HUMAN HEALTH RISK ASSESSMENT WORK PLAN FOR THE UPPER COLUMBIA RIVER SITE REMEDIAL INVESTIGATION AND FEASIBILITY STUDY

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ACRONYMS AND ABBREVIATIONS

95UCL	95% Upper Confidence Limit
ABS_d	Dermal Absorption Fraction
ACF	Area Correction Factor
ACG	Analytical Concentration Goal
ADAF	Age-Dependant Adjustment Factor
AF	Absorption Fraction
Ah	aryl-hydrocarbon
ALM	Adult Lead Model
amsl	above mean sea level
ASCTF	Area-wide Soil Contamination Task Force
AT	Averaging Time
ATSDR	Agency for Toxic Substances and Disease Registry’s
B.C. MoE	British Columbia Ministry of Environment
BERA	baseline ecological risk assessment
BEST	Biomonitoring of Environmental Status and Trends
BiOp	biological opinion
BKSF	Biokinetic Slope Factor
BPA	Bonneville Power Administration
BW	Body Weight
CCRH	Center for Columbia River History
CCT	Confederated Tribes of the Colville Reservation
CDC	Centers for Disease Control
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CF	Conversion Factor or Correction Factor
cfs	cubic feet per second
COI	chemical of interest
COPCs	Chemicals of Potential Concern
CRIEMP	Columbia River Integrated Environmental Monitoring Program
CRITFC	Columbia River Inter-Tribal Fish Commission
CTE	Central Tendency Exposure
DAD	Dermally Absorbed Dose
DA_{event}	Absorbed Dose per Event
DAF	Dermal Adherence Factor
DI	Daily Intake
DL	Detection Limit
DOI	U.S. Department of the Interior
DOJ	Department of Justice
DQOs	Data Quality Objectives
dsm^3	dry standard cubic meter(s)

ACRONYMS AND ABBREVIATIONS (cont.)

EC	Exposure Concentration
Ecology	State of Washington Department of Ecology
ED	Exposure Duration
EEF	Empiric Extrapolation Factor
EET	External Exposure Term
EF	Exposure Frequency
EOP	Estimated Order of Potency
EPA	U.S. Environmental Protection Agency
EPCs	Exposure Point Concentrations
ESI	Expanded Site Inspection
ET	Exposure Time
EV	Event Frequency
°F	degrees Fahrenheit
ft	foot or feet
ft/s	feet per second
GM	Geometric Mean
GSD	Geometric Standard Deviation
GSF	Gamma Shielding Factor
HEAST	Health Effects Assessment Summary Tables
HHRA	Human Health Risk Assessment
HIF	Human Intake Factor
HQ	Hazard Quotient
IEUBK	Integrated Exposure Uptake Biokinetic
IJC	International Joint Commission
in	inch(es)
IR	Intake Rate
IRIS	Integrated Risk Information System
kg	kilogram(s)
kg/d	kilogram(s) per day
K_p	Dermal Permeability Coefficient
L	liter(s)
LOAEL	Lowest Observed Adverse Effect Level
LOPC	Level of Potential Concern
LRF	Lake Roosevelt Forum
LRNRA	Lake Roosevelt National Recreation Area
m	meter(s)
MCLs	Maximum Contaminant Levels
µm	micrometer(s)
µg	microgram(s)
mg	milligram(s)
mg/L	milligrams per liter
mi^2	square mile(s)
MRLs	Minimal Risk Levels

ACRONYMS AND ABBREVIATIONS (cont.)

NASQAN	North American Stream Quality Accounting Network
NGVD	National Geodetic Vertical Datum
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No Observed Adverse Effect Level
NPDES	National Pollutant Discharge Elimination System
NPRI	National Pollutant Release Inventory
NPS	National Park Service
NWPPC	Northwest Power Planning Council
OFM	Office of Financial Management (Washington State)
ORIA	Office of Radiation and Indoor Air
PA/SI	Preliminary Assessments and Site Inspections
PAH	polycyclic aromatic hydrocarbon
PbB	Blood Lead
PBDE	polybrominated diphenyl ether
PbS	galena
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzo-p-dioxin
PCDF	polychlorinated dibenzofuran
PEF	Particulate Emission Factor
pg	picograms
PPRTVs	Provisional Peer Reviewed Toxicity Values for Superfund
QAPP	Quality Assurance Project Plan
RAGS	Risk Assessment Guidance for Superfund
RBA	Relative Bioavailability
RBC	Risk-Based Concentration
RfC	Reference Concentration
RfD	Reference Dose
RI/FS	Remedial Investigation and Feasibility Study
RM	River Mile
RME	Reasonable Maximum Exposure
ROS	Regression on Order Statistics
RVs	Recreational Vehicles
SA	Surface Area
SAIC	Science Applications International Corp.
SAPs	Sampling and Analysis Plans
SF	Slope Factor
SHF	Shielding Factor
SO_2	sulfur dioxide
STI	Spokane Tribe of Indians
STSC	Superfund Health Risk Technical Support Center
SVOCs	Semi-volatile Organic Compounds

ACRONYMS AND ABBREVIATIONS (cont.)

TCAI	Teck Cominco American Incorporated
TCDD	2,3,7,8-tetrachlorodibenzo-para-dioxin (dioxin)
TCM	Teck Cominco Metals Limited
TEF	Toxicity Equivalency Factor
TEQ	toxicity equivalent
t_{event}	Event Duration
TI	Total Intake
TRI	Toxic Release Inventory
TRW	Technical Review Workgroup
TWA	Time-Weighted Average
TWF	Time-Weighting Factor
UCR	Upper Columbia River
UCRWSRI	Upper Columbia River White Sturgeon Recovery Initiative
UF	Uncertainty Factor
UR	Unit Risk
USBR	U.S. Bureau of Reclamation
USCGS	U.S. Coast and Geodetic Survey
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WDFW	Washington State Department of Fish and Wildlife
WDOH	Washington State Department of Health
WHO	World Health Organization
WOE	Weight of Evidence
WPLCS	Water Quality Permit Life Cycle System
WRIA	water resource inventory area
ZnS	sphaelerite

1 INTRODUCTION

1.1 Overview of the Site

The Upper Columbia River (UCR) site is located in the north central portion of the State of Washington and includes approximately 150 river miles of the Columbia River, extending from the United States-Canada border south and west to the Grand Coulee Dam. A remedial investigation and feasibility study (RI/FS) is currently underway in response to concerns regarding historical discharges of hazardous substances into the Columbia River, including but not limited to discharges of granulated slag, liquid effluents, emissions, and accidental spills and "upsets" from smelting processes and facility operations by Teck Cominco Metals Limited (TCM) at the Trail facility located in Trail, British Columbia.

On June 2, 2006, the United States (on behalf of the U.S. Environmental Protection Agency (EPA) and Department of Justice (DOJ)) and Teck Cominco American Incorporated (TCAI) signed a Settlement Agreement for Teck Cominco to perform an RI/FS of the UCR Site. In accordance with the settlement agreement, TCAI will complete the baseline ecological risk assessment and EPA will complete the baseline human health risk assessment (HHRA).

1.2 Purpose of this Document

This document is the work plan for the baseline HHRA. The purpose of this document is to: 1) describe the risk assessment approaches that will be utilized in the baseline HHRA, and 2) evaluate the data that are presently available to determine if they are adequate to support the baseline HHRA, or whether additional data collection is needed. It is important to note that this document was developed based on the current understanding of the UCR Site, nature and extent of contamination, chemicals of interest, and human exposure scenarios. To the extent that these change in the future, the baseline HHRA will incorporate new information as appropriate.

The description of the risk assessment approach is stratified into three components: exposure assessment, toxicity assessment, and risk characterization. The exposure assessment component includes the site conceptual model, a description of how exposure estimates will be derived, and a summary of the exposure parameters that will be used to estimate exposures. The toxicity assessment component includes a summary of the toxicity data that will be used to evaluate site-related exposures. The risk characterization component describes how risk estimates will be calculated from the exposure estimates and toxicity data.

The data adequacy assessment evaluates available environmental data and exposure parameters to determine if the existing data are adequate to support human health risk management decisions. One part of the data adequacy assessment is a preliminary set of risk calculations for each exposure scenario. It is important to emphasize that these preliminary calculations are not expected to yield accurate estimates of risk in most cases. Rather, the purpose of these calculations is to help identify significant data needs and guide future data collection efforts in support of the baseline HHRA.

1.3 Organization of this Document

In addition to this introduction, this report is organized into the following sections:

Section 2	This section provides a description of the site location and history, as well as the environmental setting and land use.
Section 3	This section summarizes the chemical stressors and sources to the site.
Section 4	This section describes the general risk assessment strategy that will be used to evaluate potential human exposures in the baseline HHRA.
Section 5	This section describes the methods that will be used to characterize human exposure at the site in the baseline HHRA. This includes a summary of the site conceptual model, the environmental media and chemicals of potential concern, the human exposure scenarios of potential concern at the site, and the equations used to derive estimates of exposure.
Section 6	This section summarizes the toxicity factors used to calculate cancer and non-cancer risk in exposed humans from the chemicals of interest at the site in the baseline HHRA.
Section 7	This section summarizes the methods that will be used to characterize and interpret non-cancer and cancer risk to humans from exposures to chemicals in environmental media at the site in the baseline HHRA.
Section 8	This section summarizes applicable site investigations and available data that characterize the nature and extent of environmental contamination at the site.
Section 9	This section evaluates the adequacy of available environmental data sets and exposure parameter information to support human health risk management decision-making.
Section 10	This section provides recommendations for data collection to reduce uncertainties in the future baseline HHRA.
Section 11	This section provides full citations for EPA guidance documents, site-related documents, and scientific publications referenced in this document.

All tables, figures, maps, and appendices cited in the text are provided at the end of the document.

2 SITE DESCRIPTION

This section provides a general characterization of the Site, including descriptions of Site history and usage, physical characteristics, and ecological resources.

2.1 Site Characteristics and Use

The UCR Site is located in north central Washington (Map 2-1). The Site extends along the Columbia River from the border between the United States and Canada downstream to the Grand Coulee Dam (EPA 2006d). The Site includes the areal extent of contamination and all suitable areas in proximity to such contamination necessary for implementation of response actions.

Immediately upstream of the Grand Coulee Dam, the impounded river forms Lake Roosevelt reservoir. The elevation of water maintained within Lake Roosevelt is managed by the U.S. Bureau of Reclamation (USBR) to provide flood control, irrigation, recreation, fisheries, navigation, flow regulation, and power generation (EPA 2005a). The maximum water elevation maintained in Lake Roosevelt (or full pool elevation) is 1,290 feet above mean sea level (amsl). During the annual operating cycle, water levels in the reservoir are typically drawn down between January and April to accommodate increased spring flows. The level of drawdown is determined based on estimates for the spring runoff volumes and the projected runoff at The Dalles (USBR 2007a; EPA 2005a). At full pool, Lake Roosevelt extends at least 133 miles upriver to U.S. Geological Survey (USGS) river mile (RM) 730, within 15 miles of the Canadian border, and is bordered by over 600 miles of publicly available shoreline (EPA 2005a; LRF 2006a; NPS 2006c). At the northern end of the Site, the free-flowing reach of the UCR is generally undeveloped, bordered by the Colville National Forest to the west (EPA 2003a). Highway 25 runs adjacent to the eastern shore of this portion of the river, which is characterized by largely undeveloped public and private land.

The upland area surrounding the Site is generally thinly populated and consists of forests and farmland. Communities located along Highway 395 to the west of the UCR include Barstow and Boyds. Communities located to the east of the UCR, along Highway 25, include, from north to south, Northport, Evans, Marcus, Rice, Daisy, Gifford, Cedonia, Hunters, Fruitland, and Enterprise. Further south, the Colville Indian Reservation borders Lake Roosevelt to the north and west for approximately 93 river miles. This area includes several communities, the largest of which are Coulee Dam, Inchelium, and Keller (EPA 2003a). The Spokane Indian Reservation borders approximately 8 miles of the reservoir to the east, just south of the community of Enterprise and north of the Spokane River.

2.2 Human Settlement and Cultural Resources

This section provides an overview of the prehistory, native peoples, and Euroamerican historical development of the UCR drainage. It is intended to offer an introductory framework for addressing the diverse cultural resources of this area. Primary sources of information on the prehistory of the area are Ames et al. (1998), Goodal et al. (2004), and Pokotlyo and Mitchell

(1998); for Native peoples, the sources are Kennedy and Bouchard (1998), Lahren (1998), Miller (1998), and Ross (1998); and for Euroamerican history, McKay and Renk (2002).

Human prehistory of the UCR area extends back at least 10,000 years. Although settlements were dispersed and occupied for short periods of time, major resource locations such as Kettle Falls were already being intensively utilized. Kettle Falls is one of the most significant cultural sites in the Western Hemisphere; early artifacts of human occupation there date from about 8,800 to 9,600 years ago (Chance 1986). Permanent villages at Kettle Falls and other locations along the UCR, supported by a substantial salmon fishery, have existed for at least 3,000 years (Kennedy and Bouchard 1998; Lahren 1998; Miller 1998; Ross 1998). Approximately 3,000 years ago, the general patterns of land and resource use among native peoples are evident in the archaeological record. These patterns include residence through the winter at established village locations, with seasonal shifts to resource locations during the summer (although some villages may have been occupied year-round). Native groups were much larger and less mobile than during the early millennia of human occupation. Salmon increasingly dominated the diet of native peoples, eventually becoming the single most important element in the diet. There is evidence of considerable cultural continuity from this period through Euroamerican contact in the late 1700s and early 1800s. At the time of initial Euroamerican presence in the region, which began in the early 1800s, Native American tribes and their sub-groups in the UCR area included: Lakes (sngaytskstx), Colville (sx̱weyi'7lhp), Sanpoil (snpgwa`ylxex), Lower Spokane (sḵasi`lhni) and Moses (snḵ`e7`iwsx) (Bouchard and Kennedy 1979). The Lakes people are named for their lands around Lower and Upper Arrow lakes and Slocan Lake but their homeland extended down the Columbia River to the vicinity of modern Northport, Washington. By the later 1800s, there were Lakes villages as far south as Kettle Falls. The Colville occupied the Columbia River valley south of the Lakes people to near the mouth of Wilmont Creek. Below the Colville on the Columbia River were the Spokane on the east bank of the Columbia and in the Spokane River drainage and the Sanpoil on the west bank.

There were no boundaries in a modern sense between these groups, and group homelands were defined primarily by geographic areas of traditional and regular use. Furthermore, the extensive network of kin, marriage, and exchange relationships that radiated across the Columbia Plateau made the homeland “boundaries” highly permeable. In addition, major resource locations such as Kettle Falls attracted hundreds, if not thousands, of visitors from within and outside the region to fish, trade, and socialize.

Contacts between native populations and Euroamericans in the UCR region began in the early 1800s as Canadian and American fur companies established trading posts throughout the Pacific Northwest. Spokane House was founded on the lower Spokane River in 1810 and a nearby competing post, Fort Spokane, was founded in 1812. Both posts were eventually abandoned and a new one established at Kettle Falls, known as Fort Colville. These fur-trading operations dominated Euroamerican use of the UCR region into the early 1850s.

A harbinger of growing American interest in the region was the Tshimakain Mission, founded in 1838 near the modern location of Ford, and St. Paul’s Mission built in 1847 near Kettle Falls (NPS 2007b). The discovery of gold in the upper Columbia drainage spurred a mining boom beginning in the late 1850s and continuing through the late 19th century. Conflicts between

Indians and miners led to the 1855 Yakama War; in 1880-1882, a military post (Fort Spokane) was established at the mouth of the Spokane River (the fort was closed as a military post in 1899 and operated as an Indian school from 1900 to 1908). Other federal acts during this era further impacted tribal cultures as individual allotments of lands were made to tribal members in efforts to contain tribal movement and provide lands and resources for settlers and development.

Many of the modern towns in the UCR region were founded from the late 1850s through the 1880s as mining communities or as supply centers for the mining districts. Farming, grazing, and timber grew increasingly important to the development of the area through the early 1900s. By the late 19th century, European farmers and loggers had settled widely in central Washington. Chinese immigrant miners and other laborers also arrived during this time. Irrigation-dependent farming rose to prominence in the early 20th century.

With the growing demand of settlers, treaties were signed in 1855 to cede Indian lands to the federal government. Only one of these treaties (the Yakima Treaty) included groups in the present study area. The Yakima Treaty created the modern Yakama Reservation, which is to the southwest of the UCR region. The Colville Reservation was created by executive order in 1872; the Spokane Reservation was created by executive order in 1881. Portions of the UCR Site are located within the Colville and Spokane reservations. The present boundaries of the reservation include approximately 1.4 million acres (2,200 square miles), including northern and western shorelines of approximately 93 miles of the UCR extending upstream from Grand Coulee Dam (Map 2-1) (CCT 2008). The reservation is the home of members of The Confederated Tribes of the Colville Reservation (CCT), which include the Colville, the Nespelem, the San Poil, the Lakes, the Palus, the Wenatchee, the Chelan, the Entiat, the Methow, the Okanogan, the Moses Columbia, and the Nez Perce (CCT 2008).

The original north boundary of the reservation was the Canadian border; this former "North Half" of the Colville Indian Reservation continues to be an important homeland to the CCT. The CCT exercises certain management and regulatory authority in this area from the northern boundary of the current reservation north to the Canadian border, bounded by the Okanogan and Columbia rivers. CCT-owned land and individual tribal members reside on the North Half and use the lands, waters, and natural resources for cultural and subsistence uses as they do on the reservation. In Antoine v. Washington, the Supreme Court affirmed the Colville Tribes' rights to hunt and fish on the North Half (Alexander Antoine v. State of Washington 420 US 194. 1975). The total population of the Colville Reservation in the year 2000 was estimated to have been approximately 7,600 people (Washington State Office of Financial Management [OFM] 2006).

The Spokane Reservation is the home of members of three bands of the Spokane Tribe of Indians (STI): Upper, Middle, and Lower Spokane (STI 2008). The Spokane Reservation originally consisted of 154,602 acres. A joint resolution of Congress was passed in 1902 to allot the reservation. The Secretary of the Interior was authorized to sell unallotted surplus lands in 1908, and it was opened up for homestead entry in 1909. The Upper and Middle Spokane signed an agreement in 1887, ratified in 1892, to be removed to the Coeur d'Alene Reservation. In 1958, 2,752 acres was restored to the Spokane Indian Reservation by an act of Congress. Today, the reservation includes approximately 160,000 acres of land (250 square miles), including an eastern shoreline of approximately 8 miles of the UCR extending upstream from the confluence with the Spokane River (Map 2-1) (STI 2008). The total population of the Spokane Reservation in the year 2000 was estimated to have been approximately 2,000 people (OFM 2006). The UCR Site remains the permanent homeland for the STI people today.

A western power shortage associated with World War II led Franklin D. Roosevelt to authorize the Columbia Basin Project, including the Grand Coulee Dam and Banks Lake, a holding reservoir. The implementation of this project altered the historical, cultural, and natural resources of the UCR, leading to present day conditions. The construction of Grand Coulee Dam in the late 1930s and the creation of Lake Roosevelt also created opportunities for recreation that have gained greater importance in the local economies over the past 30 to 40 years as mining and timber production have declined. Historic-period communities that were located along the Columbia River and were either destroyed or relocated with the creation of Lake Roosevelt included Keller, Peach, Lincoln, Gerome, Gifford, Inchelium, Daisy, Kettle Falls, Marcus, Boyds, and Fort Colville.

Physical traces of past human settlement in the UCR region can be seen in the hundreds of prehistoric archaeological sites recorded along the river, the dozens of historically documented Indian village locations, and the remains of historic-period farms, ranches, and communities. All cultural and historical sites along the river are protected under state and/or federal law.

Development of the Grand Coulee Dam and concerns about inundation of archeological sites along the waterways where aboriginal tribes had camps stimulated much of the documentation of the prehistory of the UCR Valley. The EPA (EPA 2004b) identifies four phases of archeological investigations: pre-inundation investigations during the 1930s and 1940s by the Columbia Basin Archaeological Survey, post-inundation salvage excavations by the University of Idaho and Washington State University in the 1960s and 1970s, numerous cultural resource surveys of portions of the reservoir from the 1960s through 1996, and since 1996, archeological and cultural investigations instituted by an intensive compliance agreement program managed and implemented by federal agencies (Bonneville Power Administration [BPA], USBR, and NPS) and the tribes. As of 2006, more than 600 archaeological sites have been recorded between the Canadian border and the dam (EPA 2007b). The archaeological record with respect to cultural historical sequence, prehistoric land use, subsistence, settlement/housing, and trade was reviewed by Galm and Luttrell (1994, as cited in EPA 2004b).

The majority of the project area is in federal or tribal jurisdiction, but some areas outside these jurisdictions may be subject to Washington laws that address Indian burials, historic cemeteries, and archaeological and historical resources.

In addition to archeological cultural resources, continuing use of some areas by tribal peoples and other communities may constitute traditional cultural properties that are also legally protected. In addressing cultural and natural resources, it is important to note that many traditional communities do not distinguish between “natural” and “cultural” resources. Most – if not all – plants and animals also have cultural meaning and play important roles in the cultural life of the community, as do many natural landmarks and features. Elements such as clean water or salmon, which Western culture tends to view as distinct from human life, are often viewed as integral to both individual and group identity. Natural and cultural resources are therefore considered so interwoven that they cannot be addressed separately. In a somewhat similar manner, salmon have achieved an iconic status in the Pacific Northwest as part of the distinctive identity of the region.

2.2.1 Current Demographics

The UCR area includes several towns and communities outside of the Colville and Spokane reservations that are adjacent to or near the river. Demographic profiles based upon the 2000 United States census are available for some of the larger communities. This information is summarized below and in Table 2-1.

The total population of Northport in 2000 was 336, with a median age of 42.8 years (Table 2-1). Six percent of the population in 2000 was under age 5 and 17.3 percent was age 65 or older. Of the total population of Northport, 94.9 percent are categorized as white (U.S. Census Bureau 2006).

The total population of Marcus in 2000 was 117, with a median age of 43.5 years. Of the total population in 2000, 6 percent was under 5 years and 14.5 percent was 65 years and over. The racial diversity of Marcus was similar to that of Northport (U.S. Census Bureau 2006).

The total population of Kettle Falls in 2000 was 1,527, with a median age of 34.4 years; 8.3 percent of the population in 2000 was under age 5 and 15.8 percent was age 65 or older. Of the total population of Kettle Falls, 91.3 percent was categorized as white, 3.9 percent as American Indian/Alaska Native, and 2.8 percent as Hispanic/Latino (U.S. Census Bureau 2007a).

The total population of Coulee Dam in 2000 was 1,044, with a median age of 44.5 years (see Table 2-1). The percentage of the total population under 5 years of age was 5 percent, and 65 years and older was 20.3 percent. Coulee Dam is a racially diverse community with 64.6 percent of the population categorized as white, 29.1 percent as American Indian/Alaska native, 2.8 percent as Hispanic/Latino, and less than 1 percent Black/African-American or Asian (U.S. Census Bureau 2006).

The city of Grand Coulee had a total population of 897 in 2000, with a median age of 45.3; 5.5 percent of the population was under 5 years of age and 23.6 percent of the population was over 65 years of age. In 2000, 81.3 percent of the population was categorized as white, 12.5 percent as American Indian/Alaska Native, and 4.9 percent as Hispanic/Latino (U.S. Census Bureau 2007a).

The total population of Inchelium in 2000 was 389, with a median age of 32.9 years. The percentage of the total population under 5 years of age was 5.4 percent and 65 years and older was 10.5 percent. In 2000, 76.6 percent of the population was categorized as American Indian/Alaska Native, 20.3 percent as white, and 1.5 percent as Hispanic/Latino (U.S. Census Bureau 2006).

The total population of zip code 99137 in 2000, which includes the towns of Hunters and Cedonia, was 306, with a median age of 41.5 years. The percentage of the total population under

5 years of age was 4.2 percent and 65 years and older was 15.4 percent. In 2000, 87.6 percent of the population was categorized as white, 4.6 percent as American Indian/Alaska Native and 1.3 percent as Hispanic/Latino (U.S. Census Bureau 2007b).

In 2000, the total population of the Colville Indian Reservation was 7,587. The terrain of the Colville Indian Reservation is mountainous and mostly forested, with a small amount of farmland. The Colville Indian Reservation is thinly populated with an average of 3.6 persons per square mile (OFM 2006). Logging and mining dominate the economy (EPA 2003a).

In 2000, the total population of the Spokane Indian Reservation was 2,004 (OFM 2006). The area east of the UCR is a mixture of forest and farmland, with a population density of 14.3 persons per square mile. Forest products manufacturing dominates the economy (EPA 2003a).

The area south of the Site is generally flat with low rolling hills and is primarily agricultural. The population density is 4.2 persons per square mile (EPA 2003a).

2.2.2 Site Uses

A summary of primary uses of the UCR Site by residents and visitors is described below.

2.2.2.1 Recreation and Occupational Uses

A large portion of Lake Roosevelt has been designated as the Lake Roosevelt National Recreation Area (LRNRA), which is managed by the NPS. The LRNRA attracts more than 1.3 million visitors per year (NPS 2006c). According to the Fiscal Year 2003 Annual Performance Plan, the park employs approximately 54 permanent and 49 seasonal employees and receives up to 4,000 hours of volunteer labor annually. Maintenance and administrative offices for the park are located in Coulee Dam, Spring Canyon, Fort Spokane, and Kettle Falls (NPS 2006c).

Portions of Lake Roosevelt that are not included in the LRNRA are managed by CCT and STI. The NPS, CCT, and STI cooperate as managing partners as described in the Lake Roosevelt Cooperative Management Agreement (the 5-party agreement). Designated recreational uses of the LRNRA include boating, fishing, swimming, wading, camping, canoeing, and hunting.

Developed areas overseen by the NPS include 22 boat launches, 27 campgrounds, and three concessionaire-operated marinas (Seven Bays, Keller Ferry, and Kettle Falls Marinas) that provide moorage, boat rental, fuel, supplies, food service, and other services. Map 2-2 is a reproduction of an NPS map showing water management zones of the lake and recreational facilities along the UCR (LRF 2007b; EPA 2007a). Two Rivers Marina (not part of the National Recreation Area) is owned and operated by the STI.

The remainder of the Lake Roosevelt shoreline managed by the NPS is undeveloped. The NPS allows camping on any undeveloped shoreline. The Colville and Spokane Indian reservations also provide opportunities for recreational visitors to fish and camp at the UCR (NPS 2006c). Recreational users may include occasional visitors, local residents, and tribal members. NPS employees and volunteers also are present at the Site as part of their work responsibilities and may use the Site for recreation on a regular basis.

As part of EPA's Phase I beach investigation, EPA visited 15 beaches that were known to be frequented by the public based on input from the CCT, the STI, the State of Washington, and NPS (EPA 2006c). The beaches visited by EPA were:

- Black Sand Beach
- Northport City Boat Launch
- Dalles Orchard
- North Gorge Campground
- Marcus Island Campground
- Kettle Falls Swim Beach
- Haag Cove
- French Rocks Boat Launch
- Cloverleaf Beach
- AA Campground
- Rogers Bar Campground
- Columbia Campground
- Lincoln Mill Boat Ramp
- Keller Ferry
- Spring Canyon Campground

The locations for all 15 beaches are shown on Map 2-3. Typical human activities on the beach areas include dry beach play (digging in sand), shallow water play (wading, splashing, or swimming), camping, picnicking, cooking, and boat launching and retrieval (EPA 2006c).

2.2.2.2 Surface Water Use

Surface water in the UCR is a major source of irrigation water for commercial agriculture. According to the USBR, surface water from the UCR is used to fill Banks Lake to the south and to subsequently provide irrigation to over 600,000 acres of agricultural lands located south of Banks Lake, east of the Columbia River, and north of the Snake River (USBR 2006b).

Based on water right information provided by the Washington State Department of Ecology (Ecology), 77 current surface water rights along the UCR and the Kettle, Spokane, and Sanpoil river arms of Lake Roosevelt are potentially used for domestic supply, including multiple-purpose water rights (Table 2-2; O'Brien 2007, pers. comm.). The approximate locations of these surface water rights are shown on Map 2-4.

Public water systems are defined as all systems serving more than one single-family residence or more than five residences on the same farm, and are classified as either Group A or Group B depending on the number of people served and the number of residential connections (Figure 2-1). Surface water from the UCR is currently identified as a source for three Group A public water supply systems (Washington Department of Health [WDOH] 2007). The three Group A systems are listed below; their locations are shown on Map 2-4. In addition, the City of Grand Coulee formerly drew water for its municipal supply from the UCR just upstream of the dam, but this source was discontinued in February 2006 (Wilson 2007, pers. comm.).

System ID	System Name	County	Surface Water Source Use
38400	Kettle Falls Water Department	Stevens	Emergency[a]
28695	Grand Coulee Dam	Grant	Permanent
15400	Coulee Dam Water Department	Okanogan	Permanent

[a] Surface water is used by Kettle Falls system only to augment its fire suppression system water supply (EPA 2003a). This source has not been used since 1989 (Gassaway 2007, pers. comm.).

No Group B systems use UCR surface water; however, one Group B system draws from the Sanpoil River within the boundary of Lake Roosevelt (Map 2-4; WDOH 2007).

2.2.2.3 Fisheries and Hatchery Operations

The UCR currently supports numerous species of game and non-game fish. Rainbow trout, kokanee salmon, walleye, and smallmouth bass are the primary fish harvested from the UCR either by boaters or shoreline anglers. Other game fish include largemouth bass, yellow perch, lake whitefish, mountain whitefish, brook trout, burbot, cutthroat trout, black crappie, pumpkinseed, and yellow bullhead (LRF 2006c). Historically, the white sturgeon fishery was important in the upper portion of the reservoir (RM 702 and above); however, this fishery was closed in 1996 to protect a failing population (Upper Columbia White Sturgeon Recovery Initiative [UCRWSRI] 2002).

Historically, the UCR was a subsistence fishery for Native American populations. For the Colville and Spokane tribes, anadromous and resident fish (mainly salmon but also steelhead trout, whitefish, and other species) were the principal subsistence fishery. Since the construction of the Columbia River dams, some resident fish (primarily rainbow trout and kokanee salmon) have become a necessary alternative as a subsistence resource. The waters of Lake Roosevelt within the Colville and Spokane reservations continue to be managed by the tribes as a subsistence fishery (EPA 2007a). The draft Fish and Wildlife Resource Management Plan for the Colville Reservation includes several provisions for creating/maintaining both ceremonial and subsistence fisheries of resident and anadromous fish in Lake Roosevelt (CCT 2006).

Prior to 1930, an estimated annual average of 1.1 million adult salmonids (*i.e.*, steelhead trout and Chinook, coho, and sockeye salmon) migrated past the current site of Grand Coulee Dam

(Scholz et al. 1986). In addition, the second-largest Native American fishery in the Columbia Basin was at Kettle Falls, roughly 108 river miles upstream of the dam site. Scholz et al. (1986) indicated approximately 300,000 to 1.5 million adult salmon were harvested annually at Kettle Falls and in the Spokane River, with the majority taken at Kettle Falls. As partial mitigation for the losses of salmon in the UCR resulting from construction of Grand Coulee Dam, the BPA constructed two fish hatcheries: the Spokane Tribal Hatchery and the Sherman Creek Hatchery. These facilities were intended to supplement salmonid populations in the UCR to mitigate native salmonid losses due to ecosystem alterations caused by the dam. The Spokane Tribal Hatchery (located on the Spokane Reservation) is operated by the STI and began production in 1991 (Northwest Power Planning Council [NWPPC] 2006a). The Sherman Creek Hatchery is located adjacent to Sherman Creek on the west bank of the UCR near Kettle Falls. This hatchery is operated by the Washington State Department of Fish and Wildlife (WDFW) and began production in 1992 (NWPPC 2006b). Together, these hatcheries serve as a combined effort to rear both kokanee and rainbow trout. The hatcheries and associated net pens (described below) have annually produced up to 800,000 yearling rainbow trout and 3.4 million yearling kokanee for release into the UCR from 1991 to 2005. Typical annual releases have been approximately 500,000 rainbow trout and 500,000 kokanee yearlings.

The UCR fisheries have been tracked by the Lake Roosevelt Fisheries Evaluation Program since 1988 in order to 1) monitor progress toward meeting harvest goals and objectives, 2) evaluate the performance of hatchery releases of selected species, and 3) identify potential effects of hydropower operations on the fisheries (Lee et al. 2006).

Based on evaluations completed to date, harvesting does not appear to be a significant factor in reducing the abundance of the targeted fish species in the UCR, nor does it appear to jeopardize the ability of these species to maintain viable populations. For example, the rainbow trout fishery is supported primarily by a successful hatchery-based put and take program. The harvest of hatchery kokanee is minimal, with the majority of it comprising wild fish (Lee et al. 2006). Successful spawning of wild kokanee in the UCR has not been detected, and minimal spawning occurs in tributaries. Hence, kokanee likely enter the UCR from upstream lakes, such as Lake Kootenay, Lake Pend Oreille, and Arrow Lake (BPA 2006b).

The abundance of the walleye population in the UCR appears to be fairly constant and able to sustain current harvest levels (Lee et al. 2006). WDFW determined that UCR walleye are underexploited by anglers, based on data collected during the fall walleye index net surveys during 2002 and 2005. Those surveys found a moderate population density, average growth, low weight to length ratios (*i.e.,* a condition factor), and adequate recruitment (Divens 2006; Lee et al. 2006). As a result, Washington State harvest regulations for bag limits have changed from five to eight fish per day.

Burbot harvest is believed to be low based on daytime creel surveys (Lee et al. 2006). However, because anglers commonly target burbot at night when creel surveys are not conducted, the harvest may be underestimated. Sampling data suggest the burbot population in the UCR is small, and the length-to-weight ratio of the population is below average, indicating food limitation (Lee et al. 2006; Woller 2006). Small populations with limited food supply are likely vulnerable to overharvest as has occurred in the nearby Kootenay River (Paragamian et al. 2000). However, the effect of harvesting on the burbot population in the UCR is unknown.

2.3 Physical Setting

The physical characteristics of the UCR influence the distribution of potential contaminants released to the Site, potential exposure to those contaminants, and the development and evaluation of potential remedial alternatives. This section presents an overview of Site geology, hydrogeology, hydrology, river reach characteristics, and climate.

2.3.1 Geology

The UCR is situated within two geologic provinces: the Okanogan Highlands and the Columbia Basin (Map 2-5). The UCR is located along the division between the eastern and western Okanogan Highland regions. The Okanogan Highlands, which are typified by rounded mountains and deep, narrow valleys, include both shores of the Columbia River above the confluence with the Spokane River. The Selkirk, Chewelah, and Huckleberry mountains are located east of the Columbia River and the Kettle, Sanpoil, and other mountains are located west of the river (Washington Department of Natural Resources [WDNR] 2006). Below the confluence with the Spokane River, the Columbia Basin borders the southern shore of the Columbia River.

The Okanogan Highlands comprise Proterozoic basement rocks onto which were deposited, or accreted, a westward younging assemblage of sedimentary terrains and metamorphic complexes abundantly intruded by differentiated granitic plutons of Mesozoic Age (Stoffel et al. 1991). The Columbia Basin consists of a series of basalt layers (Columbia River Basalts) that are interbedded with layers of tuffs, sandstones, and conglomerates.

The UCR region was extensively modified by glacial activities during the Pleistocene. The UCR is located within the footprint of the ancestral glacial Lake Columbia, which formed at least three times during the Pleistocene glacial period. The glacial lake and its tributaries deposited coarser materials interbedded with silt and clay, forming deltas. As the last glacier retreated, the Columbia River caused rapid erosion and large-scale landslides of unconsolidated lacustrine deposits (Washington Water Research Center [WWRC] 1996). The repeated breaking of a massive ice dam that contained Lake Missoula, a massive lake formed from glacial melt waters, caused flood waters to pour through the Spokane Valley and into the Columbia Basin. These waters cut extensive and deep channels through the silt and basalt below the confluence with the present-day Spokane River (WDNR 2006). More recently, with the construction of Grand Coulee Dam and the flooding of Lake Roosevelt, the higher river levels have resulted in saturation of these glaciofluvial terraces and their consequent collapse; more than 300 landslides are documented along the UCR (Jones et al. 1961).

As shown in Map 2-6, surface geology along the shore of the UCR north of the Kettle River consists of gravel, sand and clay deposited by glacial streams adjacent to or downstream from temporary ice fronts. The surface geology south of the Kettle River consists of basalt, and, in some places along the south shore of the reservoir, the basalt cliffs rise nearly 1,000 feet above the lake (NPS 2002).

2.3.2 Hydrogeology

Hydrogeology of the Site is described in the following sections with details on groundwater aquifers and groundwater movement and use.

2.3.2.1 Aquifers in the Project Site Vicinity

Principal surficial aquifers of Washington State are shown on Map 2-7 (USGS 1985). Aquifers present in the project area are the Columbia Plateau Basalts (south of the lower reach of Lake Roosevelt) and alluvial deposits adjacent to and in valleys of tributaries to the reservoir. With the exception of the Columbia Plateau Basalts, much of the project area is underlain by geologic formations that cannot store or yield significant quantities of groundwater for water supply uses (USGS 1985).

Water-bearing units within the Columbia Plateau Basalts are the major aquifer in eastern Washington (Whitehead 1994). Three basalt units have been assessed and mapped in detail (Whitehead 1994), in order of increasing depth: the Saddle Mountains Basalt, Wanapum Basalt, and Grande Ronde Basalt. Large quantities of groundwater are present in fractures and rubble zones that occur between lava flows in each of these basalt units. Wells completed in the Columbia Plateau Basalts are capable of yields on the order of 3,000 gallons per minute (USGS 1985).

Limited local aquifers are present in the Site vicinity in permeable glacial alluvial deposits and in permeable sedimentary rocks (sandstones and limestones) (Whitehead 1994). Yields of wells completed in these aquifers are in the tens to hundreds of gallons per minute, depending upon the aquifer extent and groundwater recharge (Whitehead 1994).

The aquifer that provides the water supply for the City of Northport is an example of a permeable glacial deposit that contains useable quantities of groundwater. The sand and gravel deposits that comprise this aquifer extend from ground surface to depths greater than 200 feet, with static water levels on the order of 75 feet below ground surface (Weston Solutions, Inc. [Weston] 2004a). Maximum pumping rates from these wells range from 20 to 100 gallons per minute (Weston 2004a).

2.3.2.2 Groundwater Occurrence and Movement

Groundwater in the project area occurs in pore spaces between sand and gravel particles of unconsolidated aquifers and in fractures or voids of rock aquifers. These aquifers receive recharge from percolation of precipitation into the ground and leakage from surface water bodies (Whitehead 1994). Groundwater flows from higher-elevation recharge areas to lower elevations in the project area, where it discharges into streams, lakes, or rivers, or is pumped from the ground for various uses.

Shallow perched groundwater has been observed at elevations up to 160 feet above the full pool level of the reservoir (Riedel et al. 1997). A study by Thompson (1977), using thermal infrared imagery, identified extensive areas of bank seepage, spring discharge, stream inflow, and subsurface discharge into Lake Roosevelt. Observations of bank seepage and groundwater discharge correlated with the presence of unconsolidated glacial sediments, rather than bedrock. Shallow groundwater seepage into the reservoir has been identified as a contributor to soil instability and landslides (Jones et al. 1961).

Movement of water between the reservoir and the adjacent geologic strata depends upon a number of factors, including reservoir stage, bank storage and discharge during various reservoir stages, elevation and gradients of adjacent shallow aquifers, and regional discharge of groundwater into the reservoir from deeper aquifers (Thompson 1977).

Groundwater in the Columbia Plateau Basalts aquifer discharges to Lake Roosevelt at the northern edge of the south-sloping Columbia basalts (Whitehead 1994). Lower reaches of the Columbia River farther to the south (and outside of the UCR study area) subsequently receive discharge from this extensive basalt aquifer. Groundwater in the three Columbia Plateau Basalts units may flow upward or downward among the units, depending upon local water level and pumping conditions (Whitehead 1994).

