US Army Corps of Engineers®
Portland District

SEDIMENT QUALITY REPORT

ALBENI FALLS DAM
COLUMBIA RIVER BASIN
PEND OREILLE RIVER, IDAHO

Albeni Falls Dam, Lake Pend Oreille, and Pend Oreille River

Sediment Quality Report
August 2020

EXECUTIVE SUMMARY

The Clark Fork–Pend Oreille River system drains 64,750 square kilometers of the Pacific Northwest in the United States and Canada, of which 62,651 square kilometers are upstream of Albeni Falls Dam. The Clark Fork–Pend Oreille system is the third-largest tributary of the Columbia River after the Snake River and Kootenai River. It enters the Columbia River in British Columbia just upstream (about 0.5 kilometers) from the U.S.-Canada border. The hydrology of the Clark Fork–Pend Oreille River has been modified by the construction of numerous dams, resulting in an alteration of the natural flow regime and sediment transport.

Sediment contamination exists in the Clark Fork–Pend Oreille system, largely upstream of Lake Pend Oreille in the Clark Fork River. From the 1880s through the 1980s, contaminants were introduced to the upper Clark Fork watershed from mining operations, ore processing, and tailings disposal, which left sediments in the Clark Fork contaminated with metals (Andrews 1987). Although most major sources of mining contamination are located upstream of Lake Pend Oreille, elevated concentrations of cadmium, copper, lead, and zinc have been measured in the Pend Oreille River near Albeni Falls Dam (Beckwith 2002; Bowers, Caldwell, and Dutton 2003). These elevated metals concentrations suggests that some contaminants from the mining operations in the upper Clark Fork watershed have been transported downstream into Lake Pend Oreille and the Pend Oreille River (Woods 2004).

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ACRONYMS

Acronym	Description
µg/kg	Micrograms per Kilogram
Corps	U.S. Army Corps of Engineers
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
SEF	Sediment Evaluation Framework
TMDL	Total Maximum Daily Load
USGS	U.S. Geological Survey

SECTION 1 - INTRODUCTION

1.1 STUDY AREA

The Clark Fork–Pend Oreille River system drains 64,750 square kilometers of the Pacific Northwest in the United States and Canada, of which 62,651 square kilometers are upstream of Albeni Falls Dam. The Clark Fork–Pend Oreille system is the third-largest tributary of the Columbia River after the Snake River and Kootenai River. It enters the Columbia River in British Columbia just upstream (about 0.5 kilometers) from the U.S.-Canada border. The hydrology of the Clark Fork–Pend Oreille River has been modified by the construction of numerous dams, resulting in an alteration of the natural flow regime and sediment transport.

Sediment contamination exists in the Clark Fork–Pend Oreille system, largely upstream of Lake Pend Oreille in the Clark Fork River. From the 1880s through the 1980s, contaminants were introduced to the upper Clark Fork watershed from mining operations, ore processing, and tailings disposal, which left sediments in the Clark Fork contaminated with metals (Andrews 1987). Although most major sources of mining contamination are located upstream of Lake Pend Oreille, elevated concentrations of cadmium, copper, lead, and zinc have been measured in the Pend Oreille River near Albeni Falls Dam (Beckwith 2002; Bowers, Caldwell, and Dutton 2003). These elevated metals concentrations suggests that some contaminants from the mining operations in the upper Clark Fork watershed have been transported downstream into Lake Pend Oreille and the Pend Oreille River (Woods 2004).

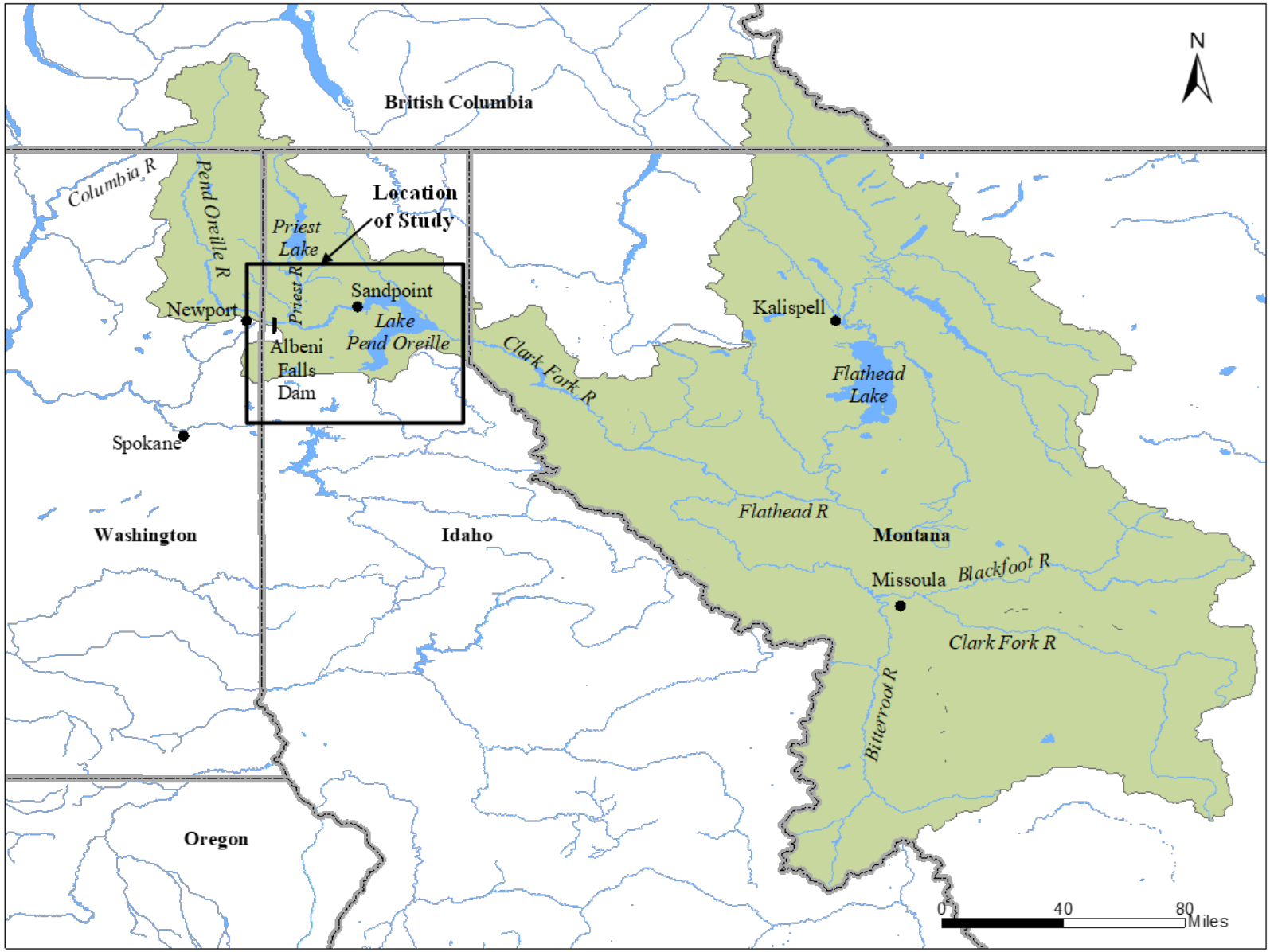
A summary of sediment quality data collected in Lake Pend Oreille and the Pend Oreille River upstream and downstream of Albeni Falls Dam will be presented.

