INJURY ASSESSMENT PLAN FOR THE

UPPER COLUMBIA RIVER SITE, WASHINGTON

Prepared for the Upper Columbia River Trustee Council

Confederated Tribes of the Colville Reservation

Spokane Tribe of Indians

U.S. Department of the Interior
U.S. National Park Service
U.S. Bureau of Reclamation
U.S. Fish and Wildlife Service
U.S. Bureau of Indian Affairs
U.S. Bureau of Land Management

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EXECUTIVE SUMMARY

The Upper Columbia River Site (UCRS) is located entirely within Washington State. The geographic scope of the UCRS is currently defined as the Columbia River and Lake Roosevelt south of the Canada-US border to the Grand Coulee Dam, and associated wetland, riparian, flood plain, and upland terrestrial and lacustrine habitats influenced or affected by historic smelter and pulp industry operations. The diversity of geological, hydrologic, and climatic conditions within the UCRS creates a wide range of habitats for fish and wildlife species, including upland, riparian, palustrine, lacustrine, and riverine areas. The UCRS is home to more than 75 mammal species, 200 bird species, 15 reptile species, 10 amphibian species, and 30 fish species. For thousands of years, Native Americans have used the natural resources of the area for subsistence activities such as hunting and fishing; for gathering plants, foods, and medicines; and for conducting religious ceremonies.

Smelting, fertilizer production, pulp mills, and mining and milling operations located in Canada and the United States have released contaminants to the UCRS through effluent discharges or spills, and/or slag disposal. Primary sources of hazardous substances include the Teck Resources Limited (Teck) facilities in Trail, British Columbia (BC) and the Zellstoff Celgar (Celgar) pulp mill in Castlegar, BC. Substantially smaller contributions are suspected from sites such as the Le Roi Smelter in Northport, Washington (WA). The United States Environmental Protection Agency (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.

Based on historical data, the Trustees have identified a provisional list of chemicals of potential concern (COPCs) that have been released into the UCRS. The provisional list of COPCs includes: arsenic, cadmium, copper and copper sulfate, chromium, lead, mercury, zinc, polycyclic aromatic hydrocarbons, organochlorine pesticides, polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans, chlorinated phenolics, resin and fatty acids, polychlorinated biphenyls, and sulfuric acid.

The Confederated Tribes of the Colville Reservation (CCT), the Spokane Tribe of Indians (STI), the State of Washington (as represented by the Department of Ecology), and the United States Department of the Interior (USDOI, as represented by the National Park Service (NPS), the United States Bureau of Reclamation (USBOR), the United States Fish and Wildlife Service (USFWS), the Bureau of Indian Affairs (BIA), and the Bureau of Land Management (BLM), collectively act on behalf of the public as Trustees for the natural resources of the UCRS. The natural resources and associated services over which the Trustees have authority include:

- *Surface Water Resources* – water transported by the Columbia River and its tributaries including suspended, bank, bed, and shoreline sediments.

- *Geological Resources* – elements of the Earth's crust such as soils, sediments, rocks, and minerals, including petroleum and natural gas, that are not included in the definitions of groundwater, surface water, biological resources, and air resources.

- *Groundwater Resources* – water located below the surface of the land or water, including aquifers and hyporheic groundwater. The rocks or sediments through which the groundwater moves are also included in the definition of groundwater resources.

- *Air Resources* – naturally-occurring constituents of the atmosphere, including those gases essential for human, plant, and animal life.

- *Biological Resources* – fish, wildlife, and other biota, including aquatic and terrestrial species; game, nongame, and commercial species; threatened, endangered, and State sensitive species; macroinvertebrates (mussels); terrestrial and aquatic plants; and other living organisms.

- *Human Uses of Natural Resources* – including recreational and tribal uses.

The Trustees have responsibility for assessing the nature and extent of natural resource injuries resulting from hazardous substance releases and for determinig the scale of associated damages through the natural resource damage assessment (NRDA) process described, in part by 43 Code of Federal Regulations (CFR) Part 11. Through the NRDA process, the Trustees determine the appropriate type and scale of compensation required to make the public whole for past injuries, as well as injuries to natural resources that have not been, nor are expected to be, addressed through remedial (i.e., "cleanup") activities. When injuries are the result of a release of one or more hazardous substances, the NRDA process typically follows the regulations at 43 CFR 11, which USDOI developed to provide a standardized and cost-effective process for assessing damages. The following sections describe the steps in the injury assessment phase of a NRDA that conforms to the USDOI regulations:

- *Preassessment Screen* – The purpose of a preassessment screen (PAS) is to provide a rapid review of readily-available information to ensure that there is a reasonable probability of making a successful claim before monies and efforts are expended in carrying out an assessment. As documented in the September 2010 preassessment screen, the Trustees have determined, in accordance with 43 CFR § 11.23, that a NRDA of injuries to natural resources within the UCRS is warranted. Specifically, the PAS confirmed that:

  - A release of a hazardous substance occurred;
  - Natural resources for which the Federal or State agency or Indian tribe may assert trusteeship have and/or are likely to have been adversely affected by the release;
  - The quantity and concentration of the released hazardous substance is sufficient to potentially cause injury to those natural resources;
  - Data sufficient to pursue an assessment are readily available or likely to be obtained at reasonable cost; and,
  - Response actions, if any, carried out or planned do not or will not sufficiently remedy the injury to natural resources without further action.

- *Assessment Planning* - After determining, through a PAS, that an assessment is warranted, Trustees proceed to the development of an Assessment Plan, which is prepared to ensure completion of the assessment at a reasonable cost relative to the anticipated magnitude of damages.
- *Injury Determination* - In the injury determination phase, Trustees collect and analyze site-specific data in order to assess whether one or more of the site's natural resources are injured.
- *Injury Quantification* - Once the injuries are identified, the Trustees must determine the effect of the release on the injured resources, in terms of a reduction in the quality or quantity of services the resources provide relative to conditions had the releases not occurred (baseline conditions).

This document, the Injury Assessment Plan, describes the activities that the Trustees currently are prepared to pursue as part of the injury determination phase of the NRDA. The Trustees will present their approach to subsequent assessment phases (injury quantification, damage determination) in addenda to this Plan.

The Trustees will gather and analyze data and information from a variety of sources to support the determination of natural resource injuries associated with discharges of hazardous substances into the UCRS. These data sources fall into three general categories, including:

- Current and historical data;
- Remedial investigation (RI) data; and,

- Damage assessment data.

The Trustees are preparing to initiate the UCRS injury determination in stages, as necessary, to determine the appropriate type and scale of compensation required to make the public whole for any past or future injuries to natural resources associated with releases of hazardous substances. In the first stage of the process, a preliminary assessment will be conducted primarily with existing information and with information from the remediation investigation/feasibility study (RI/FS) activities. This analysis is likely to address multiple media types and will likely involve comparison of COPC concentrations to applicable standards, criteria, guidelines, and/or other injury thresholds. Since requisite information is currently lacking, this analysis will generate a very conservative estimate of damages, potentially supplemented with a limited amount of additional data collected to ensure the best use of RI/FS data for injury assessment purposes. The second stage of the assessment will encompass new investigations, if required. The Trustees will prepare, and make public, specific sampling and analysis plans, either as appendices or supplements to this Injury Assessment Plan. Consistent with the USDOI regulations, injury determination (and quantification) will be evaluated on a resource-by-resource basis.

1. Introduction

The Confederated Tribes of the Colville Reservation (CCT), the Spokane Tribe of Indians (STI), the State of Washington (as represented by the Department of Ecology), and the United States Department of the Interior (USDOI, as represented by the National Park Service (NPS), the United States Bureau of Reclamation (USBOR), the United States Fish and Wildlife Service (USFWS), the Bureau of Indian Affairs (BIA), and the Bureau of Land Management (BLM), are collectively Trustees for natural resources pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 107(f) and Section 300.600 of the National Contingency Plan. As documented in the September 2010 Preassessment Screen (PAS), the Trustees have determined, in accordance with 43 Code of Federal Regulations (CFR) 11.23, that a natural resource damage assessment (NRDA) of injuries to natural resources within the area known as the Upper Columbia River Site (UCRS) is warranted. This document begins the process of documenting the Trustees' intentions with regard to an assessment of injuries and natural resource damages, focusing on the injury determination phase. The Trustees will publish details describing subsequent phases of the assessment process as they are developed.

1.1 Physical Description of the Upper Columbia River Site

The geographic scope of the UCRS is currently defined as the Columbia River and Lake Roosevelt south of the Canada-US border to the Grand Coulee Dam, and associated wetland, riparian, flood plain, and upland terrestrial and lacustrine habitats influenced or affected by historic smelter and pulp industry operations. Construction of the Grand Coulee Dam created Lake Roosevelt, a 133-mile long reservoir with over 600 miles of shoreline at full pool. BOR manages Lake Roosevelt's surface water for multiple purposes including flood control, hydroelectric power production, irrigation, fisheries, and other beneficial uses (USBOR 2009). The NPS, BOR, CCT, STI, and BIA cooperatively manage lands within the UCRS for various subsistence and recreational activities, as outlined in the 1990 Lake Roosevelt Cooperative Management Agreement. The NPS manages a significant portion of the reservoir area as the Lake Roosevelt National Recreation Area. A large portion of the UCRS is also located within the boundaries of the CCT and STI reservations; the site is also within the CCT's former reservation lands (ceded lands), within which the CCT has certain reserved rights and entitlements.

1.2 Ecological and Cultural Description of the Upper Columbia River Site

The diversity of geological, hydrologic, and climatic conditions within the UCRS creates a wide range of habitats for fish and wildlife species, including upland, riparian, palustrine, lacustrine, and riverine areas. The UCRS is home to more than 75 mammal species, 200 bird species, 15 reptile species, 10 amphibian species, and 30 fish species. For thousands of years, Native Americans have used the natural resources of the area for subsistence activities such as hunting and fishing; for gathering plants, foods, and medicines; and for conducting religious ceremonies. 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, or gathering rights. In order to be able to subsist on the 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, and thus developed a set of Surface Water Quality Standards (STI 2008) and a Hazardous Substances Control Act (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. Limitations on the use of the river and its resources also have a negative effect on the cultural and spiritual wellbeing of the Tribes.

1.3 Organization of the Injury Assessment Plan

The remainder of this Plan comprises five sections. In Section 2, the Trustees provide an overview of the categories of natural resources within the UCRS for which they have trust authority, as well as the specific contaminants, and their sources that have the potential to cause injury to those resources. Section 3 describes the NRDA process in more detail, while Sections 4 and 5 present the specific considerations regarding the injury determination component of that process in the context of the UCRS. Section 4 focuses on two required elements: confirmation of natural resources' exposure to hazardous substances and a preliminary determination of the period over which natural resources would be expected to recover following exposure and injury. Section 5 outlines the Trustees' proposed approach for determining and documenting injury to UCRS resources. Section 6 describes the quality assurance procedures that will govern all Trustee assessment activities.

2. Overview of Natural Resources and Contamination

2.1 Description of Natural Resources and Services

The Upper Columbia River Site (UCRS), located entirely within Washington State, currently includes the Columbia River from the US-Canada border downstream to the Grand Coulee Dam, encompassing riverine, riparian, lacustrine, palustrine and upland habitats. The following sections provide brief descriptions of the five general categories of natural resources that will be the focus of this assessment – surface water resources, geological resources, groundwater resources, air resources, and biological resources. The description of the biological resources category comprises three sub-categories: aquatic species, avian species, and mammalian species. In addition, human use services provided by these natural resources, including recreational and tribal uses, are briefly described in this section.

2.1.1 Surface Water Resources

Surface water resources means the waters of the United States, including the sediments suspended in water or lying on the bank, bed, or shoreline and sediments in or transported through coastal and marine areas. The hydrology of the UCRS is influenced by aquifers, groundwater, and surface waters including the Columbia River and its tributaries. The Columbia River upstream of the UCRS contributes up to 90 percent of the surface water volume to Lake Roosevelt, with the remaining 10 percent coming from the Spokane, Kettle, Colville, and Sanpoil Rivers.

2.1.2 Geological Resources

For the purposes of this assessment, geological resources means those elements of the Earth's crust such as soils, sediments, rocks, and minerals, including petroleum and natural gas, that are not included in the definitions of ground and surface water resources.

2.1.3 Groundwater Resources

Groundwater resources means water in a saturated zone or stratum beneath the surface of the land or water, and the rocks or sediments through which the groundwater moves. It includes groundwater resources that meet the definition of drinking water supplies. It also includes aquifers and hyporheic groundwater.

2.1.4 Air Resources

Air resources means those naturally occurring constituents of the atmosphere, including those gases essential for human, plant, and animal life.

2.1.5 Biological Resources

Biological resources means those natural resources referred to in Section 101(16) of CERCLA as fish, wildlife, and other biota. Fish and wildlife include marine and freshwater aquatic and terrestrial species; game, nongame, and commercial species; and threatened, endangered, and State sensitive species. Other biota encompass shellfish, terrestrial and aquatic plants, and other living organisms not otherwise listed in this definition. More than 75 species of mammals, 200 species of birds, 30 species of fish, 15 species of reptiles, and 10 species of amphibians may occur within the UCRS.

2.1.5.1 Aquatic Species

The UCRS contains over 30 species of fish, of which at least 13 are native. Some of the native fish species include burbot, westslope cutthroat, bull trout, redband trout, lake whitefish, mountain whitefish, sucker, and white sturgeon. An international recovery effort is underway in response to the declining populations of native white sturgeon [see preassessment screen (PAS) for further information on the status and importance of this species in the UCRS (UCRNRTC 2010)]. Non-native walleye and hatchery-reared triploid rainbow trout support a large recreational fishery within the UCRS. Other important recreational fisheries exist for burbot, smallmouth bass, and various warm water fish species. The UCRS also contains a variety of benthic macroinvertebrates, ranging from mussels to amphipods and midges.

2.1.5.2 Avian Species

A variety of birds use the UCRS including raptors, passerines, water birds, and shorebirds. Raptors, such as bald eagles and osprey use riparian habitats for nesting, foraging, and rearing of young. Passerines utilize numerous habitat 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 water birds depend on the UCRS, including common merganser, Canada goose, mallard, common loon, red-necked grebe, spotted sandpiper, belted kingfishers, and great blue heron.

2.1.5.3 Mammalian Species

Many large resident mammals depend on UCRS habitats for wintering and rearing, such as mule deer, white-tailed deer, bighorn sheep, moose, elk, cougar, black bear, bobcat, lynx, and wolves. Other mammals, such as mink, muskrat, and river otter, depend on UCRS riparian and wetland habitats for foraging and rearing.

2.1.6 Human Uses of Natural Resources

The primary human use services provided by URCS natural resources are recreational and Tribal.

2.1.6.1 Recreational Uses

The UCRS is an important, diverse recreational region that supports a wide range of recreational uses, including fishing, hunting, hiking, boating, camping, swimming, and wildlife viewing. Lake Roosevelt National Recreation Area (LRNRA), located within the UCRS, comprises more than 312 miles of shoreline. LRNRA is a destination location that provides more than 26 campgrounds and 22 public boat launches and receives more than 1.4 million visitors each year. The CCT provides an additional 10 maintained campgrounds and one public boat launch for tribal and recreational uses on their reservation within the UCRS. The STI provides three additional campgrounds for tribal and recreational uses on their reservation within the UCRS.

2.1.6.2 Tribal Uses

A large portion of the UCRS is located within the boundaries of CCT and STI Reservations. The site is also within the CCT's and STI's former Reservation lands, within which the CCT and STI has certain reserved rights and entitlements. The STI and CCT exercise management and regulatory protection of the resources within the UCRS under Tribal and Federal authorities. These tribes have traditionally interacted with and heavily relied upon the natural resources of the area through subsistence activities, such as hunting, fishing, gathering, and using natural resources for spiritual and medicinal purposes. Both tribes actively manage the resources of the UCRS for Tribal uses, sustenance, and sustainability. The UCRS also plays a central role in tribal gatherings, ceremonies, and religious traditions. Both tribes are inextricably tied to the river and the plants and animals living throughout the UCRS and it remains the tribes' homeland (see also Section 5.5.1).

2.2 Sources of Contaminants

The UCRS has a long history of supporting resource-based industries, including timber and mining. Contaminants associated with smelting, fertilizer production, and pulp mills entered the UCRS from Canada and the United States through both intentional discharges and spills. Primary sources of hazardous substances include the Teck Resources Limited (Teck) facilities in Trail, British Columbia (BC) and the Zellstoff Celgar (Celgar) pulp mill in Castlegar, BC. Substantially smaller contributions are suspected from sites, such as the Le Roi Smelter in Northport, WA (Bortleson *et al.* 1994). The United States Environmental Protection Agency (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).

2.2.1 Teck Smelter and Facilities

The Teck smelter is located approximately 10 miles upstream of the US-Canada border in Trail, BC. Operations at this location began in 1896, when the primary activity was smelting gold and copper (G3 Consulting 2001). In 1901, smelter operations expanded to include furnaces for lead production. Zinc production began in 1916, followed by the construction of plants for the production of nitrogen- and phosphorous-based fertilizers in 1930 (USEPA 2008; MESL 1997). Phosphorous-based fertilizer production ended in 1994. Current operations smelt primarily zinc and lead, but also include the handling of an array of other associated extracted elements including cadmium, silver, gold, bismuth, antimony, cobalt, copper, indium, germanium, thallium, and mercury. In addition to metals production, the Teck facilities also produce arsenic products, sulfur, sulfuric acid, ammonium sulfate fertilizers, and ferrous granules (USEPA 2003).

Prior to 1996, Teck systematically discharged granulated slag (a by-product of the smelting process) directly into the Columbia River. The USEPA (2008) estimates that, by mid-1995 (when temporary stock piling and later extensive modernization of the lead smelting facility eliminated routine discharges to the river), Teck and its predecessors had discharged over 23 million tons of slag into the river. Slag is a black, solid smelter waste, and can appear as a glassy, coarse sand or finer grained material consisting predominantly of ferrous granules. While variable in precise composition and structure, slag contains up to one percent copper and up to three percent zinc, as well as antimony, arsenic, barium, chromium, manganese, and other hazardous substances (Cox *et al.* 2005). Slag resulting from older smelting practices (in the early part of the 20th century) had substantially higher levels of zinc (up to 15 percent; Cox *et al.* 2005; Paulson and Cox 2007).