2.3.2.3 Groundwater Use

Groundwater from wells and springs in the Site vicinity (*e.g.,* Fort Spokane spring, EPA 2007a) is used for public and domestic potable water supply, irrigation, power generation, and industry. Data compiled by Lane (2004) indicate that groundwater withdrawals in the portions of the Site located in Ferry and Stevens counties are much lower than withdrawals from the more prolific basalt aquifers south of Lake Roosevelt in Lincoln County (Figure 2-2). Groundwater used for irrigation accounts for over 90 percent of the withdrawals in Lincoln County. Map 2-8 shows the approximate locations of 3,312 water wells and 12 water supply springs identified within approximately 5 miles of the UCR and Lake Roosevelt shoreline (Ecology 2007a).[1]

Public water systems are defined as all systems serving more than one single family residence or more than five residences on the same farm, and are classified as Group A or Group B, depending on the number of people served and the number of residential connections (Figure 2-1). Information regarding Group A and Group B water systems that use groundwater as a source was obtained from the WDOH (2006b). The WDOH identified 131 water systems within 5 miles of the UCR and Lake Roosevelt shoreline that utilize groundwater (springs or wells) as a source (Table 2-3).

Wellhead protection areas (*i.e.,* a 10-year zone of groundwater travel) are identified by WDOH for 16 of these Group A systems, which are shown in Map 2-9 and listed in Table 2-4 (WDOH 2006a). Delineation of wellhead protection areas is required of Group A water systems in Washington State and is required by the federal Safe Drinking Water Act to support prevention of groundwater contamination.

2.3.3 Hydrology

General hydrology of the UCR is discussed in this section. Detailed discussion of the UCR river reaches from a hydrodynamics perspective is also provided.

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[1] Five miles was selected as an arbitrary extent to illustrate groundwater information within the area.

2.3.3.1 Overview

The Columbia River watershed is large and complex, with an area of approximately 260,452 square miles (mi^2) that encompasses parts of seven states (Washington, Oregon, Nevada, Utah, Idaho, Wyoming, and Montana) and one Canadian province (British Columbia). The watershed encompasses areas drained by several major tributaries, including the Pend Oreille, Kootenay, Okanogan, Wenatchee, Spokane, Yakima, Snake, Deschutes, Willamette, Cowlitz, and Lewis rivers. The head of the Columbia River is at Columbia Lake in Canal Flats, British Columbia. The river flows approximately 1,245 miles (approximately 470 miles in Canada) before reaching the Pacific Ocean along the border between Oregon and Washington. The river enters the United States in northeastern Washington, just south (downstream) of the confluence with the Pend Oreille River. For this work plan, consistent with the Agreement between Teck Cominco American Incorporated (TCAI) and EPA, the study area is the section of the UCR between the U.S.-Canadian border and Grand Coulee Dam, a river reach extending approximately 150 miles downstream of the international border.

Grand Coulee Dam was built to provide power generation, irrigation, and flood control. Construction began in the 1930s and was completed in 1941. In June 1942, the impounded reservoir of Lake Roosevelt reached its full pool water surface elevation of 1,290 feet amsl (USBR 2006a) (1,288.6 feet National Geodetic Vertical Datum [NGVD] 1927). Major tributaries that influence hydraulic conditions at the U.S.-Canadian border are the Columbia and Pend Oreille rivers. Principal tributaries that join the UCR within the study area are the Kettle, Colville, Spokane, and Sanpoil rivers. Numerous smaller tributaries also join the UCR within the study area, including Deep, Onion, Sheep, Sherman, Hall, Ninemile, and Hawk creeks.

A simple water budget for the UCR was calculated as shown in Tables 2-5 and 2-6. Long-term average flows were calculated for the Columbia River upstream of its confluence with the Kootenay River as well as for the Kootenay, Pend Oreille, Kettle, Colville, Spokane, and Sanpoil rivers. Flow gaging stations for these tributaries were selected based on proximity to the Columbia River as well as the length of the period of record for each gaging station. The gaging stations used to develop the water budget are shown in Table 2-5. Flow data for the entire period of record were used to determine the long-term average for each station. In developing the water budget, it was assumed that changes in daily or seasonal flow due to flow regulation at dams would change only the timing and magnitude of peak events but not impact the long-term flow from any given tributary.

Long-term averages for the individual tributaries were summed moving downstream to determine the cumulative long-term average flow in the Columbia River below the confluence with each tributary. Long-term averages for a number of stations along the Columbia River were also calculated for comparison to the cumulative values and are given in Table 2-6 with gaging station information given in Table 2-5. These measured flow rates compare favorably with the cumulative values calculated from the individual tributaries.

The calculated long-term average flow entering from each tributary was compared to the sum of the flows entering the UCR system and the relative contributions were determined. Approximately 90 percent of the flow at Grand Coulee Dam enters the system at the international border, with 40 percent coming from the Columbia, 26 percent from the Kootenay, and 24 percent from the Pend Oreille. The additional 10 percent enters the system between the border and the Grand Coulee Dam, with 3 percent coming from the Kettle River and 7 percent from the Spokane River. Less than 1 percent of the flow at the Grand Coulee Dam enters the system through the Colville and Sanpoil rivers. These estimates do not account for contribution from bank storage and groundwater influx.

Flow regimes in the UCR have varied over time. Over the past century, three distinct flow regimes have existed, as described below:

1. **Unregulated (before Grand Coulee Dam or upstream flow control).** Before flow regulation began, UCR flows were governed by precipitation and runoff, particularly the amount of snowpack and snowmelt. During the unregulated era, the river was free-flowing and subject to large, periodic high-flow (flood) events.
2. **Downstream Control (after Grand Coulee Dam but before upstream flow control**). During the period of downstream control, UCR flows were determined by unregulated upstream flow and water-level regulation at Grand Coulee Dam. Although periodic high-flow events still occurred, the extent of the Lake Roosevelt impoundment and backwater effects in upstream areas were controlled entirely by operations at Grand Coulee Dam.
3. **Regulated (after Grand Coulee Dam and after upstream flow control**). During the contemporary era of regulation (post-1972), river flows are controlled by the operation of upstream dams in addition to management operations at Grand Coulee Dam (EPA 2007b). As a result of the combined effects of dam operations, the size and frequency of large flood events has been reduced. This is more fully described in Section 3.2.3.3 below.

2.3.3.2 Flow Regulation across the U.S.-Canadian Border

River flow crossing the border from Canada is regulated by a series of upstream dams in Canada and the U.S. located on the Columbia, Duncan, Kootenay, and Pend Oreille rivers. Major dams upstream of the study area (including the Spokane River) are shown in Map 2-10. Flow regulation by these dams alters the natural hydrology of the UCR by reducing the magnitude and duration of peak flows, increasing low flows, and reducing the overall variability of flows.

The USGS flow gage at the U.S.-Canadian border has operated continuously since March 1, 1938. As measured at this gage, a significant change in the hydrograph occurred starting in late 1972 to early 1973. This coincides with the construction of Mica Dam (on the Columbia River in British Columbia) and Libby Dam (on the Kootenay River in Montana) and marks a major change in the coordination of flood control at the upstream dams. Because of the impacts that upstream regulation has on the UCR, analyses of river flow for the periods before and after 1973 should be considered separately.

Statistical measures of mean daily flow at the USGS border gage are shown in Table 2-7. The results are split into two intervals, using January 1, 1973, as a representative date for the shift in hydrographic characteristics. Mean annual flows for the two intervals are similar, with the post-1973 interval showing a slight (approximately 4 percent) decrease. However, peak flows and flow variability are quite different. The highest mean daily discharge from the pre-1973 interval was 549,000 cubic feet per second (cfs), which occurred in June 1948. In contrast, the highest mean daily discharge from the post-1973 interval was 302,000 cfs, which occurred in June 1997. As seen in the hydrograph (Figure 2-3), annual variation in river flow was much higher before 1973 than after, reflecting the influence of flood-control regulation by upstream dams. The difference between the two intervals is most apparent when comparing mean monthly flows (*i.e.,* mean of the daily averaged flows separately for each specific month in the multi-year intervals) (Figure 2-4). As shown in Figure 2-4, mean monthly flows prior to 1973 were much higher during the peak snowmelt months of May, June, and July and were generally lower the remainder of the year. Thus, the general effect of coordinated water regulation at upstream dams since 1973 has been a substantial reduction in annual peak flow through storage of seasonal snowmelt, and an increase in the annual median flow and corresponding decrease in flow variability, as stored water is released throughout the remainder of the year.

2.3.3.3 Water-Level Regulation for Lake Roosevelt

The Columbia River was free-flowing until 1933 when Rock Island Dam was constructed at USGS RM 483, followed by Bonneville Dam in 1937 at USGS RM 146, and then Grand Coulee Dam between USGS RM 596 and 597 in 1941.

The Grand Coulee Dam project was authorized several years prior to the outbreak of World War II; it was renamed and reauthorized by the Columbia Basin Project Act of 1943 (U.S. Fish and Wildlife Service [USFWS] 2007b). The project began with fund allocations for Grand Coulee Dam pursuant to the National Industrial Recovery Act of June 16, 1933, and was specifically authorized for construction by the Rivers and Harbors Act approved August 30, 1935 (Center for Columbia River History [CCRH] 2007; USBR 2007b). Construction of Grand Coulee Dam commenced in 1933, and by 1939, the dam began impounding water to form Lake Roosevelt (Figure 2-5). The main structure of the dam was completed by December 31, 1941; it took less than a year for the reservoir to reach full pool elevation (EPA 2007a).

In June 1942, the reservoir reached its full pool level, raising the original water surface 280 vertical feet from 1,010 to 1,290 feet amsl at the dam and inundating more than 70,000 acres of riparian and upland habitat (Merker 1993). At full pool (1,290 feet amsl), the reservoir has a surface area of approximately 82,300 acres and extends upstream of Grand Coulee Dam approximately 133 miles to Onion Creek (USGS RM 730), approximately 15 river miles south (downstream) of the U.S.-Canadian border. However, it is worth noting that the channel is constricted (and conveyance reduced) through the Little Dalles (USGS RM 728) and that water levels upstream of this point may rise during high flow events (U.S. Coast and Geodetic Survey [USCGS] 1950).

Just upstream of the U.S.-Canadian border, the Columbia and Pend Oreille rivers above the border supply the majority of the annual inflow (90 percent) to Lake Roosevelt, with the remainder primarily supplied by the Spokane, Sanpoil, Kettle, and Colville rivers (Table 2-5) (Stober et al. 1981).

Construction of Grand Coulee Dam was authorized by the U.S. Congress to provide electric power, flood control, and irrigation water (CCRH 2007). Power production and flood control were initially provided in 1941, although irrigation uses did not expand until after 1952, when pumping stations began transporting Columbia River water to Banks Lake. In total, the dam and reservoir produce more than 20 billion kilowatt-hours of power annually (EPA 2007b), while providing 5.2 million acre-feet of flood control storage, and water to irrigate 671,000 acres of farmland through the Columbia Basin Irrigation Project. Fisheries and recreational needs within Lake Roosevelt were considered secondary to power, flood control, and irrigation at that time. The dam was not outfitted with a fish ladder or other device to allow passage of adult salmon upstream and consequently it blocks anadromous fish from 1,149 miles of spawning and rearing habitat. In 1969 and 1974, the reservoir was drawn down well below its normal operating range to add a third powerhouse for expanded power production (EPA 2007b). The lowest drawdown on record occurred during this period of construction, at an elevation of 1,160 feet, roughly 130 feet below full pool (Figure 2-5).

Lake Roosevelt's surface elevation, inflow, and outflow are systematically controlled in order to meet the authorized flood protection, hydroelectric power production, irrigation, and downstream flow objectives. Grand Coulee Dam has historically been operated to maximize the storage capability of the reservoir for retention of flood waters during the spring runoff, to meet irrigation demand and downstream flow targets during the dry summer months (LRF 2007c), and to maintain the highest pool levels possible for maximum power generation at all other times of the year. Overall, the reservoir is highest immediately after the spring runoff (in May and June), gradually decreases through August, and holds relatively stable from September to December (EPA 2007a). With resumption of autumn rains, the reservoir gradually begins to fill until late in the year, when flood control constraints begin to dictate operations in anticipation of next year's spring runoff, and the cycle begins again. By the mid 1980s to early 1990s, water management for fish, wildlife, and recreation, was a secondary consideration (NPS 2007a).

In 1984, the Northwest Power Planning Council (NWPPC) (now Northwest Power and Conservation Council) planned for the implementation of fish restoration and enhancement projects. Hydropower operations were being scrutinized by fisheries managers in the Lower Columbia River, and they argued that salmon smolt survival downstream of Lake Roosevelt was low due to insufficient flows down the Columbia River during the spring seaward migration. In response, the NWPPC recommended implementation of a water budget to both increase and extend Columbia River flows during the spring season for juvenile salmon and steelhead migration (NWPPC 1994). The water budget, in theory, reduced average reservoir elevation and water retention time in Lake Roosevelt.

In 1995, the listing of Snake and Columbia river salmon and steelhead under the Endangered Species Act resulted in the water budget being replaced by a set of operational rules that were included in the National Marine Fisheries Service (NMFS; now referred to as National Oceanic and Atmospheric Administration [NOAA] Fisheries) Biological Opinion (BiOp), known as the 1995 BiOp (NMFS 1995). The 1995 BiOp affected Lake Roosevelt hydropower operations by requiring increased outflows during spring and summer.

To achieve this objective, the spring reservoir elevation was required to be at flood control rule curves[2] by April 15 to maximize available water for lower river flow augmentation in May and June. Prior to the 1995 BiOp, Lake Roosevelt pool elevation was frequently below that required for flood control due to power generation.

In addition, the 1995 BiOp required Lake Roosevelt to be drawn down 10 feet from full pool to a reservoir elevation of 1,280 feet in August. The August drawdown had not occurred historically. A final effect of the 1995 BiOp was an overall reduction in water retention time in Lake Roosevelt due to hydropower operation of Grand Coulee Dam and the upstream storage facilities, such as Libby and Hungry Horse dams. The upstream dams were required to send water downstream in spring and summer, thereby increasing Lake Roosevelt inflows and outflows.

In 1998, NOAA Fisheries appended the 1995 BiOp to include steelhead and referred to the new version as the 1998 BiOp (NMFS 1998). Theoretically, the volume of water contributed by Lake Roosevelt for flow augmentation was the same as prior years, but spread over a longer period. Reservoir volume is a function of reservoir elevation; therefore, lower reservoir elevations result in smaller volumes and shorter water retention times. Thus, the 1998 BiOp likely reduced reservoir elevations and volumes, thereby further reducing water retention time.

In 2000, NOAA Fisheries presented a new hydropower system BiOp, referred to as the 2000 BiOp (NMFS 2000). The 2000 BiOp had one additional effect on Lake Roosevelt: during lower than average runoff years (< 92 million acre-feet forecast at The Dalles), the reservoir was to be drawn down to 1,278 feet (1,280 feet in normal to wet years) by August 31 (*i.e.,* 2 feet lower than previous operations) (EPA 2007b). This has further reduced water retention times. Operators bring the pool elevation back up to 1,285 feet amsl (1,283 feet at a minimum) by September 30 to improve access by mature kokanee to tributary spawning areas and the Sherman Creek adult kokanee trap for egg collection (EPA 2007a).

The extent of water level increases is expected to be influenced by interactions between flow magnitude, reservoir pool level, and conveyance limitations through the Little Dalles. At typical low pool levels, with a water surface elevation of approximately 1,245 feet amsl (EPA 2007a), the reservoir extent is reduced and ends near USGS RM 704. Outflow from Lake Roosevelt occurs via discharge through the dam to the Middle Columbia River or through pumped discharge to Banks Lake for irrigation storage.

Although reservoir elevations are systematically managed, the extent of the elevation fluctuations can be somewhat unpredictable due to varying annual runoff flows. Figure 2-6 illustrates the variable runoff volumes at The Dalles, Oregon, which is the location upon which annual flood control capacity management at Lake Roosevelt is based (USBR 2007a).

In general, reservoir elevation will decrease from January to April, increase during May and June, decrease in July and August, and hold fairly stable from September to December.

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[2] Flood Control Rule Curves relate precipitation to reservoir levels based on flood control needs. The curves determine the amount of water to discharge out of the reservoir(s) in order to capture spring snowmelt and minimize flooding. The current date per the 2000 and 2004 BiOps to be at flood control rule curves is April 10 (EPA 2007b).

Figure 2-7 illustrates the 1995 to 2005 reservoir elevation minima, maxima, average, and standard deviations. As depicted, reservoir elevation differs annually, based on the runoff volume for that particular year. Flood control has the greatest influence on elevation, and flood control targets are a function of projected runoff. As previously mentioned, The Dalles, is the system flood control point for the Columbia Basin, and therefore flood control operations at all storage facilities are managed based on the projected runoff at The Dalles. During the 1995 through 2005 water years, runoff has varied by 100 million acre-feet, from a low of about 60 million acre-feet in 2001 to a high of almost 160 million acre-feet in 1997 (see Figure 2-6).

The wide variation in runoff strongly influences the extent of reservoir elevation change, resulting in a range of pool elevations as shown in Figure 2-7. The water retention time is affected and also varies widely among years from a spring minimum of 30 days during low runoff years to 12 days during high runoff years (Figure 2-8). Lake Roosevelt's average annual water retention time is approximately 45 days.

2.3.4 Characteristics of UCR Reaches

For this document, the UCR project area has been divided into six reaches that correspond to relatively distinct physiographic units (Map 2-1). Boundaries for the six reaches were selected based on consideration of distinct geomorphic features (*e.g.,* channel width, sinuosity, confluence with major tributaries), general hydraulic or hydrodynamic characteristics (depth, location of the reservoir pool, riverbed characteristics, flow velocity), and expected differences regarding the principal mechanisms for transport or deposition of particle-bound chemicals of interest (COIs). More information about hydrodynamics and fate and transport of sediment in the UCR is provided in the *RI/FS Work Plan* (EPA 2008a). As previously described, UCR hydrology changed significantly with the construction of Grand Coulee Dam and again with the implementation of coordinated flood control operations at upstream dams beginning in 1973. These flow regime differences are expected to have influenced the initial transport of sediment and COIs in the UCR and may continue to influence their redistribution in the future. Therefore, the changing nature of flow in the UCR was also considered as the boundaries for river reaches were selected.

Characteristics of each river reach have changed over time in response to the construction of Grand Coulee Dam and subsequent upstream flow regulation. As shown in Figure 2-5 and Table 2-7, the timing and magnitude of river flows show clear differences over time. Importantly, flow velocities, cross-sectional areas, and other hydraulic characteristics (width, depth, wetted perimeter, etc.) of each reach have also changed. It is reasonable to expect that these hydrologic and hydraulic alterations have impacted the historical and contemporary patterns of sediment and contaminant transport in the river.

2.3.4.1 Reach 1 (USGS RM 745 to RM 730)

Reach 1 extends from the U.S.-Canadian border (USGS RM 745) southward past the city of Northport to USGS RM 730, near Onion Creek (Map 2-1). The northern section of the reach – approximately 3 miles in length – is relatively shallow and narrow, retaining much of its historical hydraulic characteristics, and is expected to run free much of the time. Water depth at the border was recently reported to be approximately 14 feet (EPA 2004b) and is consistent with soundings from the 1947-1949 surveys conducted by the USCGS (1950).

The southern section of the reach – approximately 12 miles in length – is just upstream of the Lake Roosevelt reservoir and is influenced by the pool level. As flow in the UCR varies and pool elevations change in response to dam operations, this section of the river transitions from a free-running riverine reach to a lacustrine (lake-like) reach. Reported water depths at the downstream end of this reach are 50 feet or more in the main channel (USGS topographic map, Northport, Washington, 1:24,000; 1,289-foot pool elevation). Several notable geomorphic features exist in the southern half of Reach 1. There is a large gravel bar at USGS RM 738 on the northern bank across from Deadmans Eddy. Aerial photographs suggest that some depositional features exist at the downstream point of the bar. There are also well-defined erosional terraces marking various reservoir pool levels. This suggests that the gravel bar may be a relict feature pre-dating upstream flood-control operations and potentially pre-dating the construction of Grand Coulee Dam as well. At USGS RM 737, the channel thalweg makes several sharp turns between Steamboat Rock and Sand Point. Two minor tributaries enter the UCR at this point, Big Sheep Creek on the northern (left downstream) bank and Deep Creek on the southern (right downstream) bank. Although these tributaries are small, aerial photographs suggest that both tributaries exhibit deltaic features at their confluence with the UCR, further suggesting that these creeks may be an important source of native watershed sediments to the UCR downstream of the U.S.-Canadian border. The mouths of both tributaries are well protected by backwaters, and the mouth of Big Sheep Creek is protected further by two islands (Steamboat Rock).

Detailed characterizations of the riverbed in Reach 1 are not available. However, present information indicates that the bed consists of large (non-cohesive) particle types – gravel, cobbles, and boulders (EPA 2005c). In 2005, 15 mid-channel sites were identified for sampling, but sediment cores could not be obtained because of the coarse-grained nature of the riverbed and/or the high current speeds experienced (EPA 2006a).

2.3.4.2 Reach 2 (USGS RM 730 to RM 711)

Reach 2 extends from near Onion Creek (USGS RM 730) to the approximate upstream head of Marcus Flats (USGS RM 711) (Map 2-1). Historically, Reach 2 was a swift riverine reach, running southwest from USGS RM 730, first through a narrow, deep canyon and a series of rapids called the Little Dalles, then broadening slightly over the remainder of the run down to USGS RM 711 (Symonds 1883). The constriction at Little Dalles was widened as part of Grand Coulee Dam construction efforts (1933 to 1942) by removing a rock island down to 1,255 feet along with part of the southern riverbank (McKay and Renk 2002). This section of the UCR is inundated by the Lake Roosevelt pool approximately 70 percent of the time (EPA 2004b). However, currents through the widened canyon are swift at lower pool levels. Although more sinuous than upstream areas, Reach 2 is still a relatively narrow channel with few embayments or shoreline irregularities. At USGS RM 726, the UCR makes a sharp bend, with the thalweg adjacent to the southern (left downstream) bank. This location, China Bend, was historically a broad, low floodplain that is now capped by an artificial island (China Bar). Downstream of China Bend, the UCR becomes more sinuous as it proceeds through a series of three additional broad bends before reaching the end of the reach. Water depths in this reach vary with reservoir pool elevations. For a pool elevation of 1,289 feet, USGS (topographic map, Northport, Washington, 1:24,000) shows that the thalweg deepens rapidly from 50 feet at the upstream end of Reach 2 to more than 100 feet in the vicinity of the Little Dalles a mile further downstream (USGS RM 729). From there, the thalweg decreases to approximately 60 to 70 feet until about USGS RM 718, where it narrows and deepens again to 100 feet through another drowned gorge. Further downstream, thalweg depths vary between 70 and 90 feet through the remainder of the reach. Despite the deep and narrow thalweg, depths on the inundated historical floodplain are 20 feet or less at a number of locations (China Bend, USGS RM 726; North Gorge, USGS RM 719; north of Bossburg, USGS RM 717; Snag Cove, USGS RM 714; Evans and Powell, USGS RM 712 and 711).

Like Reach 1, detailed characterizations of the riverbed in Reach 2 are not available; sediment-sampling efforts in 2005 were repeatedly thwarted by the presence of cobbles and boulders in the main channel and sampling locations were often moved laterally onto what would have been the historical floodplain (EPA 2006b). This suggests that the riverbed comprises cobbles and boulders in the area of the thalweg with deposits of finer material in protected areas and on the historical floodplain, which is now inundated frequently by the Lake Roosevelt pool.

2.3.4.3 Reach 3 (USGS RM 711 to RM 699)

Reach 3 extends from the approximate upstream head of Marcus Flats (USGS RM 711) to just downstream of Kettle Falls (USGS RM 699; Map 2-1). The characteristics of Reach 3 include distinct geomorphic features that are believed to influence particle transport (and corresponding chemical transport and fate) under historical and contemporary flow regimes. At USGS RM 710 and again between USGS RM 706 and 707, the UCR thalweg makes two sharp (90-degree) bends while passing through a relatively broad floodplain in the area of Marcus Flats. To the north of the second bend, the Kettle River joins the UCR. The Kettle River is the first significant tributary confluence downstream of the U.S-Canadian border, with a mean annual flow of approximately 3,000 cfs (USGS 2006a) (Table 2-5). Between USGS RM 704 and 703, the UCR thalweg descends through a steep, narrow constriction. Prior to the construction of the Grand Coulee Dam, this was a powerful series of cascades known as Kettle Falls. A photograph of Kettle Falls (Figure 2-9), illustrates conditions prior to completion of Grand Coulee Dam. Kettle Falls is now inundated by the Lake Roosevelt pool. However, during occasions of extreme drawdown (*e.g.,* during construction of the third powerhouse at the Grand Coulee Dam) Kettle Falls re-emerges. Downstream of the Kettle Falls constriction, the UCR runs through a relatively straight, narrow channel until the confluence with the Colville River at USGS RM 699.

Some aspects of the riverbed in Reach 3 have been characterized. Unlike Reaches 1 and 2, extensive areas of the bed in Reach 3 are reported to contain a large fraction of sand-sized sediment and granulated slag. Seven-foot sediment cores taken from the contemporary thalweg (*i.e.,* the historical channel) between the upstream (USGS RM 708) and downstream (USGS RM 704) limits of Marcus Flats indicate that a relatively uniform and continuous deposit of black granulated slag exists (EPA 2004b). There are also cross-channel gradients in bed composition and grain size. Sediment cores collected from locations across the thalweg and adjacent historical (submerged) floodplain indicate that higher concentrations of granulated slag and coarser particle sizes occur in areas nearest to the thalweg and that granulated slag content and particle size typically decrease with distance from the thalweg (EPA 2004b). Axial gradients also exist. When viewed from upstream to downstream, the UCR sediment data show that downstream of Marcus Flats, there is a distinct decrease in the fraction of sand-sized particles in mid-channel samples (EPA 2004b).

Historically, Reach 3 may have been similar to Reaches 1 and 2 in terms of water depths, flow velocities, and sediment transport potentials. Prior to construction of Grand Coulee Dam, seasonal high flows may have had the potential to transport sand and even fine gravel-sized sediment and granulated slag through the historical channel to downstream reaches. However, the function and extent of historical floodplain areas differentiate Reach 3 from upstream reaches. For example, when the UCR overflowed its historical banks (reflecting the impact of the channel constriction around Kettle Falls), flow velocities and sediment transport potentials in floodplain areas are expected to have been much smaller than conditions through the historical channel. This decrease in transport potential could have contributed to the significant deposition of sediment (particularly granulated slag) throughout the historical Marcus Flats floodplain.

Under contemporary regulation of pool levels, Reach 3 is expected to be inundated much of the year. Full-pool water depths during seasonal high pool levels are expected to be 50 feet or more over the historical floodplain and more than 100 feet along sections of the thalweg. As a result, flow velocities and sediment transport potentials through Marcus Flats, when pool elevations are high, are expected to be smaller than existed for the historical channel and floodplain since the construction of Grand Coulee Dam and the creation of the Lake Roosevelt pool. Following the initiation of upstream flow control (beginning around 1973), seasonal high flows decreased by nearly 50 percent as determined from 7-day annual maxima reported by the USGS for the intervals 1938-1973 and 1973-2006. Further, sediment transport capacity is proportional to velocity raised to a power of 2, 3, or even 5 (*e.g.,* Soulsby 1997; van Rijn 1996). This suggests that contemporary sediment transport potentials may be one-fourth to one-eighth of those for historical conditions. Consequently, contemporary deposition potentials in this reach for sediment, granulated slag, and contaminants are expected to be considerably larger than historical values. These simple transport assessments are substantiated by measured gradients in grain size and bed composition (EPA 2004b) as previously noted. Additional analysis of river flow and shear stresses (a determinant of transport potential) are presented in the *RI/FS Work Plan* (EPA 2008a). It should be noted that the hydrologic model presented in EPA (2008) was developed using historical bathymetric data obtained between 1947 and 1949. Given the transitional nature of Reach 3 and known changes to the system over time, it is likely that there have been some changes in bathymetry which would impact the outcome of the transport assessment.

2.3.4.4 Reach 4 (USGS RM 699 to RM 640)

Reach 4 extends from just downstream of Kettle Falls (USGS RM 699) to just upstream of the confluence with the Spokane River (USGS RM 640). Because of the length and expected differences in sediment and contaminant transport regimes, exposure, and habitat over time, this reach is further divided into two subreaches. Reach 4a extends from USGS RM 699, at the confluence of the Colville River, to USGS RM 676, just upstream of Inchelium. Reach 4b extends from USGS RM 676 to USGS RM 640 near the confluence with the Spokane River. These reaches collectively represent the middle reservoir. Water levels through the middle reservoir vary as a function of water management at Grand Coulee Dam. Through Reaches 4a and 4b, the reservoir is roughly 0.25 to 1.75 miles (0.4 to 2.8 kilometers [km]) wide. Water depths through these reaches range from 100 to 300 feet (30 to 91 meters [m]), but can become quite shallow near the banks, reflecting the topography of the drowned river valley. The Colville River contributes less than 1,000 cfs of flow to the UCR on a mean annual basis. Reach 4a borders the Colville Indian Reservation, and Reach 4b borders both the Colville and Spokane Indian Reservations.

Landslides and erosion along the banks of the flooded valley that forms the reservoir shore have been noted in numerous areas of both reaches (Carpenter 1984; Jones et al. 1961; EPA 2004b) as shown on the maps for the Phase I sediment study included in the *RI/FS Work Plan* (EPA 2008a). This erosion occurs when fluctuating reservoir levels expose steep water-saturated shorelines that fail under their own weight. Additional erosion may be caused by the hydraulic action of waves on the banks, which can preferentially erode and transport finer material from the shoreline and deposit it in deeper sections of the reservoir. Thus, the sediment remaining from failed or wave-eroded banks may be the source of coarse sediment found in some nearshore areas of the reservoir bed.

Before the construction of Grand Coulee Dam, Reach 4 would likely have been a transitional reach for sand deposition. The historical thalweg was still quite narrow over much of the region (based on 1947-1949 USCGS bathymetry), but there are a number of reaches where the historical channel appears to widen and where bathymetric contours are much less steep, suggesting that the UCR in this region flowed through a series of cascades and broad pools. Given changes in the UCR flow regime over time, some of these historical pools might contain granulated slag that was discharged before the dam was constructed as well as native sands that originated from the Kettle and Colville rivers. Cores taken in the historical thalweg at USGS RM 692 and 676 showed deep (3- to 5-foot and 5- to 7-foot core intervals) elevated concentrations of COIs usually associated with granulated slag, although typical granulated slag particles themselves were not observed (EPA 2006a). The deepest interval of Core 676 included a small amount (< 10 percent) of coarser “gravelly material” that may be indicative of deposition under much higher flow conditions than occurred for the remainder of the core.

Under present-day conditions, maximum flow velocities in these reaches are expected to be low, rarely exceeding 2 to 3 feet per second (ft/s), even under conditions of low pool elevation and high flow at the U.S.-Canadian border (EPA 2006a; see Figures 2-3 to 2-5). Sediment transport capacities for these conditions will also be low. Under such conditions, only the finest particles will remain suspended in the water column. Evidence for this transport pattern can be seen in terms of the grain size distribution of the sediment bed. Whereas bed sediments in Reach 3 are composed of 80 to 100 percent coarse particles, there is a pronounced shift in bed sediment grain size distributions observed in Reach 4. In general, mid-channel bed sediments in Reach 4a are largely fine-grained with a moderate coarse fraction (10-20 percent sand, 60-70 percent silt, and 10-20 percent clay/colloidal; EPA 2006a). However, there is a trend of progressively decreasing grain size from upstream to downstream. Mid-channel bed sediments in Reach 4b are also fine-grained but have a larger fraction of very fine particles (10-20 percent sand, 50-60 percent silt, and 30-40 percent clay/colloidal; EPA 2006a). One possible explanation for the increasing fineness of bed sediment is that little coarse sediment is delivered from upstream under present flow and water-management regimes. Alternatively, this may also reflect the deposition of fine sediment washed from the banks and from landslide events by waves and rainfall runoff.

As water levels change, submerged river terraces and more recent bed deposits and bars may be periodically exposed at the surface. At high pool levels, the extent of riparian areas is minimized because most nearshore areas are inundated. At low pool levels, the extent of riparian areas can increase considerably. Sediment in exposed areas can desiccate over time and very fine particles may be subject to aeolian (windblown) transport.

2.3.4.5 Reach 5 (USGS RM 640 to RM 617) and Reach 6 (USGS RM 617 to near RM 597)

Reach 5 extends from USGS RM 640 to USGS RM 617. Within Reach 5, the Spokane River (long-term average annual flow of 7,670 cfs as measured at Long Lake; USCGS 1950) joins the Columbia River at USGS RM 639. Reach 6 extends from USGS RM 617 to the Grand Coulee Dam (near USGS RM 597). Within Reach 6, the Sanpoil River joins the UCR between USGS RM 615 and 614. These reaches collectively represent the Lower Reservoir. Reaches 5 and 6 both border the Colville Indian Reservation. Both reaches can be characterized as a lacustrine environment with slow-moving water.

Water levels at Grand Coulee Dam (and throughout the reservoir) vary as a function of water management needs. Near the dam, the reservoir is roughly 1 mile (1.6 km) wide with maximum water depths that can exceed 400 feet (120 m; EPA 2007a), giving the reservoir lake-like characteristics. Water levels in the reservoir are managed for power generation, flood control, irrigation, recreation, and fisheries management. In a typical year, water level drawdown begins in early winter and continues until a minimum pool level is reached in the early spring. The extent of this drawdown is determined from the water content of snowpack in the watershed, with a larger water content resulting in a larger drawdown. Runoff from snowmelt and upstream releases causes the reservoir to fill until a maximum pool level (1,290 feet elevation) is reached in early summer. A mid-summer drawdown of approximately 10 feet can also occur as needed for fisheries management purposes. In response to changing flows and periodic drawdown, hydraulic residence times in the reservoir can be relatively short and highly variable, averaging 45 days, despite the lake-like appearance of the reservoir (Underwood et al. 2004).

In Reaches 5 and 6, sediment transport, contaminant transport and fate, and contaminant exposure are expected to be influenced by relatively short hydraulic residence times as a result of water management at Grand Coulee Dam. In many locations, shear valley walls rise nearly 1,000 feet (300 m) above the original river floodplain. Landslides and erosion along the banks of the flooded valley that forms the shores of Lake Roosevelt have been noted in numerous areas of both reaches (Jones et al. 1961; EPA 2006a; Whetten et al. 1969) as shown in the *RI/FS Work Plan* (EPA 2008a). Over time, this erosion may occur as a consequence of the added weight of water when soil pore spaces are saturated and reservoir levels fluctuate. Erosion may also be caused by the hydraulic action of flow and waves on the banks. As noted previously, sediment from failed or eroded banks might be the source of coarse sediment found in nearshore areas of the reservoir bed.

As noted for Reach 4, submerged river terraces and more recent bed deposits and bars may be periodically exposed at the surface as water levels change. At high pool, the extent of riparian areas is minimized as most nearshore areas are inundated. At low pool, exposed beach can increase considerably. Sediment in exposed areas can desiccate and very fine particles may be subject to aeolian transport.

Given contemporary water depths, flow velocities in Reaches 5 and 6 are typically low (< 1 ft/s) and sufficient to transport only very fine particle sizes such as silt, clay, and organic detritus. In general, mid-channel bed sediments are almost entirely fine-grained. However, there is a trend of decreasing grain size between reaches. In Reach 5, bed samples from the mid-channel are approximately 50 percent silt and 50 percent clay/colloidal, whereas in Reach 6, bed samples show increased fining and are roughly 40 percent silt and 60 percent clay/colloidal (EPA 2006a). One reason for the fineness of bed sediment is that little coarse sediment is delivered from upstream. Although the bed is in general very fine, one area where more coarse sediment occurs (40-50 percent sand) is near the confluence with the Sanpoil River. Although less pronounced, bed sediment is also somewhat coarser where the Spokane River enters the reservoir (20-30 percent sand).

Historically, water depth would have been much smaller and flow velocities much larger than those for contemporary conditions. Although detailed analyses have not been completed to date, it is reasonable to infer that before the construction of Grand Coulee Dam, Reaches 5 and 6 would have been similar to historical conditions upstream in Reach 4. Based on inferences drawn from 1947-1949 USCGS bathymetry, Reaches 5 and 6 may have been transitional reaches with respect to sand transport and deposition. The historical thalweg is somewhat broader than exists in Reach 4 (again based on 1947-1949 USCGS bathymetry), but there are also areas where the historical channel appears to widen and where bathymetric contours are much less steep.

2.3.5 Climate/Meteorology

The UCR area lies in the rain shadow of the Cascade Mountains, and therefore average annual rainfall is low in comparison to the western portion of the state. The northern areas of the Site receive about 20 inches of precipitation a year (NPS 2006b). Moving south, the climate becomes far more arid with average annual precipitation at Grand Coulee Dam of approximately 10 inches. This precipitation occurs mostly in the winter and spring, while summer months are generally hot and dry. Trends in the last 50 to 100 years show a general decrease in winter precipitation and increase in summer precipitation (Ferguson 1999).

During the summer months, temperatures at the Site typically range from 75°F to 100°F in daytime, dropping to 50°F to 60°F at night (NPS 2006a; 2006b). Fall and spring provide plenty of sunshine and cooler temperatures. During these transitional times, the temperatures vary between 50°F and 80°F during the daytime and 30°F and 50°F in the night (DOI 2006). Winters can be extremely cold in this area with cold winds sweeping across the flat terrain. Daytime temperatures are generally between 25°F and 40°F, and nighttime temperature ranges may be as low as 15°F to 20°F. Trends in the last 50 to 100 years indicate a slight increase in winter temperatures and slight decrease in summer temperatures (Ferguson 1999).

As a transition-type climate zone, the climate within the Site is characterized by the interactions of three distinct types of air masses (Ferguson 1999):

- Moist marine air from the west that moderates seasonal temperatures
- Continental air from the east and south that is dry and cold in winter and hot with convective precipitation and lightning in summer
- Dry arctic air from the north that brings cold air to the area in winter and helps cool the area in summer

The timing and extent of influence of these competing air masses is controlled largely by synoptic weather patterns and complex local topographic features that vary across the Site. For instance, prolonged periods of drought occur when Pacific storms are deflected around the region, preventing the intrusion of moist marine air. At these times, dry continental conditions prevail.

Similarly, frosts and freezing conditions commonly occur when arctic air invades the area. Crop damage may be associated with such frosts when they occur before winter hardening in autumn or after bud break in spring. Cold damage also may occur in winter if a warm marine intrusion is followed by a sweep of arctic air (Ferguson 1998; 1999).

In addition, the unique interplay between these three air mass types results in dramatic weather changes during transition periods between the different air masses (Ferguson 1996). The most unique of these transitions is rain-on-snow flooding that occurs when warm, wet marine air displaces cold, arctic conditions in winter. This rain-on-snow flooding, coupled with the spring runoff of snowmelt that typically occurs in April and May, is a major source of water in the reservoir and therefore is tied to the management of water levels in Lake Roosevelt (LRF 2006d).

Another characteristic interplay is the strong, gusty wind that occurs during transitions between continental and marine air masses, mainly in spring and summer (Ferguson 1996). It has been reported that in particularly warm and dry years, 8 to 20 gusty wind events can occur within the Site. The cool, moist air masses from Pacific storms, which progress eastward, are dramatically different than the hot, dry continental air masses. As the air masses meet, the associated fronts can be very strong. These weather fronts often are associated with strong, gusty local winds. This effect is most significant when the seasonal upper-level flow pattern includes frequent southerly or northerly flow over the Site.