SECTION 2 - WATER QUALITY

2.1 GENERAL DESCRIPTION

The Clark Fork–Pend Oreille River Basin drains about 64,750 square kilometers in southern British Columbia, western Montana, northern Idaho, and northeastern Washington (Figure 2-1). The Clark Fork River originates in the Rocky Mountains of western Montana and flows northwest about 560 kilometers to Lake Pend Oreille. Major tributaries of the Clark Fork River include the Flathead River, Blackfoot River, and Bitterroot River. The Pend Oreille River begins at the outlet of Lake Pend Oreille, flows eastward for about 47 kilometers to Albeni Falls Dam and then flows to the northwest for about 145 kilometers to the confluence with the Columbia River in British Columbia. Major tributaries of the Pend Oreille River include the Priest River (Figure 2-1).

Figure 2-1. Location of Albeni Falls Dam in the Clark Fork–Pend Oreille River Basin Watershed



Albeni Falls Dam is a U.S. Army Corps of Engineers (Corps) project located near the Washington-Idaho border on the Pend Oreille River at River Kilometer 145. The dam became operational in 1952 and is about 4 kilometers upstream and east of the city of Newport, Washington; 41.8 kilometers west of the city of Sandpoint, Idaho; and 47 kilometers downstream from Lake Pend Oreille (Figure 2-1). Lake Pend Oreille is a natural lake that is located in a glacially scoured basin in the Purcell Trench in Northern Idaho (Fields, Woods, and Berenbrock 1996). The Clark Fork River is the major inflow to the lake, supplying about 85 percent of the surface water inflow to the lake and the outlet arm (Frenzel 1991).

Lake Pend Oreille is the largest and deepest lake in Idaho and the fifth-deepest lake in the United States with a maximum width of about 10.8 kilometers and a maximum depth of about 357 meters (Fields, Woods, and Berenbrock 1996). Although Lake Pend Oreille is a natural lake, Albeni Falls Dam is authorized for regulation of the lake level for flood control, navigation, fish and wildlife conservation, recreation, and power generation. Before the project became operational in 1952, the annual surface elevation of Lake Pend Oreille varied according to seasonal inflows, from an average fall/winter low of about 624.2[1] meters to an average spring runoff high of about 628.5 meters, with a maximum spring elevation of 631.5 meters recorded on June 9, 1948 (Corps 2000). After reaching a maximum elevation during spring runoff, the lake gradually receded to an elevation of about 624.8 meters by August and reached its minimum elevation of about 624.2 meters by October.

Current Lake Pend Oreille regulating procedures are briefly described below. After the spring runoff period is completed (usually late May to early July), Lake Pend Oreille is maintained in a 0.15-meter summer operation range between elevations 628.5 and 628.6 meters until the end of the summer recreation season. A fall drawdown generally begins after Labor Day, and the lake is stabilized at a minimum control elevation for the winter typically by December 1. Historically, the Corps has drafted Lake Pend Oreille to a winter elevation of either 625.1 meters or 626.6 meters for kokanee (*Oncorhynchus nerka*) spawning and managed within a 0.3 meter operating band through March. However, since 2011, Lake Pend Oreille regulating procedures have been operating under the flexible winter power operations plan. Under flexible winter power operations, the lake is held at the winter elevation until kokanee spawning is complete. Then, the Bonneville Power Administration may use up to 1.5 meters (625.1 to 626.6 meters) of flexibility available in Lake Pend Oreille during the winter instead of holding the winter pool at a constant elevation. This operation may result in Lake Pend Oreille's pool fluctuating up to 1.5 meters during the winter months. Bathymetric data indicates that there is a 6.8 percent reduction in lake surface area and a 1.8 percent reduction in lake volume between the typical full pool and winter pool lake elevations of 628.6 meters and 625.1 meters (Fields, Woods, and Berenbrock 1996).

[1] All elevations in this Appendix are referenced to NGVD29 datum.

2.2 CLIMATE AND GEOLOGY

The climate of the Lake Pend Oreille watershed is influenced by easterly moving weather systems from the Pacific Ocean. Winters are generally cloudy, cool, and wet, with November through March being the wettest months. Most of the snowpack in the mountains falls between November and April. Summers are typically warm and dry, with little rainfall occurring from June through September. Sandpoint, Idaho (elevation 628.5 kilometers), is the closest long-term (1910 to 2008) weather station to Lake Pend Oreille. The mean annual precipitation at Sandpoint is about 81 centimeters, with an annual snowfall of about 178 centimeters (Western Region Climate Center [WRCC] 2009). The mean annual temperature is about 7.8°C, with extremes recorded of −38°C and 40°C (WRCC 2009). Typically, December and January are the coldest and wettest months while July is the warmest and driest month. The first snowfall usually occurs in early November, and heavy snows can occur throughout the winter, as can extended periods of melting and freezing. The snowpack generally remains in the area from December through March or April.

Lake Pend Oreille watershed is dominated by high, forested, northwest-trending mountain ranges separated by broad valleys. Elevations range from about 600 meters immediately downstream of Albeni Falls Dam to more than 3,000 meters in the Rocky Mountains of British Columbia. The topography in the immediate Lake Pend Oreille watershed is characterized by steep mountain slopes that plunge directly into the lake. The mountains rise steeply from the lake to elevations of 1,500 to 2,000 meters, and vegetation is dominated by coniferous forest. The immediate Lake Pend Oreille watershed is dominated by Precambrian aged low metamorphic grade metasedimentary rocks of the Belt-Purcell Supergroup (Idaho Geological Survey [IGS] 2002). Sediments in the area are from the Pleistocene glaciation, when the Cordilleran ice sheet advanced southward along the Purcell Trench from Canada. These glacial advances scoured out the Lake Pend Oreille Basin.

