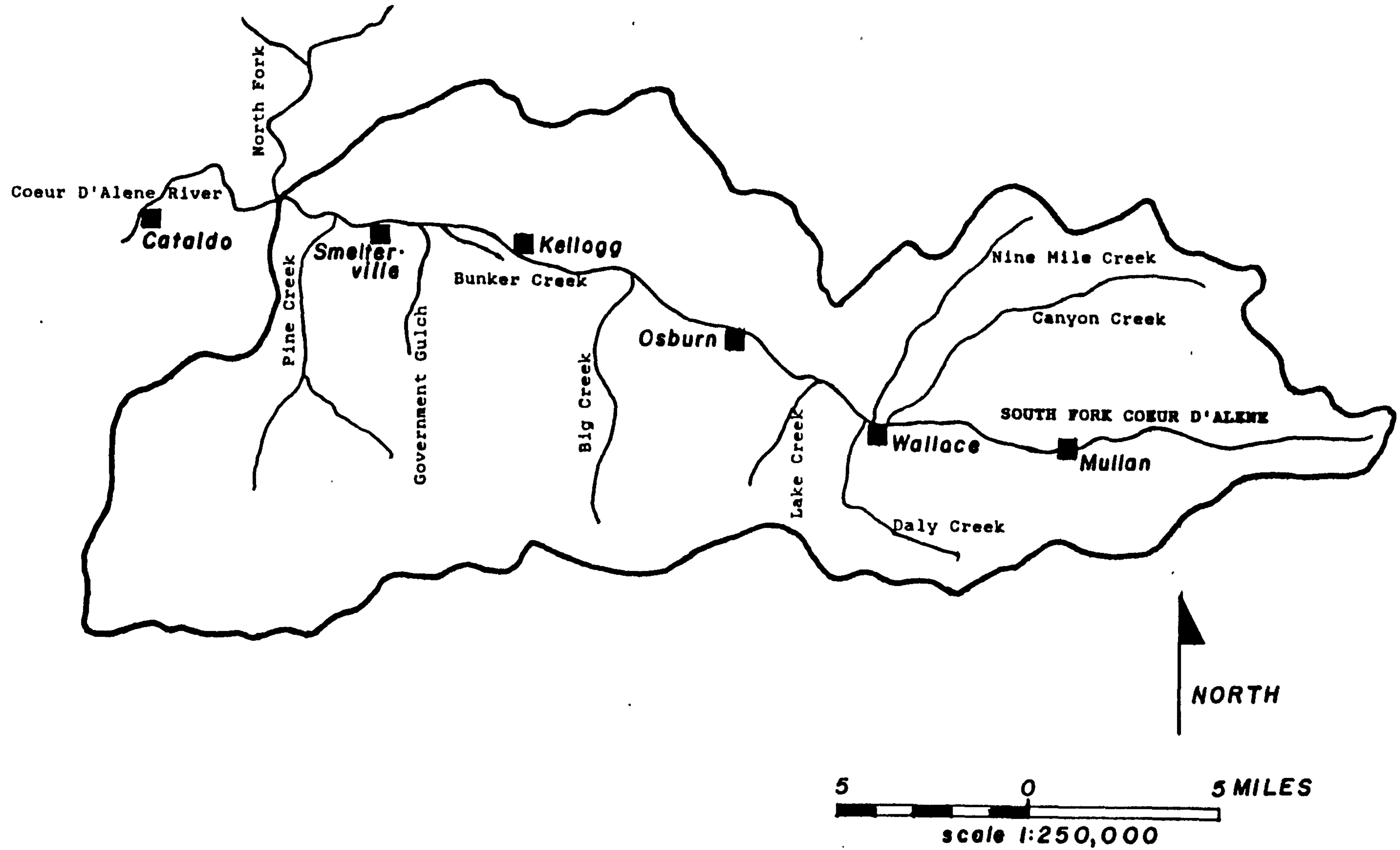


Figure 1. Map of the South Fork Coeur d'Alene River Basin.

assistance of Bill Bogue of the Ambient Monitoring and Analysis Branch in using the EPA Region 10 database, and of Vaughn Blethen, Ken Mosbaugh, and Bella Patheal of the Region 10 Water Division for providing the NPDES data used in the study.

## 1.1 Background

Water quality problems in the South Fork have been caused by direct discharge of mine waters, mill tailings, and industrial wastes by the mining companies from the 1880's until the 1960's. In 1964, it was estimated that an average of 2217 tons per day of tailings slurries were discharged to the South Fork (Cornell et al., 1964).

The Bunker Hill Superfund Site is a 21-square mile area that lies within the study area. This three-by-seven mile rectangular-shaped site is aligned in an east-west direction along the river from Elizabeth Park at the upstream end to the City of Pinehurst on the western and downstream end. Major features of the Superfund Site include the actively operating zinc mine, mill, concentrator, associated tailings disposal facilities, and an abandoned smelter complex. The smelter complex includes a lead smelter; electrolytic zinc plant; silver and cadmium refining plants; a phosphoric acid and phosphate fertilizer plant; and associated wastes, buildings, and impoundments.

The first tailings pond in the river basin was built in 1927 for the Bunker Hill Operation between the towns of Pinehurst and Smelterville. By December of 1968, tailings ponds had been built by the other milling operations. These ponds resulted in a significant reduction in the amount of suspended solids discharged to the river. However, the many years of heavy-metal-contaminated discharges have impacted the river sediments from Mullan to Coeur d'Alene Lake.

In 1978 the Idaho Water Resources Board evaluated the resource management problems of the South Fork Couer d'Alene River Basin and developed a plan for rehabilitation of the area. The component materials found in the floodplain of the river were mapped on aerial photographs. Extensive tailings deposits were found to exist in the floodplain near the cities of Kellogg and Osburn, at Cataldo Flats, and in various tributary gulches. The floodplain was determined to be composed of a mixture of alluvium and tailings throughout most of the basin. Tailings deposited downstream of the South Fork at Cataldo Flats had made the area unsuitable for agricultural use (Eisenbarth and Wrigley, 1978).

The U.S.D.A. Soil Conservation Service has recently mapped the soils of the basin and has classified the chemically treated ores from the milling process as "slickens" which are located in basins, flood plains, and valley floors of the study area. The "slickens" soils are detrimental to plant growth due to heavy metals concentrations (USDA, 1989). Tailings deposited in the flood plain of the South Fork are unstable and erode easily during high flows. Suspended sediment continues to be deposited in slow reaches of the river. During high flows, loadings of metals to the river increase although concentrations of metals in the water decrease as a result of dilution. During low-flow periods, however, the heavy metal concentrations in the South Fork are high enough to be toxic to most aquatic plants and animals. In comparison to the North Fork of the river, species diversity and quantity are much lower in the South Fork due to high concentrations of zinc, copper, and lead in the waters downstream of Mullan (Eisenbarth and Wrigley, 1978).

Concentrations of zinc and cadmium in the South Fork have remained at levels detrimental to aquatic life, even years after tailings pond installations. Water quality data collected from December 1968 through March 1970 (Mink et al., 1971) showed that significant increases in mean zinc concentrations in the South Fork were a result of inflows from the Lucky Friday settling pond at Mullan, from seepages through historic mine wastes deposited in Canyon Creek, and from Government Gulch, which is the site of the abandoned zinc and cadmium refining plants within the Bunker Hill Complex. Lake Creek, Nine Mile Creek, and Big Creek were found to produce no significant loading of zinc to the South Fork at that time. Levels of cadmium in the water below Canyon Creek and Government Gulch were above recommended limits for fish.

Impacts of historic minerals-related discharges to Lake Coeur d'Alene have been documented. A 1987 study by the U. S. Geological Survey of water quality in the lake was instituted in part because of trace element water quality problems resulting from mining and ore-processing activities in the basin. Bottom sediments in the lake contain high concentrations of cadmium, lead, and zinc. Hypolimnetic (near the bottom) waters in the lake contained concentrations of total recoverable cadmium which exceeded the chronic toxicity criteria on some occasions. Total recoverable lead concentrations exceeded the acute toxicity criteria in several samples. Total recoverable zinc concentrations exceeded the acute and chronic toxicity criteria throughout the study (Woods, 1989).

Bibliographies of literature and studies related to the Coeur d'Alene River basin have been compiled by the U.S. EPA and others (U.S. EPA, 1985; Wai et al., 1985; and Savage, 1986). Recent interest in the environmental problems in the basin has resulted in the formation of the Coeur d'Alene River Basin Interagency Group, with members from various federal, state, and local agencies, the Coeur d'Alene Indian Tribe, and individual property owners. The group's purpose is to assist in coordinating basin studies and recommending future work on the Coeur d'Alene River. Also, the EPA Region 10 has recently proposed to add the South Fork to its Clean Water Act Section 304-L "short list" of waters not expected to meet water quality standards due to minerals-related discharges from the study area.

## 1.2 Metals of Concern

### 1.2.1 Arsenic

Arsenic is a rare but ubiquitous element that is extremely mobile in natural waters. Arsenic cycles through the aquatic environment in the sediment, the water column, and the biota. Adsorption and desorption with sediment dominate the arsenic cycle. Adsorption is the controlling mechanism in acidic, aerobic fresh waters. Sediments and the ocean are the primary sinks for arsenic. Arsenic may form organic complexes. Arsenic's chemical speciation is very important in determining its distribution, mobility, toxicity, and aquatic fate. The +3 and +5 valence states of arsenic are the most common in natural waters. The +3 state is more toxic than the +5 state. For this reason, the speciation is important in determining its toxicity. Arsenic is toxic to and bioaccumulated by biota (Callahan, Slimak, and others; 1979).

### 1.2.2 Cadmium

Cadmium is a relatively rare element. When associated with lead and zinc ores, cadmium occurs naturally as a sulfide salt. Its source in aquatic systems is generally from mining and smelting operations. It has no biological benefit and is toxic to aquatic life and mammals (U.S. EPA, 1988).

Transport of cadmium in natural waters is controlled by the ion speciation, mainly the divalent cation. Cadmium forms both inorganic and organic complexes. Sorption processes are important in the transport and partitioning of cadmium and in determining its potential for remobilization. The most important factor in reducing the cadmium load in waters is sorption. Cadmium is more mobile in acidic water than in alkaline water. Cadmium is strongly accumulated through both food and water by fresh water organisms, and may even displace zinc (an essential element) in certain enzymes (Callahan, Slimak, and others; 1979).

### 1.2.3 Copper

Copper is found in most natural waters at concentrations not known to have any toxic effects to humans or aquatic life. Decreased water hardness enhances the toxicity of copper. Copper is an essential trace element (U.S. EPA, 1988).

Processes which control the fate of copper in natural waters are: complex formation, sorption, and bioaccumulation. Copper is present mainly as the divalent cation in water and has a strong tendency to form inorganic and organic complexes. This is most important in determining its aquatic fate. In fact, even if total copper concentrations are high, complexation, precipitation, and adsorption to particulates can reduce dissolved copper concentrations to very low levels. Copper has an affinity for hydrous oxides of manganese and iron, carbonate minerals, organic matter, and clays. Sorption to these materials effects a decrease in the dissolved phase and thus, reduces its mobility. In addition, copper is strongly accumulated by biota (Callahan, Slimak, and others; 1979).

### 1.2.4 Lead

Lead enters the waters through dust fallout, precipitation, leaching, erosion of soil, street runoff, and municipal or industrial waste discharges. It is toxic to animals and humans and has been found to accumulate in body tissues. Lead has no nutritional or other beneficial value to living organisms. In waters, the toxicity of lead is affected by pH, hardness, presence of other metals, and organic matter (U.S. EPA, 1988).

Lead is not very soluble in water. Lead has a strong tendency to form complexes with organic matter and to sorb with the particulate phases in the aquatic environment. The ligands of river water complex with almost all the dissolved lead is such systems. Lead is more mobile in acidic waters. In alkaline waters, lead is removed from the dissolved phase very quickly. Above pH 7, most of the lead is in the solid phase. The process of sorption is a controlling mechanism in the fate of lead in the aquatic environment, reducing dissolved lead levels and causing an enrichment of lead in the sediment. Lead is accumulated by aquatic biota (Callahan, Slimak, and others; 1979).

### 1.2.5 Mercury

Mercury is extremely toxic to humans and is acquired by aquatic organisms through direct contact or through the food chain. The fate of mercury in natural water is controlled by its strong affinity for adsorption onto inorganic and organic particulates which causes its removal from the water. Sediments are the major sink for mercury in the aquatic environment. Dissolved mercury is removed from the water within a short time, generally near its source. Mercury is a liquid at normal temperatures and is not very soluble in water. Mercury is bound strongly with sediment in river water and can be transported through sedimentary mobilization. Mercury is strongly accumulated by biota (Callahan, Slimak, and others; 1979).

### 1.2.6 Zinc

At moderately low concentrations, zinc is a beneficial and essential element for human and animal metabolism. It usually occurs in nature as a sulfide, often associated with sulfides of other metals. The solubility and toxicity of zinc is influenced by pH and other factors in the aquatic environment (U.S. EPA, 1988).