Analysis of meteorological monitoring data collected along the UCR indicates that the dominant wind directions are from northeast to southwest and from southwest to northeast (DOI 2006). However, wind direction distributions showed strong seasonal variation. Furthermore, topographic conditions affect local meteorology. Many steep-walled valleys and canyons along the UCR can channel and accelerate winds to very high speeds (Ferguson 1998). These significantly strong winds may occur in directions that are different from prevailing directions. The meteorological stations along the UCR (Map 2-11) reflect special characteristics of the microclimates in these areas.

2.4 Ecological Resources

The UCR study area is approximately 150 miles in length, translating to more than 600 miles of shoreline (Creveling and Renfrow 1986; LRF 2006e). Aquatic life, wildlife, and vegetation within the UCR project area are discussed in this section, including listing status by state and federal resource agencies. Additional ecological receptors may be identified during the problem formulation process for the baseline ecological risk assessment (BERA). Important habitat areas identified within the UCR study area are also discussed.

2.4.1 Wildlife and Aquatic Life

Tables 2-8 and 2-9 summarize the terrestrial and aquatic species (respectively) that have been reported in the UCR study area.[3] These data were compiled by a number of researchers' databases including WDFW (2006), Seattle Audubon Society (2006), BPA (2006a; 2006b; 2006c; 2006d; 2006e), Lake Roosevelt Forum (2006b), Marcot et al. (2003), Quigley et al. (2001), Hebner et al. (2000), Cassidy et al. (1997), and Creveling and Renfrow (1986).

2.4.1.1 Wildlife

There are 97 species of mammals (upland, aquatic dependent), 250 species of birds (upland, aquatic dependent), 15 species of reptiles, and 10 species of amphibians reported to occur in the area (Table 2-8). Large mammals include black bear and grizzly bear, elk, lynx, mountain lion, bighorn sheep, whitetail deer, mule deer, and moose. Smaller mammals include beavers, otters, moles, muskrats, mink, badgers, raccoons, skunks, bobcats, coyotes, foxes, porcupines, rabbits, squirrels, chipmunks, marmots, pikas, bats, gophers, rats, voles, shrews, and mice.

Birds reported in the watershed include raptors such as ospreys, eagles, falcons, hawks, harriers, and kestrels. Passerine birds (songbirds) include swallows, finches, jays, chickadees, kinglets, ravens, magpies, robins, sparrows, flycatchers, blackbirds, and juncoes. Water birds include mallards, pintails, teal, goldeneyes, canvasbacks, grebes, coots, scaup, mergansers, loons, and geese. Shorebirds include plovers, killdeer, sandpipers, gulls, snipes, grebes, and yellowlegs. Grassland birds include grouse, doves, pigeons, pheasants, and turkeys.

Several reptilian and amphibian species have been reported in the area. Reptilian species include turtles, lizards, skinks, and snakes. Amphibian species include toads, frogs, and salamanders.

Some of the wildlife species reported within the area and the surrounding watershed are listed as threatened or endangered (state, federal), including the northern leopard frog, American white pelican, ferruginous hawk, northern goshawk, sage and sharp-tailed grouse, sandhill crane, upland sandpiper, pygmy rabbit, western gray squirrel, gray wolf, fisher, woodland caribou, grizzly bear, and Canada lynx (Table 2-8).

There are also many wildlife species reported within the area whose possible decline is a matter of concern to federal and state resource agencies. These species are identified in Table 2-8 as any of the following: federal candidate, state candidate, state sensitive, state monitored, proposed

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[3] Scientific names are included in Tables 2-6 and 2-7 for wildlife and aquatic life.

sensitive, and proposed threatened. Species of concern include the western toad, Columbia spotted frog, sagebrush lizard, common loon, osprey, northern goshawk, golden eagle, peregrine falcon, burrowing owl, Columbia sharp-tailed grouse, Columbia spotted frog, loggerhead shrike, Pacific water shrew, myotis bats, Townsend's big-eared bat, Washington ground squirrel, Western pocket gopher, and wolverine.

2.4.1.2 Aquatic Life

Native species of fish in the area include peamouth, northern pikeminnow, kokanee salmon, rainbow trout, bull trout, white sturgeon, burbot, chiselmouth, mountain whitefish, sculpin, and sucker species (Table 2-9). Chinook salmon, once native to the UCR, occur in the reservoir as "wash-downs" from Lake Coeur D'Alene where they have been stocked (LRF 2007a). Introduced (non-native) species include carp, tench, lake whitefish, brook trout, brown trout, walleye, yellow perch, largemouth bass, smallmouth bass, black crappie, pumpkinseed, channel catfish, brown bullhead, and yellow bullhead. A number of aquatic invertebrate species are also reported within the area, including the California floater (*Anodonta californiensis*), a mussel species that is a candidate for listing by both federal and state resource agencies (WDFW 2006).

2.4.1.3 Invasive Aquatic Species

The UCR contains a few nuisance species, nonindigenous species that adversely affect the environment. Eurasian milfoil (*Myriophyllum spicatum*) is the primary nuisance macrophyte species in the UCR. This plant is present in some embayments, especially in the Spokane Arm, but it does not occur in high densities throughout the UCR (Weaver 2006). The UCR also contains nonindigenous nuisance fish species (*e.g.,* carp, smallmouth bass, walleye). Walleye were introduced to the UCR in the 1950s and were prevalent by the 1970s (USBR 1985). This species has likely played a major role in shaping the current fish community of the UCR through predation on other fish species. Baldwin et al. (2003) estimated 15 percent of the hatchery kokanee released in the Kettle Falls area were preyed upon by walleye over a 41-day period in 1999. The extent of predation throughout the years is unknown, but it likely exceeds 15 percent of the release.

2.4.2 Vegetation

As previously mentioned, the climate of portions of the Site and surrounding area is semi-arid and varies a great deal from one end of the Site to the other (LRF 2006b), with the southern (lower) portion near Grand Coulee Dam being generally hotter and drier. Vegetation in this area (Grand Coulee Dam to Keller Ferry) includes steppe (bunch grass grassland) and shrub-steppe. Common species within this section of the reservoir include grasses such as bluebunch wheatgrass (*Pseudoroegneria spicata)*, needle-and-thread grass (*Hesperostipa comata)*, and Idaho fescue (*Festuca idahoensis)*; forbs such as arrowleaf balsamroot (*Balsamorhiza sagittata*), northern buckwheat (*Eriogonum* spp.), brittle prickly pear (*Opuntia* spp.), alumroot (*Heuchera* spp.), and lupine (*Lupinus* spp.); and shrubs such as big sagebrush (*Artemisia tridentata)*, rabbitbrush (*Chrysothamnus nauseosus*), and antelope bitterbrush (*Purshia tridentata)* (Hebner et al. 2000; LRF 2006b). Irrigated agricultural lands are also present.

Between Keller Ferry and the upper end of the Spokane River Arm at Little Falls Dam is a transition from shrub-steppe to ponderosa pine forest (Hebner et al. 2000), with common trees including ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*). Grasses in the steppe/shrub-steppe zone here are also common. Forbs include arrowleaf balsamroot, northern buckwheat, and lupine; shrubs include big sagebrush, rabbitbrush, antelope bitterbrush, snowberry (*Symphoricarpos albus*), greasewood (*Sarcobatus vermiculatus*), and service berry (*Amelanchier arborea*) (Hebner et al. 2000; LRF 2006b). Trees in this portion of the UCR watershed include black cottonwood (*Populus trichocarpa*), ponderosa pine, and Douglas-fir.

Areas around the middle and upper reservoir, between the Spokane River and Kettle Falls, receive approximately 17 to 20 inches of precipitation a year (LRF 2006b). This area is covered with a dense mix of ponderosa pine and Douglas-fir (Hebner et al. 2000; LRF 2006b). The steppe environment within this area is less distinct. Grasses in this region of the reservoir include those present in the lower reservoir with the addition of pinegrass (*Calamagrostis rubescens*). Common forbs include hairy goldstar (*Crocidium multicaule*), phlox (*Phlox* spp.), and nodding onion (*Allium cernuum*); shrubs include chokecherry (*Prunus virginiana*), serviceberry, wild rose (*Rosa acicularis)*, Douglas hawthorn (*Crataegus douglasii*), snowberry, occasionally some smooth sumac (*Rhus glabra*), and blue elderberry (*Sambucus cerulea*) (Hebner et al. 2000). Alder (*Alnus* spp.), willow (*Salix* spp.), hazelnut (*Corylus cornuta*), and black cottonwood are common along riparian areas (Hebner et al. 2000). The Rocky Mountain juniper (*Juniperus virginiana*) can be found next to the shoreline and on rocky river bars.

The upper portion of the UCR (*i.e.,* north of Kettle Falls to Onion Creek near the U.S.-Canadian border) is dominated by ponderosa pine, Douglas-fir, and western larch (*Larix occidentalis*). Some lodgepole pine (*Pinus contorta*), grand fir (*Abies grandis*), Rocky Mountain maple (*Acer glabrum*), western paper birch (*Betula papyrifera)*, and aspen (*Populus grandidentata)* can also be found (Hebner et al. 2000). Among the pines and in dry, rocky areas, a variety of shrubs occur, including mallow ninebark (*Physocarpus malvaceus*), creeping Oregon grape (*Berberis repens*), elderberry, chokecherry, snowberry, deer brush (*Ceanothus sanguineus*), and red-stem ceanothus (*Ceanothus velutinus*) (Hebner et al. 2000). Dominant grassland species include bluebunch wheatgrass, Idaho fescue, and pinegrass (Hebner et al. 2000; LRF 2006b).

Threatened plant species reported within the area include the little bluestem (*Schizachyrium scoparium var. scoparium*) and the Palouse milk-vetch (*Astragalus arrectus*) (WDNR 2006). An endangered plant species reported in the area is the Columbia crazyweed (*Oxytropis campestris var. columbiana*) (WDNR 2006). Other reported plant species include a number whose decline is a matter of concern to the state. These species include fuzzytongue penstemon (*Penstemon eriantherus var. whitedii*), the least bladdery milk-vetch (*Astragalus microcystis*), and the Nuttall’s pussy-toes (*Antennaria parvifolia*) (WDNR 2006).

2.4.3 Habitat

Map 2-12 shows the areas near or within the Site that have been listed by state or federal resource agencies as priority habitat (WDFW 2006) or wetlands (USFWS 2006), or have been identified as other endangered habitat in close proximity to the UCR banks at full pool.

3 ASSESSMENT OF CHEMICAL SOURCES

This section provides an overview of the known and potential chemical sources in the vicinity of the study area. The information presented here is intended to be a summary; it is not a definitive discussion of all possible sources of chemicals to the study area.

3.1 Mine, Mill, and Smelting Operations

Ore mining and mineral processing has been occurring in the UCR region, in both the U.S. and Canada, since at least the late 1800s. Most of the operations in the U.S. took place in Stevens and Ferry counties (Orlob and Saxton 1950; Wolff et al. 2005). Mining activities in the drainage basin also occurred in the Metaline mining district in Pend Oreille County, Washington. The locations of the mines and mills in the UCR drainage basin, including that north of the border, and along tributaries to the UCR are shown in Map 3-1. As part of the Upper Columbia River Expanded Site Inspection conducted by EPA in 2001 and 2002, EPA collected sediment samples and visited a number of U.S. mine and mill sites in the northern portion of the study area, including mines and mills along tributaries to the UCR, plus several additional mines and mills located along the Pend Oreille River to the east.

The expanded site investigations (see list below) and the Phase 1 remedial investigation (EPA 2006a) documented sediment contamination along the Upper Columbia River Site from the U.S.-Canada border to the Grand Coulee Dam. Based on these results, the EPA concluded that both the smelter in Trail, British Columbia, and the former Le Roi Smelter in Northport, Washington, are sources of contamination to the UCR Site; however, the Trail smelter was identified as the "primary source of contamination" (EPA 2003a). The mines and mills along the tributaries to the UCR were not identified as current sources of contamination to the Site.[4] The mines and mills in the drainage basin may be investigated in the future if anomalous and significant contaminant concentrations (relative to risk) are found at confluences of tributaries with the UCR and a potential upstream source is suspected. With the exception of the Spokane River, Phase 1 sediment sampling by EPA (2005b) near the mouth of selected major UCR tributaries did not identify the presence of notably elevated COI concentrations indicative of major watershed sources of contamination from historical mine and mill sites.

Summaries of the findings and recommendations of the EPA expanded site investigation are provided in the following reports:

- EPA 2001a (2001 Sediment Investigation Trip Report, Upper Columbia River/Lake Roosevelt Expanded Site Inspection. December 2001. Prepared by Roy F. Weston Inc. for EPA Region 10, Seattle, WA).

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[4] Some of these mines and mills had localized contaminant concentrations that met EPA requirements for time-critical and non-time-critical removal actions. The following sites have been addressed under EPA's removal program: Anderson-Calhoun Mine and Mill, Bonanza Mill, LeRoi Smelter, Colville Post and Pole, and Cleveland Mine and Mill. The Josephine Mill No. 1 and Grandview Mine and Mill are currently being addressed under EPA's removal program.

- EPA 2002a (Preliminary Assessments and Site Investigations Report, Lower Pend Oreille River Mines and Mills, Pend Oreille County, Washington. April 2002. Prepared by Ecology and Environment, Inc. for EPA Region 10, Seattle, WA).
- EPA 2002b (Preliminary Assessments and Site Inspections Report, Upper Columbia River Mines and Mills, Stevens County, Washington. October 2002. Prepared by Ecology and Environment, Inc. for EPA Region 10, Seattle, WA).
- EPA 2003a (Upper Columbia River Expanded Site Inspection Report, Northeast Washington. March 2003. Prepared by Ecology and Environment, Inc. for EPA Region 10, Seattle, WA).
- EPA 2004c (Hecla Knob Hill Mine Site Inspection Report, Ferry County, Washington. July 2004. Prepared by Weston Solutions, Inc. for EPA Region 10, Seattle, WA).
- EPA 2004d (South Penn Mine Site Inspection Report, Ferry County, Washington. September 2004. Prepared by Weston Solutions, Inc. for EPA, Region 10, Seattle, WA).
- EPA 2004i (Mountain Lion Mine Site Inspection Report, Ferry County, Washington. September 2004. Prepared by Weston Solutions, Inc. for EPA, Region 10, Seattle, WA).

The following subsections provide summary information for the Teck Cominco Metals Ltd. facility in Trail, British Columbia, and the former Le Roi Smelter in Northport, Washington

3.1.1 Trail, British Columbia, Teck Cominco Facility

The Teck Cominco facility in Trail, British Columbia, is located on the Columbia River approximately 10 miles upstream from the U.S.-Canada border. Smelter operations have been underway in Trail since 1896 (G3 Consulting 2001a). The original facilities were built in 1896 to smelt copper and gold ores from the Rossland Mines (G3 Consulting 2001b). Onsite operations were designed to separate gold and copper thermally from gold ores mined. At that time, roasting technology was crude and limited to the heap method. The ore was piled up with cordwood and limestone intermixed and set aflame. With such crude processes, the smelter was capable of producing a matte of 50 percent pure copper (*i.e.*, industrially worthless until further refined), while the lead, which was prevalent within local ores, could not be extracted. As a result, further refining was required at Heinze's refinery in Butte, Montana (www.crowsnest-highway.ca). The Spokane Falls & Northern Railway company was reluctant to transport the copper matte and offered an alternative to surrounding area mining companies willing to construct a smelter in Northport, Washington. The owners of the Le Roi Gold Mining Company of Spokane registered in the state of Washington in August 1897, and the Le Roi smelter was operational by February 1898 (www.crowsnest-highway.ca).

The resulting competition (*i.e.*, lack of ore and manpower) temporarily halted smelting operations in Trail. On March 1, 1898, the Canadian Pacific Railway negotiated the purchase of the Trail smelter and associated railway rights and immediately began modernization activities. By July 1898, the facility, under the name Canadian Smelting Works, was tied into the West Kootenay power grid and by December of that year smelting operations were underway

(Cominco 2000). As the number of lead mines within the surrounding area (*i.e.*, Canada and the western U.S.) grew, the decision was made in 1901 to broaden the smelter's base and include lead furnaces. The new furnaces were unsophisticated, however, and until 1902 the resulting impure bullion was transported to the American Smelting and Refinery Company's plant in Tacoma, Washington, for further processing. With the development of the Betts electrolytic process in 1902, the facility was able to produce pure lead, fine silver, and gold. Recognizing the value of securing a source of ore and concentrate, Canadian Smelting Works began working toward the consolidation of surrounding area mines with the smelting facility. This consolidation process culminated in 1906, and the Canadian Smelting Works became known as the Consolidated Mining and Smelting Company of Canada (www.crowsnest-highway.ca). Zinc production began in 1916. By 1925, the facility consisted of a complex of structures housing a lead plant, an electrolytic zinc plant, a foundry, a machine shop, and a copper-rod mill (www.crowsnest-highway.ca). Fertilizer plants were built at the Trail smelter in 1930, facilitating the production of both nitrogen- and phosphorus-based fertilizers (MacDonald 1997). The facility constructed and operated a heavy water plant from 1944 to 1955 (www.crowsnest-highway.ca).

The smelter was officially renamed Cominco in 1966 (G3 Consulting 2001b). In addition to lead, zinc, cadmium, silver, gold, bismuth, antimony, indium, germanium, and arsenic, the Cominco facility also produced sulfuric acid and liquid sulfur dioxide. Ammonia, ammonium sulfate, and phosphate fertilizers were produced at the plant until August 1994, at which time production of the phosphate-based fertilizer was terminated (MacDonald 1997).

Major current operations at the facility include primary smelting of zinc and lead concentrates and secondary smelting for production of a variety of metal products (*e.g.*, antimony, bismuth, cadmium, cobalt, copper, germanium, gold, indium, mercury, silver, and thallium), arsenic products, granular and crystallized ammonium sulfate fertilizers, sulfur, sulfuric acid, sulfur dioxide (SO_2), and ferrous granules (*i.e.*, granulated slag) (EPA 2003a).

While information regarding releases at the Teck Cominco Trail facility prior to the 1970s has not been provided, known discharges and emissions from the Trail facility, historic and current, that have relevance to the UCR Site include but are not limited to:

- Discharges of granulated slag to the Columbia River
- Liquid effluent discharges to the Columbia River
- Atmospheric emissions (stack and fugitive)
- Potential discharges to the Columbia River via groundwater migration from under the smelter and from surface water runoff
- Accidental spills and releases to the Columbia River from Trail facility operations

These emissions are described in the following subsections. More information about Trail facility operations and current processes is provided in the *RI/FS Work Plan* (EPA 2008a).

3.1.1.1 Slag

Granulated fumed slag is a byproduct of the smelting furnaces at the Trail facility. Slag is the primary solid-phase byproduct that was discharged directly to the Columbia River. Slag consists predominantly of sand-sized glassy ferrous granules which contain various quantities of trace and major metals. Potential environmental effects of slag discharged to the river include both chemical effects (increased metal loads, potential bioaccumulation, toxicity problems in biota) and physical effects (scouring of plants and animals from river substrates, damage to soft tissues of aquatic insects and fish, smothering of habitat) (G3 Consulting 2001b; Nener 1992; WDOH 1994; Columbia River Integrated Environmental Monitoring Program [CRIEMP] 2005; Cominco 1997).

According to a summary report prepared by consultants to Cominco, the routine discharge of slag into the Columbia River was discontinued in mid-1995. Prior to this, up to 145,000 tons of slag had been discharged annually. The *RI/FS Work Plan* (EPA 2008a) presents a preliminary sediment transport analysis evaluating various size fractions of granular slag, using historical flow and river/reservoir stage information. The preliminary analysis demonstrates that slag materials representing a range of grain sizes (silt to pebbles) may be transported downstream a considerable distance (Marcus Flats and beyond). This slag will settle out in slower-flowing reaches and localized hydrodynamically sheltered areas along the river (G3 Consulting 2001a). EPA has estimated at least 23 million tons of granulated fumed slag was discharged into the Columbia River (EPA 2006a). Currently, Cominco slag is stockpiled onsite while awaiting purchase (G3 Consulting 2001a; MacDonald 1997) or is sold and transported offsite (TCAI 2008) under the product name “ferrous granules.” Sales to the cement industry are the primary outlet for barren slag from Trail Operations. However, there are many sources of iron available to the cement industry, and this competitive market limits the ability of Trail Operations to sell all the barren slag it produces. For the past few years, production has exceeded sales of ferrous granules, and this has led to a net accumulation of the material at Trail Operations. In 2001, to alleviate an inventory backlog created when the specification for cement industry customers became more stringent, Teck Cominco applied for and was granted permission to transport up to 225,000 tonnes of barren slag material to the tailings pond at Teck Cominco's Kimberly Operations. This tailings pond, which spans approximately 140 acres (63 hectares), arose from many decades of milling and flotation of ores from Kimberley's Sullivan mine. In 2003, approximately 58,000 tonnes of off-specification barren slag were moved to Kimberley by truck. At the end of 2003, approximately 180,000 tonnes of ferrous granules were stored in Trail awaiting sale to customers (Teck Cominco Metals Ltd. 2003).

3.1.1.2 Effluent

Historically, wastewater effluent from the Cominco facility has been discharged to the Columbia River through five outfalls: one outfall from the Warfield Fertilizer Operation, three submerged outfalls from the metallurgical plants, and one from the slag launder system. The average discharges for dissolved metals from 1980 to 1996 were as high as 18 kilograms per day (kg/d) of arsenic, 62 kg/d of cadmium, 200 kg/d of lead, and 7,400 kg/d of zinc. Additionally, fertilizer plant operations contributed up to 4 kg/d of total mercury and 350 kg/d of dissolved zinc (Cominco 1997).

3.1.1.3 Stack Emissions

Atmospheric sulfur emissions historically have been a significant component of facility stack emissions, due to the sulfide-bearing ores (*e.g.,* galena [PbS] and sphaelerite [ZnS]) that make up the primary input (*i.e.,* feedstock) to the Trail facility. Historically, the Cominco smelter discharged sulfur dioxide into the air through a brick stack 409 feet high. The air pollution traveled south and remained trapped in the northern Stevens County, Washington, Columbia River Valley. In 1925, the Trail Smelter increased the discharge of sulfur dioxide into the air from 4,700 to 10,000 tons a month. The citizens of Northport complained that sulfur pollution was threatening their health and environment. They formed a "Citizens Protective Association" of farmers and property owners who sent letters of protest to politicians in both Ottawa and Washington. The matter, known as the Trail Smelter Case of 1926 to 1934, was the first case of air pollution brought before an international tribunal (Northport Pioneers 1981).

The Canadian government suggested that the fumes problem should be placed on the agenda of the International Joint Commission (IJC). The IJC did not consider the case until 1928. In 1931, the IJC recommended that the Canadian government stop polluting the atmosphere and pay damages assessed against the corporation in the amount of $350,000. The U.S. government, speaking for all of the claimants, refused to accept the $350,000 award, and asked that the case be reexamined by an arbitration tribunal. In 1935, President Franklin D. Roosevelt formally announced that the Treaty of Arbitration was in effect (Northport Pioneers 1981). The tribunal was constituted under, and its powers derived from and limited by, the Convention between the United States of America and the Dominion of Canada signed at Ottawa in 1935, also termed "The Convention" (Cloutier 1941). In 1938, the appointed members of the tribunal announced their decision assessing an additional $78,000 in damages for injuries sustained from 1932 to 1937. They also decided that a regime or measure of control should be applied to the operations of the Trail Smelter and should remain in full force unless and until modified in accordance with the amendment or suspension of the regime. The tribunal also decided that no damage caused by the Trail Smelter in Washington State occurred with respect to the period from October 1, 1937, to October 1, 1940 (Cloutier 1941).

Reductions in SO_2 emissions were achieved in 1931 due to the construction of the Warfield Fertilizer plant, which absorbed and scrubbed SO_2 from stack emissions for the production of fertilizer, and the termination of copper smelting that year.

The first air emission permits were issued to the facility on September 9, 1975, and covered all onsite operations at that time (*i.e.,* fertilizer, lead, and zinc operations). Current permits require continuous monitoring of SO_2, particulates, lead, zinc, and cadmium in several stacks. In addition, the facility monitors ambient air quality at stations within and around the facility and the surrounding area. Each station is monitored for SO_2, total particulate matter, and trace metals. Active facility permits include several stack emissions monitoring requirements (*e.g.,* continuous monitoring of SO_2, particulates, lead, zinc, and cadmium). Other permits addressing air, waste storage, and landfills have been issued by the B.C. Government to the facility. A summary of existing facility permits/licenses is presented in the *RI/FS Work Plan* (EPA 2008a).

In 1977, Cominco began a modernization program consisting of numerous projects that continued through the 1980s and 1990s. Some examples of these projects included controlling spills and dust, building a new lead smelter, installing air emissions controls, eliminating discharge of slag, replacing the phosphate plant with an ammonium sulfate fertilizer production operation, and reducing effluent discharges.

WDOH (1994) concluded from air quality simulation modeling performed by Ecology that Trail Smelter pollutants could move down the Columbia River Valley and produce moderately high (24-hour average) pollutant concentrations in the Northport area. In addition, in 2003, the Area-wide Soil Contamination Task Force (ASCTF) estimated the extent of lead and arsenic contamination that might be associated with air emissions from the Trail and Le Roi smelters (ASCTF 2003). This estimate was based on observations of smoke and the maximum extent of injury to trees from sulfur dioxide documented in 1929. The map (Map 3-2) shows the area of soil potentially impacted by air emissions to include the UCR Site as far south as Kettle Falls. The defined area of potential impact from both smelters is influenced by the local topography. The deep valley of the Columbia River where the smelters are located provides a channel that influences air dispersion, in part by limiting wind direction along the axis of the river, with the prevailing winds carrying smoke from Trail down the Columbia River valley past Northport.

3.1.1.4 Groundwater Discharge

In 2001, Cominco initiated a groundwater investigation of the Trail Smelter Facility as part of their ongoing work to inventory and characterize potential sources of contamination to the environment. The purpose of the investigation was to obtain an estimate of the quantities of dissolved metals and other substances discharging into the Columbia River, via groundwater, from under the smelter. The investigation consisted of the installation and testing of 18 groundwater monitoring wells at eight locations, including five along the bank of the Columbia River. The investigation found evidence of groundwater contamination (Cominco 1998). Additional work conducted as part of the groundwater investigation at the smelter site included installation of five more monitoring wells in 2002 to allow a more complete assessment of the contaminant loadings to the Columbia River. Additionally, regional groundwater investigations were begun to identify surface water drainages in the Cominco area that may be affected by contaminated groundwater discharge (Teck Cominco Metals Ltd. 2003a). It is not known to what degree this contaminated groundwater discharge may impact surface water quality in the Columbia River.

3.1.1.5 Electronic-waste Management

In 2005, a pilot-scale study was conducted at the Trail facility to assess the feasibility of initiating an electronic waste (e-waste) recycling program, wherein the plastics and woods associated with e-waste would serve as reducing agents for the fuming furnace. The plastics and wood are consumed in the furnace as chemical reductants, liberating carbon dioxide and water vapor. In addition, and critical to the overall processing of e-wastes, is the effective treatment of plastic components because these materials may form organic pollutants such as dioxins/furans, polycyclic aromatic hydrocarbons (PAHs), and polybrominated diphenyl ethers (PBDEs) when burned. The pilot-scale study was conducted over a period of 13 days at the No. 2 slag fuming furnace associated with onsite lead operations.

Strict environmental monitoring was conducted at all potential discharge points, including stacks (gases and particulates), effluents (C-III outfall), and ambient air. Monitoring results showed that emissions of regulated persistent organic pollutants were comparable to baseline levels. Specifically, emissions from the No. 2 fuming furnace were lower than Environment Canada's level of quantification for dioxins/furans (*i.e.,* 32 picograms [pg] toxicity equivalent [TEQ] per dry standard cubic meter [dsm^3]), while the production-based release of PAHs was significantly lower than the Canadian National Pollutant Release Inventory (NPRI) reporting threshold. Given the success of pilot-scale studies, the British Columbia Ministry of Environment (B.C. MoE) issued a one-year temporary permit to conduct an e-waste recycling program. Based on the positive environmental performance of the one-year program, the B.C. MoE will issue a new permit to the Trail facility for e-waste recycling.

Additional details about e-waste processing and recycling are provided in the *RI/FS Work Plan* (EPA 2008a).

3.1.1.6 Accidental Spills and Releases, Permit Exceedances, and Variances

The Trail facility has historically and recently experienced a number of accidental spills into the Columbia River. According to records obtained from Environment Canada's spilltracker database and the B.C. MoE, chemicals released since 1983 include a variety of metals and metalloids, nutrients, slag, suspended soils, and oils (Table 3-1). Information about spills prior to 1983 is not readily available, but releases of similar (and potentially additional) chemicals are expected to have occurred periodically over the history of Trail operations. Information regarding permit limit exceedances and variances is maintained by regulatory agencies in Canada.

3.1.1.7 Other Potential Teck Cominco Trail Facility Sources

Other potential chemical sources associated with the Trail facility include its materials management operations, historical phosphate fertilizer operations, polychlorinated biphenyls (PCBs), and other nonpoint sources (*e.g.,* releases via Stoney Creek), which are discussed below.

Materials Management: Of the 14 permits currently held by the Trail facility (Table 3-2), four are related to management and storage of solid materials (*e.g.,* slag and arsenic) that may be related to COIs for the UCR Site.

Phosphate Fertilizer: Uranium was likely present in phosphate ores used in Trail fertilizer production and historically released into the river as phosphogypsum waste. Uranium has been detected in surface sediments in the UCR and measured concentrations show a spatial gradient, with highest concentrations near the U.S.-Canada border and decreasing concentrations further downstream (EPA 2006ea). The screening beach risk assessment (EPA 2006f) identified elemental uranium as a COI. In addition, the uranium/radium series decay chain (see Figure 5-2) includes several radionuclides that are known carcinogens.

PCBs: Since the late 1970s, PCB equipment (*e.g.,* electrical transformers) has been phased out and the equipment has been destroyed at approved hazardous waste management facilities such as the Swan Hills Treatment Centre in Alberta. All PCB equipment and/or PCB-containing wastes have been removed from the Trail facility. As a result, it is PCB-free and the existing permit (Permit No. 08443) will no longer be required nor renewed. Further investigation may be required to identify information on PCB releases and disposal at the Trail Facility.

Non-point Sources: Stoney Creek, located just upstream of the Cominco smelter near RM 755, has also contributed chemicals to the Columbia River (Teck Cominco 1998). Teck Cominco's 1997 environmental report identified Stoney Creek as a significant contributor of contaminants to the Columbia River (Cominco 1998). MacDonald (1997) identifies Stoney Creek as the single largest source of dissolved arsenic, cadmium, and zinc to the Columbia River. Stoney Creek concentrations in 1995 exceeded the permitted levels for the Trail facility's metallurgical sewers. The Stoney Creek watershed is affected by Teck Cominco's past waste dumping and storage activities, which contributed metal-laden drainage from seepage and surface runoff. This stream also received runoff from the urban area and a municipal landfill. Water and sediment in Stoney Creek contained elevated arsenic, cadmium, copper, lead, and zinc levels compared to other tributaries prior to 1997. In 1997 and 1998, a seepage collection system along the banks of Stoney Creek was designed and constructed to redirect drainage containing zinc, cadmium, and arsenic to the effluent treatment plant. Stoney Creek metal levels in both water (loads, calculated as concentration multiplied by flow) and sediment were reportedly reduced substantially between 1995 and 1999, with the exception of copper levels, which increased in sediment (G3 Consulting 2001b). In addition, in 2003 and 2005, two significant sources of contaminant seepage into Stoney Creek were addressed. A closed industrial landfill was capped in 2003 with an engineered, low-permeability, composite clay and synthetic membrane; in 2005, a permanent storage system was created for arsenic-contaminated wastes using a low-permeability double liner at the base of the material and membrane cap. These two source control measures have improved water quality within Stoney Creek. For example, average zinc concentrations in Stoney Creek declined from 26 milligrams per liter (mg/L) in 1995 to 6.2 mg/L in 1999; average arsenic concentrations declined from 2.0 to 0.9 mg/L during the same period, and copper concentrations from 16 to 6.3 micrograms per liter (μg/L) (Table I.30 in Golder Associates 2003).

Possible contributions of chemical from other non-point sources on the Trail facility have not been evaluated. However, surface soil, stormwater, and groundwater data from the facility are available for review.

3.1.2 Le Roi/Northport Smelter

The Le Roi/Northport Smelter (Le Roi) is a former smelter located approximately 7 river miles downstream of the U.S.Canadian border in Northport, Washington. The Le Roi Smelter property encompasses approximately 32 acres and is accessed from the Northport-Waneta Road via Highway 25 (Science Applications International Corp. [SAIC] 1997). The former smelter operations area occupies approximately the eastern two-thirds of the site, and a former lumber mill occupies the remaining portion. The smelter buildings, which are no longer standing, included the furnace building, the roaster building, and the crusher and ore building (Heritage 1981).

In 1892, D.C. Corbin, owner of the Spokane Falls and Northern Railroad, built a rail line to reach the town of Northport, then consisting of a lumber mill and several tents. The railroad tracks were located adjacent to the Le Roi site. In 1896, Mr. Corbin donated the site to the Le Roi Mining and Smelting Company for the construction of the Breen Copper Smelter. In 1896, the Breen Copper Smelter began refining copper and gold ores from mines in northeast Washington, as well as copper ore from B.C., for the Le Roi Mining and Smelting Company. In 1901, the Le Roi Company smelting operations reorganized with the Red Mountain smelting operations to become the Northport Smelting and Refining Company (Northport Pioneers 1981).

The copper and gold ore was processed by heap roasting, which involves open burning of the raw ore prior to placing it in a furnace. A slag brick platform was used for the initial burning, or heap roasting, of the ore. Burned ore was placed in a furnace that produced iron and slag waste. Some of the waste was formed into slag bricks that were then used as construction materials for onsite as well as offsite buildings. The gold and copper concentrate was shipped off the site by rail for further refining. At the peak of operation, the Le Roi Smelter processed 500 tons of ore per day; operations were suspended in 1909. In 1914, the Le Roi Smelter reopened to process lead ore from Leadpoint, Washington, to meet government demand during World War I. Lead smelting operations during this period produced up to 30 tons per day of airborne sulfur emissions (Weston 2004b). Slag was the main byproduct of smelting operation at the site. This material was sorted in piles on the site or discharged directly to the river via underground launders (EPA 2004a). Operations ceased permanently in 1921, and the smelter site remained inactive until 1953. The furnace, roaster, and crusher and ore buildings were removed from the site during this period of inactivity. From 1953 to 2001, the western portion of the site was used as a lumber mill; no wood treatment or chemical use was reported for this period of operation (Weston 2004b).

Emissions from the Le Roi facility that have potential relevance to the UCR Site include:

- Discharges of slag to the Columbia River
- Drainage to the Columbia River from seepage and surface runoff of materials stored onsite
- Stack emissions
- Effluent discharge and accidental spills

From 1993 to 2004, the EPA conducted preliminary assessments, site inspections, and a removal site evaluation. Northport residential and commercial properties were identified in 2003 and 2004 for a removal action. Removal assessment activities included sampling of residential and commercial properties in and around the Northport community, sampling of public areas, and collecting drinking water samples from residents. All sampling results were compared to regulatory levels provided by the State of Washington Department of Ecology (Ecology) for response actions conducted at Northport (Weston 2005).

A removal action was conducted on the Le Roi property and in the town of Northport by EPA in 2004 (Weston 2004b; Weston 2005). Contaminated soils were consolidated at the smelter site (11-acre area), covered with a polyethylene sheet and clean soil, and vegetated.

3.2 Additional Potential Chemical Sources

As part of the RI, the potential for contaminants of concern reaching the Upper Columbia River Site from the industrial and non-industrial discharges identified below may also be investigated if significant anomalous occurrences or distributions of chemicals are detected during the course of the RI/FS at concentrations that exceed background or risk-based screening levels.

3.2.1 Pulp Mill Operations

The Zellstoff Celgar Ltd. (Zellstoff) bleached kraft pulp mill is located in Castlegar, B.C., approximately 30 river miles upstream of the U.S.-Canada border. Prior to Zellstoff's acquisition of the pulp mill in February of 2005, the pulp mill was operated by the Celgar Pulp Company (Celgar). From 1961 until mid-1993, the mill primarily used chlorine in its bleaching process. The pulp mill discharged effluent containing chlorinated organic compounds, including dioxins and furans, into the Columbia River (USGS 1994). As a result of health implications of dioxin and furan levels in fish downstream of pulp mills, the provincial and federal governments initiated fish sampling in the Columbia River from 1988 to 1990 as part of a nationwide survey. Levels in a variety of species downstream of Celgar, including rainbow trout, showed low or normal background levels of contamination, with the exception of whitefish, which showed levels above background. In response to these findings, a consumption advisory was issued by the local Medical Health Officer recommending that consumers of whitefish caught in the vicinity of the area of Hugh Keenlyside Dam to the U.S.-Canada border limit their consumption to one meal per week. The 1990 whitefish consumption advisory prompted voluntary changes to the mill's bleach plant to reduce chlorinated furan (*i.e.,* 2,3,7,8-tetrachlorodibenzofurans [TCDF]) effluent discharges into the Columbia River (CRIEMP, 2005).[5]

As a result of pulp process effluent discharges, a fiber mat formed downstream of Celgar's outfalls. Fiber mats often form when effluent containing wood debris and pulp fibers is discharged into an aquatic environment and then settles to the substrate and accumulates. While fiber mats are readily degraded by microorganisms (producing ammonia and hydrogen sulfide byproducts), they often contain persistent chemicals from pulp production and bleaching processes. Persistent chemicals documented in other fiber mats have included PAHs, tetrachlorodibenzo-p-dioxins, and heavy metals (USGS 1994).

Plant modernization in 1994 included the installation of a chlorine dioxide bleach plant and a secondary treatment system for process effluent. Following modernization of the mill, discharges of chlorinated organic chemicals were reduced from 2,755 to 330 kg/d, and polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) were

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[5] Fish advisories have also been issued for the consumption of walleye, whitefish, and sturgeon from Lake Roosevelt due to mercury and dioxin concerns (WDOH 2002). The health advisory for mercury in these fish is a state-wide advisory.

undetectable in the waste stream (EPA 2004b). A fiber and fly ash recovery system was also implemented that subsequently led to the reduction of the fiber mat located downstream of the process outfalls, and the recovery boiler previously responsible for high reduced-sulfur emissions was decommissioned, resulting in lower sulfur releases and improved air quality (EPA 2004b). The Zellstoff mill has reported annually to the Canadian NPRI since at least 1994; reported releases include surface water discharges of ammonia and air releases of chlorine, chlorinated compounds, methanol, and sulfuric acid (Environment Canada 2007).

3.2.2 Toxics Release Inventory Sites

The EPA Toxic Release Inventory (TRI) is a public database dating from 1988 that contains information regarding toxic chemical releases, transfers, and other waste management activities associated with U.S. facilities. Industrial sources and the associated chemicals based on TRI information (from 1996 to 2005) from Stevens, Ferry, and Lincoln counties are listed in Table 3-3; the locations of those in the vicinity of the study area are shown on Map 3-3. As shown in Table 3-3, releases by industries over the reporting period have included air and/or land releases of metals, ammonia, chlorine compounds, and volatile compounds.

The Canadian NPRI is a legislated, publicly-accessible inventory of pollutants released, disposed of, and sent for recycling by facilities across Canada. Annual reporting to the NPRI is mandatory under the Canadian Environmental Protection Act (Environment Canada 1999) for industrial and other facilities that meet reporting requirements. A summary of historical releases from Teck Cominco Trail facility operations (NPRI ID# 3802) from 1994 to 2007 is available on-line[6].

3.2.3 Water Quality Discharge Permitted Sites

Additional releases of COIs may have occurred or continue to occur as industrial stormwater or wastewater discharges to the UCR and its tributaries. Discharges to surface waters are regulated by the Clean Water Act. The administration of discharge permits through the National Pollutant Discharge Elimination System (NPDES) program in Washington has been delegated to Ecology.