2.3 LAND USE

The Clark Fork–Pend Oreille River watershed is a sparsely populated mountainous area with a majority of the land in the basin being government owned or managed (Maret and Dutton 1999). About 75 percent of the land is covered by forest, while rangeland and agricultural land comprise about 11 and 8 percent, respectively (Beckwith 2002). The Clark Fork–Pend Oreille River watershed experienced rapid growth between 1990 and 2005 (Montana Department of Environmental Quality [MDEQ] et al. 2007). The total population in the watershed was about 375,000 in 2005, with the majority of growth and population (over 310,000) in Montana. Major population centers for each state are concentrated near Missoula and Butte in Montana, near Sandpoint in Idaho, and near Newport in Washington (MDEQ et al. 2007).

The economy of the watershed relies heavily on forest products, mining, hydropower, recreation (tourism), technology, and agriculture. In the past, timber and mining were the main drivers of employment in the region; however, recently tourism and recreation

have become more important. In addition, the retail trade and service industry also provide employment opportunities in the watershed (Corps 2000).

2.4 CONTAMINANT SOURCES

Historical and current point source discharges of contaminants that may impact sediments in Lake Pend Oreille and the Pend Oreille River exist in the watershed. Extensive mining has occurred throughout the watershed since the late 1800s. Hundreds of hard-rock mines are known to exist in the Clark Fork–Pend Oreille River watershed with these mines and smelters being among the largest in the nation (Maret and Skinner 2000). Copper was the major metal that was mined, but the area also produced zinc, manganese, lead, silver, cadmium, bismuth, selenium, tellurium, and gold (Beckwith 2002). Andrews (1987) estimated that 100 million tons of mining and ore-processing waste were discharged into the headwaters of the Clark Fork River and its tributaries from 1880 to 1982. As a result of historical mining and smelting operations in the upper Clark Fork River watershed, the area along the Clark Fork River from Butte, Montana, downstream to Missoula, Montana, has been designated as the largest contiguous Superfund site in the nation.

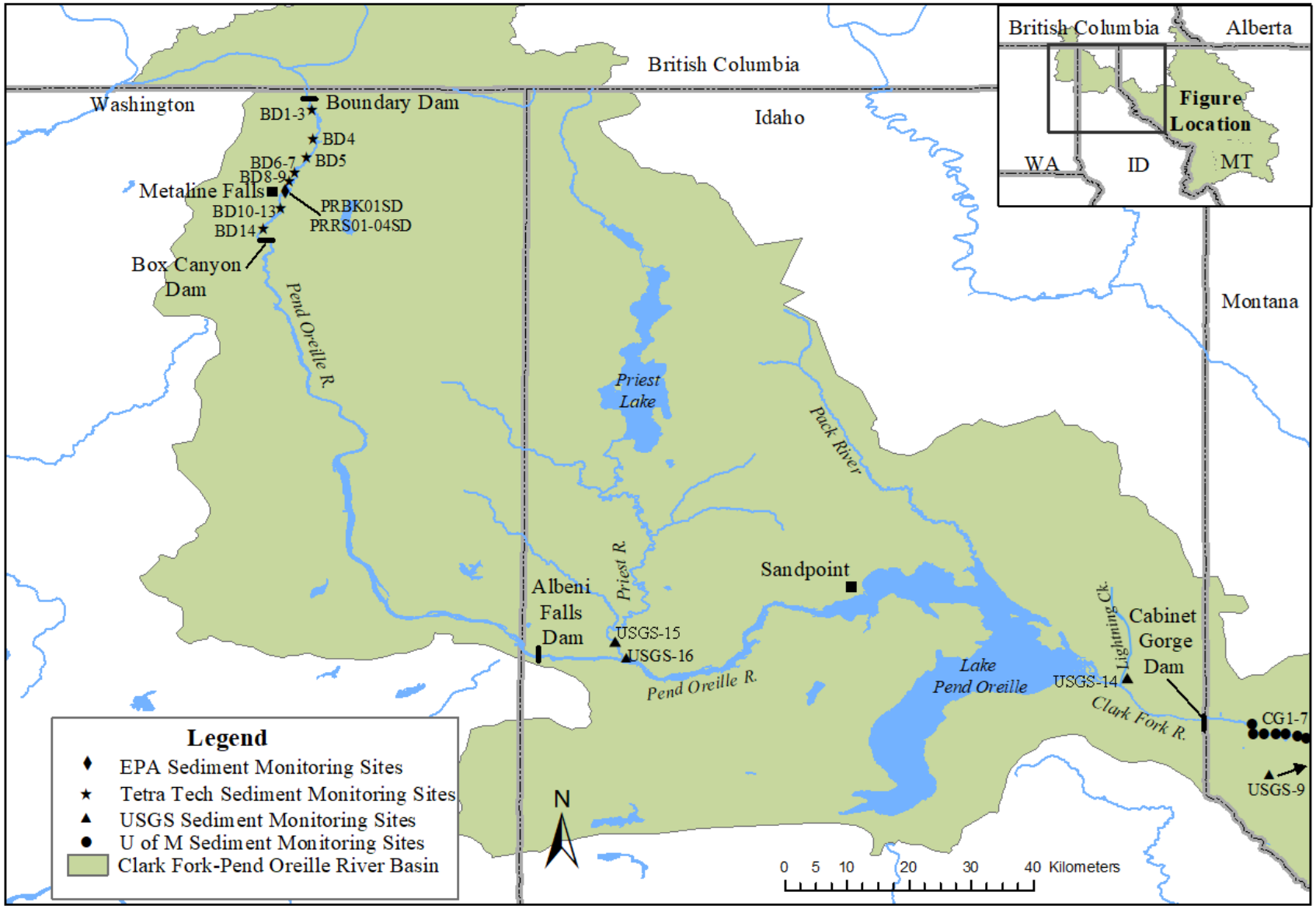
Elevated concentrations of metals in stream, river, and floodplain sediments have been documented in the Clark Fork–Pend Oreille River watershed far downstream of historical mining and smelting operations (Johns and Moore 1985; Axtmann and Luoma 1991). Sediment metal concentrations in the Pend Oreille River suggest that metal enriched sediments have been transported as far downstream as the Priest River, just upstream of Albeni Falls Dam (Beckwith 2002). Modeling studies predict that elevated sediment metal concentrations were likely transported from the upper Clark Fork River downstream to Lake Pend Oreille (Axtmann and Luoma 1991).

