Preassessment Screen

for the

Upper Columbia River Site, Washington

Upper Columbia River Natural Resource Trustee Council

November 2009

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Acronyms and Abbreviations

Ag	silver
As	arsenic
Au	gold
BC	British Columbia
$CaCO_3$	calcium carbonate
CAS	Chemical Abstract Service
CCT	Confederated Tribes of the Colville Reservation
Cd	cadmium
Celgar	Includes Zellstoff Celgar, Zellstoff Celgar Limited Partnerhip, Celgar Pulp Company, and all past and current names of the pulp mill facility in Castlegar, BC.
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
Cr	chromium
Cu	copper
$CuSO_4$	copper sulfate
DOI	Department of the Interior
EC_{50}	median effective concentration
Ecology	Washington State Department of Ecology
H_2SO_4	sulfuric acid
Hg	mercury
HSCA	Hazardous Substances Control Act

LC_{50}	median lethal concentration
LRNRA	Lake Roosevelt National Recreation Area
µg/g	micrograms per gram, or parts per million, commonly used to express metals concentrations in tissues
µg/L	micrograms per liter, or parts per billion, commonly used to express metals concentrations in water
mg/kg	milligrams per kilogram, or parts per million, commonly used to express metals concentrations in tissues, sediments and soils
mg/L	milligrams per liter, or parts per million, used to express $CaCO_3$ concentration in water (water hardness)
NRDA	Natural Resource Damage Assessment
NRWQC	National Recommended Water Quality Criteria
PAS	preassessment screen
Pb	lead
PCB	polychlorinated biphenyl
pg/g	picograms per gram, or parts per trillion, commonly used to express chlorinated organic compound (e.g., dioxin/furan) concentrations in tissues
PRP	Potentially Responsible Party
RI/FS	Remedial Investigation and Feasibility Study
SO_2	sulfur dioxide
SQG	sediment quality guidelines
State	Washington State
STI	Spokane Tribe of Indians
SWQS	Surface Water Quality Standards

TCDD	2,3,7,8-tetrachlorodibenzo-*p*-dioxin
TCDF	2,3,7,8-tetrachlorodibenzofuran
Teck	Includes past and current names of the smelting operation in Trail, British Columbia: Cominco, Teck Cominco Canada, Teck Cominco Limited, Teck Resources Limited, Teck; also includes Teck Cominco American Inc., a U.S. subsidiary of Teck Cominco
TEF	toxic equivalency factor
TEQ	toxicity equivalent
UCRS	Upper Columbia River Site
USBIA	U.S. Bureau of Indian Affairs
USBLM	U.S. Bureau of Land Management
USBOR	U.S. Bureau of Reclamation
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USNPS	U.S. National Park Service
WDFW	Washington State Department of Fish and Wildlife
WDOH	Washington State Department of Health
Zn	zinc

I. Introduction, Scope, and Authority

Hazardous substances have come to be located within the Upper Columbia River and associated areas, known as the Upper Columbia River Site (UCRS), through intentional and accidental releases into the Columbia River from paper milling and metals smelting operations in British Columbia (BC), in the case of smelting for over a century. Concerns over plumes of smoke and dust drifting from the upstream smelter have been reported since the 1920s (Wirth 1996). Granulated slag and liquid effluent from smelting operations and fertilizer production byproducts have also been discharged or continue to be discharged to the Columbia River. In addition, chlorinated effluent from pulp mill operations were discharged to the Columbia River in BC from 1961 to 1993. As a result, people in Tribal communities, other local communities and visitors may have experienced lost uses, and loss of cultural and spiritual experiences, due to the presence of contaminants in the Upper Columbia River that may have resulted in injury to natural resources.

This document is the preassessment screen (PAS), prepared pursuant to title 43 CFR Part 11, for the UCRS. The UCRS encompasses a 151-mile-long stretch of the Columbia River from the U.S.-Canada border downstream to Grand Coulee Dam, including the riverine, lake, riparian, wetland and upland areas along the river. A detailed site description is found within section II (A) of this document.

The purpose of the PAS document is to evaluate the need to conduct a formal natural resource damage assessment (NRDA) as authorized under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), 42 U.S.C. § 9601 *et seq*., as amended; the Oil Pollution Act of 1990, 33 U.S.C. § 2701 *et seq*.; and the Clean Water Act (CWA), 33 U.S.C. § 1251 *et seq*. Listed below are the criteria that must be met to proceed past the preassessment phase to the full assessment phase of the NRDA process.

1) A discharge of oil or release of hazardous substance has occurred.
2) Natural resources for which a State or Federal agency or Indian Tribe may assert trusteeship under CERCLA have been or are likely to have been adversely affected by the discharge or release.
3) The quantity and concentration of the discharged oil or released hazardous substances is sufficient to potentially cause injury to those natural resources.
4) Data sufficient to pursue an assessment are readily available or likely to be obtained at reasonable cost.
5) Response actions from Superfund remedial activities carried out or planned do not or will not sufficiently remedy the injury to natural resources without further action.

This document has been prepared pursuant to title 43 CFR § 11.23(e) for the US Department of the Interior (DOI, as represented by the National Park Service (USNPS), Bureau of Reclamation (USBOR), Fish and Wildlife Service (USFWS), Bureau of Indian Affairs (USBIA) and Bureau of Land Management (USBLM)); Washington State (State), as represented by Department of Ecology (Ecology); and the Confederated Tribes of the Colville Reservation (CCT) and the Spokane Tribe of Indians (STI), both federally recognized Tribes with Reservations established by Executive Order. Pursuant to CERCLA Section 107 (f) and Section 300.600 of the National Contingency Plan, these four sovereign entities are trustees for all the natural resources that may potentially be injured by contaminant releases into the UCRS, and are herein collectively referred to as the Trustees.

II. Study Site Information and Background

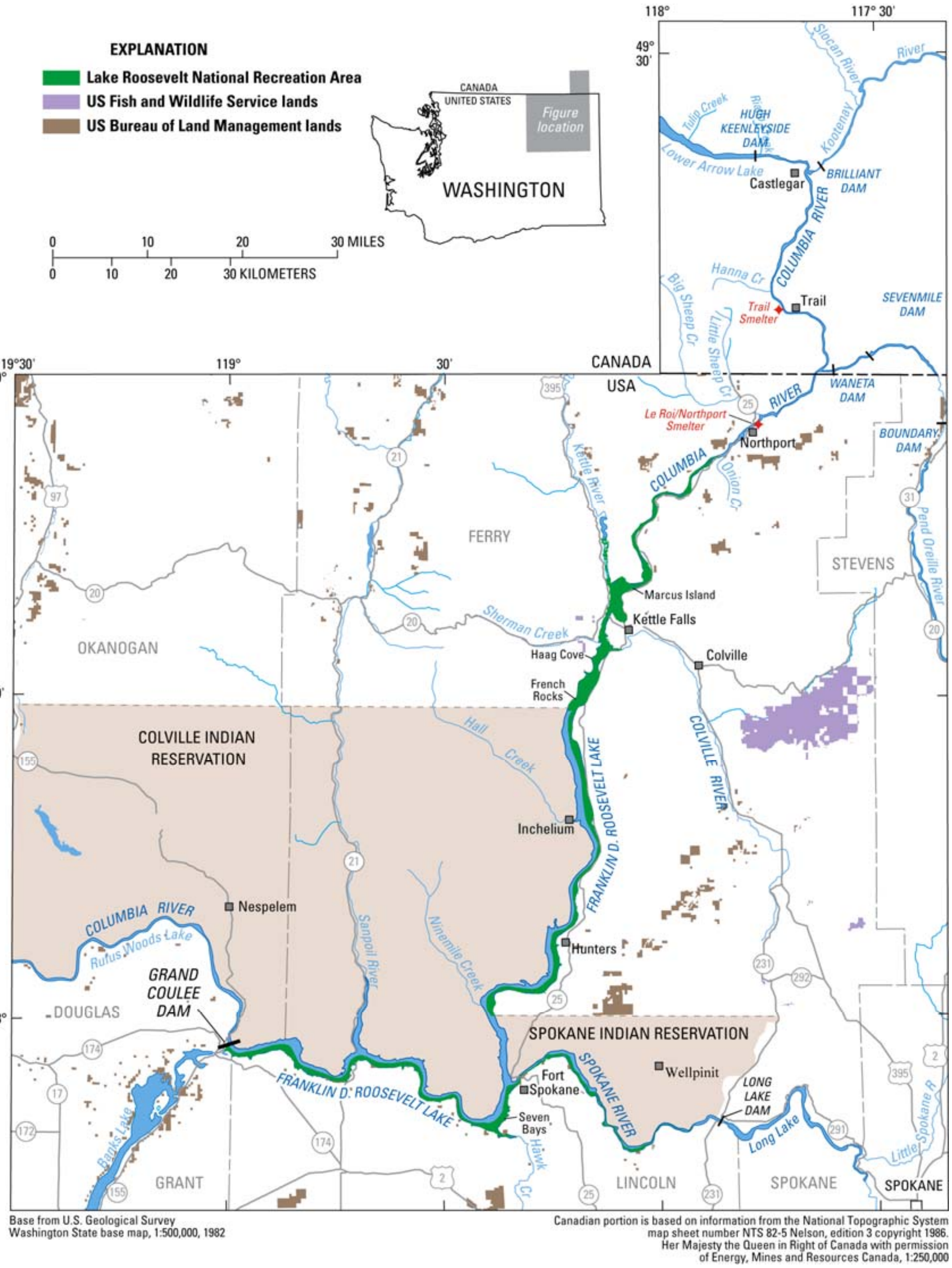
A. Upper Columbia River Site Description and Information

The UCRS is located entirely within Washington State. The UCRS extends along the Columbia River from the US-Canada border downstream 151 miles to Grand Coulee Dam, encompassing riverine, riparian, lacustrine, palustrine and upland areas surrounding this reach of the river (Figure 1). The US Environmental Protection Agency (USEPA, 2008) defines the site to include the areal extent of contamination and all other areas in proximity to such contamination necessary for implementation of response actions.