Ecology's Water Quality Permit Life Cycle System (WPLCS) database contains information on all facilities with regulated discharge permits, which stipulate specific limits and conditions of allowable discharge that may impact surface water quality. Locations of current permitted facilities in the vicinity of the UCR are illustrated in Map 3-4, and are listed in Tables 3-4 and 3-5. The information in Table 3-4 is organized by water resource inventory area (WRIA), and provides an overview of facility types discharging to several of the watersheds that ultimately drain to the UCR. Discharges from some permitted sites are also reported to the TRI, discussed above. Discharge water quality monitoring results for current permits are available from Ecology but are not presented here.

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[6] http://www.ec.gc.ca/pdb/querysite/facility_history_e.cfm?opt_npri_id=0000003802&opt_report_year=2007

3.2.4 Municipal and Non-point Sources

A variety of municipal and non-point sources are potentially relevant to the UCR Site, including:

- Municipal wastewater treatment plants that discharge into the Colville, Sanpoil, Spokane, and Pend Oreille rivers
- Municipal wastewater treatment plants in Castlegar and Trail that discharge into the Columbia River
- Point and non-point sources along the Spokane River
- Agricultural runoff of nutrients and pesticides to surface water

4 GENERAL HUMAN HEALTH RISK ASSESSMENT STRATEGY

There are two different risk characterization approaches that can be utilized when calculating risk estimates from environmental chemicals – a total risk approach and an incremental risk approach. In the "total risk" approach, risks are calculated for all chemicals that are present at a site that are above a level of potential concern. If the total concentration of some chemicals are due in whole or in part to natural ("background") levels of the chemical, this information is discussed as part of the risk characterization section. In the "incremental risk" approach, attention is focused only on the increase in risk that is due to releases from the site, and the risks from "background" levels of chemicals are not characterized or presented.

EPA carefully considered both these options, and determined that the "total risk" approach is most appropriate at this site. That is, risks will be evaluated for all chemicals, even if they are attributable to natural or other non-site-related sources. This approach is preferred because it provides the most complete and thorough characterization of risks from environmental chemicals, allowing both risk managers and the public to evaluate the magnitude of the "background" risk, the increment caused by site-related releases, and the total risk. This approach is consistent with EPA's *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites* (EPA 2002c), which recommends that the baseline risk assessment address site-specific background issues at the end of the risk assessment in the risk characterization.

One advantage of a "total risk" approach is that the role of background is within the context of risk interpretation (*i.e.,* background data are not utilized to "screen out" chemicals or exposure pathways). Therefore, a determination of data needs and data collection efforts are not delayed by a lack of appropriate background data.

One of the implications of this decision is that data are needed to characterize environmental concentration at all areas of the site where concentrations are above a level of concern, even if it is known that levels are close to or indistinguishable from "background". Although this adds to the time and cost of the site characterization effort, EPA believes that the effort is worthwhile because of the added information that is derived.

5 EXPOSURE ASSESSMENT APPROACH

Exposure is the process by which human or ecological receptors come into contact with chemicals in the environment. In general, receptors can be exposed to chemicals in a variety of environmental media (*e.g.,* soil, water, air, food), and these exposures can occur through several pathways (*e.g.,* ingestion, dermal contact, inhalation). This section summarizes the environmental media and chemicals of potential concern at the UCR Site, identifies human exposure pathways, and describes the methods used to quantify exposure from each pathway.

5.1 Site Conceptual Model

5.1.1 Sources

This section provides a summary of the primary, secondary, and tertiary sources of chemicals entering the UCR. Primary refers to the original source (*e.g.,* discharge point) of a chemical constituent, while secondary and tertiary sources are environmental media (abiotic or biotic) that receive chemical inputs from a primary or secondary source through direct discharge or through chemical transport and fate mechanisms. The primary sources for the UCR are defined below and depicted in on the left side of Figure 5-1.

- **Ambient Atmospheric Constituents:** Ambient atmospheric constituents are those chemicals that are transported to and deposited at the UCR Site from global or regional atmospheric sources and are not tied to a specific point source.

- **Smelter Operations:** This includes current and historical chemical discharges via stacks, liquid effluent, or slag discharges from the Trail or LeRoi smelter operations.

- **Industrial Operations:** A number of industrial operations are located above the U.S.-Canadian border near Trail, (*e.g.,* Zellstoff mill) or along tributaries to the UCR within the U.S. (*e.g.,* Spokane River) that historically discharged or currently discharge chemicals to the UCR.

- **Municipal Point and Nonpoint Sources:** Municipal point sources include effluent discharges from wastewater treatment plants located adjacent to the UCR or connected through tributaries to the UCR (*e.g.,* plants located in Trail, BC, Colville and Chewelah, WA). Nonpoint sources include storm water runoff or storm sewer effluent from local communities within the UCR drainage basin.

- **Agricultural Nonpoint Sources:** Many of the areas surrounding the UCR have historically and are currently used for agricultural purposes. Chemicals potentially are released to the UCR through runoff or spray drift from historical or current agricultural operations.

5.1.2 Transport and Fate Mechanisms for Exposure Media of Interest

Chemicals released from primary sources can undergo a variety of physical, chemical, and biological transport and fate mechanisms related to both environmental processes (*e.g.,* wind dispersion, erosion, dissolution, bioaccumulation) and human behavior (*e.g.,* irrigation, track-in). These mechanisms (illustrated in Figure 5-1) influence the distribution of chemicals from their sources to environmental media throughout the UCR.

The UCR Site is used for recreation, subsistence hunting, fishing, and gathering, and for cultural pursuits important to local Native American tribes. Surface water and groundwater from the site is used for irrigation and possibly other uses (*e.g.,* showering at campgrounds, in sweat lodges). In addition, the CCT, STI, NPS, State of Washington, and local municipalities maintain facilities within the site (*i.e.,* parks and campgrounds, marinas, ferry boats operations, and archeological sites), which provide additional opportunities for occupational contact with the site. Many residences are also located adjacent to the site. Therefore, potential scenarios for exposure to COIs at the site may include:

- Short-term and long-term recreational activities (*e.g.,* camping, fishing, hunting, boating)
- Tribal cultural/ceremonial/spiritual activities (*e.g.,* sweat lodge use, basket-weaving)
- Traditional or contemporary subsistence camping, hunting, fishing, and gathering activities
- Occupational activities
- Residential activities

Environmental media to which humans may be exposed in the above scenarios include air, surface water, groundwater, beach sediment, upland soil, indoor dust, and biota. The following sections describe the fate and transport mechanisms as they relate to the environmental media of interest associated with human exposures.

> **Outdoor Air:** Chemicals in the air can be transported via wind dispersion, aerial deposition, or resuspension. Wind dispersion is the process by which chemicals are transported locally, regionally, or globally via wind currents to different locations. Aerial deposition is the settling of chemicals from air to sediment, soil, or surface water via wet or dry deposition. Chemicals in sediments or soils may also become resuspended into the air due to windstorm events (*i.e.,* as particulate matter or vapor phase) and may be transported to other locations via wind dispersion and aerial deposition. At the UCR Site, this may occur when sediments are exposed during reservoir drawdown periods.
>
> **Surface Water:** Chemical transport in surface water occurs through several physical, chemical, and biological mechanisms. Physical transport processes include in-stream flow (*i.e.,* longitudinal, horizontal, and vertical movement), infiltration (*i.e.,* movement into groundwater), advection (*i.e.,* bulk movement of chemicals in water), and diffusion (*i.e.,* movement from high chemical concentration to low chemical concentration). Chemical transport mechanisms include precipitation (*i.e.,* dissolved chemicals forming solids due to chemical and environmental characteristics) and adsorption (*i.e.,* attachment

of dissolved chemicals to solid materials). Uptake of chemicals in dissolved or solid forms by biota may result in bioaccumulation in the tissues of ecological receptors. In addition, chemicals in surface water may be transported to other media as a result of human behavior (*e.g.,* irrigation, use in sweat lodges, etc.).

Sediment: Chemicals in sediment also are subject to several physical, chemical, and biological processes. Physical release mechanisms affected by reservoir operations and in-stream flow include entrainment (*i.e.,* longitudinal transport of suspended, bedload, or bank sediments), deposition (*i.e.,* settling and accumulation or burial of sediments onto banks or floodplain soils), erosion (*i.e.,* bank wasting or slumping due to reservoir operations), and wind dispersion of fine sediments following seasonal drawdown. Chemical transport processes include dissolution (*i.e.,* dissolving into solution), adsorption/desorption (*i.e.,* attachment or detachment of chemicals to sediment particles), and decrepitation/weathering (*i.e.,* the wasting or breaking up of particles resulting in chemical releases). Biological uptake of chemicals from sediment may lead to the bioaccumulation of chemicals in tissues of ecological receptors. In addition, chemicals in sediment may be transported to other media as a result of human behavior (*e.g.,* track-in into indoor dust on shoes and clothing, suspension of particulates into surface water as a result of human disturbances such as wading and swimming).

Groundwater: Release of chemicals to groundwater generally occurs through infiltration from surface water. Chemicals also enter groundwater through release from sediments through dissolution and desorption. Bank seepage occurs via advection (upwelling) and may affect surface water through discharge from the side banks during pool drawdown. In addition, chemicals in groundwater may be transported to other media as a result of human behavior (*e.g.,* irrigation, showering, other residential water uses).

Upland Soil: Chemicals in upland soils also undergo several physical, chemical, and biological processes. Physical release mechanisms include entrainment (*i.e.,* transport of particles via storm water runoff), aerial deposition (*i.e.,* settling of solid particles), erosion (*i.e.,* wasting of soil surfaces by wind or surface water flow), and wind dispersion of fine particles. Some chemicals become irreversibly bound in soil particles through the “aging” process and are no longer available for transport or biological uptake. Chemical transport processes include dissolution, adsorption/desorption, and decrepitation. Biological uptake of chemicals from soils may lead to the accumulation of chemicals in terrestrial plants and wildlife. Chemical concentrations in upland soils may also be influenced as a result of irrigation with surface water and/or groundwater. In addition, chemicals in upland soil may be transported to other media as a result of human behavior (*e.g.,* indoor dust via track-in).

Biota: The predominant form of chemical transport to biota is through bioaccumulation of chemicals following exposure via ingestion of, direct contact with, or inhalation of environmental media. Chemicals are accumulated in various tissues (*e.g.,* liver, kidney, brain, or muscle depending upon the chemical) and are transferred throughout the food web. Many of these organisms (especially fish, shellfish, game animals, waterfowl, and some types of plants) may be utilized for food or other purposes by humans. In addition, livestock or human food crops that are raised in areas that have been irrigated with site water or have been impacted by airborne releases from the site might also be affected.

Indoor Dust: Dust inside buildings and structures (*e.g.,* residences, offices, recreational vehicles) may become impacted as a result of soil/sediment track-in by humans on clothing and other vectors (*e.g.,* pets), and deposition of solid particles suspended in indoor air.

Indoor Air: Air inside buildings and structures may be influenced as a result of cross-ventilation with outdoor air and suspension of indoor dust contaminated via track-in or windborne deposition. Indoor air may also be influenced by volatile chemicals release from surface water or groundwater that is being used indoors for activities such as showering, dishwashers, toilets, etc.

Sweat Lodge Air: In a sweat lodge, water is poured over heated rocks, which results in chemicals in surface water becoming suspended in the sweat lodge air as water aerosols (*i.e.,* flashing) or volatilizing as gases.

Smoke-filled Air: In cases where plant materials are burned by humans during food preparation/preservation and/or ceremonial/medicinal activities, chemicals in the plant tissues may become suspended in the air as solid particulates in smoke.

5.1.3 Area of Interest

Delineation of the UCR Site boundaries is not within scope of this work plan. For the purposes of evaluating potential human health risks, the UCR Site is defined as the interval between minimum and maximum extent of the river channel during the year (*i.e.,* lowest and highest elevation reached by the river during the year), plus other areas that may have been potentially impacted by releases. These other areas include locations that may have been impacted by air emissions from the source or wind-blown dispersion of dust from exposed sediment, or lands that are irrigated with water from the site.

5.1.4 Chemicals of Interest (COIs)

Table 5-1 presents a list of initial COIs. This list was developed using information about known and potential sources and data obtained during other investigations and monitoring events. These initial COIs include metals and metalloids, pesticides, semi-volatile organic chemicals (SVOCs), PAHs, PCBs, dioxins/furans, and PBDEs.

As noted previously, uranium was likely present in phosphate ores used in Trail fertilizer production and released into the river as phosphogypsum waste. Several radionuclides are part of the decay chain for uranium (see Figure 5-2) and have potential to contribute substantially to UCR Site cancer risks. Therefore, radionuclides associated with the U-238 decay chain were added to the list of COIs.

It should be noted that the list of COIs for the UCR is preliminary and may be updated to include additional chemicals if new information about sources (*e.g.,* historical operations or releases) or detected chemicals come to light during the course of the RI/FS. The list of COIs will be refined in the baseline HHRA based on the results of an initial risk characterization to identify chemicals of potential concern (COPCs).

5.1.5 Exposed Populations

5.1.5.1 Recreational Visitor Populations

At the UCR Site, there are numerous campgrounds, public access beaches, boat launches, and picnic areas which are frequented by recreational visitors that engage in a variety of activities, including camping, swimming, fishing, hunting, boating, hiking, etc. Three categories of recreational visitor will be evaluated in the HHRA, depending on the duration and frequency of site visitation:

- **Short-term recreational visitor** - This population is composed of individuals that visit the river for no more than 14 days/year.

- **Seasonal recreational visitor** - This population is composed of individuals (either local or non-local) that take up semi-permanent residence at the site for an extended period (*e.g.,* May to September) each year.

- **Year-round recreational visitor** - This population is composed of individuals that reside locally and visit the site with a high frequency throughout the year.

5.1.5.2 Worker Populations

There is a wide range of different types of worker scenarios that might be evaluated at the UCR Site. Because it is assumed that an outdoor worker is likely to be more exposed than an indoor worker, the outdoor worker is selected as the receptor population of chief concern. Two types of worker populations may be exposed within the site boundary.

- **Contact intensive workers** - This population is composed of workers who engage in excavation activities (*e.g.,* archaeological, artifact excavation), construct or repair buildings, utilities or other facilities at campgrounds and other areas of the site. Because of the nature of the work performed (*i.e.,* digging holes, trenches, footings, etc.) this type of worker is assumed to have a relatively high opportunity for contact with contaminated site soils and sediments.

- **Non-contact intensive** - This population is composed of workers who are regularly employed at campgrounds and boat launches along the river, but who do not usually engage in activities that result is extensive contact with contaminated site soils or sediments. This might include, for example, park rangers, boat dock workers, etc.

5.1.5.3 Subsistence Populations

Subsistence populations are composed of individuals who rely upon the site to provide food as well as other needs (*e.g.,* medicines, clothing, etc.). For the HHRA, two categories of subsistence populations will be evaluated:

- **Traditional** - This population is defined as individuals who live off the land in accordance with Native American traditions. These individuals spend a large fraction of time engaged in fishing, hunting, and gathering activities at the site, and obtain all of their food, clothing, and medicines from the site.

- **Modern** - This population is defined as individuals with a current lifestyle that is mixture of traditional Native American and modern lifestyles. These individuals obtain some of their food by fishing, hunting and gathering activities at the site, and obtain the remainder of their requirements from modern sources.

5.1.5.4 Residential Populations

Although residences are not expected to be located within the minimum to maximum extent of the river channel (*i.e.,* between the low and high pool elevations), there are numerous residences located in close proximity to the UCR Site. These residences have the potential to be impacted by wind-blown dispersion of exposed sediments/soils along the UCR. In addition, residents that frequent the UCR Site to engage in recreational, occupational, or subsistence activities may track-in sediment from the site on clothing or shoes.

5.1.6 Exposure Pathways

As described above, several types of environmental media may be contaminated as a result of point and non-point releases along the UCR, including sediment, surface water, air, groundwater, and biota. Figure 5-3 presents the likely routes by which recreational visitor, worker, subsistence, and residential populations might come into contact with contaminants in the environment. Those pathways that are complete are identified with a checkmark. Those pathways that are potentially complete (*e.g.,* exposures to groundwater and amphibians/reptiles) are identified with a question mark. Pathways that are incomplete are shown as an open box. As shown, humans may be exposed to contaminants in environmental media by several pathways, including ingestion, inhalation, and dermal contact exposure scenarios.

It is important to note that not all of these exposure pathways are likely to be of equal concern or require equal levels of investigation. An issue that EPA considered in detail is the best approach for dealing with exposure pathways that are suspected to be “minor”. For example, if a person is exposed to contaminated sediment at exposed beaches by ingestion, dermal contact, and inhalation, it would usually be suspected that the ingestion pathway would contribute the largest risk, and that omitting the other pathways would result in only a small underestimate of total exposure and risk. The benefit of such an approach would be the reduced time and cost of collecting the data necessary to support an evaluation of the “minor” pathways. However, this approach is often subject to criticism related to the uncertainty that arises when a complete exposure pathway is omitted from quantitative evaluation.

At this site, EPA has determined that the preferred approach is to quantitatively evaluate all complete exposure pathways in the baseline HHRA, even those that may be suspected to be minor. The benefit of this approach is that risk estimates are based on total exposure, thus the confidence in the resulting assessment is increased. In addition, this approach is maximally transparent, in that it demonstrates quantitatively the relative contribution of each exposure pathway to the total risk.

As appropriate, the exposure scenarios for each receptor population will be refined in the baseline HHRA using information provided by the future site-specific recreational and tribal-use surveys.

5.1.6.1 Recreational Visitor Pathways

The following exposure scenarios will be evaluated for recreational visitor populations:

- Incidental ingestion of and dermal contact with beach sediment during recreational activities
- Incidental ingestion of and dermal contact with surface water during recreational activities (*e.g.,* while swimming or wading)
- Inhalation of outdoor air near beaches
- Ingestion of fish, wild game, and waterfowl derived from the UCR Site
- Ingestion of drinking water derived from untreated groundwater or UCR surface water
- Inhalation of indoor air and incidental ingestion of indoor dust inside RVs, campers, and tents
- Dermal contact with and inhalation of volatiles from untreated groundwater during showering at UCR facilities

All three types of recreational visitors are assumed to engage in the same types of activities (*e.g.,* camping, swimming, fishing, hunting, boating, hiking, etc.), but with differing frequencies and durations. Because year-round recreational visitors reside off-site, indoor exposures are evaluated under the residential exposure scenarios (*i.e.,* indoor exposures inside RVs, campers, and tents are evaluated for short-term and seasonal recreational visitors only).

5.1.6.2 Worker Pathways

The following exposure scenarios will be evaluated for worker populations:

- Incidental ingestion of and dermal contact with beach sediment and surface water during occupational activities
- Inhalation of outdoor air near beaches
- Ingestion of drinking water derived from untreated groundwater or UCR surface water

As described previously, it is assumed that exposures are likely to be lower for indoor workers than outdoor workers. Therefore, occupational exposures are assumed to occur entirely outdoors (*i.e.,* this receptor population is not exposed to indoor air or dust).

5.1.6.3 Subsistence Pathways

The following exposure scenarios will be evaluated for subsistence populations:

- Incidental ingestion of and dermal contact with beach sediment during subsistence activities (*e.g.,* fishing, hunting, gathering)
- Incidental ingestion of and dermal contact with surface water during subsistence activities
- Inhalation of outdoor air near beaches
- Ingestion of fish, plants, wild game, and waterfowl derived from the UCR Site
- Ingestion of crops irrigated with and livestock watered with impacted groundwater or untreated UCR surface water
- Ingestion of drinking water derived from untreated groundwater or UCR surface water

Because subsistence populations reside off-site, indoor exposure scenarios are evaluated as part of residential exposure scenarios.

There are also several tribal-specific exposure scenarios that are evaluated under the traditional subsistence scenario, including:

- Inhalation of chemicals in sweat lodges due to use of untreated UCR surface water
- Incidental ingestion of and dermal contact with plant materials from the UCR Site during basket-weaving activities
- Dermal contact with animal tissues from the UCR Site during preparation/preservation activities
- Dermal contact with plant and animal tissues from the UCR Site used medicinally and/or ceremonially
- Inhalation of smoke derived from burning of plant materials during medicinal/ceremonial or preparation/preservation activities

5.1.6.4 Residential Pathways

The following exposure scenarios will be evaluated for residential populations:

- Incidental ingestion of and dermal contact with residential yard soil
- Inhalation of outdoor air near residences
- Inhalation of indoor air and incidental ingestion of indoor dust inside residences
- Dermal contact with and inhalation of volatiles from untreated groundwater during showering and other indoor water uses
- Ingestion of drinking water derived from untreated groundwater or UCR surface water

5.2 Selection of Exposure Areas

An exposure area (also referred to as an exposure unit or exposure point) is an area where a receptor (visitor, worker, etc.) may be exposed to one or more environmental media. Within the exposure area, contact with each medium is assumed to be random when considered on the time scale of the exposure scenario being evaluated (usually many years). Selection of the bounds of an exposure area is based mainly on a consideration of the likely activity patterns of the exposed receptors.

At this time, site-specific information on area usage is not available. It is expected that most receptors will access the Columbia River and Lake Roosevelt primarily from public access areas, such as designated campgrounds, swimming areas, boat launches, and marinas. Over the course of multiple years, it is suspected that most individuals will access the UCR Site at a number of different locations rather than always going to the exact same location. Therefore, the upper limit of the size of an exposure area will be a reach. As described in Section 2.3.4 above, the UCR Site was segregated into six reaches (Map 2-1) based on consideration of distinct geomorphic features, general hydraulic characteristics, and expected differences regarding the principal mechanisms for transport or deposition of particle-bound chemicals of interest.

- **Reach 1** extends from the U.S-Canada border (USGS RM 745) southward past the city of Northport to USGS RM 730, near Onion Creek.

- **Reach 2** extends from near Onion Creek (USGS RM 730) to the approximate upstream head of Marcus Flats (USGS RM 711)[7].

- **Reach 3** extends from the approximate upstream head of Marcus Flats (USGS RM 711) to just downstream of Kettle Falls (USGS RM 699).

- **Reach 4** extends from just downstream of Kettle Falls (USGS RM 699) to just upstream of the confluence with the Spokane River (USGS RM 640) and represent the middle reservoir. This reach is further divided into two sub-reaches
- **Reach 4a** extends from USGS RM 699, at the confluence of the Colville River, to USGS RM 676, just upstream of Inchelium. **Reach 4b** extends from USGS RM 676 to USGS RM 640 near the confluence with the Spokane River.

- **Reach 5** extends from USGS RM 640 to USGS RM 617.

- **Reach 6** extends from USGS RM 617 to the Grand Coulee Dam (near USGS RM 597).

However, because some individuals may tend to visit the UCR Site within a use area that is smaller than the reaches specified above, the lower size limit of an exposure area will be represented as a single beach. It is believed that, over time, preferential exposure will not occur within an area smaller than a single beach.

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[7] This document assumes that the specified lower bound of the reach is inclusive and the upper bound is exclusive (*e.g.,* Reach 2 includes river miles < RM 730 and ≥ RM 711).

It is anticipated that future site-specific recreational and tribal-use surveys will provide information on typical use scenarios and patterns for the UCR Site. The exposure areas utilized in the baseline HHRA will be delineated using information from these site-specific surveys and may differ from the exposure areas described above.

5.3 Evaluation of Exposures to Non-Lead Chemicals

5.3.1 Basic Equations

5.3.1.1 Ingestion Exposures

The amount of a chemical which is ingested is referred to as "intake" or "dose". For non-lead chemicals, exposure is quantified using an equation of the following general form:

$$DI = C \cdot (IR / BW) \cdot (EF \cdot ED / AT)$$

where:

DI = Daily intake of chemical (mg of chemical per kg of body weight per day).

C = Concentration of the chemical in the contaminated environmental medium (soil, sediment, water, food) to which the person is exposed. The units are mg/L for water, and mg/kg for solid media.

IR = Intake rate of the contaminated environmental medium. The units are L/day for aqueous media, and kg/day for solid media.

BW = Body weight of the exposed person (kg).

EF = Exposure frequency (days/year). This describes how often a person is likely to be exposed to the contaminated medium over the course of a typical year.

ED = Exposure duration (years). This describes how long a person is likely to be exposed to the contaminated medium during their lifetime.

AT = Averaging time (days). This term specifies the length of time over which the average dose is calculated. Usually, two different averaging times are considered:

"Chronic" exposure includes averaging times on the scale of years (typically ranging from 7 years to 70 years). This exposure duration is used when assessing non-cancer risks.

"Lifetime" exposure employs an averaging time of 70 years. This exposure interval is selected when evaluating cancer risks.

Note that the factors EF, ED, and AT combine to yield a factor between zero and one. Values near 1.0 indicate that exposure occurs nearly continuously over the specified averaging period, while values near zero indicate that exposure occurs infrequently.

For mathematical convenience, the general equation for calculating dose can be written as:

$$DI = C \cdot HIF$$

where:

HIF = Human Intake Factor. This term describes the average amount of an environmental medium contacted by the exposed person each day. The value of HIF is typically given by:

$$HIF = (IR / BW) \cdot (EF \cdot ED / AT)$$

The units of HIF are L/kg-day for aqueous media and kg/kg-day for solid media.

Because one or more exposure parameters (*e.g.,* intake rates, body weight, and exposure frequency) may change as a function of age, exposure calculations for non-cancer risks are often performed separately for children and adults. However, for estimating excess cancer risks from exposure to a chemical, because the same individual may be exposed beginning as a child and extending into adulthood, exposure is calculated as the time-weighted average (TWA) lifetime exposure:

$$DI_{TWA} = C \cdot [(IR_c / BW_c) \cdot (EF_c \cdot ED_c / AT) + [(IR_a / BW_a) \cdot (EF_a \cdot ED_a / AT)]$$

where the subscripts “c” and “a” refer to child and adult, respectively.

5.3.1.2 Dermal Exposures

Exposure to a chemical by the dermal pathway is generally expressed in terms of the amount of chemical that is absorbed into the body rather than the amount ingested or inhaled. The amount of a chemical which is absorbed across the skin is referred to as the dermally absorbed dose (DAD), which is quantified using an equation of the following general form (EPA 2004e):

$$DAD = DA_{event} \cdot EF \cdot ED \cdot EV \cdot SA / (BW \cdot AT)$$

where:

DAD = Dermally absorbed dose (mg of chemical per kg of body weight per day).

DA_{event} = Absorbed dose per event (mg of chemical per square centimeter of skin surface area per event). This is media-specific and is further described below.

EF = Exposure frequency (days/year). This describes how often a person is likely to be exposed to the contaminated medium over the course of a typical year.

ED = Exposure duration (years). This describes how long a person is likely to be exposed to the contaminated medium during their lifetime.

EV = Event frequency (events/day). This describes the number of times per day a person comes in contact with a contaminant in soil.

SA = Surface area (cm^2). This describes the amount of skin exposed to the contaminated media.

BW = Body weight of the exposed person (kg).

AT = Averaging time (days). This term specifies the length of time over which the average dose is calculated.

For chemicals in soil or sediment, DA_{event} is estimated as follows:

$$DA_{event} = C \cdot CF \cdot DAF \cdot ABS_d$$

where:

C = Chemical concentration in soil or sediment (mg of chemical per kg of soil or sediment).

CF = Conversion factor (10^{-6} kg/mg).

DAF = Dermal adherence factor (mg of soil per square centimeter of skin surface area per event). This describes the amount of soil that adheres to the skin per unit of surface area.

ABS_d = Dermal absorption fraction (unitless). This value is chemical-specific and represents the contribution of absorption of a chemical across a person's skin from soil to the systemic dose. Table 5-2 summarizes the dermal absorption fraction values for each chemical.

For chemicals in water, DA_{event} is estimated as follows:

$$DA_{event} = K_p \cdot C \cdot t_{event}$$

where:

K_p = Dermal permeability coefficient of compound in water (cm/hr). This value is chemical-specific. Table 5-3 summarizes the dermal permeability coefficients for each chemical.

C = Chemical concentration in water (mg of chemical per cubic centimeter of water).

t_{event} = Event duration (hr/event). This describes how long a person is likely to be exposed to the contaminated medium per exposure event.

For mathematical convenience, the general equation for calculating DAD can be written as:

Soil/Sediment: $DAD = C_{soil/sediment} \cdot ABS_d \cdot HIF_{soil/sediment}$

Water: $DAD = C_{water} \cdot K_p \cdot HIF_{water}$

where:

$$HIF_{soil/sediment} = (SA \cdot DAF \cdot EF \cdot ED \cdot EV \cdot CF) / (BW \cdot AT)$$

$$HIF_{water} = (SA \cdot EV \cdot EF \cdot ED \cdot t_{event}) / (BW \cdot AT)$$

The units of HIF are kg/kg-day for soil and sediment, and cm^2-hr/kg-day for water.

As described above, when the same individual may be exposed beginning as a child and extending into adulthood, exposure was calculated as the time-weighted average (TWA) lifetime exposure for evaluating cancer risks. For non-cancer risks, children and adults were evaluated separately.

Dermal exposures will only be evaluated for COIs with appropriate dermal absorption fraction values (for soil/sediment exposures) or dermal permeability coefficients (for water exposures).

5.3.1.3 Inhalation Exposures

Inhalation exposures are evaluated in accordance with the inhalation dosimetry methodology presented in EPA's *Risk Assessment Guidance for Superfund (RAGS) Part F: Inhalation Risk Assessment* (EPA 2009). It should also be noted that this approach is not applied to inhalation exposures to radionuclides (see Section 5.4.1).

In accordance with EPA (2009), the human intake equation does not include an inhalation rate (m^3/day) or body weight because the amount of the chemical that reaches the target site is not a simple function of these factors. Instead, the interaction of the inhaled contaminant with the respiratory tract is affected by factors such as species-specific relationships of exposure concentrations to deposited/delivered doses and physiochemical characteristics of the inhaled contaminant (EPA 2009). Therefore, the inhaled exposure concentration (EC) for chronic exposures is calculated as:

$$EC = C \cdot (ET \cdot EF \cdot ED / AT)$$

where:

EC = Exposure Concentration (μg/m^3). This is the time-weighted concentration based on the characteristics of the exposure scenario being evaluated.

C = Concentration of the chemical in air (μg/m^3) to which the person is exposed.

ET = Exposure time (hours/day). This describes how long a person is likely to be exposed to the contaminated medium over the course of a typical day.

EF = Exposure frequency (days/year). This describes how often a person is likely to be exposed to the contaminated medium over the course of a typical year.

ED = Exposure duration (years). This describes how long a person is likely to be exposed to the contaminated medium during their lifetime.

AT = Averaging time (hours). This term specifies the length of time over which the time-weighted average concentration is calculated.

For mathematical convenience, the general equation for exposure concentration can be written as:

$$EC = C \cdot TWF$$

where:

TWF = Time-Weighting Factor (unitless). The value of TWF is given by:

$$TWF = (ET \cdot EF \cdot ED / AT)$$

As described above, when the same individual may be exposed beginning as a child and extending into adulthood, exposure was calculated as the time-weighted average (TWA) lifetime exposure for evaluating cancer risks. For non-cancer risks, children and adults were evaluated separately.

5.3.2 Exposure Parameters

For every exposure pathway of potential concern, it is expected that there will be differences between different individuals in the level of exposure at a specific location due to differences in intake rates, body weights, exposure frequencies, and exposure durations. Thus, there is normally a wide range of average daily intakes between different members of an exposed population. Because of this, all daily intake calculations must specify what part of the range of doses is being estimated. Typically, attention is focused on intakes that are "average" or are otherwise near the central portion of the range, and on intakes that are near the upper end of the range (*e.g.,* the 95th percentile). These two exposure estimates are referred to as Central Tendency Exposure (CTE) and Reasonable Maximum Exposure (RME), respectively. Both CTE and RME receptors will be evaluated in the baseline HHRA.

When selecting CTE parameters, the intake variables for a specific exposure pathway (*e.g.,* body weight, ingestion rate, exposure frequency, exposure duration) are usually based on mean or median values, such that the CTE represents the "typical" or "average" exposure.

When selecting RME parameters, the intake variables are selected such that the combination of the intake variables results in a "reasonable" maximum estimate of the daily intake (EPA 1989a). In other words, some inputs are set equal to mean values (*e.g.,* body weight) and some inputs are set equal to upper bound values (*e.g.,* ingestion rates, exposure frequency, and exposure duration), such that the resulting combination yields an estimate that is RME (EPA 1989a).

As noted above, because exposure parameters (*e.g.,* intake rates, body weight, and exposure frequency) may change as a function of age, values were selected separately for children (0-6 years) and adults (7+ years). As appropriate, the baseline HHRA may utilize more refined age grouping bins, such as those recommended in EPA's *Guidance on Selecting Age Group*s (EPA 2005d), to characterize exposures.

Table 5-4 presents a summary of RME HIF values (for ingestion and dermal pathways) and TWF values (for inhalation pathways) by receptor and exposure pathway. Detailed information on exposure parameters for each exposed population is provided below.

5.3.2.1 Residential and Worker Exposure Parameters

The EPA has collected a wide variety of data and has performed a number of studies to help establish default values for most residential and worker exposure parameters (and some recreational exposure parameters). The chief sources of these standard default values are the following documents:

- EPA 1989a. Risk Assessment Guidance for Superfund (RAGS). Volume I. Human Health Evaluation Manual. Part A.
- EPA 1991a. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors."
- EPA 1993a. Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure. Draft.
- EPA 1996b. Soil Screening Guidance: User's Guide.
- EPA 1997a. Exposure Factors Handbook, Volumes I, II, and III.

- EPA 1998a. Ambient Water Quality Criteria Derivation Methodology.
- EPA 2002d. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites.
- EPA 2002f. Child-Specific Exposure Factors Handbook.
- EPA 2004e. Risk Assessment Guidance for Superfund (RAGS). Volume I. Human Health Evaluation Manual. Part E: Supplemental Guidance for Dermal Risk Assessment.

If default exposure parameters were not available, professional judgment was used in selecting appropriate exposure parameter values. Tables 5-5 and 5-6 present the CTE and RME parameters that will be used in the baseline HHRA for worker and residential populations, respectively.

5.3.2.2 Recreational Visitor and Modern Subsistence Exposure Parameters

Currently, site-specific exposure parameters for recreational visitor or modern subsistence exposure scenarios are limited or absent. Fish consumption rates for recreational visitor populations and modern subsistence populations were based on site-specific information from the following studies, respectively:

- Patrick, 1997. Consumption Patterns of Anglers Who Frequently Fish Lake Roosevelt. Washington State Department of Health.
- EPA 2002g. Estimated Per Capita Fish Consumption in the United States, Volume 1. Data from a 1991-1992 study by the Columbia River Inter-Tribal Fish Commission (CRITFC).

When site-specific information was not available, exposure parameters were based on default values recommended in EPA guidance documents when available. However, EPA has not established default exposure parameters for some of the exposure pathways of potential concern at this site for these populations, so some parameters were selected by use of professional judgment.

Prior to the baseline HHRA, it is expected that two exposure surveys will be conducted at the UCR Site which will provide site-specific data on recreational visitor and modern subsistence exposure scenarios. The U.S. Department of the Interior (DOI) is responsible for planning and conducting a recreational use and fish consumption survey for the UCR RI/FS. In addition, there will also be a site-specific survey to evaluate consumption and use of local resources, and other lifestyle factors of the CCT population that may contribute to their exposure to COIs at the UCR site. It is anticipated that the CTE and RME parameters for recreational and modern subsistence exposure scenarios used in the baseline HHRA will be derived from site-specific information collected in these surveys.

Tables 5-7 to 5-10 present the RME parameters for recreational visitor and modern subsistence populations used to calculate preliminary risk estimates in this HHRA Work Plan for the purposes of informing data needs.

5.3.2.3 Traditional Subsistence and Tribal-Specific Exposure Parameters

At the UCR Site, exposure parameters developed by the Spokane Tribe provide site-specific information on traditional subsistence exposure scenarios. These parameters are available in the following documents:

- Harper et al., 2002. The Spokane Tribes' Multipathway Subsistence Exposure Scenario and Screening Level RME. *Risk Analysis* 22(3):513-526.
- EPA 2005e. Midnite Mine Human Health Risk Assessment Report.

Exposure parameters recommended in the site-specific literature were used whenever possible. If site-specific exposure parameters were not available, professional judgment was used in selecting appropriate exposure parameter values or deriving values from EPA guidance documents.

It is recognized that these site-specific exposure parameters likely represent "upper-bound" values as opposed to RME estimates (EPA 2005e), but insufficient information is available to define a alternative point estimates (either RME or CTE). Therefore, the baseline HHRA will evaluate traditional subsistence exposure scenarios based only on available "upper-bound" exposure parameter estimates.

Tables 5-11 and 5-12 present the upper-bound exposure parameters for traditional subsistence populations and tribal-specific exposure scenarios that will be used in the baseline HHRA.

To the extent that the CCT survey provides information on tribal-specific exposure scenarios (*e.g.,* sweat lodge use, basket-weaving exposures), the baseline HHRA will utilize these site-specific data to derive CTE and RME estimates for these exposure scenarios.

5.3.3 Exposure Point Concentrations (EPCs)

Because of the assumption of random exposure over an exposure area, risk from a chemical is related to the arithmetic mean concentration of that chemical averaged over the entire exposure area. Since the true arithmetic mean concentration cannot be calculated with certainty from a limited number of measurements, the EPA recommends that the 95% upper confidence limit (95UCL) of the arithmetic mean at each exposure point be used when calculating exposure and risk at that location (EPA 1992).

The mathematical approach that is most appropriate for computing the 95UCL of a data set depends on a number of factors, including the number of data points available, the shape of the distribution of the values, and the degree of censoring (*i.e.,* samples below the detection limit) (EPA 2002e). Because of the complexity of this process, the EPA Technical Support Center has developed a software application called ProUCL v4.0 (EPA 2007c) to assist in the estimation of 95UCL values. ProUCL calculates 95UCLs for a data set using several different strategies and recommends which 95UCL is considered preferable based on the properties of the data set. A minimum of 5 samples and 2 distinct detected values is required to calculate 95UCLs in ProUCL. If the minimum data requirements for ProUCL are not met, the exposure point concentration (EPC) is set equal to the maximum detected value. If ProUCL provides more than one “recommended” 95UCL to use (*e.g.,* Chebeshev or Bootstrap), the higher recommended value is used as the EPC.

5.4 Evaluation of Exposures to Radionuclides

5.4.1 Internal Exposures

Internal exposure to radionuclides is based on the lifetime cumulative dose that is ingested or inhaled, expressed in units of picoCuries (pCi). Because one or more exposure parameters (*e.g.,* intake rates, exposure frequency, exposure duration) may change as a function of age and the same individual may be exposed beginning as a child and extending into adulthood, when estimating oral exposure to radionuclides, the total intake (TI) is calculated as follows:

$$TI = C \cdot (IR_c \cdot EF_c \cdot ED_c + IR_a \cdot EF_a \cdot ED_a)$$

where:

TI = Total Intake (pCi)

C = Concentration of the radionuclide in the environmental medium (soil, sediment, water, food, air) to which the person is exposed. The units are pCi/L for water, pCi/g for solid media, and pCi/m^3 for air.

IR = Intake rate of the environmental medium. The units are L/day for aqueous media, g/day for solid media, and m^3/day for air.

EF = Exposure frequency (days/year). This describes how often a person is likely to be exposed to the contaminated medium over the course of a typical year.

ED = Exposure duration (years). This describes how long a person is likely to be exposed to the contaminated medium during their lifetime.

Note that subscripts “c” and “a” refer to child and adult, respectively.

Tables 5-5 to 5-12 provide activity-specific ingestion rates, exposure frequencies, and exposure durations that are assumed for each receptor. Inhalation rates used in the evaluation of radionuclide exposures will be based on receptor and activity-specific recommended values in the *Exposure Factors Handbook* (EPA 1997a).