In addition to the sediment contamination from historical mining operations, the communities of Butte and Missoula in Montana, Sandpoint in Idaho, and Newport in Washington continue to discharge secondary treated water to the Clark Fork and Pend Oreille Rivers. In addition, to these larger point sources, there are numerous small community wastewater systems and individual septic systems.

2.5 SEDIMENT CHARACTERIZATION STUDIES

An extensive literature and database search found little sediment quality data in the immediate vicinity of Albeni Falls Dam, in the Pend Oreille River upstream of the dam, or in Lake Pend Oreille (Figure 2-2). A moderate amount of sediment quality data was available in the Pend Oreille River about 100 kilometers downstream of Albeni Falls Dam near Metaline Falls, Washington, and in the vicinity of Boundary Dam, Washington. Although considerable sediment data is available for the Clark Fork River in Montana, most of the data was collected from the upper Clark Fork River Basin hundreds of kilometers upstream of Lake Pend Oreille.

Figure 2-2. Locations of Sediment and Water Quality Monitoring Stations in the Clark Fork–Pend Oreille River Basin Watershed



2.5.1 University of Montana Lower Clark Fork Reservoirs Study (1985)

The University of Montana collected grab samples of bottom sediments at 7 locations in the Cabinet Gorge Dam Reservoir in the lower Clark Fork River about 10 kilometers upstream of Lake Pend Oreille (Figure 2-2). Two of the seven locations were at the mouth of pristine tributaries and classified as background sites (Johns and Moore 1985). All grab samples were collected with a stainless steel Peterson dredge, with only that part of the sample not touching the side of the dredge being collected. Samples were analyzed for total and acetic acid extractable arsenic, copper, and zinc. Acetic acid extractable metals represent the fraction held in amorphous iron oxides, some manganese hydrous oxides, and some organic fractions.

2.5.2 U.S. Geological Survey Clark Fork–Pend Oreille River Basin Study (1998)

The United States Geological Survey (USGS) collected 13 streambed sediment samples in the Clark Fork–Pend Oreille River Basin during low-flow conditions from June to September 1998 (Beckwith 2002; Bowers, Caldwell, and Dutton 2003). Of these 13 basinwide stations, one was located on the Pend Oreille River about 10 kilometers upstream of Albeni Falls Dam, and one was located on the Clark Fork River downstream of St. Regis, Montana, about 175 kilometers upstream of Lake Pend Oreille (Figure 2-2). At each station, a representative sample was collected from the upper 2 centimeters of fine-grained streambed sediment from 5 to 10 depositional zones along a 100- to 200-meter reach. Samples were collected using plastic spoons, wet sieved through a 63-micrometer nylon mesh, and shipped in plastic containers to the laboratory. Samples were analyzed for 45 inorganic elements, including metals, carbon, phosphorus, and 109 synthetic organic compounds including polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), phthalates, and organochlorine pesticides.

2.5.3 U.S. Environmental Protection Agency Lower Pend Oreille River Study (2002)

The U.S. Environmental Protection Agency (EPA) tasked the Washington State Department of Ecology (Ecology) and Ecology & Environment Inc. to collect sediment samples in the Lower Pend Oreille River about 100 kilometers downstream of Albeni Falls Dam (EPA 2002). Sediment samples were collected in June 2001 at 5 locations in the Pend Oreille River downstream of Metaline Falls, Washington (Figure 2-2). Samples were collected from the top 8 centimeters of sediment using either plastic spoons and bowls (metals) or stainless steel spoons and bowls (organics). Sediment samples were analyzed for selected chemicals such as metals, organochlorine pesticides, and organic carbon.

2.5.4 Boundary Hydroelectric Project Toxic Assessment Study (2009)

Tetra Tech collected and analyzed sediment chemistry samples at 14 locations in the Pend Oreille River about 100 kilometers downstream of Albeni Falls Dam in March 2008 (Tetra Tech 2009). Sediment samples were collected in the river between Box Canyon

Dam and Boundary Dam using a stainless steel Van Veen sampler lowered from a boat (Figure 2-2). Samples were collected from the top 10 to 15 centimeters of sediment and analyzed for metals, PCBs, acid volatile sulfide, particle size, and organic carbon.

2.6 CONTAMINANTS OF CONCERN

Many pollutants tend to be associated with particles that settle out onto bottom sediments. At great enough concentrations, these compounds may be harmful to benthic organisms and may bioaccumulate in fish and other aquatic organisms. Sediment samples from the lower Clark Fork–Pend Oreille River in Montana, Idaho, and Washington have been analyzed for metals, nutrients, organochlorine pesticides, PAHs, PCBs, and phthalates.

2.6.1 Metals

Metals of concern include arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, and zinc. Sources of these metals exist upstream and downstream of Albeni Falls Dam and Lake Pend Oreille from historical mining and smelter activities in the watershed. Elevated concentrations of metals can be toxic to benthic and aquatic organisms and bioaccumulate.

2.6.2 Nutrients

Nutrients of concern that are found in sediments include phosphorus and nitrogen compounds, including ammonia. Elevated concentrations of phosphorus and nitrogen compounds in sediments may be an indication of an upstream source of these nutrients to the ecosystem. Additionally, elevated phosphorus concentrations may result in increased algal growth leading to eutrophication or nutrient enrichment of surface waters. High ammonia concentrations in sediments can be toxic to benthic organisms.

2.6.3 Organochlorine Pesticides

Organochlorine pesticides are chlorinated hydrocarbons used extensively as pesticides from the 1940s through the 1970s. Most organochlorine pesticides are no longer sold in the United States. However, many of these pesticides are extremely persistent in the environment. Pesticides, such as DDT (Dichlorodiphenyltrichloroethane),that were banned years ago are still found in the environment. Since the early 1970s, organochlorine pesticides such as DDT have been shown to be harmful to aquatic invertebrates, fish, birds, and mammals (USGS 1996).

2.6.4 Polychorinated Biphenyls

PCBs were developed in the 1940s and used in the manufacturing of transformers, capacitors, and many other heat transfer devices. 1n 1979, their manufacture and import was banned in the United States due to evidence of the chemical compounds' toxicity to humans and animals, persistence in the environment, and tendency to bioaccumulate. PCBs are mixtures of different congeners of chlorobiphenyls.