Construction on Grand Coulee Dam began during the 1930s and was completed in 1941. The impoundment formed Lake Roosevelt; at full pool the reservoir spans a length of 133 miles, with over 600 miles of shoreline. Lake Roosevelt's surface water is managed by the USBOR for multiple purposes including flood control, hydroelectric power production, irrigation, fisheries and other beneficial water uses (USBOR 2009). Seasonal reservoir fluctuations may occur in excess of 80 feet, but typically are about 45 feet (USNPS 1997). Major tributaries influencing flow in the Columbia River at the UCRS include the Pend Oreille, Kettle, Colville, Sanpoil and Spokane Rivers.

The USNPS, USBOR, CCT, STI and USBIA cooperatively manage lands within the UCRS for various subsistence and recreational activities, as outlined in the Lake Roosevelt Cooperative Management Agreement (1990). A significant portion of the reservoir area has been designated as the Lake Roosevelt National Recreation Area (LRNRA) and is managed by the USNPS. A large portion of the UCRS is also located within the boundaries of the CCT and STI Reservations (Figure 1). In addition, this site is within the CCT's former Reservation lands (ceded lands) within which the CCT has certain reserved rights and entitlements. For thousands of years Native Americans have used the natural resources of the area for subsistence activities, such as hunting, fishing, gathering plants, foods, and medicines and conducting religious ceremonies. The site is culturally rich and sensitive. Today people of the CCT and STI Tribal communities continue to live on and utilize natural resources from within the site, and practice their religious beliefs and ceremonies.

Figure 1. Map of the Upper Columbia River in northeastern Washington, including the Lake Roosevelt National Recreation Area and the Colville and Spokane Tribe Reservations.



Geology and Landscape

The UCRS consists of diverse glaciated land features including both the Okanogan Highlands and Columbia Basin geologic provinces. The Okanogan Highlands in the northern portion is a mountainous and highly mineralized region containing many precious and base-metal deposits. Formed by complex geologic processes, it is comprised of miogeosynclinal metasedimentary rocks to the east and eugeosynclinal metasedimentary rocks (containing volcanic units) to the west (Washington State Department of Natural Resources 2009). The southern landforms are distinctly different and were formed by large basaltic lava flows occurring during the Miocene Epoch (USNPS 1997). The southern portion was heavily shaped by the Glacial Lake Missoula Floods which scoured the ancient basalt creating the Channeled Scablands (USNPS 1997). This region’s unique geologic features can be observed throughout the southern portion of the UCRS.

The hydrology of the UCRS is influenced by aquifers, groundwater, and surface waters including the Columbia River and its tributaries. The aquifers that occur within the UCRS include both basaltic aquifers of the Columbia Plateau and alluvial deposits. Groundwater within the UCRS is recharged through infiltration of precipitation primarily from higher elevations and through surface waters. Groundwater movement bordering the Upper Columbia River is dependant on several factors including aquifer exchange, reservoir dynamics, bank storage, and surface inputs (Thompson 1977).

The Columbia River upstream of the UCRS contributes up to ninety percent of the surface water volume into Lake Roosevelt, with the remaining ten percent coming from the Spokane, Kettle, Colville, and Sanpoil Rivers (Stober et al. 1981). Surface water flows are heavily regulated throughout the Columbia Basin. A series of dams regulate flows into the UCRS within Canada (Figure 1). Within the US, Upper Columbia River flow is regulated at Grand Coulee Dam. Dams also regulate flows on the Spokane River and the Pend Oreille River. These series of dams on the Columbia and its tributaries have altered the natural hydrograph of the Upper Columbia River by reducing the spring peak flows, increasing the fall and winter flows, and altering the natural variability within seasonal flows (USEPA 2008).

The UCRS lies within the rain shadow of the Cascade Range resulting in a semi-arid climate. The northern portion of the UCRS receives more rain than the southern portion and these differences account for the floristic diversity found within the area. The southern portion is semi-arid and consists of steppe and sage-steppe flora including big sagebrush (*Artemisia tridentata*), antelope bitterbrush (*Purshia tridentata*), bluebunch wheatgrass (*Pseudoroegneria spicata*), and brittle prickly pear (*Opuntia* spp.). Between the northern and southern areas a transition occurs dominated by ponderosa pine (*Pinus ponderosa*), and a mixture of sage-steppe species. The northern portion of the UCRS is primarily forested consisting of species such as douglas fir (*Pseudotsuga mensiesii*), western larch (*Larix occidentalis*), grand fir (*Abies grandis*), oregon grape (*Berberis repens*), and red-stem ceanothus (*Ceanothus velutinus*).

Natural Diversity

The diversity of geologic, hydrologic, and climatic conditions that occur within the UCRS creates a wide range of habitats for fish and wildlife species. Habitats for fish and wildlife include upland, riparian, palustrine, lacustrine, and riverine areas. Several areas have been identified by the USFWS and Washington State Department of Fish and Wildlife (WDFW) as priority or endangered habitats (WDFW 2006; USFWS 2006) based on key benefits that they provide for fish and wildlife.

There are over 75 species of mammals, 200 species of birds, 15 species of reptiles, and 10 species of amphibians that may occur within the UCRS (USNPS 1997). Some of these species reside within the area and others use the area seasonally. Many of theses species rely on the wide range of habitat types within the UCRS for completion of key life-cycle requirements, such as nesting, rearing, wintering, and migration. There are many large resident mammals that depend on these habitats for wintering and rearing, such as mule deer (*Odocoileus hemionus*), bighorn sheep (*Ovis canadensis*), moose (*Alces alces*), elk (*Cervus canadensis*), and black bear (*Ursus americanus*). Other mammals depend on a variety of habitats, including riparian and wetland habitats, for foraging and rearing such as mink (*Mustela vison*), muskrat (*Ondatra zibethicus*), and river otter (*Lontra canadensis*). A variety of birds use the UCRS including raptors, passerines, waterbirds, and shorebirds. Raptors, such as bald eagles (*Haliaeetus leucocephalus*) and osprey (*Pandion haliaetus*) use riparian habitats for nesting, foraging, and rearing of young. Passerines utilize a numerous habitats types within the area to nest and rear young, including species of jays, sparrows, flycatchers, swallows, and chickadees. The UCRS is located within the Pacific Flyway and provides waterfowl with stopover habitat to forage and replenish nutritional reserves during migration. Additionally, the UCRS aquatic habitats offer waterfowl an area for nesting and rearing. Many types of waterbirds depend on the UCRS, such as common merganser (*Mergus merganser*), Canada goose (*Branta canadensis*), mallard (*Anas platyrhynchos*), red-necked grebe (*Podiceps grisegena*), common loon (*Gavia immer*), and various other aquatic-dependent birds, including belted kingfishers (*Megaceryle alcyon*) and great blue heron (*Ardea herodias*). Amphibians and reptiles also depend on aquatic habitats found within the UCRS. Three species of amphibians are federal candidate species for listing under the Endangered Species Act (ESA), including western toad (*Bufo boreas*), northern leopard frog (*Rana pipiens*), and Columbia spotted frog (*Rana luteiventris*).

The UCRS contains over 30 species of fish, of which at least 13 are native. Some of the native fish species include westslope cutthroat (*Onchorynchous clarki lewisi*), bull trout (*Salvelinus confluentus*), redband trout (*Onchorynchous mykiss*), a focus of CCT recovery efforts, lake whitefish (*Coregonus clupeaformis*), mountain whitefish (*Prosopium williamsoni*), and white sturgeon (*Acipenser transmontanus*) which are the focus of a multinational recovery effort due to population decline from lack of natural recruitment. The white sturgeon constituted an important fishery until closure in 1996 to protect the remaining population. Hatchery programs managed by WDFW and STI support fisheries for kokanee salmon (*Onchorynchous nerka*) and rainbow trout (*Onchorynchous mykiss*). Nonnative walleye (*Sander vitreus*) supports a large recreational fishery within the UCRS. Other important recreational fisheries exist for burbot (*Lota lota*), smallmouth bass (*Micropterus dolomieui*) and various warmwater fish species.

Of the fish and wildlife species potentially inhabiting or occasionally occupying habitat within the UCRS, three are federally listed species under the ESA. They include bull trout (threatened), grizzly bear (*Ursus arctos horribilis*, threatened) and Canada lynx (*Lynx canadensis*, threatened). The recently delisted gray wolf (*Canis lupus*) has also been observed within the UCRS on several occasions (WDFW 2006). Two listed plant species, Ute ladies'-tresses (*Spiranthes diluvialis*, threatened) and Spalding's catchfly (*Silene spaldingii*, threatened) may also be found at the site.

Many classes of invertebrates are found within the UCRS and provide key ecological functions, including food resources for higher vertebrates and nutrient cycling. However, the paucity of studies conducted within the UCRS limits the ability to provide a comprehensive list of species that may be present. For example, the California floater (*Anodonta californiensis*), a federally listed freshwater mussel species of special concern, is known to occur within the area, but several other species have been noted upstream, including the western floater (*Anodonta kennerlyi*). Other invertebrates include crustaceans, and various benthic invertebrates such as midges, mayflies, and oligochaetes, daphnids, and cladocera. Invertebrates provide key trophic linkages to higher organisms within the UCRS.