5.4.2 External Exposures

Individuals that are present at the UCR site during recreational, occupational, or subsistence activities on beaches and shorelines and may be exposed to external radiation due to radionuclides present in sediments. For this pathway, exposure is calculated as follows:

$$EET = C \cdot (ET / 24\ hr/d) \cdot (EF / 356\ d/yr) \cdot ED \cdot CF$$

where:

EET = External exposure term (pCi·yr/g)

C = Concentration of the chemical in the contaminated soil or sediment (pCi/g) to which the person is exposed.

ET = Exposure time (hours/day). This describes how long a person is likely to be exposed to the contaminated medium over the course of a typical day.

EF = Exposure frequency (days/year). This describes how often a person is likely to be exposed to the contaminated medium over the course of a typical year.

ED = Exposure duration (years). This describes how long a person is likely to be exposed to the contaminated medium during their lifetime.

CF = Correction factor (unitless). This adjusts exposure estimates to account for site-specific conditions.

When calculating external exposure estimates for radionuclides, there are several types of correction factors that may be applied to account for site-specific factors such as the exposure area size (area correction factor, ACF), radiation shielding (gamma shielding factor, GSF), shoreline type, and ground surface roughness (Eckerman and Ryman 1993; EPA 2000a). For outdoor exposure scenarios, the GSF is assumed to be 1.0. For the purposes of assessing reach-specific exposures, the recommended default ACF of 0.9 (EPA 2000a) will be used. Because reach characteristics and conditions may vary widely, and to ensure exposure estimates are conservative, no adjustments will be made to account for shoreline type or surface roughness. These correction factors will be discussed in the uncertainty section of the baseline HHRA. As appropriate, the correction factors will be adjusted in the beach-specific exposure assessments to account for beach-specific conditions.

Dermal uptake from contact with contaminated soil or water is generally not an important route of uptake for radionuclides, which have small dermal permeability constants (EPA 1989a).

5.5 Evaluation of Exposures to Lead

5.5.1 Overview

Exposure to lead is evaluated using a somewhat different approach than for most other chemicals. First, because lead is widespread in the environment, exposure can occur by many different pathways. Thus, lead exposure assessment generally includes all exposure pathways rather than just those that are site-related exposures. Consequently, data are needed on both site-related and non-site (background) exposures to lead. Second, because studies of lead exposures and resultant health effects in humans have traditionally been described in terms of blood lead level[8], lead exposures are typically assessed using an uptake-biokinetic model that predicts blood lead level from a specified exposure, rather than simply calculating an estimated dose.

5.5.2 Exposure Models

5.5.2.1 Model Used for Children

The EPA has developed an Integrated Exposure Uptake Biokinetic (IEUBK) model for predicting the likely range of blood lead levels in a residential population of young children (age 0-84 months) exposed to a specified set of environmental lead levels (EPA 1994a). This model requires as input data on the levels of lead in soil, dust, water, air, and diet at a particular location, and on the amount of these media ingested or inhaled by a child living at that location. All of these inputs to the IEUBK model are central tendency point estimates. These point estimates are used to calculate an estimate of the central tendency (the geometric mean) of the distribution of blood lead values that might occur in a population of children exposed to the specified conditions. Assuming the distribution is lognormal, and given (as input) an estimate of the variability between different children (this is specified by the geometric standard deviation or GSD), the model calculates the expected distribution of blood lead values.

5.5.2.2 Model Used for Adults

The Adult Lead Model (ALM) has been identified by EPA's Technical Workgroup for Lead (EPA 2003a) as a reasonable interim methodology for assessing risks to adults and older children from exposures to lead. When adults are exposed, the sub-population of chief concern is pregnant women and women of child-bearing age, since the blood lead level of a fetus is nearly equal to the blood lead level of the mother (Goyer 1990).

The ALM predicts the blood lead level in an adult with a site-related lead exposure by summing the "baseline" blood lead level (PbB0) (that which would occur in the absence of any site-related exposures) with the increment in blood lead that is expected as a result of increased exposure due to contact with a lead-contaminated site media. The latter is estimated by multiplying the average daily absorbed dose of lead from site-related exposure by a "biokinetic slope factor" (BKSF). Thus, the basic equation for ongoing exposure to lead is:

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[8] The concentration of lead in the blood is usually abbreviated "PbB", and is expressed in units of micrograms of lead per deciliter of blood (µg/dL). One dL is equal to 100 mL.

$$PbB = PbB0 + BKSF \cdot \sum (Pb_i \cdot IR_i \cdot AF_i \cdot EF_i / 365)$$

where:

PbB = Geometric mean blood lead concentration (µg/dL) in women of child-bearing age) that are exposed at the site

PbB0 = "Baseline" geometric mean blood lead concentration (µg/dL) in women of child-bearing age in the absence of exposures to the site

BKSF = Biokinetic slope factor (µg/dL blood lead increase per µg/day lead absorbed)

Pb_i = Lead concentration in medium ‘i’ (µg/g for solid media, µg/L for water, µg/m^3 for air)

IR_i = Intake rate of medium ‘i’ (g/day for solid media, L/day for water, m^3/day for air)

AF_i = Absolute absorption fraction for lead in medium ‘i’ (dimensionless)

EF_i = Exposure frequency for contact with site media ‘i’ (days per year)

Once the geometric mean (GM) blood lead value is calculated, the full distribution of likely blood lead values in the population of exposed people can then be estimated by assuming the distribution is lognormal with a specified GSD.

5.5.3 Evaluation of Intermittent Exposures

Both the IEUBK model and the ALM are designed to evaluate exposures that are approximately continuous. When exposures are intermittent, use of these models becomes more difficult. The Technical Review Workgroup (TRW) for Lead has recommended that the IEUBK model and the ALM only be applied to exposures that exceed a minimum frequency of one day per week and a minimum duration of 3 consecutive months (EPA 2003b). Three months is considered to be the minimum exposure to produce a quasi-steady-state blood lead concentration. The reliability of the models for predicting blood lead concentrations for exposure durations shorter than 3 months has not been assessed.

Because neither the ALM nor the IEUBK are recommended for use in evaluating risks from exposure scenarios less than 90 days in duration, the TRW for Lead recommends that the predictions from the ALM or IEUBK with a 90-day exposure scenario be used to develop an upper-bound estimate for exposures less than 90 days. In accordance with this recommendation, the short-term recreational visitor scenario (*i.e.,* a 14-day exposure) is evaluated based on a 90-day exposure as an upper-bound estimate.

5.5.4 Model Inputs and Exposure Parameters

5.5.4.1 IEUBK Model

Table 5-13 presents the default inputs to the IEUBK model used in the evaluation of lead risks to children. Baseline exposure parameters are based on IEUBK model defaults, while site-specific exposure parameters are based on site-specific data and professional judgment, and are the same as used for quantifying exposure to other chemicals in site media.

The baseline HHRA will consider use of alternative values for input parameters in the IEUBK model, provided that the alternatives can be supported with site-specific data of adequate quality.

5.5.4.2 ALM

Table 5-14 summarizes the parameters selected for use in the ALM for assessing lead exposures for adults. As above, intake rates and exposure frequencies for contact with site media are the same as the exposure parameters utilized for non-lead chemicals, and most of the biokinetic parameters are the defaults recommended by EPA (1996a). The baseline geometric mean blood lead value (PbB0) and the individual geometric standard deviation are derived from data reported by the National Health and Nutrition Evaluation Survey (NHANES III), Phases I and II for women in the West Census region, aged 17-45 (SRC 2006).

As noted above, the baseline HHRA will consider use of alternative values for input parameters in the ALM, provided that the alternatives can be supported with site-specific data of adequate quality.

5.5.5 Exposure Point Concentrations (EPCs)

In accordance with EPA guidance (1994a, 2003c), the EPC for lead in a medium at an exposure area is equal to the arithmetic mean of the measured values for that medium. When calculating the arithmetic mean, all results ranked as non-detect were evaluated in ProUCL using Regression on Order Statistics (ROS).

6 TOXICITY ASSESSMENT APPROACH

6.1 Overview

The objective of a toxicity assessment is to identify what adverse health effects a chemical causes, and how the appearance of these adverse effects depends on exposure level. In addition, the toxic effects of a chemical frequently depend on the route of exposure (oral, inhalation, dermal) and the duration of exposure. Thus, a full description of the toxic effects of a chemical includes a listing of what adverse health effects the chemical may cause, and how the occurrence of these effects depends upon dose, route, and duration of exposure.

The toxicity assessment process is usually divided into two parts: the first characterizes and quantifies the non-cancer effects of the chemical, while the second addresses the cancer effects of the chemical. This two-part approach is employed because there are typically major differences in the time-course of action and the shape of the dose-response curve for cancer and non-cancer effects.

6.2 Non-Cancer Effects

Essentially all chemicals can cause adverse health effects at a sufficient dose. However, when the dose is sufficiently low, typically no adverse effect is observed. Thus, in characterizing the non-cancer effects of a chemical, the key parameter is the threshold dose at which an adverse effect first becomes evident. Doses below the threshold are considered to be safe, while doses above the threshold are likely to cause an effect.

The threshold dose is typically estimated from toxicological data (derived from studies of humans and/or animals) by finding the highest dose that does not produce an observable adverse effect, and the lowest dose which does produce an effect. These are referred to as the “No-observed-adverse-effect-level” (NOAEL) and the “Lowest-observed-adverse-effect-level” (LOAEL), respectively. The threshold is presumed to lie in the interval between the NOAEL and the LOAEL. However, in order to be conservative (protective), non-cancer risk evaluations are not based directly on the threshold exposure level, but on a value referred to as the Reference Dose (RfD). The RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.

The RfD is derived from the NOAEL, LOAEL or benchmark dose by dividing by an “uncertainty factor” (UF) that reflects the limitations of the data used. If the data are from studies in humans, and if the observations are considered to be very reliable, the UF may be as small as 1.0. However, the UF is normally at least 10, and can be much higher if the data are limited. UFs are assigned to account for uncertainty arising from extrapolation of animal data to humans, the use of a LOAEL instead of a NOAEL, the use of less than chronic exposure, and other limitations in the available data (*e.g.,* lack of reproductive data, etc.).

The effect of dividing the NOAEL or the LOAEL by a UF is to ensure that the RfD is not higher than the threshold level for adverse effects. Thus, there is always a "margin of safety" built into an RfD, and doses equal to or less than the RfD are nearly certain to be without any risk of adverse effect. Doses higher than the RfD may carry some risk, but because of the margin of safety, a dose above the RfD does not mean that an effect will necessarily occur. The protectiveness of this margin of safety will vary from chemical to chemical, depending upon the quality of the data and the size of any applied UF. A chemical for which large UF has been applied will generally have a higher margin of safety than a chemical with a smaller UF.

6.3 Cancer Effects

For cancer effects, the toxicity assessment process has two components. The first is a qualitative evaluation of the weight of evidence (WOE) that the chemical does or does not cause cancer in humans. Typically, this evaluation is performed by the EPA (1986a), using the system summarized below:

WOE Group	Meaning	Description
A	Known human carcinogen	Sufficient evidence of cancer in humans.
B1	Probable human carcinogen	Suggestive evidence of cancer incidence in humans.
B2	Probable human carcinogen	Sufficient evidence of cancer in animals, but lack of data or insufficient data in humans.
C	Possible human carcinogen	Suggestive evidence of carcinogenicity in animals.
D	Cannot be evaluated	No evidence or inadequate evidence of cancer in animals or humans.
E	Not carcinogenic to humans	Strong evidence that it does not cause cancer in humans.

More recently, EPA has revised the weight of evidence descriptions and its approach for evaluating the carcinogenic potential of environmental contaminants, as described in EPA (2005a). However, these revised descriptions have not yet been developed for some chemicals.

For chemicals which are classified in Group A, B1, B2, or C, using the EPA (1986a) guidelines, the second part of the toxicity assessment is to describe the carcinogenic potency of the chemical. This is done by quantifying how the number of cancers observed in exposed animals or humans increases as the dose increases. Typically, it is assumed that the dose-response curve for cancer has no threshold, arising from the origin and increasing linearly until high doses are reached. Thus, the most convenient descriptor of cancer potency is the slope of the dose-response curve at low doses (where the slope is still linear). This is referred to as the Slope Factor (SF), which has dimensions of risk of cancer per unit dose.

Estimating the cancer Slope Factor is often complicated by the fact that observable increases in cancer incidence usually occur only at relatively high doses, frequently in the part of the dose-response curve that is no longer linear. Thus, it is necessary to use mathematical models to extrapolate from the observed high dose data to the desired (but unmeasurable) slope at low dose. In order to account for the uncertainty in this extrapolation process, EPA typically chooses to employ the upper 95th confidence limit of the slope as the Slope Factor. That is, there is a 95 percent probability that the true cancer potency is lower than the value chosen for the Slope Factor. This approach ensures that there is a margin of safety in cancer as well as non-cancer risk estimates.

6.4 Toxicity Values for Chronic Ingestion and Inhalation Exposures

Toxicity values (RfD and SF values) are often estimated by a variety of different groups or agencies. EPA (2003a) describes the recommended hierarchy for selecting toxicity values for use in human health risk assessment at Superfund sites. Generally, the first preference is for EPA consensus values as listed in the Integrated Risk Information System (IRIS), an electronic database containing human health assessments for various chemicals (available online at http://www.epa.gov/iris/). If values are not available from IRIS, then the next preference is to seek Provisional Peer Reviewed Toxicity Values for Superfund (PPRTVs) developed by EPA's Superfund Health Risk Technical Support Center (STSC). If PPRTVs are not available, toxicity values may be obtained from other sources, such as the Agency for Toxic Substances and Disease Registry's (ATSDR) Minimal Risk Levels (MRLs) (available online at http://www.atsdr.cdc.gov/mrls.html), California EPA's Toxicity Criteria Database (available online at http://www.oehha.ca.gov/risk/ChemicalDB/index.asp), and EPA's Health Effects Assessment Summary Tables (HEAST) (EPA 1997a).

Most of these toxicity values are also compiled in the "Regional Screening Levels for Chemical Contaminants at Superfund Sites" tables (EPA 2008b) developed and maintained by the Department of Energy (DOE) Oak Ridge National Laboratory (ORNL) under an Interagency Agreement with EPA. In a few cases, the toxicity values as provided in the Regional Screening Level tables were adjusted as follows:

- Manganese: The oRfD (1.4E-01 mg/kg-day) was adjusted by a modifying factor of 3 when applied to water or sediment/soil/dust ingestion exposure scenarios, in accord with IRIS recommendations (http://www.epa.gov/iris/subst/0373.htm).

- Uranium: The oRfD for uranium was modified to be based on the RfD value (0.0006 mg/kg-day) provided in the *National Primary Drinking Water Regulations for Radionuclides – Final Rule* (Federal Register: December 7, 2000, Volume 65, Number 236, pp 76707-76753) in accord with the recommendation in Stifelman (2008).

Table 6-1 summarizes the non-cancer and cancer oral toxicity values used for evaluating human health risks from chemicals at the UCR Site. There are several COIs for which toxicity values are not available (see Table 6-2). For some of these COIs, it is possible to utilize toxicity values for chemicals that are similar in composition as surrogate toxicity values (*e.g.,* 2,4'-DDE). For other COIs (*e.g.,* less common trace elements), no toxicity data are available. As appropriate, the baseline HHRA will address these COIs qualitatively in the uncertainties section of the report.

6.5 Toxicity Values for Dermal Exposures

Oral toxicity factors (oRfDs and oSFs) are expressed in terms of toxicity per unit dose of chemical ingested, rather than in terms of toxicity per unit amount of chemical absorbed. However, the equations for characterizing dermal contact with chemicals provides exposure values that are based on absorbed dose rather than ingested dose. Thus, oral RfD and slope factor values must be adjusted for used in evaluating dermal exposures as follows:

$$\text{RfD(dermal)} = \text{RfD(oral)} \cdot \text{Oral absorption fraction}$$

$$\text{SF(dermal)} = \text{SF(oral)} / \text{Oral absorption fraction}$$

Table 6-3 lists the oral absorption fractions (ABS_{GI}) used to adjust oral toxicity values for used in assessing dermal exposure, as recommended in EPA (2004e). If chemical-specific oral absorption fractions are not available, a value of 1.0 was assumed in accord with dermal guidance (EPA 2004e).

6.6 Toxicity Values for TCDD-like Congeners

In the case of dioxins/furans and PCBs, concentration values for several sediment and fish tissue samples were measured and expressed as concentrations of individual congeners. When individual congener results are available, the data are consolidated into a single toxicity-weighted concentration value. This concentration, referred to as "TEQ" (TCDD equivalent concentration), is equal to the concentration of 2,3,7,8-tetrachlorodibenzo-para-dioxin (TCDD) that would be of equivalent toxicity to humans.

The relative potency of an individual congener compared to TCDD is expressed in terms of the Toxicity Equivalency Factor (TEF). Table 4-5 lists current consensus TEF values for mammals (including humans) for the sub-set of 6 dioxin, 10 furan, and 12 PCB congeners that act by a mechanism similar to TCDD. These TEF values were developed by a panel of experts assembled by the World Health Organization (Van den Berg et al. 2006). Note that TEFs are often based on limited data, and so they are only approximations of the relative toxicity of each congener, rounded up (in order to be conservative) to the nearest half order of magnitude. Also note that most TEFs are based on relative binding affinity of the congener for the aryl-hydrocarbon (Ah) receptor, and so do not account for potential differences between congeners with regard to absorption and distribution to target tissues.

Based on the TEF values given in Table 6-4, the toxicity of any mixture of dioxin/furan/PCB congeners in a site medium can be estimated by calculating the TEQ concentration in the medium as the TEF-weighted sum of each of the TCDD-like congeners, as follows:

$$TEQ = \sum C_i \cdot TEF_i$$

where:

C_i = Concentration of congener ‘i’
TEF_i = Toxicity equivalency factor for congener ‘i’

6.7 Toxicity Values for PCB Mixtures

PCBs consist of 209 individual congeners. Aroclors are commercial mixtures of PCB congeners that contain all or most of the individual congeners in varying ratios. When Aroclors are released into the environment, the original congener composition of the PCB mixture changes due to differential fate and transport processes. The cancer potency of PCB mixtures is determined using a tiered approach that considers how partitioning and bioaccumulation affect potential exposure scenarios. Table 6-5 summarizes the oral slope factor tiers for PCBs.

6.8 Toxicity Values for PAHs

Oral slope factors for PAH-class compounds were based on the cancer slope factors for benzo(a)pyrene (BaP) multiplied by the Estimated Order of Potency (EOP) values provided in EPA (1993):

$$oSF(PAH_i) = oSF_{BaP} \cdot EOP(PAH_i)$$

In cases where EPA (1993) did not provide an EOP, values were supplemented by the EOPs provided in Collins et al. (1998). Table 6-6 summarizes the EOPs used when calculating cancer risks from PAHs.

6.9 Toxicity Values for Radionuclides

EPA classifies all radionuclides as known human cancer causing agents (Group A carcinogens). Cancer slope factors for radionuclides are specific to the exposure pathway being evaluated (inhalation, ingestion, external exposure). These slope factors are summarized in HEAST, which can be accessed online at http://www.epa.gov/radiation/heast/index.html. The April 16, 2001 update of HEAST for radionuclides incorporates all new values based on Federal Guidance Report No. 13 (Eckerman et al. 1999), which was developed for EPA’s Office of Radiation and Indoor Air (ORIA). Table 6-7 presents the cancer slope factors for radionuclides in the U-238 decay chain (see Figure 5-2).

6.10 Adjustments for Relative Bioavailability (RBA)

An accurate assessment of human exposure to ingested chemicals requires knowledge of the amount of chemical absorbed from the gastrointestinal tract into the body from site media compared to the amount of absorption that occurred in the toxicity studies used to derive the toxicity factors. This ratio (amount absorbed from site media compared to amount absorbed in toxicity tests) is referred to as Relative Bioavailability (RBA). If a value for RBA is available for a chemical in a medium, it is used to adjust the toxicity factors for that chemical as follows:

$$RfD_{adj} = RfD \cdot RBA$$

$$SF_{adj} = SF / RBA$$

The RBA for chemicals in water and air are generally assumed to be 1.0. Likewise, the RBA for chemicals in soil, sediment and food is usually assumed to be 1.0 for most organic compounds, but may be less than 1.0 for some inorganic compounds.

In most cases, it is desirable to have reliable site-specific RBA data for a chemical in a medium in order to support adjusting the toxicity factors for that chemical. However, in some cases, data from other sources can be used. For the purposes of calculating preliminary risk estimates, the RBA was assumed to be 1.0 in all cases except the following:

- For cadmium, the RBA for food and soil compared to water was 0.5 (EPA 2007a)
- For lead, a default RBA of 0.6 for soil was assumed (EPA 1994; 2003b)
- For arsenic, an RBA of 0.8 was used for soil based on the results of a swine study performed for the Ruston/North Tacoma Superfund site in Tacoma, WA and Triumph Tailings site in Triumph, ID (EPA 1996; 2000).

EPA (2007b,c; 2008b) provides guidance on the application and use of methods to estimate site-specific RBA values in soils and sediments. In accord with guidance, the baseline HHRA will use site-specific RBA estimates derived from *in vivo* tests in an appropriate animal model when available. If *in vivo* data are not available, *in vitro* data from a validated and EPA-accepted test will be used if available. Such an *in vitro* method has been developed for lead (EPA 2008c), but no such method has been approved for other metals. Therefore, baseline HHRA risk calculations for other chemicals will use default RBA values. However, *in vitro* data for arsenic and other metals may be considered in the uncertainty section of the baseline HHRA, as appropriate.

6.11 Toxicity of Lead

Excess exposure to lead can cause a wide range of adverse effects in exposed individuals, especially on the nervous system. When the exposed population includes both children and adults, attention is generally focused on blood lead levels in the children is because: 1) young children typically have higher exposures to lead-contaminated media per unit body weight than adults, 2) young children typically have higher lead absorption rates than adults, and 3) young children are more susceptible to effects of lead than are adults (Rodier, 1995; Rodier, 2004). When the exposed population consists primarily of adults, attention is usually focused on women of child-bearing age, since elevated blood lead levels in a pregnant woman may cause adverse effects in the fetus.

It is difficult to identify what degree of lead exposure can be considered safe for children and fetuses. Some studies report subtle signs of lead-induced effects in children and perhaps adults below 10 µg/dL, with population effects becoming clearer and more definite in the range of 30-40 µg/dL (Canfield et al. 2003; Lanphear et al. 2005). Of special concern are the claims by some researchers that effects of lead on neurobehavioral performance, heme synthesis, and fetal development may not have a threshold value, and that the effects are long-lasting (EPA 1986b; Lanphear et al. 2005; Ris et al. 2004).

After a thorough review of all the data, EPA has identified 10 µg/dL as the blood lead level at which effects begin to occur that warrant avoidance, and has set as a goal that there should be no more than a 5% chance that a child will have a blood lead value above 10 µg/dL (EPA 1991b; 1994; 1998). Likewise, the Centers for Disease Control (CDC) has established a guideline of 10 µg/dL in preschool children which is believed to prevent or minimize lead-associated cognitive deficits (CDC 1991). By analogy, a value of 10 µg/dL is also generally applied to a fetus *in utero*.

7 RISK CHARACTERIZATION APPROACH

7.1 Non-Lead Chemicals

7.1.1 Non-Cancer

The potential for non-cancer effects is evaluated by comparing the estimated exposure level of a receptor over a specified time period to a reference threshold that represents the exposure below which it is unlikely for even sensitive populations to experience adverse health effects (EPA 1989a). This ratio of exposure to toxicity is called a Hazard Quotient (HQ). If the HQ for a chemical is equal to or less than one, it is believed that there is no appreciable risk that non-cancer health effects will occur. If an HQ exceeds one, there is some possibility that non-cancer effects may occur, although an HQ above one does not indicate an effect will definitely occur. This is because of the margin of safety inherent in the derivation of all toxicity values (see Section 6.2). However, the larger the HQ value, the more likely it is that an adverse effect may occur. Non-cancer HQs for each chemical are calculated as described below.

Ingestion and Dermal Exposures. For most chemicals, the potential for non-cancer effects is evaluated by comparing the estimated daily intake of the chemical over a specific time period with the RfD for that chemical derived for a similar exposed period, as follows (EPA 1989a):

$$HQ = DI / RfD$$

where:

DI = Daily Intake (mg/kg-day)
RfD = Reference Dose (mg/kg-day)

Inhalation Exposures. For inhalation exposures, the potential for non-cancer effects is evaluated by comparing the time-weighted exposure concentration (EC) over a specific time period to the iRfC, or the acute toxicity value, for that chemical, as follows (EPA 1994c):

$$HQ = EC / iRfC$$

where:

EC = Exposure Concentration ($\mu g/m^3$)
iRfC = Inhalation Reference Concentration ($\mu g/m^3$)

7.1.2 Cancer

The excess risk of cancer from exposure to a chemical is described in terms of the probability that an exposed individual will develop cancer because of that exposure. Excess cancer risks are summed across all carcinogenic chemicals and all exposure pathways that contribute to exposure of an individual in a given population. The level of total cancer risk that is of concern is a matter of personal, community, and regulatory judgment. In general, the EPA considers excess cancer risks that are below about 1E-06 to be so small as to be negligible, and risks above 1E-04 to be sufficiently large that some sort of remediation is desirable[9]. Excess cancer risks that range between 1E-04 and 1E-06 are generally considered to be acceptable (EPA 1991c), although this is evaluated on a case by case basis, and EPA may determine that risks lower than 1E-04 are not sufficiently protective and warrant remedial action. Cancer risks for each chemical are calculated as described below.

Ingestion and Dermal Exposures. The excess risk of cancer from ingestion and dermal exposure to a chemical is calculated as follows (EPA 1989a):

$$\text{Excess Cancer Risk} = 1 - \exp(-DI_L \cdot SF)$$

where:

DI_L = Daily Intake, averaged over a lifetime (mg/kg-day)
SF = Slope Factor $(\text{mg/kg-day})^{-1}$

In most cases (except when the product of $DI_L \cdot SF$ is larger than about 0.01), this equation may be accurately approximated by the following:

$$\text{Excess Cancer Risk} = DI_L \cdot SF$$

Inhalation Exposures (Non-Radionuclides). The excess risk of cancer from inhalation exposure for non-radionuclide COIs is calculated based on inhalation unit risk (iUR) values, as follows (EPA 2009):

$$\text{Excess Cancer Risk} = EC \cdot iUR$$

where:

EC = Exposure Concentration $(\mu g/m^3)$
iUR = Inhalation Unit Risk $(\mu g/m^3)^{-1}$

Radionuclide Exposures. The excess risk of cancer from radionuclide exposure is calculated as follows:

Internal Exposures –

$$\text{Excess Cancer Risk} = TI \cdot SF_i$$

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[9] Note that excess cancer risk can be expressed in several formats. A cancer risk expressed in a scientific notation format as 1E-06 is equivalent to 1 in 1,000,000 or 10^{-6}. Similarly, a cancer risk of 1E-04 is equivalent to 1 in 10,000 or 10^{-4}. For the purposes of this document, all cancer risks are presented in a scientific notation format (*i.e.,* 1E-06).

where:

TI = Total Intake (pCi)
SF_i = Slope Factor for internal exposure route 'i' (risk/pCi)

External Exposures –

$$\text{Excess Cancer Risk} = \text{EET} \cdot SF_{ext}$$

where:

EET = External exposure term (pCi·yr/g)
SF_{ext} = Slope Factor for external exposures (risk/yr per pCi/g)

7.1.2.1 Evaluation of PCB Mixtures

Because PCBs can cause cancer through both dioxin-like and non-dioxin-like modes of action, it is important to consider the contribution from both when estimating the total risk. In accordance with EPA guidance (EPA 1996d; 2000), cancer risk from ingestion of dioxin-like PCB congeners will be evaluated based on a TEQ approach (see Section 6.6 above) using the dioxin slope factor of 1.3E+05 $(mg/kg/day)^{-1}$. Cancer risk from non-dioxin-like PCB congeners will be evaluated based on the high risk and persistence upper-bound slope factor of 2.0 $(mg/kg/day)^{-1}$ (see Table 6-5). The total PCB cancer risk is calculated as:

$$\text{Total PCB Cancer Risk} = \text{Dioxin-like Cancer Risk} + \text{Non-Dioxin-like Cancer Risk}$$

If PCB congener data are available (or both congener data and Aroclor data are available), dose estimates for non-dioxin-like PCBs will be calculated as the sum of the non-dioxin-like PCB congener concentrations. If PCB congener data are not available, then dose estimates for non-dioxin-like PCBs will be based on Aroclor concentrations[10]. This approach likely overestimates the non-dioxin-like cancer risk because: 1) the upper-bound slope factor includes an unknown toxicity contribution from dioxin-like PCB congeners, and 2) the Aroclor concentration includes all PCB congeners (dioxin-like and non-dioxin-like). The risk estimation method for each scenario is illustrated in the following table:

Available Data	**Risk Estimation Method**	
	Dioxin-like PCBs	**Non-dioxin-like PCBs**
PCB Congeners (with or without Aroclor)	Exposure: PCB TEQ Slope factor: dioxin	Exposure: ∑ non-dioxin-like PCB congeners Slope factor: Aroclor
Aroclor only	Exposure: PCB TEQ (estimated from Aroclor - see Section 8.2.2) Slope factor: dioxin	Exposure: Aroclor Slope factor: Aroclor

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[10] Ideally, Aroclor concentrations would be adjusted to exclude the dioxin-like PCB congeners (these congeners are evaluated based on a TEQ approach). However, if PCB congener data are not available, this adjustment cannot be performed.

7.1.2.2 Evaluation of Carcinogens with Mutagenic Modes of Action

For chemicals identified as having a mutagenic mode of action for carcinogenesis (identified with an “m” footnote in Table 6-1), cancer risks were estimated in accordance with the Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens EPA (2005). In brief, because chemical-specific data are not available for these chemicals, the default age-dependant adjustment factors (ADAFs) were applied to the non-age dependant cancer slope factor to account for differences in potency that may occur from exposure during early life (up to age 16). The Supplemental Guidance further indicates that any grouping of ages in the exposure assessment will need to be integrated with the ADAF age groupings to derive age group-specific risk estimates.

For example, under current Superfund guidance, residential exposures are divided into two age intervals:

Child = 0 - 6 years
Adult = 7 - 30 years

Thus, residential risks may be assessed by dividing the exposure into four intervals:

Age Interval	Age (years)	Exposure Duration (yrs)	ADAF (unitless)
1	0 - <2	2	10
2	2 - <6	4	3
3	6 - <16	10	3
4	16 - <30	14	1

Note: Alternate age bins may be considered to address site-specific scenarios (*e.g.,* the upper cut-off for the traditional subsistence adult would be 16 - 70 years).

For each age interval ‘i’, the cancer risk for exposure by a specified pathway is computed as:

$$\text{Risk}_i = C \cdot (\text{HIF} \cdot \text{ED}_i / \text{ED}_{\text{total}}) \cdot \text{SF} \cdot \text{ADAF}_i$$

where:

Risk_i = Excess cancer risk for age interval ‘i’
C = concentration of chemical in the exposure medium (*e.g.,* mg/kg for sediment)
HIF = human intake factor for the exposure medium (*e.g.,* kg/kg-day for sediment)
ED_i = exposure duration for age interval ‘i’ (years)
ED_{total} = total exposure duration (years)
SF = cancer slope factor $(\text{mg/kg-day})^{-1}$
ADAF_i = Age-dependant adjustment factor for age interval ‘i’ (unitless)

Total risk to the individual is the sum of the risks across all age intervals:

$$\text{Total Risk} = \text{Risk}_{0\text{-}<2} + \text{Risk}_{2\text{-}<6} + \text{Risk}_{6\text{-}<16} + \text{Risk}_{16+}$$

As seen in the equation above, the HIF term is time-weighted (ED_i / ED_{total}) to be specific to the age interval 'i'. Table 7-1 summarizes how the HIFs were adjusted for each receptor population to account for early-life susceptibility. This table also includes an example of this adjustment calculation for incidental ingestion of sediment exposures by traditional subsistence receptors.

7.1.3 Combining Risks Across Chemicals and Exposure Pathways

If an individual is exposed to the same chemical in more than one medium, then the total risk from that chemical is the sum of the risks across each medium, both for cancer and for non-cancer effects. For the CTE receptor, the summation is straightforward. However, for the RME case, summation is more complicated. This is because an individual who is an RME receptor for one pathway (*e.g.,* ingestion of soil) is not likely to also be an RME receptor for other independent pathways (*e.g.,* ingestion of water, inhalation of air, etc.). Thus, if the RME risk estimates for a series of independent exposure pathways are added, the resulting risk is likely to be much higher that the true RME risk. In order to avoid this potentially substantial overestimation of RME risks, the total risk is estimated as the highest of the pathway-specific RME values plus the sum of the CTE risks for the remaining pathways (EPA 1989a).

If an individual is exposed to more than one chemical, then the total cancer risk is estimated by summing the chemical-specific risks across all carcinogenic chemicals. For non-carcinogenic effects, a screening-level estimate of the total non-cancer risk is derived simply by summing the HQ values across all chemicals. This total is referred to as the screening level Hazard Index (HI_{SL}). If the HI_{SL} value is less than one, non-cancer risks are not expected from any chemical, alone or in combination with others. If the value of the HI_{SL} exceeds one, then it is appropriate to re-evaluate so that HQ values are added only if they affect the same target tissue or organ system (*e.g.,* the liver) because chemicals which do not cause toxicity in the same tissues are not likely to cause additive effects (EPA 1989a).

At the UCR Site, it is likely that some individuals will be exposed via multiple exposure scenarios. For example, an individual may reside near the site, work on the site during the week, and fish or hunt at the site on the weekends. In this case, risks estimates for the residential, occupational, and recreational exposure scenarios may all apply. Therefore, total risk to an individual is computed as the sum of risks across all exposure pathways that apply to that individual. In order to avoid double counting exposures (*i.e.,* an individual cannot simultaneously be more than one type of receptor), total risk calculations will be time-weighted.

7.2 Lead

As described above in Section 5, exposure to lead is generally evaluated by using mathematical models to estimate the distribution of blood lead values in a population of people exposed to lead under a specified set of conditions. As noted in Section 6, blood lead levels that exceed 10 µg/dL are generally considered to be undesirable, and EPA has established a goal that the probability that any exposed child or pregnant female will have a blood lead level above 10 µg/dL should not be greater than 5%. For convenience, the probability of a blood lead value exceeding 10 µg/dL is referred to as P10. In accord with this approach, in this document, health risks from lead are judged to be acceptable if the value of P10, calculated using the IEUBK model or the ALM, does not exceed 5%.

As discussed above, P10 values are based on all sources of lead exposure, including both site-related exposures and "baseline" (non-site related) exposures. At this site, several populations of receptors are exposed to lead both from site-related and non-site-related sources. In order to characterize the effect of the site-related exposures for each population of this type, the IEUBK lead model was run twice. In the first model run, the effect of non-site exposures was evaluated. In the second run, the effect of site plus non-site exposures combined were evaluated. By comparing the two model runs, both the total and incremental risk attributable to site-impacted media at the site may be characterized.

For child receptors, risks were calculated using the IEUBK model in batch mode. The age entered into the batch file was 50 months, because the blood lead value in this month is close to the average blood level in a child exposed from 0-84 months. Exposures associated with the "baseline" scenario were entered into the IEUBK model input pages as usual. Exposures from the numerous types of site-related exposures (intake of soil, sediment, water, air and diet) were calculated separately and expressed in terms of average daily absorbed dose, as follows:

$$\text{Total absorbed dose } (\mu g/day) = \Sigma\, C_i \cdot (IR_i \cdot EF_i \cdot AFi) / AT$$

where:

C_i = Average lead concentration in site-related medium 'i'
IR_i = Intake rate of site medium 'i'
EF_i = Exposure frequency (days/year) to site medium 'i'
AF_i = Absorption fraction for lead in site medium 'i'
AT = Averaging Time (days)

The resulting estimate of average daily absorbed dose from site media was then entered into the IEUBK model using the IEUBK model's "alternate" menu, without revision to the baseline parameters.

A similar approach was used to evaluate incremental and total lead risks to adults using the ALM.

8 ENVIRONMENTAL DATA SUMMARY

To date, there have been a number of investigations conducted at the UCR Site to assess and evaluate potential contamination in surface water, sediment, air, and biota. A detailed review of historical investigations is provided in EPA (2005). While the historical investigations provide useful information on spatial and temporal trends, if temporal changes are evident or expected based on process knowledge, it is necessary to restrict available data to be representative of current conditions for the purposes of evaluating potential risks in the baseline HHRA.

Based on a review of site documents, there are several mine, mill, and smelting operations which have discharged within the UCR region historically, and there are several current point and non-point sources of potential contaminants that may be influencing current conditions. The two main point sources of contamination to the river are the Teck Cominco smelter in Trail, BC, and the Celgar Pulp Mill in Castlegar, BC, upstream of Trail. Operations at the Trail facility began in 1896 and continue today. While the Trail smelter has made several upgrades in its operational processes through the years, one of the most significant process changes is the cessation of granulated slag discharges in mid-1995. Operations at the Celgar Pulp Mill began in 1960 and underwent a process change in the early 1990s that significantly decreased emissions of dioxins and furans.

Based on this information, a date cut-off of 1995 was utilized for all environmental data sets evaluated for use in the HHRA. If a temporal evaluation of these data sets identifies significant changes in chemical levels post-1995, then the date cut-off may be adjusted as necessary to ensure that data represents current exposure levels.

8.1 Available Data

8.1.1 Surface Water

Human exposures to surface water may occur under a variety of exposure scenarios. In most instances, on-site exposures are expected to occur primarily in shallower water near beach areas (*e.g.,* recreational visitors during wading/playing activities, workers during occupational activities) which may be directly influenced by sediment disturbances resulting from these activities. Recreational visitors may also be exposed to surface water further away from beach areas (*e.g.,* during swimming). Therefore, for the purposes of evaluating potential risks to human health, data are needed which represent both "types" of surface water (*i.e.,* disturbed surface water from shallow areas near beaches and surface water from open water).

Several sources are available that provide information on chemical concentrations in undisturbed surface water at the UCR Site post-1995. These studies are summarized below.

USGS NASQAN. As part of the USGS North American Stream Quality Accounting Network (NASQAN) program, a surface water monitoring station located in Northport (Station# 12400520 at RM 735) has been sampled about 12 to 15 times per year from January 1995 to September 2000. At each sampling time, a filtered water sample was analyzed for metals, pesticides, nutrients, major ions, and various water quality parameters. Appendix A-1 summarizes the surface water data from the NASQAN Northport station. Map 8-1 (red dot) shows the location of this monitoring station.

Ecology Water Quality Monitoring. For the past 50 years, the Washington State Department of Ecology has conducted monthly water quality monitoring at hundreds of stream stations throughout the state. One of the monitoring stations sampled as part of this program is located northeast of Northport at the bridge crossing the UCR on State Highway 25 (Station# 61A070 at RM 735). From January 1995 to June 2007, an unfiltered and filtered water sample was collected on a monthly basis for analysis of metals (bimonthly), nutrients, major ions, flow, and various water quality parameters. Appendix A-2 summarizes the surface water data from the Ecology Northport station. Map 8-1 (yellow dot) shows the location of this monitoring station.

Scofield and Pavlik-Kunkel (2007). Surface water was sampled monthly at 11 locations across Lake Roosevelt from January 1998 to March 2000 by STI as an extension of the annual limnological sampling performed as part of the Lake Roosevelt Fisheries Evaluation Program. Map 8-2 shows the locations of these sampling stations. In 1998, two unfiltered grab samples were collected during each sampling event at each location – one sample from within the photic zone and one sample below the photic zone. In 1999 and 2000, a single unfiltered vertically integrated sample across the photic zone was collected during each sampling event at each location. All water samples were processed in Spokane, WA at the certified Spokane Tribal Laboratory for total recoverable metals and several water quality parameters.