Consequently, many forms of PCBs exist and are generally referred to by their commercial mixture names called Aroclors (EPA 2012a).

2.6.5 Polycyclic Aromatic Hydrocarbons

PAHs are a class of organic compounds that contain two or more fused aromatic (benzene) rings that can be toxic to aquatic biota at elevated concentrations. PAHs are often classified into two groups based on their molecular structure: Low Molecular Weight and High Molecular Weight. PAHs occur naturally in coal, crude oil, and gasoline. Sources of PAHs to the environment are largely a product of the incomplete combustion of coal, oil, gas, wood, and garbage. Numerous potential sources of PAHs exists in the environment including vehicles, power plants, home heating, and coal-tar asphalt sealants. Emissions of PAHs are largely atmospheric, and atmospheric deposition is considered to be a major pathway to the aquatic environment (EPA 2013).

2.6.6 Phthalates

Phthalates are a synthetic organic compound that are primarily used as plasticizers in polyvinylchloride products. Additionally, phthalates are commonly used in the manufacture of many kinds of plastic products. Because phthalates are used in so many industrial and consumer products, they are pervasive in the environment (EPA 2012b).

2.7 EXISTING 303(D) AND TOTAL MAXIMUM DAILY LOADS

The lower Clark Fork River, Lake Pend Oreille, and the Pend Oreille River were identified by the Idaho Department of Environmental Quality (IDEQ) as water quality impaired and not fully supporting aquatic life in the IDEQ 2014 Integrated Report (IDEQ 2018). The 2014 IDEQ Clean Water Act 303(d) Category 5 list included the lower Clark Fork River for temperature, Lake Pend Oreille for mercury in fish tissue, and the Pend Oreille River for temperature and dissolved gasThe 303(d) Category 5 list is defined by EPA as waters with one or more beneficial uses being impaired or threatened, and a total daily maximum load (TMDL) is required to address the impairment or threat. The lower Clark Fork River currently has EPA-approved TMDLs for cadmium, copper, zinc, and total dissolved gas. Lake Pend Oreille has an EPA-approved TMDL for nearshore total phosphorus.

The Pend Oreille River was identified by the Washington Department of Ecology (Ecology) as water quality impaired and not fully supporting aquatic life in the Ecology 2016 Integrated Report (Ecology 2018). The Pend Oreille River was included in the 2016 Ecology 303(d) list Category 5 for water temperature and pH, and fish tissue mercury and PCBs. The Pend Oreille River currently has EPA-approved TMDLs for total dissolved gas.

2.8 FRESHWATER SEDIMENT SCREENING LEVELS

The Pacific Northwest Sediment Evaluation Framework (SEF) manual provides a regional framework for assessing, characterizing, and evaluating sediments in the Pacific Northwest (Northwest Regional Sediment Evaluation Team Agencies 2016). The

SEF developed freshwater sediment quality guidelines for evaluating sediment chemical analytical results based on screening levels and bioaccumulation criteria.

SECTION 3 - RESULTS AND DISCUSSION

Sediment quality results are summarized below for the Clark Fork–Pend Oreille River upstream and downstream of Albeni Falls Dam. The upstream of the dam summary used data collected in the early 1980s by the University of Montana (Johns and Moore 1985), and in 1998 by the USGS (Beckwith 2002). Downstream summary data was collected in 2001 by the Washington Department of Ecology and Ecology & Environment Inc. (EPA 2002), and in 2007 by Tetra Tech (Tetra Tech 2009). General locations for sediment sampling are shown in Figure 2-2.

3.1 UPSTREAM OF ALBENI FALLS DAM SEDIMENTS

3.1.1 Conventionals

Concentrations of total carbon ranged from 2.6 percent in the Clark Fork River at St. Regis to 1.9 percent in the Pend Oreille River upstream of the Priest River (Table 3-1). Inorganic carbon fractions were extremely low measuring 0.06 percent in both the Clark Fork River and Pend Oreille River stations. Organic carbon fractions ranged from 2.5 percent in the Clark Fork River to 1.8 percent in the Pend Oreille River. These carbon concentrations were greater than both background stations. Phosphorus concentrations in sediments were low and were slightly greater in the Clark Fork River (0.12 percent) compared to the Pend Oreille River (0.07 percent), with both stations similar to background concentrations. Sulfur concentrations were low and similar between the Clark Fork River (0.1 percent) and Pend Oreille River (0.12 percent) samples, and slightly greater than background. Unfortunately, grain size was not collected by the USGS (Bowers, Caldwell, and Dutton 2003). Grain size and total organic carbon are important because concentrations of these two parameters can correlate to concentrations of metals and other contaminants. As such, differences in contaminant concentrations may partly be attributed to differences in these conventional parameters.

Table 3-1. Sediment Carbon and Metals Concentrations in the Lower Clark Fork and Pend Oreille Rivers

		Station Location		Background Station	
Parameters	Unit	USGS-9 Clark Fork River at St. Regis, Montana	USGS-16 Pend Oreille River above Priest River, Idaho	USGS-14 Lightning Creek at Clark Fork, Idaho	USGS-15 Priest River near Priest River, Idaho
Aluminum	(µg/g)	6.10	8	8	8.3
Arsenic	(µg/g)	22	10	8.3	7
Cadmium	(µg/g)	1	0.75	0.17	0.13
Calcium	(percent)	0.86	1	1.2	1.7
Chromium	(µg/g)	48	56	33	40
Copper	(µg/g)	140	93	26	19
Iron	(µg/g)	3.1	2.8	3.8	2.8
Lead	(µg/g)	53	47	25	26
Lithium	(µg/g)	39	47	24	33
Magnesium	(percent)	0.99	1.4	0.88	1.1
Mercury	(µg/g)	0.33	0.18	0.02	0.02
Nickel	(µg/g)	17	23	14	15
Phosphorus	(percent)	0.12	0.07	0.07	0.15
Potassium	(percent)	2.1	2.6	2.5	2.6
Selenium	(µg/g)	0.36	0.38	0.15	<0.1
Silver	(µg/g)	0.7	0.54	0.61	0.85
Sodium	(percent)	1.1	1	1.7	1.9
Sulfur	(percent)	0.1	0.12	<0.05	0.05
Zinc	(µg/g)	320	210	79	75
Inorganic carbon	(percent)	0.06	0.06	0.01	0.02
Organic carbon	(percent)	2.5	1.8	1.2	0.88
Carbon, total	(percent)	2.6	1.9	1.2	0.9

Notes:
Source: (Bowers et al. 2003)

3.1.2 Metals

Sediment metal concentration data has been collected upstream of Albeni Falls Dam by the USGS in the Pend Oreille River upstream of the Priest River (USGS-16) and in the Clark Fork River at St. Regis (USGS-9), as well as in background tributaries (USGS-14 and USGS-15)(Figure 2-2). Additionally, sediment concentrations of selected metals have been collected by the University of Montana in the Clark Fork River at Cabinet Gorge Dam Reservoir.