Teck also released contaminants, including metals, into the Columbia River through effluent discharges and spills. During their operational period, the fertilizer plants reportedly discharged up to four kilograms (kg) per day of total mercury and 350 kg/day of dissolved zinc. Effluent from metals production during the period 1980-1996 averaged 18 kg/day arsenic, 62 kg/day cadmium, 200 kg/day lead, and 7,400 kg/day zinc (Cominco 1997). These metals have been carried downstream into the UCRS potentially causing adverse effects on human health and ecological receptors.

Throughout its history, smelter stack emissions have released contaminants such as sulfur dioxide and metals into the atmosphere, primarily due to sulfide-bearing ores that provide feedstock to the smelter. In 1925, sulfur dioxide emissions from the smelter stack were estimated at 10,000 tons per month (USEPA 2008). Smelter operations have been occurring since the early 1900s. Production has included copper, gold, lead, and zinc, and other toxic metals that are suspected of being released through stack emissions. The smelter is located within a deep valley with variable upper- and lower-level wind patterns from the northeast, which bring historic and present-day smelter emissions into the UCRS. Denuded vegetation from sulfur dioxide emissions, documented in 1929-1931, indicated that sulfur dioxide emissions from the smelter traveled down the Columbia River at least as far as Kettle Falls, and that the impacted area grew each year (IJCH 1930). In addition, residents of the area documented the effects of acidic deposition, such as prematurely rusting fences and other metal infrastructure. Historic smelter emissions have potentially impacted upland soils and other resources. Goodzari (2002a; 2002b) documented aerial deposition originating from the smelter and measured elevated arsenic, cadmium, copper, lead, mercury, and zinc concentrations in soil as far south as the US-Canada border.

Discharges from the Teck facility may also be contributing contaminants to shallow groundwater through on-site soil and sediment fluxes and surface water movement. Studies investigating shallow hyporheic groundwater contamination within the UCRS are lacking, but studies conducted by Teck north of the border have found elevated metals concentrations in groundwater; these metals were released from the facility (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 complete) inventory of spills from 1980 to 2008. Very little information regarding earlier spills is available, although periodic spills of similar chemical nature and similar or greater magnitude would likely have occurred over the history of operations at the facility. At least 300 spills have occurred at Teck since 1980, resulting in the release of hazardous substances such as arsenic, cadmium, mercury, lead, zinc, various acids and oils, ammonium and phosphorus compounds, slag, and other unidentified substances (USEPA 2008). In May 2008, up to 10,000 kg of hydrofluorosilisic acid and up to 1,000 kg of lead were released into the Columbia River over a four hour period (Washington State Department of Ecology 2008a; 2008b).

2.2.2 Zellstoff Celgar Pulp Mill

Zellstoff Celgar Pulp Mill is located approximately 30 miles upstream from the US-Canada border in Castlegar, BC. 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 containing dioxins and furans (by-products of bleached kraft pulp mills) were discharged into the river (Johnson *et al.* 1991a). Elevated chlorinated compound concentrations have been found in various media, including fish and mussels, downstream of the mill. Dioxin concentrations detected in Columbia River fish tissues in the early 1990s were sufficiently elevated to warrant a Washington State Department of Health advisory for consumption of sport fish (WDOH 1991). In 1994, facility modernization efforts included installation of 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 into the Columbia River (USEPA 2008).

2.2.3 Secondary Sources

The Le Roi Smelter in Northport, Washington (WA), approximately seven miles from the US-Canada border, operated sporadically from 1896 to 1921 and produced slag as well as airborne stack emissions that resulted in elevated lead concentrations in soils near the smelter. In 2004, the USEPA conducted a removal action at the Le Roi property as well as properties in the town of Northport (Weston 2004; 2005).

The Spokane River is a tributary to the Upper Columbia River, and, thus, may provide a pathway for additional metals contamination lower in the Lake Roosevelt portion of the UCRS. The Bunker Hill Mining and Metallurgical Complex, comprising Coeur d'Alene Basin mining districts, is a source of metals, most notably lead, zinc, and cadmium, released into the Coeur d'Alene and Spokane Rivers. Human health-related clean-up at this site has been underway since the 1990s and ecological clean-up began more recently.

Various mining and milling activities in Washington State have occurred in proximity to the UCRS and 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 where it encounters the Spokane River. Remedial and NRD activities at the Midnite Mine site are ongoing. Additionally, federal and state investigations and actions have been conducted or are ongoing 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 broader Upper Columbia River water or sediments.

2.3 Chemicals of Potential Concern

The Trustees have determined that the quantity and concentration of hazardous substances released to the environment in and around the UCRS are sufficient to potentially cause injury to natural resources. Specifically, the Trustees have determined that water, sediment, and biological tissue samples collected from the UCRS, which were obtained through 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 Trustees identified a number of chemicals of potential concern (COPCs) for non-human receptors that have been released into the UCRS, including but not limited to this list:

1. Arsenic
2. Cadmium
3. Copper and copper sulfate
4. Chromium
5. Lead
6. Mercury
7. Zinc
8. Polycyclic aromatic hydrocarbons (PAHs)
9. Organochlorine pesticides
10. Polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans (PCDDs/PCDFs)
11. Chlorinated phenolics
12. Resin and fatty acids
13. PCBs
14. Sulfuric acid

The following sections describe each of these ecological COPCs identified in the PAS, including their potential impact on the affected natural resources discussed above. Additional COPCs may be identified as additional data become available and/or based on the results of screening using applicable water quality standards and other relevant benchmarks.

2.3.1 Arsenic

Arsenic occurs naturally in rock, soil, water and air. However, arsenic in the environment can also be a result of human activities. Plants can accumulate arsenic via uptake from soil and/or deposition from air onto leaves. Animals uptake arsenic through ingestion of contaminated plants, water or sediment, or through dermal exposure. Adverse effects on living organisms include death, poor growth, or reproductive failure.

2.3.2 Cadmium

Cadmium is a natural element that is usually found as a mineral combined with other elements such as oxygen (cadmium oxide), chlorine (cadmium chloride), or sulfur (cadmium sulfate, cadmium sulfide). All soils and rocks, including coal and mineral fertilizers, contain some cadmium. Cadmium occurs naturally in air, water and soil and is a by-product of the smelting of other metals such as zinc, lead, and copper. Cadmium in the environment can also be a result of human activities. Cadmium has been shown to affect photosynthesis and transpiration in plants, and is toxic to a wide range of micro-organisms, primarily affecting growth and reproduction. Cadmium is toxic to aquatic life, and is highly persistent in the environment. In addition, cadmium will concentrate or bioaccumulate in aquatic animals.

2.3.3 Copper

Copper is a naturally occurring metal element. Copper in the environment can also be a result of human activities. Copper in soils can disrupt processes such as nutrient cycling or inhibit mineralization of nitrogen and phosphorous. Unlike other heavy metals, copper is not readily bioaccumulated. However, many plants, mussels, and some fish are very sensitive to copper toxicity and will often display metabolic disturbances and growth inhibition at relatively low levels. Copper sulfate is a combination of an inorganic salt and copper, which is an essential trace element in plant and animal nutrition. It is primarily used as a fungicide to control bacterial and fungal diseases on crops. It is highly soluble and mobile in aquatic environments. Copper sulfate is toxic to fish, aquatic invertebrates and plants at high concentrations, and may cause significant decreases in aquatic populations.

2.3.4 Chromium

Chromium is a naturally occurring element and is present in the environment in many forms. Chromium in the environment can also be a result of human activities. Chromium can be transported as particles in the atmosphere or as dissolved compounds, and has been shown to result in chronic toxicity to aquatic life. It can also impede plant growth and development by altering the germination process and inhibiting growth in roots, stems and leaves. High levels of chromium can also have a negative impact on plant physiological processes such as photosynthesis and mineral nutrition.

2.3.5 Lead

Lead is a naturally occurring metal; however, much of the lead currently in the environment is a result of human activities. Lead accumulates in living tissues, soils and sediments, and is persistent in water. Lead exposure can lead to death of mammals, birds or fish, and death or reduced growth in plants. Ecosystems near point sources of lead demonstrate a wide range of adverse effects including losses in biodiversity, changes in community composition, decreased growth and reproductive rates in plants and animals, and neurological effects in vertebrates.

2.3.6 Mercury

Mercury is a naturally occurring chemical element that does not break down in the environment and can accumulate in the food chain, particularly in fish and other aquatic species. Mercury in the environment can also be a result of human activities. Even at low levels of concentration, mercury exposure represents a major hazard to organisms. For example, fish that have been exposed to mercury exhibit a wide variety of physiological, reproductive and biochemical abnormalities. Birds exposed to mercury show a reduction in food intake, poor growth, increased enzyme production, decreased cardiovascular function, changes in blood parameters, immune response, and behavioral changes. Piscivorous birds and mammals may also be exposed to mercury from the consumption of aquatic prey (i.e., benthic invertebrates, mussels, and fish) through biomagnification and have been shown to experience reproduction failure.

2.3.7 Zinc

Zinc is one of the most common, naturally occurring elements in the earth's crust. Zinc in the environment can also be a result of human activities. The toxicity of zinc to plants and animals is generally low; however, soils with an excessive zinc burden can be toxic to plants. At relatively low levels in surface water, zinc can cause behavioral avoidance in fish.

2.3.8 Polycyclic aromatic hydrocarbons

PAHs are a diverse class of organic compounds that include about one hundred individual substances containing two or more fused benzene (or aromatic) rings. There are a variety of sources of PAHs. However, these substances are most commonly associated with the incomplete combustion of wood and fossil fuels. The behavior of PAHs in surface waters depends on a variety of chemical-specific and site-specific factors, with physical-chemical properties playing an important role in determining their fate in aquatic systems. Releases of PAHs into aquatic ecosystems pose a number of potential risks to aquatic and terrestrial organisms. Water-borne PAHs can be acutely lethal to invertebrates, fish, and amphibians. Long-term exposure to sub-lethal levels can impair survival, growth, and reproduction. Similarly, exposure to sediment-associated PAHs can adversely affect the survival, growth, and reproduction of benthic invertebrates. In benthic fish, exposure to certain PAHs [e.g., benzo(a)pyrene] in sediments has been linked to proliferation of pre-cancerous lesions and tumors. Although PAHs are rapidly metabolized in fish tissues, they can accumulate in the tissues of benthic invertebrates. Accordingly, ingestion of the tissues of aquatic organisms can adversely affect the survival and reproduction of avian and mammalian wildlife species.

2.3.9 Organochlorine Pesticides

Organochlorine pesticides is the term that is commonly applied to a group of substances that are used as pesticides and include one or more chlorine atoms in their molecular structure. Although most local sources have been eliminated, exposure to organochlorine pesticides still represents a concern in North America. Due to their persistence in the environment and their physical-chemical properties, organochlorine pesticides are commonly present in bed sediments in the vicinity of manufacturing and release locations. Accordingly, organochlorine pesticides continue to be released into surface water and other environmental media from contaminated sediments and by long-range atmospheric transport from other areas. Concerns associated with releases of organochlorine pesticides to aquatic ecosystems are associated with their bioaccumulation and effects on higher trophic-level consumers, such as aquatic-dependent birds and mammals (e.g.,egg-shell thinning in birds exposed to DDTs).

2.3.10 Polychlorinated Dibenzo-*p*-dioxins and Polychlorinated Dibenzofurans

PCDDs/PCDFs are formed as an unintentional by-product of incomplete combustion, and are also a by-product of bleached kraft pulp mills. They are a known developmental toxin in animals that can cause skeletal deformities, kidney defects, and weakened immune responses in the offspring of animals exposed during pregnancy. Certain fish species also exhibit delayed embryonic development and higher mortality when exposed to PCDDs/PCDFs. These substances have been shown to cause a wide range of immunologic effects in animals, including decreased host resistance to infectious disease.

2.3.11 Chlorinated Phenolics

Chlorinated phenolics (chlorophenols) are a group of chemicals in which chlorines have been added to phenol. Chlorophenols are generally used as pesticides, but they are also produced during the bleaching of wood pulp with chlorine. Most chlorophenols are released into water, and adsorb to soil and sediments in lakes, rivers, or streams. In laboratory studies, high levels of chlorophenols have been shown to cause death and affect liver and immune system function in plants, animals, birds, and fish.

2.3.12 Resin and Fatty Acids

Resin acids are carboxylic acids that are derived from the natural resins found in coniferous trees. Processing by the pulp and paper industry results in the extraction of resin acids from softwood and, subsequently, in the release of these substances into aquatic ecosystems. Inputs of resin acids originating from pulping operations have significant potential to affect aquatic resources in receiving water systems. Importantly, resin acids are one of the primary sources of toxicity in softwood pulping effluents, accounting for up to 70 percent of the whole-effluent toxicity. The degradation products of resin acids are much less toxic than the parent compounds. As resin acids are known to accumulate in fish food organisms, it is likely that bioaccumulation in fish or wildlife is possible via ingestion of contaminated-food organisms.

2.3.13 Polychlorinated Biphenyls

PCBs are a group of man-made chemicals that contains 209 individual compounds. PCBs were widely used in the past but were banned in the 1970s in many countries because of environmental concerns. They are highly persistent, bioaccumulative, and toxic to fish and other aquatic organisms. PCBs may have reproductive and immunotoxic effects in wildlife, and have been shown to cause cancer in animals. In addition, they have been shown to cause other health effects in animals such as effects on the immune system, reproductive system, nervous system, endocrine system, and other health effects.

2.3.14 Sulfuric Acid

Sulfuric acid is a clear, colorless, oily liquid that is very corrosive. It can also be found in the air as small droplets or attached to small particles. It also contributes to the formation of acid rain. Sulfuric acid is moderately toxic to aquatic life. Plants, birds, or animals exposed to sulfuric acid exhibit burns and other skin conditions.

3. Natural Resource Trustees and the Damage Assessment Process

3.1 Statement of Authority for Asserting Trusteeship

Federal law[1] establishes the authority under which representatives of Federal, State, and Tribal governments act on behalf of the public as trustees for natural resources. For the Upper Columbia River Site (UCRS), trusteeship is shared among four governments.

- The **Confederated Tribes of the Colville Reservation** (CCT), whose ancestral lands and current and former reservation lands include portions of the UCRS. The CCT exercises management and regulatory authority within approximately 1.5 million acres of former reservation lands and waters, in addition to the over 1.6 million acres of current reservation lands and waters. CCT management and regulatory programs including Environmental Trust, Fish & Wildlife, Parks & Recreation, Forestry, Planning, and History/Archeology, provide for the protection of tribal water rights; cultural, water, air, forest and soil resources; environmental and human health values; and fish and wildlife species (including the recovery and management of listed populations) and their supporting habitats to meet cultural, subsistence and recreational needs. In addition, tribal parks maintain recreational and tribal campgrounds and provide regulatory enforcement of tribal and federal law within the UCRS. The Tribes' History/Archeology Program, whose mission is to protect, preserve and perpetuate the Tribes history, culture and traditions for future generations, also provides for the enforcement of tribal and federal archeological laws and regulations within the site;
- The **Spokane Tribe of Indians** (STI), whose ancestral lands and current reservations include portions of the UCRS;
- The **State of Washington**, as represented by the Washington Department of Ecology; and
- The **United States of America**, with trustee responsibility delegated to the United States Department of the Interior (USDOI) and the Department agencies with management responsibilities for lands or specific natural resources within the assessment area. In this case, five agencies are participating as co-Federal trustees, including:
  - The National Park Service, which manages more than 300 miles of shoreline, more than 47,000 acres of water surface, and nearly 13,000 acres of land within the Lake Roosevelt National Recreation Area;

[1] The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended (42 U.S.C. 9601 *et seq.*), the Oil Pollution Act (OPA, 33 U.S.C. 2701 *et seq.*), and the Federal Water Pollution Control Act [the "Clean Water Act" (CWA)], as amended (33 U.S.C. 1251 *et seq.*).

- The Bureau of Reclamation, operator of the Grand Coulee Dam which marks the downstream extent of the UCRS;
- The United States Fish and Wildlife Service (USFWS), with responsibility for the protection of migratory birds, threatened and endangered species, and their supporting habitats within the assessment area. USFWS also manages the Little Pend Oreille National Wildlife Refuge, located within the UCRS drainage basin;
- The Bureau of Indian Affairs (BIA), whose mission is to protect and improve the trust assets of Tribes such as the CCT and STI; and,
- The Bureau of Land Management (BLM), which manages approximately 24,000 acres of land within the UCRS.

Collectively, the Trustees have responsibility for assessing the nature and extent of natural resource injuries resulting from hazardous substance releases and for determining the scale of associated damages.

3.2 Trustee Council Formation

In May 2007, the Federal, State, and Tribal trustees entered into a Memorandum of Understanding (MOU) that acknowledges the importance of collaboration in the pursuit of their natural resource restoration objectives and the importance of integrating and coordinating the natural resource damage assessment (NRDA) with ongoing and future studies, as well as with any mitigation, remedial, and restoration activities in the Upper Columbia River and Lake Roosevelt watershed. Central to the MOU is the establishment of a Trustee Council, comprising one voting member from each of the four governments with trustee authority. The Council is responsible for:

1. Providing vision to, and coordinating planning and implementation of, the NRDA process, consistent with their management of resources for which they serve as Trustee;
2. Serving as a single point of contact for the development of policy and positions regarding communications from the Trustees to United States Environmental Protection Agency (USEPA) and the potentially responsible parties;
3. Formulating priorities, proposals, plans, and budgets, as needed, to accomplish coordination with USEPA or to conduct NRDA activities; and,
4. Coordinating public outreach and education, as well as media contact and content.

All Trustee Council decisions are made by consensus.

3.3 The Natural Resource Damage Assessment Process

A NRDA process consists of trustees determining the appropriate type and scale of compensation required to make the public whole for injuries to natural resources that have not been, nor are expected to be, addressed through remedial (i.e., "cleanup") activities. When injuries are the result of a release of one or more hazardous substances, the NRDA process typically follows the regulations at 43 Code of Federal Regulations (CFR) Part 11, which USDOI developed to provide a standardized and cost-effective process for assessing damages. The following sections describe the steps in the injury assessment phase of a NRDA that conforms to the USDOI regulations.