Appendix A-3 presents summary statistics for surface water data collected by STI stratified by metal. As seen, there was high data censoring across the samples, with detection frequencies often less than 20% for most metals. As discussed in Scofield and Pavlik-Kunkel (2007), the high censoring frequency hampered the ability to perform meaningful comparisons to acute and chronic criteria for aquatic receptors (*i.e.*, developed for the protection of fish and benthic invertebrates). However, this may not preclude the use of this data in human exposure scenarios. Because human exposures to surface water are likely to be closer to the surface, samples collected at depths greater than 3 meters below the surface were excluded from the surface water data set. The authors also noted that field collection methods utilized lead weights to hold water samplers vertically in water column. Therefore, results for lead are questionable and were excluded from the surface water data set.

UCR Expanded Site Investigation (EPA 2003a). The UCR Expanded Site Inspection (ESI) Report included one unfiltered surface water sample collected in May 2001 near the municipal drinking water system intake in Lake Roosevelt (Station CW002 at RM 597). During sampling, the collection bottle was lowered from the EPA research vessel to approximately 1,208 feet amsl, which was identified as the elevation of the intake point by a representative of the City of Grand Coulee (EPA 2001b). This sample was analyzed for metals, pesticides, PCBs (as Aroclor), PAHs, SVOCs, and VOCs. Appendix A-4 summarizes the surface water data from station CW002.

Paulson et al. (2006). In September 2004, Paulson et al. (2006) collected several water samples as part of an evaluation of the release of trace elements from UCR sediment to several types of reservoir waters (*e.g.,* surface water, pore water, water incubated with sediment, water tumbled with sediment). Water samples collected from stations LR-5A and LR-7 (see green dots on Map 8-1) are representative of surface water samples taken near the lake surface from the side of the boat. Other water samples were representative of overlying water from within the sediment box core and were excluded from the surface water data set. Each water sample was filtered prior to analysis for metals. Appendix A-5 summarizes the results for surface water from station LR-5A and LR-7.

For the purposes of the baseline HHRA, only samples designated as unfiltered were utilized in the surface water data set (*e.g.,* filtered samples from the USGS NASQAN station were not included).

8.1.2 Sediment

For the purposes of the baseline HHRA, sediment exposures are expected to occur due to occupational, recreational, and subsistence activities on beaches and exposed shorelines (*e.g.,* during drawdown periods), and potentially also during wading/swimming in shallow waters of the UCR. Therefore, the sediment data set was restricted to studies that provided data on exposed beaches and depositional areas as well as sediment collected from shallower waters. Data on sediments collected from deeper waters and mid-channel samples (Era and Serdar 2001; Paulson et al. 2006; EPA 2005 Phase I Sediment Study cores) were excluded because humans are not expected to come into direct contact with deeper submerged sediments.

Several sources are available that provide information on chemical concentrations in sediments at the UCR Site post-1995. These studies are summarized below (presented in chronological order by sampling date).

Majewski et al. (2003). This USGS study was conducted in April-May 2001 (during a drawdown period) to investigate metals concentrations in fine-grained sediments from beaches along the UCR to determine the potential for human exposure to metals in airborne dusts. As part of this study, two types of sediment samples were collected – targeted samples (T) and spatially distributed (SD) samples. The six targeted sediment samples (T01 to T06) were selected because they had large expanses of exposed fine-grained material which could be a source for airborne particulates and due to their proximity to downwind communities. At each targeted location, three samples were collected representing a lower, middle, and upper elevation. The eighteen spatially distributed sediment samples (SD01 to SD18) were collected from exposed depositional areas in the UCR between Northport and the Grand Coulee Dam. Sediment samples were representative of the upper 2-3 cm of sediment and were sieved at the analytical laboratory to obtain a size fraction of 63 µm prior to analysis for metals. Map 8-3 shows the location of the targeted and spatially distributed sediment sampling locations. Appendix A-6 summarizes the sediment results for each station.

Because the effect of sieving the sample prior to analysis may influence metal concentrations (either increasing or decreasing depending upon the size characterization of the sediment), these data were not included in the sediment data set utilized for the purposes of assessing exposures via ingestion and dermal contact. Sediment data from Majewski et al. (2003) may be used in the baseline HHRA to refine an assessment of inhalation exposures to airborne dust.

UCR Expanded Site Investigation (EPA 2003a). In May-June 2001 (during a drawdown period), 49 surficial sediment samples (0-8 inches) were collected from the UCR (CS004 through CS052) as part of the UCR Expanded Site Investigation (ESI) (EPA 2003a). Map 8-4 shows the location of each sediment sampling location. Surficial sediment samples were collected from locations that were below the mean high water elevation, and included both exposed and submerged sediments. Two subsurface sediment samples (18-24 inches) were also collected from Haag Cove (CS017) and Marcus Flats north of Pingston Creek (CS024). Bulk sediment samples were analyzed for metals, pesticides, and PCBs (as Aroclor). Appendix A-7 summarizes the sediment results for each station.

As described above, sediment samples collected as part of the UCR ESI included both exposed and submerged sediments. Exposed sediments were collected from beaches using stainless steel bowls and spoons, while submerged sediments were collected using a petite ponar dredge sampler deployed from the back of a boat (surface water depths typically ranged from 6 to 30 ft). Because submerged sediment samples collected at depth may not be representative of samples that would be encountered during human exposure scenarios, these sediment samples were excluded from the sediment data set. Exposed sediment samples collected using spoons and bowls (or hand augers) were retained. The sample collection method was determined from a review of the field collection notes (EPA 2003; Appendix F).

Preliminary Assessments and Site Inspections for UCR Mills and Mines (E&E 2002). As part of the Preliminary Assessments and Site Inspections (PA/SI) for UCR Mills and Mines (E&E 2002), nine surficial sediment samples (0-6 inches) were collected in June 2001 from the sandbar/beach and boat launch areas in the UCR near the LeRoi/Northport Smelter. Each bulk sediment sample was analyzed for metals. Map 8-5 shows the location of each sediment sampling location (NSSL01SD to 09SD). Appendix A-8 summarizes the sediment results for each station.

Cox et al. (2005). In September 2002, Cox et al. (2005) collected sediment cores from 5 stations and riverine sediments from 3 stations along the UCR. These samples were collected to evaluate the occurrence of metallurgical slag and concentrations of trace elements in UCR sediments. Of the locations sampled, most sediments were collected from deep waters (>20 meters) and were excluded from the sediment data set. Only samples from two stations (RSS-724 and RSS-743) were collected from beach deposits immediately adjacent to the UCR at RM 724 and 743, respectively. Sediments from station RSS-743 were sieved and sorted to remove as much of the non-slag material as possible prior to analysis for trace elements. Results for the sorted sample from RSS-743 are presented in Cox et al. (2005), while results for the unsorted sample are presented in Paulson et al. (2006). For the purposes of evaluating human health exposures, only the results from the unsorted sample were retained. Appendix A-9 summarizes the sediment results for the unsorted sediment sample from RM 743.

EPA Phase I 2005 Sediment Study. EPA (2006a) collected surficial sediments (upper 10-15 cm) from the UCR in April-May 2005. Three types of sediment samples that were collected as part of this investigation are included in the surface sediment data set for use in evaluating human health exposures – beach samples, transect samples, and bioassay samples. Each of these samples is discussed in more detail below.

- Beach sediment stations included 15 sampling locations in campgrounds, boat launch areas, and swimming beaches between EPA RM 762 and EPA RM 600. At each beach, a 3-point composite sample was collected along three elevations (lower, middle, upper)[11]. The following beaches were sampled (presented from upstream to downstream):

  − Black Sand Beach (EPA RM 742)
  − Northport City Boat Launch (EPA RM 735)*
  − Dalles Orchard (EPA RM 730)
  − North Gorge Campground (EPA RM 718)
  − Marcus Island Campground (EPA RM 708)
  − Kettle Falls Swim Beach (EPA RM 700)*
  − Haag Cove (EPA RM 697)
  − French Rocks Boat Launch (EPA RM 690)
  − Cloverleaf Beach (EPA RM 675)
  − AA Campground (EPA RM 673)
  − Rogers Bar Campground (EPA RM 658)
  − Columbia Campground (EPA RM 642)*
  − Lincoln Mill Boat Ramp (EPA RM 633)
  − Keller Ferry No. 2 (EPA RM 615)
  − Spring Canyon Campground (EPA RM 600)

  At three beaches (denoted with "*" in the above list), an aliquot of each of the three individual grab samples[12] that were composited for each elevation were also analyzed.

- Transect sediment stations included 74 sampling locations distributed along the UCR from the US-Canada border to the Grand Coulee Dam. In the upper portion of the UCR (above EPA RM 720), 24 transects were spaced about every one mile. In the lower portion of the UCR (below EPA RM 720), 50 transects were spaced about every three miles. At most transect stations, three grab samples were collected – two shallow water bank samples (one from the east bank and one from the west bank), and a mid-channel sediment sample (from the center of the historical river channel)[13]. At a subset of five stations, 4-6 additional transect grab samples were collected at even intervals across the entire channel. As noted above, because human exposures are likely to occur only with sediment in shallow waters, only the terminal end samples for each transect location were included in the sediment data set (*i.e.,* mid-channel samples were excluded)[14].

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[11] In tables and figures, beach sample locations are identified with the suffix *B1*, *B2*, and *B3* to represent the upper (1285 ft amsl), middle (1270 ft amsl), and lower (1255 ft amsl) elevations, respectively.

[12] In tables and figures, beach grab samples are identified with the suffix *L* (left), *C* (center), and *R* (right).

[13] In tables and figures, transect sample locations are identified with the suffix *X1*, *X2*, and *X3*. The *X1* and *X3* locations represent the east and west bank samples, respectively. The *X2* location represents the mid-channel sample.

[14] At transect locations RM733 and RM737, the mid-channel (*X2*) samples were relocated to the banks (EPA 2006a, Table 2-3). Therefore, these samples were also included in the sediment data set.

- Bioassay sediment stations included 50 sampling locations distributed along the UCR. With the exception of three locations – EPA RM 734, EPA RM 730, and EPA RM 687 – bioassay stations were co-located with the transect bank stations. The three bioassay sediment samples that were not co-located with the transect stations were collected several feet below the water line at the time of the sampling. While these samples were collected for the purposes of evaluating benthic invertebrate toxicity, they are representative of sediments that may be encountered as part of a wading or swimming exposure scenario, and thus were retained in the sediment data set for the baseline HHRA.

Map 8-6 presents a map of the EPA 2005 Phase I sediment sampling locations (detailed maps of these sampling locations are provided in Appendix H). All bulk sediment samples were analyzed for metals, pesticides, PCBs (as Aroclors), PAHs, and SVOCs. Beach sediments were also analyzed for dioxin/furan congeners. Appendix A-10 summarizes the sediment results from EPA 2005 Phase I Sediment Study.

The EPA 2005 Phase I Sediment Study also collected subsurface sediment cores at 9 sampling locations from mid-channel (within the historic river channel) and submerged side-bank locations to a maximum water depth of 200 feet. As noted above, because humans are not expected to come into contact with these deep sediments, the core samples were not included in the sediment data set.

Ecology (2007). The Washington State Department of Ecology collected 10 surficial sediments (0-6 inches) from 8 locations as part of a site reconnaissance visit on May 14, 2007 (during a drawdown period). Five-point composite sediment samples (within a 10-ft radius) were collected using a stainless steel spoon from near-shore, side-bank depositional areas in the northern portion of the UCR Site. Sediment samples were air dried and sieved to 2 mm prior to analysis of arsenic, cadmium, copper, lead, and zinc. Map 8-7 shows the location of each sediment sample. Appendix A-11 summarizes the sediment results from the Ecology (2007) site reconnaissance visit.

8.1.3 Outdoor Air

As illustrated in the fate and transport mechanisms diagram (Figure 5-1), outdoor air may be impacted by two mechanisms of contamination:

1. *Direct emissions from Trail facility mining/smelting operations.* The area of principal interest is in the northern-most portion of the UCR Site (*e.g.,* Northport).

2. *Windblown suspension/dispersion of exposed sediments/soils.* This transport mechanism is of principal interest in locations where there are large expanses of exposed contaminated sediments and the potential for windblown erosion and transport is high (*e.g.,* Marcus Flats).

Therefore, for the purposes of evaluating potential risks to human health, data are needed which represent both "types" of outdoor air. Three sources are available which provide information on chemical concentrations in outdoor air at the UCR Site.

Ecology Phase I–IV Air Monitoring. In response to requests by Northport residents, Ecology conducted an air quality study from December 1992 through December 1998, in cooperation with Washington State Department of Health (WDOH). Because Phases I through III of the study were conducted prior to 1995 (December 1992 to August 1994), these data were excluded from this evaluation. In the spring of 1997, the Trail facility implemented a process change in the lead smelting operation. Phase IV was conducted between September 1997 and December 1998 (Ecology 1998), after the implementation of the new process. As part of Phase IV, air monitoring data were collected at three stations in and near Northport. Map 8-8 shows the approximate location of each air monitoring station (shown as red circles). On a regular basis (collection frequencies ranged from daily to weekly), a 24-hour composite sample was collected from each station and analyzed for arsenic, cadmium, lead, and zinc.

TCM Air Monitoring. Starting in January 1994, TCM has been operating a parallel monitoring station at the Sheep Creek air monitoring station near Northport (see Map 8-8). Since January 1994, every six days a composite sample has been collected from this air monitoring station and analyzed for arsenic, cadmium, lead, and zinc[15].

USGS Air Monitoring. Since 2002, the USGS has been conducting an air quality study to investigate the occurrence and distribution of trace elements in air along Lake Roosevelt (USGS 2006b). Air monitoring samples have been collected from three sampling stations, including Marcus Flats/Kettle Falls[16], Inchelium, and Seven Bays. Map 8-8 shows the approximate location of each air monitoring station (shown as green triangles). In general, on a weekly basis from January through September, a 24-hour sample was collected from each station and analyzed for metals.

8.1.4 Other Types of Air

No data are available which provide measured concentrations of COIs in air inside residences, campers, and RVs, within sweat lodges, or while performing food preparation/preservation or ceremonial/medicinal activities.

8.1.5 Upland Soil

As illustrated in the fate and transport mechanisms diagram (Figure 5-1), upland soil at the UCR Site may be impacted by a variety of mechanisms, including aerial deposition from stack emissions, aerial deposition from windblown exposed sediments, historical flood (overbank) deposition, and irrigation.

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[15] Air monitoring data from the TCM Northport air monitoring station had not been verified at the time of this document. These data will be reviewed and any necessary corrections will be incorporated into the air data set prior to the baseline HHRA.

[16] The monitoring station at Kettle Falls was only sampled in 2002. Beginning in 2003, this monitoring station was moved to Marcus Flats.

While there have been several soil sampling efforts conducted near the UCR Site, sampling locations were targeted in areas designed to characterize sources that are not attributable to the Trail facility. The PA/SI for UCR Mills and Mines in Stevens County (E&E 2002) investigated 15 different mines and mills located throughout the county and collected samples of source materials at each (*e.g.,* waste rock, tailings). However, these materials are unlikely to be representative of upland soils within the UCR Site.

The LeRoi Site Removal Evaluation (EPA 2004f) conducted soil sampling throughout Northport in 2003-2004 to assess potential impacts from the LeRoi Smelter. Many locations were subsequently remediated; therefore, these soil samples are no longer representative of current conditions.

In 2005, ten soil samples were collected from northeastern Washington State as part of the biomonitoring program component of the Trail Ecological Risk Assessment. These samples were analyzed for arsenic, cadmium, and lead. Data from these samples were not available at the time of this report.

8.1.6 Groundwater

As noted previously in Section 2.3.2.3, there are 3,312 water wells, 12 water supply springs, and 131 public water systems that utilize groundwater located within 5 miles of the UCR and Lake Roosevelt shoreline. However, it is unclear which of these wells may be directly influenced by the UCR Site and which, if any, would be utilized directly as potable water sources without some water treatment process.

National Park Service well reports are available for several wells throughout the recreation area from 1995-2004. It is not known at this time how, or if, these wells are utilized by human populations of interest. However, it is assumed that they may be used for drinking water and showering within the recreation area. Data from these wells were not electronically available at the time of this report. However, these data will be added to the project database prior to the baseline HHRA.

8.1.7 Aquatic Biota

A large portion of the UCR Site is part of the Lake Roosevelt National Recreation Area (LRNRA), which is managed by the National Park Service (NPS). The LRNRA attracts more than 1.3 million visitors annually (NPS 2006d). The UCR Site includes numerous boat launches, campgrounds, and marinas, as well as areas of undeveloped shoreline, which provide opportunities for recreational visitors to fish for a variety of species.

The UCR Site also includes approximately 93 miles of shoreline that lies within the Colville and Spokane Indian Reservations. The waters of Lake Roosevelt within the reservations are managed by the Tribes as a subsistence fishery. In addition, harvesting of shellfish, edible and medicinal aquatic plants, and materials for construction of household and cultural implements (*e.g.,* baskets, mats) contribute to the subsistence culture of the CCT and STI.

Four sources are available which provide information on chemical concentrations in fish tissue at the UCR Site post-1995. No measured data are available which provide information on chemical concentrations in other types of aquatic biota (*e.g.,* shellfish, aquatic plants) at the UCR Site.

Hinck et al. (2004). The USGS collected fish in November 1997 near Northport (Station 504) as part of the Biomonitoring of Environmental Status and Trends (BEST) Program. A total of 4 composite samples were collected at this station. Each composite sample included 10 whole fish, with one composite per species (largescale sucker and rainbow trout) per sex. Samples were analyzed for organochlorine chemical residues and a subset of elemental contaminants. Appendix A-12 summarizes the fish tissue results for Station 504 collected as part of the BEST program. Because Hinck et al. (2004) only provides summary statistics (*i.e.,* raw data for each sample are not given), these data were not included in the fish tissue data set.

Munn (2000). The USGS collected fish during the summer and fall of 1998 from two reaches within the UCR Site. The upper reach extended from Kettle Falls to Northport, and the lower reach extended from the Spokane River to the Grand Coulee Dam. A total of 8 rainbow trout, 5 mountain whitefish, and 8 walleye were collected from the upper reach, and a total of 16 rainbow trout and 8 walleye were collected from the lower reach. Rainbow trout and whitefish were filleted and samples were submitted for analysis of dioxin and furan congeners. Rainbow trout were also analyzed for “dioxin-like” PCB congeners and PCB as Aroclors. Walleye were filleted, the skin was removed, and samples were submitted for mercury analysis. Appendix A-13 summarizes the fish tissue results from Munn (2000).

EPA Phase I 2005 Fish Tissue Study. EPA (2006b) collected fish in September and October of 2005 from six focus areas extending the length of the UCR Site. Map 8-9 shows the location of each focus area. Five types of fish were targeted for sampling, including burbot, walleye, rainbow trout, whitefish, and largescale sucker. Most samples were submitted whole body samples for analysis of TAL metals, dioxin and furan congeners, and PCBs (as Aroclors). A subset of walleye and rainbow trout samples were submitted as skin-on fillet and offal samples. About 10% of all samples were analyzed for PCB congeners and arsenic speciation. Appendix A-14 summarizes the fish tissue results from EPA Phase I Study.

Johnson et al. (2006). The Washington State Department of Ecology collected four fish composite samples from the UCR near Kettle Falls as part of the 2005-2006 Statewide PBDE Survey. Samples were collected in September-October 2005 and included a single composite of each of four species, including largescale sucker, rainbow trout, walleye, and lake whitefish. Each composite represented skin-on fillets from 4-5 individual fish (using equal weight aliquots from each fish). All samples were analyzed for PBDE congeners. Appendix A-15 summarizes the fish tissue results from the 2005-2006 Statewide PBDE Survey.

8.1.8 Terrestrial Biota

No measured data are available which provide information on chemical concentrations in terrestrial plants or animals (*e.g.,* wild game, waterfowl, terrestrial plants, crops, livestock) at the UCR Site.

8.2 Data Management

8.2.1 Data Compilation

The site investigations discussed above were reviewed and available analytical results were compiled by EPA contractors into a UCR project-specific Microsoft Access® database (provided electronically in Appendix C). Detailed information on document gathering and data compilation efforts completed is provided in CH2M Hill (2005a; 2005b; 2006) and SRC (2008; 2009).

8.2.2 Data Reduction Methods

As part of regular data management operations, data from each of the site investigations were re-formatted to standardize chemical nomenclature and concentration units across studies for each medium. Because the purpose of the baseline HHRA is to evaluate exposures for the UCR, samples collected from rivers and tributaries outside of the UCR were excluded. In addition, samples collected for the purposes of assessing quality control in the field (*e.g.,* field duplicates, field/trip blanks) and in the analytical laboratory (*e.g.,* laboratory duplicates, matrix spikes) were excluded.

In the project-database, analytical results included three types of data qualifiers (laboratory, project, and validation). If any one of these data qualifiers was identified as “R”, the result was ranked as rejected and was excluded. If any one of these data qualifiers was identified as “U”, the result was ranked as non-detect. With the exception of Aroclor results in fish (discussed below) and calculations of TEQ, all results ranked as non-detect were evaluated in ProUCL using Regression on Order Statistics (ROS). When calculating estimates of TEQ from dioxin/furan and PCB congeners, non-detects were evaluated at one-half the reported detection limit. If the detection limit was not provided, the result was excluded.

<u>Total PCB Concentrations</u>

Based on Aroclor data. Analysis of PCBs as Aroclors by gas chromatography involves a comparison of the chromatogram of peaks to diagnostic patterns for different commercial Aroclor mixtures (*i.e.,* 1242, 1254, 1260, etc.). The analyst selects the mixture that best represents the observed sample chromatogram when reporting concentrations for an environmental medium (EPA Method 8082A). In some instances, when the observed sample chromatogram has peak characteristics that could be represented by either of two different mixtures (*e.g.,* 1254 and 1260), results may be reported for both; however, these results should be interpreted as alternate estimates of one concentration, not two independent estimates that should be summed. Therefore, total PCB concentrations for each sample (based on Aroclor data) were estimated as follows:

- If a single Aroclor mixture is reported as detect, the total PCB concentration is equal to the detected Aroclor concentration.

- If more than one Aroclor mixture is reported as detect, the total PCB concentration is equal to the sum of the detected Aroclor concentrations[17].

- If all Aroclor mixtures are reported as non-detect, the total PCB concentration is non-detect and reported as less than the maximum Aroclor detection limit for the sample.

Based on congener data. If PCB congener data is available, the total PCB concentration for the sample is equal to the sum of all PCB congeners. When calculating the sum, congeners that were non-detect were evaluated at one-half the reported detection limit.

PCB TEQ Estimation

In the case of PCBs in fish samples, for samples where the amount of PCBs present was reported both as Aroclor and as PCB congeners, risk calculations based on the congener (TEQ) approach yielded risk values about 3-5 times higher than if the risk calculations were performed based on Aroclor:

Tissue Type	N Sample Pairs	Risk Ratio (PCB TEQ-based/ Aroclor-based)
Whole body	31	5.3
Fillet	8	3.1

Based on this, an empiric extrapolation factor (EEF) was developed to convert the reported Aroclor concentration to an estimated PCB TEQ concentration for the purposes of assessing risks from PCB in fish:

$$C(\text{PCB TEQ}) = C(\text{Aroclor}) \cdot \text{EEF}$$

The mean values of EEF are equal to the mean risk ratio, corrected for the relative oral slope factors:

$$\text{EEF} = \text{Risk ratio} \cdot \text{oSF(Aroclor)} / \text{oSF(TCDD)}$$

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[17] This approach was not applied to 5 walleye fillet samples (Sample IDs 05364201 through 205) collected as part of the 2005 EPA Phase I Fish Tissue Study. In these samples, results were provided for Aroclor 1260 and Aroclor 1254, as well as Aroclor 1254/1260. For the purposes of estimating Total PCB as Aroclors for these samples, results for Aroclor 1254 and Aroclor 1260 were used in preference to the combined Aroclor 1254/1260.

The resulting mean values for EEF are shown below:

Tissue Type	Mean EEF (mg/kg PCB TEQ per mg/kg Aroclor)
Whole body	8.2E-05
Fillet	4.7E-05

These tissue-specific extrapolation factors were utilized to estimate PCB TEQ values for all fish tissue samples that were analyzed for Aroclor but not PCB congeners.

9 DATA ADEQUACY EVALUATION

Data Quality Assessment (DQA) is the process of evaluating the adequacy of existing data to determine if the data are sufficient to support risk assessment and risk management decision-making. EPA has developed guidance documents (EPA 2006i,j) of the DQA process, and the methods described below are in general accord with this guidance.

9.1 Scope of the Data Quality Assessment

As discussed above, estimation of risk from exposure to environmental contaminants requires three basic types of data:

1. Measures of the concentration of the contaminants in environmental media
2. Estimates of human exposure to each environmental medium
3. Toxicity factors that quantify risk per unit level of exposure

Of these three types of data, site-specific data are required for item 1 (environmental concentrations), and are desirable for item 2 (human exposure parameters), especially when the exposure scenarios being evaluated are not typical. Site-specific toxicity data (item 3) are not generally collected on a site-specific basis, and are not part of the data adequacy assessment presented in this document.

9.2 Evaluation of Environmental Concentration Data Adequacy

An evaluation of the adequacy of site-specific environmental concentration data must consider a number of potentially important factors. First, the data must be representative of the exposure area being evaluated. This includes both *spatial* representativeness (if the chemical is not distributed equally across all parts of the exposure area) and *temporal* representativeness (if the concentration in a medium varies over time). For example, at this site, concentrations of metal constituents of slag in shoreline and beach sediments (*e.g.,* arsenic, copper, iron, lead, zinc) tend to be higher in upstream than downstream locations, and concentrations of particulates in air may vary widely between calm and high wind conditions.

Second, the statistical uncertainty in the data must not be so large as to prevent reliable decision-making. This uncertainty is mainly a function of the number of samples that have been collected, and the degree of variation between samples. However, the magnitude of the uncertainty that is acceptable is not a constant, but depends on how close the risk estimates are to a decision threshold. For example, assume that the excess cancer risk level that will be considered unacceptable is 1E-04. If the best estimate of cancer risk from some particular pathway were 2E-05, it might seem this pathway would be considered acceptable. However, if the uncertainty in the risk estimate is large (*e.g.,* 20-fold), then the upper bound on risk would be 4E-04, which would not be considered acceptable. In contrast, if the best estimate and upper bound estimates of risk were each 100-fold lower (2E-07 and 4E-06), then even though the risk estimates are still uncertain, they might be sufficient for risk management decision-making, since there is high confidence that the risks are well below the decision threshold.

Third, the data must be collected using analytical methods that have adequate detection limits. One common way to define an adequate detection limit is to require that the detection limit be somewhat lower than a level of concern in the environmental medium that corresponds to some specified level of risk. This is referred to as the Risk-based Concentration (RBC). For example, if the RBC for some chemical in sediment were 1 mg/kg, and all of the analytical results were obtained using a method with a detection limit of 5 mg/kg, then it would not be certain that the chemical was below a level of concern even if all of the values were non-detect. However, if a chemical is detected in most samples of a medium from an exposure unit, this indicates the detection limit is adequate, even if the detection limit exceeds the level of concern. For example, if the RBC were 1 mg/kg, the detection limit were 5 mg/kg, and the measured values ranged from 10 to 100 mg/kg, the data would be adequate for estimating exposure and risk.

Figure 9-1 outlines the procedure that is used in this document to evaluate environmental concentration data adequacy.

The first step in the process is to identify a risk level of potential concern (LOPC) for cancer and non-cancer effects. Choosing each LOPC is a risk management judgment. In this data adequacy assessment, the LOPC is defined as 1/10 the target risk, where the target cancer risk is 1E-05 and the target non-cancer hazard quotient is 1.0. Therefore, the LOPC for cancer is 1E-06 and the LOPC for non-cancer is 0.1. A factor of 1/10 is used to account for potential additivity of risks between pathways and between chemicals. It is important to stress that these LOPCs are used for evaluation of data adequacy only and are not risk management goals.

Given LOPCs for cancer and non-cancer, the DQA process begins by querying the site database to isolate all of the data for samples of a specified medium collected from a specified location.

First, the data set is evaluated to determine if data are available for all chemicals of interest (COIs) in that medium. If all of the appropriate COIs for that medium have not been analyzed, this constitutes a potential data gap. Note that the identification of COIs for a specified medium may take into account knowledge of fate and transport processes, and be limited to those COIs reasonably expected to occur (*e.g.,* dioxins/furans have very low water solubility and are unlikely to be present at detectable levels in water). For the purposes of risk assessment support, the COI list may also be limited to those COIs with available toxicity data.

Next, the spatial and temporal representativeness of the data are evaluated. With regard to temporal representativeness, two time scales must be considered – within year and between year. For example, if the concentrations of one or more COIs are expected to vary seasonally, data are needed within each year to adequately characterize the temporal pattern and the annual mean. If the yearly average values are tending to change between years, then data are needed from multiple years to adequately characterize these trends. If the data lack representativeness and may tend to be biased low, the data are presumably not adequate. If the data are not representative but are likely to be biased high, they may still be adequate and should be carried through the rest of the data adequacy evaluation.

Next, the detection limit (DL) for each COI is evaluated. If the detection frequency is high (>70%), the DL is adequate. If the detection frequency is less than 70%, risks based on the mean DL are compared to the LOPC. If the risks based on the mean DL are less than or equal to the LOPC, the DL is adequate. Otherwise, the DL may not be adequate and it may be necessary to investigate if alternative analytical methods with lower DLs are needed.

Finally, preliminary screening level risk calculations are performed using the 95UCL of the mean, and the resulting values are compared to the LOPCs for cancer and non-cancer. Table 9-1 summarizes how the results of this comparison procedure are used to evaluate the need for additional data collection. In brief, if the screening level risk is below the LOPC, then it is concluded that current data are adequate and that no further data collection effort is needed. If the risk exceeds the LOPC by a small amount, then collection of additional data will usually not be warranted, but this is evaluated on a case-by-case basis, considering factors such as the relative risk of the pathway, the level of uncertainty in the risk estimates, and the cost and feasibility of additional data collection. If the risk estimate substantially exceeds the LOPC, the uncertainty in the data is evaluated by comparing the 95UCL of the mean to the mean. If the ratio of the 95UCL to the mean is small (< 2), the uncertainty in the EPC is usually considered acceptable, and collection of additional data is generally not warranted. If the ratio is larger than 2, the statistical uncertainty in the data is sufficiently large that additional data collection may be needed.

For the purposes of this document, exposure media are classified as primary, secondary, and tertiary based on fate and transport mechanisms (see Figure 5-1). A primary exposure medium is a medium that may be directly impacted by source releases (*e.g.,* surface water, sediment, outdoor air impacted by smelter emissions). A secondary exposure medium is a medium that may become impacted as a result of fate and transport processes with a primary medium (*e.g.,* outdoor air impacted by windblown sediment, uptake of COIs into aquatic plant tissue from contact with contaminated sediments, volatization of COIs in surface water into sweat lodge air). Similarly, a tertiary exposure medium is a medium that may become impacted as a result of fate and transport processes with a secondary medium.

A special case arises when there are no data for an exposure medium, but it is possible to estimate the concentration of COIs in that medium using a conservative fate and transport model. For example, there are currently no data on the concentration of metals in aquatic plant tissues (a secondary medium) at the site, but it is possible to estimate plant tissue levels from measured levels of metals in site sediments (a primary medium) using conservative plant uptake models. In this case, the estimated concentration values (*e.g.,* metals in plant tissues) are subjected to the same data quality evaluation process and decision rules as described above. If it is determined the modeled data are not sufficient to support reliable risk assessment and risk management decision-making, then additional data are generally needed. The most direct strategy to address this data need is to collect sufficient measurements of the modeled medium to avoid the need for modeling. However, collection of measured data may be deferred in the following cases:

- If the data set for the primary medium used for modeling is poor, collection of associated modeled secondary or tertiary media may be deferred until the primary medium has been adequately characterized.

- If tertiary media exposure estimates are based on modeled or estimated (rather than measured) concentration values in a secondary media, collection of the tertiary medium may be deferred until the secondary medium has been adequately characterized.

An assessment of the adequacy of environmental concentration data for the UCR Site is presented in Section 9.5.

9.3 Evaluation of Exposure Parameter Data Adequacy

Evaluating the adequacy of human exposure parameters is similar to the approach used for environmental data, except that issues of detection limit do not apply. That is, human exposure parameters should be representative of the average (CTE) and high-end (RME) exposures experienced by different individuals in the population being evaluated, and the uncertainty around the estimates should not be so large as to prevent reliable risk management decision-making.

Ideally, all exposure parameters used at a site would be based on site-specific data obtained through reliable site-specific surveys or measurements. This is not feasible in all cases (*e.g.,* measurement of incidental intake of sediment), but site-specific surveys can usually be used to obtain reliable estimates of site-specific exposure frequencies and durations, and intake rates for dietary items (*e.g.,* food, water) from site-related sources.

In this document, the only site-specific human exposure parameters presently available are the values identified by the Spokane tribe to represent the traditional subsistence scenario (Harper et al. 2002; EPA 2005e). While site-specific information on fish ingestion rates is available from a Lake Roosevelt angler study (Patrick 1997), the application of this information to each of the recreational visitor populations depends upon assumptions regarding fishing frequency. All other exposure parameters are based either on default values recommended by EPA, or values selected based on professional judgment.

An assessment of the adequacy of exposure parameter values is presented in Section 9.6.

9.4 Preliminary Risk Estimates

As noted above, evaluating the adequacy of environmental data and human exposure parameters may depend in some cases on the magnitude of the risk estimates based on the available data. Initial risk calculations for non-lead chemicals and lead are presented in Appendix D-1 and D-2, respectively, for each of the exposure pathways of potential concern at this site. Risks were calculated using the methods described above (Sections 5 to 7), and the data that are presently available for the site (Section 8).

In cases where measured data were not available (*e.g.,* terrestrial biota), preliminary risk estimates were derived using uptake/transfer models from the literature and/or conservative assumptions. Therefore, the resulting estimates are uncertain and likely to be biased high.

Ideally, preliminary risk estimates would have been evaluated both by reach and by beach, to represent the full range of exposure area sizes. However, the available exposure media data sets were insufficient to provide meaningful statistics grouped by beach. Therefore, preliminary risk estimates are presented based on reach-specific exposure areas only.

As described previously, there are four main receptor populations of interest for the UCR Site, which include several recreational visitor, worker, subsistence, and residential exposure scenarios. For the purposes of performing preliminary risk calculations, exposures were evaluated for the maximally exposed receptor (*i.e.,* the receptor with the highest HIF for the exposure route). Depending upon the exposure route, the maximally exposed receptor is often the traditional subsistence exposure scenario (for outdoor exposures) or the residential exposure scenario (for indoor exposures) (see Table 5-11).

Because of the limited nature of the environmental and exposure parameter data presently available, <u>these initial risk calculations are intended only to assess data adequacy to guide future data collection efforts and to prioritize data needs, not to support risk management decisions.</u> Results may not provide reliable or accurate risk estimates.

9.5 Environmental Data Adequacy Evaluation

Environmental concentration data for each medium for each reach were evaluated as described above (see Figure 9-1). The results are presented below, grouped by environmental medium.

9.5.1 Surface Water

As noted previously, human exposure to surface water may occur under a variety of exposure scenarios. This includes some scenarios that occur in shallow water near beach areas which may be directly influenced by sediment disturbances caused by human activities (*e.g.,* recreational visitors during wading/playing activities, workers during occupational activities) and scenarios that occur in open water further away from beach areas (*e.g.,* during swimming). Therefore, for the purposes of evaluating potential risks to human health, data are needed which represent both “types” of surface water (*i.e.,* disturbed surface water from shallow areas and surface water from open areas). Currently, none of the available surface water samples are representative of disturbed conditions.

<u>Spatial Representativeness</u>

As shown in Table 9-2, multiple samples of unfiltered surface water are available from one location (Northport) in Reach 1. Surface water data for other downstream reaches are fairly limited (1-4 samples per reach depending upon the COI). Because of potential effects of discharges from point and non-point sources throughout the UCR Site, this density of sampling stations for surface water is not adequate to provide spatially representative surface water data for any reach or any beach other than the Northport boat launch area. Rather, several stations per exposure area are required to provide adequate spatial representativeness.

Temporal Representativeness

For the Ecology water quality monitoring location in Northport (station 61A070), a total of about 30-65 samples (depending upon the analyte) are available from January 1995 through June 2007. Figure 9-2 Panel A presents example temporal patterns for lead in unfiltered surface water from the Northport monitoring station. As seen, there may be a slight trend toward decreasing concentrations from 1995 to 2007. This pattern is also seen for many of the common metals (figures not shown). However, the gap in samples[18] between 1998 and 2002 make determination of any temporal trends difficult.

Since 1979, Environment Canada has been conducting weekly sampling of conditions in the Columbia River at a monitoring location near Waneta, BC (station BC08NE0001) just upstream of the U.S.-Canada border. Although this sampling location is outside of the UCR Site, measured surface water data from this monitoring station may be useful in determining potential temporal variability in the upper-most portion of the site. Figure 9-2 Panel B presents example temporal patterns for lead in unfiltered surface water from the Waneta monitoring station from January 1995 to June 2008. As shown, measured lead concentrations at Waneta are generally similar to those measured in Northport (Panel A), and concentrations appear to be decreasing from 1995 to 2008. This temporal pattern is also seen for many of the common metals (figures not shown).

Surface water data from the Waneta monitoring station also provide information on seasonal variability in the upper-most portion of the site. Figure 9-3 presents the average monthly surface water concentration for zinc at Waneta (from 1995 to 2008). As shown, concentrations tend to increase during the spring run-off and decrease during the drier summer months. It is important to note that, because the Waneta monitoring station is located above the zone of reservoir influence, it is not possible to draw conclusions from these data about seasonal patterns in surface water due to reservoir drawdown practices.

Downstream of Reach 1, the available data are too censored (*i.e.,* concentrations were below the method detection limit) to draw conclusions about temporal patterns in surface water.

Available data suggest that there are both long-term temporal changes and seasonal patterns in surface water in the upper-most portion of the site. Because release rates from known and unknown sources across the UCR Site are likely to be changing over time, and because available surface water do not provide information on conditions beyond the upper-most portion of the site, additional surface water data are needed to represent current conditions and seasonal variability throughout the UCR Site.

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[18] Due to unexpected gaps in sampling frequencies between years and anomalous concentration values, the surface water data set from the Ecology water quality monitoring station is under review. If relevant surface water samples have been omitted from the UCR project database or errors are noted, data will be updated prior to the baseline HHRA.

Adequacy of the Analytical Suite

For the unfiltered samples collected from the Northport station (Reach 1), most have been analyzed for arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc (see Table 9-2). Unfiltered surface water samples in other reaches primarily provide data for most of the common metals. Only one surface water sample collected in Reach 6 provides measured data for non-metal COIs, this sample was also analyzed for pesticides, PAHs, SVOCs, and PCBs (as Aroclor). No surface water samples have been analyzed for the less common trace elements, radionuclides, dioxins/furans, or PBDEs.

Although surface water samples have not been analyzed for the less common trace elements, toxicity data are limited or absent for these analytes, and it is anticipated that their contribution to risks are likely to be minor relative to the common metals. Therefore, analysis of these analytes in surface water is not a critical data gap for the purposes of evaluating risks.

With regard to the U-238 decay series radionuclides, the most likely potential source of these radionuclides was phosphogypsum discharged into the Columbia River from historic phosphate fertilizer production at the Trail facility. Because this process is no longer active, it is unlikely that elevated levels of radionuclides remain in surface water. In addition, PCBs, dioxins/furans, and PBDEs would be expected to be sorbed to organic materials in sediment and in biotic tissues in preference to water. Therefore, analysis of these analytes in surface water samples from open water is not a critical data gap for the purposes of evaluating risks.

However, because “disturbed” surface water will likely contain higher levels of suspended sediments which may have been influenced by historical discharges, measured concentration data are needed for these radionuclides, PCBs, dioxins/furans, and PBDEs in disturbed water samples.