Speciation of the zinc ion controls its transport and fate in natural waters. Of the heavy metals, zinc is one of the most mobile. The zinc ion and compounds of zinc formed with the ligands of surface waters are soluble in acidic or neutral waters. In reducing environments, precipitation of zinc sulfide will control its mobility. In most cases, zinc will be present as a divalent cation and will be easily adsorbed. The tendency for sorption is dependant on pH and salinity of the water and the nature of the sorbent. If pH exceeds 7, zinc will generally be removed from solution. Below pH 6, little zinc will be adsorbed. Zinc is strongly accumulated by all organisms, even when it occurs in low concentrations (Callahan, Slimak, and others; 1979).

## 2.0 METHODS

Water quality data for the period of interest were compiled from the following sources:

1) EPA Region 10 chemical data from water monitoring during 1986 late-summer low-flow conditions (U.S. EPA Region 10 files).

2) Water quality data collected by Dames & Moore in 1987 and 1988 to support the Superfund Remedial Investigation at the Bunker Hill Site (Dames & Moore, 1990).

3) National Pollutant Discharge Elimination System (NPDES) discharge monitoring reports for permitted discharges in the South Fork drainage (U.S. EPA Region 10 files).

4) U.S. Geological Survey discharge and water quality data from the Cataldo gaging station on the Coeur d'Alene River (U.S. EPA Region 10 files).

Table 1 is a list of the South Fork Coeur d'Alene River (SFCDR) Basin sampling locations listed in order of distance downstream from the basin headwaters. A diagram (not to scale) showing the relationship of the sampling locations to the basin is displayed on Figure 2.

**TABLE 1. SOUTH FORK COEUR D'ALENE BASIN SAMPLE SITES**

| STATION{1} | STATION NAME AND LOCATION |
|---|---|
| 153541 | SFCDR at culvert in Shoshone Park above Mullan |
| 153368 | SFCDR below Lucky Friday #003 Tailings Pond |
| SF-1 | SFCDR above Mullan 30 ft upstream from old hwy bridge |
| 153097 | SFCDR 100 ft above Canyon Creek at Wallace |
| 153125 | Canyon Creek at mouth at Wallace |
| 153132 | Nine Mile Creek at mouth at Wallace |
| 153100 | SFCDR 100 ft above Lake Creek |
| 153137 | Lake Creek at mouth |

| | |
|---|---|
| 153104 | SFCDR at bridge above Big Creek |
| 153147 | Big Creek at mouth |
| SF-2 | SFCDR at downstream side of bridge at Elizabeth Park |
| 03E009 | SFCDR above Kellogg |
| 153148 | Milo Creek near mouth |
| IG-1 | Italian Gulch near mouth |
| MC-2 | Milo Creek near mouth |
| MC-1 | Milo Creek 30 ft upstream from water supply intake |
| 153108 | SFCDR at Bunker Avenue Bridge at Kellogg |
| JC-1 | Jackass Creek near mouth |
| SF-3 | SFCDR downstream of New Street Bridge at Kellogg |
| 03Z038 | Cook Creek near mouth |
| CC-1 | Cook Creek near mouth |
| 03#061 | Bunker Hill CIA Seep #1 to SFCDR |
| CIA-1 | Bunker Hill CIA Seep #1 to SFCDR |
| 03#062 | Bunker Hill CIA Seep #2 to SFCDR |
| CIA-2 | Bunker Hill CIA Seep #2 to SFCDR |
| 03#063 | Bunker Hill CIA Seep #3 to SFCDR |
| 03#064 | Bunker Hill CIA Seep #4 to SFCDR |
| 03#065 | Bunker Hill CIA Seep #5 to SFCDR |
| 03#066 | Bunker Hill CIA Seep #6 to SFCDR |
| SF-4 | SFCDR 250 ft upstream from confluence with Bunker Crk |
| 153362 | SFCDR 100 ft upstream from confluence with Bunker Crk |
| 03Y001 | Bunker Creek at Bunker Hill Company monitor |
| 153165 | Bunker Creek at mouth |
| BC-2 | Bunker Creek near mouth |
| BC-1 | Bunker Creek above Central Treatment Plant outfall |
| 03Y002 | Government Gulch at Bunker Hill Company monitor |
| 153152 | Government Gulch at mouth |
| GG-3 | Government Gulch at mouth |
| GG-2 | Government Gulch above Zinc Plant |
| GG-1 | Government Gulch 100 ft upstream of supply intake |
| 153110 | SFCDR at Airport Avenue Bridge near Smelterville |
| SF-5 | SFCDR 250 ft upstream from Smelterville theater road |
| SF-6 | SFCDR above Page STP outfall near west end of runway |
| 153333 | SFCDR above Pine Creek |
| SF-7 | SFCDR above Pine Creek |
| 153207 | Pine Creek near mouth |
| PC-2 | Pine Creek near mouth |
| LP-1 | Little Pine Creek upstream from Pinehurst |
| PC-1 | Pine Creek above Pinehurst |
| SF-8 | SFCDR upstream from the railroad bridge below Pine Crk |
| 153023 | SFCDR at mouth |
| 153019 | North Fork CDR above confluence with SFCDR at Enaville |
| NF-1 | North Fork CDR 300 ft above confluence with SFCDR |
| 112WRD | USGS Gaging Station near Cataldo |
| 153018 | Coeur D'Alene River near I-90 Bridge at Cataldo |

{1} The source of station numbers are as follows:
The 6-digit alphanumeric codes are STORET station numbers, except 112WRD which is a USGS station number.
All other station numbers are from Dames & Moore (1990).

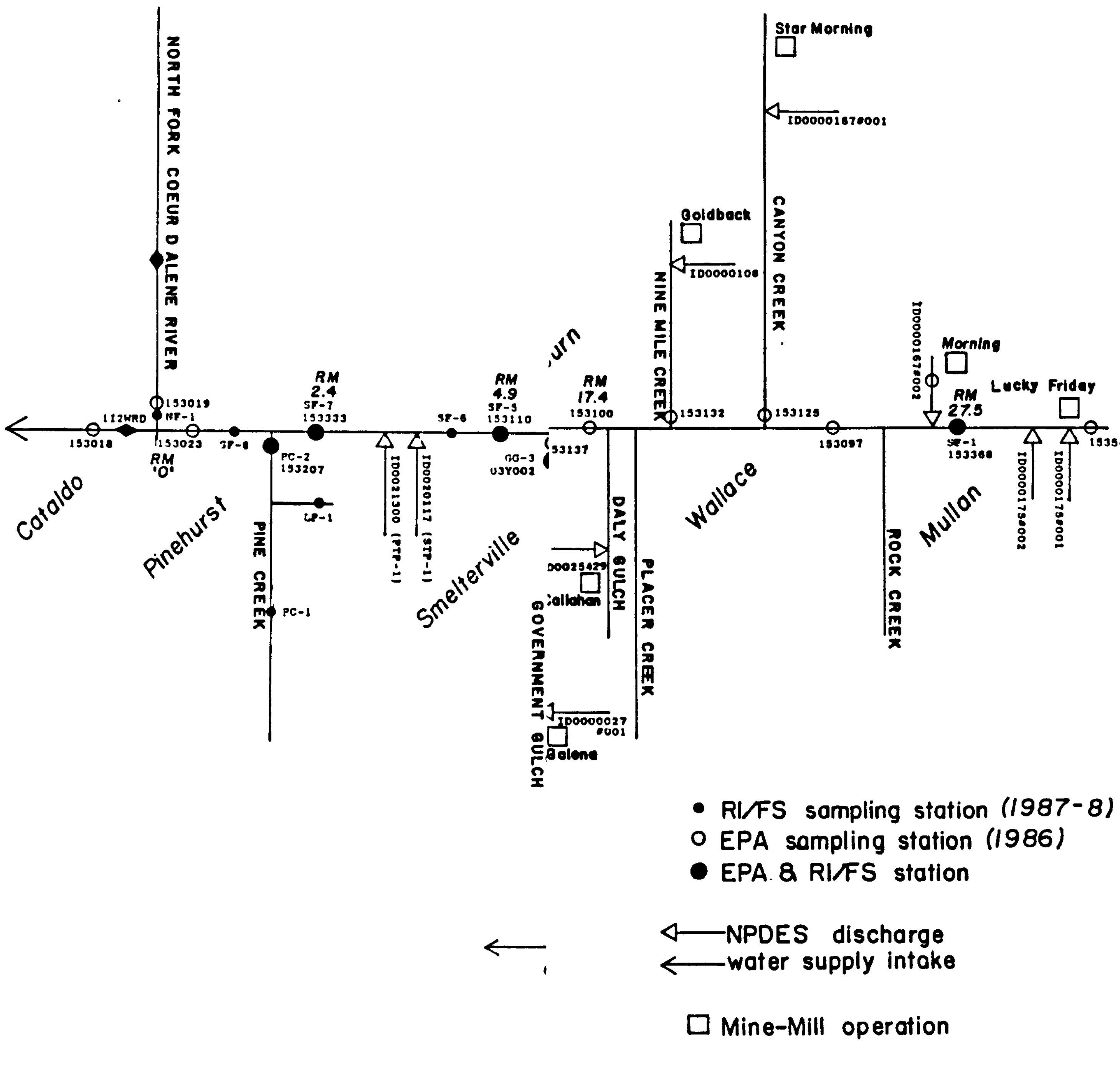


Figure 2. Diagram of the Sou

## 2.1 EPA Water Quality Monitoring Data

Beginning in 1972 and following passage of the Clean Water Act, which required limits on point source discharges, EPA Region 10 began a chemical monitoring program on the South Fork Coeur d'Alene River (Hornig et al., 1988). From 1972 until 1986, late-summer low-flow monitoring for heavy metals was conducted. During the most recent monitoring period, metals analysis of fish tissue and sediment was also performed on samples collected from the entire drainage basin, including Lake Coeur d'Alene. Heavy metals of concern to EPA have been zinc, cadmium, and copper for aquatic life and lead and cadmium for human and animal health.

Total and dissolved parameters were analyzed during the 14-year term. Samples collected for total metals analysis were unfiltered. Samples collected for determination of dissolved metals were filtered in the field with a 0.45 micrometer filter. Values for total and dissolved metals were found to be nearly equal during low-flow sampling periods (Hornig et al., 1988). For this reason, dissolved metals were not analyzed for most of the EPA monitoring stations in 1986. The data acquired from the EPA low-flow studies are available on the Region 10 STORET database management system. Water quality data for 1986 for the South Fork basin downstream to Cataldo were used for this study.

## 2.2 Bunker Hill Remedial Investigation

A Remedial Investigation/Feasibility Study (RI/FS) at the Bunker Hill Superfund Site has been ongoing since 1987, when the prior owner-operator of the facility signed an EPA Order on Consent to conduct the investigation under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA, also known as Superfund). Dames & Moore is conducting the studies on behalf of Gulf Resources and Chemical Corporation. Surface water monitoring was performed during 1987 and 1988 and some of the data are available on the EPA Region 10 STORET computerized database system.

Surface water data from the investigation have been reported and summarized (Dames & Moore, 1990). Analysis of samples collected during September 1987 and May 1988 were used for this study. Water samples were collected beginning in August 1987 and until October 1988 and were analyzed for dissolved and total priority pollutant metals. Baseline samples were collected manually from 8 stations on the South Fork and on numerous tributaries in September and December 1987 and in April, May, August, and October 1988. Depending on depth of the water, samples were collected at South Fork stations using either the equal-width depth-integrated or the grab method. The channel size determined the width increment and samples were generally taken from at least six points along the stream channel section. Composite water samples taken for total metals analysis were unfiltered. Samples collected for determination of dissolved metals were filtered with a 0.45 micrometer filter.

Dames & Moore established two stream gaging stations with continuous flow recorders on the South Fork at the upstream and downstream boundaries of the Superfund site. In addition to these stations at Elizabeth Park and Pinehurst, stream gaging stations were established near the mouth of two major tributaries to the South Fork on Bunker Creek and Government Gulch. The South Fork drainage area is 178 square miles at the Elizabeth Park station and is 284 square miles upstream of Pinehurst. At the City of Kellogg within the Bunker Hill site, the river drains an area of 194 square miles. The annual mean precipitation during the period from 1951 to 1980 was 30 inches at Kellogg. Average flow in the South Fork at Kellogg during the U.S.G.S. period of record from 1975 to 1982 was 371 cfs. From September 1987 to August 1988, the annual precipitation was 73 percent of the 30-year average (1951-1980) at 22 inches. Minimum flow during the investigation was 42 cfs at Elizabeth Park and 60 cfs at Pinehurst. Peak flows occurred in mid-April with a second lower peak occurring in May 1988 (Dames & Moore, 1990).

## 2.3 NPDES Discharge Information

Discharge Monitoring Reports (DMRs) and Fact Sheets related to the NPDES permitted discharges were obtained from the EPA Region 10 Water Permits and Compliance Branch. The Fact Sheets were examined to determine the locations of the discharges. Average monthly flow rates for the point sources were reported in cubic feet per second (cfs) or millions of gallons per day (mgd). Depending on the NPDES permit requirements for each discharge, sampling and analysis for total metals was done on a daily, weekly, or monthly basis. Mean monthly concentrations reported in the DMRs in units of micrograms or milligrams per liter (ug/l or mg/l) were used to determine the loadings of metals from each discharge. The monthly periods examined were September 1 to 30, 1986; September 1 to 30, 1987; and May 1 to 30, 1988. Table 2 lists the NPDES identification numbers for the discharges which were permitted during the study period 1986 through 1988.