3.3.1 Preassessment Screen

The purpose of a preassessment screen (PAS) is "to provide a rapid review of readily available information . . .[to] ensure that there is a reasonable probability of making a successful claim before monies and efforts are expended in carrying out an assessment" [43 CFR § 11.23(b)]. Trustees are expected to determine that each of following five criteria [described at 43 CFR § 11.23(e)] have been met before proceeding with an assessment.

1. *A discharge of oil or a release of a hazardous substance has occurred*.
2. *Natural resources for which the Federal or State 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 substance 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, if any, carried out or planned do not or will not sufficiently remedy the injury to natural resources without further action*.

The UCRS Trustees completed a PAS of the UCRS in September 2010 and determined that each of the five criteria has been met (UCRNRTC 2010).

3.3.2 Determination to Pursue a Type B Assessment

The USDOI regulations describe two types of damage assessment: Type A and Type B. Type A assessments rely upon one of two models (one for releases into water in coastal and marine environments, the other for releases into the Great Lakes) that require limited observation of field conditions and depend on simplifying assumptions. In addition to the geographic constraints, application of a Type A model is generally warranted only when a release is a discrete event of relatively small magnitude and short duration. In all other cases, trustees perform Type B assessments, which comprise more extensive and site-specific data collection and analysis activities. The regulations at 43 CFR Part 11 primarily address the steps necessary for completion of a Type B assessment. Since the Type A models are not applicable to releases associated with the UCRS, the Trustees have determined that a Type B assessment is warranted.

3.3.3 Assessment Planning

After determining, through a PAS, that an assessment is warranted, trustees proceed to the development of an Assessment Plan, which is prepared to guide planning of assessment that can be conducted at a reasonable cost relative to the anticipated magnitude of damages. An Assessment Plan describes the studies and other analytic steps the trustees currently understand necessary to undertake to (1) determine the nature and extent of natural resource injuries, (2) quantify the reduction in natural resource services resulting from the documented injuries, and (3) determine the appropriate magnitude of damages. This initial version of the Assessment Plan addresses the first step in this process – injury determination. Note that before describing any Type B assessment methodologies in an Assessment Plan, trustees are required to confirm that at least one natural resource described as potentially injured in the PAS has in fact been exposed to a released hazardous substance (see Section 4.1 for more information on the current understanding of exposure of natural resources to site-related COPCs).

3.3.4 Injury Determination

The USDOI regulations define the specific conditions under which surface water, groundwater, air, geological, or biological resources are considered to be injured. In the injury determination phase, trustees review or collect and analyze site-specific data in order to assess whether one or more of the site’s natural resources exhibit characteristics that satisfy a regulatory definition of injury. An injury determination also depends on the trustees’ ability to describe the injury as a direct result of a particular release, or history of releases, of hazardous substances. A key element in documenting the attribution of injury to a source is the *pathway determination*, which describes how a hazardous substance, upon release from a source, moves through the environment such that exposure to a natural resource, sufficient to result in injury, can occur.

3.3.5 Injury Quantification

Once the injuries are defined, the trustees determine the effect of the release on the injured resources, in terms of a reduction in the quality or quantity of services the resources provide relative to their baseline condition, as described further below.

3.3.5.1 Extent of Injury

Trustees have two options for determining the extent to which natural resources have been injured. The first option is simply to measure the total area, volume, or number of affected resources within the assessment area (i.e., direct quantification of injury) and to then describe these measures in terms of resource services. Alternatively, Trustees can directly quantify the change in services (i.e., the physical and biological functions performed by the resource, which are the result of the physical, chemical, or biological quality of the resource) rather than the change in the resources themselves. The USDOI regulations provide for this direct quantification of services when (1) the change in services is known to result from an injury, (2) it is possible to measure this change without first measuring a change in resource area, volume, number, etc., and (3) services are anticipated to provide a better indication of damages than would direct quantification of injury [43 CFR § 11.71(f)].

In quantifying injuries, trustees must also be cognizant of several statutorily prescribed circumstances in which compensation for those injuries is excluded, including in particular:

1. "Irreversible and irretrievable commitment[s] of natural resources" as documented in an Environmental Impact Statement or similar analysis; and,
2. Damages that result from releases of hazardous substances that occurred wholly before the enactment of CERCLA in December 1980 [43 CFR § 11.71(g)].

3.3.5.2 Reduction in Services Relative to the Baseline Condition of Injured Resources

Central to the injury assessment is the concept of baseline, as the trustees ultimately seek compensation based on the objective of restoring injured resources and services to their baseline condition. Baseline is defined as the conditions that would have existed within the assessment area *but for* the release of hazardous substances, "taking into account both natural processes and those that are the result of human activities" [43 CFR § 11.72(b)(1)]. In other words, the baseline condition recognizes any changes to the environment that were not related to the presence of hazardous substances associated with the release(s) being investigated.

The regulations instruct the trustees to document baseline conditions using historical data from the assessment area, if those data are from credible sources, or, when historical data are not available or sufficiently applicable, using historical or newly collected data from one or more reference areas. In the latter case, the reference area(s) are selected based on their similarity to the assessment area, with the exception of the presence of, and exposure of natural resources to, the hazardous substances in question.

Establishing baseline can be challenging when releases of hazardous substances have occurred over a large area and especially over a long time period (making it less likely that historical data of sufficient quantity or quality are available or that collection of data from a control area can be accomplished cost-effectively). As necessary, the regulations permit trustees to use "substitute" baseline data that do not "represent fully the baseline conditions" subject to documenting that:

1. They do not cause the difference between baseline and the conditions in the assessment area to exceed the difference that would be expected if the baseline were completely measured;
2. It is not technically feasible or cost-effective to measure the baseline conditions fully; and,
3. The substitute data are believed to provide the closest possible approximation of actual baseline conditions [43 CFR § 11.72(b)(5)].

3.3.5.3 Recoverability of Injured Resources

The final element of the trustees' quantification of injured resources is a determination of the length of time required for injured resources to recover to their baseline condition absent any active restoration measures. However, this determination does take into account any remedial response actions that are being or are anticipated to be undertaken. In this way, the trustees can focus restoration efforts on the "residual" injury that remains after any remedial response. During the damage determination phase of the assessment, the trustees use this information to inform the identification and evaluation of restoration alternatives, and to assess compensatory damages for any "interim loss" of services (i.e., the services that would have been provided by injured natural resources during the period that begins with the onset of injury and ends with the return of the resources to their baseline condition).

3.3.6 Relationship of the Damage Assessment to Remedial Activities

The UCRS NRDA will occur while remedial response (i.e., "cleanup") investigations and activities at the site are ongoing. Such an occurrence is not uncommon, but does require careful consideration of the relationship between the two efforts, since they have compatible, but not entirely overlapping, objectives. Remedial objectives are risk-based; that is, they focus on reducing to acceptable levels the risk to human health and ecological receptors associated with exposure to site contaminants. The risk levels determined to be acceptable do not necessarily (and often do not) correspond to the baseline condition of injured natural resources. Therefore, the trustees claim represents the damages associated with the "residual injury" that remains at a site following the completion of a remedial response. Generally speaking, a more aggressive remedy will result in less residual injury and a shorter period of "interim losses" for which compensation would be required, while a more passive remedy will result in a longer period of interim loss and potentially larger damages. Thus, the trustees and the response authority have the ability to work together and with the potentially responsible parties to shape the relationship between remedial response costs and natural resource damages. When trustees determine that onsite, physical restoration is appropriate and cost-effective, they are careful to ensure that the activities are complementary to ongoing or planned remedial (cleanup) actions.

Independent of the relationship between remediation and restoration, trustees will typically take advantage of data collected during the remedial investigation process as part of the injury assessment. Although they are ultimately used for a different purpose (i.e., for assessing risk and determining target cleanup levels), data that describe the concentrations of hazardous substances in geological, groundwater, surface water, sediments, soils, or the tissues of biological organisms can be used to establish that a natural resource has been injured.

3.3.7 Public Participation in the Assessment Process

When natural resources are injured, trustees act on behalf of the public to restore those resources and the services they provide to their baseline condition. While much of the trustees' efforts depend on specialized scientific and technical knowledge, public input is critical to the process to ensure that the trustees are fulfilling their obligation to everyone who is interested in or affected by their efforts.

By regulation, the Trustees make specific documents available for formal public review, beginning with this Injury Assessment Plan and including any subsequent addenda to the Plan that describe in more detail one or more assessment activities. In each case, the Trustees will make the document available for public review for a minimum of 30 calendar days before initiating any of the planned activities. The Trustees have sole discretion to determine whether comments they receive warrant modification of any part of the Injury Assessment Plan.

The UCRS Trustees will develop a public involvement program to better ensure effective and informed public outreach throughout the assessment process. Potential public involvement activities under consideration include, but are not limited to:

- Periodically meeting with the general public, affected interest groups, and other organizations;
- Preparing and distributing periodic newsletters or fact sheets; and,
- Posting reports, data, and other information on a web site dedicated to the assessment.

3.3.8 Cooperation with Potentially Responsible Parties

The Trustees have invited, and will continue to encourage, the active participation of the potentially responsible parties in the damage assessment process. The potentially responsible parties may agree to fund all or a portion of the studies described in the Injury Assessment Plan.

4. Confirmation of Exposure and Preliminary Determination of Recovery Period

4.1 Introduction

Using the available information on the chemical characteristics of the effluent streams and other releases from industrial facilities, a number of chemicals of potential concern (COPCs) have been identified in the Upper Columbia River Site (UCRS), including:

- Metals [i.e., arsenic (As), cadmium (Cd), copper (Cu), chromium (Cr), lead (Pb), mercury (Hg), and zinc (Zn));
- Polycyclic aromatic hydrocarbons (PAHs);
- Organochlorine pesticides;
- Polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans (PCDDs/PCDFs);
- Chlorinated phenolics;
- Resin and fatty acids; and,
- Polychlorinated biphenyls (PCBs).

Sulfuric acid and copper sulfate have also been released from sources located within the UCRS study area and/or upstream of the UCRS. All of these substances are currently considered to be COPCs at the UCRS; however acquisition of additional information could result in expansion or refinement of this provisional list of COPCs in the future. This chapter provides a summary of selected data that confirm that natural resources have been exposed to COPCs in the UCRS. A preliminary determination of recovery period is also provided in this chapter.

4.2 Confirmation of Exposure

The United States Department of the Interior (USDOI) Natural Resource Damage Assessment (NRDA) regulations state that an Assessment Plan should confirm that: *"at least one of the natural resources identified as potentially injured in the preassessment screen has in fact been exposed to the released substance"* [43 CFR. **§** 11.37(a)].

The NRDA regulations also state that a natural resource has been exposed to a hazardous substance if *"all or part of [it] is, or has been, in physical contact with . . . a hazardous substance, or with media containing. . . [the] hazardous substance*" [43 CFR **§** 11.14(q)]. Furthermore, the USDOI regulations state that "[*w]henever possible, exposure shall be confirmed by using existing data, such as those collected for response actions . . . or other available studies or surveys of the assessment area"* [43 CFR § 11.37(b)]. The following sections of this Plan provide confirmation, based on a review of the existing data, that a number of potentially adversely affected natural resources have been exposed to hazardous substances. These natural resources include but are not necessarily limited to:

- Surface water resources, including surface water and sediments;
- Groundwater resources;
- Geological resources; and,
- Biological resources.

The following discussion is not intended to provide a comprehensive review of the existing information on exposure of natural resources to hazardous substances in the UCRS. Rather, it is intended to provide the necessary and sufficient information to demonstrate that natural resources have been exposed to COPCs at the Site.

Hazardous substances have been documented in abiotic (i.e., water, sediment, soil) and biological media within the UCRS over the past several decades and current studies have confirmed that such contamination has not yet abated. More specifically, various investigations have confirmed that hazardous substances occur in surface water, pore water, sediments, invertebrate tissues, and fish tissues at the Site. The substances that have been measured most frequently at elevated concentrations include toxic metals (such as As, Cu, Cd, Cr, Pb, Hg, and Zn), organochlorine pesticides, PCBs, and PCDDs/PCDFs (Johnson *et al.* 1991a; 1991b; Serdar *et al.* 1994; Era and Serdar 2001; Paulson and Cox 2007; Besser *et al.* 2008; CH2MHill 2006). Elevated contaminant concentrations in abiotic media and aquatic organisms resulted in listing the Upper Columbia River on the Washington State list of water bodies in which beneficial uses are impaired due to pollution [as per Section 303(d) of the federal Clean Water Act (CWA)]. The summaries of the available information on contaminant concentrations and associated exposures of trust resources to COPCs, presented below by media type, were obtained from the preassessment screen (PAS; UCRNRTC 2010).

4.2.1 Surface Water

Numerous contaminant spills have occurred at the Teck facility in Trail, British Columbia (BC) over the last several decades, in addition to systematic operational releases of effluent and granulated slag, 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 sulfuric acid (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 in 1997 estimated to be over 3,000 kg (MESL 1997) and another spill in 1980 estimated to be over 2,800 kg.

Numerous other spills have also occurred on the UCRS. Johnson *et al.* (1988) evaluated data from the USGS water quality monitoring station at Northport, WA and reported that the data indicated highly variable metals (As, Cd, Cu, Hg, Pb, and Zn) concentrations near the US-Canada border. At times, these concentrations greatly exceeded acute and chronic national recommended Water Quality Criteria (WQC) (USEPA 2006; Table 4.1). For example, during a four-year period (1984-1988), Cd concentrations exceeded the acute WQC on six different occasions, with concentrations up to 21 μg/L measured in surface water at the Northport monitoring station. These concentrations were over seven times higher than the acute WQC and over 23 times higher than the chronic WQC in effect at that time. Similarly, mercury concentrations exceeded the acute WQC by nearly three times and the chronic WQC by over 580 times following a spill in 1983. As recently as May of 2008, an acid and Pb release occurred at Teck, with up to 6,500 kg of hydrofluorosilisic acid and up to 9,500 kg of Pb discharged into the Columbia River over a four hour period [Washington Department of Ecology (WDOE) 2008a *pers. Comm*]. Pb concentrations in water samples collected by WDOE at Kettle Falls the day after the spill exceeded chronic WQC (WDOE 2008b *pers. comm*.). Other water quality monitoring data, including data collected by the BC Ministry of the Environment (1975-77), indicated that sporadically-elevated concentrations of these COPCs could be related to discharges from the Teck facility (Smith 1987).

4.2.2 Pore Water

Pore water is the water that occupies the spaces between sediment particles in lakes and streams. Because benthic invertebrates, including freshwater mussels, and some species of fish are closely associated with sediments and utilize the interstitial spaces within sediments for feeding, spawning, and cover (particularly during sensitive life-stages), these organisms can be exposed to contaminants in pore water. Such exposure to contaminants in pore water can result in direct toxicity (USEPA 2003; 2005) and/or accumulation of contaminants in tissues, resulting in exposure of higher-trophic level species to bioaccumulative COPCs.

Table 4.1. Examples of UCRS surface water metals (Cd, Hg, Pb) concentrations (µg/L) that have exceeded chronic WQC for the protection of aquatic life, Canadian water quality guidelines (WQGs) for protection of aquatic life, and Spokane Tribe of Indians chronic surface water quality standards (SWQSs). (UCRNRTC 2010)

Metal	Year	Measured Concentration in the UCRS	National Recommended WQC[1]	Canadian WQG[2]	STI SWQS[3]
Cd[4], dissolved	1984	18	0.9	1.1	1.0
	1985	17			
	1986	21			
	1988	9			
Hg[4], dissolved	1980	1	0.012	0.012	0.01
	1983	7			
	1988	0.8			
Pb[5], total	2008	7.8	2.8	3.2	2.5

[1] National Recommended Water Quality Criteria (USEPA 2006); adjusted for hardness
[2] Environment Canada, compendium of environmental quality benchmarks (MacDonald *et al.* 1999).
[3] STI Surface Water Quality Standards (STI 2010).
[4] From Johnson *et al.* (1988).
[5] WDOE (2008b pers. comm.)

The results of investigations conducted previously indicate that dissolved metals in pore water from UCRS sediment samples have the potential to exceed concentrations that cause adverse effects to benthic invertebrates and fish. More specifically, the existing data confirm that dissolved metals concentrations are elevated in pore water within the UCRS (Johnson *et al.* 1990; Paulson and Cox 2007; Besser *et al.* 2007). In the early 1990s, WDOE conducted a pore-water evaluation and found that concentrations of Cd, Cu, Pb, and Zn exceeded federal WQC for the protection of aquatic life. More recently, the United States Geological Survey (USGS) collected pore-water samples from eight sites throughout the UCRS and reported the following median metals concentrations measured for those locations. The data demonstrated that the concentrations of Cd, Cu, and Pb exceeded the federal WQC for the protection of aquatic life (Table 4.2).

Table 4.2. Pore-water concentrations (µg/L) measured in the UCRS (Paulson and Cox 2007) compared to USEPA freshwater chronic criteria for the protection of aquatic life, STI chronic criteria (STI 2008) and to reference concentrations. (Reproduced from UCRNRTC 2010)

Metal	USEPA Chronic Criteria[1]	Canadian WQG[2]	STI Chronic Criteria[3]	Measured UCRS Concentrations	Reference Concentration[4]
Cd	0.22	0.033	1.0	<0.1 to 0.48	<0.1
Cu	7.7	2.36	9.0	< 0.5 to 9.2	0.55
Pb	2	3.18	2.5	0.5 to 4.9	0.5

[1] National Recommended Water Quality Criteria (USEPA 2006); adjusted for hardness.
[2] CCME (1999); guideline based on water hardness of 100 mg/L CaC02.
[3] STI Surface Water Quality Standards (STI 2010).
[4] Reference concentrations were those reported in Paulson and Cox (2007) for comparison to study area. Reference samples collected from Sanpoil River.