Cultural/Recreational

Members of the STI have traditionally lived close to the land and continue to do so. The STI has not relinquished any on-Reservation hunting, fishing, and gathering rights. In order to be able to subsist on these natural resources reserved for the STI through federal agreements and Executive Orders, the STI realized that the resources must be essentially clean and free of contaminants. This realization led to development of the STI's Surface Water Quality Standards (SWQS, STI 2008) and the Hazardous Substances Control Act (HSCA, STI 2006). Both instruments are based on consumption of traditional foods at traditional rates, for traditional durations. Likewise, the CCT historically lived, and continue to live, along the banks of the Columbia River and its tributaries. The culture of these tribes is inextricably tied to the river and the plants and animals living along and in the river. Fishing, hunting, plant gathering, swimming and traditional ceremonies continue to be significant parts of Tribal life. The presence of contamination would serve to decrease and degrade traditional foods and may preclude the use of the river and its beaches for swimming and other recreational uses. These limitations on the use of the river and its resources also have a negative impact on the cultural and spiritual wellbeing of the Tribes and their members.

The UCRS supports many recreational uses, including but not limited to fishing, hunting, hiking, boating, camping, swimming, and wildlife viewing. Over 1.3 million people visit the LRNRA each year (USNPS 2009). These visitors contribute to the local economies through the purchase of fuel, food, services, lodging, fishing tackle, and other supplies.

There are five eastern Washington counties (Ferry, Stevens, Lincoln, Grant, and Okanogan) as well as the Spokane and Colville Reservations which benefit from recreational dollars.

Hazardous substances have come to be located within the UCRS through intentional and accidental releases into the Columbia River from metals smelting and paper milling operations in BC, in the case of smelting for over a century. Concerns over plumes of smoke and dust drifting from the upstream smelter have been reported since the 1920s (Wirth 1996). Granulated slag and liquid effluent from smelting operations and fertilizer production byproducts have also been discharged or continue to be discharged into the Columbia River. In addition, chlorinated effluent from pulp mill operations were discharged to the Columbia River in BC from 1961 to 1993. As a result, people in Tribal communities and other local communities, visitors, and natural resources may have been exposed to contaminants in the Upper Columbia River that potentially have resulted in injury to natural resources.

B. Sources of Hazardous Substance Releases, Current and Past Uses, and Relevant Facility Operations

The USEPA is currently conducting a Remedial Investigation and Feasibility Study (RI/FS) at the UCRS. The RI/FS is currently being conducted through a settlement agreement reached on June 2, 2006, between the USEPA and Teck (USEPA 2006a). The purpose of the RI/FS is to investigate the nature and extent of contamination within the UCRS and to develop a baseline risk assessment for human and environmental health, as well as to develop and evaluate any necessary remedial actions (USEPA 2008). The USEPA began the RI/FS process due to concerns of contamination within the UCRS from discharges of granulated slag, liquid effluent, and accidental spills into the Columbia River from Teck near Trail, BC (USEPA 2008). Phase I of the RI/FS began in 2005, which included sediment and fish sampling within the UCRS.

The UCRS has a long history of mining and mineral processing, and timber-related industry which have resulted in widespread environmental contamination. Contaminants associated with smelting, fertilizer production, and pulp mills entered the Columbia River in Canada through both intentional discharge and spills. Primary sources of hazardous substances include Teck and the Zellstoff Celgar (Celgar) pulp mill in Castlegar, BC. Known and potential secondary sites, such as the Le Roi Smelter in Northport, WA, are also present in the Columbia River drainage. The USEPA has identified Teck as the "primary source of contamination" (USEPA 2003) in the UCRS for metals and metalloids. The Celgar pulp mill is the primary known source of dioxins (Johnson et al. 1991a).

Teck Smelter and Facilities

Teck is located approximately 10 miles upstream of the US-Canada border in Trail, BC. The current owner of the operation is Teck Resources Limited (known as Teck). The original facilities and smelter have been in operation since 1896 (G3 Consulting 2001) when they functioned primarily to smelt gold (Au) and copper (Cu). In 1901 the smelter was expanded to include lead (Pb) furnaces and was producing pure Pb, silver (Ag), and Au by 1906. By this time the company, known as Consolidated Mining and Smelting Company of Canada, had consolidated surrounding area mines with the smelting facility in order to secure sources of ore and concentrate. Zinc (Zn) production began in 1916 (USEPA 2008). Fertilizer plants producing both nitrogen- and phosphorous-based fertilizer were built in 1930 (MacDonald Environmental Services 1997). However, phosphorous fertilizer production was halted in 1994. The smelter was renamed Cominco in 1966. Current operations smelt primarily Zn and Pb, but also produce cadmium (Cd), Ag, Au, bismuth, antimony, cobalt, Cu, indium, germanium, thalium and mercury (Hg). In addition to metals production, the facilities also produce arsenic (As) products, sulfur, sulfuric acid (H_2SO_4), ammonium sulfate fertilizers and ferrous granules (USEPA 2003).

Prior to 1996 Teck intentionally dumped granulated slag (a byproduct of the smelting process) directly into the Columbia River. The USEPA (2008) estimates that over 23 million tons of slag were discharged into the river from the beginning of its production up until mid-1995, at which time there was extensive modernization of the Pb smelting facility, and routine discharges to the river discontinued. Slag is a glassy, sand-like solid consisting predominantly of ferrous granules. It contains up to 1% Cu and up to 3% Zn, as well as antimony, As, barium, chromium (Cr), manganese and other metals (Cox et al. 2005). Slag particles have been transported downstream, where they settle out in slower-flowing reaches. Based on current literature, these metals have the potential to leach into surrounding waters and create toxic concentrations for biota (Paulson and Cox 2007). Slag may also smother spawning and rearing habitats, physically scour aquatic habitats reducing macrophyte communities, and potentially cause physical damage to aquatic biota (USEPA 2008).

Teck has released contaminants, including metals, into the Columbia River through effluent discharges and spills. The fertilizer plants, operational from 1930 to 1994, reportedly discharged up to 4 kg/day of total Hg and 350 kg/day of dissolved Zn. The metal production effluents averaged 18 kg/day of As, 62 kg/day of Cd, 200 kg/day of Pb, and 7,400 kg/day of Zn from 1980 to 1996 (Cominco 1997). These metals were carried downstream into the UCRS creating potential risk to human health and ecological receptors.

Throughout its history, smelter stack emissions have released contaminants such as sulfur dioxide (SO_2) into the atmosphere, primarily due to sulfide-bearing ores that provide feedstock to the smelter. In 1925, SO_2 emissions from the smelter stack were estimated at 10,000 tons per month (USEPA 2008). By the early 1900s, smelter production included Cu, Au, Pb and Zn, and thus toxic metals have also been released through stack emissions since early in the smelter's history. In 1977 Teck began smelter facility improvements to install air emission controls, build a new Pb smelter, and other upgrades.

The smelter is located within a deep valley with predominant winds from the northeast, which bring smelter emissions into the UCRS. Denuded vegetation from SO_2 emissions, documented in 1929, indicated that smelter emissions traveled down the Columbia River at least as far as Northport. Historic smelter emissions have potentially impacted upland soils and other resources. Goodzari (2002a, 2002b) documented aerial deposition originating from the smelter and measured elevated As, Cd, Cu, Pb, Hg and Zn concentrations in soil, as far as the US-Canada border. However, a data gap exists on soil contamination and resulting impacts to the natural floristic structure within the UCRS potentially caused by stack emission contaminants.

Teck may also be contributing contaminants to groundwater through on-site soil percolation and surface water seepage. Studies investigating groundwater contamination within the UCRS are lacking, but studies conducted north of the border have found elevated metals concentrations in groundwater (Cominco 1998).

A large number of spills and releases into the Columbia River from Teck have occurred over the last several decades. USEPA (2008) presents an extensive (but not necessarily all-inclusive) inventory of spills from 1980 to 2008. Very little information regarding earlier spills is available, although periodic spills of similar chemical nature would likely have occurred over the history of operations at the facility. There have been at least 300 spills at Teck since 1980, resulting in the release of hazardous substances such as As, Cd, Hg, Pb, Zn, various acids and oils, ammonium and phosphorus compounds, slag and unidentified substances (USEPA 2008). In May of 2008, an acid and Pb release occurred at the Teck facility, releasing up to 10,000 kg of hydrofluorosilisic acid and up to 1,000 kg of Pb into the Columbia River over a four hour period (Ecology 2008 *pers. comm.*).

Zellstoff Celgar Pulp Mill

Zellstoff Celgar Pulp Mill is located approximately 30 miles upstream from the US-Canada border in Castlegar, BC. The pulp mill is operated by Zellstoff Celgar Limited Partnership, a subsidiary to Mercer International, the largest northern bleached softwood kraft market pulp producers in the world. The company was formerly operated (prior to 2005) by Celgar Pulp Company. From 1961 through 1993 the mill used chlorine in its bleaching process and subsequently discharged chlorinated organic compounds into the Columbia River (Bortleson et al. 1994). During this time, an estimated 26 million gallons per day of untreated effluent were discharged into the river, with the primary contaminants of concern being dioxins and furans (byproducts of bleached kraft pulp mills) (Johnson et al. 1991a). Dioxin concentrations in fish tissues in the early 1990s were sufficiently elevated to warrant a health advisory for consumption of sport fish, issued by the Washington State Department of Health (WDOH 1991). In 1994 the plant was modernized to install a chlorine dioxide bleach plant as well as a secondary treatment system to process effluent. These improvements resulted in substantially reduced discharges of chlorinated organic compounds (USEPA 2008). Elevated chlorinated compound concentrations have been found in various media including fish and mussel tissues downstream of the mill. Elevated levels of dioxins and other chlorinated organic compounds in fish tissues may result in injury to piscivorous wildlife.