Sediment metals concentrations collected by the USGS in the Clark Fork and Pend Oreille Rivers, as well as at background stations located on Lightning Creek and the Priest River, are summarized in Table 3-1 (Bowers, Caldwell, and Dutton 2003). In general, metal concentrations at the Clark Fork and Pend Oreille River stations were similar and moderately high. Concentrations of arsenic and silver at the Clark Fork River at St. Regis station exceeded the SEF screening level. Concentrations of metals such as cadmium, copper, lead, and zinc were substantially greater at the Clark Fork and Pend Oreille River stations compared to background. This data suggests that metal

contamination from the upper Clark Fork River has been transported downstream through Lake Pend Oreille and into the Pend Oreille River.

Limited data on sediment metal concentrations existed in the Clark Fork River in Cabinet Gorge Reservoir, about 10 kilometers upstream of Lake Pend Oreille (Table 3-2). Sediment concentrations for the University of Montana 1985 study represent acetic acid extractable concentrations and not total metal concentrations. In general, acetic acid concentrations are substantially less than total metal concentrations. Acetic acid extractable arsenic concentrations in the reservoir were low and similar to background samples. Copper and zinc concentrations were moderate and considerably greater than background concentrations. The enrichment over background in copper and zinc in the Cabinet Gorge Reservoir sediments suggests that metal contamination from the upper Clark Fork River has been transported downstream to Lake Pend Oreille (Johns and Moore 1985).

Table 3-2. Sediment Quality Data Collected in the Lower Clark Fork River at Cabinet Gorge Reservoir

Paramters	Reservoir Station Locations					Background Sites	
	CG1	CG2	CG3	CG4	CG5	CG6	CG7
Metals (mg/kg)							
Arsenic	1.2	1.7	1.3	1.8	1.6	0.9	0.3
Copper	16	25	10	26	19	2	<0.3
Zinc	137	123	80	117	97	21	3

Notes:

< The analyte was undetected at the associated detection limit

Source: (Johns and Moore 1985)

3.1.3 Organic Contaminants

The USGS Clark Fork–Pend Oreille River Basin sediment study analyzed selected sediments for selected organic contaminants including organochlorine pesticides, PCBs, PAHS, phthalates, and phenols (Bowers, Caldwell, and Dutton 2003). For the Pend Oreille River Basin, only the Clark Fork River at St. Regis and the Lightning Creek at Clark Fork River sediment samples were analyzed for organic contaminants. Sediments were analyzed for both currently used organochlorine pesticides and "legacy" organochlorine pesticides such as DDTs that were banned years ago but are still found in the environment. PCBs that were analyzed included the most common Aroclors and were quantified at total PCBs. Aroclors are commercial mixtures of PCBs that were developed for their thermal stability and banned in the 1970s due to toxicity concerns. PAHs, phthalates, and phenols that were analyzed included many of the most common compounds found in the environment. (Table 3-3).

Concentrations of most organic contaminants were similar between the two stations and below the detection limit or estimated for most parameters. Only p-Cresol (1,100 micrograms per kilogram [µg/kg]) and Phenol (72 µg/kg) were detected at concentrations that did not have an estimate flag. There are no sediment screening levels for p-Cresol, while Phenol concentrations were less than the SEF screening level 1 concentrations.

Table 3-3. Lower Clark Fork–Pend Oreille River Basin Sediment Analysis for Selected Organic Contaminants

Analysis		USGS-9 Clark Fork at St. Regis, Montana	USGS-14 Lightning Creek at Clark Fork, Idaho
Polycyclic Aromatic Hydrocarbons/Phenols			
1-Methylphenanthrene	(µg/kg)	<50	<50
1-Methylpyrene	(µg/kg)	<50	<50
2,2'-Biquinoline	(µg/kg)	<50	<50
2,6-Dimethylnaphthalene	(µg/kg)	<50	<50
2-Ethylnaphthalene	(µg/kg)	<50	<50
Acenaphthene	(µg/kg)	<50	<50
Acenaphthylene	(µg/kg)	<50	<50
Anthracene	(µg/kg)	<50	<50
Benz[a]-anthracene	(µg/kg)	<50	<50
Benzo-[a]-pyrene	(µg/kg)	<50	<50
Benzo-[b]-fluoranthene	(µg/kg)	<50	<50
Benzo-[ghi]-perylene	(µg/kg)	<50	<50
Benzo-[k]-fluoranthene	(µg/kg)	<50	<50
Chrysene	(µg/kg)	<50	<50
Dibenz-[a,h]-anthracene	(µg/kg)	<50	<50
Fluoranthene	(µg/kg)	e13	<50
Indeno-[1,2,3-cd]-pyrene	(µg/kg)	<50	e5.9
Napthalene	(µg/kg)	<50	<50
p-Cresol	(µg/kg)	1,100	<50
Penanthrene	(µg/kg)	<50	<50
Phenol	(µg/kg)	72	<50
Pyrene	(µg/kg)	<50	<50
Phthalates			
bis(2-Ethylhexyl) phthalate	(µg/kg)	e33	e23
Butylbenzyl phthalate	(µg/kg)	<50	e20
Diethylphthalate	(µg/kg)	<50	<50
Dimethyl phthalate	(µg/kg)	<50	<50
Di-nbutyl phthalate	(µg/kg)	<50	e30
Organochlorine Pesticides			
Aldrin	(µg/kg)	<1.0	<1.0
Dieldrin	(µg/kg)	<1.0	<1.0
Endrin	(µg/kg)	<2.0	<2.0
Lindane	(µg/kg)	<1.0	<1.0
p,p'-DDD	(µg/kg)	<1.0	<1.0
p,p'-DDE	(µg/kg)	<1.0	<1.0
p,p'-DDT	(µg/kg)	<2.0	<2.0
Polychlorinated Biphenyls			
Total PCBs	(µg/kg)	<50	<50