## 2.4 Cataldo Gaging Station

Data from the U.S.G.S. instantaneous stream flow gaging station located at Cataldo were used for this study (U.S. EPA Region 10 STORET database). Samples were collected during 1987 and 1988 and waters were analyzed for dissolved metals. Stream flows at Cataldo, downstream of the confluence of the South Fork with the North Fork Coeur d'Alene River, were 312 cfs on September 2, 1987 and 2,420 cfs May 25, 1988. The pH at this station was 7.1 in September 1987 and 6.6 in May 1988.

## TABLE 2. SOUTH FORK COEUR D'ALENE BASIN POINT SOURCE DISCHARGES

| IDENTIFICATION NUMBER | RIVER MILES | DESCRIPTION |
|---|---|---|
| ID0000175#001 | 27.8 | Hecla Mining Company at Mullan Lucky Friday No. 3 Tailings Pond |
| ID0000175#002 | 26.6 | Hecla Mining Company at Mullan Lucky Friday No. 2 Tailings Pond |
| ID0000167#002 | 26.3 | Hecla Mining Company at Mullan Morning Tunnel Outfall |
| ID0000167#001 | 19.1 | Hecla Mining Company at Canyon Creek |
| ID0000108 | 18.7 | Goldback Mines at Nine Mile Creek |
| ID0025429 | 18.0 | Asarco Inc. at Daly Creek |
| ID0000027#001 | 17.1 | Asarco Inc. Galena Mine at Lake Creek |
| ID0000027#002 | 15.3 | Asarco Inc. Coeur Mine at Osburn |
| ID0000159 | 13.1 | Asarco Inc. Consolidated Silver Mine at Osburn |
| ID0000060#001 | 11.2 | Sunshine Mining Company Tailings Pond at Big Creek |
| ID0000060#002 | 11.2 | Sunshine Mining Company Cooling Water at Big Creek |
| ID0000078#006 | 5.4 | Bunker Hill Mining Central Treatment Plant at Bunker Creek (CTP-1) |
| ID0000078#002 | 5.4 | Bunker Hill Bunker Creek Monitoring Station |
| ID0000078#009 | 5.0 | Bunker Hill Number 96 Mine Tunnel Discharge |
| ID0000078#008 | 5.0 | Bunker Hill Booster Station Overflow |
| ID0000078#002 | 5.0 | Bunker Hill Goverment Gulch Monitoring Station |
| ID0020117 (STP-1) | 3.2 | Smelterville Sewage Treatment Plant |
| ID0021300 (PTP-1) | 3.1 | SFCD Sewer Dist. Page Treatment Plant |

## 2.5 Calculation of Metal Loadings

Flow in cfs and metal loadings in lbs/day were calculated for each ambient water monitoring station and each point source discharge. Tables displaying the loadings of arsenic, cadmium, copper, lead, mercury, and zinc were compiled onto spreadsheets and are included in the report appendix. Field measurements of electrical conductivity (EC) and pH for each sampling location are shown in the appendix tables. Sampling locations are listed in order of distance downstream from the headwaters.

Loadings based on total metal concentrations were calculated for the 1986, 1987, and 1988 ambient water quality monitoring stations by STORET. Dissolved metals loadings were also calculated for September 1987 and May 1988 because dissolved data was available for those months. Printouts containing the STORET information were obtained, and the loadings were tabulated in order of decreasing river-miles. For stations in which more than one sample was collected during the month of interest, the loadings were calculated using the arithmetic average concentration and measured pH and EC were arithmetically averaged. For metals concentrations which were below the laboratory detection limit, loadings were calculated using the detection limit as the sample concentration.

Loadings for the point sources were calculated from the data reported in the NPDES monthly discharge monitoring reports. Average monthly flow was converted from units of millions of gallons per day (MGD) to cubic feet per second (cfs) for each discharge. Metal loadings were calculated using the average monthly constituent concentration and one of the following formulas:

LOAD (lbs/day) = average flow (CFS) * concentration (ug/l) * 0.0054

LOAD (lbs/day) = average flow (MGD) * concentration (mg/l) * 8.35

In cases for which pH ranges were reported, the mean pH for the month was listed. The appendix tables list all the relevant information available for each location. In 1986, metals concentration data were available for certain stations sampled for the fish tissue and aquatic toxicity study. However, flow rates were not available for all of these stations. If flow rates were not measured at the station, loadings were not calculated.

The loadings for each station along the South Fork were examined in conjunction with Figure 2 to determine the incremental load (in lbs per day) of each metal contributed to the river along each reach. Then the loadings calculated for the tributaries and point discharges were noted to determine the amount contributed by each particular source to the South Fork. In the case where a particular source for a loading could not be identified, the load was interpreted to have come from the entire reach. For cases in which portions of the river's total load could be tied to one or more identifiable sources, those loads were subtracted from the total reach load to determine the portion of the load coming from non-point sources along the reach of the river.

Stick-type figures were developed to display the cadmium, lead, and zinc loading results for the low-flow and high-flow periods, respectively (Horner et al., 1986). Loadings that were attributed to an identifiable source were shown as a tributary load on the figures. Loadings shown for an entire reach of the river are the metals contributed along the reach that cannot be linked to a specific source.

Tables summarizing the loading results for arsenic, cadmium, copper, lead, and zinc were compiled for each month of interest. Limited loading data were available for mercury. For the majority of samples for which data were available, undetectable quantities of mercury were reported.

## 3.0 RESULTS

This discussion of results is limited to interpretations made and loadings calculated from the data collected from the South Fork Coeur d'Alene River Basin during 3 month-long periods: September 1986, September 1987, and May 1988.

### 3.1 Water Quality

Total metals concentration ranges in milligrams per liter (mg/l) for pollutants in the South Fork waters for September 1986 were: Cadmium--0.004 to 0.029 mg/l; Copper--0.015 to 0.026 mg/l; Lead--0.007 to 0.188 mg/l; Zinc--0.496 to 2.91 mg/l. Cadmium concentrations were highest at the Airport Avenue bridge near Smelterville. Lead concentrations were highest near the mouth of the South Fork, and zinc concentrations were highest at the station just upstream of Pine Creek. The September 1987 concentration ranges for pollutants were: Cadmium--0.002 to 0.015 mg/l; Lead--0.019 to 0.048 mg/l; and Zinc--0.02 to 2.91 mg/l. The highest cadmium concentration was at the Elizabeth Park station (SF-2). The concentration of lead and zinc was highest at the station just upgradient from Pine Creek (SF-7). The station upstream of Mullan (SF-1) had the lowest concentration of these metals. In May of 1988, total metals concentrations in mg per liter ranged as follows: Cadmium--0.004 to 0.012; Lead--0.005 to 0.188 and Zinc--0.020 to 0.806. The highest concentrations were found at the station above Pine Creek (SF-6 and SF-7) for cadmium and below Pine Creek (SF-8) for lead and zinc.

The EPA primary and secondary Maximum Contaminant Levels for the National Drinking Water Regulations (see 40 CFR Part 141 and 143, July 1, 1990) and Aquatic Life Criteria (acute and chronic) are shown in Table 3 for the six metals of concern. Concentrations of cadmium at the Elizabeth Park station (SF-2) and downstream exceeded primary drinking water standards in September 1986 and September 1987. Aquatic Life Criteria for cadmium were exceeded at Kellogg (SF-3) and downstream stations in September 1986, September 1987, and May 1988. Lead exceeded the primary drinking water standard during high-flow in 1988 at the downstream end of the Bunker Hill Superfund Site (SF-8) and exceeded the Aquatic Life Criteria at Elizabeth Park (SF-2) and stations downstream on the South Fork to Pinehurst (SF-8) only during the high-flow period. Aquatic Life Criteria for zinc were exceeded during all three months from Elizabeth Park (SF-2) downstream to Pinehurst (SF-8) and were not exceeded above Mullan (SF-1). Secondary drinking water standards for zinc were never exceeded.

**TABLE 3. EPA WATER QUALITY STANDARDS AND CRITERIA** {1}

| **Constituent** | **As** | **Cd** | **Cu** | **Pb** | **Hg** | **Zn** |
|---|---|---|---|---|---|---|
| National Drinking Water Standards, Maximum Contaminant Levels(mg/l) | | | | | | |
| **Primary** | 0.05 | 0.01 | | 0.05 | 0.002 | |
| **Secondary** | | | 1.0 | | | 5.0 |
| Fresh Water Aquatic Life Criteria(mg/l) | | | | | | |
| **Acute** | | | | | | |
| at Hardness (as CaCO3): | | | | | | |
| 50 mg/l | 0.36 | 0.0018 | 0.0092 | 0.034 | 0.0024 | 0.065 |
| 100 mg/l | 0.36 | 0.0039 | 0.018 | 0.082 | 0.0024 | 0.12 |
| 200 mg/l | 0.36 | 0.0086 | 0.034 | 0.2 | 0.0024 | 0.21 |
| **Chronic** | | | | | | |
| at Hardness (as CaCO3): | | | | | | |
| 50 mg/l | 0.19 | 0.00066 | 0.0065 | 0.0013 | 0.000012 | 0.059 |
| 100 mg/l | 0.19 | 0.0011 | 0.012 | 0.0032 | 0.000012 | 0.11 |
| 200 mg/l | 0.19 | 0.002 | 0.021 | 0.0077 | 0.000012 | 0.19 |

{1} U.S. EPA, 1988

Total and dissolved concentrations ranges for the constituents were very similar except for cadmium and lead. Maximum dissolved lead during the above time periods was 0.015 mg/l, orders of magnitude less than the total concentrations. This may be explained in part by the poorly soluble nature of lead and its tendency to sorb with the particulate phase.

Dissolved metals concentrations from the Cataldo station were arsenic of 1 ug/l on May 15, 1987; cadmium ranging from 2 to 4 ug/l from October 1986 to May 1988; lead ranging from below 5 to 13 ug/l in May of 1987; and concentrations for zinc of 280 to 860 ug/l from October 1986 to May of 1988.

### 3.2 Metal Loadings

Total metals loadings in pounds per day of arsenic, cadmium, copper, lead, and zinc were calculated for September 1986 and 1987 and May of 1988. Mercury loadings were calculated for May 1988 only because mercury was not detected during the low-flow months.

Tables 4, 5, and 6 summarize percentages of the total load at the most downstream station contributed by each reach, tributary, or point source. Positive values of percentage loading contributed indicate that loadings are occurring along that particular reach of the river as a result of point or non-point sources or from remobilization of river bed or floodplain sediments. Negative values in Tables 4, 5, and 6 indicate that a particular metal loading has decreased in that reach. Mechanisms for this process are adsorption to particulates or river bed sediments, ion exchange, and precipitation or decrease in flow.

Table 4 shows the percentage of the total load found at the Cataldo station contributed by each identified source area in September, 1986. Table 5 shows the percentage of the total load found in the waters of the South Fork below Pine Creek contributed by each source area in September 1987. Table 6 shows the percentage of the total load for each of the five constituents found in the South Fork below Pine Creek in May 1988. Also shown in Table 6 is a ratio comparison of the load contributed to the Coeur d'Alene River by the North Fork and the South Fork. The ratio compares the total metals load at the SF-8 and NF-1 stations.

Since only dissolved metals data for 1987 and 1988 were available for the Cataldo station, dissolved loadings were calculated for stations along the South Fork for September 1987 and May 1988 in order to compare the total dissolved loadings of metals at Cataldo to those which originate in the South Fork. See the report appendix for more detailed total and dissolved loadings information for each of the three months for South Fork river reaches, tributaries, and point sources at each station.

## TABLE 4. 1986 LOW-FLOW TOTAL METALS LOADING RESULTS

**Percentage of Basin-Wide Loading Contributed by Each Reach**

| SOURCE | Arsenic | Cadmium | Copper | Lead | Zinc |
|---|---|---|---|---|---|
| **South Fork:** | | | | | |
| Above Mullan | 25 | 0 | 0 | 0 | 0 |
| RM 27.5 to 19.4 | 25 | 8 | 0 | 0 | 4 |
| Canyon Creek | 0 | 33 | 0 | 250 | 29 |
| Nine Mile Creek | 0 | 8 | 0 | 50 | 7 |
| RM 19.4 to 17.4 | -25 | 1 | 50 | 100 | 2 |
| RM 17.4 to 8.3 | 0 | 8 | 0 | -150 | 8 |
| Milo Creek | 0 | 0 | 0 | 50 | tr |
| RM 8.3 to 6.9 | -25 | -8 | 50 | -150 | -12 |
| RM 6.9 to 5.5 | 25 | 0 | -100 | -50 | 24 |
| Bunker Creek | 0 | 25 | 0 | 0 | 5 |
| Government Gulch | 0 | 17 | 0 | 100 | 2 |
| RM 5.5 to 4.9 | 25 | 16 | 50 | 0 | 3 |
| RM 4.9 to 2.4 | -50 | 0 | 50 | 150 | 14 |
| RM 2.4 to 0.4 | 25 | -8 | 50 | 350 | -7 |
| Pine Creek | 0 | 0 | 0 | 0 | tr |
| **North Fork** | 25 | 8 | 200 | 50 | tr |
| Confluence to Cataldo | 50 | 8 | -250 | -650 | 21 |
| | --- | --- | --- | --- | --- |
| Load at Cataldo (%) | 100 | 100 | 100 | 100 | 100 |

tr -- metals loading accounts for less than 0.5 % of total load

## TABLE 5. 1987 LOW-FLOW TOTAL METALS LOADING RESULTS

**Percentage of Basin-Wide Loading Contributed by Each Reach**

| SOURCE | Arsenic | Cadmium | Copper | Lead | Zinc |
|---|---|---|---|---|---|
| Above Mullan | 11 | 0 | 100 | 7 | tr |
| RM 27.5 to 9.1 | 67 | 100 | 0 | 67 | 66 |
| RM 9.1 to 6.9 | 0 | -25 | 0 | -27 | -21 |
| CIA Seep #1 | 0 | 0 | 0 | 0 | 9 |
| CIA Seep #2 | 11 | 0 | 0 | 0 | 41 |
| RM 6.9 to 5.5 | -78 | 0 | 0 | -7 | -26 |
| Bunker Creek | 0 | 0 | 0 | 7 | tr |
| Government Gulch | 0 | 25 | 0 | 13 | 3 |
| RM 5.5 to 4.9 | 67 | 0 | 0 | 7 | 6 |
| RM 4.9 to 3.4 | 0 | -25 | 0 | -7 | 8 |
| RM 3.4 to 2.4 | 11 | 25 | 0 | 40 | 16 |
| Page Treatment Plant | 0 | 0 | 0 | 7 | tr |
| RM 2.4 to 1.3 | 0 | 0 | 0 | -14 | -2 |
| Pine Creek | 11 | 0 | 0 | 7 | tr |
| South Fork Basin (%) | 100 | 100 | 100 | 100 | 100 |