Secondary Sources

The Le Roi Smelter in Northport, Washington, approximately seven miles from the US-Canada border, is a second smelting operation potentially impacting the UCRS. The smelter operated sporadically from 1896 to 1921, with peak production occurring during World War I. The Le Roi smelter occupied approximately 32 acres and released airborne stack emissions, resulting in elevated Pb concentrations in soils surrounding the Northport area, as well as slag. The USEPA conducted a removal action at the Le Roi property and some properties in the town of Northport in 2004 (Weston 2004; Weston 2005). The action resulted in the demolition cleanup of the smelter facility and the cleanup of nearby impacted residential properties.

The Coeur d'Alene Basin mining districts released metals into the Coeur d'Alene and Spokane Rivers. This site, known as the Bunker Hill Mining and Metallurgical Complex, is currently undergoing CERCLA cleanup actions. The Spokane River is a tributary to the Upper Columbia River, and metals enrichment via the Spokane River has been reported.

Potential Secondary Sources

Various mining and milling activities in Washington State have occurred in the proximity of the UCRS which may have resulted in localized mine-waste releases within the watershed. For example, mining and milling associated with the Midnite Mine released metals and other contaminants that have been detected as far downstream as the Blue Creek delta along the Spokane River. This site is currently undergoing CERCLA action. Additionally, federal and state investigations and actions have been conducted on several historic mining and milling operations in the watershed. None of these actions or investigation reports document that these mining-related operations are notable sources of contamination to Upper Columbia River water or sediment quality.

Other secondary sources that could influence water and sediment quality at the UCRS include municipal wastewater treatment facilities that discharge into the Columbia, Colville, Sanpoil, Spokane, and Pend Oreille Rivers. Secondary source considerations also include certain point and non-point sources, for example storm water run-off. No studies have been found that would demonstrate municipal wastewater and non-point discharges represent an actual and significant secondary source.

Hazardous substances identified at the UCRS

Hazardous substances released into the UCRS from industrial sources include, but are not limited to the substances listed in Table 1. The list of hazardous substances potentially released into the Columbia River from the industrial facilities identified above is likely much more extensive. However, Table 1 presents the primary set of hazardous substances for which data related to natural resource exposure were readily available, and thus provided the focus of this PAS.

Table 1. Name, abbreviation and Chemical Abstract Service (CAS) Registry number of several of the hazardous substances released into the UCRS from industrial sources.

Hazardous substance name	Abbreviation	CAS Registry No.
Metals and Metalloids		
arsenic	As	7440382
cadmium	Cd	7440439
copper	Cu	7440508
chromium	Cr	7440473
lead	Pb	7439921
mercury	Hg	7439976
zinc	Zn	7440666
Organics		
2, 3, 7, 8-tetrachlorodibenzo-p-dioxin	2,3,7,8-TCDD	1746016
2, 3, 7, 8-tetrachlorodibenzofuran	2,3,7,8-TCDF	51207319
chlorinated phenolics;	na	na
polychlorinated biphenyls	PCBs	1336363
Other		
sulfur dioxide	SO_2	7446095
sulfuric acid	H_2SO_4	7664939
copper sulfate	$CuSO_4$	7758987

C. Potentially Responsible Parties

The Potentially Responsible Parties (PRPs) identified at this site include the following:

Teck, which refers to all past and current owners/operators of the smelting operation in Trail, BC, including Teck Resources Limited, (the current owner) Cominco, Teck Cominco Canada, Teck Cominco Metals Limited, Teck Cominco Limited; for the purposes of this PAS, Teck also includes Teck Cominco American Incorporated, a US subsidiary of Teck Cominco. The smelter has been in operation since 1896, when it was built for the purpose of processing Cu and Au. Teck's Trail smelter currently is one of the world's largest Zn and Pb smelting and refining complexes. The smelting operation also produces various precious and specialty metals, fertilizer products, and other chemicals (USEPA 2008).

Zellstoff Celgar Limited Partnership, operator of the Celgar pulp mill in Castlegar, BC from 2005 to the present, and Celgar Pulp Company, operator until it was aquired by Zellstoff Celgar in 2005 (USEPA 2008). Celgar is currently one of the largest modern kraft pulp mills in North America with an annual production capacity of 495,000 air dried metric tonnes. The plant is operated by Celgar and is owned by Mercer International, one of the largest northern bleached softwood kraft market pulp producers in the world in terms of production capacity.

D. Damages Excluded from Liability under CERCLA

Certain damages are excluded from liability under CERCLA as stated in title 43 CFR Part 11.24 (b). These damages include those resulting from federally-permitted discharges or activities as defined in Section 101 (10) of CERCLA (including activities permitted under the CWA, Clean-Air Act, Solid Waste Disposal Act, etc.); discharges resulting in damage that were specifically identified as an irreversible and irretrievable commitment of natural resources in an environmental impact statement or other comparable environmental analysis; and damages resulting from release of a hazardous substance that occurred wholly before the enactment of CERCLA. We have concluded that any potential natural resource injury and related damages at the UCRS resulting from hazardous substances released by the aforementioned PRPs are not excluded from liability under CERCLA, or the Washington state Model Toxics Control Act (Chapter 70.105D RCW), based on the following: discharges or releases from upstream sources were not federally-permitted as defined in Section 101 (10) of CERCLA; to our knowledge, there has never been an irreversible and irretrievable commitment of natural resources in an environmental impact statement or other comparable environmental analysis at the UCRS; and the UCRS has received a considerable amount of contamination resulting from upstream sources since CERCLA was enacted in 1980. Hazardous substances continue to be present from releases into the UCRS, therefore, potentially causing injury to natural resources.

E. Response Actions Taken or Planned

At this time, the RI/FS at the UCRS is in the early stages of implementation. Because the nature and extent of contamination, and risks to human health and the environment have not yet been fully defined, it is unknown what remedial actions will be proposed by USEPA for the site. The USEPA has, however, conducted removal actions within the UCRS. A removal action was conducted at the Le Roi smelter in 2004, primarily to remove As and Pb contaminated soils from the Northport community (Weston 2005). In addition, Teck and Ecology have recently signed a detailed voluntary agreement to remove slag from the Black Sand Beach, a beach within the UCRS. However, these actions were not intended, nor designed to completely eliminate exposure and injury to trust resources.

III. Preliminary Identification of Resources at Risk

A. Affected Media

Elevated concentrations of hazardous substances have been found in water, pore water, sediments and biota within the Columbia River from the US-Canada border downstream to Grand Coulee Dam (Johnson et al. 1991a; Serdar et al. 1994; Era and Serdar 2001; Paulson and Cox 2007; Besser et al. 2008). Contaminants may move throughout the area by physical, geochemical and biological actions, and movement may be influenced by hydraulic and hydrologic conditions. Hazardous substances that were discharged into the Columbia River in the form of slag or liquid effluent resulted in contamination of sediments and surface water. Contaminated sediments, slag and their weathering components are transported downstream, and demonstrate a potential to transfer hazardous substances to surface water or pore water. Likewise, biological resources that move throughout the UCRS may distribute contaminants through physiologic mechanisms and through trophic-level transfer. Contaminants within biological tissues may bioconcentrate or biomagnify (e.g., Hg, polychlorinated biphenyls [PCBs], dioxins/furans) in organisms that occupy niches at the top of the food chain. As a result, all aquatic and wetland habitats, including those areas that are seasonally or intermittently in contact with the Upper Columbia River, may be contaminated as a result of hazardous substance releases, subsequent transport, or remobilization. In addition, upland areas may also be contaminated as a result of past smelter emissions, although sufficient data to evaluate potential nature and extent of contamination are not currently available.

B. Preliminary Identification of Pathways of Exposure

Numerous natural resources, including surface water, pore water, sediments, and biological tissues, have accumulated elevated concentrations of hazardous substances as a result of releases from identified upstream sources. Hazardous substance exposure of natural resources at the UCRS has occurred through various pathways. Upstream sources have discharged in the past, and in some cases continue to discharge contaminants into the Upper Columbia River, which flows into the UCRS. Releases of granulated slag, process waste solids and liquid effluent, as well as accidental spills from Teck into the Upper Columbia River have resulted in metals contamination of sediment and surface water. Slag deposits have elevated concentrations of trace metals which demonstrate the potential to be released through natural weathering processes (Cox et al. 2005). Suspended contaminant particulates, including slag, settle out into the sediment when lower water velocities are encountered at Lake Roosevelt. Paulson and Cox (2007) noted that liquid effluent may transfer metals to interstitial waters and sediment at the sediment-water interface, and further demonstrated that slag and contaminated sediments in turn release metals to interstitial waters of the UCRS. Releases of chlorinated organic compounds such as dioxins and furans from Celgar effluent discharges have likewise resulted in contaminated sediments in the UCRS (Johnson et al. 1991a).

Contaminants partition, in part due to weathering, between physical media (i.e., effluent and slag to surface water, pore water and sediment) and subsequently expose a variety of fish and wildlife resources. Aquatic organisms at the UCRS depend on habitat areas within the river where surface water, pore water and sediment may be contaminated with hazardous substances. Benthic invertebrates, including mussels, and some species of fish (particularly at early life-stages) are closely associated with sediments, and depend on interstitial spaces within sediments for feeding, spawning, and cover. Organisms that depend on the water-sediment interface may be exposed to contaminants in pore water and/or sediment, and in some cases may accumulate contaminants in tissues through dermal and/or dietary exposure. Dermal exposure from water and sediment may be facilitated through diffusion, active transport pumps at the gill, or through adsorption. Dietary exposure may occur from intentional consumption of water and contaminated prey, and from incidental ingestion of sediment while foraging (Rand and Petrocelli 1985). Sediments containing slag particles, and in some cases, significant masses of slag, were visually apparent in the stomach contents of suckers collected from the northern reaches of the UCRS (USEPA 2007). Slag particles have also been observed in UCRS white sturgeon stomachs (Parsley 2009 *pers. comm.*). These observations indicate that bottom-feeding fish are exposed to slag and metals enriched sediment as they forage for prey.