4.2.3 Sediments

Discharges of granulated slag from the Teck facility in Trail, BC have contributed to widespread contamination of surficial sediments in 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, in part settling along riverine shorelines and within the slower water velocity zones of the river and Lake Roosevelt. These large deposits of slag have elevated concentrations of trace metals in sediments, which are released through natural weathering processes (Cox *et al.* 2005). Effluents released from the Teck facility have also contributed to sediment contamination throughout the UCRS (Paulson and Cox 2007).

Many studies conducted over the past three decades have reported elevated metal 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 tend to be present at lower concentrations in downstream areas. Metals have also been released into the UCRS in the dissolved, colloidal, or suspended forms, resulting in contamination of sediment independent of slag deposition. More specifically, certain smelter metals, such as Hg and Cd, demonstrate transport patterns and distributions independent of other slag-associated contaminants (CH2MHill 2006; Johnson *et al.* 1988). Elevated metals concentrations have been documented in sediments 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) confirm that metal 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 As, Cd, Cu, Pb, Hg, and Zn exceeded thresholds for potential impacts to benthic organisms (Table 4.3).

Table 4.3. Measured total recoverable sediment concentrations (mg/kg DW) at the Upper Columbia River in 1986 (Johnson *et al.* 1990), 2004 (Besser *et al.* 2008) and 2005 (CH2MHill 2006) compared to consensus-based sediment quality guidelines (SQGs) for the protection of benthic receptors (MacDonald *et al.* 2000) and CCT and STI sediment standards. (Reproduced from UCRNRTC 2010)

			Measured in UCRS Sediments		
Metal	SQG	CCT[1]/STI[2] HSCA	1986	2004	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 studies have reported that elevated concentrations of chlorinated organic compounds, including PCDDs/PCDFs, occur in UCRS sediments (Hopkins *et al.* 1985; Johnson *et al.* 1991a). The primary reported source of PCDDs/PCDFs in the Upper Columbia River in Canada is the Zellstoff Celgar pulpmill in Castlegar, BC (Johnson *et al.* 1991a). These investigators also reported that elevated PCDD/PCDF concentrations in sediments occurred in depositional areas, in finer-grained sediments, and in sediments with higher total organic carbon content. This study also noted that the concentrations of PCDDs/PCDFs in the tissues of bottom-feeding fish were correlated with those in co-located sediments.

4.2.4 Benthic Invertebrates

Benthic invertebrates play major roles in nutrient cycling and transfer in aquatic ecosystems. Exposure to contaminated sediments may impact these communities by reducing the survival, growth, biomass, or reproduction of benthic invertebrates. As many fish and wildlife species depend on benthic invertebrates as a food source, reductions in the biomass of benthic invertebrates due to exposure to contaminated water and/or sediments can adversely affect a variety of biological resources. In addition, benthic invertebrates can accumulate contaminants from sediments and may transfer contaminants to higher organisms through dietary pathways.

Benthic invertebrates have been used as ecological indicators of disturbance for nearly 100 years (Peplow and Edwards 1999). In the UCRS, numerous studies have been conducted to evaluate toxicity to benthic invertebrates associated with exposure to sediments from the UCRS (Johnson *et al.* 1988; Bennett and Cubbage 1992; Bortleson *et al.* 1994; Era and Serdar 2001; Besser *et al.* 2008). The results of these studies have all demonstrated that exposure to UCRS sediments (i.e., those with elevated levels of COPCs), causes toxicity to test organisms in the laboratory. For example, Johnson *et al.* (1988) observed reduced survival, relative to a control group, in *Hyalella azteca* and *Daphnia magna* exposed to sediment from two of the six sites tested. Similarly, Bennett and Cubbage (1992) observed acute toxicity, relative to control, in *H. azteca* and *D. magna* exposed to sediment from two of the six sites tested). In addition, reduced light emission by the bacterium *Photobacterium phosphoreum* (relative to control) was observed for two of the six sites tested. Bortleson *et al.* (1994) observed reduced survival of amphipods, *Hyalella azteca*, and of cladocerans (water fleas), *Ceriodaphnia dubia*, exposed to certain sediments from the UCRS. Impaired reproduction was also observed in cladocerans exposed to sediments from three of the five sediments that were tested. Toxicity was observed at 18 out of 19 sites when the bacterium, *P. phosphoreum*, was exposed to fine-grained sediments; eight of 20 sites were classified as toxic when bacteria were exposed to pore water from UCRS sediments. Besser *et al.* (2008) reported reduced survival of amphipods at one of seven sites and reduced growth of midge at four of seven sites sampled in the UCRS. Based on a re-evaluation of the data collected by USEPA in 2005, MacDonald *et al.* (2011) reported that sediment samples from the UCRS were frequently toxic to amphipod (*H. azteca*), midge (*Chironomus dilutus*) and cladocerans (*C. dubia*). Collectively, the results of these investigations demonstrate that benthic macroinvertebrates have been exposed to COPCs and that such exposures have the potential to adversely affect the benthic community in the UCRS. Such adverse effects have occurred from at least the early 1990s to the present.

4.2.5 Freshwater Mussels

Freshwater mussels have declined by as much as 75 percent throughout North America and it has been suggested that exposure to contaminants may be one of the reasons 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, aquatic-dependent 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 abundance within the UCRS, and no tissue residue data are available for the assessment area. However, studies conducted upstream of the UCRS in British Columbia in the 1990s found that mussels in the Canadian reach of the Columbia River near Waneta are exposed to metals from the Teck facility, and mussels downstream of Celgar are exposed to dioxins and furans originating from the pulp mill. In both cases, mussels had accumulated these contaminants in their tissues. For example, freshwater mussels collected near Waneta, BC, had tissue metals concentrations significantly higher than those from Kootenay Lake (the reference location sampled for the study) (Aquametrix Ltd. 1994), while 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 (Butcher 1992; Table 4.4).

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 associated with such exposures are unknown, other receptors (e.g., sturgeon, mink, water birds) that feed on mussels produced within the UCRS may be exposed via a dietary pathway and are potentially at risk. The absence of mussel tissue data in the United States portion of the UCRS represents a data gap.

Freshwater mussels in the UCRS may also be adversely affected due to exposure to contaminated pore water. An independent USGS study recently evaluated dissolved Cu toxicity to freshwater mussels to determine juvenile mussel sensitivity to this contaminant (Wang *et al.* 2007). The resultant 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 occurring at 4.6 to 8.5 μg/L Cu (Wang *et al.* 2007). Another study determined that the glochidia (larval phases) of two endangered mussel species exhibited 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). By comparison, Paulson and Cox (2007) measured Cu concentrations of up to 9.2 µg/L in pore water collected near Northport, Washington.

Table 4.4. 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. (Reproduced from UCRNRTC 2010)

Contaminant	Measured UCRS Concentrations	Reference Concentrations[3]	Maximum Factor of Exceedance Above Reference
Cd	13.3	3.6	3.7
Cu	64.2	6.1	11
Pb	251	4	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	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).

4.2.6 Fish

A wide variety of fish species utilize habitats within the UCRS. In addition to the resident fish species, the UCRS is currently managed as a put and take fishery for triploid rainbow trout. These fisheries resources have substantial economic, recreational, ecological, and tribal importance. Exposure to COPCs can adversely affect the productivity of these communities by impairing the survival, growth, or reproduction of fish species. In addition, accumulation of COPCs in the tissues of fish can adversely affect those species that consume fish as part or all of their diets.

Data from a variety of sources indicate that fish utilizing habitats within the UCRS have been exposed to certain COPCs. More specifically, Serdar *et al.* (1994) reported that largescale suckers collected near Northport, Washington, had mean concentrations of Pb in their tissues (whole body) that were 110 times higher than the average concentrations that were measured in 315 fish-tissue samples collected at over 100 sites in the United States (i.e., as reported in Schmidt and Brumbaugh 1990). Fish-tissue samples from the UCRS also exceeded nationwide averages for Cd, Cu, Hg, and Zn (Serdar *et al.* 1994; as cited in UCRNRTC 2010).

Releases of Hg from upstream sources (including numerous Hg spills from Teck) have contributed to the elevated Hg found in the tissues of resident fish collected from the UCRS. Munn *et al.* (1995) reported that skinless walleye fillets collected from Lake Roosevelt near the Sanpoil River embayment had mean concentrations of 0.39 mg/kg wet weight Hg. Munn and Short (1997) reported that over 50 percent of walleye samples collected in the UCRS exceeded the national median value of 0.17 mg/kg. These concentrations exceeded the toxicity threshold 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 4.5 summarizes Hg concentrations that have been measured from 1986 to 2005 (UCRNRTC 2010).

Table 4.5. Mercury concentrations (mg/kg WW) measured in Upper Columbia River fish fillets and whole body (WB), 1980s to 2005 (toxicity threshold is 0.2 mg/kg WW; Beckvar *et al.* 2005). (Reproduced from UCRNRTC 2010)

Year	Fish/Tissue	Measured UCRS 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 Walleye, fillets	0.23 0.33	USEPA 2005 data[1]

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

The concentrations of Hg in the tissues of fish from the UCRS have resulted in fish consumption advisories issued by the Washington Department of Health (WDOH). An Hg-based advisory is currently in place for three species of fish (walleye, burbot, and largescale sucker; WDOH 2008a. Fish tissue Hg concentrations have also exceeded the levels that would be protective of sensitive ecological receptor groups.

The available data indicate that resident fish in the UCRS have accumulated certain organic contaminants that are typically associated with discharges from pulp and paper mills. Table 4.6 provides a summary of the maximum concentrations of PCDDs/PCDFs that have been measured in fish from the UCRS between

1990 and 2005. 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 exposed to this concentration of TCDD in their diet had an increased occurrence of deformities and reduced survival compared to control fish. Comparison of the measured concentrations of PCDDs/PCDFs in fish tissues (Table 4.6) to the effects threshold reported by Giesy *et al.* (2002) suggest that piscivorous (fish-eating) fish in the UCRS could be adversely affected through dietary exposure of contaminated prey. 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). The USEPA 2005 data indicate that PCDD and PCDF concentrations continue to be elevated in UCRS fish.

Table 4.6. 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 (toxicity threshold is 1.8 pg/g WW; Giesy *et al.* 2002). (Reproduced from UCRNRTC 2010)

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	USEPA 2005 data[1]

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

4.2.7 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 UCRS indicate that there are fewer than 1,000 wild adults remaining within the study area. The population comprises 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 in the Upper Columbia River and 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 Washington Department of Fish and Wildlife hatchery in Moses Lake, WA, with approximately 10,000-13,000 fish released annually into the Columbia River at various locations between Castlegar, BC and the Kettle Falls area (UCWSRI 2011). White sturgeon are an important resource for the Tribes, as they are traditionally used for subsistence and cultural purposes.

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. 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 percent 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 to Cu than are rainbow trout. As Paulson and Cox (2007) observed that median pore-water Cu concentrations were on the order of 9.2 μg/L in the river reach of the UCRS near Northport, it is likely that white sturgeon utilizing habitats in this reach for early rearing have been adversely affected by exposure to Cu. In addition, maximum Cu concentrations of 4.9 to 5.2 μg/L were observed in two locations upstream of the Marcus Flats area. As white sturgeon spawning and juvenile dispersal is known to occur in the upper reaches of the UCRS, and spawning adults have been located as far down as Marcus Flats, it is likely that Cu-related effects could be occurring throughout the riverine portion of the UCRS (Wang *et al.* 2011; Calfee *et al.* 2011; Little *et al.* 2011; Little and Calfee 2011).

White sturgeon inhabiting the UCRS may also be exposed to organochlorine contaminants (such as dioxins and furans) at concentrations sufficient to cause adverse effects to sturgeon or exposure/impacts 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, while other species (e.g., bald eagles) may scavenge carcasses of juvenile or 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 thereafter, 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 2,3,7,8-TCDD toxic equivalent (TEQ) values 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 percent of all TEQ values reported in an USEPA national fish survey that the authors used for comparison to study data. Table 4.7 summarizes Johnson *et al.* (1991a) data that exceeded literature-based effect levels for wildlife species. There are significant data gaps relative to current information on body burdens of PCDDs/PCDFs in white sturgeon from the UCRS. However, given the long life of white sturgeon (many adult sturgeon found in the reservoir and upper river today may have been exposed to elevated PCDD/PCDF concentrations that existed 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. Hence, white sturgeon within the UCRS have likely been exposed to PCDDs/PCDFs, as have been the wildlife species that feed on sturgeon in the UCRS.

Table 4.7. 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 River white sturgeon tissues, and literature-based effect levels. (Reproduced from UCRNRTC 2010)

Contaminant	Maximum UCRS Concentrations	Literature-Based Toxicity Threshold	Endpoint Measure
2,3,7,8-TCDD TEQ	25	10 to 12	Protection of piscivorous birds and mammals (Eisler 1986)
2,3,7,8-TCDD	4.4	0.9	Protection of Columbia River bald eagles (Buck *et al.* 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)
2,3,7,8-TCDF	222	7.5	Protection of Columbia River bald eagles (Buck *et al.* 2004)

4.2.8 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 through the consumption of aquatic prey (i.e., benthic invertebrates, mussels and fish). Adverse effects on these wildlife resources could result in economic losses in wildlife-based recreation, alterations to ecological functions, and losses to tribal members.

Available UCRS data indicate that piscivorous birds and mammals inhabiting the site may be exposed and potentially adversely affected 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 recently (2003) often exceeded literature-based toxicity thresholds for the 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 percent of USEPA nationwide surveys (Johnson *et al.* 1991a). Recently, total TEQs have ranged to 30 pg/g in the tissues of walleye collected from 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 2,3,7,8-TCDD TEQs in fish tissues, and have established dietary effect levels for birds and mammals that feed primarily on fish. Data from the UCRS indicate that fish-tissue concentrations exceeded these toxicity thresholds from the late 1980s until recently. Table 4.8 summarizes TEQ, dioxin and furan concentrations, measured over time, in fish tissues from the UCRS that exceed literature-based dietary effect thresholds for piscivorous wildlife.

Like organochlorine contaminants, Hg concentrations in UCRS fish tissues may be transferred to piscivorous birds and contribute to adverse effects on survival, growth, or reproduction. Munn and Short (1997) measured concentrations up to 0.44 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 4.5 summarizes additional Hg concentrations 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.

Table 4.8. TEQ values, 2,3,7,8-TCDD and 2,3,7,8-TCDF concentrations (pg/g WW) measured in fish tissue throughout the Upper Columbia River from 1989 to 2005, and literature-based dietary effect levels for piscivorous wildlife. (Reproduced from UCRNRTC 2010)

Maximum UCRS Concentrations (pg/g WW) by Year			Literature-based Toxicity Threshold (pg/g WW)	Endpoint Measured
2,3,7,8-TCDD 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)
2,3,7,8-TCDD	1989	4.0 (walleye) [3]	0.9	Protection of Columbia River bald eagles (Buck *et al.* 2004)
	2005	3.3 (burbot) [2]	3	Protection of piscivorous wildlife (Newell *et al.* 1987)
2,3,7,8-TCDF	1990	205 (whitefish)[1] 48 (sucker) [4]	7.5	Protection of Columbia River bald eagles (Buck *et al.* 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)

Burgess and Meyer (2008) indicated that the reproductive productivity of piscivorous birds declined by 50 percent when fish tissues exceeded 0.21 mg/kg WW of Hg. Furthermore, piscivorous bird reproduction failed completely when fish tissues exceeded 0.41 mg/kg WW of Hg. Likewise, Wiener and Spry (1996) demonstrated reproductive impairment in loons at fish-tissue concentrations of 0.1 to 0.3 mg/kg WW of Hg.

4.2.9 Upland Soils and Lakes

Widespread plumes of smoke 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 effects on 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, with concentrations that were up to 30 times greater than reported background concentrations (Goodzari *et al.* 2002a; 2002b). At stations near the US-Canada border, concentrations were five times greater than background for Pb, three times greater than background for Hg, and 1.5 to two times greater than background for Zn and Cd. This study also suggested that prevailing winds from the northeast were 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). In addition, upland areas adjacent to historic UCRS floodplains or sediments exposed by Lake Roosevelt drawdowns are subject to potential contamination via the mobilization of dried sediments by the region's strong winds. However, WDOE recently conducted a study to evaluate mercury contamination in lake sediments throughout northeast Washington (WDOE 2011). The results of this study confirmed that lakes located within the area affected by aerial emissions from the Teck facility had higher mercury levels than lakes located further from that source.

However, recent studies evaluating potential contamination in the United States resulting from smelter emissions or windblown dust, and potential adverse impacts to natural resources within the UCRS, are generally lacking and represent a data gap for this site. WDOE recently conducted a study to evaluate Hg contamination in lake sediments throughout northeast Washington (WDOE 2011). The results of this study confirmed that lakes located within the area affected by aerial emissions from the Teck facility had higher Hg levels than lakes located further from that source.

4.3 Preliminary Determination of Recovery Period

This section of the Plan provides a preliminary determination of the recovery period for the exposed natural resources of the assessment area. This preliminary determination is based on information contained in the existing literature and can serve as a basis for determining if the approach proposed for assessing adverse effects is likely to be cost effective [43 CFR § 11.31(a)(2)].

Under the USDOI NRDA regulations, a recovery period is defined as either:

- The longest length of time required to return the services of the injured resource to their "baseline condition," which is the condition that would have existed had the hazardous substance release(s) not occurred; or,
- A lesser period of time selected by the Trustees and documented in the Assessment Plan [43 CFR § 11.14(gg)].

Services are defined as the physical and biological functions performed by the resource, including the human uses of those functions. These services are the result of the physical, chemical, or biological quality of the resource [43 CFR § 11.14(nn)]. The following factors are relevant for estimating recovery times:

- Ecological succession patterns in the area;
- Growth or reproductive patterns, life cycles, and ecological requirements of biological species involved, including their reaction or tolerance to the hazardous substance involved;
- Bioaccumulation and extent of hazardous substances in the food chain; and,
- Chemical, physical, and biological removal rates of the hazardous substance from the media involved [43 CFR § 11.73(c)(2)].

Recolonization rates may also be relevant for estimating recovery times for certain natural resources. As indicated in Section 2, the provisional list of COPCs in the UCRS includes seven metals (As, Cd, Cu, Cr, Pb, Hg, and Zn), PCDDs/PCDFs, chlorinated phenolics, PCBs, sulfuric acid, PAHs, pesticides, and copper sulfate. This preliminary determination of recovery period for the Site Assessment Area discusses the natural processes that may result in losses of these COPCs from the environment. Natural resources within the UCRS will remain exposed to these COPCs as long as environmental media, such as soils, sediments, groundwater, and surface water, remain contaminated and continue to operate as exposure pathways for biological resources.