Notes:
Source: (Bowers et al. 2003)

3.2 DOWNSTREAM OF ALBENI FALLS SEDIMENTS

3.2.1 Conventionals

Sediment total organic carbon concentrations were varied in the Pend Oreille River samples collected downstream of Albeni Falls Dam (Table 3-4 and Table 3-5). Organic carbon ranged from about 0.06 to 4.5 percent for the EPA Lower Pend Oreille River Study (EPA 2002), and from about 0.4 to 11.6 percent for the Boundary Hydroelectric Toxic Assessment Study (Tetra Tech 2009). Tetra Tech (2009) also analyzed sediments for sulfides (range of 0.30 to 15.1 mg/kg) and total solids (range of 30.6 to 83.4 percent). For the Tetra Tech (2009) study, organic carbon and sulfide concentrations were generally lowest at the farthest upstream sampling stations and increased downstream in the Boundary Dam Reservoir pool (Figure 2-2). Conversely, percent total solids in the sediments were greatest at the farthest upstream stations and decreased downstream toward Boundary Dam. Sulfide and total organic carbon concentrations are important because these two parameters bind metals and PCBs in sediments and can reduce toxicity to benthic organisms.

Table 3-4. Sediment Data Collected in the Pend Oreille River for the EPA Lower Pend Oreille River Study

Paramters	Station Location				
	PRBK01SD	PRRS01SD	PRRS02SD	PRRS03SD	PRRS04SD
Metals (mg/kg)					
Aluminum	**11100**	**10700**	**8410**	**6950**	**7660**
Arsenic	**16.3**	**5.8**	**4.9**	**5.5**	**3.0 JB**
Barium	**183**	**123**	**85.6**	**44.5 JB**	**89.7**
Cadmium	0.57 JB	0.51 JB	0.09 U	0.11 U	0.88 JB
Calcium	**21500**	**24400 JL**	**2350 JL**	**3400 JL**	**12100 JL**
Chromium	**17.6**	**23.9**	**19.7**	**17.1**	**17.1**
Copper	**31.6 (AC)**	**32.1**	**23.5**	**21.8**	**19.7**
Iron	**27000**	**21700**	**14400**	**14200**	**14500**
Lead	**35.7**	**28.1**	**9.4**	**8.3**	**38.5**
Magnesium	**8910**	**11200 JL**	**4660 JL**	**4450 JL**	**7450 JL**
Manganese	**921**	**346 (AC)**	**175 (AC)**	**169 (AC)**	**152 (AC)**
Nickel	**20.9**	**19.2**	**15.6**	**14.1**	**14.5**
Potassium	2020 JB	**1730**	**1340**	978 JB	1180 JB
Selenium	1.5 U	.37 (U,AC)	0.37 (U,AC)	0.38 (U,AC)	0.46 (U,AC)
Vanadium	**28.3**	**41.6**	**32.8**	**31.5**	**21.4**
Zinc	**287**	**130**	**54**	**43.8**	**205**
PESTICIDES (mg/kg)					
4,4-DDT	6.6U	4.3U	4.2U	4.5U	5.7U
TOTAL ORGANIC CARBON (percent)					
TOC	**1.37**	**0.76**	**0.0595 J**	**0.0581 J**	**4.56**

Notes:

Bold type indicates the sample concentration is above the detection limit.

AC = Adjusted Concentration

B = the reported concentration is between the instrument detection limit and the contract required detection limit

H = high bias

J = the analyte was positively identified, the associated numerical value is an estimate

K = unknown bias

L = low bias

U =the analyte was undetected at the associated detection limit

Source: (USEPA 2002)

Table 3-5. Sediment Conventional Data Collected in the Pend Oreille River for the Boundary Hydroelectric Toxic Assessment Study

Site No.	Total Solids (%)	Water (%)	Total Organic Carbon (%)	Sulfides (mg/kg)
BD-1	31.3 – 34.4	65.6 – 68.6	2.58 – 2.78	1.22 – 2.37
BD-2	34.3 – 46.8	53.2 – 65.7	2.67 – 3.35	0.87 – 11.6
BD-3	31.9 – 32.5	67.5 – 68.1	2.93 – 3.00	11.2 – 15.1
BD-4	39.4 – 47.8	53.2 – 60.6	2.45 – 2.77	1.18 – 9.11
BD-5	65.5 – 72.2	27.8 – 34.5	1.12 – 1.73	0.59 – 5.58
BD-6	79.3 – 81.2	18.8 – 20.7	0.75 – 1.29	0.48 – 0.51
BD-7	30.6 – 83.4	16.6 – 69.4	0.53 – 11.6	0.49 – 1.36
BD-8	72.3 – 74.3	25.7 – 27.7	1.74 – 2.98	0.58 – 2.59
BD-9	52.6 – 75.1	24.9 – 47.4	1.22 – 2.04	0.58 – 0.82
BD-10	67.7 – 72.4	27.6 – 32.4	0.40 – 0.63	0.45 – 0.62
BD-11	58.8 – 72.6	27.4 – 41.2	0.52 – 1.60	0.42 – 0.62
BD-12	69.9 – 75.7	24.3 – 30.1	0.49 – 0.69	0.37 – 0.47
BD-13	72.6 – 82.2	17.8 – 27.4	0.57 – 0.67	0.30 – 0.39
BD-14	67.2 – 78.4	21.6 – 32.9	0.94 – 1.49	0.31 – 0.44

Notes:

Source: (Tetra Tech 2009)

3.2.2 Metals

Sediment metals were collected at several locations about 100 kilometers downstream of Albeni Falls Dam for the EPA Lower Pend Oreille River Study and the Boundary Hydroelectric Toxic Assessment Study (EPA 2002; Tetra Tech 2009). Concentrations of sediment samples for selected metals are summarized in Table 3-4 and Table 3-6, with general sampling locations shown in Figure 2-2. In general, sediment metal concentrations were low to moderate for both studies, with no station exceeding the SEF screening level 1, suggesting that adverse effects to the benthic community would not be expected. The highest average metal concentrations were measured for lead and zinc in the pool of Boundary Dam at stations BD-1 to BD-8 (Table 3-6). In general, metals concentrations in the Pend Oreille River just downstream of Box Canyon Dam (BD-10 to BD-14) were lowest for all metals. Historical mines, as well as waste and tailings piles, exist in the watershed between Box Canyon Dam and Boundary Dam and may be a source of lead and zinc to the river. For most metals, concentrations measured in the Lower Pend Oreille River are similar to or slightly lower than concentrations measured upstream of Albeni Falls Dam and in the lower Clark Fork River (EPA 2002; Bowers, Caldwell, and Dutton 2003; Tetra Tech 2009).