Benthic organisms may further provide dietary exposure to higher trophic-level organisms, particularly to biomagnifying contaminants such as Hg, PCBs, dioxins and furans. Benthic invertebrates provide a food resource for many species of fish and aquatic-dependent wildlife (e.g., insectivorous birds). Mussels and other shell fish provide direct food resources for fish and wildlife including white sturgeon, muskrat, river otter, mink and humans. Mussels have been noted to be a major food source for white sturgeon in the Columbia River system (Romano et al. 2002). Fish also provide a food resource for piscivorous wildlife and humans. Predatory fish species (e.g., burbot and walleye) and piscivorous birds and mammals (e.g., osprey, mink) feed on resident fish species and early life-stage or juvenile sturgeon, and other species (e.g., bald eagles) may scavenge carcasses of fish, including adult sturgeon. As a result, piscivorous birds and mammals, and humans, may be exposed to contaminants from the consumption of aquatic prey (i.e. benthic invertebrates, mussels and fish).

Another possible exposure pathway is aerial transport of smelter emissions to upland resources. Releases of smelter emissions and airborne contaminants (including toxic metals and SO_2) from the Teck and Le Roi smelters were transported by winds predominantly from the northeast, and by topographic controls. Historically, SO_2 deposition left a footprint of adversely impacted vegetation around the smelters and in downwind locations. Smelter emissions may have contaminated soils, terrestrial habitats, upland lakes, and vegetation. Surface water and erosional processes may subsequently transport contaminants from upland areas to the aquatic system in the UCRS. In addition, contaminants are potentially transported by windblown dust from exposed shorelines and beaches where contaminated sediments are present today.

The following section describes the UCRS natural resources for which currently available data demonstrate that exposure to hazardous substances has occurred, or is likely occurring. This section is not intended to be a complete inventory of potential exposures or injuries occurring in the system.

C. Documentation of Exposed Resources and Potential Adverse Effects

Hazardous substances have been documented in physical and biological media within the UCRS over the past several decades, and continue to be documented in current studies.

Studies have identified hazardous substances in surface water, pore water, sediments, invertebrate tissues, and fish tissues including toxic metals such as Cu, Cd, Zn and Hg, organochlorine pesticides, PCBs, and dioxins and furans (Johnson et al. 1991a, 1991; Serdar et al. 1994; Era and Serdar 2001; Paulson and Cox 2007; Besser et al. 2008; CH2MHill 2006). Elevated contaminant concentrations in physical and biological media have resulted in the listing of the Upper Columbia River on the 2008 Washington State 303(d) list in compliance with the CWA. Exposures and potential adverse impacts to natural resources include, but are not limited to:

- Exceedences of federal criteria for the protection of aquatic life.
- Exceedences of tribal sediment and water quality standards promulgated pursuant to the STI HSCA and CCT HSCA for the protection of aquatic life and humans that consume aquatic life.
- Past fish consumption advisories based on dioxin concentrations (WDOH 1991).
- Fish consumption advisories based on Hg concentrations (WDOHa 2008).
- Impacts to invertebrate communities, as indicated by results of bioassays conducted with UCRS sediments.
- Individual and community impacts to fish from aqueous and dietary exposures.
- Effects to wildlife that depend on aquatic prey.

Further information on contaminant concentrations and exposures with potential effects to trust resources are presented below by specific media.

Surface Water

Numerous contaminant spills have occurred at Teck over the last several decades, in addition to systematic operational releases of granulated slag and liquid effluent that have resulted in sediment and surface water contamination in the UCRS. At least 82 reported spills occurred at Teck from 1987 to 1997, including spills of H_2SO_4, fuel oil, lead slurry, As, Cd, copper sulfate ($CuSO_4$), Hg, Pb and Zn. During this period there were at least eight spills of Hg, with one spill estimated to be over 3000 kg, occurring in 1997 (MacDonald 1997), and a spill in 1980 estimated to be over 2,800 kg.

Numerous other spills have occurred on the Upper Columbia River. Johnson et al. (1988) evaluated data from the US Geological Survey (USGS) water quality monitoring station at Northport, WA. Data indicated highly variable metals (As, Cd, Cu, Hg, Pb and Zn) concentrations near the US-Canada border, which at times greatly exceeded acute and chronic National Recommended Water Quality Criteria (NRWQC). For example, during a four-year period (1984-1988) Cd concentrations exceeded acute criteria six times, with concentrations up to 21 µg/L. These concentrations were over seven times the acute criteria, and over 23 times the chronic criteria established during that time period. Mercury concentrations exceeded acute water quality criteria by nearly three times and chronic criteria by over 580 times following a spill in 1983 (Table 2). As recently as May of 2008, an acid and Pb release occurred at Teck, releasing up to 10,000 kg of hydrofluorosilisic acid and up to 1,000 kg of Pb into the Columbia River over a four hour period (Ecology 2008a *pers. comm*). Lead concentrations in water samples collected by

Ecology at Kettle Falls the day after the spill exceeded chronic NRWQC (Ecology 2008b. pers. comm.; Table 2). Other water quality monitoring data, including Ministry of the Environment data (1975-77), has often indicated that these elevated concentrations of hazardous substances were originating from Teck, and that sporadic elevated concentrations could be related to discharges from the Teck facility (Smith 1987).

Table 2. Examples of UCRS surface water metals (Cd, Hg, Pb) concentrations (µg/L) that have exceeded USEPA freshwater chronic criteria for protection of aquatic life, Canadian freshwater chronic criteria for protection of aquatic life, and STI chronic SWQS, as a result of spills at Teck.

Contaminant	Year	Measured UCRS Conc.	NRWQC[1]	Canadian Criteria[2]	STI SWQS[3]
Cd[4], dissolved	1984	18	0.9	1.1	1.03
	1985	17			
	1986	21			
	1988	9			
Hg[4], dissolved	1980	1.0	0.012	0.012	0.01
	1983	7.0			
	1988	0.8			
Pb[5], total	2008	7.8	2.8	3.2	2.5

[1] National Recommended Water Quality Criteria (USEPA 2006b); adjusted for hardness; represents criteria at time of spill.
[2] Environment Canada, compendium of environmental quality benchmarks (MacDonald et al. 1999).
[3] STI Surface Water Quality Standards (STI 2008), current chronic criteria.
[4] From Johnson et al. (1988).
[5] Ecology (2008b pers. comm.)

Pore Water

Dissolved metals in interstitial sediment pore water have the potential to exceed concentrations that cause injury to benthic invertebrates and fish. Benthic invertebrates, including mussels, and some species of fish are closely associated with sediments, and depend on interstitial spaces within sediments for feeding, spawning, and cover, particularly during sensitive life-stages. Organisms that depend on the water-sediment interface can be exposed to contaminants in pore water, and in some cases may accumulate contaminants in tissues and provide trophic-level pathways of exposure to other organisms.

Previous studies have determined that dissolved metals concentrations are elevated in pore water within the UCRS (Johnson et al. 1990, Paulson and Cox 2007, Besser et al. 2007). Ecology evaluated pore water in the early 1990s and found that concentrations of Cd, Cu, Pb, and Zn exceeded federal water quality criteria for the protection of aquatic life. More recently, USGS collected pore water samples from eight sites throughout the UCRS and reported the following median metals concentrations measured over the eight locations. The data demonstrated exceedences of federal water quality criteria for the protection of aquatic life for Cd, Cu, and Pb (Table 3).

Table 3. Pore water concentrations (µg/L) measured in the UCRS (Paulson and Cox 2007) compared to USEPA freshwater chronic criteria for protection of aquatic life, STI chronic criteria (STI 2008) and to Paulson and Cox (2007) reference concentrations.

Parameter	USEPA Chronic Criteria[1]	STI Chronic Criteria [2]	Measured UCRS Concen.	Factor of Exceedence USEPA chronic criteria	Reference Concen.[3]
Cd	0.22	1.03	<0.1 to 0.48	2.2	<0.1
Cu	7.7	8.96	< 0.5 to 9.2	1.1	0.55
Pb	2	2.5	0.5 to 4.9	2.5	0.5

[1] National Recommended Water Quality Criteria (USEPA 2006b); adjusted for hardness.
[2] STI Surface Water Quality Standards (STI 2008), chronic criteria.
[3] Reference concentrations were those reported in Paulson and Cox (2007) for comparison to study area. Reference samples collected from Sanpoil River.

Sediments

Discharges of granulated slag from Teck have contributed to widespread surficial sediment contamination at the UCRS. Prior to 1995, Teck discharged an estimated 145,000 tons of slag annually into the Upper Columbia River. These discharges were subsequently transported downstream settling along riverine shorelines and within the slower water velocity zones of the river and Lake Roosevelt. These large deposits of contaminated slag have elevated concentrations of trace metals which may be released through natural weathering processes (Cox et al. 2005). Liquid effluents from Teck also have contributed to sediment contamination (Paulson and Cox 2007).

Many studies over the past three decades have reported elevated metals concentrations in surficial sediments throughout the UCRS. In general, slag-related contaminants are found at higher concentrations in the upper reaches of the UCRS (i.e. closer to sources) and decreases downstream. Metals have also been transported into the UCRS as dissolved, colloidal, or suspended materials, resulting in sediment impacts independent of slag deposition. Certain metals, such as Hg and Cd demonstrate transport patterns and distribution independent of other contaminants (CH2MHill 2006; Johnson et al. 1988). Elevated metals concentrations have been documented since at least the early 1980s (Hopkins et al. 1985; Johnson et al. 1990), and studies conducted in 2004 and 2005 (Besser et al. 2008, CH2MHill 2006) indicated that concentrations continue to be elevated in the UCRS. In 2004, for example, USGS conducted a study to investigate sediment contamination throughout the UCRS and found that sediment concentrations exceeded reference concentrations by as much 100 times for Cu and Pb, and up to 200 times for Zn. Furthermore, concentrations of Cd, Cu, Pb, Hg, and Zn exceeded thresholds that may impact benthic organisms (Table 4).