4.3.1 Metals

Metals have been released into the UCRS in association with discharges of liquid effluents from various sources and in slag from smelting sources. For the metals that were released into water, sorption to organic and/or inorganic particulates and subsequent precipitation are major environmental fate processes. While the metals that become associated with suspended or bottom sediments can be remobilized under various conditions, they are not degraded by any process (CCME 1999). Therefore, the processes that influence cycling in the aquatic environment are likely to dictate the fate of metals released into the UCRS. Accordingly, metals are likely to be highly persistent in the aquatic ecosystem within the UCRS.

4.3.2 Polychlorinated Dibenzo-*p*-dioxins and Polychlorinated Dibenzofurans

The pulpmill in Castlegar, BC, represents the principal source of PCDDs/PCDFs in the UCRS. However, these COPCs can be released from other sources as well. The fate of several PCDD congeners in sediment has been studied both in laboratory and field mesocosm studies. In general, the results of these investigations indicate that aqueous sediments have high affinities for PCDDs and, as such, these substances may accumulate to significant levels in this medium (Czuczwa and Hites 1986). In addition, PCDDs are very stable in sediments and, therefore, tend to persist for extended periods in this environmental matrix. Furthermore, PCDDs and PCDFs that are associated with bed sediments may represent long-term sources to the aquatic food web (Kuehl *et al.* 1987; Muir 1988).

Little information was found on photolysis, hydrolysis, or microbial degradation of PCDDs or PCDFs in freshwater sediments. However, the results of several laboratory incubation studies indicate that these are likely to be minor fate processes in aqueous sediments. For example, Muir *et al.* (1985) reported that 1,3,6,8-T_4CDD added to sediment/water systems partitioned rapidly into sediments and the majority of the compound added to the system remained in the sediment phase for the duration of the experiment. After 675 days under stable aerobic conditions, 80 percent of the radiolabelled T_4CDD was still present in pond and lake sediments (as the parent compound; Muir *et al.* 1985). Similarly, Ward and Matsumura (1978) estimated that between 1 and 4 percent of the T_4CDD added to laboratory sediment/water incubations was degraded over a 588 day period.

The fate of sediment-associated PCDDs is more complex in test systems that are designed to simulate aquatic ecosystems. Tsushimoto *et al.* (1982) constructed model aquatic ecosystems (roughly 185 m^3)

that consisted of water, sediment (4.1 percent organic matter), two aquatic macrophytes (*Elodea nuttali* and *Ceratophyllum demersum*), and an unspecified fish species. Addition of T_4CDD (to a concentration of 53.7 ng/L) to these test systems resulted in a rapid increase in the concentration of this substance in sediments (up to 2,700 ng/kg) within the first four days of the study. Within 50 days, the concentration of T_4CDD in sediment had dropped to 500 ng/kg, and to 97 ng/kg within 365 days. During that period, the concentrations of T_4CDD in the macrophytes and fish increased to over 2,000 ng/kg, indicating significant transfer of this substance into biological tissues, primarily from the sediments. The macrophyte-associated T_4CDD accounted for more than 85 percent of the T_4CDD-radioactivity remaining after 365 days in this mesocosm. After 750 days, however, sediment-associated T_4CDD accounted for virtually all of the remaining T_4CDD-radioactivity measured in the system. The results of this experiment suggest that sediment-associated T_4CDD may undergo complex cycling between the abiotic and biotic components of the ecosystem.

In a similar study, Servos *et al.* (1992a) investigated the fate of 1,3,6,8-T_4CDD and O_8CDD in large (40 m^3) lake enclosures in northern Ontario. These mesocosms consisted of water (2 metres deep), sediment (25.4 percent organic carbon), and the benthic and planktonic organisms that typically occur in the lake. The results of this study indicate that these substances are very stable in bed sediments. After 720 days, sediment-associated 1,3,6,8-T_4CDD accounted for 57 percent of the ^{14}C initially added to the limnocorral. Likewise, O_8CDD in sediment accounted for 55 percent of the radiolabelled-O_8CDD originally added to the test system. In shallow outdoor pools, however, only a small proportion (7.9 to 17.7 percent) of the 1,3,6,8-T_4CDD originally added to the test system (which included water, sediment, rooted plants, and duckweed) was associated with sediments after 426 days (Corbet *et al.* 1988). These investigators suggested that photolysis, uptake and transformation by plants, and degradation in sediments were responsible for the significant losses of 1,3,6,8-T_4CDD observed during the course of the study.

In the environment, PCDDs and PCDFs are likely to be highly persistent once they are incorporated into sediments. The half-life of T_4CDD in sediment has been estimated at between 130 days (Corbet *et al.* 1988) and more than 2 years (Servos *et al.* 1992a; 1992b) in mesocosm studies. Nonetheless, important evidence exists to suggest that PCDD may persist in freshwater and marine sediments for even longer periods (OMOE 1985). For example, Jansson *et al.* (1987) reported low levels of the higher chlorinated PCDD congeners in lake sediments that were 300 to 1,000 years old. Likewise, Hashimoto *et al.* (1990) detected significant quantities of 1,2,3,4,6,7,9-H_7CDD (52 ng/kg) and O_8CDD (320 ng/kg) in deep sediments from an inland sea in Japan. These sediments were estimated to be approximately 8,120 years old. These data indicate that PCDDs may be very stable in sediments below the biologically-active layer (i.e., top 5-15 cm), particularly in areas with high sedimentation rates.

4.3.3 Polychlorinated Biphenyls

PCBs are highly persistent compounds and degrade very slowly in the environment (Eisler 1986; Erickson 1997). In fact, their resistance to most chemical degradation processes is one of the key features that led to their widespread use (Erickson 1997). However, PCBs can be degraded by microbial communities under both aerobic (i.e., in the presence of oxygen) and anaerobic (i.e., with no oxygen present) conditions. Both aerobic degradation and anaerobic dechlorination have been documented in sediments from PCB-contaminated aquatic systems (e.g., Brown and Wagner 1990; Flanagan and May 1993), although these processes are much slower for PCBs than for other compounds (Erickson 1997). Where it occurs, aerobic microbial degradation acts primarily on selected lower chlorinated PCB congeners, ultimately producing carbon dioxide, water, and chloride ions (Erickson 1997). Anaerobic microbial degradation involves dechlorination, where chlorine atoms are preferentially removed from the higher chlorinated congeners and lower chlorinated PCB congeners are produced (Brown *et al.* 1987a; 1987b; Abramowicz *et al*. 1993). Anaerobic dechlorination typically does not reduce the amount of PCBs present, but reduces the number of chlorine atoms on the PCB molecules that remain subject to dechlorination.

The ability of anaerobic microbial communities to dechlorinate PCB congeners is congener- and site-specific, with different river systems showing different patterns of dechlorination, presumably related at least in part to differences in microbial communities present (Brown *et al.* 1987a; 1987b; Rhee *et al*. 1993a; Sokol *et al*. 1994). The total PCB sediment concentration is also a primary factor regulating PCB dechlorination, with dechlorination rates increasing with increasing sediment PCB concentration (Abramowicz *et al*. 1993). An apparent threshold concentration may exist below which dechlorination is very slow or does not occur. For example, in PCB-contaminated reaches of the Hudson River (a PCB-contaminated Superfund site in New York), a threshold sediment concentration of 30 mg/kg DW was estimated for dechlorination of PCBs (USEPA 1997). Sokol *et al*. (2009) also observed a similar threshold concentration for PCB dechlorination in sediment collected from PCB-contaminated reaches of the St. Lawrence River; no dechlorination was detected at concentrations below a threshold of between 35 and 45 mg/kg DW. However, a recent evaluation of dechlorination studies conducted as part of the USEPA's reassessment of the Hudson River PCB Superfund site concluded that a threshold concentration for dechlorination is not supported by the available data (Eastern Research Group 1999). While dechlorination is predictable at higher PCB concentrations, there is some uncertainty regarding whether dechlorination occurs at lower concentrations (Eastern Research Group 1999). Rhee *et al*. (1993b) observed that dechlorination did not occur at elevated PCB concentrations (e.g., in the 1,000 to 1,500 mg/kg DW range), indicating that dechlorination may be inhibited at extremely elevated PCB concentrations as well. As summarized in Sokol *et al*. (2009), natural recovery via anaerobic dechlorination appears to be limited for the following reasons:

- Chlorine removal decreases as sediment PCB concentration decreases;
- Chlorine removal is limited by the position and pattern of chlorine substitution on the biphenyl molecule; and,
- Chlorine removal appears to be limited below a threshold concentration of approximately 30 mg/kg DW.

In the Hudson River for example, it has been estimated that dechlorination reduced the original PCB concentrations (on a mass basis) present in the river by less than 10 percent (USEPA 1997). USEPA (1997) concluded that the remaining PCBs in the Hudson River would not be further naturally remediated via dechlorination.

Other natural processes related to the loss of PCBs include volatilization and desorption into the water column (from the sediment) and migration downstream. However, both of these processes typically are slow due to the very low vapor pressure and hydrophobicity of PCB molecules (Erickson 1997). Because of the persistence of PCBs in the environment, natural recovery of PCB contamination will proceed very slowly at the Site.

4.3.4 Recovery Period (Preliminary Determination)

Sediment burial and downstream particulate transport are typically the primary loss mechanism for metals, PCBs, and PCDDs/PCDFs in riverine systems (e.g., Velleux and Endicott 1994). However, sedimentation rates in the UCRS are low due to up-gradient, system-wide hydraulic controls (Cox *et al*. 2005; Paulson and Cox 2007) and the COPCs buried in deeper sediment can be re-exposed through anthropogenic activities (e.g., dredging, boating) or through scouring associated with high-flow events. Similarly, COPCs in upland areas are likely to be persistent, both in soils and in upland aquatic environments. Although the Trustees are unable to quantify an expected natural recovery period for the Site at this time, the chemical nature of metals, PCDDs/PCDFs, and PCBs, as well as the environmental fate of theses COPCs, indicate that the natural recovery period is expected to be very long, at least on the order of many decades or, more likely, on the order of centuries, for these substances. The Trustees will conduct an evaluation of the relevant data and information to develop an appropriate working estimate of the recovery period.

5. The Upper Columbia River Injury Assessment

5.1 Introduction

The information presented in Section 4 of the Injury Assessment Plan confirms that natural resources in the Upper Columbia River Site (UCRS) assessment area have been exposed to hazardous substances. Under the United States Department of Interior (USDOI) regulations, injury is defined as a ". . . *measurable adverse change, either long- or short-term, in the chemical or physical quality or the viability of a natural resource resulting either directly or indirectly from exposure to a . . . release of a hazardous substance, or exposure to a product of reactions resulting from the . . . release of a hazardous substance.*" Accordingly, natural resources within the assessment area may have been injured as result of their exposure to hazardous substances.

An injury assessment comprises two of the steps outlined in Section 3:

- ***Injury determination***, or the process through which Trustees document "measurable adverse changes" in one or more natural resources, resulting from exposure to released hazardous substances, as well as the pathways by which exposure occurred [43 CFR §§ 11.62 and 11.63]; and
- ***Injury quantification***, in which the Trustees measure injury-induced changes in the quantity and quality of natural resource services relative to their "baseline" condition [43 CFR § 11.71(b)(2)].

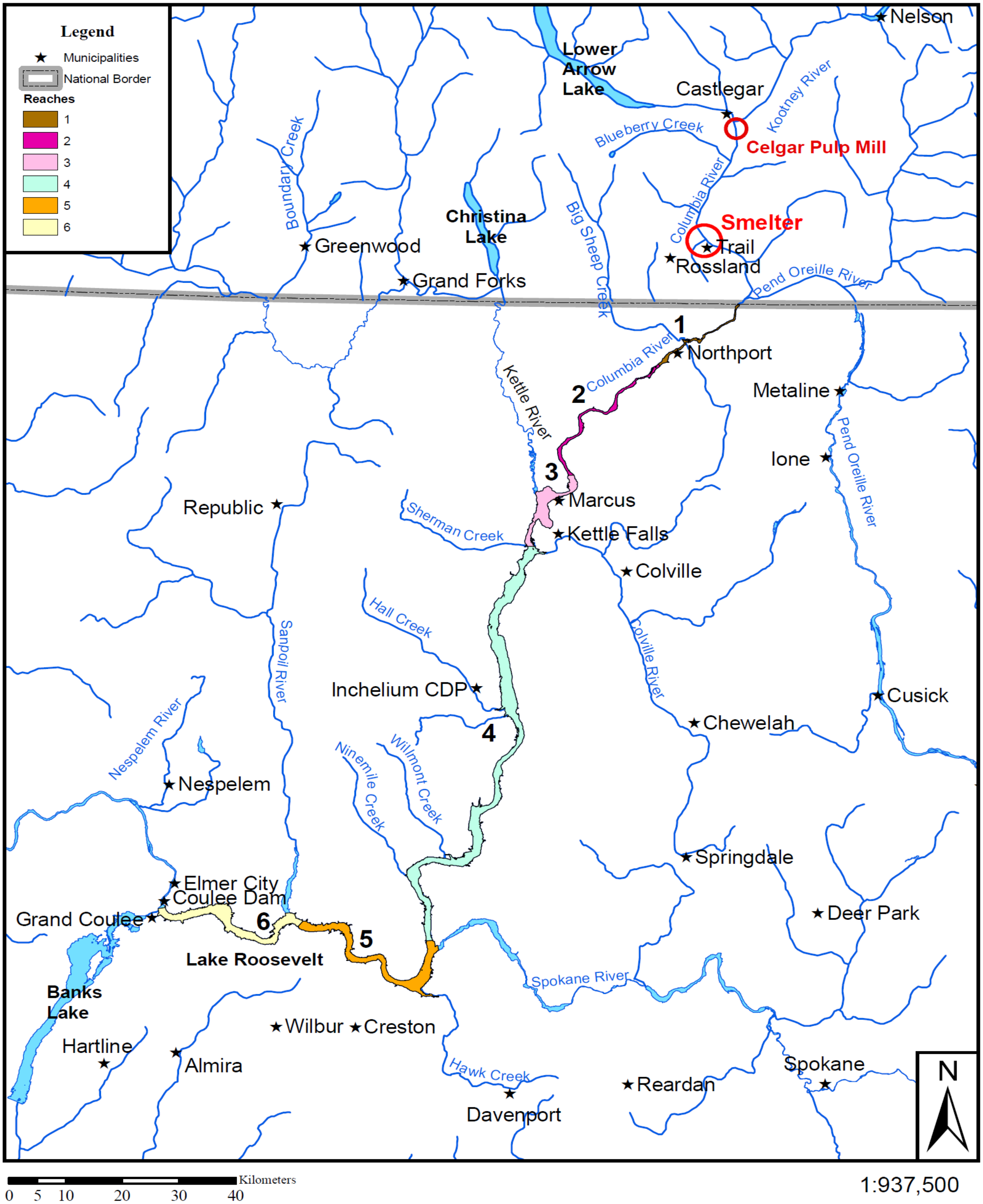
This Plan focuses on the injury determination phase of the assessment; the Trustees will present their approach to subsequent assessment phases (injury quantification, damage determination) in addenda to this Plan. By proceeding in this deliberate, incremental manner the Trustees will be able to ensure that each step of the assessment process informs the next and thus maximizes the assessment's overall cost-effectiveness.

5.2 Geographic Scope of the Natural Resource Damage Assessment

The geographic scope of the UCRS is currently defined as the Columbia River and Lake Roosevelt south of the Canada-US border to the Grand Coulee Dam, and associated wetland, riparian, flood plain, and upland terrestrial and lacustrine habitats influenced or affected by historic smelter and pulp industry operations. However, that definition of the study area does not provide a basis for evaluating spatial patterns in contamination or associated injuries to natural resources. For this reason, the riverine portions of the study area have been divided into six river reaches. The delineation of the various river reaches, summarized below and illustrated in Figure 5.1, is generally consistent with, or similar to, those used in past studies conducted by United States Geological Survey (USGS); Bortleson *et al.* (1994), Cox *et al.* (2005), and USEPA (e.g., Schut and Steffanoff 2007).

- *Reach 1 [US-Canadian Border at USGS River Mile (RM) 745 to RM 730]* – This reach is consistent with the Northport Reach identified by USGS. It begins at the upstream boundary of the Site and extends approximately to Onion Creek. This reach can be characterized as a swift river environment (i.e., riverine) that is typically unaffected by the reservoir.
- *Reach 2 (USGS RM 730 to RM 712)* – This reach is consistent with the Upper Reservoir Reach identified by USGS. It extends to the vicinity of Evans and Powell, Washington, and can be characterized as a narrow channel within the reservoir that has few shoreline embayments and irregularities.
- *Reach 3 (USGS RM 712 to RM 699)* – This reach is consistent with the upper portion of the Middle Reservoir Reach identified by USGS, and consists primarily of Marcus Flats. This reach can be characterized as a depositional area for coarse-grained sediments in the historical river channel and for fine-grained sediments in many of the shallower areas.
- *Reach 4 (USGS RM 700 to RM 640)* – This reach is consistent with the lower portion of the Middle Reservoir Reach identified by USGS and extends from above the mouth of the Colville River to above the mouth of the Spokane River. It can be further subdivided into Reaches 4a and 4b, with the boundary occurring at USGS RM 676 near Inchelium and Gifford, where the width of the overall reach narrows considerably.
- *Reach 5 (USGS RM 640 to RM 617)* – This reach is consistent with the upper portion of the Lower Reservoir Reach identified by USGS, and extends to above the mouth of the Sanpoil River. It can be characterized as a lacustrine environment with slow moving water.
- *Reach 6 (RM 617 to Grand Coulee Dam near RM 597)* – This reach is consistent with the lower portion of the Lower Reservoir Reach identified by USGS, and extends to the downstream boundary of the Site. It can be characterized as a lacustrine environment with slow-moving water.

Figure 5.1. Map of the Upper Columbia River region, showing the six reaches that will be evaluated in the NRDA.