**TABLE 6. 1988 HIGH-FLOW TOTAL METALS LOADING RESULTS**

**Percentage of Basin-Wide Loading Contributed by Each Reach**

| SOURCE | Arsenic | Cadmium | Copper | Lead | Mercury | Zinc |
|---|---|---|---|---|---|---|
| Above Mullan | 9 | 6 | 7 | tr | 0 | tr |
| ID0000060 #001 | 0 | 0 | 1 | 0 | 0 | tr |
| RM 27.5 to 9.1 | 47 | 33 | 47 | 6 | 50 | 42 |
| Milo Creek | 0 | 0 | 1 | 2 | 0 | 1 |
| RM 9.1 to 6.5 | 6 | 11 | 4 | 2 | 0 | 6 |
| CIA Seep #1 | 0 | 0 | 0 | 0 | 0 | 2 |
| Bunker Creek | 3 | 6 | 0 | 0 | 0 | 1 |
| Government Gulch | 0 | 6 | 0 | 0 | 0 | 1 |
| RM 6.5 to 4.9 | 3 | 0 | 6 | 4 | 0 | 14 |
| Pine Creek | 34 | 25 | 35 | 1 | 0 | 3 |
| RM 4.9 to 1.3 | -3 | 14 | -2 | 84 | 50 | 29 |
| South Fork Basin (%) | 100 | 100 | 100 | 100 | 100 | 100 |
| South Fork (lbs/day) | 32 | 36 | 97 | 867 | 2 | 4585 |
| North Fork (lbs/day) | 6 | 5 | 17 | 11 | 0 | 23 |
| SF:NF LOAD RATIO | 5:1 | 7:1 | 6:1 | 79:1 | 2:0 | 199:1 |

## 4.0 DISCUSSION

Figure 3 is a diagram of the South Fork Coeur d'Alene River Basin which displays the low-flow loadings of cadmium, lead, and zinc in lbs per day calculated for the months of September 1986 and 1987. The high-flow loadings of cadmium, lead, and zinc which occurred during May 1988 are shown in Figure 4. Bar graphs depicting loadings of cadmium, lead, and zinc by river-mile are presented as Figure 5 through 10. Arsenic, copper, and mercury are not shown on the diagrams because the low-flow loadings of these metals were generally less than five pounds per day in any reach of the river. Mercury was undetected during the low-flow periods.

### 4.1 Arsenic Loading

Arsenic is the only constituent for which there is a low-flow loading from a source upstream of Mullan. During September 1986, 1 lb per day of arsenic came from upstream of Mullan, 1 lb per day came from sources between Mullan and Canyon Creek, and 1 lb per day was contributed by the North Fork. Results were similar for the month of September 1987 when 1 lb per day was contributed from sources upstream of Mullan, 6 lbs per day from non-point sources upstream of Kellogg, and 3 lbs per day were contributed to the Couer d'Alene from the North Fork. All of the arsenic contributed to the river upstream of Canyon Creek cycled out of the waters,

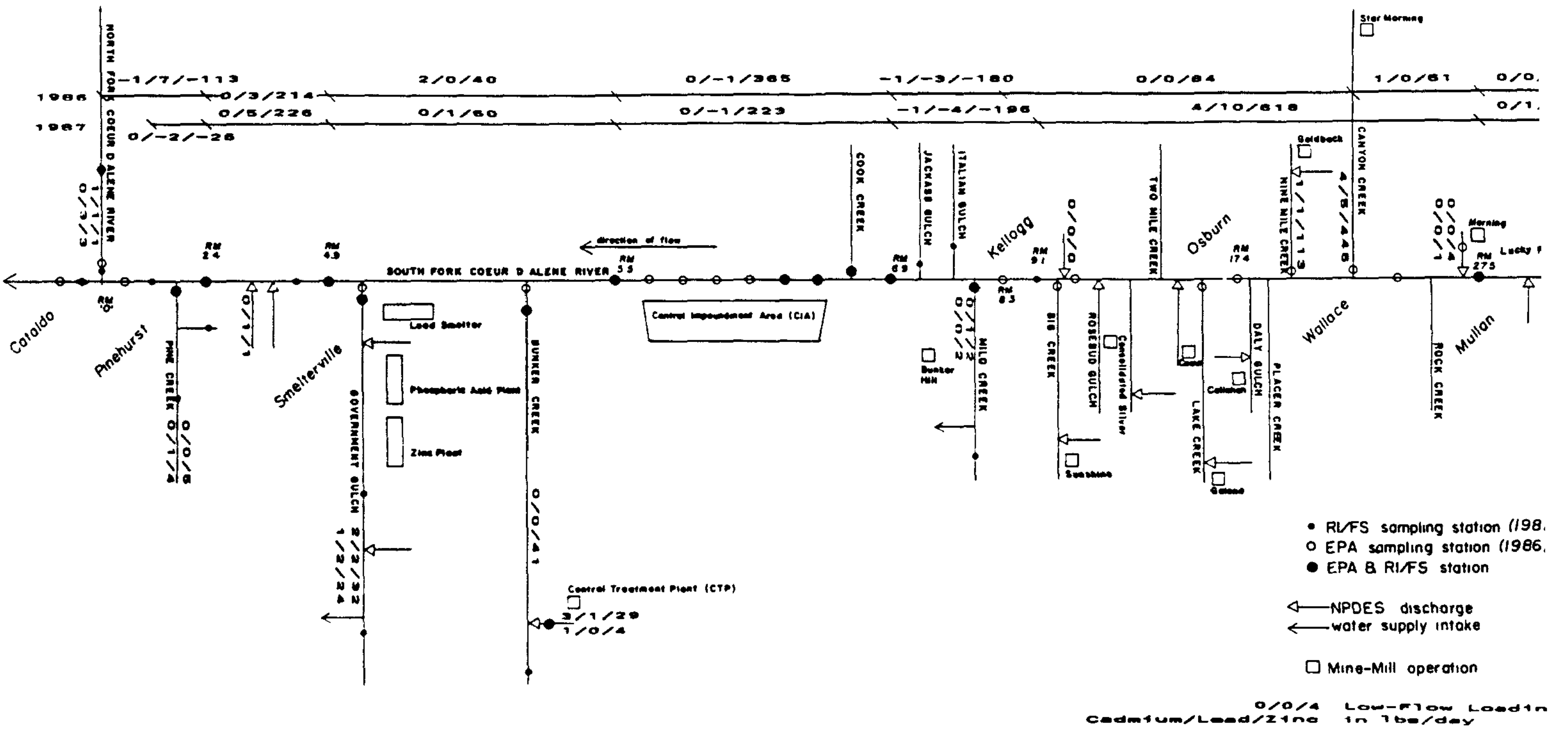


Figure 3. 1986-87 Low-Flow Loadings of Cadmium, Lead, and Zinc.

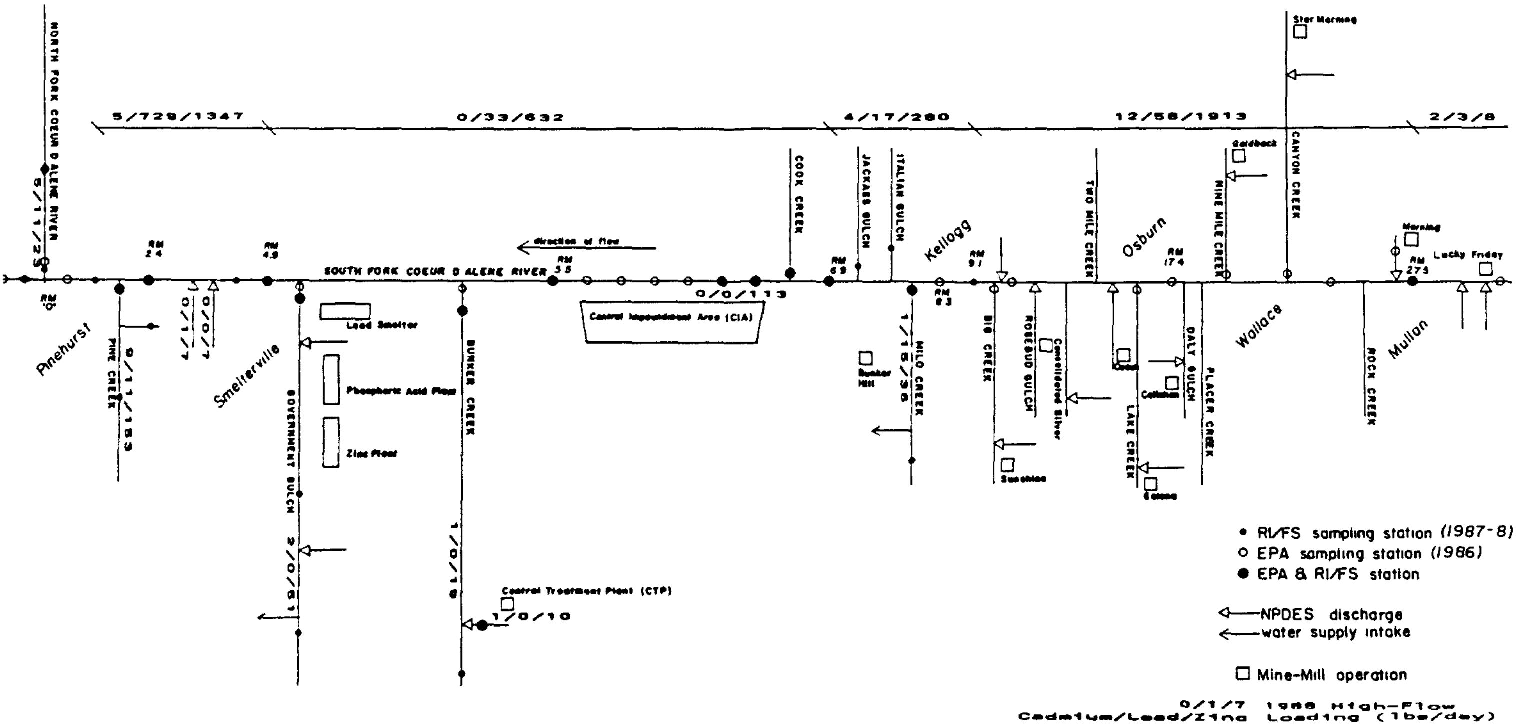


Figure 4. 1988 High-Flow Loadings of Cadmium, Lead, and Zinc.

most likely through adsorption or precipitation in the sediments, by the time the waters reached river-mile 6.9, downstream of Milo Creek. None of the tributaries contributed arsenic load to the South Fork, except in 1987 when Pine Creek was determined to be a source of 1 lb per day. Sources below the confluence with the North Fork provided a loading of 2 lbs per day to the river during September 1986.

Loads contributed during high flow are approximately three times higher than the arsenic loads detected during the low-flow months. During the high-flow month of May 1988, a total of 32 lbs per day of arsenic were contributed by sources on the South Fork, the majority coming from non-point sources and erosion of floodplain sediments between Mullan and Kellogg. Pine Creek contributed a third (11 lbs per day) of the total South Fork load. The North Fork contributed 6 lbs per day of arsenic, or one-fifth of the load provided by the South Fork basin waters.

4.2 Cadmium Loading

No cadmium load was contributed to the South Fork from upstream of Mullan during September 1986 or September 1987. Canyon Creek is the source of approximately one-third of the low-flow cadmium load in the South Fork, as evidenced by the September 1986 monitoring data. Other potentially major sources of cadmium include the Central Treatment Plant effluent to Bunker Creek (3 lbs per day in 1986) and Government Gulch (2 lbs per day in 1986) and non-point sources between river-mile 5.5 and 6.9, between the CIA and below Government Gulch. Low-flow cadmium loadings decreased in the reach of the South Fork between Kellogg and the CIA, possibly due to sorption with sediments. Up to 1 lb per day of cadmium came from sources on the North Fork, compared with 12 lbs per day originating from the South Fork in September 1986. Figure 5 displays the low-flow cadmium loadings to the river during September 1986 and September 1987.