Table 4. Measured total recoverable sediment concentrations (mg/kg dry wt.) at the UCRS in 1986 (Johnson et al. 1990), 2004 (Besser et al. 2008) and 2005 (CH2MHill 2006) compared to consensus-based sediment quality guidelines (SQGs, MacDonald et al. 2000) and CCT and STI sediment standards.

Parameter	SQG	CCT[1]/STI[2] HSCA	Measured UCRS 1986	Measured UCRS 2004	Measured UCRS 2005
As	33	9.79	7.5 to 27.9	2.8 to 32	0.65 to 74
Cd	4.98	0.99	0.6 to 5.7	0.3 to 7.7	0.036 to 16
Cu	149	31.6	65 to 4,870	10 to 2,800	3 to 3,030
Pb	128	35.8	206 to 550	10 to 1110	2.6 to 2,760
Hg	1.06	0.18	0.01 to 2.7	0.003 to 1.1	0.004 to 2.4
Zn	459	121	610 to 26,840	54 to 26,000	16 to 26,600

[1]CCT Hazardous Substances Control Act 2007.
[2]STI Hazardous Substances Control Act 2006.

Other sediment studies have reported elevated chlorinated organic compounds, including dioxins and furans (Hopkins et al. 1985; Johnson et al. 1991a). The primary reported source of dioxins and furans in the Upper Columbia River in Canada is Celgar in Castlegar, BC (Johnson et al. 1991a). Johnson et al. (1991a) observed a decreasing trend in sediment dioxin and furan concentrations from the Kettle Falls area downstream to Grand Coulee Dam, and reported that elevated dioxin and furan concentrations in sediments seemed to coincide with depositional areas, finer-grained sediments and higher total organic carbon content. This study also noted that trends in bottom-feeding fish tissue concentrations were consistent with co-located sediment concentrations.

Benthic Invertebrates

Benthic invertebrates comprise a large portion of an aquatic ecosystem's biomass and form basal trophic links of the food chain. Benthic invertebrates also play major roles in nutrient cycling and transfer within aquatic media. These organisms depend on uncontaminated sediments for completion of key life-cycle requirements. Exposure to contaminated sediments may impact these communities and limit benthic growth, biomass, habitat range, reproduction, and disrupt ecological function. A reduction in benthic biomass from contaminated water and sediments may result in a reduction of other organisms (aquatic and terrestrial wildlife) that depend on this food resource. Also, benthic invertebrates accumulate contaminants from sediments and may transfer contaminants to higher organisms through a dietary pathway.

Benthic invertebrates have been used as ecological indicators of disturbance for nearly 100 years (Peplow and Edwards 1999). Benthic invertebrate taxa display a wide range of sensitivity to disturbance (i.e. contaminants) making them useful to quantify impacts from community structural indices.

Numerous studies have evaluated the toxicity of UCRS sediments to benthic invertebrates through sediment bioassays conducted over two decades (Johnson et al.

1988; Bennett and Cubbage 1992; Bortleson et al. 1994; Era and Serdar 2001; Besser et al. 2008). These studies have all demonstrated that certain contaminated UCRS sediments illicit toxic effects to test organisms in the laboratory. Johnson et al. (1988) observed reduced survival and Bennett and Cubbage (1992) observed acute toxicity to *Hyalella azteca* and *Daphnia magna* in 2 out of 6 sites tested, relative to control. Both studies reported reduced *Photbacterium phosphoreum* light emission in 2 of 6 sites tested, relative to control. Bortleson et al. (1994) observed reduced survival of *Hyalella azteca* and *Ceriodaphnia* in 3 out of 5 and 2 out of 5 sites, respectively, and reduced *Ceriodaphnia* reproduction in 3 out of 5 sites. *Photbacterium phosphoreum* toxicity was observed in 18 out of 19 sites when exposed to fine-grained sediments, and in 8 out of 20 sites when exposed to pore water. Besser et al. (2008) observed reduced survival of amphipods at 1 out of 7 sites and reduced growth of midge at 4 out of 7 sites. Findings from these studies indicate that metals in UCRS sediments are bioavailable to benthic macroinvertebrates, and have resulted in potential injury to the benthic community in the UCRS from at least the early 1990s to the present.

Freshwater Mussels

Freshwater mussels have declined by as much as 75% throughout North America, and it is suggested that exposure to contaminants may be a reason for their widespread decline (Wang et al. 2007). Freshwater mussels provide key ecological functions including trophic linkages, water quality, habitat, and nutrient cycling. Freshwater mussels filter large volumes of water each year and release particles that are more readily available as food for benthic invertebrates. Mussels also provide direct food resources for fish and wildlife including muskrat, river otter, mink, water birds (including waterfowl and shorebirds) and humans. Mussels have also been noted to be a major food source for white sturgeon in the Columbia River system (Romano et al. 2002).

Few studies have evaluated mussel distribution and density within the UCRS, and no tissue residue data are available for this area. Studies were conducted upstream of the UCRS in BC in the 1990s, and found that mussels in the Canadian reach of the Columbia River near Waneta are exposed to metals from Teck, and mussels downstream of Celgar are exposed to dioxins and furans originating from the pulp mill, and have accumulated these contaminants in tissues. Freshwater mussels collected near Waneta, BC, had tissue metals concentrations significantly higher than in Kootenay Lake (the reference location sampled for the study), and mussels collected downstream of Celgar had 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) and 2,3,7,8- tetrachlorodibenzofuran (TCDF) concentrations significantly higher than those collected from the study reference location upstream of Celgar (Table 5).

Table 5. Mussel tissue metals concentrations (mg/kg[1]) measured in the Upper Columbia River in Canada, near Waneta (Aquametrix Ltd. 1994) and dioxin and furan concentrations (pg/g[2]) measured downstream of Celgar (Butcher 1992), compared to respective reference locations.

Parameter	Measured UCRS Concentrations	Reference Concentrations[3]	Maximum Factor of Exceedence
Cd	13.3	3.6	3.7
Cu	64.2	6.1	11
Pb	251	4.0	63
Zn	962	214	4.5
2,3,7,8-TCDD	3.3 to 3.9	1.9	2
2,3,7,8-TCDF	280 to 290	9.0	32

[1] mg/kg is equivalent to parts per million, a common unit for expressing metals conc. in tissue.
[2] pg/g is equivalent to parts per trillion, a common unit for expressing organic conc. in tissue.
[3] Reference samples collected from Kootenay Lake (Aquametrix Ltd. 1994) and upstream of Celgar (Butcher 1992).

Elevated contaminant concentrations in Upper Columbia River mussel tissues upstream of the US-Canada border suggest that mussels downstream of the border may also be accumulating contaminants. While the potential adverse effects to mussels from such exposures are unknown, other receptors (e.g., sturgeon, mink, water birds, etc.) at the UCRS that feed on mussels may also be exposed via a dietary pathway and are potentially at risk. The absence of mussel tissue data in United States portion of Upper Columbia River represents a significant data gap for the UCRS.

Freshwater mussels in the UCRS may also be injured via exposure to pore water or direct dissolution of contaminants in sediments. An independent USGS study recently evaluated dissolved Cu toxicity to freshwater mussels to determine juvenile mussel sensitivity to this contaminant. Data indicate that mussels are very sensitive to Cu, with reduced survival occurring at 8.5 to 9.8 µg/L Cu and reduced growth at 4.6 to 8.5 µg/L Cu (Wang et al. 2007). Another study determined that glochidia (larval phases) of two endangered mussel species experienced impaired viability (inability to close valves) due to Cu exposure, with median effective concentrations (EC_{50}s) < 10 µg/L Cu (Gillis et al. 2008). Paulson and Cox (2007) measured Cu concentrations in pore water within the UCRS up to 9.2 µg/L Cu near Northport, Washington.

Fish

The UCRS supports a large fishery resource that is valuable from an economic, recreational, ecological, and cultural standpoint. However, elevated contaminants, including metals and chlorinated organic compounds (e.g., dioxins and furans) have been measured within resident fish tissue for nearly the last thirty years.

Fish within the UCRS have been exposed to and accumulate metals from upstream sources. Whole-body samples of largescale suckers collected near Northport, Washington, had mean Pb concentrations 110 times higher than the 1984 USFWS National Survey average, from 315 samples collected at over 100 sites. These samples also exceeded nationwide averages for Cd, Cu, Hg, and Zn (Serdar et al. 1994).

Releases of Hg from upstream sources (including numerous Hg spills from Teck) have contributed to the elevated Hg found in UCRS resident fish tissues. Munn et al. (1995) reported walleye skinless fillets collected near the Sanpoil River embayment had mean concentrations of 0.39 mg/kg wet weight Hg. Munn and Short (1997) reported that over 50% of walleye samples collected in the UCRS exceeded the national median value of 0.17 mg/kg. These concentrations exceed threshold values of 0.2 mg/kg estimated to be protective of juvenile and adult fish (Beckvar et al. 2005). Data collected in 2005 by USEPA indicated that Hg concentrations continue to be elevated in UCRS fish tissues. Table 6 summarizes Hg concentrations that have been measured from the 1980s to 2005.

Table 6. Mercury concentrations (mg/kg ww) measured in UCRS fish fillets and whole-bodies (wb), 1980s to 2005.