5.3 Temporal Scope of the Natural Resource Damage Assessment

For the purposes of injury determination and quantification, the Trustees will evaluate past, present, and expected future injuries to natural resources in the UCRS.

5.4 Data Sources

The Trustees will gather and analyze data and information from a variety of sources to support the determination of natural resource injuries associated with discharges of hazardous substances into the UCRS. These data sources fall into three general categories, including:

- Current and historical data;
- Existing and future remedial investigation (RI) data; and,
- Damage assessment data.

Each of these candidate data sources are briefly described below.

5.4.1 Current and Historical Data

The Trustees will gather and evaluate any available historical data and information that is relevant for assessing injuries to natural resources associated with exposure to site-related chemicals of potential concern (COPCs), including metals, polychlorinated dibenzo-*p*-dioxins/polychlorinated dibenzofurans (PCDDs/PCDFs), polychlorinated biphenyls (PCBs), and other hazardous substances. The data sources that will be acquired and evaluated to support the natural resource damage assessment (NRDA) include:

- Articles published in the peer-reviewed literature;
- State, tribal and federal government data and reports; and
- Industry data and reports.

5.4.2 Remedial Investigation Data

In 1999, the Confederated Tribes of the Colville Reservation petitioned the United States Environmental Protection Agency (USEPA) to conduct an assessment of hazardous substance contamination in the UCRS (CH2M Hill 2006). The petition expressed concerns about possible risks to human health and the environment associated with contamination in the river. In 2000, USEPA completed a preliminary assessment and concluded that further data collection was warranted at the UCRS. Accordingly, USEPA conducted an expanded site assessment in 2001, which included collection of sediment samples to evaluate sediment contamination. The results of this investigation indicated that contamination was widespread in riverine and lacustrine sediments and that a remedial investigation/feasibility study (RI/FS) was needed to evaluate potential risks to human health and the environment associated with exposure to contaminants at the site. The USEPA initiated the RI/FS in 2004 with the design and implementation of a Phase 1 sampling program (CH2M Hill 2006).

In 2006, Teck American Inc. (Teck) entered into a voluntary agreement with the USEPA to fund and conduct the RI/FS of the UCRS from the International Border to the Grand Coulee Dam. Under the terms of this settlement agreement, most of the RI/FS is being conducted by Teck, with oversight provided by USEPA. However, USEPA is responsible for conducting the human health risk assessment.

A variety of studies have already been conducted under the RI/FS and it is likely that additional studies will be conducted over the next three to five years. To date, studies have been, or will be, conducted by USEPA or Teck to obtain data and information on:

- Surface-water chemistry;
- Sediment chemistry (including beach sediment chemistry);
- Pore-water chemistry;
- Fish-tissue chemistry;
- Toxicity of selected COPCs in surface water to white sturgeon and rainbow trout;
- Toxicity of surface water from the UCRS to white sturgeon;
- Toxicity of sediments to benthic invertebrates;
- Toxicity of sediments to white sturgeon;
- Tribal use of natural resources in the UCRS; and,
- Recreational use of natural resources in the UCRS.

The Trustees will monitor relevant studies being conducted under the RI/FS and, if appropriate, will participate in the studies by reviewing study plans, observing field work, and/or requesting the splitting of samples for independent analysis. This work will help ensure the usability of the RI/FS data in the NRDA injury assessment.

5.4.3 Damage Assessment Data

While there is a substantial quantity of historical and RI-generated data available for the UCRS, it is likely that certain data gaps will exist that will limit the Trustees' ability to adequately determine injuries to natural resources. To address these data gaps, the Trustees may design and implement a number of focused investigations under the NRDA. The types of studies that may be implemented under the NRDA are described in Section 5.5 of this document.

5.4.4 Data Evaluation

The Trustees are committed to ensuring that only data of known and acceptable quality are used in the NRDA. Accordingly, the assessment will rely on information with sufficient supporting documentation. Data sources will be screened to verify that supporting documentation is available and sufficient to allow for an evaluation of the reliability and usability of the information. Data sources should have the following types of supporting documentation available to be considered usable:

- Sampling methodology, including information on sample location, environmental media sampled, and measurement units;
- Chemical analysis, including information on specific analytes, detection limits, and analytical methodology;
- Raw data or data tabulations (i.e., rather than data summaries or figures only); and,
- Accompanying quality assurance/quality control (QA/QC) data, separate QA/QC reports, or summaries of QA/QC results (i.e., to support evaluations of accuracy and precision).

The supporting documentation available for each potential data source will be acquired and evaluated to determine the acceptability of the data for the assessment. Data considered acceptable for the NRDA will be compiled into one or more electronic databases for analysis. The development of such databases (i.e., data entry and validation) and subsequent data analysis (statistical analysis, generation of figures) will be conducted following established QA/QC protocols. The overall objective of this QA/QC program will be to ensure that the data used in the assessment provide an accurate representation of the data presented in the original document or data source. Steps to ensure data quality will include verification of all data entered into the databases (to eliminate data entry errors; i.e., data verification), review of all calculations performed on the data (including verification of all mathematical equations), and compilation and review of computer logs to track database changes and modifications. Database auditing will also be conducted to identify potentially erroneous values and facilitate final data verification.

5.5 Injury Determination

The Trustees will conduct the UCRS injury determination in stages. In the first stage of the process, a preliminary assessment will likely be conducted primarily with existing information and with information from the RI/FS activities, potentially supplemented with a limited amount of additional data collected to ensure the best use of RI/FS data for injury assessment purposes. The second stage of the assessment will likely encompass new investigations, if required. The Trustees will prepare, and make public, specific sampling and analysis plans, either as appendices or supplements to this Injury Assessment Plan.

The natural resources under the trusteeship of the Trustees that have been potentially injured by releases of hazardous substances into the UCRS include, but are not limited to:

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

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

- Traditional Tribal subsistence hunting, fishing, and gathering uses;
- Cultural and spiritual use;
- Wildlife viewing and tracking;
- Recreational hunting and fishing;
- Outdoor recreation;
- Option and existence values (e.g., knowledge that a unit of the U.S. National Parks System exists, whether or not one chooses to visit it)
- Consumptive water uses (drinking, livestock watering, irrigation or other activities that consume water);
- Tribal reserved water rights
- Habitat that provides essential functions to support flora, fauna, and subsistence uses;
- Options for providing enhancement and conservation of threatened and endangered species; and
- Corridors for migratory species.

Consistent with the USDOI regulations, injury determination (and quantification) will be evaluated on a resource-by-resource basis. However, natural resources and the ecological services they provide are interdependent. For example, in the river environment, surface water, bed, bank, and suspended sediments, floodplain soils, and riparian vegetation together provide habitat (including lateral and longitudinal connectivity between habitats) for aquatic biota, semi-aquatic biota, and upland biota dependent on access to the river or riparian zone. Furthermore, these areas provide habitat for subsistence hunters, fishers, and gatherers, and support traditional subsistence-based economies. Hence, injuries to individual natural resources may cause ecosystem-level service reductions. Importantly, it is the entire ecosystem and associated services that may be injured as a result of the releases of hazardous substances. While this assessment will be conducted on a resource-by-resource basis, the evaluation of injury, service losses, and associated damages, will also consider the processes that lead to the loss of ecosystem services within and across these natural resources.

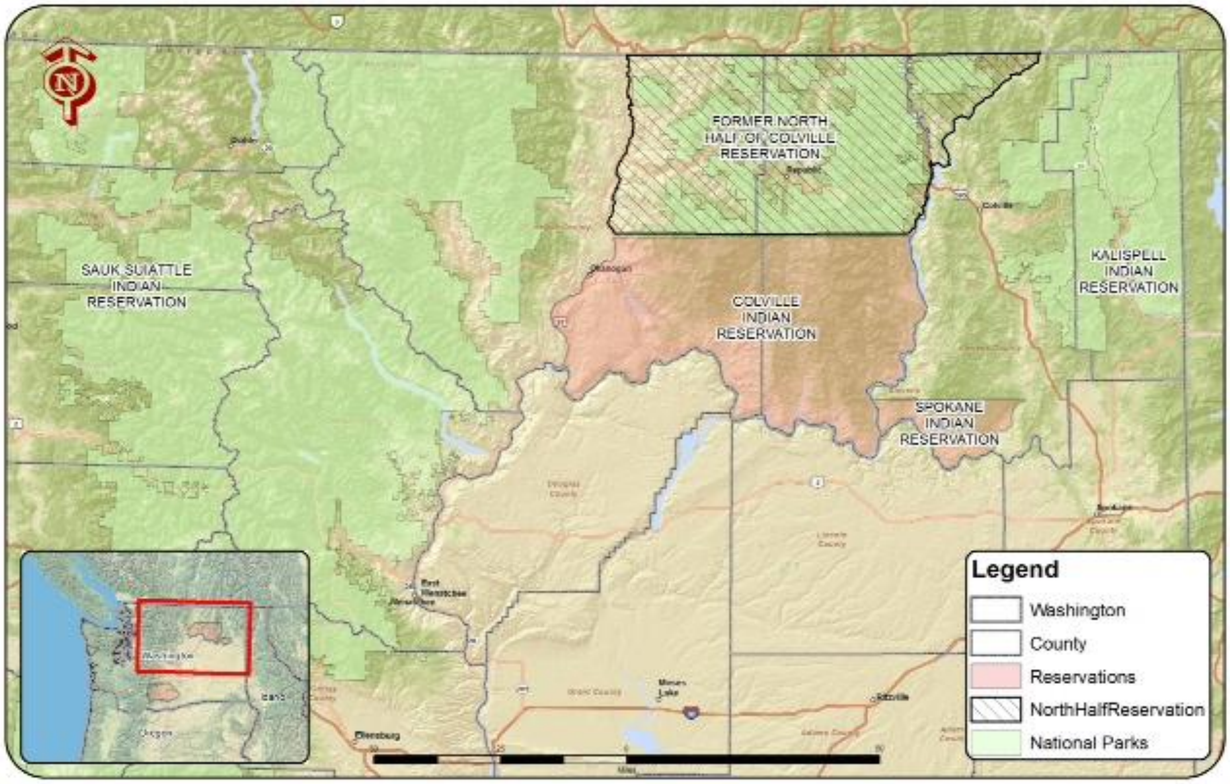
Additionally, it should be noted that the USDOI assessment procedures set out at 43 CFR 11.10 are not mandatory. Therefore, it is understood that the Trustees reserve all rights and remedies under applicable law to assess and assert claims for injuries to natural resources.

5.5.1 Tribal Services

Indigenous peoples and tribal communities utilize and hold values for natural resources to an extent and in ways that are different from the general population (Gregory and Trousdale 2009; Harper 2002; Nadasdy 2003; Turner 2005). In addition, the role that natural resources play in the culture of Indigenous communities may differ from that of the general population. As such, NRDAs that address tribal trust resources need to consider natural resource injuries, compensable losses, and restoration actions specific to the tribal community's use of natural resources.

Members of both the Confederated Tribes of the Colville Reservation and the Spokane Tribe of Indians utilize the resources of the UCRS within their Reservations and ceded lands (see Figure 5.2). As a result of the presence of hazardous contaminants in the environment of the UCRS, the services provided by natural resources to these tribal members and their tribal communities may have been diminished. For example, tribal members may have chosen to forgo the opportunity to fish in the Upper Columbia, given concerns over the health of this fishery resource (CH2M Hill 2006). The presence of contamination in the environment may have decreased the abundance or quality of traditional foods. The use of the river and its beaches for swimming and recreation may also have been compromised. While some studies have been conducted related to the role of hazardous contaminants in tribal communities of the UCRS (e.g., WESTAT 2010) additional studies may be needed to more fully understand the role of hazardous contaminants in UCRS tribal member use of natural resources. In the context of injury determination, it is appropriate to consider those resources that provide services to tribal members, particularly resources that support cultural integrity and continuity.

Figure 5.2 Colville and Spokane Indian Reservations and Ceded Lands (CCT 2011)



The Trustees will include, in the assessment, contaminant thresholds that might lead to a loss of natural resource services. For example, members of tribal communities in the UCRS may limit their use of a resource and modify their behavior at contaminant concentrations that are lower than that which would lead a member of the general public to change his or her behavior. They may utilize resources in a manner that differs from the general public, or use different resources altogether. Consideration of tribal-specific uses of natural resources during the injury determination phase will help to assure that the full suite of possible natural resource injuries of concern to the Tribal trustees are considered in the context of the damage assessment, in turn providing a sound basis for restoration planning.

5.5.2 Recreational Fishing

The Trustees will assess the value of the loss of recreational fishing use in the UCRS that is attributable to the release of hazardous substances. In the UCRS, losses are associated with the existence of consumption advisories for a variety of species, made necessary for the protection of human health by the presence of contaminants in the river system. The contamination and advisories have likely changed the way that anglers view the river and its fisheries and may alter angler behavior and reduce the enjoyment that each angler receives from a fishing trip. Common responses by anglers when faced with contamination and any associated advisories at their preferred fishing location include fishing less frequently or not at all, fishing in less desirable locations, traveling further to fish, converting to catch-and-release angling, or pursuing a different activity altogether. Each of these responses can result in a change in the value of the fishery to an angler, or in economic terms a change in their consumer surplus. As part of the injury determination, the Trustees will document the nature and timing of UCRS advisories. In subsequent phases of this assessment (i.e., as part of injury quantification and damage determination), the Trustees will determine the magnitude of, and the loss of consumer surplus that is associated with, angler responses to the advisories.

5.5.3 Surface Water Resources

The USDOI regulations define surface water resources as surface water, sediment suspended in water, or sediment lying on the bank, bed, or shoreline [43 CFR § 11.14(pp)]. Surface water and sediment are discussed separately here. The relevant definitions of injury to surface water resources that may be evaluated by the Trustees include, but are not limited to, the following:

- Concentrations and duration of substances in excess of drinking water standards as established by Sections 1411-1416 of the Safe Drinking Water Act (SDWA), or by other applicable laws or regulations that establish such standards for drinking water, in surface water that was potable before the release [see 43 CFR § 11.62(b)(1)(i)];
- Concentrations and duration of substances in excess of applicable water quality criteria established by Section 304(a)(1) of the Clean Water Act (CWA), or by other applicable laws or regulations that establish such criteria, in surface water that, before the release, met the criteria and is a committed use as habitat for aquatic life, water supply, subsistence, or recreation [see 43 CFR § 11.62(b)(1)(iii)]; and
- Concentrations and duration of substances sufficient to have caused injury to groundwater, air, geological, or biological resources, when exposed to surface water; suspended sediments; or bed, bank, or shoreline sediments [43 CFR § 11.62(b)(1)(v)].

5.5.3.1 Approach to the Assessment of Injury to Surface Water

A step-wise approach will likely be used to evaluate injury to surface water in the UCRS. In the first step of this process, the designated uses of the UCRS will be identified. Next, the available surface water chemistry data for the UCRS and for suitable reference areas will be identified, acquired, evaluated, and compiled in a GIS-compatible relational database. Subsequently, the tribal water quality standards (WQS), state WQS, ambient WQC, and/or other injury thresholds that have been established to protect drinking water supplies, aquatic life, wildlife, and human health will be collated. In this evaluation, the surface water chemistry data for the selected reference areas may be used to establish baseline conditions in the UCRS. Finally, the concentrations of chemicals of potential concern (COPCs) in surface water from the UCRS and from the selected reference areas will be compared to the applicable WQSs and/or WQC, and/or other injury thresholds. Consistent with the definitions provided in USDOI regulations [43 CFR § 11.62(b)(1)(i); 43 CFR § 11.62(b)(1)(iii)], surface water resources will be considered to be injured when the concentrations of COPCs measured in surface water exceed the applicable WQSs or WQC and exceed the concentrations measured in surface water from the selected reference areas. Because water quality conditions can vary on both spatial and temporal scales, this analysis will be conducted in such a manner as to support an evaluation of injury to surface water on spatial and temporal scales (i.e., to determine where and when surface water resources have been injured).

5.5.3.2 Approach to the Assessment of Injury to Sediments

Ecosystem services provided by sediment include habitat for benthic, epibenthic, and other biological resources dependent on the aquatic habitats in the Assessment Area. In addition, sediment contributes to services provided by surface water, including suspended sediment transport processes, cover for fish and their supporting ecosystems, primary and secondary productivity, geochemical exchange processes, and nutrient cycling and transport.

Hazardous substances in sediment can cause injury to biological resources through direct toxicity to sediment-dwelling benthic macroinvertebrates or sediment-dwelling fish and through transfer of bioaccumulative COPCs to higher trophic-level organisms (i.e., through food web transfer of contaminants). Hazardous substances in sediment can also cause injury to surface water resources exposed to the sediment. The approach that will be used to evaluate injury to sediments is discussed in this section, while the procedures that will be applied to assess injury to sediment-dwelling organisms, fish, and wildlife associated with exposure to sediment-associated COPCs are described in the section on biological resources.

Injury to sediments in the UCRS is expected to be evaluated using an approach that is consistent with the one that will be applied to the surface water injury determination. First, the available sediment chemistry data for the UCRS and for suitable reference areas will be identified, acquired, evaluated, and compiled in a GIS-compatible relational database. Next, applicable sediment quality standards (SQSs), criteria (SQC), guidelines (SQGs), and/or other injury thresholds that have been established by tribal, state, federal, and other jurisdictions for the protection of aquatic life, wildlife, and human health will be identified and collated. The available data on the concentrations of COPCs in appropriately-selected reference sediments and/or in sediment cores will be used to establish baseline conditions in the UCRS. Finally, the concentrations of COPCs in whole-sediment samples from the UCRS and from the selected reference areas could be compared to the applicable SQSs, SQC, or SQGs, and/or other injury thresholds.

Consistent with the definitions provided in the USDOI regulations [43 CFR § 11.62(b)(1)(i); 43 CFR § 11.62(b)(1)(iii)], surface water resources will be considered to be injured when the concentrations of COPCs measured in sediments exceed the applicable SQSs, SQC, or SQGs and exceed the concentrations measured in sediment samples from the selected reference areas. Because sediment quality conditions can vary on both spatial and temporal scales, this analysis will be conducted in such a manner as to support an evaluation of injury to sediments on spatial and temporal scales (i.e., to determine where and when sediments have been injured).