During May 1988, the South Fork contributed 36 lbs per day and the North Fork 5 lbs per day of cadmium to the Coeur d'Alene River. High-flow cadmium loadings are shown in Figure 6. Sources upstream of Mullan provided 6 percent of the total South Fork load to the Coeur d'Alene River. Non-point sources or erosion of floodplain sediments between Mullan and Kellogg provided one-third of the South Fork's total load. Pine Creek, which was not a source of cadmium during the low-flow months, contributed 25 percent (9 lbs per day) of the South Fork cadmium load during high flow. High-flow loadings of cadmium from the South Fork below Pine Creek in May 1988 were three to six times higher than the low-flow loadings measured during September 1986 and 1987.

4.3 Copper Loading

No low-flow loadings of copper were detected above Mullan at river-mile 29.0 in September 1986. Non-point sources of copper between Mullan and Kellogg account for the relatively minor (1 to 2 lbs per day) of copper loading in the South Fork upstream of the CIA. A total low-flow load of 3 lbs per day was contributed to the Coeur d'Alene River by the South Fork, compared to the 2 to 4 lbs per day provided by the North Fork. The similarity of the North Fork and South Fork loadings during low-flow conditions may be explained by the widespread distribution of copper in rocks in the region.

High-flow loadings of copper were markedly higher than those for the low-flow months. The South Fork loading, measured below Pine Creek, totalled 97 lbs per day of copper, compared to the September 1987 loading of 1 lb per day at that station. During the May 1988 high-flow period, most of the copper loading came from non-point sources upstream of Kellogg, which contributed 47 lbs per day. Milo Creek was the source of 1 lb per day of copper, and Pine Creek was the source of 34 lbs per day of copper during May 1988. The South Fork loading of copper was six times the 17 lbs per day contributed by the North Fork.

4.4 Lead Loading

Low-flow lead loadings are shown in Figure 7. There were no lead loadings contributed to the South Fork from upstream of Canyon Creek during the low-flow months (see Figure 3). Canyon Creek and Nine Mile Creek contributed 5 and 1 lbs per day of lead, respectively, to the South Fork as measured during September 1986. An additional 2 lbs per day was contributed by non-point sources along the river from Canyon Creek to downstream of Daly Gulch. Milo Creek contributed 1 lb per day of lead in 1986, and less than 0.5 lbs per day in 1987. Nearly all the lead contributed by the above-mentioned sources drops out of the waters in the reach downstream from Osburn to river-mile 5.5 at Bunker Creek.

Bunker Creek and Pine Creek were not sources for lead during the low-flow months. A loading of 2 lbs per day of lead was calculated for the NPDES discharge monitoring station in Government Gulch during both of the September periods. Non-point sources or erosion of river bed sediment along the South Fork downstream of Government Gulch were a source of 10 lbs per day of lead in September 1986 and 5 lbs per day in September 1987. During the September months, the South Fork lead load to the Coeur d'Alene River was 14 to 15 lbs per day. The North Fork contributed 1 lb per day of lead during the low-flow month in 1986 and 3 lbs per day of lead in 1987.

Over eight hundred pounds per day of lead was contributed to the South Fork by non-point sources and erosion of river bed sediments during the high-flow month of May 1988. Figure 8 is a bar chart showing the high-flow lead loadings. The lead load at SF-8 downstream of Pine Creek was 867 lbs per day, compared to 11 lbs per day at NF-1 on the North Fork. Lead has an affinity for binding with sediments. For this reason, loadings of lead during

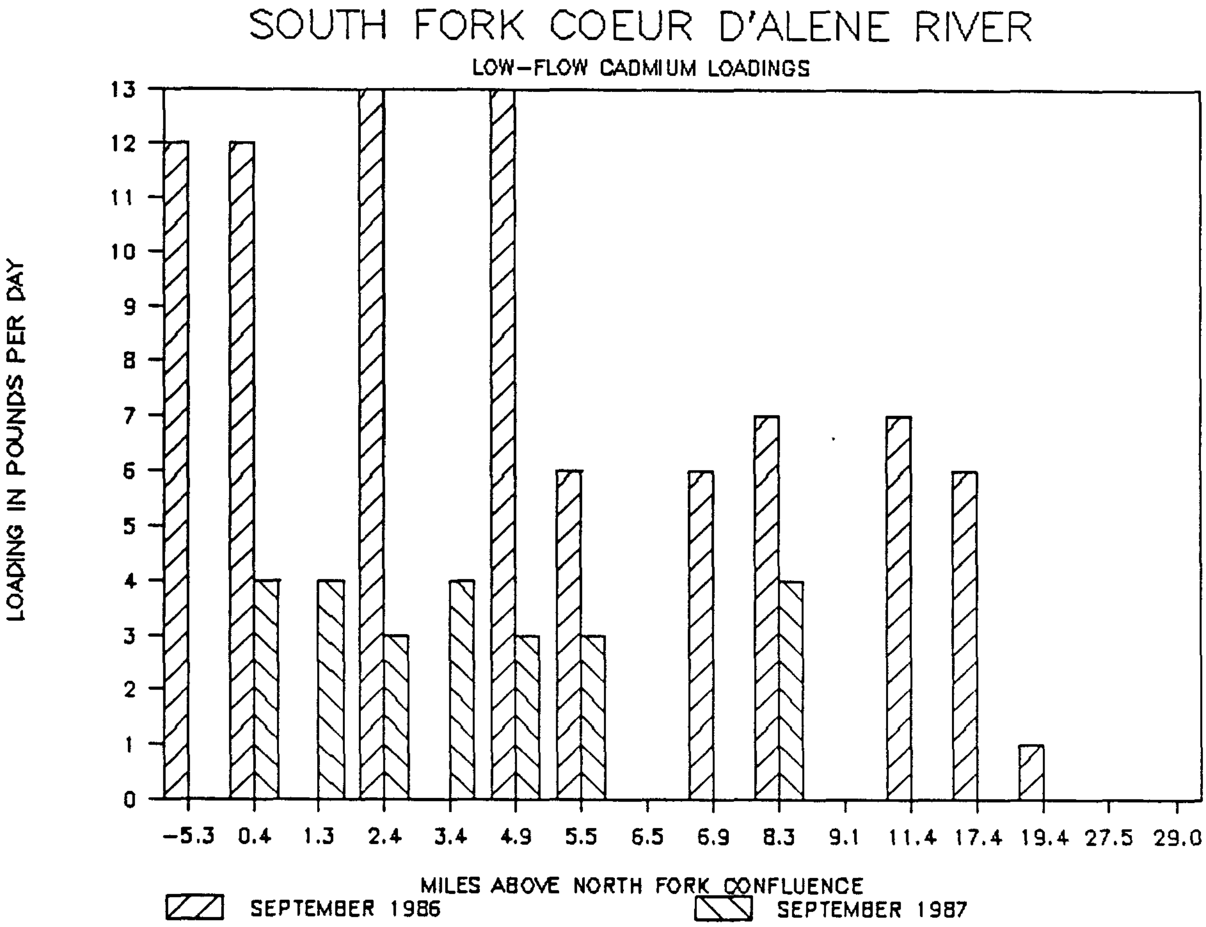


Figure 5. Bar Graph of Low-Flow Loadings of Cadmium by River-Mile.

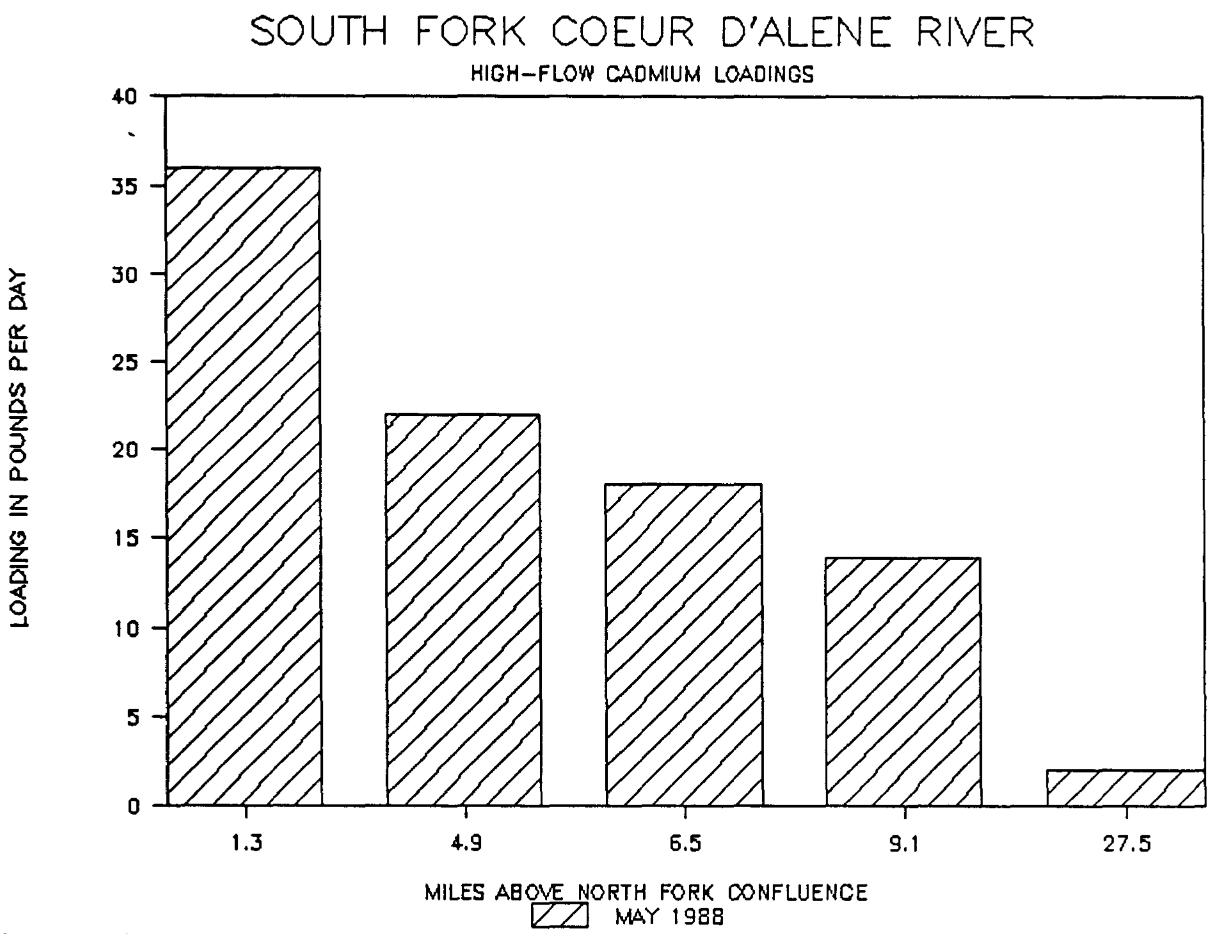




Figure 6. Bar Graph of High-Flow Loadings of Cadmium by River-Mile.

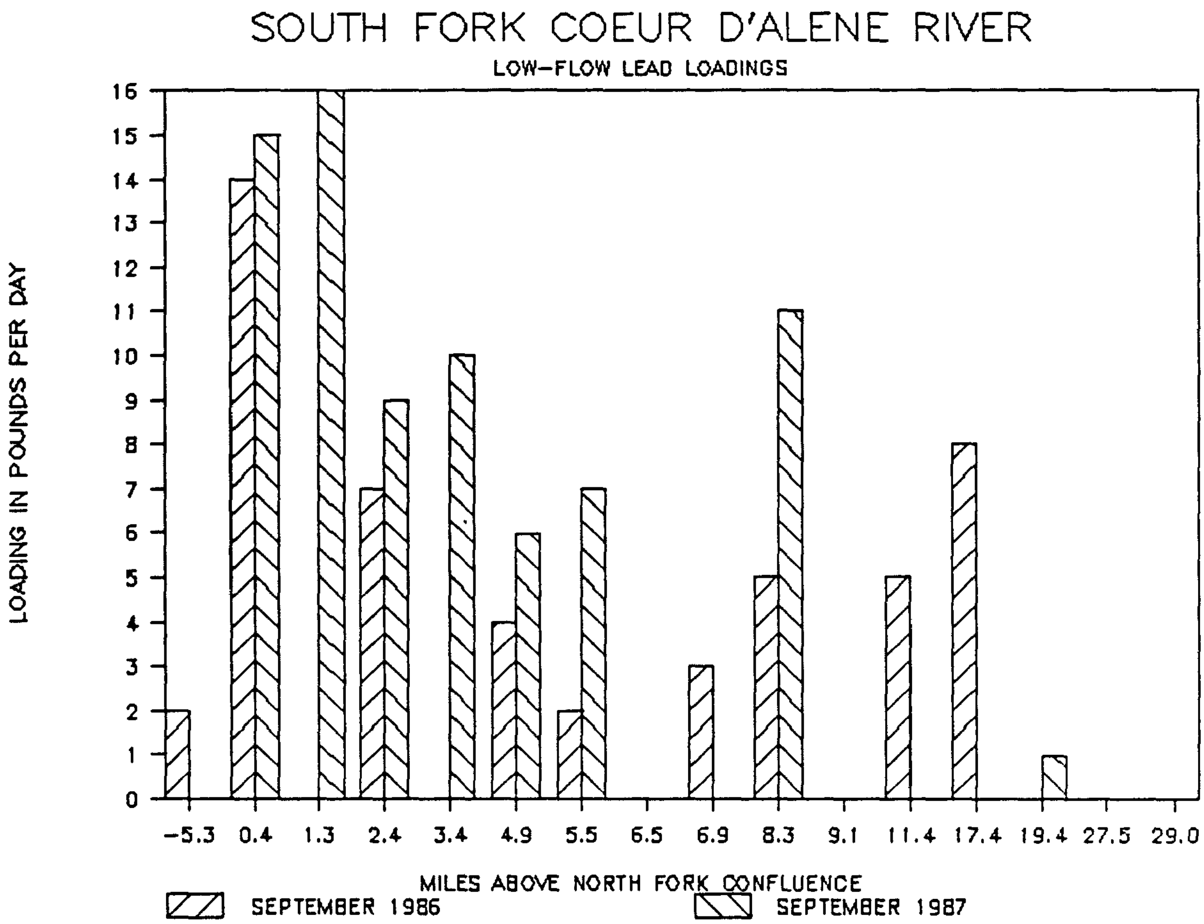


Figure 7. Bar Graph of Low-Flow Loadings of Lead by River-Mile.