In order to assess potential human health risks to COIs, additional data are needed which provide measured unfiltered surface water concentrations in open water for all of the common metals, and the list of COIs for pesticides, PAHs, and SVOCs presented in Table 5-1. Measured data are also needed which provide unfiltered surface water concentrations in disturbed water for all of the common metals, and the list of COIs for radionuclides, pesticides, PAHs, SVOCs, PCBs, dioxins/furans, and PBDEs presented in Table 5-1.

Adequacy of Detection Limit (DL) Evaluation

Appendix E summarizes the DL evaluation for ingestion and dermal contact exposures to surface water from the Northport station (Reach 1). As seen, all analyzed metals that were infrequently detected (< 70%) had DLs that were less than the LOPC and deemed adequate for assessing human health risks.

Downstream of Reach 1, nearly all of the available surface water samples were collected as part of the study conducted by Scofield and Pavlik-Kunkel (2007). As noted previously, the detection frequency for most metals of interest was less than 20% in this study (*i.e.,* concentrations in surface water were below the DL). However, an evaluation of the average DLs from this study (see Appendix E) shows that, with the exception of antimony, arsenic, cadmium, cobalt, selenium, and silver, the DLs that were achieved in the study were less than the LOPC and deemed adequate for assessing human health risks.

Uncertainty Evaluation

Appendix F1 presents the ProUCL output which details the 95UCL calculation for each metal in surface water from the Northport station (Reach 1). Because only one sample is available for Reach 6, it is not possible to calculate 95UCLs for any COI. Appendix F2 summarizes the uncertainty in the 95UCL for surface water from the Northport station (Reach 1). For all chemicals, the ratio of the 95UCL to the arithmetic mean was less than 2. This is consistent with the observation that there is a small amount of between-sample variability at this sampling location. Based on this, it is expected that large sets will not be required to limit uncertainty in the EPCs for most exposure areas.

Preliminary Risk Calculations

Due to the high censoring frequency in the surface water data sets downstream of Reach 1, preliminary risk calculations were performed using surface water data from the Northport station (Reach 1) only.

Appendix D presents the preliminary risk calculations for incidental ingestion and dermal contact exposures to surface water near Northport. As seen, estimated risks were at or below the LOPC for all analyzed metals based on the incidental ingestion and dermal exposure scenarios, indicating that these exposure pathways are likely to be minor in the upper-most portion of the UCR Site. However, because all the available surface water data represent undisturbed surface water samples, potential risks from exposures under disturbance scenarios where the surface water contains suspended sediment particles from beaches (*e.g.,* wading/playing/fishing in shallower water) are likely to be higher.

At this time, it is not known if untreated UCR surface water is utilized as drinking water. To address this potential exposure scenario, Appendix D also presents preliminary risk estimates for the ingestion exposures to drinking water. As seen, estimated risks from use of untreated surface water under a long-term drinking water scenario were above the LOPC for arsenic, although the arsenic EPC was about 20-times lower than the current arsenic maximum contaminant level (MCL)[19] for drinking water. Based on the results of the preliminary risk calculations using limited data, risks from drinking water ingestion exposures to metals are likely to be minor in the upper-most portions of the UCR Site.

Although the surface water results from Scofield and Pavlik-Kunkel (2007) had high censoring, they do provide some useful information on expected metal concentrations in the UCR below Reach 1. As noted above, metal concentrations in most samples were reported as non-detect. These results suggest that metal concentrations in undisturbed surface water downstream of Reach 1 are likely to be low.

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[19] http://www.epa.gov/safewater/contaminants/index.html

Conclusions

Available surface water data are quite limited in that they are representative of undisturbed exposure conditions, are restricted to a single location (Northport), and only analyzed for a subset of metals. The data adequacy assessment shows that:

- Measured data are needed which represent disturbed surface water from shallow areas near beaches and surface water from open areas.
- Additional sampling stations (several per reach) are needed to provide spatial representativeness.
- Additional sampling times are needed to ensure data are representative of current conditions and seasonal variability.
- Additional unfiltered surface water samples are needed which provide measured data on all of the common metals, as well as all COIs for pesticides, PAHs, and SVOCs. Analysis of radionuclides, PCBs, dioxins/furans, and PBDEs are also needed for disturbed surface water samples.
- Based on the limited data from the Northport station, risks from incidental ingestion and dermal contact exposures to metals in surface water appear to be low in the upper-most portion of the UCR Site. However, risk estimates are likely to be biased low because they are based on undisturbed surface water samples.
- Based on the limited data, risks from ingestion of surface water as drinking water appear to be low for the subset of metals analyzed.

9.5.2 Surface Sediment

As noted previously, sediment exposures are expected to occur due to occupational, recreational, and subsistence activities on beaches and exposed shorelines (*e.g.,* during drawdown periods), and potentially also during wading/swimming in shallow waters of the UCR. Therefore, for the purposes of evaluating potential risks to human health, data are needed which represent exposed beaches and depositional areas, as well as sediments from shallow waters.

Spatial Representativeness

By River Mile

As shown in Table 9-3, most reaches have at least 20 surface sediment samples available. With the exception of three beaches (*e.g.,* Northport Boat Launch, Kettle Falls Swim Beach, and Columbia Campground), surface sediment data are too limited to calculate reliable beach-specific statistics.

Most of the available sediment samples were collected during the EPA 2005 Phase I sampling effort and are representative of either beach sediments or bank sediments from the terminal ends of the transect stations (see Map 8-6). EPA 2005 Phase I transect stations were systematically spaced 1-mile apart above EPA RM 720 and 3-miles apart below EPA RM 720. Because of the systematic sampling design that was employed in this study, these sediment data are spatially representative within each reach and across the UCR Site.

Figure 9-4 presents the patterns of arsenic and lead in surface sediments on beaches and banks as a function of river mile. As seen, the highest sediment concentrations occur in the upper reaches (Reaches 1 and 2). With few exceptions (*e.g.,* beryllium, nickel, vanadium), this spatial pattern is also seen for most of the common metals (figures not shown). This is likely because depositional sediments in these upper reaches are influenced by historical discharges of granulated slag from the Teck Cominco Trail facility. Granulated slag is enriched with aluminum, antimony, arsenic, calcium, copper, iron, manganese, silica, and zinc (Bortelson et al. 2001). For some beaches (*e.g.,* Black Sand Beach), granulated slag material is readily apparent. In these upper reaches, sediment concentrations span a wide range of concentrations. In the lower reaches, sediment concentrations tend to be similar across reaches and spatial patterns are not evident.

While the existing sediment data span across the entire UCR Site and are generally spatially representative, there are a number of beaches used by humans that have not been sampled. In addition, with the exception of a few beaches, the available sediment data are too limited to assess beach-specific exposure areas. Therefore, any future data collection efforts for sediment at beaches that are important for human use should employ a sampling design that would allow for the calculation of exposures on a beach-specific basis.

By Elevation

One of the important processes that influences fate and transport of contaminants in exposed sediment is water level fluctuations as a result of Grand Coulee Dam operations. Ongoing reservoir management protocols have maintained a fairly controlled set of conditions in the UCR. On average, water elevation from June through December is at about 1,285 ft amsl. From January through May, water elevation decreases steadily, with a typical low pool elevation of about 1,245 ft amsl in April/May (EPA 2003a).

While it is expected that most recreational visitors would be exposed to sediments in the summer months during a higher pool conditions, other populations of interest (*e.g.,* subsistence, occupational) may have year-round exposures to sediments. Because slag and other contaminants are deposited on beaches via water transport, and because the level of the water may vary over time, it is possible that the level of contamination in beaches may vary as a function of elevation above the low water level. If so, individuals who are exposed primarily along the waters edge (*e.g.,* individuals that wade or fish) may be preferentially exposed to sediments from the lower elevation, while individuals that camp or hunt may be exposed to sediments from the middle or upper elevations. If spatial gradients are apparent as a function of elevation, these differences would need to be addressed when estimating exposures for each population.

In the EPA 2005 Phase I beach sampling study, three composite samples per beach (comprised of 3 subsamples each) were collected below the high water mark which represent a lower, middle, and upper elevation to evaluate potential differences in sediment concentrations as a function of elevation. Table 9-4 presents the results for each sample stratified by elevation and beach. Figure 9-5 presents a comparison of sediment concentrations at the lower elevation to concentrations at the middle and upper elevation for arsenic, cadmium, copper, iron, lead, and zinc[20]. In these graphs, values are plotted above zero when concentrations are higher at lower elevation relative to middle or upper elevation, and values are plotted below zero when concentrations are higher at middle or upper elevations relative to lower elevation. As shown, in the upper reaches (*i.e.,* upstream of about river mile 700, Reaches 1-3), there is a general tendency for concentrations at the lower elevation to be higher than the middle or upper elevation. In the lower reaches, differences in concentration as a function of elevation are not apparent.

However, just because spatial gradients may be present in the upper reaches, this does not necessarily mean that these differences are important for the purposes of making risk management decisions. If the risk management decision for the exposure area when accounting for differences in elevation is the same as when differences in elevation are ignored, then characterizing changes in sediment concentration as a function of elevation is of less importance.

Appendix I presents an evaluation of total risks from incidental sediment ingestion for each beach calculated based on the beach-wide mean and stratified by elevation. In this evaluation, total risks (across all metals) for each beach are compared to the LOPC based on each approach. These results show that the risk management decision based on a beach-wide approach rarely differs from the decision based on an elevation-specific approach (*i.e.,* risk estimates for each approach are either both above the LOPC or both below the LOPC). While this evaluation is based on a small number of samples, it suggests that spatial gradients as a function of elevation are unlikely to be important for the purposes of making risk management decisions at most beaches.

Temporal Representativeness

Concentrations of COIs in sediments may tend to vary over time due to on-going sediment transport processes (*e.g.,* deposition, erosion). Conceptually, there are two time frames to consider in assessing potential temporal variability of sediment concentrations: seasonally (within a year) and long-term (across many years).

With regard to seasonal (within-year) variation, once sediments become exposed during drawdown, it is expected that concentrations would remain approximately constant until they become re-submerged. Consequently, within-year variations in exposed sediments (the principal medium of interest for human health) are likely to be minimal.

With regard to long-term trends, surface sediment samples have been collected during periods of reservoir drawdown (*i.e.,* spring) in 2001 (EPA ESI, PA/SI), 2002 (Cox et al. 2005), 2005 (EPA 2005 Phase I Sediment Study), and 2007 (Ecology 2007d). Figure 9-6 presents the sediment concentrations for arsenic and lead by river mile for each investigation. As seen, concentrations tended to be generally similar between studies (*i.e.,* across years). While these data are too limited to support a definitive assessment of temporal variability, the available data support the conclusion that wide variability in sediment concentrations as a function of time is not readily

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[20] These metals were selected because they are likely to be constituents of granulated slag and have a detection frequency of at least 80%.

apparent. Because time trends are not readily apparent, the existing sediment data are likely to be representative of current conditions.

Adequacy of the Analytical Suite

Surface sediment samples from all reaches were analyzed for most COIs (see Table 5-1). Those COIs that were not analyzed include many of the less common trace elements (referred to as "other metals" in Table 5-1), radionuclides, PCB congeners, and PBDEs. Although sediment samples have not been analyzed for the less common trace elements, there are limited toxicity data available for these analytes, and it is anticipated that their contribution to risks are likely to be minor relative to the common metals. Therefore, analysis of the less common trace elements in sediments is not a critical data gap for the purposes of evaluating risks.

Although surface sediments were not analyzed for PCB congeners, they were analyzed for total PCBs as Aroclor and results show that all but one sediment sample was non-detect. This suggests that PCBs are not likely to be of potential concern in surface sediment. However, by analogy to the findings for fish tissues (see Section 8.2.2), if it is assumed that PCB risks based on a TEQ approach might be higher than risks based on Aroclor, it is possible that risk estimates for PCBs in sediments based on the congener approach might contribute to the total TEQ risk. Because PCBs are bioaccumulative in aquatic tissues, the measurement of PCB congeners in fish and shellfish, rather than sediment, is likely to be a more important metric of potential exposure for human populations. Therefore, analysis of PCB congeners in surface sediments is not a critical data gap for the purposes of evaluating risks.

Based on this information, with the exception of radionuclides and PBDEs, the existing sediment data set provides measured data for all COIs that are likely to be most important for the purposes of assessing potential human health risks. In order to assess potential human health risks, data are needed which provide measured sediment concentrations for the list of COIs for radionuclides and PBDEs presented in Table 5-1.

Detection Limit Evaluation

Appendix E summarizes the DL evaluation for incidental ingestion and dermal exposures to sediment for each reach. As seen, all analyzed COIs had DLs that were less than the LOPC based on dermal exposures and most analyzed COIs had DLs that were less than the LOPC based on incidental ingestion exposures and deemed adequate for assessing human health risks. Analytes that were infrequently detected (< 70%) with DLs that were at or above the LOPC based on incidental ingestion exposure included antimony, thallium, uranium, and N-nitrosodi-n-propylamine. To the extent feasible, future data collection efforts of sediment should investigate if alternative analytical methods for these analytes are available which may be able to achieve lower DLs.

Uncertainty Evaluation

Appendix F1 presents the ProUCL output which details the 95UCL calculation for each COI in sediment for each reach. Appendix F2 summarizes the uncertainty in the 95UCL for sediment for each reach. For most chemicals, the ratio of the 95UCL to the arithmetic mean was less than 2. Based on this, it is expected that large sets will not be required to limit uncertainty in the EPCs for most reaches and most COIs. However, the ratio of the 95UCL to the arithmetic mean was higher than 2 for several metals, PAHs, and dioxins/furans in one or more reaches. These results indicate that additional data may be needed to reduce uncertainty in the EPC for these COIs.

Preliminary Risk Calculations

Ideally, preliminary risk calculations would have been performed grouped by reach and by beach, to represent the full range of exposure area sizes. However, the available surface sediment data set is too limited to provide meaningful statistics grouped by beach for most areas. Therefore, preliminary risk estimates were calculated based on reaches only. Appendix D presents the preliminary risk calculations for incidental ingestion and dermal exposures to sediments for each reach.

Estimated risks from incidental ingestion of sediment were above the LOPC for several metals and dioxins/furans. Because screening level non-cancer HQs were above 1 for several metals and cancer risks were above 1E-04 for arsenic, high priority should be given to future data collection efforts designed to address uncertainties related to the evaluation of incidental ingestion of metals in sediment. Because screening level risks from incidental ingestion of dioxins/furans in sediment were below 1E-05, additional data collection is not likely to be necessary, but a final decision to collect dioxin/furan sediment data will be deferred until other exposure scenarios have been adequately characterized.

With the exception of arsenic, estimated risks from dermal exposures were below the LOPC for all analyzed COIs in all reaches, indicating that this exposure pathway is likely to be minor for most COIs. For arsenic, because screening level risks from dermal contact with sediment were at or below 2E-05 for all reaches, and because dermal contact risks were about 20 times lower than risks from incidental ingestion, additional data collection is not likely to be necessary to address this exposure scenario. However, a final decision to collect additional data will be deferred until other exposure scenarios have been adequately characterized.

Based on the preliminary risk estimates, reducing uncertainties in exposures to metals in sediment should be given priority when addressing HHRA data needs in future data collection efforts.

Other Data Limitations

Size-Fractioning

Initial exposure estimates were based on concentrations from bulk sediment samples. As described above, the main pathway by which humans are likely to be exposed to contaminants in sediment is by incidental ingestion of sediment particles adhering to the hands. Although data are limited, for soil exposures, it is generally expected that smaller “fine” particles are more likely to adhere to the hands than coarse particles. For sediment exposures, due to the wet nature of sediments, the adherence of coarse particles may occur more frequently relative to soils, but the degree to which this may occur is unknown. Studies at other sites have shown that concentrations of metals between different size fractions (*e.g.,* fine, coarse) can vary greatly from concentrations reported in the bulk sample (EPA 2001c; 2007g).

At the UCR Site, information on variation of metal concentrations as a function of grain size is limited. During the 2005 EPA Phase I Sediment Study, sediment samples from three beaches – Northport Boat Launch (EPA RM 735), Kettle Falls Swim Beach (EPA RM 700), and Columbia Campground (EPA RM 642) – were separated into particles less than 75 µm ("fine") and particles greater than 75 µm ("coarse"). Table 9-5 summarizes the metal concentrations for each size fraction at each location. Figure 9-7 presents a comparison of metal concentrations in the fine fraction to the coarse fraction. In this figure, a ratio greater than 1.0 indicates that concentrations in the fine fraction were higher than the coarse fraction. Based on a review of this figure, these data show:

- At beaches in the lower reaches (Kettle Falls Swim Beach and Columbia Campground), concentrations in the fine fraction tend to be about 2 times higher than the coarse fraction for all metals.
- At the Northport Boat Launch, concentrations in the coarse fraction were higher than the fine faction for several metals, including aluminum, antimony, calcium, chromium, cobalt, copper, iron, manganese, potassium, selenium, sodium, and zinc. This is consistent with the hypothesis that these metals are associated with the coarse-grained granulated slag materials that have been deposited in the upper reaches.
- For mercury, concentrations in the fine fraction were consistently higher than the coarse fraction at all beaches.

Based on these limited data, it appears that sediment concentrations of metals vary as a function of particle size and that the relationship between the particle size and concentration will likely vary spatially. Therefore, in order to determine the relative importance of size-fractioning on sediment concentrations at the UCR Site, additional information is needed on metal concentrations across a range of size fractions. Because the sediment characteristics may vary through out the UCR Site, size-fractioning results should be representative of all exposure reaches.

The selection of the appropriate size-fractioning cut-offs is based on professional judgment. In other EPA regions, when evaluating human health risks from soil ingestion, a 250 µm cut-off (60 mesh sieve) has been used to separate coarse particles from fine particles. According to Choate et al. (2006), dermally adhering soil is mostly composed of particles less than 125 µm (115 mesh sieve). At the UCR Site, sediment particles less than 63 µm are expected to be representative of airborne dusts generated during ambient and high-wind conditions (Majewski et al. 2003). In addition, STI (2006) states that sediment particles less than 63 µm are representative of the size fraction most likely to be incidentally ingested by Tribal members. Therefore, at the UCR Site, it will also be useful to separate the fine fraction even further using a 63 µm cut-off (250 mesh sieve). Based on this information, there are four sediment size fractions of potential interest for the purposes of evaluating exposures in the baseline HHRA:

- 2 mm - 250 µm
- 250 µm - 125 µm
- 125 µm - 63 µm
- < 63 µm

Relative Bioavailability

When evaluating ingestion exposures of metals from sediment, the relative bioavailability (RBA) was set equal to default values (*i.e.,* 80% for arsenic, 60% for lead, 100% for all other metals). However, in many cases, the absorption of metals from sediment is not as high as from food or water, so this approach will often tend to overestimate risks from incidental ingestion of sediment. Therefore, it would be desirable to have reliable site-specific RBA data for metals in sediment in order to support adjusting the toxicity factors for the baseline HHRA. As noted above, because the sediment characteristics may vary through out the UCR Site, RBA results should be representative of all exposure reaches.

Conclusions

While the existing sediment data set does provide information on spatial and temporal variability for a majority of the COIs, the data adequacy assessment shows that:

- Additional sampling stations are needed to provide measured data for areas of importance for human use and to allow for beach-specific exposure evaluations.
- Preliminary risk estimates suggest that risks from dermal contact exposures to sediment are low and appear to be minor relative to incidental ingestion exposures.
- Risks from incidental ingestion of metals in sediment have the potential to contribute substantially to total risks; therefore, high priority should be given to future data collection efforts designed to address uncertainties in this exposure scenario.
- Additional surface sediment samples are needed which provide measured data on the list of COIs for radionuclides and PBDEs.
- Site-specific information on RBA and metal concentrations in different sediment size fractions are needed to reduce uncertainties in estimated risks from incidental ingestion of metals in sediment in the baseline HHRA.

9.5.3 Subsurface Sediment

Human exposures to subsurface sediments at the UCR Site may occur on beaches and exposed shorelines as a result of digging (*e.g.,* child digging in beach sediment, worker digging footings) and excavating activities (*e.g.,* archaeological, artifact excavation).

As seen in Table 9-6, there are only two samples (one from Marcus Flats near Pingston Creek in Reach 3 and one from the flats near Haag Cove in Reach 4a) which provide information on subsurface sediments (18-24 inches) from beaches along the UCR. These samples were collected in the spring of 2001 as part of the ESI (EPA 2003a) and were analyzed for metals, pesticides, and PCBs (as Aroclor). Table 9-7 summarizes the results from these samples. As seen, pesticides and PCBs were not detected in any sample but several common metals were detected. Co-located surface (0-6 inches) sediment data is only available for the sample from Haag Cove. A comparison of the metal concentrations in the surface sample to the subsurface sample at this location shows that the surface sediment tended to have higher metals concentrations than the subsurface sediment (*e.g.,* cadmium, lead, mercury, and zinc were more than 10 times higher in the surface).

These data are not sufficient to provide adequate information on spatial (vertical or longitudinal) or temporal representativeness for the purposes of evaluating human exposures, so additional subsurface sediment data are needed. Because human receptors are not likely to be exposed to sediments deeper than 30 inches under typical exposure scenarios (*e.g.,* without digging/excavating heavy equipment), initial sampling efforts should focus on the collection of subsurface sediments within this depth range. Because different receptor populations may be exposed to varying depths of sediment, future sampling efforts should also stratify subsurface sediment samples into varying depth intervals. For example, recreational scenarios (*e.g.,* child playing in beach sand) may occur at maximum depth of 18 inches, while occupational scenarios (*e.g.,* digging associated with archaeological or maintenance activities) may encounter depths up to 30 inches.

In addition, only a subset of the COIs were analyzed in the available subsurface sediment samples. In order to assess potential human health risks to COIs in subsurface sediments, additional data are needed which provide measured concentrations for the list of COIs for common metals, radionuclides, pesticides, PAHs, SVOCs, PCBs, dioxins/furans, and PBDEs presented in Table 5-1.

Analysis of subsurface sediments for the less common trace elements is not deemed necessary because there are limited toxicity data available for these analytes and it is anticipated that their contribution to risks are likely to be minor relative to the common metals. Therefore, analysis of these analytes in subsurface sediment is not a critical data gap for the purposes of evaluating risks.

Conclusions

Based on a review of this extremely limited data set for subsurface sediment, the data adequacy assessment shows that:

- Additional sampling stations (several per reach) and depth intervals (up to 30 inches) are needed to provide spatial representativeness.
- Additional sampling times are needed to ensure data are representative of current conditions.
- Additional subsurface sediment samples are needed to provide measured data on the complete list of COIs (see Table 5-1) for common metals, radionuclides, pesticides, PAHs, SVOCs, PCBs, dioxins/furans, and PBDEs.
- The available data set is too limited to perform preliminary risk calculations for exposures of receptors to subsurface sediments.

9.5.4 Outdoor Air Directly Impacted by Smelter Emissions

Current operations at the Trail facility include primary smelting of zinc and lead concentrates and secondary smelting for production of a variety of metal products (EPA 2008). As part of these smelting operations, stack emissions release particulates, sulfur dioxide, and metals into the air which can then be carried downwind into the Columbia River Valley.

Spatial Representativeness

The town of Northport, Washington is located near the U.S.-Canada border, and is the nearest community located downwind of the Trail facility. However, human exposures to outdoor air impacted by smelter emissions are likely to extend beyond Northport (*i.e.*, there are residences near the U.S.-Canada border outside of Northport). Therefore, the density of sampling stations for outdoor air is not adequate to provide spatially representative data for locations outside of Northport and additional monitoring stations per exposure area may be needed to characterize exposures.

Temporal Representativeness

The Ecology air monitoring stations in Northport provide measured outdoor air data from September 1997 to December 1998 for three monitoring stations – Northport School, Bennetch, and Sheep Creek. The TCM air monitoring station in Northport at Sheep Creek provides measured data from 1995 through 2006. At each air monitoring station, 24-hour samples have been collected on approximately a weekly basis.

Figure 9-8 presents an example of the temporal patterns for arsenic, cadmium, lead, and zinc in outdoor air at each monitoring station in Northport. As shown, metal concentrations in outdoor air show a marked decrease between 1995 and 1998. A decrease in air concentrations is also seen beginning in January 2000. This decrease in air concentrations is likely due to the implementation of a new technological process at the Trail facility. Because the goal of the risk assessment is to evaluate risks under current site conditions, the data adequacy evaluation for exposures to outdoor air in Northport was restricted to air samples collected post-1999.

Adequacy of the Analytical Suite

As shown in Table 9-8, measured data are only available for arsenic, cadmium, lead, and zinc for air monitoring stations in Northport (Reach 1). In order to assess potential human health risks to COIs in outdoor air due to smelter emissions, additional data are needed which provide measured concentrations for the full list of common metals presented in Table 5-1.

Analysis of outdoor air for the less common trace elements is not deemed necessary because there are limited toxicity data available for these analytes and it is anticipated that their contribution to risks are likely to be minor relative to the common metals. Therefore, analysis of these analytes in outdoor air is not a critical data gap for the purposes of evaluating risks.

As noted above, the principal human health COIs for outdoor air due to stack emissions from the Trail facility are metals. Therefore, analysis of other non-metal COIs is not a critical data gap for the purposes of evaluating risks.

Detection Limit Evaluation

Appendix E summarizes the DL evaluation for outdoor air in Northport (Reach 1). As seen, all analyzed metals had DLs that were less than the LOPC and deemed adequate for assessing human health risks.

Uncertainty Evaluation

Appendix F1 presents the ProUCL output which details the 95UCL calculation for each COI in outdoor air in Northport (Reach 1). Appendix F2 summarizes the uncertainty in the 95UCL for outdoor air. As seen, the ratio of the 95UCL to the arithmetic mean was less than 2 for all analyzed metals. Based on this, it is expected that large sets will not be required to limit uncertainty in the EPCs for these metals.

Preliminary Risk Calculations

Appendix D presents the preliminary risk calculations in Northport (Reach 1). As seen, estimated risks were slightly above the LOPC for arsenic. Because screening level risks from inhalation of metals in outdoor air were low (*i.e.,* HQs < 0.1 and risks < 1E-05), this suggests that exposures to these metals in air are likely to be minor. However, because measured data are only available for arsenic, cadmium, lead, and zinc, it is not possible to determine potential risks from other metals.

Conclusions

While the existing outdoor air data set does provide information on spatial and temporal variability for several metals, the data adequacy assessment shows that:

- Additional sampling may be needed to provide spatial representativeness outside of Northport.
- Because of the potential for decreasing time trends, additional sampling is needed in Northport to characterize current conditions.
- Additional outdoor air samples are needed in Northport to provide measured data on the full list of common metals.
- Based on the available data for arsenic, cadmium, lead, and zinc, potential risks from inhalation of these metals are likely to be minor. But, it is not possible to determine potential risks from other metals.

9.5.5 Outdoor Air Impacted by Windblown Sediments

As a result of reservoir operations, water levels in the UCR fluctuate seasonally. At full pool (1,290 ft amsl), Lake Roosevelt extends upstream from Grand Coulee Dam to approximately Onion Creek (RM 730). During typical low pool conditions in the spring, water levels drop to about 1,245 ft amsl exposing large areas of sediment along the UCR (EPA 2003a). In these exposed areas, fine-grained sediment particles may become airborne as a result of atmospheric disturbances.

Spatial Representativeness

The USGS air monitoring stations in Kettle Falls/Marcus Flats, Inchelium, and Seven Bays (Reaches 3, 4b, and 5, respectively) provide measured outdoor air data from January 2002 to May/June 2006. These monitoring locations were selected because they represent areas near large expanses of exposed sediment which become exposed during drawdown and may become airborne. At each air monitoring station, 24-hour samples have been collected on approximately a weekly basis from January through September across several years.

Figure 9-9 presents an example of arsenic concentrations for each air monitoring station. As seen, mean arsenic concentrations for each monitoring station tend to be generally similar, but there may be a slight tendency for mean concentrations to decrease with increasing distance downstream. As shown in Figure 9-10, a similar spatial pattern is seen for several other metals (cadmium, copper, lead, zinc).

These data suggest that spatial patterns may be present in outdoor air. However, the existing measured data do not provide adequate information on spatial trends across all beaches or reaches where human exposures may occur.

Temporal Representativeness

Figure 9-11 presents an example of the temporal patterns for arsenic in outdoor air at each monitoring station from 2002 to 2006. As shown, air concentrations tend to vary both within years and across years. With regard to long-term trends, measured concentrations in 2002-2003 appeared to be somewhat lower than 2004-2005 based on a visual comparison (this trend is most evident at the Kettle Falls/Marcus Flats station). This may be due to the fact that reservoir levels were not as low in 2002-2003 (Majewski and Kahle 2005), thus there was less exposed sediment than in more recent years. The increase could also be due to changes in sampling methodology implemented in 2004 to focus the sampling days to time periods when sediments were exposed (Kahle and Majewski 2003). Based on the available data, long-term trends are not apparent.

Figure 9-12 presents an example of the short-term variability in arsenic concentrations at each monitoring station in 2005. In this figure, the timeframe of the maximum reservoir drawdown period in 2005 (*i.e.,* lake elevation less than about 1260 ft amsl) is shaded and mean daily wind speeds at each monitoring location are displayed. As shown, arsenic air concentrations tended to be fairly variable within the year. Although the highest arsenic concentrations in air near Marcus

Flats tended to coincide with the beginning of the spring drawdown period, based on the available data, there does not appear to be a clear relationship between elevated arsenic air concentrations and the spring reservoir drawdown period or wind speed. However, additional outdoor air data would be need to be collected on a smaller time-scale (*e.g.,* daily, hourly) to better understand these relationships.

While these data provide general information on outdoor air concentrations over a wide range of time, it is not clear if these data have adequately captured results from high wind events. During periods of reservoir drawdown when larger areas of dried sediments become exposed, these high wind events may greatly increase concentrations of COIs in outdoor air and may be important in assessing potential acute health impacts from short-term inhalation exposure scenarios.

Adequacy of the Analytical Suite

As shown in Table 9-9, measured data are available for most metal COIs (both the common metals and the less common trace elements). No outdoor air samples were analyzed for non-metal COIs or radionuclides.

Because pesticides, PAHs, SVOCs, PCBs, dioxins/furans, and PBDEs have relatively low volatility, their presence in air can be predicted from PM10 measures. Therefore, analysis of these analytes in outdoor air is not a critical data gap for the purposes of evaluating risks.

In order to assess potential human health risks to COIs in outdoor air, additional data are needed which provide measured concentrations for the full list of COIs for common metals and radionuclides presented in Table 5-1.

Detection Limit Evaluation

Appendix E summarizes the DL evaluation for outdoor air for each reach. As seen, all analyzed metals had DLs that were less than the LOPC and deemed adequate for assessing human health risks.

Uncertainty Evaluation

Appendix F1 presents the ProUCL output which details the 95UCL calculation for each metal in outdoor air in each reach. Appendix F2 summarizes the uncertainty in the 95UCL for outdoor air for each reach. As seen, the ratio of the 95UCL to the arithmetic mean was less than 2 for most metals in most reaches. Based on this, it is expected that large sets will not be required to limit uncertainty in the EPCs for these chemicals. The ratio of the 95UCL to the arithmetic mean was higher than 2 for several metals. With the exception of barium and beryllium, inhalation toxicity data are not available for these analytes; therefore, additional sampling is not a critical data gap for baseline HHRA. For barium and beryllium, results indicate that additional data may be needed to reduce uncertainty in the EPC for these COIs.

Preliminary Risk Calculations Under Routine Conditions

Based on Measured Data

Appendix D presents the preliminary risk calculations for inhalation exposures to metals in outdoor air in Reaches 3, 4b, and 5 (where measured data are available). As seen, estimated risks were above the LOPC for barium and manganese. However, because HQs for these metals tended to be low (*i.e.,* ≤ 0.3), this suggests that risks from long-term inhalation of metals in outdoor air are likely to be minor.

Based on Estimated Data

Because measured concentration data in air are not available for all COIs and all reaches, inhalation exposures were also evaluated using outdoor air concentrations predicted from measured concentrations in sediment using a particulate emission factor (PEF) of 1.3E-08 kg soil/m^3 air. This PEF is based on the approach recommended in EPA's *Soil Screening Guidance* (EPA 1996b), using site-specific adjustments to account for potential differences in UCR Site vegetative cover, average annual wind speed, source area size, and particle size enrichment (see Table 9-9). As shown in Appendix D, with the exception of manganese in Reaches 1 and 2, risks based on this predictive approach were below the LOPC for all COIs. For manganese, HQs tended to be low (*i.e.,* ≤ 0.3), which suggests that risks from long-term inhalation of COIs in outdoor air impacted by sediment-derived particulates are likely to be minor.

A comparison of PEF-estimated air concentrations to measured concentrations shows that measured metals concentrations tended to be 2-50 times higher than estimated concentrations. The basis for the discrepancy between measured and estimated concentrations of metals in air is not known. This may suggest that the PEF used to estimate outdoor air concentrations is too low. However, the PEF utilized was more than 10 times higher than the default PEF[21] recommended in the *Soil Screening Guidance* (EPA 1996b). If it were assumed that the PEF were 1,000 times higher than the value used above, predicted risks for most metals would be above the LOPC, but all non-metal COIs would be below the LOPC. This indicates that that inhalation exposures from non-metal COIs are likely to be negligible.

The differences between measured and PEF-estimated concentrations of metals in air could also suggest that contributions of sediment-derived metals in outdoor air are minor compared to other sources under routine conditions. In order to determine the potential contribution of sediment-derived particulates to outdoor air concentrations, measured data are needed on the concentrations of metals in background outdoor air.

Because screening level risks from long-term inhalation of outdoor air were low based on both measured air data and PEF-estimated data, additional data collection under routine (ambient) conditions is not likely to be necessary to address this exposure scenario. A final decision to collect additional data will be deferred until other sediment-associated exposure scenarios have been adequately characterized.

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[21] Default PEF of 1.32E+09 m^3air/kg soil (which is equivalent to 7.58E-10 kg soil/m^3 air).

Preliminary Risk Calculations Under Windstorm Conditions

As discussed above, long-term exposures to COIs in outdoor air under routine conditions is likely to be low. However, under windstorm conditions, outdoor air concentrations may be much higher; therefore, it is important to assess potential health impacts from short-term exposures to air concentrations during wind storm events. A comparison of the maximum detected concentrations at the USGS monitoring stations to acute inhalation toxicity benchmarks (see Appendix J), shows that results are below the LOPC for all metals at all stations.

However, the available measured data specific to wind storm events are quite limited (*i.e.,* there are only a handful of observations noted as "high wind event" from the USGS air monitoring stations in the lower reaches), and it is not clear if these data have adequately captured results from high wind events. Therefore, collection of measured data on metals and radionuclides in outdoor air measurements during windstorm events is identified as a data gap that requires additional data collection. Initially, outdoor air data collection efforts should focus on those locations where there are large expanses of exposed contaminated sediments and the potential for windblown erosion and transport is high during high wind conditions.

Conclusions

The data adequacy assessment for outdoor air shows that:

- Based on the available data, potential risks from inhalation of sediment-derived COIs in outdoor air under routine conditions are likely to be low. Additional data collection under routine (ambient) conditions is not likely to be necessary to address this exposure scenario.
- Measured levels of metals in background air are needed to determine the potential contribution of sediment-derived particulates to outdoor air concentrations.
- Sampling is needed to specifically target levels of common metals and radionuclides in outdoor air that occur during high wind dust storms at beaches with exposed sediment. Future data collection efforts should focus on those locations where there are large expanses of exposed contaminated sediments and the potential for windblown erosion and transport is high during high wind conditions.

9.5.6 Indoor Dust

Dust inside tents, campers, and recreational vehicles (RVs). For recreational visitor populations, it is anticipated that dust concentrations inside tents, campers, and RVs is likely to be closely related to outdoor soil/sediment, so the need to separate the two exposure pathways is not clear. Further, it is expected that a majority of time spent at the site will be outdoors, so the relative contribution of indoor dust to incidental soil/sediment/dust intake will likely be low compared to outdoor soil/sediment. Finally, there are no data on the relative intakes of soil/sediment and indoor dust by recreational populations, so the intake factor selected has been chosen to include both. Thus, incidental soil/sediment ingestion exposure calculations for recreational visitors include the indoor dust pathway, and indoor dust exposures are not quantified separately here.

Dust inside residences. No data are available which provide information on indoor dust concentrations inside residences that may be impacted due to fugitive dust and/or track-in. Typically, residential exposure scenarios assume that indoor dust is derived in large part (70%) from soil particles originating in the yard of the property. However, this conceptual model does not account for direct track-in from non-yard sources. At the UCR site, individuals who frequent site beaches may bring contaminated sediment back to the home on shoes or clothing, and this could contribute to indoor dust contamination. Wind-blown sediment transport might also be important in some cases. The relative magnitude of these pathways for dust contamination with sediment is unknown, and might range from very minor to potentially quite significant. In the absence of measured data, the preliminary risk estimates conservatively assume that the contribution from non-yard sources is large.

For the purposes of this document, an evaluation of residential exposures to indoor dust was performed based on an assumption that indoor dust concentrations were equal to 70% of measured concentrations in surface sediment (EPA 1994a). Note that this assumption is likely to be conservative, since it is based on a scenario in which the residence is entirely surrounded by the source material (yard soil). At the UCR site, residences are located outside of the beach areas and away from the source (beach sediment), and hence the opportunity for airborne or track-in contamination of dust with sediment is much reduced.

Because indoor dust concentrations are estimated from surface sediment, all of the data limitations noted in the surface sediment data adequacy section above (Section 9.5.2) with regard to spatial and temporal representativeness, analytical suite adequacy, and the uncertainty evaluation also apply to indoor dust.

Detection Limit Evaluation

Because no data have been reported for COIs in indoor dust in residences near the site, no evaluation of detection limits is possible.

Preliminary Risk Calculations

Appendix D presents the preliminary risk calculations for ingestion of indoor dust by residents. As seen, estimated risks were above the LOPC for several metals, but below the LOPC for all other non-metal COIs. Because the preliminary risk estimates exceed the LOPC, this pathway can not be identified as insignificant for metals, and indoor dust data is identified as a data gap. However, because of the high uncertainty in the estimation approach, collection of indoor dust will be deferred until measured yard soil data are available and the on-site exposure scenarios have been adequately characterized.

Conclusions

Measured indoor dust data from residences potentially impacted by UCR sediments were not available, so dust concentrations were estimated from surface sediment data using a simplified assumption (*i.e.,* indoor dust = 0.70 * surface sediment). The data adequacy assessment shows that:

- Based on estimated data, risks to residents from ingestion of metals in indoor dust were above the LOPC. Therefore, this pathway can not be identified as insignificant and indoor dust is identified as a data gap.
- Based on estimated data, potential risks from ingestion of non-metal COIs in indoor dust are likely to be low.
- Collection of indoor dust will be deferred until measured yard soil data are available and the on-site exposure scenarios have been adequately characterized.

9.5.7 Indoor Air in Residences, Tents, Campers, and RVs

No measured data are available which provide information on air concentrations inside residences, tents, campers, or recreational vehicles (RVs).

Indoor air has the potential to be influenced by several site media, including outdoor air (via ventilation) and indoor dust (via re-suspension of particulates derived from track-in and windborne deposition). The relationship between outdoor air and indoor air will depend upon the amount of shielding offered by the structure (*i.e.,* structures act as barrier to airborne dusts). For example, comparisons of lead air concentrations indoors and outdoors for residences near lead point sources shows that indoor air concentrations are typically 30%-80% of outdoor air concentrations (EPA 1989b). The relationship between indoor dust and indoor air will depend upon re-suspension and deposition rates that can vary as a function of human activity patterns, flooring materials, dust reservoir source materials, etc.