5.5.4 Groundwater Resources

Groundwater resources provide a number of essential ecosystem services in the UCRS and support a variety of human uses. For example, groundwater discharges enhance habitats for terrestrial and aquatic vegetation. In addition, recharge of surface water resources by groundwater often augments base flows and regulates the temperature of stream systems. Fish often target such groundwater discharges for spawning and early rearing activities. Groundwater is also used as a drinking water source in various areas within the UCRS basin. The relevant definitions of injury to groundwater resources include:

- Exceedances of drinking water standards, established by Sections 1411-1416 of the SDWA, or by other applicable laws or regulations that establish such standards for drinking water, in groundwater that was potable before the release [see 43 CFR § 11.62(c)(1)(i)];
- Exceedances of applicable WQC established by Section 304(a)(1) of the CWA, or by other applicable laws or regulations that establish such criteria for domestic water supplies, in groundwater that before the release met the criteria and is a committed use as a domestic water supply [see 43 CFR § 11.62(c)(1)(iii)]; and,

- Concentrations of hazardous substances in groundwater sufficient to have caused injury to surface water, air, geological, or biological resources, when exposed to groundwater [43 CFR § 11.62(c)(iv)].

5.5.4.1 Approach to the Assessment of Injury to Groundwater Resources

It is possible that groundwater resources in the UCRS have been contaminated by releases of COPCs to soil and subsequent transport to groundwater. However, this is likely to be a relatively minor pathway throughout much of the UCRS. Of greater concern is the release of COPCs associated with historical effluent discharges to pore water or hyporheic zones in UCRS sediments. Hence, exposure of benthic invertebrates and/or other aquatic organisms (e.g., larval white sturgeon) to contaminated pore water represents the primary groundwater resource concern that will be addressed through the NRDA of the UCRS.

Injury to groundwater resources may be evaluated by comparing pore-water chemistry data to applicable WQSs or WQC. As a first step, the available pore-water chemistry data for the UCRS will be identified, acquired, evaluated, and compiled in a GIS-compatible relational database. Both *in situ* (i.e., field-collected samples) and *ex situ* (i.e., laboratory-collected samples using peepers, centrifugation, and/or other relevant methods) measurements of pore-water chemistry may be used in this evaluation. Subsequently, the tribal WQSs, state WQSs, ambient WQC, and/or other injury thresholds that have been established to protect aquatic life will be collated. In this evaluation, the pore-water chemistry data for reference areas may be used to establish baseline conditions in the UCRS if other baseline data are not available for this study area. Finally, the concentrations of COPCs in pore-water samples from the UCRS and from the selected reference areas could be compared to the applicable WQSs, WQC, and/or other injury thresholds. Consistent with the definitions provided in the USDOI regulations [43 CFR § 11.62(b)(1)(i); 43 CFR § 11.62(b)(1)(iii)], groundwater resources will be considered to be injured when the concentrations of COPCs measured in pore water exceed the applicable WQSs, WQC, or other injury thresholds and exceed the concentrations measured in pore water from the selected reference areas. Because pore-water quality conditions can vary on both spatial and temporal scales, this analysis will be conducted in such a manner as to support an evaluation of injury to surface water on spatial and temporal scales (i.e., to determine where and when groundwater resources have been injured).

5.5.5 Geological Resources

Geological resources are defined in the USDOI regulations as "*those elements of the Earth's crust such as soils, sediments, rocks, and minerals . . . that are not included in the definitions of ground and surface water resources*" [43 CFR § 11.14(s)]. Geological resources at the UCRS primarily include floodplain and upland soils.

Ecosystem services provided by floodplain and upland soils include habitat for all biological resources that are dependent on riparian, floodplain, wetland or terrestrial habitats in the basin. More specifically, soils provide habitat for migratory birds and mammals; habitat for soil biota; growth media and nutrients for plants; carbon storage, nitrogen fixation, decomposition, and nutrient cycling; soil organic matter; hydrograph moderation; and, geochemical exchange processes. Human use services include recreation (hiking, picnicking), residences, access corridors, and other land uses. The relevant definition of injury to geological resources is:

- Concentrations sufficient to injure other resources, including terrestrial organisms and vegetation (via toxicity), groundwater, and wildlife [43 CFR § 11.62(e)].

5.5.5.1 Approach to the Assessment of Injury to Geological Resources

Geological resources in the UCRS may have been contaminated by COPCs through two primary pathways. First, wetland, riparian, and terrestrial soils located within the area affected by aerial emissions from the Teck facility in Trail, BC may have been contaminated by wet or dry deposition of airborne COPCs. In addition, soils located within the floodplain of the UCRS may have been contaminated by deposition of effluents, fine sediment or slag during high flow events. As such, soils throughout the UCRS study area may have been contaminated by a variety of COPCs.

Injury to soils in the UCRS will be evaluated using an approach that is consistent with the one that will be applied to the sediment injury assessment. First, the available soil chemistry data for the UCRS and for suitable reference areas will be identified, acquired, evaluated, and compiled in a GIS-compatible relational database. Next, applicable soil quality standards, benchmarks, and/or toxicity thresholds that have been established for the protection of soil invertebrates, wildlife, and human health will be identified and collated. The available data on the concentrations of COPCs in soil samples from reference areas or appropriately-selected locations within the UCRS will be used to establish baseline conditions in the UCRS. Finally, the concentrations of COPCs in surficial soil samples from the UCRS and from the selected baseline or reference areas will be compared to the applicable SoQSs, benchmarks for soil, or the selected toxicity thresholds. Consistent with the definitions provided in the USDOI regulations [43 CFR § 11.62(e)], geological resources will be considered to be injured when the concentrations of COPCs measured in soil samples exceed the applicable SoQSs or toxicity thresholds and exceed the concentrations measured in soil samples from the selected reference areas. Because soil quality conditions can vary on both spatial and temporal scales, this analysis will be conducted in such a manner as to support an evaluation of injury to soils on spatial and temporal scales (i.e., to determine where and when soils have been injured).

5.5.6 Air Resources

The USDOI regulations define air resources as those naturally-occurring constituents of the atmosphere, including those gases essential for human, plant, and animal life [43 CFR § 11.14(b)]. The NRDA regulations state that an injury to air resources has resulted if one or more of the following changes in the physical or chemical quality of the air resource is measured as:

- Concentrations of emissions in excess of standards for hazardous air pollutants established under Section 12 of the Clean Air Act or by other applicable air standards established for the protection of public welfare or natural resources [see 43 CFR § 11.62(d)(1)].

5.5.6.1 Approach to the Assessment of Injury to Air Resources

Air resources in the UCRS may have been contaminated by COPCs through two primary pathways. First, prevailing winds may have transported aerial emissions from the Teck facility in Trail, BC to areas located on the US side of the Canada-US border. In addition, wind erosion can result in contamination of air resources through resuspension of contaminated floodplain soils and exposed sediments (i.e., during draw-down events).

Injury to air in the UCRS may be evaluated, potentially using a step-wise approach. In the first step, the available air quality data for the UCRS and for suitable reference areas could be identified, acquired, evaluated, and compiled in a GIS-compatible relational database. Next, applicable air quality standards for hazardous substances that have been established for the protection of human welfare or natural resources will be identified and collated. The available data on the concentrations of COPCs in air at appropriately-selected reference location(s) or published literature will likely be used to establish any necessary baseline conditions in the UCRS because baseline data are not readily available for the study area. Finally, the concentrations of COPCs in air samples from the UCRS and from the selected reference areas could be compared to the applicable standards and/or other injury thresholds. Consistent with the definitions provided in the USDOI regulations [43 CFR § 11.62(d)(1)], air resources will be considered to be injured when the concentrations of COPCs measured in air samples exceed the applicable air quality standards or other injury thresholds and exceed the concentrations associated with reference conditions. In addition, data on the chemical composition of floodplain soils, upland soils, and/or exposed sediments may also be used to predict air quality conditions in areas subject to wind erosion. Because air quality conditions can vary on both spatial and temporal scales, this analysis will be conducted in such a manner as to support an evaluation of injury to air resources on spatial and temporal scales (i.e., to determine where and when air resources have been injured).

5.5.7 Biological Resources

A wide variety of ecological receptors could be exposed to contaminated environmental media in the UCRS. The receptor groups for which potentially complete exposure pathways exist in aquatic, riparian, and upland ecosystems within the UCRS can be classified into 10 main categories, including:

- Microbiota (e.g., bacteria, fungi and protozoa);
- Aquatic plants (including phytoplankton, periphyton, and aquatic macrophytes);
- Terrestrial plants (including riparian plants and other terrestrial plants that inhabit floodplain areas);
- Aquatic invertebrates (including zooplankton, benthic invertebrates, and freshwater mussels);
- Terrestrial invertebrates;
- Fish (including benthic and pelagic fish, with species representing various feeding guilds present at the site);
- Amphibians;
- Aquatic-dependent reptiles (e.g., turtles, water snakes);
- Aquatic-dependent and terrestrial birds (including species representing various feeding guilds); and,
- Aquatic-dependent and terrestrial mammals (including species representing various feeding guilds).

While all of these receptor groups utilize habitats within the UCRS study area, the assessment of injury to biological resources will focus primarily on benthic invertebrates, terrestrial invertebrates, fish, herpatiles (amphibians and reptiles), birds, and mammals. Injury to other biological resources may also be evaluated depending on the results of preliminary determinations of injury (i.e., based on comparison of the concentrations of COPCs in abiotic media to applicable standards or toxicity thresholds).

Based on an initial review of existing data, definitions of injury relevant to evaluation of injuries to biological resources include the following:

- Concentrations of a hazardous substance sufficient to exceed action or tolerance levels established under Section 402 of the Food, Drug and Cosmetic Act, 21 U.S.C. 342, in edible portions of organisms, or levels established under any other applicable laws or regulations [see 43 CFR § 11.62(f)(1)(ii)];
- Concentrations of a hazardous substance sufficient to exceed levels for which an appropriate health agency has issued directives or advisories to limit or ban consumption of such organism [see 43 CFR § 11.62(f)(1)(iii)]; and,
- Concentrations of a hazardous substance sufficient to cause the biological resource or its offspring to have undergone at least one of the following adverse changes in viability: death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunctions in reproduction and growth), or physical deformations [43 CFR § 11.62(f)(1)(i)].

The following sections of this document describe the approaches that the Trustees expect to use to evaluate injuries to benthic invertebrates, terrestrial invertebrates, fish, herpatiles, birds, and mammals utilizing habitats within the UCRS.

5.5.7.1 Approach to the Assessment of Injury to Benthic Macroinvertebrates

Multiple lines-of-evidence (LOEs) may be used to evaluate injury to sediments and sediment-dwelling organisms in the UCRS, including:

- Surface-water chemistry data;
- Whole-sediment chemistry data;
- Pore-water chemistry data;
- Invertebrate-tissue chemistry data; and,
- Whole-sediment toxicity data.

In the first step of the evaluation, the available data on the concentrations of COPCs in abiotic media (i.e., surface water, pore water, and sediment) would be compiled. Subsequent comparison of COPC concentrations to applicable standards and/or injury thresholds would provide a basis for identifying the hazardous substances that are likely to cause or substantially contribute to adverse effects on ecological receptors (i.e., COPCs). In addition, the results of the preliminary evaluations could support identification of sensitive benthic invertebrates that may require additional consideration.

The Trustees understand that hazardous substances have been released to the UCRS in different chemical forms. As a result, the availability of these COPCs to benthic invertebrates (i.e., bioavailability) may differ from that for other sites in the United States. For this reason, the Trustees may develop site-specific tools for supporting classification of sediments as toxic or not toxic to benthic invertebrates and for evaluating the magnitude of effects at various concentrations of COPCs. If possible, such tools will be developed using matching sediment chemistry, pore-water chemistry, and sediment toxicity data that are generated under the RI (i.e., using procedures generally consistent with those used to develop injury thresholds for benthic invertebrates at other contaminated sites; e.g., MacDonald *et al.* 2010). If insufficient data are available from RI-related studies, additional studies will be considered to obtain the information needed to develop relationships between exposure of benthic invertebrates to COPCs and sediment toxicity. Such investigations may be conducted on splits of sediment samples collected to support the RI-related studies or on sediment samples collected explicitly to facilitate Trustee-lead studies. While the nature and scope of such investigations cannot be determined until the scope of the RI-related studies is known, it is possible that Trustee-lead studies could include:

- Investigations to evaluate exposure of invertebrates to the site-related COPCs in environmental media (e.g., surface water, pore water, water collected at the sediment-water interface, benthic invertebrate tissues);
- Long-term toxicity tests with amphipods (*Hyalella azteca*) or midge (*Chironomus dilutus*), focusing on survival, growth, biomass, reproduction, and the viability of the offspring of exposed adults;
- Long-term toxicity tests with freshwater mussels (*Lampsilis siliquoidea*), focusing on survival, growth, and biomass; and/or,
- Surveys of the distribution, abundance, and diversity of freshwater mussels and/or other species in the UCRS.

While many of the COPCs that occur in UCRS sediments can be toxic to benthic invertebrates, certain hazardous substances that have been released into the river system can also accumulate in the tissues of sediment-dwelling organisms. Such substances can accumulate to levels that adversely affect the benthic invertebrates themselves and/or the fish and wildlife species that consume these organisms. To support the assessment of injuries to benthic invertebrates, the available data on the concentrations of COPCs in invertebrate tissues from the UCRS will be collected, evaluated, and collated. In addition, toxicity thresholds (i.e., critical body residues) for benthic invertebrates will be acquired from the scientific literature. Comparison of the tissue-residue data to the toxicity thresholds for benthic invertebrates will provide a basis for identifying key COPCs that require further investigation.

It is likely that certain investigations conducted under the RI will provide relevant data for evaluating bioaccumulation in the UCRS. The results of such studies will be reviewed and evaluated to identify any weaknesses or data gaps that need to be addressed. Subsequently, one or more Trustee-lead investigations may be designed and implemented to provide the data and information needed to further evaluate the effects of bioaccumulative COPCs in the UCRS. Such studies could include:

- Bioaccumulation and food-web modeling;
- 28-d to 56-d bioaccumulation tests with the oligochaete worm, *Lumbriculus variegatus*; and/or,
- Field collection and chemical analysis of invertebrates from various habitat types in the UCRS.

5.5.7.2 Approach to Assessment of Injury to Terrestrial Invertebrates

Multiple LOEs could be used to evaluate injury to soils and soil-dwelling organisms in the UCRS, including:

- Soil chemistry data;
- Soil toxicity data; and/or,
- Invertebrate-tissue chemistry data.

In the first step of the evaluation, the available data on the concentrations of COPCs in upland and floodplain soils would be compiled. Subsequent comparison of COPC concentrations to applicable standards and/or toxicity thresholds will provide a basis for identifying the substances that are likely causing or substantially contributing to adverse effects on ecological receptors (i.e., COPCs).

The Trustees understand that hazardous substances have been released to the UCRS from a variety of sources and in different forms. As a result, the availability of these COPCs to terrestrial invertebrates (i.e., bioavailability) may differ from that for other sites in the United States. For this reason, the Trustees may evaluate injury to soil-dwelling organisms using site-specific data and information. For example, soil toxicity-tests with indicator species [such as springtails (e.g., *Folsomia candida*) or earthworms (*Eisenia foetida*)] may be conducted to evaluate soil toxicity directly. The resultant data may also be evaluated in conjunction with matching soil-chemistry data to support the development of site-specific toxicity thresholds for selected COPCs that occur at elevated concentrations in upland and floodplain soils. The procedures used in such an analysis would be analogous to those that have been applied to develop toxicity thresholds for sediment (see MacDonald *et al.* 2010 for more information).

While many of the COPCs that occur in UCRS soils can be toxic to soil invertebrates, certain hazardous substances that have been released can accumulate in the tissues of soil-dwelling organisms. Such substances can accumulate to levels that adversely affect the invertebrates themselves or the wildlife species that consume these organisms. To support the assessment of injuries to invertebrates, the available data on the concentrations of COPCs in invertebrate tissues from the UCRS may be collected, evaluated, and collated. In addition, injury thresholds (i.e., critical body residues) for soil-dwelling invertebrates will be acquired from the scientific literature. Comparison of the tissue-residue data to the injury thresholds for terrestrial invertebrates will provide a basis for identifying key COPCs that require further investigation. If the requisite data are not available, the Trustees may design and implement a field sampling program to acquire the required data on the concentrations of COPCs in invertebrate tissues or conduct laboratory bioaccumulation tests by exposing selected terrestrial invertebrate species to UCRS soils.

5.5.7.3 Approach to Assessment of Injury to Fish

Multiple LOEs could be used to evaluate injury to fish in the UCRS, including data on:

- Surface-water chemistry;
- Surface-water toxicity;
- Whole-sediment chemistry;

- Pore-water chemistry;
- Whole-sediment toxicity;
- Fish-tissue chemistry; and,
- Prey-tissue chemistry.

In the first step of the evaluation, the available data on the concentrations of COPCs in abiotic media (i.e., surface water, pore water, and sediment) will be compiled. Subsequent comparison of COPC concentrations to applicable standards and/or injury thresholds for fish will provide a basis for identifying the substances that are likely to cause or substantially contribute to adverse effects on fish (i.e., COPCs).

A great deal of information is available in the literature to support evaluation of the toxicity of site-related COPCs to numerous species of fish. More specifically, data from water-only toxicity tests provide sufficient data to generate species-sensitivity distributions for many of the COPCs that have been released into the UCRS. In addition, site-specific water-only toxicity tests have been conducted under the RI to support development of toxicity thresholds for certain COPCs (i.e., cadmium, copper, lead, and zinc) for fish species of special concern, such as white sturgeon. Furthermore, whole-sediment toxicity tests have been conducted under the RI to better understand the potential for adverse effects on the early life stages of white sturgeon associated with exposure to contaminated sediments. The results of these RI-related studies will be reviewed and evaluated to determine if they provide the information necessary to assess injuries to fish in the UCRS. If insufficient data are available from RI-related studies, additional studies may be conducted to obtain additional information needed to evaluate injury to piscivorous, invertivorous, carnivorous, and detrivorous fish in UCRS. While the nature and scope of such investigations cannot be determined until the scope of the RI-related studies is known, it is possible that Trustee-lead studies could include:

- Investigations to evaluate exposure of fish to the site-related COPCs in environmental media (e.g., surface water, pore water, sediment-water interface, benthic invertebrates);
- Investigations to evaluate the toxicity of site-related COPCs to fish;
- Investigations to evaluate the toxicity of environmental media (e.g., water, sediment) from the site to fish;
- Investigations to determine the concentrations of COPCs in the tissues of selected fish species; and/or,

- Investigations to evaluate the abundance, distribution, and health of various fish species.