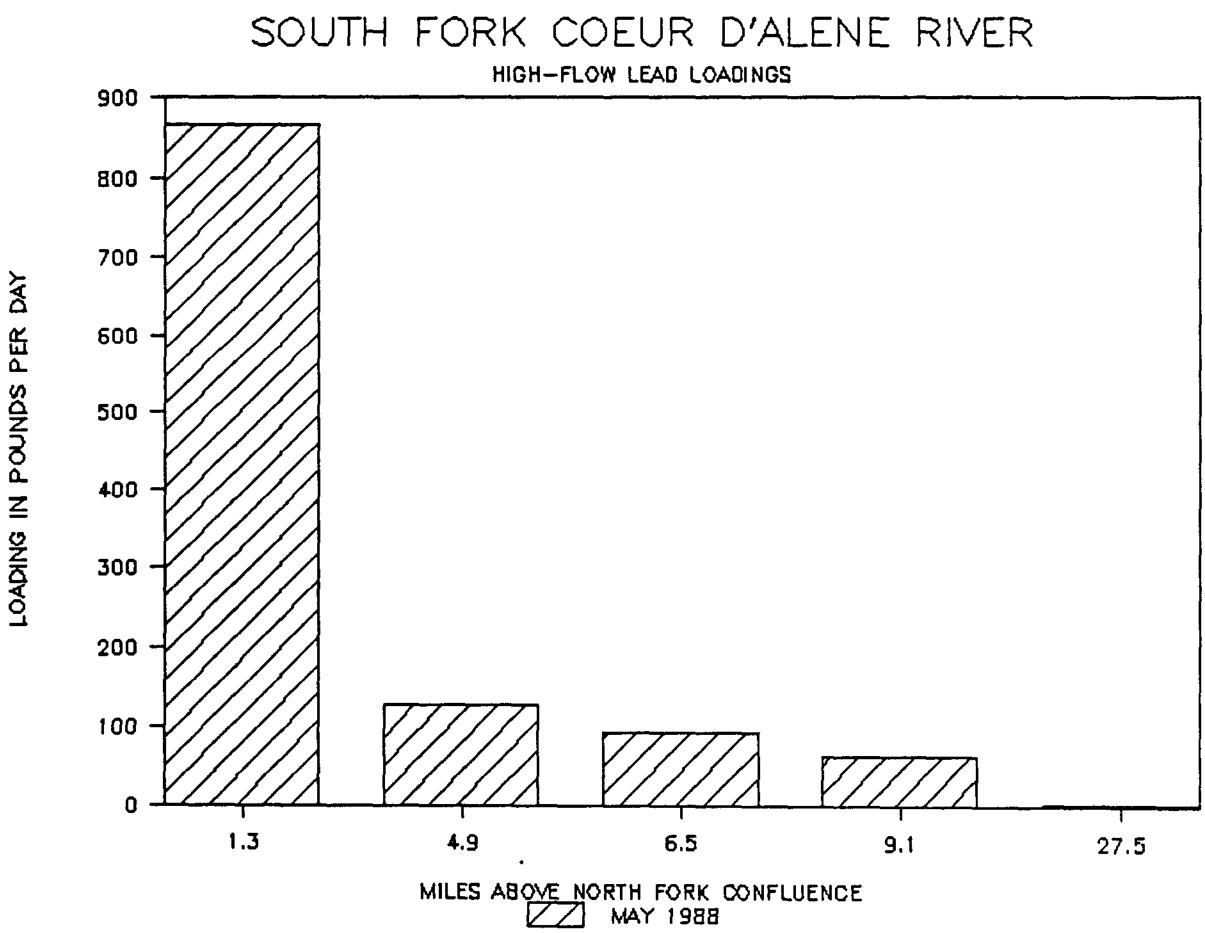




Figure 8. Bar Graph of High-Flow Loadings of Lead by River-Mile.

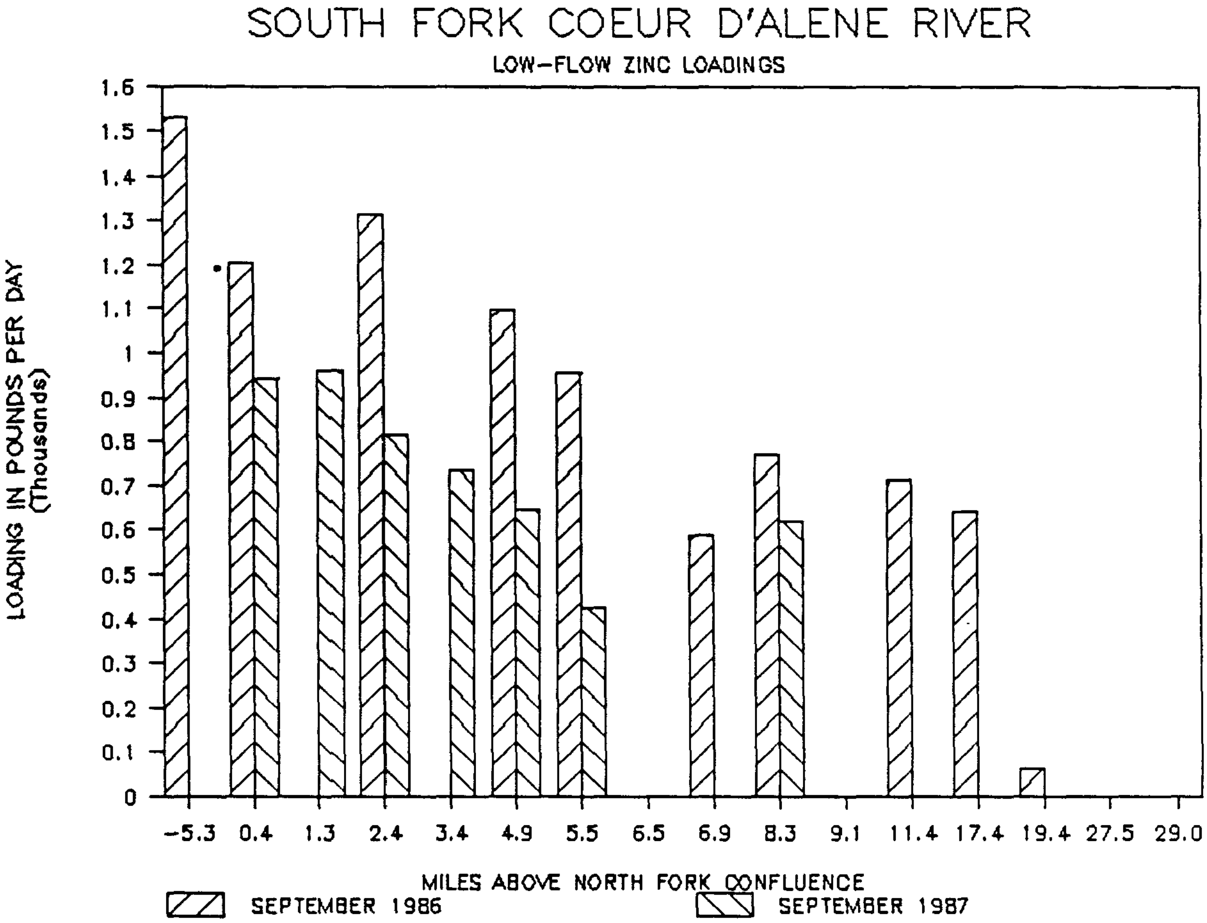


Figure 9. Bar Graph of Low-Flow Loadings of Zinc by River-Mile.

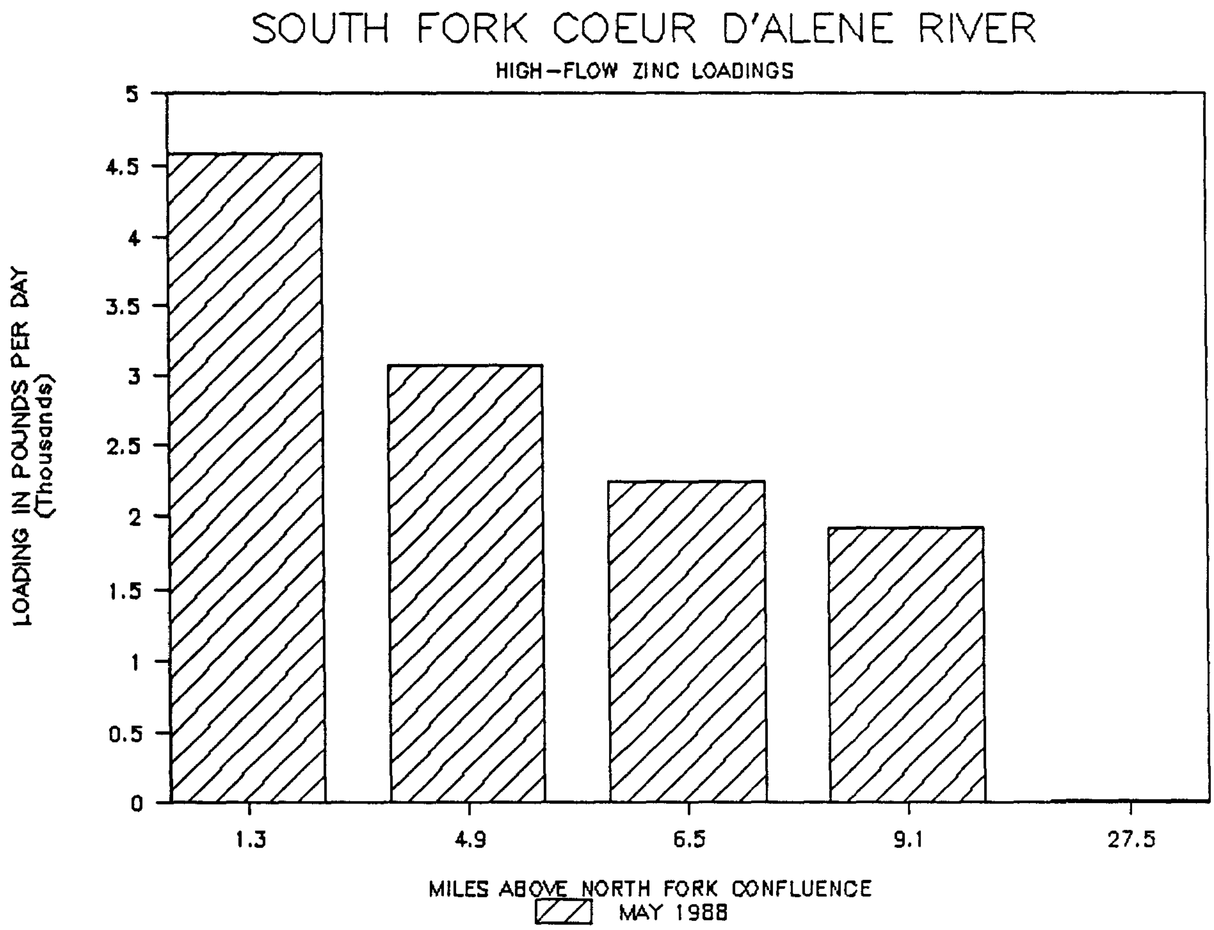




Figure 10. Bar Graph of High-Flow Loadings of Zinc by River-Mile.

high-flow runoff events may be especially large due to stream bank erosion and bed-load sediment movement. The greatest lead loading to the river, 730 lbs per day, was contributed from non-point sources and erosion of floodplain sediment along the river between Government Gulch and Pinehurst. This reach runs through an area known locally as Smelterville Flats. Although tributaries upstream of Milo Creek were not sampled during May 1988, it was determined that Milo Creek contributed 15 lbs per day; Page Treatment Plant effluent contributed 1 lb per day; and Pine Creek contributed 11 lbs per day. Bunker Creek and Government Gulch provided no lead loading to the South Fork during the high-flow month. However, a portion of the runoff from these drainages is diverted into ponds or to the Central Treatment Plant.