Table 3-6. Sediment Metals and Organics Data Collected in the Pend Oreille River for the Boundary Hydroelectric Toxic Assessment Study

Site No.	Arsenic (mg/kg)	Cadmium (mg/kg)	Lead (mg/kg)	Mercury (mg/kg)	Zinc (mg/kg)	PCBs (mg/kg)
BD-1	13.2 – 14.3	0.45 – 0.63	29.6 – 33.7	0.052 – 0.062	117.5 – 145.3	—
BD-2	9.41 – 11.7	0.48 – 0.61	24.9 – 33.5	0.045 – 0.046	125.7 – 146.4	<0.05
BD-3	11.8 – 15.6	0.51 – 0.67	27.2 – 33.2	0.057 – 0.064	127.4 – 151.5	—
BD-4	9.46 – 10.8	0.56 – 0.68	26.5 – 32.7	0.042 – 0.059	136.9 – 151.1	<0.05
BD-5	5.01 – 7.17	0.34 – 0.70	17.5 – 30.1	0.015 – 0.020	110.1 – 196.2	—
BD-6	3.75 – 5.78	0.16 – 0.19	14.5 – 17.8	<0.01	52.4 – 71.3	—
BD-7	3.85 – 5.85	0.97 – 1.12	59.9 – 147.3	0.015 – 0.036	299.2 – 385.7	<0.05
BD-8	3.80 – 4.18	0.79 – 0.92	115.4 – 291.2	<0.01 – 0.019	461.4 – 518.2	—
BD-9	2.06 – 5.52	0.11 – 0.26	10.0 – 26.6	<0.01 – 0.12	34.1 – 35.4	—
BD-10	5.05 – 9.11	0.24 – 0.30	14.6 – 19.2	0.024 – 0.030	77.4 – 101.4	—
BD-11	6.11 – 8.90	0.32 – 0.45	9.85 – 15.8	0.015 – 0.025	102.0 – 150.5	—
BD-12	3.74 – 6.03	0.18 – 0.29	18.0 – 19.4	<0.01 – 0.016	68.6 – 96.7	—
BD-13	2.02 – 4.44	0.24 – 0.54	4.26 – 44	<0.01	25.1 – 40.2	<0.05
BD-14	2.89 – 3.68	0.10 – 0.13	4.76 – 7.15	<0.01	39.2 – 45.2	—

Notes:
Source: (Tetra Tech 2009)

3.2.3 Organic Contaminants

Concentrations of organochlorine pesticides in sediment samples collected for the Lower Pend Oreille River Study are summarized in Table 3-4. All samples were below the detection limits presented. Concentrations of PCBs in selected sediment samples collected for the Boundary Hydroelectric Toxic Analysis Study are presented in Table 3-6. PCBs were not detected in any sample in the Pend Oreille River.

SECTION 4 - CONCLUSIONS AND RECOMMENDATIONS

Although considerable amounts of sediment data exists in the Clark Fork River, only limited data is available for the lower Clark Fork River immediately upstream of Lake Pend Oreille. Moreover, very little sediment quality data exists in Lake Pend Oreille and the Pend Oreille River upstream of Albeni Falls Dam, with more data available downstream of the dam.

4.1 UPSTREAM OF ALBENI FALLS DAM

Sediment metals concentrations in the lower Clark Fork River were similar to concentrations in the Pend Oreille River upstream of Albeni Falls Dam, which suggests that metal contamination from the upper Clark Fork River has been transported downstream through Lake Pend Oreille and into the Pend Oreille River. Concentrations of copper and zinc in the Cabinet Gorge Reservoir just upstream of Lake Pend Oreille were substantially greater than background concentrations. This data suggests that copper and zinc concentrations are enriched in the reservoir likely from the transport of metals downstream in the Clark Fork River. In general, metal concentrations at the Clark Fork River and Pend Oreille River stations were similar and moderately high. Concentrations of arsenic and silver at the Clark Fork River at St. Regis station exceeded the SEF screening level. Concentrations of metals such as cadmium, copper, lead, and zinc were substantially greater at the Clark Fork and Pend Oreille River stations compared to background. This data suggests that metal contamination from the upper Clark Fork River has been transported downstream through Lake Pend Oreille and into the Pend Oreille River.

The limited amount of sediment organic contaminant data collected in the Lower Clark Fork–Pend Oreille River system upstream of Albeni Falls Dam suggests that little contamination is present. Organochlorine pesticides, PCBs, PAHs, phthalates, and phenols measured in two sediment samples were low, with most compounds below the detection limit. Only p-Cresol and phenol were detected at concentrations that did not have an estimate flag.

4.2 DOWNSTREAM OF ALBENI FALLS DAM

Sediment metals concentrations in the lower Pend Oreille River were low to moderate for both studies, with no station exceeding the SEF screening level 1, suggesting that adverse effects to the benthic community would not be expected. Concentrations of lead and zinc were lowest at the farthest upstream sampling location near Box Canyon Dam and were greatest in the Boundary Dam Reservoir downstream of Metaline Falls, Washington. For most metals, concentrations measured in the Lower Pend Oreille River were similar to or slightly lower than concentrations measured upstream of Albeni Falls Dam. Concentrations of organochlorine pesticides and PCBs measured in selected sediment samples were all below laboratory reporting limits.

4.3 RECOMMENDATIONS

A more detailed sediment sampling program should be conducted in Lake Pend Oreille and the Pend Oreille River upstream and immediately downstream of Albeni Falls Dam. Of particular importance are sediments in Lake Pend Oreille where the Clark Fork River enters the lake. It is likely that the elevated metals concentrations measured in the lower Clark Fork River were transported into Lake Pend Oreille. Sampling should focus on the Clark Fork River delta and along the northern boundary of Lake Pend Oreille where most of the flow from the Clark Fork River moves through the lake. Additional sediment sampling in the Pend Oreille River should be conducted upstream of Albeni Falls Dam. In particular, the area upstream of the Priest River should have more extensive sampling to determine the extent of any sediment contamination that may exist. A focus downstream of the dam would be on sediments in the reach between Albeni Falls Dam and the Kalispel Tribe of Indians to determine if any transport of metals from the Clark Fork River has occurred in this reach.

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