The information obtained from the literature, from RI-related studies, and from Trustee-related studies will be integrated and used to evaluate injuries to fish in the UCRS. Injury determination will be made by comparing the measured concentrations of COPCs to standards, criteria, or toxicity thresholds for water, pore water, sediment, prey tissues, and/or fish tissues. In addition, direct measurements of adverse effects to fish will be used to confirm the determinations made using the data on exposure to COPCs.

5.5.7.4 Approach to Assessment of Injury to Amphibians and Reptiles

Multiple LOEs could be targeted for use in evaluating injury to amphibians and reptiles in the UCRS, including data on:

- Surface-water chemistry;
- Surface-water toxicity;
- Whole-sediment chemistry;
- Pore-water chemistry; and,
- Prey-tissue chemistry.

Few data are available in the literature to support evaluation of the toxicity to amphibians or reptiles associated with exposure to the hazardous substances of interest at the UCRS. While data from water-only toxicity tests are available for determining the sensitivity of certain amphibians to a limited suite of contaminants, such information is generally unavailable for reptiles. In addition, virtually no data are available for evaluating the toxicity to amphibians or reptiles associated with exposure to COPCs in sediments or diets. Furthermore, it is unlikely that investigations will be conducted under the RI to fill this important data gap.

To address limitations on the available data, a step-wise approach will be used to assess injury to these receptor groups. In the first step of the evaluation, the available data on the concentrations of COPCs in abiotic media (i.e., surface water, pore water, and sediment) will be compiled. Subsequent comparison of COPC concentrations to applicable standards and/or injury thresholds for amphibians or reptiles will provide a basis for identifying the substances that are likely to cause or substantially contribute to adverse effects on these receptors (i.e., COPCs). These results will be reviewed and evaluated to determine if amphibians or reptiles are more sensitive to key site-related COPCs (i.e., Cd, Cu, Pb, Zn) than are fish or invertebrates. If not, injury to amphibians and reptiles may be inferred from the results of the assessments for fish and invertebrates (i.e., because herpatiles would tend to have lower exposure to COPCs than would fish or invertebrates). If amphibians or reptiles are found to be more sensitive to site-related COPCs than fish or invertebrates, additional Trustee-lead studies may be designed and implemented to support injury evaluations. Such studies would be designed to:

- Evaluate exposure of amphibians and reptiles to site-related COPCs at the UCRS;
- Evaluate toxicity of site-related COPCs to amphibians and/or reptiles, with a focus on reproductive and early-life stage toxicity; and/or,
- Evaluate the toxicity to amphibians and/or reptiles associated with exposure to environmental media from the UCRS, with a focus on reproductive and early-life stage toxicity.

The results of any such studies would then be used to determine if exposure to COPCs in the UCRS would be sufficient to injure amphibians or reptiles. More specifically, the information obtained from the literature, from RI-related studies, and from Trustee-related studies will be integrated and used to evaluate injuries to amphibians and/or reptiles in the UCRS. Injury determination will be made primarily by comparing the measured concentrations of COPCs to standards, criteria, or toxicity thresholds for water, pore water, sediment, and/or prey tissues or by inference from injury determinations for other receptors. In addition, direct measurements of adverse effects to amphibians or reptiles may be used to confirm the determinations made using the data on exposure to COPCs.

5.5.7.5 Approach to the Assessment of Injury to Higher Trophic Level Organisms

In addition to causing injury to macroinvertebrates, fish and other aquatic organisms, hazardous substances in sediment can also injure higher trophic level organisms through bioaccumulation in the food chain. Injury to avian and mammalian species may be evaluated using a food-web modeling approach. In this approach, focal species will be identified for each of the following feeding guilds (Note: preliminary focal species are identified in parentheses):

<u>Aquatic-Dependent Birds</u>

- Piscivorous birds (e.g., kingfisher);
- Carnivorous birds (e.g., great-blue heron);
- Insectivorous birds (e.g., wood duck); and,

- Sediment-probing birds (e.g., spotted sandpiper).

<u>Terrestrial Birds</u>

- Carnivorous birds (e.g., red-tailed hawk);
- Omnivorous birds (e.g., turkey); and,
- Soil-probing birds (e.g., to be determined).

<u>Aquatic-Dependent Mammals</u>

- Piscivorous mammals (e.g., otter);
- Carnivorous mammals (e.g., mink);
- Insectivorous mammals (e.g., big-eared bats); and,
- Omnivorous mammals (e.g., raccoon).

<u>Terrestrial Mammals</u>

- Carnivorous mammals (e.g., to be determined);
- Omnivorous mammals (e.g., deer mouse); and,
- Herbivorous mammals (e.g., to be determined).

Subsequently, average daily doses (ADDs) of each bioaccumulative COPC will be estimated using information on the home range size, body weight, daily food intake rate, and diet of the focal species (including incidental soil or sediment ingestion rates), together with data on the concentrations of COPCs in abiotic media and prey species. These calculated ADDs will be compared to toxicity reference values (i.e., injury thresholds) available in the literature to identify the species/receptor groups that are likely to be injured by exposure to bioaccumulative COPCs. Based on the results of the preliminary evaluations of injury to birds and mammals, additional studies may be designed and implemented to confirm that these biological resources have been injured. Trustee-lead studies to evaluate injury to birds and/or mammals could include:

- Investigations to further document exposure of birds or mammals to site-related COPCs;
- Investigations to evaluate the health and behavior of birds exposed to environmental media from the site;

- Investigations to evaluate early-life stage toxicity and/or reproductive toxicity to birds exposed to environmental media from the site;
- Investigations to evaluate the health and behavior of mammals exposed to environmental media from the site; and/or,
- Investigations to evaluate early-life stage toxicity and/or reproductive toxicity to mammals exposed to environmental media from the site.

The results of such studies will be used to confirm the predictions of injury made using the results of food-web models for the selected focal species.

5.6 Design and Implementation of Natural Resource Trustee-Lead Injury Studies

As indicated in the previous sections, additional studies may be required to complete the injury determination. The Trustees will evaluate the need for additional studies as part of the evaluation of natural resource injures.

5.7 Pathway Evaluation

According to the USDOI regulations, the Trustees are required to evaluate and describe the pathways by which hazardous substances have been transported from the points of release to where they have come to be located and result in exposure of natural resources in the assessment area. In this context, a pathway is defined as "*the route or medium through which oil or a hazardous substance is or was transported from the source of the discharge or release to the injured resource*" [43CFR §11.14(dd)]. The pathway is determined by "*either demonstrating the presence of the oil or hazardous substances in sufficient concentrations in the pathway resource or by using a model that demonstrates that the conditions existed in the route and in the oil or hazardous substances such that the route served as a pathway*" [43 CFR § 11.63(a)(2)]. Natural resources, either singly or in combination with other media, can serve as exposure pathways. For example, the re-suspension of contaminated sediment can result in exposure of surface water resources, floodplain soil resources, sediment resources, and biota in downstream areas.

At the UCRS, COPCs have been released to the environment from effluents, granulated slag, aerial emissions, and various other lesser sources (See Section 2.2 for details; MacDonald *et al.* 2007). Releases of hazardous substances have resulted in contamination of surface water, sediments, pore water, floodplain soils, and upland soils within the study area. These abiotic media can represent secondary sources of COPCs, potentially resulting in contamination of abiotic media in downstream areas and/or biological resources. Through pathway determination, the Trustees will document how hazardous substances enter and move through the environment, including how they are transferred among species in the food web.

The Trustees will conduct a pathway evaluation as part of the injury determination phase of the assessment of the UCRS [43 CFR § 11.63]. The pathway evaluation will focus on evaluating the extent to which the hazardous substances documented at the site can be attributed to releases by the potentially responsible parties and the subsequent downstream migration throughout the UCRS. This evaluation will likely be based on:

- Available information on releases of hazardous substances to the UCRS, including from potentially responsible party facilities and from other sources;
- The RI, including the baseline problem formulation and associated conceptual site model that are prepared as part of the RI;
- Spatial and temporal trends of hazardous substance concentrations in natural resources, including surface water and sediment, groundwater, floodplain soils, and biota;
- Hydraulic parameters and streamflow characteristics;
- Sediment characteristics, including slag content;
- Suspended sediment loads;
- Fate and transport models (if available); and,
- Atmospheric data.

6. Quality Assurance Management

The Upper Columbia River Site (UCRS) natural resource Trustees intend to collect and analyze chemical, biological, and physical data as part of the Upper Columbia River site Natural Resource Damage Assessment (NRDA). In order for the Trustees to have confidence in the data developed through the damage assessment, a structured process for ensuring quality must exist. Therefore, the Trustees will develop project-specific Quality Assurance (QA) plans for each major data collection effort that is part of the Upper Columbia River NRDA. The QA Plans may be independent documents or may be incorporated into project-specific work plans.

The purpose of each project-specific QA Plan will be to assist the Trustees in developing defensible data that will provide a solid foundation for their decisions. The QA plans developed for this NRDA will be based on United States Environmental Protection Agency (USEPA) requirements for Quality Assurance Project Plans (EPA QA/R-5, March, 2001) and USEPA Guidance for Quality Assurance Project Plans (EPA QA/G-5, February 1998), or other appropriate models. In general, each project-specific QA Plan should provide sufficient detail to demonstrate that:

- The project's technical and quality objectives (i.e., data quality objectives) are identified and agreed upon;
- The intended measurements or data acquisition methods are appropriate for achieving Trustee objectives;
- Assessment procedures are sufficient for confirming that data of the type and quality needed and expected are obtained; and
- Any limitations on the use of the data can be identified and documented.

Accordingly, the plans developed for this assessment will address the four general elements identified by USEPA guidance[2], as described below:

- **Project Management -** documents that the project has a defined goal(s); that the participants understand the goal(s) and the approach to be used; and, that the planning outputs have been documented;

[2] U.S. Environmental Protection Agency. “Guidance for Quality Assurance Project Plans: EPA QA/G-5.” U.S. EPA, Office of Environmental Information, EPA/240/R-02/009, December 2002. http://www.epa.gov/quality/qs-docs/g5-final.pdf

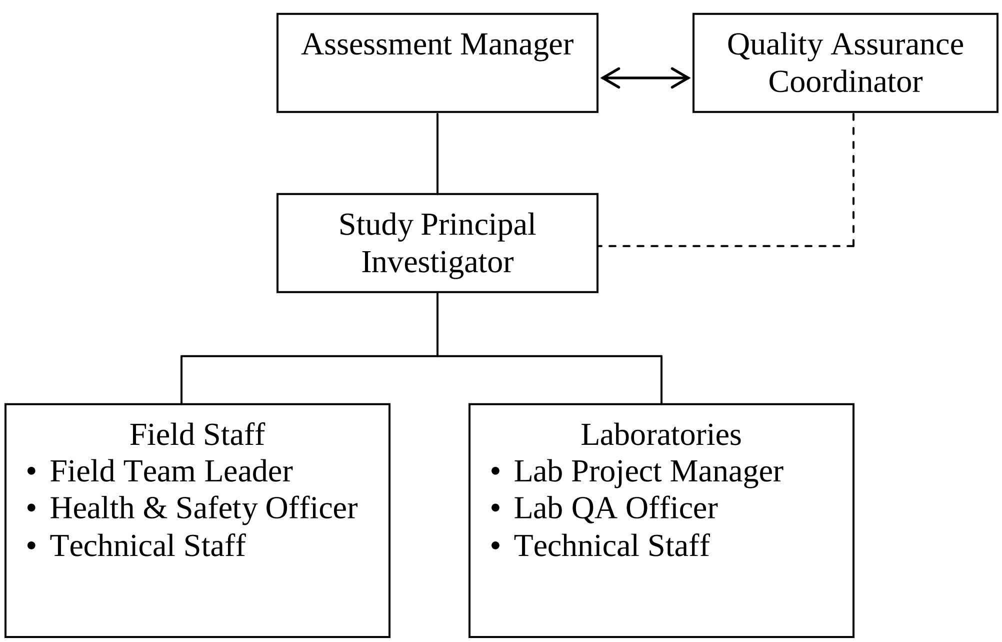
- **Data Generation and Acquisition -** ensures that all aspects of project design and implementation including methods for sampling, measurement and analysis, data collection or generation, data handling, and quality control (QC) activities are identified and documented;
- **Assessment and Oversight -** assesses the effectiveness of the implementation of the project and associated QA and QC activities; and
- **Data Validation and Usability -** addresses the QA activities that occur after the data collection or generation phase of the project is completed.

Each of these elements is discussed briefly below.

6.1 Project Management

Project organization, roles, and responsibilities help ensure that individuals, identified in Figure 6.1 below, are aware of specific areas of responsibility for quality assurance, as well as internal lines of communication and authority. Organizational roles and responsibilities may vary by study or task, depending on the lead agency and project team performing the investigation, and should be described in the Quality Assurance Project Plan. The overall QA organization for the damage assessment is shown in Figure 6.1 below.

Figure 6.1 Project Quality Assurance Organization



The Assessment Manager is the designated Trustee representative who is responsible for the review and acceptance of the project-specific QA plan and ensuring that various Trustee agency efforts are in accordance with requirements of the UCRS NRDA.

The overall conduct of the quality system for the damage assessment is the responsibility of the QA Coordinator appointed by the Trustee Council. The responsibilities of this individual include, but are not limited to: development of an Analytical QA Plan; reviewing/assisting project leaders (e.g., principal investigators) with the development of project-specific QA plans; conducting audits and ensuring implementation of both project and overall QA plans; archiving samples, data, and all documentation supporting the data in a secure and accessible form; and, reporting to the Trustee Council.

Study-specific Principal Investigators (PIs) ensure that QA guidance and requirements are followed. The PI or the designee will note significant deviations from the QA plan for the study, and report the deviations to the Assessment Manager and the QA Coordinator.

The Field Team Leader (FTL) supervises day-to-day field investigations, including sample collection, field observations, and field measurements. The FTL generally is responsible for all field quality assurance procedures defined in the Quality Assurance Project Plan. The Laboratory Project Manager, with input from the Lab QA Officer is responsible for monitoring and documenting the quality of laboratory work.

6.2 Data Generation and Acquisition

Prior to the initiation of major work, studies identified in the Injury Assessment Plan that either generate or acquire data to be used in the Upper Columbia River Site NRDA will have a prepared study plan to be submitted to and approved by the QA Coordinator or designee. Each study plan should include, at a minimum:

- Rationale for generating or acquiring the data;
- Proposed method(s) for generating or acquiring the data;
- Data quality requirements for the study or project and the types of quality control materials and procedures to be used in determining if the data meet these requirements;
- In-house quality assessment procedures to be used in evaluating the outcome; and,
- Description of the interpretation, including statistical analyses, of the data.

Project-specific QA plans for each study may be based on USEPA guidance, such as USEPA Guidance for Quality Assurance Project Plans (EPA QA/G-5) or some other model, but will describe the experimental data generation or data collection design for the project including the types and number of samples required, the design of the sampling network, sampling locations and frequencies, and the rationale for the design.

In addition, project-specific QA plans will often describe or reference standard operating procedures (SOPs) for all sampling or data generating methods and analytical methods, including sample handling and custody in the field, in the laboratory, and during transport. As appropriate, documentation included with the final report(s) from each study will include: field logs for the collection of the samples, chain of custody records, and QA/QC documentation. Documentation will be specific for each study but each project-specific plan will identify the appropriate documentation and provide for retention. All studies are required to comply with Good Laboratory Practice Standards for facilities, apparatus, and physical/chemical and biological test systems. This includes descriptions of maintenance, inspections of instruments, and acceptance testing of instruments, equipment, and their components, as well as the calibration of such equipment and the maintenance of all records relating to these exercises.

6.3 Assessment and Oversight

Studies that include the generation or acquisition of data may be audited by the QA Coordinator or designee. These reviews will include both technical system audits (i.e., qualitative evaluations of operational details) and data and report reviews (i.e., evaluations of data quality, adequacy of documentation, and technical performance characteristics). The purpose of these reviews is to ensure that the project-specific plan is being implemented as described.

If, in the professional opinion of the QA Coordinator, the results of a review indicate a compromise in the quality of the data being collected or reported, the QA Coordinator has the authority to stop work by oral direction. The QA Coordinator will promptly report to the Trustee Council Assessment Manager and describe the necessity for this direction.

6.4 Data Validation and Usability

All study plans, work plans, and final reports will be reviewed for adequacy of design and appropriateness of methodology by the Trustees or their designates. Analytical data may be validated by an independent third party. Validation of analytical data will assist the analyst or analytical facility in developing data that meet the requirements for precision and accuracy. It is expected that data validation will use the project-specific QA plans and USEPA Guidance on Environmental Verification and Validation (EPA QA/G-8).

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IN WITNESS WHEREOF the Trustees have adopted this Injury Assessment Plan on the dates noted below.

THE CONFEDERATED TRIBES OF THE COLVILLE RESERVATION

By: ______________________ 12-27-12 (Date)

Name: Richard Swan Sr.

Title: Colville Business Council, serving as Confederated Tribes of the Colville Reservation's Authorized Official

THE SPOKANE TRIBE OF INDIANS

By: ______________________ (Date)

Name: BJ Kieffer

Title: Director, Department of Natural Resources

THE DEPARTMENT OF THE INTERIOR

By: ______________________ (Date)

Name: Lorri J. Lee

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12/17/2012
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Title: Pacific Northwest Regional Director,
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Department of the Interior's Authorized Official

THE STATE OF WASHINGTON

By: ______________________________ (Date) 12/18/12
Name: James J. Pendowski
Title: Program Manager, Toxics Cleanup Program,
Washington State Department of Ecology