### 4.5 Zinc Loading

Low-flow zinc loadings are shown in Figures 3 and 9. During September 1986, some 29 percent of the total zinc load measured at Cataldo came from non-point sources in Canyon Creek, and 7 percent came from Nine Mile Creek. In September 1987, 66 percent of Cataldo's total zinc load came from non-point sources upstream of Kellogg. Between SF-3 at river-mile 6.9 upstream of the CIA and SF-4 at river mile 5.5, 360 lbs per day of zinc was contributed in September 1986, and 220 lbs per day were contributed in September 1987. The most-likely source of these low-flow zinc loads is the CIA tailings impoundment (see Figure 3). In addition, more than 200 lbs per day of zinc were contributed by non-point sources between river-mile 4.9 below Government Gulch and river-mile 2.4 upstream of Pine Creek. Overall, the South Fork contributed between 900 and 1200 lbs per day of zinc to the Coeur d'Alene River during the September low-flow months. In comparison, from one (1) to three (3) lbs per day of zinc were contributed by the North Fork.

More than 2 tons of zinc per day were contributed to the Coeur d'Alene River during the high-flow month of May 1988, compared with 23 lbs per day contributed by the North Fork. High-flow zinc loadings are shown in Figures 4 and 10. Sources between Mullan and Kellogg accounted for 1900 lbs per day of zinc, and sources in Smelterville Flats provided 1300 lbs per day of zinc to the South Fork. As calculated at SF-8, high flow loadings of zinc were nearly five times higher during high-flow than during the September 1987 low-flow month.

## 5.0 CONCLUSION

Because most of the point sources of metals to the South Fork have been effectively controlled, the water quality degradation in the basin is in large part a result of non-point sources and remobilization of floodplain sediment. Tailings are dispersed throughout the floodplain and continue to degrade the waters by their availability to leaching and erosion. Impacts to the river are greatest during high flow because increased river flow rates and surface water runoff to the river channel result in an increase in contaminant loads to the river. Water quality also becomes critical for aquatic life during low-flow periods when metal concentrations peak. Low-flow concentrations of zinc and cadmium remain above levels for protection of aquatic life set by national criteria.

Canyon Creek is a major source of cadmium, lead, and zinc loading to the South Fork during low-flow periods. The data suggest that Canyon Creek may also provide the bulk of the high-flow loadings of metals other than lead to the South Fork. Pine Creek is also a source of loadings of arsenic, cadmium, and copper. Loadings of mercury were detected in two reaches of the South Fork and only during high-flows.

Sources within the Bunker Hill Superfund Site boundaries contribute loadings of arsenic, cadmium, copper, lead, and zinc to the river during low-flow. In addition to these constituents, mercury is contributed during high-flow periods. The Central Impoundment Area (CIA) is a major source of zinc during low-flow periods when metal concentrations in the river become elevated. During low- and high-flow periods, the Smelterville Flats area downstream of Government Gulch is a source of lead, most probably due to stream bank erosion and bed load movement.

A portion of the heavy metal loadings are a result of resuspension of contaminated river sediment. Consequently, some loadings of heavy metals will continue indefinately in the absence of very extensive, and perhaps impractical, basin-wide remediation efforts. However, relatively large loadings come from specific sources, and mitigative measures focused on areas such as Canyon Creek, Pine Creek, the Central Impoundment Area, and Smelterville Flats should be given consideration. Long-term monitoring in the South Fork river basin could be used to determine the water quality impacts and overall effectiveness of specific mitigative measures.

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# APPENDIX

# TO

# DISTRIBUTION OF HEAVY METAL LOADINGS TO THE SOUTH FORK COEUR D'ALENE RIVER IN NORTHERN IDAHO

LOADINGS FOR LOW-FLOW MONTH OF SEPTEMBER 1986

| STATION | RM | Ave Flow (cfs) | Total Loading (lbs/day) As | Cd | Cu | Pb | Hg | Zn | pH | Field EC (uS) |
|---|---|---|---|---|---|---|---|---|---|---|
| SOUTH FORK COEUR D'ALENE RIVER STATIONS | | | | | | | | | | |
| 153541 | 29.0 | 6.1 | 1 | 0 | 0 | 0 | -- | -- | 6.35 | 45 |
| 153368 | 27.5 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 153097 | 19.4 | 27.1 | 2 | 1 | 0 | 0 | -- | 61 | -- | -- |
| 153100 | 17.4 | 54.8 | 1 | 6 | 1 | 8 | -- | 644 | 7.92 | 130 |
| 153104 | 11.4 | 59.8 | 2 | 7 | 0 | 5 | -- | 712 | 7.50 | 135 |
| 03E009 | 8.3 | 78.0 | 1 | 7 | 1 | 5 | 0 | 769 | 7.77 | 138 |
| 153108 | 6.9 | 73.9 | 0 | 6 | 2 | 3 | -- | 591 | 8.14 | 140 |
| 153362 | 5.5 | 70.8 | 1 | 6 | 0 | 2 | -- | 956 | 7.38 | 183 |
| 153110 | 4.9 | 78.3 | 2 | 13 | 1 | 4 | -- | 1098 | 7.56 | 299 |
| 153333 | 2.4 | 86.6 | 0 | 13 | 2 | 7 | 0 | 1312 | -- | 287 |
| 153023 | 0.4 | 97.8 | 1 | 12 | 3 | 14 | -- | 1204 | -- | -- |
| 153018 | -5.3 | 332.0 | 4 | 12 | 2 | 2 | -- | 1533 | -- | -- |
| TRIBUTARIES TO THE SOUTH FORK | | | | | | | | | | |
| 153125 | 19.1 | 15.3 | 0 | 4 | 0 | 5 | -- | 446 | 7.05 | 98 |
| 153132 | 18.7 | 3.9 | 0 | 1 | 0 | 1 | -- | 113 | 6.70 | 99 |
| 153137 | 17.1 | 0.7 | 0 | 0 | 0 | 0 | -- | 0 | 8.54 | 285 |
| 153147 | 11.2 | 6.2 | 1 | 0 | 0 | 0 | -- | 0 | 7.71 | 210 |
| 153148 | 7.8 | 1.1 | 0 | 0 | 0 | 1 | -- | 2 | -- | -- |
| 03Z038 | 6.2 | -- | -- | -- | -- | -- | -- | -- | -- | 206 |
| 03#061 | 6.0 | -- | -- | -- | -- | -- | -- | -- | 6.22 | 900 |
| 03#062 | 6.0 | -- | -- | -- | -- | -- | -- | -- | 6.28 | 1010 |
| 03#063 | 6.0 | -- | -- | -- | -- | -- | -- | -- | -- | 1090 |
| 03#064 | 6.0 | -- | -- | -- | -- | -- | -- | -- | -- | 620 |
| 03#065 | 5.6 | -- | -- | -- | -- | -- | -- | -- | 7.27 | 162 |
| 03#066 | 5.6 | -- | -- | -- | -- | -- | -- | -- | -- | 170 |
| 03Y001 | 5.4 | 2.7 | -- | -- | -- | -- | -- | 17 | -- | 750 |
| 153165 | 5.4 | 6.6 | 0 | 3 | 0 | 0 | 0 | 70 | 7.57 | 1250 |
| 03Y002 | 5.0 | 0.5 | -- | -- | -- | -- | -- | 15 | -- | 100 |
| 153152 | 5.0 | 0.6 | 0 | 0 | 0 | 0 | 0 | 14 | 7.42 | 87 |
| 153207 | 2.3 | 8.8 | 0 | 0 | 0 | 0 | -- | 5 | -- | 32 |
| 153019 | 0.0 | 234.0 | 1 | 1 | 4 | 1 | -- | 1 | -- | -- |
| NPDES POINT SOURCE DISCHARGES | | | | | | | | | | |
| 10000175 | 27.8 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 20000175 | 26.6 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 20000167 | 26.3 | 0.5 | -- | 0 | 0 | 0 | 0 | 4 | 7.80 | -- |
| 10000167 | 19.1 | 0.0 | -- | -- | -- | -- | -- | -- | -- | -- |
| 10002549 | 18.0 | 0.8 | -- | 0 | 0 | 0 | 0 | 0 | 7.80 | -- |
| 10000027 | 17.1 | 0.3 | -- | 0 | 0 | 0 | 0 | 0 | 7.20 | -- |
| 0000159 | 13.1 | 0.4 | -- | 0 | 0 | 0 | 0 | 0 | 8.40 | -- |
| 10000060 | 11.2 | 0.9 | 0 | 0 | 0 | 0 | 0 | 0 | 6.70 | -- |
| 20000060 | 11.2 | 0.0 | -- | -- | -- | -- | -- | -- | -- | -- |
| 60000078 | 5.4 | 5.3 | -- | 3 | 0 | 1 | 0 | 29 | 7.80 | -- |
| 20000078 | 5.4 | 3.7 | -- | 2 | -- | 2 | 0 | 39 | 7.20 | 925 |
| 90000078 | 5.0 | 0.0 | -- | -- | -- | -- | -- | -- | -- | -- |
| 80000078 | 5.0 | 0.0 | -- | -- | -- | -- | -- | -- | -- | -- |
| 20000078 | 5.0 | 0.6 | -- | 2 | -- | 2 | 0 | 32 | 7.30 | 113 |
| 0020117 | 3.2 | 0.8 | -- | -- | -- | -- | -- | -- | 7.10 | -- |
| 0021300 | 3.1 | 3.8 | -- | -- | -- | -- | -- | -- | 6.90 | -- |

0 = loading less than 0.5 pounds per day
-- = parameter was not measured

LOADINGS FOR LOW-FLOW MONTH OF SEPTEMBER 1987
SOUTH FORK COEUR D'ALENE RIVER STATIONS

| STATION | RM | Ave Flow (cfs) | Total Loading (lbs/day) As | Cd | Cu | Pb | Hg | Zn | pH | Field EC (uS) |
|---|---|---|---|---|---|---|---|---|---|---|
| SF-1 | 27.5 | 7.7 | 1 | 0 | 1 | 1 | 0 | 1 | 8.00 | 105 |
| SF-2 | 9.1 | 51.6 | 7 | 4 | 1 | 11 | 0 | 619 | 7.90 | 195 |
| SF-3 | 6.5 | 52.5 | 7 | 3 | 1 | 7 | 0 | 425 | 8.30 | 210 |
| SF-4 | 5.5 | 51.3 | 1 | 3 | 1 | 6 | 0 | 648 | 7.40 | 255 |
| SF-5 | 4.9 | 54.1 | 7 | 4 | 1 | 10 | 0 | 736 | 7.50 | 375 |
| SF-6 | 3.4 | 52.2 | 7 | 3 | 1 | 9 | 0 | 815 | 7.70 | 360 |
| SF-7 | 2.4 | 61.3 | 8 | 4 | 1 | 16 | 0 | 963 | 7.30 | 355 |
| SF-8 | 1.3 | 72.9 | 9 | 4 | 1 | 15 | 0 | 941 | 7.40 | 325 |

TRIBUTARIES TO THE SOUTH FORK

| STATION | RM | Ave Flow (cfs) | As | Cd | Cu | Pb | Hg | Zn | pH | Field EC (uS) |
|---|---|---|---|---|---|---|---|---|---|---|
| MC-1 | 7.8 | 0.6 | 0 | 0 | 0 | 0 | 0 | 0 | 7.40 | 15 |
| MC-2 | 7.8 | 0.9 | 0 | 0 | 0 | 0 | 0 | 2 | 7.70 | 85 |
| CIA-1 | 6.0 | 1.6 | 0 | 0 | 0 | 0 | 0 | 87 | 6.20 | 1050 |
| CIA-2 | 6.0 | 3.3 | 1 | 0 | 0 | 0 | 0 | 385 | 6.00 | 1150 |
| BC-1 | 5.4 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 7.90 | 120 |
| BC-2 | 5.4 | 2.4 | 0 | 0 | 0 | 0 | 0 | 2 | 8.30 | 1750 |
| GG-1 | 5.0 | 0.8 | 0 | 0 | 0 | 0 | 0 | 0 | 7.30 | 25 |
| GG-2 | 5.0 | 0.3 | 0 | 0 | 0 | 0 | 0 | 0 | 7.00 | 40 |
| GG-3 | 5.0 | 0.1 | 0 | 0 | 0 | 0 | 0 | 8 | 4.40 | 285 |
| PC-1 | 2.3 | 7.8 | 1 | 0 | 1 | 1 | 0 | 6 | 7.30 | 40 |
| LP-1 | 2.3 | 0.1 | 0 | 0 | 0 | 0 | 0 | 0 | 7.40 | 70 |
| PC-2 | 2.3 | 5.9 | 1 | 0 | 0 | 1 | 0 | 4 | 7.30 | 35 |
| NF-1 | 0.0 | 25.8 | 3 | 0 | 2 | 3 | 0 | 3 | 7.50 | 35 |