Year	Fish/Tissue	Hg Concentrations	Study
1986	Walleye, fillets	0.05 to 0.24	Johnson et al. (1988)
1994	Walleye, fillets	0.11 to 0.44	Munn and Short (1997)
1997	Largescale sucker, wb	0.15	Hink et al. (2004)
2005	Largescale sucker, wb	0.23	EPA 2005 data[1]
	Walleye, fillets	0.33	
	Wild rainbow trout, fillets	0.12	
	Burbot, wb	0.20	

[1] Mean concentrations in fish collected from the lower reservoir reach, where Hg concentrations were typically the highest; summarized in WDOH (2008b).

Persistent Hg concentrations in fish tissues have resulted in fish consumption advisories issued by the WDOH. There is currently an advisory for three species of fish (walleye, burbot and largescale sucker) for elevated Hg (WDOH 2008a). Fish tissue Hg concentrations have exceeded levels that would be protective of sensitive groups. Elevated contaminant concentrations resulting in advisories typically result in a loss of fisheries resources in terms of use and consumption.

Resident fish have also accumulated organic contaminants within the UCRS from discharges by upstream sources such as the Celgar pulp mill in Castlegar, B.C. Elevated dioxin concentrations measured in UCRS fish in the early 1990s prompted WDOH to issue a health advisory for consumption of sport fish (WDOH 1991). Giesy et al. (2002) reported reduced growth, reproduction, fecundity and survival of adult rainbow trout fed a diet of 1.8 pg /g of 2,3,7,8-TCDD. Furthermore, offspring of adult fish had an increased occurrence of deformities and a reduction in survival compared to control fish. Concentrations greater than 1.8 pg/g 2, 3, 7, 8-TCDD have been measured in UCRS fish in the 1990s and in 2005 (Table 7), indicating that dioxins in UCRS fish tissues may directly impact piscivorous (fish-eating) fish populations through dietary exposure of contaminated prey. Elevated concentrations of 2,3,7,8-TCDF have also been found in UCRS fish throughout the same time period (Table 7). The USEPA 2005 data indicate that dioxin and furan concentrations continue to be elevated in UCRS fish.

Table 7. Maximum 2,3,7,8-TCDD and 2,3,7,8-TCDF concentrations (pg/g ww) measured in Upper Columbia River fish in 1990 and 2005.

Year	Fish/Tissue	2,3,7,8-TCDD	2,3,7,8-TCDF	Study
1990	Largescale sucker	2.6	48	Johnson et al. (1991b)
	Whitefish	2.7	205	Johnson et al. (1991a)
2005	Sucker	2.8	83	USEPA 2005 data[1]
	Burbot	3.3	6.9	

[1] Concentrations were calculated from USEPA 2005 raw data using fish-based toxic equivalency factors (TEFs); values are lipid normalized.

White Sturgeon

Sturgeon are long-lived, benthic oriented fish that have been shown to be very sensitive to some chemical exposures, particularly at early life-stages (Dwyer et al. 2005, Little and Calfee 2008). White sturgeon population estimates for the Upper Columbia River indicate that there are fewer than 1000 wild adults remaining within the study area. The population is comprised of older adults indicating a lack of recruitment and/or high levels of mortality occurring during their early life-stages. White sturgeon were an important sportfish for Lake Roosevelt prior to the closure of the fishery in 1996, due to concerns over the declining population. In 2001 a pilot hatchery program was established in BC to supplement the wild population (UCWSRI, 2002). Currently, white sturgeon are spawned and reared at the BC hatchery and at a WDFW hatchery in Moses Lake, WA, and approximately 10,000-12,000 are released annually into the Columbia River, at various locations from Castlegar, BC down stream to the Kettle Falls area. White sturgeon are an important resource to the Tribes, traditionally used for subsistence and cultural purposes.

Recent studies conducted by the USGS indicate that early life-stages of Upper Columbia white sturgeon are very sensitive to aqueous Cu exposure (Little and Calfee 2008). This population of white sturgeon was tested at 30 days-post-swim-up. The lethal concentration resulting in 50% mortality (LC_{50}) was 4.9 µg/L Cu at an ecologically relevant water hardness of 90.5 mg/L $CaCO_3$. These data indicate that early life-stage white sturgeon are greater than 14 times more sensitive than rainbow trout, and may be suffering from acute Cu toxicity within contaminated areas at the UCRS. Paulson and Cox (2007) observed a median pore water Cu concentration of 9.2 µg/L in the river reach of the Upper Columbia River (near Northport). Maximum Cu concentrations of

4.9 to 5.2 µg/L were observed in two locations upstream of the Marcus Flats area, in separate trials conducted during the study. White sturgeon spawning and juvenile dispersal is known to occur in the upper reaches of the Upper Columbia River, and spawning adults have been located as far down as Marcus Flats. The pore water Cu concentrations measured in these areas exceeded early life-stage LC_{50} concentrations for white sturgeon within the reaches of the Upper Columbia River that are most important for white sturgeon reproduction. After hatching, white sturgeon exhibit a short downstream dispersal, where they hide within interstitial spaces of the sediments until they absorb their yolk-sacs and begin exogenous feeding (Kynard and Parker 2005). These unique life-history traits may expose early life-stage and juvenile white sturgeon to elevated Cu concentrations found in pore water in upstream areas within the UCRS where slag-enriched sediments are located.

White sturgeon inhabiting the UCRS may also be exposed to organochlorine contaminants (such as dioxins and furans) at concentrations sufficient to cause injury to sturgeon, or exposure/injury to piscivorous wildlife. Predatory fish species (e.g., walleye) and piscivorous birds and mammals (e.g., osprey, mink) feed on early life-stage or juvenile sturgeon, and other species (e.g., bald eagles) may scavenge carcasses of juvenile or even adult fish. The Celgar pulp mill used chlorine in its bleaching process from 1961 to 1993, and process effluents were discharged into the Upper Columbia River. During this period of time, and immediately following, dioxin and furan concentrations in fish tissues and other media were substantially elevated. Johnson et al. (1991a) reported elevated 2,3,7,8-TCDD and 2,3,7,8-TCDF concentrations and TEQ values (toxicity equivalents of all dioxin and furan congeners detected) in sturgeon head muscle collected from the UCRS. The maximum TEQ value reported was 25 pg/g, with a mean value of 17 pg/g. These values were within the top 10% of all TEQ values reported in a USEPA national fish survey that the authors used for comparison to study data. Table 8 summarizes Johnson et al. (1991a) concentrations that exceeded ecologically relevant dioxin and furan literature-based effect levels. There are significant data gaps relative to current information on Upper Columbia white sturgeon dioxin and furan tissue burdens. However, given the long life of white sturgeon (i.e., many adult sturgeon found in the reservoir and upper river today would possibly have been exposed to elevated dioxin and furan concentrations prior to facility upgrades) and the persistent nature of these chemicals, it would be reasonable to expect that concentrations in white sturgeon tissues may still be substantially elevated, and that exposure and injury may be occurring to white sturgeon and/or species that feed on sturgeon in the UCRS.

Table 8. TEQ values, 2,3,7,8-TCDD and 2,3,7,8-TCDF concentrations (pg/g ww) measured by Johnson et al. (1991a) in Upper Columbia white sturgeon tissues, and literature-based effect levels.

Maximum Concentrations	Literature-based Effect Level	Literature Endpoint
25 (TEQ)	10 to 12	Protection of piscivorous birds and mammals (Eisler 1986)
4.4 (TCDD)	0.9	Protection of Columbia River bald eagles (Buck 2004)
	1.8	Reduced survival, fecundity and reproduction in rainbow trout (Giesy et al. 2002)
	2.4 to 4.2	Sub-lethal, lethal effects to fish (Eisler 1986)
222 (TCDF)	7.5	Protection of Columbia River bald eagles (Buck 2004)

Wildlife

The UCRS supports a wide diversity of wildlife resources that depend on aquatic species for food. Piscivorous birds and mammals may be exposed to contaminants from the consumption of aquatic prey (i.e. benthic invertebrates, mussels and fish). Injury to these wildlife resources could result in economic losses in wildlife-based recreation, alterations to ecological functions, and subsistence and cultural losses to tribal members.

Available UCRS data indicate that piscivorous birds and mammals inhabiting the site may be exposed and potentially injured as a result of organochlorine contaminant exposure. TEQ values for dioxins, furans and dioxin-like PCB congeners measured in various fish species throughout the 1980s, 1990s and more recent data often exceeded literature-based effect levels, or threshold values, for protection of wildlife. In 1990, TEQs in lake whitefish and white sturgeon were the highest ever reported in the Columbia River, and were in the top 10% of USEPA nationwide surveys (Johnson et al. 1991a). Recently, total TEQs have ranged from 0 to 30 pg/g in walleye tissues within the UCRS (USEPA 2005 data), indicating that fish tissue concentrations of dioxins, furans and dioxin-like PCB congeners remain elevated with respect to piscivorous wildlife exposure. Numerous studies have evaluated TEQs, dioxin, furan and PCB congeners in fish tissues, and have established dietary effect levels for birds and mammals that feed primarily on fish. UCRS data indicate that fish tissue concentrations have exceeded these effect levels from the late 1980s until recently. Table 9 summarizes TEQ, dioxin and furan concentrations, measured over time, in fish tissues in the UCRS that exceed ecologically relevant literature-based dietary effect levels for piscivorous wildlife.

Table 9. TEQ values, 2,3,7,8-TCDD and 2,3,7,8-TCDF concentrations (pg/g ww) measured in fish tissue throughout the UCRS from 1989 to 2005, and literature-based dietary effect levels for piscivorous wildlife.