NPDES POINT SOURCE DISCHARGES

| STATION | RM | Ave Flow (cfs) | As | Cd | Cu | Pb | Hg | Zn | pH | Field EC (uS) |
|---|---|---|---|---|---|---|---|---|---|---|
| 10000175 | 27.8 | 0.0 | -- | 0 | 0 | 0 | 0 | 0 | 7.55 | -- |
| 20000175 | 26.6 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 20000167 | 26.3 | 0.5 | -- | 0 | 0 | 0 | 0 | 1 | 7.70 | -- |
| 10000167 | 19.1 | 0.0 | -- | -- | -- | -- | -- | -- | -- | -- |
| 10025429 | 18.0 | 0.8 | -- | 0 | 0 | 0 | 0 | 0 | 8.20 | -- |
| 10000027 | 17.1 | 0.3 | -- | 0 | 0 | 0 | 0 | 0 | 7.70 | -- |
| 10000027 | 15.3 | 0.0 | -- | -- | -- | -- | -- | -- | -- | -- |
| 0000159 | 13.1 | 0.0 | -- | -- | -- | -- | -- | -- | -- | -- |
| 10000060 | 11.2 | 0.1 | 0 | 0 | 0 | 0 | 0 | 0 | 7.70 | -- |
| 20000060 | 11.2 | 0.0 | -- | -- | -- | -- | -- | -- | -- | -- |
| 60000078 | 5.4 | 3.5 | -- | 0 | 0 | 1 | 0 | 4 | 8.60 | |
| CTP-1 | 5.4 | 3.4 | 0 | 0 | 0 | 0 | 0 | 23 | 9.30 | 1750 |
| 20000078 | 5.4 | 2.6 | -- | 0 | 0 | 1 | 0 | 4 | 6.10 | 850 |
| 90000078 | 5.0 | 0.0 | -- | -- | -- | -- | -- | -- | -- | -- |
| 80000078 | 5.0 | 0.0 | -- | 0 | 0 | 0 | 0 | 0 | 6.30 | 50 |
| 20000078 | 5.0 | 0.5 | -- | 1 | 2 | 0 | 0 | 24 | 4.70 | 160 |
| STP-1 | 3.2 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 7.10 | 390 |
| PTP-1 | 3.1 | 3.4 | 0 | 0 | 0 | 1 | 0 | 1 | 7.30 | 265 |

0 = loading less than 0.5 pounds per day
-- = parameter was not measured

LOADINGS FOR HIGH-FLOW MONTH OF MAY 1988
SOUTH FORK COEUR D'ALENE RIVER STATIONS

| STATION | RM | Ave Flow (cfs) | Total Loading (lbs/day) As | Cd | Cu | Pb | Hg | Zn | pH | Field EC (uS) |
|---|---|---|---|---|---|---|---|---|---|---|
| SF-1 | 27.5 | 84.3 | 3 | 2 | 7 | 3 | 0 | 9 | 7.20 | 35 |
| SF-2 | 9.1 | 667.0 | 18 | 14 | 54 | 61 | 1 | 1930 | 7.15 | 68 |
| SF-3 | 6.5 | 726.0 | 20 | 18 | 59 | 93 | 1 | 2246 | 7.15 | 58 |
| SF-5 | 4.9 | 801.0 | 22 | 22 | 65 | 126 | 1 | 3071 | 7.55 | 90 |
| SF-8 | 1.3 | 1186.0 | 32 | 36 | 97 | 867 | 2 | 4585 | 7.25 | 78 |
| TRIBUTARIES TO THE SOUTH FORK | | | | | | | | | | |
| MC-2 | 7.8 | 9.4 | 0 | 0 | 1 | 15 | 0 | 36 | 6.60 | 40 |
| IG-1 | 7.5 | 0.3 | 0 | 0 | 0 | 0 | 0 | 0 | 7.40 | 90 |
| JC-1 | 6.9 | 1.0 | 0 | 0 | 0 | 0 | 0 | 0 | 7.30 | 50 |
| CC-1 | 6.2 | 0.2 | 0 | 0 | 0 | 0 | 0 | 0 | 7.40 | 110 |
| CIA-1 | 6.0 | 1.3 | 0 | 0 | 0 | 0 | 0 | 113 | 6.15 | 1375 |
| BC-1 | 5.4 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 6.80 | 135 |
| BC-2 | 5.4 | 3.7 | 1 | 2 | 0 | 0 | 0 | 29 | 8.20 | 1425 |
| GG-2 | 5.0 | 1.9 | 0 | 0 | 0 | 0 | 0 | 1 | 6.90 | 40 |
| GG-3 | 5.0 | 1.7 | 0 | 2 | 0 | 0 | 0 | 51 | 6.30 | 115 |
| PC-1 | 2.3 | 419.0 | 11 | 9 | 34 | 11 | 0 | 145 | 7.30 | 20 |
| LP-1 | 2.3 | 1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 7.40 | 65 |
| PC-2 | 2.3 | 417.0 | 11 | 9 | 34 | 11 | 0 | 153 | 7.30 | 25 |
| NF-1 | 0.0 | 212.0 | 6 | 5 | 17 | 11 | 0 | 23 | 7.20 | 25 |
| NPDES POINT SOURCE DISCHARGES | | | | | | | | | | |
| 10000175 | 27.8 | 0.5 | -- | 0 | 0 | 0 | 0 | 1 | 7.30 | -- |
| 20000175 | 26.6 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 20000167 | 26.3 | 0.6 | -- | 0 | 0 | 0 | 0 | 1 | 7.30 | -- |
| 10000167 | 19.1 | 0.0 | -- | -- | -- | -- | -- | -- | -- | -- |
| 10000108 | 18.7 | 0.0 | -- | -- | -- | -- | -- | -- | -- | -- |
| 10025429 | 18.0 | 0.9 | -- | 0 | 0 | 0 | 0 | 0 | 6.60 | -- |
| 10000027 | 17.1 | 1.0 | -- | 0 | 0 | 0 | 0 | 0 | 7.30 | -- |
| 0000159 | 13.2 | 0.0 | -- | -- | -- | -- | -- | -- | -- | -- |
| 10000060 | 11.2 | 1.7 | 0 | 0 | 1 | 0 | 0 | 7 | 7.20 | -- |
| 20000060 | 11.2 | 0.0 | -- | -- | -- | -- | -- | -- | -- | -- |
| 60000078 | 5.4 | 4.4 | -- | 1 | 0 | 1 | 0 | 5 | -- | -- |
| CTP-1 | 5.4 | 4.3 | 0 | 1 | 0 | 0 | 0 | 10 | 8.15 | 1475 |
| 20000078 | 5.4 | 5.3 | -- | 2 | 0 | 2 | 0 | 33 | 6.55 | 1100 |
| 20000078 | 5.0 | 2.0 | -- | 0 | 0 | 0 | 0 | 2 | 6.40 | 13 |
| 90000078 | 5.0 | 0.0 | -- | 0 | 0 | 0 | 0 | 0 | 6.30 | -- |
| 80000078 | 5.0 | 0.0 | -- | -- | -- | -- | -- | -- | -- | -- |
| 20000078 | 5.0 | 2.1 | -- | 3 | 0 | 0 | 0 | 65 | 6.10 | 65 |
| STP-1 | 3.2 | 0.4 | 0 | 0 | 0 | 0 | 0 | 7 | 7.50 | 310 |
| PTP-1 | 3.1 | 3.9 | 0 | 0 | 0 | 1 | 0 | 7 | 7.30 | 205 |

0 = loading less than 0.5 pounds per day
-- = parameter was not measured

DISSOLVED LOADINGS FOR LOW-FLOW PERIOD IN 1987
SOUTH FORK COEUR D'ALENE RIVER STATIONS

| STATION | RM | Ave Flow (cfs) | Total Loading (lbs/day) As | Cd | Cu | Pb | Hg | Zn | pH | Field EC (uS) |
|---|---|---|---|---|---|---|---|---|---|---|
| SF-1 | 27.5 | 7.7 | 1 | 0 | 1 | 1 | 0 | 1 | 8.00 | 105 |
| SF-2 | 9.1 | 51.6 | 7 | 4 | 1 | 5 | 0 | 624 | 7.90 | 195 |
| SF-3 | 6.5 | 52.5 | 7 | 3 | 1 | 5 | 0 | 405 | 8.30 | 210 |
| SF-4 | 5.5 | 51.3 | 1 | 3 | 1 | 5 | 0 | 618 | 7.40 | 255 |
| SF-5 | 4.9 | 54.1 | 7 | 3 | 1 | 6 | 0 | 684 | 7.50 | 375 |
| SF-6 | 3.4 | 52.2 | 7 | 3 | 1 | 5 | 0 | 820 | 7.70 | 360 |
| SF-7 | 2.4 | 61.3 | 8 | 3 | 1 | 6 | 0 | 970 | 7.30 | 355 |
| SF-8 | 1.3 | 72.9 | 9 | 3 | 1 | 2 | 0 | 933 | 7.40 | 325 |
| CATALDO | -3.5 | 312.0 | 2 | 7 | 2 | 8 | 0 | 1078 | 7.10 | 133 |
| TRIBUTARIES TO THE SOUTH FORK | | | | | | | | | | |
| MC-1 | 7.8 | 0.6 | 0 | 0 | 0 | 0 | 0 | 0 | 7.40 | 15 |
| MC-2 | 7.8 | 0.9 | 0 | 0 | 0 | 0 | 0 | 2 | 7.70 | 85 |
| CIA-1 | 6.0 | 1.6 | 0 | 0 | 0 | 0 | 0 | 89 | 6.20 | 1050 |
| CIA-2 | 6.0 | 3.3 | 1 | 0 | 0 | 0 | 0 | 394 | 6.00 | 1150 |
| BC-1 | 5.4 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 7.90 | 120 |
| BC-2 | 5.4 | 2.4 | 0 | 0 | 0 | 0 | 0 | 1 | 8.30 | 1750 |
| GG-1 | 5.0 | 0.8 | 0 | 0 | 0 | 0 | 0 | 0 | 7.30 | 25 |
| GG-2 | 5.0 | 0.3 | 0 | 0 | 0 | 0 | 0 | 0 | 7.00 | 40 |
| GG-3 | 5.0 | 0.1 | 0 | 0 | 0 | 0 | 0 | 9 | 4.40 | 285 |
| PC-1 | 2.3 | 7.8 | 1 | 0 | 1 | 1 | 0 | 6 | 7.30 | 40 |
| LP-1 | 2.3 | 0.1 | 0 | 0 | 0 | 0 | 0 | 0 | 7.40 | 70 |
| PC-2 | 2.3 | 5.9 | 1 | 0 | 0 | 1 | 0 | 3 | 7.30 | 35 |
| NF-1 | 0.0 | 25.8 | 3 | 0 | 2 | 3 | 0 | 3 | 7.50 | 35 |
| NPDES POINT SOURCE DISCHARGES | | | | | | | | | | |
| STP-1 | 3.2 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 7.10 | 390 |
| PTP-1 | 3.1 | 3.4 | 0 | 0 | 0 | 0 | 0 | 1 | 7.30 | 265 |

0 = loading less than 0.5 pounds per day

DISSOLVED LOADINGS FOR HIGH-FLOW PERIOD IN 1988
SOUTH FORK COEUR D'ALENE RIVER STATIONS

| STATION | RM | Ave Flow (cfs) | As | Cd | Cu | Pb | Hg | Zn | pH | Field EC (uS) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total Loading (lbs/day) | | | | | | | |
| SF-1 | 27.5 | 84.3 | 3 | 2 | 7 | 3 | 0 | 9 | 7.20 | 35 |
| SF-2 | 9.1 | 667.0 | 18 | 16 | 54 | 14 | 1 | 2040 | 7.15 | 68 |
| SF-3 | 6.5 | 726.0 | 20 | 16 | 59 | 36 | 1 | 2305 | 7.15 | 58 |
| SF-5 | 4.9 | 801.0 | 22 | 27 | 65 | 39 | 1 | 3084 | 7.55 | 90 |
| SF-8 | 1.3 | 1186.0 | 32 | 28 | 97 | 52 | 2 | 4461 | 7.25 | 78 |
| CATALDO | -3.5 | 2420.0 | 13 | 26 | 13 | 65 | 1 | 3659 | 6.60 | 62 |
| **TRIBUTARIES TO THE SOUTH FORK** | | | | | | | | | | |
| MC-1 | 7.8 | | | | | | | | | |
| MC-2 | 7.8 | 9.4 | 0 | 0 | 1 | 13 | 0 | 39 | 6.60 | 40 |
| IG-1 | 7.5 | 0.3 | 0 | 0 | 0 | 0 | 0 | 0 | 7.40 | 90 |
| JC-1 | 6.9 | 1.0 | 0 | 0 | 0 | 0 | 0 | 0 | 7.30 | 50 |
| CC-1 | 6.2 | 0.2 | 0 | 0 | 0 | 0 | 0 | 0 | 7.40 | 110 |
| CIA-1 | 6.0 | 1.3 | 0 | 0 | 0 | 0 | 0 | 122 | 6.15 | 1375 |
| BC-1 | 5.4 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 6.80 | 135 |
| BC-2 | 5.4 | 3.7 | 1 | 2 | 0 | 0 | 0 | 29 | 7.20 | 1425 |
| GG-2 | 5.0 | 1.9 | 0 | 0 | 0 | 0 | 0 | 1 | 6.90 | 40 |
| GG-3 | 5.0 | 1.7 | 0 | 2 | 0 | 0 | 0 | 55 | 6.30 | 115 |
| PC-1 | 2.3 | 419.0 | 11 | 9 | 34 | 11 | 0 | 149 | 7.30 | 20 |
| LP-1 | 2.3 | 1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 7.40 | 65 |
| PC-2 | 2.3 | 417.0 | 11 | 9 | 34 | 11 | 0 | 155 | 7.30 | 25 |
| NF-1 | 0.0 | 212.0 | 6 | 5 | 17 | 6 | 0 | 23 | 7.20 | 25 |
| **NPDES POINT SOURCE DISCHARGES** | | | | | | | | | | |
| STP-1 | 3.2 | 0.4 | 0 | 0 | 0 | 0 | 0 | 4 | 7.50 | 310 |
| PTP-1 | 3.1 | 3.9 | 0 | 0 | 0 | 1 | 0 | 6 | 7.30 | 205 |

0 = loading less than 0.5 pounds per day