Maximum UCRS Concentrations (pg/g ww) by Year			Literature-based Effect Levels (pg/g ww)	Literature-based Endpoint
TEQ	*1990*	23 (whitefish)[1]	10 to 12	Protection of piscivorous birds and mammals (Eisler 1986);
	2005	30 (walleye)[2]		
			4.75	Protection of piscivorous birds (Ministry of the Environment).
TCDD	*1989*	4.0 (walleye)[3]	0.9	Protection of Columbia River bald eagles (Buck 2004);
	2005	3.3 (burbot)[2]		
			1.8	Reduced survival, fecundity and reproduction in rainbow trout (Giesy et al. 2002);
			2.4 to 4.2	Sub-lethal, lethal effects to fish (Eisler 1986);
			3.0	Protection of piscivorous wildlife (Newell 1987).
TCDF	*1990*	205 (whitefish)[1]		
		48 (sucker)[4]	7.5	Protection of Columbia River bald eagles (Buck 2004).
	2005	6.9 (burbot)[2]		
		83 (sucker)[2]		

[1] Johnson et al. (1991a)
[2] USEPA 2005 data
[3] Johnson (1990)
[4] Johnson et al. (1991b)

Like organochlorine contaminants, Hg concentrations in UCRS fish tissues may also be causing exposure and injury to piscivorous birds. Munn and Short (1997) measured concentrations up to 0.44 µg/g (equivalent to mg/kg) Hg in walleye. Concentrations up to 0.52 µg/g Hg were measured in northern pikeminnow following a large spill of Hg by upstream sources (Marr 1980; Arnquist 1980). Table 6 summarizes additional Hg concentrations (in mg/kg) that have been measured in UCRS fish tissues over time. These concentrations have often exceeded dietary-effect levels that have been shown to cause adverse effects to piscivorous birds. Burgess et al. (2008) estimated that when fish tissues exceeded 0.21 µg/g Hg piscivorous bird reproductive productivity declined by 50%. Furthermore, the same research determined that when fish tissues exceeded

0.41 µg/g Hg piscivorous bird reproduction failed completely. Likewise, Wiener and Spry (1996) demonstrated reproductive impairment in loons at fish tissue concentrations of 0.1 to 0.3 µg/g ww Hg.

Upland Soils

Widespread plumes of smoke and dust originating from smelting operations at Teck have been reported at the UCRS since the 1920s. During the 1920s, farmers began complaining about the visible smoke that drifted south from the Teck smelter, resulting in noticeable destruction of surrounding crops and vegetation. More recent studies conducted in Canada in the late 1990s found that concentrations of As (4.6 to 157 mg/kg), Cd (0.6 to 16 mg/kg), Cu (14 to 106 mg/kg), Pb (47 to 1,279 mg/kg), Hg (0.02 to 1.39 mg/kg), and Zn (85 to 1,632 mg/kg) were elevated in soils surrounding the smelter; these concentrations were up to 30 times greater than reported background concentrations (Goodzari et al. 2001). At stations near the US-Canada border, concentrations were 5 times greater than background for Pb, 3 times greater than background for Hg, and 1.5 to 2 times greater for Zn and Cd . This study also suggested that prevailing winds from the northeast are capable of carrying stack emissions a considerable distance from the smelter (Goodzari et al. 2002a). Other studies have documented a decline in species plant diversity near the Teck smelter (Nielsen and Kovats 2004; Zvereva et al. 2008). However, recent studies evaluating potential soil contamination in the United States resulting from smelter emissions, and potential adverse impacts to natural resources within the UCRS are lacking, and represent a data gap for this site.

D. Potentially Affected Resources

The DOI, State, CCT and STI collectively have trusteeship over natural resources that have been exposed to, and potentially impacted by, hazardous substances as a result of intentional and accidental releases to the UCRS. The natural resources include, but are not limited to:

- Surface water.
- Sediments.
- Federal or State listed threatened and endangered species.
- Migratory birds including raptors, passerines, waterfowl, piscivorous birds and other avian species.
- Resident fish species.
- Aquatic-dependant wildlife, including piscivorous wildlife.
- Terrestrial wildlife.
- Reptiles and amphibians.
- Aquatic and terrestrial invertebrates.
- Aquatic and terrestrial plants.
- Riparian, wetland, riverine, and lacustrine habitats.
- Upland soils.
- Groundwater.

The resources listed above provide services that may have been lost due to contamination. These services include, but are not limited to, the following:

- Tribal subsistence.
- Cultural and spiritual use.
- Habitat which provides essential functions to support fish and wildlife populations.
- Consumptive water uses (drinking, livestock watering, irrigation or other activities that consume water).
- Options for providing enhancement and conservation of threatened and endangered species.
- Wildlife viewing.
- Corridors for migratory species.
- Hunting and fishing.
- Outdoor recreation.
- Option and existence values (e.g., knowledge that a unit of the USNPS exists, whether or not one chooses to visit it).

It should be noted that little or no data are available for upland natural resources, such as upland habitat (including lakes located in upland areas), terrestrial wildlife, soil invertebrates, ground water, and as discussed in section III.C., recent upland soil data within the US. As such, these resources were not evaluated for potential exposure and injury. The Trustees acknowledge that there are substantial data gaps at the UCRS related to these and other resources, and the services they provide, and that future data collection may indicate exposure and potential injury of these resources.

IV. Preassessment Screen Criteria

As discussed in the introduction to this document, title 43 CFR Part 11.23(e) identifies the five criteria that must be addressed in order for the Trustees to proceed with an NRDA. Our conclusions regarding the five criteria are discussed below.

1) **A discharge of oil or release of hazardous substance has occurred.** Numerous studies identified in this PAS have documented substantial releases of hazardous substances, including but not limited to metals, dioxins and furans into US reaches of the Upper Columbia River. These releases have originated predominantly from mineral processing and industrial facilities north of the US border, and have occurred over an extensive time period.

2) **Natural resources for which a State or Federal agency or Indian Tribe may assert trusteeship under CERCLA have been or are likely to have been adversely affected by the discharge or release.**

Natural resources for which State, Federal and Indian Tribes may assert trusteeship have been adversely impacted in the past and are likely to continue to be adversely impacted by hazardous substances. Studies conducted at this site have documented elevated metals and dioxin/furan concentrations in water, sediment, and biological tissues within the UCRS, which have been attributed to releases from upstream sources. Further, it is likely that contaminated natural resources could adversely impact other natural resources through various pathways of exposure (e.g., direct contact, dietary exposure).

3) The quantity and concentration of the discharged oil or released hazardous substances is sufficient to potentially cause injury to those natural resources. Water, sediment and biological tissue samples collected from the UCRS over decades of research conducted at the site contain hazardous substances at concentrations that:

1) Exceed criteria or guidelines established for the protection of aquatic life;
2) Equal or exceed effect levels shown to cause injury to fish, aquatic invertebrates, birds and mammals; and/or
3) Warrant consumption advisories for human populations.

The following summarizes general study findings highlighted in this PAS that can be associated with potential injury of water, sediment, fish, aquatic invertebrates, birds, mammals and potentially other natural resources.

Surface water

- Exceedences of federal acute and chronic metals criteria, and Spokane Tribe of Indians chronic Surface Water Quality Standards, in surface water as a result of spills at Teck.
- Cadmium, copper and lead exceedences of chronic National Recommended Water Quality Criteria in pore water.
- Cadmium, copper, mercury, lead and zinc exceedences of Sediment Quality Guidelines and sediment standards promulgated by the Confederated Tribes of the Colville Reservation and the Spokane Tribe of Indians to protect the environment and health.

Aquatic biota

- Elevated mercury concentrations in resident fish tissue sufficient to warrant consumption advisories.
- Dioxin concentrations in fish tissue shown to impair growth, reproduction and survival of offspring of piscivorous fish.
- Copper concentrations in pore water at or above concentrations shown to have adverse effects to sensitive aquatic receptors (early life-stage white sturgeon, freshwater mussels).
- Dioxin/furan/polychlorinated biphenyl tissue concentrations in white sturgeon above concentrations shown to impair growth, reproduction and survival of fish, and above thresholds for protection of bald eagles/piscivorous birds and mammals.

- UCRS sediments have been shown to cause adverse impacts to laboratory test organisms (potential macroinvertebrate injury).

Piscivorous birds and mammals

- Dioxin/furan/polychlorinated biphenyl concentrations in UCRS fish tissue exceed numerous literature thresholds for protection of bald eagles, piscivorous birds and mammals.
- Mercury tissue concentrations in UCRS fish at or above concentrations shown to cause reproductive impairment or failure in piscivorous birds.

4) **Data sufficient to pursue an assessment are readily available or likely to be obtained at reasonable cost.**
Data for the site are numerous and will be useful to conduct injury assessment in a more cost effective manner. Additional studies will be needed to address data gaps, confirm pathways of exposure and quantify injury and service losses. It is expected that these additional data may be obtained at reasonable costs.

5) **Response actions from Superfund remedial activities carried out or planned do not or will not sufficiently remedy the injury to natural resources without further action.**
The USEPA may identify and complete remedial actions which will likely reduce contaminant exposure within the UCRS. At this time it is not known what remedial actions will occur, and therefore it is not possible to evaluate the expected natural resource benefit from the remedy. However, given the geographic extent of the UCRS it is unlikely that these actions will completely eliminate exposure and injury to trust resources and additional restoration actions will be required to minimize residual injury. At other large contaminated sites, or "mega-sites" in the region, e.g., the Coeur d'Alene River Basin in northern Idaho, remedial actions have not fully addressed exposure and injury to natural resources, and substantial restoration activities will be required.

Furthermore, injury has likely occurred to-date as a result of the existing contamination, and will continue to occur until a fully protective remedy is implemented. Future remedial actions will not address services losses incurred thus far from these past and on-going injuries, and therefore, additional restoration will be required.

V. Final Determination

In accordance with 43 CFR 11.23(b), the Trustees find that the five criteria prerequisites for proceeding with a natural resource damage assessment at the UCRS have been met. We have further determined that there is a reasonable probability of achieving a successful claim for injuries and damages to natural resources resulting from releases of hazardous substances from the primary sources identified in this PAS.

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