For the preliminary risk calculations performed to assess potential data needs, estimated indoor air concentrations were calculated as follows:

$$C_{\text{air, indoor}} = C_{\text{air, outdoor}} \cdot (1\text{-SHF}) + C_{\text{sediment}} \cdot F_{\text{sd}} \cdot \text{DRF} \cdot \text{CF}$$

where:

$C_{\text{air, indoor}}$ = Estimated indoor air concentration (mg/m^3 air)
$C_{\text{air, outdoor}}$ = Outdoor air concentration (mg/m^3 air)
SHF = Shielding factor; fraction of outdoor air that is shielded from indoor air (unitless)
C_{sediment} = Sediment concentration (mg/kg)
F_{sd} = Fraction of indoor dust attributable to sediment (unitless)
DRF = Dust resuspension factor (µg dust/m^3 air)
CF = Conversion factor (10^{-9} kg/ µg)

Indoor air concentration estimates were calculated based on the following conservative assumptions:

- the shielding factor (SF) was 0 (*i.e.,* there is no shielding)
- the fraction of indoor dust attributable to sediment (F_{sd}) was 0.70 (see Section 9.5.6)
- the dust resuspension factor (DRF) was 54 µg /m^3 [based on mean peak PM_{10} levels measured during simulated residential activities (Qian et al. 2008)]

Because indoor air concentrations are estimated from outdoor air and sediment, all of the data limitations noted in the data adequacy sections for these media above (Sections 9.5.2, 9.5.4, and 9.5.5) with regard to spatial and temporal representativeness, analytical suite adequacy, and the uncertainty evaluation also apply to indoor air.

Detection Limit Evaluation

Because no data have been reported for COIs in indoor air in inside tents, campers, or RVs at the site or in residences near the site, no evaluation of detection limits is possible.

Preliminary Risk Calculations

Based on Measured Outdoor Air Data

Appendix D presents the preliminary risk calculations from inhalation exposures to indoor air for each reach where measured outdoor air data are available. As seen, estimated risks were above the LOPC for several metals, including arsenic, barium, cadmium, cobalt, and manganese.

Based on Estimated Outdoor Air Data

Because measured outdoor air concentration data are not available for all COIs and all reaches, inhalation exposures were also evaluated using outdoor air concentrations predicted from measured concentrations in sediment using a PEF approach (see Section 9.5.5 for details). As shown in Appendix D, risks based on this predictive approach were above the LOPC for several metals, but below the LOPC for all non-metal COIs. This indicates that that inhalation exposures from non-metal COIs are likely to be negligible.

Because the preliminary risk estimates exceed the LOPC, this exposure pathway can not be identified as insignificant, and indoor air data is identified as a data gap. However, because of the high uncertainty in the estimation approach, collection of data on indoor air may be deferred until on-site exposure scenarios have been adequately characterized and measured data on site-specific background levels of metals in environmental media of interest have been collected.

Conclusions

Measured indoor air data were not available, so indoor air concentrations were estimated from outdoor air and indoor dust based on a conservative modeling approach. The data adequacy assessment shows that:

- Based on estimated data, risks from inhalation of metals in indoor air were above the LOPC. Therefore, this pathway can not be identified as insignificant and indoor air is identified as a data gap.
- Based on estimated data, potential risks from inhalation of non-metal COIs in indoor air which are derived from outdoor air particulates and resuspended indoor dust are likely to be low.
- Collection of indoor air may be deferred until on-site exposure scenarios have been adequately characterized and measured data on site-specific background levels of metals in environmental media of interest have been collected.

9.5.8 Sweat Lodge Air

No measured data are available which provide information on air concentrations in sweat lodges utilizing UCR surface water as a water source.

For the preliminary risk calculations performed to assess potential data needs, air concentrations were estimated using a simplified model of bulk water transport to air that assumes a water transfer factor of 0.15 liters of water per m^3 of air based on air saturation at 150^o F (reported in the Midnite Mine HHRA as a reasonable estimate of air temperature in a sweat lodge).

$$C_{air} = C_{water} \cdot TF$$

where:

C_{air} = Estimated air concentration inside sweat lodge (mg/m^3 air)
C_{water} = Surface water concentration (mg/L)
TF = Water transfer factor (0.15 L water/m^3 air)

It is suspected that this approach is likely to be conservative for non-volatile constituents such as metals, and hence air concentrations for metals estimated in this way are more likely to be biased high than low.

Because sweat lodge air concentrations are estimated from surface water, all of the data limitations noted in the surface water data adequacy section above (Section 9.5.1) with regard to spatial and temporal representativeness, analytical suite adequacy, and the uncertainty evaluation also apply to sweat lodge air.

Detection Limit Evaluation

Appendix E summarizes the DL evaluation for sweat lodge air estimated from unfiltered surface water data from Northport (Reach 1). As seen, estimated risks based on the mean DL for cadmium were above the LOPC. These results indicate that the cadmium DL achieved for surface water was not adequate to assess potential risks from sweat lodge exposures. To the extent feasible, future data collection efforts of surface water should investigate if alternative analytical methods for cadmium are available which may be able to achieve a lower DL. Note that DL requirements for surface water for the purposes of estimating sweat lodge exposures may be more stringent than those needed for water ingestion or dermal exposures because they are based on different toxicity values (*i.e.,* inhalation *vs*. oral).

Preliminary Risk Calculations

Appendix D presents the preliminary risk calculations for sweat lodge exposures to surface water from Northport (Reach 1). As seen, risks from inhalation exposure based on estimated sweat lodge air concentrations were above the LOPC for arsenic and cadmium. Cadmium was infrequently detected (18%) and, as noted above, risks are principally attributable to an inadequate DL. Although estimated risks for arsenic were slightly above 1E-05, because they are based on a limited surface water data set (*i.e.,* data are restricted to a single sampling location and were only analyzed for a subset of metals), collection of measured sweat lodge air data may be deferred until UCR surface water concentrations have been better characterized. Data needs for sweat lodge exposures will then be re-evaluated using the improved surface water data set.

Conclusions

Measured air data from sweat lodge exposures were not available, so air concentrations were estimated using a simplified model based on the limited surface water data set. Preliminary risks from inhalation of arsenic in sweat lodge air were above the LOPC. Therefore, this pathway can not be identified as insignificant and sweat lodge air is identified as a data gap. However, collection of measured sweat lodge air data may be deferred until UCR surface water concentrations have been better characterized.

9.5.9 Smoke-Filled Air from Burning of Plant Materials

When plant materials from the site are burned (*e.g.,* smoking game collected from the site, burning of plants used in medicinal treatments or Tribal ceremonies), smoke from the burning material may lead to inhalation exposure of humans. No data are available for the levels of contaminants that might be present in the smoke from burning site materials, measured data are not available on the levels in the materials that are likely to be burned, and no information is available on exposure parameters (*e.g.,* frequency, duration) for this scenario. For these reasons, no attempt was made in this document to perform initial risk calculations.

Collection of measured air data associated with this exposure scenario will be deferred until additional information is available on this exposure scenario, the types of materials that may be burned, and the COI concentrations in these materials.

9.5.10 Upland Soil

For the purposes of this document, upland soils are defined as soils located above the high pool water mark (although they may be within the historical floodplain). As described previously, upland soil at the UCR Site may be impacted by a variety of mechanisms, including aerial deposition from stack emissions, aerial deposition from windblown exposed sediments, historical flood (overbank) deposition, and irrigation.

Currently, no data are available that provide measured soil data in upland areas at the UCR Site. Therefore, for the purposes of this evaluation, it was assumed that COI concentrations in upland soils (including residential yard soils) were similar to concentrations in beach sediment. It is suspected that this assumption is likely to be conservative (at least for locations outside the historic floodplain), and that actual concentrations in upland soils are probably lower than concentrations in beach sediment.

Because upland soil concentrations are assumed to be equal to sediment, all of the preliminary risk estimates and data limitations noted in the data adequacy section for sediment (Section 9.5.2) also apply to upland soil.

Detection Limit Evaluation

Because no data have been reported for COIs in upland soils at the site, no evaluation of detection limits is possible.

Preliminary Risk Calculations

Appendix D presents the preliminary risk calculations for residential incidental ingestion and dermal exposures to soils for each reach. As seen, estimated risks from incidental ingestion of soil were above the LOPC for several metals. However, because it was assumed that upland soil concentrations were equal to beach sediment concentrations, risks may be biased high. Therefore, direct measurements of metals in upland soils at the UCR Site are needed.

With the exception of arsenic, estimated risks from dermal exposures to upland soil were below the LOPC for all analyzed COIs in all reaches, indicating that this exposure pathway is likely to be minor for most COIs. For arsenic, because screening level risks from dermal contact were below 1E-05 for all reaches, additional data collection is not likely to be necessary to address this exposure scenario. However, a final decision to collect additional data will be deferred until other exposure scenarios have been adequately characterized.

Conclusions

Measured upland soil data are not available, so soil exposure scenarios were evaluated based on the conservative assumption that soil concentrations were equal to measured concentrations in beach sediment. The data adequacy assessment shows that:

- Preliminary risk estimates suggest that risks from dermal contact exposures to soil are generally low, but risks from incidental ingestion of metals in upland soil have the potential to contribute to total risks.
- Measured upland soil data are needed for metals to allow for human exposure evaluations. Future data collection efforts for upland soils should focus on those areas where human exposures may occur that are most likely to be impacted by aerial and floodplain deposition.

9.5.11 Groundwater

Groundwater at the UCR Site has the potential to be impacted as a result of infiltration of contaminated surface water and also by leaching from contaminated sediment. As noted previously, there are 3,312 water wells, 12 water supply springs, and 131 public water systems that utilize groundwater located within 5 miles of the UCR and Lake Roosevelt shoreline. At the time of this report, measured groundwater data from locations near the UCR Site were not available.

Currently, it is unclear which wells in the vicinity of the UCR Site may be directly influenced by the river or Lake Roosevelt and which, if any, would be utilized directly as potable water sources without some treatment process. Therefore, information is needed to determine the location of groundwater wells that are influenced by surface water from the site and utilized directly as a potable water source. The list of COIs for future groundwater sample collection efforts will be determined based on a review of additional data for UCR surface water and sediment.

9.5.12 Fish/Shellfish

Spatial Representativeness

Nearly all of the available fish tissue samples were collected as part of the EPA 2005 Phase I Fish Tissue Study. As shown in Figure 6-8, sampling focus areas included locations in every exposure reach. Note that Reach 4 was not split into 4a and 4b in this investigation. Fish that were collected included a number of different species, including walleye, rainbow trout (wild and hatchery), lake whitefish, largescale suckers, and burbot. Fish tissue samples represent several tissue types, including fillet, whole body, offal, and gullet.

EPA (2007b) provides a detailed assessment of spatial trends by species and location for each tissue type. The following general conclusions were drawn:

- Tissue concentrations of cadmium, copper, lead, nickel, and uranium were greatest in the largescale sucker, with concentrations tending to be higher in the most upstream portions of the site. Based on an analysis of gut content, a large portion of the whole body concentration for largescale sucker may be from slag and or sediment in the gut. Zinc was also elevated in largescale suckers and mountain whitefish, particularly in the most upstream area (*i.e.,* Reach 1).

- Tissue concentrations of arsenic were 3-5 times higher in burbot compared to other species. Total arsenic tissue concentrations in burbot increased downstream (*i.e.,* higher in the lake-like portion of the site).

- Mercury was detected in tissues of all species evaluated, with the highest concentrations in walleye, burbot, and largescale suckers. The elevated concentrations in walleye and burbot are consistent with their feeding habits (*i.e.,* both are higher trophic level consumers that feed on other fish). There is a significant downstream increase in mercury tissue concentrations.

- Total PCB tissue concentrations (as Aroclor) were similar for walleye, wild and hatchery rainbow trout, lake whitefish, and burbot. Concentrations in largescale suckers were about 2.5 times higher than other species.

- Lake whitefish, largescale sucker, and burbot had the highest tissue concentrations of dioxins/furans. In general, concentrations were higher in the downstream samples for these species.

The existing whole-body fish tissue data have been collected from locations that span across the entire UCR Site and appear to be spatially representative (*i.e.,* all six of the main reaches are represented). However fillet tissue data are only available for a subset of the reaches (Reaches 1, 3, and 6). Therefore, additional data are needed on fillet tissues in all exposure reaches. In addition, there may be particular locations that warrant sampling due to increased human use.

Temporal Representativeness

Because most of the data were collected in the fall of 2005 as part of the EPA Phase I Fish Tissue Study, it is not possible to evaluate temporal patterns in fish tissues using measured data. However, an evaluation of temporal trends for surface water and sediment indicate that, while temporal patterns may be present, abiotic media concentrations do not exhibit wide temporal variability. While it is unlikely that fish tissue concentrations are varying widely over time, additional fish tissue data may be warranted to ensure data are representative of current and potentially future conditions.

Species Representativeness

Depending upon the receptor population (*e.g.,* recreational anglers, subsistence fisherman, tribal members), there may be a variety of fish species and tissue types (*e.g.,* fillet, organs) ingested in the diet and utilized as part of cultural practices. In the past, fish sampling efforts have focused on those species that are most likely to be important for human exposures. The species of primary focus for anglers include kokanee, rainbow trout, walleye, and smallmouth bass, while burbot, whitefish, suckers, and white sturgeon tend to be targeted less frequently (Patrick 1997).

A review of the available fish tissue data show that, with the exception of kokanee and white sturgeon, most of the key species targeted by anglers are represented. Because white sturgeon are very long-lived and live on or near the river bottom throughout their life, it is possible that this species may tend to be of more importance for bioaccumulative chemicals relative to other harvested species. Since spring 2002, fishing for white sturgeon upstream of Grand Coulee Dam to the U.S.-Canada border has been halted due to declining numbers[22]. However, sturgeon fishing may be allowed in the future if the population recovers.

Measured concentrations in shellfish are not available for the UCR Site.

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[22] http://uppercolumbiasturgeon.org/FAQs/FAQs.html

Adequacy of the Analytical Suite

As shown in Table 9-10, the available fish tissue data set for fillet and whole body tissues includes analyses of the common metals, PCBs (as Aroclor), PCB congeners (for a smaller subset of samples), and dioxin/furan congeners. While these COIs tend to be the most important bioaccumulative chemicals, other COIs may also accumulate in tissues. No fish tissue samples have been analyzed for the less common trace elements, radionuclides, pesticides, PAHs, and SVOCs. Only four fillet samples from Reach 3 provide measured data on PBDE congeners.

Analysis of fish tissues for the less common trace elements is not deemed necessary because there are limited toxicity data available for these analytes and it is anticipated that their contribution to risks are likely to be minor relative to the common metals. Therefore, analysis of these analytes in fish tissue is not a critical data gap for the purposes of evaluating risks.

In order to assess potential human health risks from ingestion of fish, additional data are needed which provide measured fish tissue concentrations for the complete list of COIs for radionuclides, pesticides, PAHs, SVOCs, and PBDEs presented in Table 5-1.

Detection Limit Evaluation

Appendix E summarizes the DL evaluation for fish ingestion in each reach. As seen, several metals had low detection frequencies (< 70%) and DLs that were not less than the LOPC. These results indicate that the DLs achieved for fish tissue were not adequate to assess potential risks from fish ingestion exposures for these COIs. To the extent feasible, future fish tissue data collection efforts should investigate if alternative analytical methods for these metals are available which may be able to achieve a lower DL.

Because results from multiple congeners are combined into a single TEQ, detection limit adequacy for congeners was evaluated using a different approach. For each sample, risks were first calculated by evaluating non-detect results at the reported detection limit. Then, risks were re-calculated by evaluating non-detect results at zero. If congener detection limits are not adequate, it is expected that estimated risks would be above the LOPC when non-detects are evaluated at the detection limit and below the LOPC when non-detects are evaluated at zero. Figure 9-13 presents a comparison of average estimated risks based on the two non-detect approaches for a traditional subsistence exposure scenario. As seen, estimated risks were above the LOPC regardless of the non-detect approach. This indicates that risks are primarily driven by detects and the contribution of non-detect congeners to the total TEQ is generally small. Therefore, the achieved detection limits for congeners were adequate to assess potential risks from fish ingestion exposures.

Uncertainty Evaluation

Appendix F1 presents the ProUCL output which details the 95UCL calculation for each COI in fish tissue for each reach. Appendix F2 summarizes the uncertainty in the 95UCL for each COI in fish tissue for each reach. As seen, the ratio of the 95UCL to the arithmetic mean was higher than 2 for PCBs in fillet tissues and several metals and PCBs in whole body tissues in one or more reaches. These results indicate that additional data may be needed to reduce uncertainty in the EPCs for these COIs.

Preliminary Risk Calculations

Appendix D presents the preliminary risk calculations for fish ingestion exposures based on measured concentrations for each reach. Risks were calculated using two alternate estimates of EPC – based on fillet tissues and based on whole body tissues. As seen, estimated risks were above the LOPC for several metals (including mercury), PBDEs, PCBs, and dioxins/furans. Because screening level non-cancer HQs were above 1 and cancer risks were above 1E-04 for several COIs, high priority should be given to future data collection efforts designed to address uncertainties related to the evaluation of ingestion of these COIs in fish tissues.

Other Data Limitations

Arsenic that accumulates in fish tissue is generally a mixture of inorganic arsenic (this is the form that is of chief concern for human health risk) and various organic forms of arsenic (these are of much lesser health concern). Therefore, evaluation of risks from arsenic in fish requires information on the fraction of the total arsenic that is inorganic. The EPA 2005 Phase I Fish Study included arsenic speciation analysis on approximately 20% of the collected tissue samples. However, many of the analyzed samples failed to meet the specified Analytical Concentration Goals (ACGs), causing a majority of the arsenic speciation results to be qualified as non-detect or estimated values (EPA 2007b). For the purposes of the preliminary risk calculations, it was assumed that 10% of the measured total arsenic in fish tissue was inorganic (EPA 2003b). As seen in Appendix D, based on this assumption, estimated risks from ingestion of arsenic in fish tissues were above the LOPC. Therefore, future data collection efforts to characterize the concentrations of COIs in fish tissue should include analyses using methods that provide reliable information on the fraction of total arsenic that is inorganic.

Conclusions

While the existing fish tissue data set does provide information on spatial variability for a majority of the COIs for several species and tissue types, the data adequacy assessment shows that:

- Based on the available data, risks from ingestion of several metals, PBDEs, PCBs, and dioxins/furans due in fish tissue have the potential to contribute substantially to total risks; therefore, high priority should be given to future data collection efforts designed to address uncertainties in this exposure scenario.
- Additional sampling is needed to provide information on fish tissue levels under current site conditions and fillet tissue samples are needed for all exposure reaches.
- Fish tissue samples are needed which provide measured data on COIs for radionuclides, pesticides, PAHs, SVOCs, and PBDEs, as well as arsenic speciation.
- Future data collection efforts should include analysis of all 209 PCB congeners (*e.g.,* EPA Method 1668A) in preference to analysis of total PCBs as Aroclors.

- Data are needed for species that are important in the diet of recreational and/or subsistence populations, specifically including white sturgeon, kokanee, and shellfish.

9.5.13 Game/Waterfowl

No data are available which provide measured tissue concentrations in wild game/waterfowl from the UCR Site.

For the purposes of this report, tissue concentrations were estimated using bioaccumulation (uptake) factors. Ideally, a tissue estimation approach for mobile wildlife receptors that are exposed both in upland areas and along beaches would incorporate information on both exposure media:

$$C_{tissue} = AUF \cdot C_{sediment} \cdot BAF_{sediment} + (1\text{-}AUF) \cdot C_{soil} \cdot BAF_{soil}$$

where:

AUF = area use factor for beaches
C_i = COI concentration in medium ‘i’
BAF_i = receptor-specific bioaccumulation factor for medium ‘i’

If the receptor were only exposed along beaches, the AUF would be 1. If the receptor were only exposed in upland areas, the AUF would be 0. In the case of wild game and waterfowl, the true AUF is likely to be higher than 0 but less than 1, with a tendency to probably be higher for waterfowl than wild game. Currently, information on AUF is not available for wild game or waterfowl and there are no measured data available for upland soils. Therefore, for the purposes of performing preliminary risk calculations, it was assumed that COI concentrations in upland soils were similar to concentrations in beach sediment (the equivalent of setting the AUF to 1). This assumption is likely to be highly conservative (at least for locations outside the historic floodplain) since it is anticipated that concentrations in upland soils are much lower than concentrations in beach sediment.

For the purposes of this report, exposure scenarios for large game (*e.g.,* deer, elk) were evaluated based on estimated tissue concentrations derived from uptake models for beef (see Appendix B).

No uptake models were available for the purposes of estimating waterfowl tissue concentrations; therefore, waterfowl tissue data is identified as a data gap.

Because game tissue concentrations were estimated from measured sediment and surface water data, all of the data limitations noted in the surface water and surface sediment data adequacy sections above (Section 9.5.1 and 9.5.2, respectively) with regard to spatial and temporal representativeness, analytical suite adequacy, and the uncertainty evaluation also apply to estimated tissues.

Detection Limit Evaluation

Because no data have been reported for COIs in tissues from waterfowl or game species harvested at the site, no evaluation of detection limits is possible.

Preliminary Risk Calculations

It is important to note that there is high uncertainty in the modeling approach for large game (*i.e.*, based on a beef uptake model which assumes upland soil concentrations are equal to beach sediment) and the resulting tissue concentrations are likely to be biased high. The preliminary risk calculations based on estimated game tissue concentrations were derived solely to support an initial prioritization of data collection needs for the baseline HHRA.

Appendix D presents the preliminary risk calculations for wild game exposures based on estimated tissue concentrations for each reach. As seen, estimated risks from ingestion of game were above the LOPC for several COIs, including many of the common metals, dioxins/furans, PCBs, and several pesticides and PAHs/SVOCs.

With the exception of PCBs and dioxins/furans, potential risks based on dermal contact with tissues during food preparation/preservation activities were below the LOPC for all COIs, indicating that this is likely to be a minor exposure pathway for most chemicals. Because screening level risks for PCBs and dioxins/furans from dermal contact with game were typically below 1E-05, and because dermal contact risks were more than 100-1000 times lower than risks from ingestion, additional data collection is not likely to be necessary to address this exposure scenario. However, a final decision to collect additional data will be deferred until other on-site exposure scenarios have been adequately characterized.

Conclusions

Measured game tissue data were not available, so large game concentrations were estimated from sediment and surface water using uptake models for beef. Based on this approach, initial risk calculations indicated some risks may exceed the LOPC. However, because of the high uncertainty in the modeling approach for game (*i.e.*, based on a beef uptake model which assumes upland soil concentrations are equal to beach sediment), collection of measured tissue data may be deferred until data on upland soils have been better characterized. It is important to note that, even if measured data were available for upland soils, there is still no site-specific information to adjust the AUF and the application of the available uptake model would still be highly uncertain.

There are no measured waterfowl tissue data from the UCR and waterfowl-specific uptake models were not available to estimate tissue concentrations. Because of the relatively high exposure potential for waterfowl, the absence of waterfowl tissue data is considered a high priority data gap. However, collection of measured data may be deferred if a conservative method to estimate waterfowl tissue concentrations demonstrates that estimated risks will not exceed the LOPC.

If it is determined that data collection is needed in the future, because sampling of game/waterfowl for the sole purpose of tissue analysis may not be feasible, an option may be to collect opportunistic tissue samples of game/waterfowl from local hunters.

9.5.14 Terrestrial (Upland) Plants

No data are available which provide measured tissue concentrations in terrestrial (upland) plants at the UCR Site.

For the purposes of this report, terrestrial plant tissue levels of chemicals were evaluated based on soil uptake models for terrestrial plants from the literature (see Appendix B). Currently, there are no measured data available for upland soils. Therefore, preliminary risk calculations were performed assuming that COI concentrations in upland soils were similar to concentrations in beach sediment. This assumption is likely to be highly conservative since it is anticipated that concentrations in upland soils are much lower than concentrations in beach sediment.

Because terrestrial plant tissue concentrations were estimated from measured sediment data, all of the data limitations noted in the surface sediment data adequacy section above (Section 9.5.2) with regard to spatial and temporal representativeness, analytical suite adequacy, and the uncertainty evaluation also apply to plant tissues.

Detection Limit Evaluation

Because no data have been reported for COIs in terrestrial plant tissues from the site, no evaluation of detection limits is possible.

Preliminary Risk Calculations

It is important to note that there is high uncertainty in the modeling approach for terrestrial plants (*i.e.,* upland soil is assumed to have COI concentrations equal to beach sediment) and the resulting tissue concentrations are likely to be biased high. Therefore, the preliminary risk calculations based on these estimated terrestrial plant tissue concentrations were derived solely to support an initial prioritization of data collection needs for the baseline HHRA.

Appendix D presents the preliminary risk calculations for terrestrial plant exposures based on estimated tissue concentrations for each reach. As seen, estimated risks from ingestion of gathered terrestrial plants in the diet were above the LOPC for several COIs, including many of the common metals, dioxins/furans, PCBs, and several pesticides and PAHs/SVOCs. Screening level risk estimates for metals tended to be higher than for non-metal COIs. Estimated risks for non-metal COIs were generally low (*i.e.,* HQs were less than 0.1 and cancer risks were typically at or below 1E-05).

Potential risks based on tribal exposure scenarios, such as dermal contact with terrestrial plant materials during medicinal/ceremonial activities, were below the LOPC for all COIs, indicating that this is likely to be a minor exposure pathway.

Conclusions

Measured terrestrial plant tissue data were not available, so concentrations were estimated using plant uptake models. Based on this approach, initial risk calculations indicated some risks may exceed the LOPC. However, because of the high uncertainty in the modeled concentrations of contaminants in terrestrial plant tissues (*i.e.,* estimates are based on the assumption that upland soil concentrations are equal to beach sediment), collection of measured terrestrial plant tissue data may be deferred until upland soils have been better characterized.

9.5.15 Aquatic (Riparian) Plants

No data are available which provide measured tissue concentrations in aquatic (riparian) plants at the UCR Site.

Aquatic (riparian) plant tissue levels of chemicals were estimated using plant uptake models from the literature. As shown in Appendix B, available sediment uptake models for aquatic plants were fairly limited (models are only available for metals and PCBs). For COIs where aquatic plant uptake models were not available, tissue concentrations were estimated based on uptake models for terrestrial plants.

Because aquatic plant tissue concentrations were estimated from measured sediment data, all of the data limitations noted in the surface sediment data adequacy section above (Section 9.5.2) with regard to spatial and temporal representativeness, analytical suite adequacy, and the uncertainty evaluation also apply to aquatic plant tissues.

Detection Limit Evaluation

Because no data have been reported for COIs in aquatic plant tissues from the site, no evaluation of detection limits is possible.

Preliminary Risk Calculations

It is important to note that, because of uncertainties in the modeling approach for aquatic plants, the preliminary risk calculations based on these estimated plant tissue concentrations were derived solely to support an initial prioritization of data collection needs for the baseline HHRA.

Appendix D presents the preliminary risk calculations for aquatic plant exposures based on estimated tissue concentrations for each reach. As seen, estimated risks from ingestion of gathered aquatic plants in the diet were above the LOPC for several COIs, including many of the common metals, dioxins/furans, PCBs, and several pesticides and PAHs/SVOCs. Screening level risk estimates for metals tended to be higher than for non-metal COIs. Estimated risks for non-metal COIs were generally low (*i.e.,* HQs were less than 0.1 and cancer risks were typically at or below 1E-05).

Potential risks from dermal contact based on tribal exposure scenarios, such as dermal contact with aquatic plant materials during medicinal/ceremonial activities and during basket weaving activities, were below the LOPC for all COIs, indicating that these are likely to be minor exposure pathways. Preliminary risk estimates for incidental ingestion of aquatic plant materials during basket weaving activities were above the LOPC for arsenic and bis(2-chloroethyl)ether. However, because screening level risks were at or below 1E-05 for all reaches, additional data collection is not likely to be necessary to address this exposure scenario. A final decision to collect additional data will be deferred until site-specific information is available on potential basket-weaving exposure scenarios.

Conclusions

Measured aquatic plant tissue data were not available, so concentrations were estimated using aquatic plant uptake models. Preliminary risks based on estimated tissue concentrations in aquatic plants were above the LOPC. Therefore, this exposure pathway can not be identified as insignificant and aquatic plant data is identified as a data gap. However, data collection for aquatic plants may be deferred until information on the species that may be utilized by humans is provided by site-specific surveys.

9.5.16 Crops Irrigated with UCR Water

No data are available which provide measured tissue concentrations in crops that have been irrigated with UCR Site water.

Appendix G presents the screening level approach used to estimate the increase in concentration of chemicals in garden soil attributable to long-term irrigation with UCR Site surface water. For the purposes of this report, crop tissue concentrations were estimated based on soil to terrestrial plant uptake models from the literature (see Appendix B). Because tissue concentrations were estimated from measured surface water data, all of the data limitations noted in the surface water data adequacy section above (Section 9.5.1) with regard to spatial and temporal representativeness, analytical suite adequacy, and the uncertainty evaluation also apply to crops.

Detection Limit Evaluation

Because no data have been reported for COIs in crops from the site, no evaluation of detection limits is possible.

Preliminary Risk Calculations

It is important to note that there is high uncertainty in the modeling approach for irrigated crops. Therefore, the preliminary risk calculations based on estimated crop tissue concentrations were derived solely to support an initial prioritization of data collection needs for the baseline HHRA.

Appendix D presents the preliminary risk calculations for ingestion of irrigated crops based on estimated tissue concentrations for Reach 1[23]. As seen, estimated risks were above the LOPC for several metals. It is important to note that, although preliminary risk estimates were above the

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[23] Because tissue concentrations were estimated from surface water, and uncensored surface water data are only available from Northport (Reach 1), irrigated crop exposures could only be evaluated in Reach 1.

LOPC, the fraction of the total risk attributable to irrigation was usually less than about 15% for most metals, and estimated risks based on "background" (*i.e.,* un-impacted by irrigation) soil conditions were also above the LOPC. This suggests that the screening level approach utilized to estimate crop tissue concentrations may be overly conservative.

Conclusions

Measured concentrations of COIs in crops from the site were not available, so concentrations were estimated using soil to terrestrial plant uptake models available in the literature. Garden soil concentrations utilized in the plant uptake model were estimated using screening level approach based on a limited surface water data set (*i.e.,* data are restricted to a single sampling location and were only analyzed for a subset of metals). Based on this approach, initial risk calculations indicated risks exceed the LOPC. However, because of the high uncertainty in the estimation approach and limitations in the surface water data set, the collection of measurements of COIs in crops from the site may be deferred until UCR surface water concentrations have been better characterized and measured data for upland soil are available.

9.5.17 Livestock

No data are available which provide measured tissue concentrations in livestock that utilize water derived from the UCR Site as a drinking water source or are fed plant materials irrigated with UCR Site water.

For the purposes of this report, livestock tissue concentrations were estimated based on uptake models for beef from the literature (see Appendix B). Because tissue concentrations were estimated from measured surface water data, all of the data limitations noted in the surface water data adequacy section above (Section 9.5.1) with regard to spatial and temporal representativeness, analytical suite adequacy, and the uncertainty evaluation also apply to livestock.

Detection Limit Evaluation

Because no data have been reported for COIs in tissues of livestock watered using UCR-derived water and/or grazed in areas potentially impacted by site media, no evaluation of detection limits is possible.

Preliminary Risk Calculations

It is important to note that there is high uncertainty in the modeling approach for livestock. Therefore, the preliminary risk calculations based on estimated livestock tissue concentrations were derived solely to support an initial prioritization of data collection needs for the baseline HHRA.

Appendix D presents the preliminary risk calculations for ingestion exposures of livestock based on estimated tissue concentrations for Reach 1[24]. As seen, estimated risks from ingestion of livestock watered with water from the site were above the LOPC for several metals. However, as noted above, estimated risks based on “background” soil conditions were also above the LOPC. Therefore, resulting risk estimates for livestock exposure scenarios may be overly conservative.

Conclusions

Measured concentrations of COIs in livestock from the site were not available, so concentrations were estimated from beef uptake models available in the literature. Based on this approach, initial risk estimates indicated risks exceed the LOPC. However, because of the high uncertainty in the modeled concentrations of contaminants in livestock tissues and limitations in the surface water data set (*i.e.,* data are restricted to a single sampling location and were only analyzed for a subset of metals), the collection of measurements of COIs in livestock from the site may be deferred until UCR surface water concentrations have been better characterized and measured data for upland soil are available.

If it is determined that direct measurements of COIs in livestock from the site are needed in the future, because collection of livestock for the sole purpose of tissue analysis may not be feasible, an option may be to collect opportunistic tissue samples of livestock from local farmers.

9.5.18 Environmental Data Adequacy Conclusions Summary

As noted in the sections above, there are several environmental media for which the currently available data may not be adequate to support reliable risk calculations in the baseline HHRA. One of the goals of the data adequacy assessment was to use the preliminary risk estimates to help inform and guide future data collection efforts and prioritize data needs for the baseline HHRA.

Table 9-11 summarizes the non-lead COIs for each exposure pathway where the preliminary risk estimates indicated that further assessment is warranted. Each exposure pathway and COI is ranked as low, moderate, or high with regard to priority for future data needs based on the magnitude of the LOPC exceedance. As seen, the following exposure scenarios and COIs were ranked as having high priority for future data collection based on preliminary risk estimates:

- Incidental ingestion of metals in disturbed surface water
- Incidental ingestion of metals in beach sediments
- Ingestion of metals, dioxins/furans, and PCBs in fish

In addition, there are several environmental media for which COI data were limited or absent. Table 9-12 summarizes the data adequacy of each analytical suite for each environmental medium. As noted, in some cases, it was possible to calculate preliminary risks using estimated data (*e.g.,* estimating tissue concentrations from measured sediment) to determine if the lack of

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[24] Because tissue concentrations were estimated from surface water, and uncensored surface water data are only available from Northport (Reach 1), livestock exposures could only be evaluated in Reach 1.

measured data is a critical data gap. In cases where it was not possible to derive meaningful estimates from the available data, the absence of measured data for these media is an important data gap for the purposes of assessing potential risks in the baseline HHRA and should be given priority in future data collection efforts. The following analytical suites were identified as having high priority:

- Surface water (undisturbed conditions) – metals, pesticides, PAHs, and SVOCs
- Surface water (disturbed conditions) – metals, radionuclides, pesticides, dioxins/furans, PCBs, PAHs, SVOCs, and PBDEs
- Surface sediment – radionuclides and PBDEs
- Subsurface sediment – metals, radionuclides, pesticides, dioxins/furans, PCBs, PAHs, SVOCs, and PBDEs
- Outdoor air (directly impacted by stack emissions) – metals
- Groundwater[25] – metals, radionuclides, pesticides, PAHs, and SVOCs
- Fish tissue – arsenic speciation, radionuclides, pesticides, PAHs, and SVOCs
- Shellfish tissue – metals, arsenic speciation, radionuclides, pesticides, dioxins/furans, PCBs, PAHs, SVOCs, and PBDEs
- Waterfowl tissue[26] – metals, radionuclides, pesticides, dioxins/furans, PCBs, PAHs, SVOCs, and PBDEs

Another important data need for the baseline HHRA is the characterization of background levels in environmental media. Note that “background” is intended to indicate the concentration that would have been present in a medium in the absence of releases from the source(s) of concern. Thus, “background” may include both naturally-occurring levels of chemicals such as metals and some organics, as wells as levels of other organics that do not occur naturally but are widely dispersed (ubiquitous) in the environment due to anthropogenic area sources. Because many of the COIs for the UCR Site may also be present at background levels in the environment, measured data are needed on the background levels of COIs in each environmental medium. This will allow the baseline HHRA to make comparisons to background and determine whether estimated risks are site-related.

9.6 Exposure Parameter Data Adequacy Evaluation

As noted above, human exposure parameters are considered to be adequate if they are based on reliable site-specific information that is representative of the exposure scenario being addressed, and if the uncertainty around the estimates is not large enough to prevent reliable risk management decision-making. Parameters based on conservative default values or professional judgment may be adequate if the risk estimates based on those parameters are below a LOPC, but improved exposure data are desirable when risk estimates based on default or judgment-based parameters approach or exceed the LOPC.

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[25] The COI list for groundwater may be refined after review of additional surface water and sediment data.

[26] Collection of measured waterfowl tissue data may be deferred if a conservative method to estimate concentrations demonstrates that risks will not exceed the LOPC.

Table 9-13 provides an overview of the basis of the exposure parameters used in the initial risk calculations presented in the document, along with an indication of whether the initial risk calculations are above or below the LOPC. Data adequacy conclusions are presented below.

- For ingestion and dermal exposure to surface water, exposure parameters are based on default values or professional judgment, but nearly all risk estimates are below the LOPC. However, disturbed surface water concentration values are likely to be higher than current data suggest. While it is not likely that site-specific data can be obtained on actual water ingestion rates, collection of site-specific data on the types of behaviors that may lead to surface water ingestion, along with site-specific data on actual exposure frequency and duration to surface water, would be valuable for the purposes of reducing uncertainties in the baseline HHRA.

- For exposure to groundwater while showering, exposure parameters are based on default values or professional judgment. Although risk calculations could not be performed because measured groundwater data were not available, it is considered likely that use of default shower parameters will be adequate to support decision-making.

- For incidental ingestion exposure to sediment and soil, most exposure parameters are based on default values or professional judgment, and risk estimates based on these assumed parameters exceed the LOPC. While it is not likely that site-specific data can be obtained on actual sediment or soil ingestion rates, collection of site-specific data on the types of behaviors that may lead to incidental ingestion, along with site-specific data on actual exposure frequency and duration, would be valuable for the purposes of reducing uncertainties in the baseline HHRA.

- For inhalation exposure to outdoor air, most exposure parameters are based on default values or professional judgment. Although most risk estimates do not exceed the LOPC, collection of site-specific data on the frequency and duration of outdoor activities would be valuable for the purposes of reducing uncertainties in the baseline HHRA.

- For indoor residential exposure to air and dust, exposure parameters are based on default values or professional judgment, and risk estimates based on these parameters exceed the LOPC. However, it is considered likely that use of default parameters will be adequate to support decision-making.

- For ingestion of fish, shellfish, game, and plants from the site, site-specific intake data are available for the traditional subsistence scenario, but not for any of the other populations that ingest these site-derived dietary items. Because initial risk calculations are above the LOPC in most cases, collection of site-specific data on actual ingestion rates of fish, shellfish, game, and plants by each of these populations would be valuable for the purposes of reducing uncertainties in the baseline HHRA. Because concentration levels of some chemicals differ substantially between different tissues of the organism, data are also needed on the types of tissues (*e.g.,* muscle only, whole body, organs) ingested by recreational visitors and subsistence populations.

- For ingestion of crops and livestock grown in areas potentially impacted by irrigation or other site-related releases, site-specific exposure values are available for the traditional subsistence population, but not for the modern subsistence population. Because initial risk calculations are above the LOPC, collection of site-specific data on actual ingestion rates of crops and livestock by subsistence populations would be valuable for the purposes of reducing uncertainties in the baseline HHRA.

- For inhalation exposure to chemicals in sweat lodge air, site-specific data on frequency and duration of exposure are available for one tribal community (STI) but not for the other (CCT). Because initial risk calculations are above the LOPC, collection of tribal-specific data on sweat lodge use is needed in deriving improved estimates of exposure for this activity.

- For incidental ingestion of plant material during basket-making activities, exposure parameters are based only on assumed values for frequency and duration. However, initial risk estimates based on conservative assumptions indicate that exceedances of the LOPC are low for this exposure pathway, so collection of tribal-specific data on the duration and frequency of this activity is not critical.

- No site-specific exposure parameters are available to characterize dermal contact associated with plant material during activities such as basket weaving, preparation and application of medicines, and during ceremonial activities. Likewise, no parameters are available to characterize dermal contact with game animals during skinning, butchering, and preservation activities. However, initial risk calculations using conservative assumptions indicate that the dermal pathways rarely exceed the LOPC, so collection of detailed dermal exposure parameters is not critical.

- No site-specific exposure parameters are available to characterize inhalation exposures that may occur, either while preparing or preserving foods, or during ceremonial activities. Because it is not possible to perform initial risk calculations for this exposure pathway based on the data that presently exist, collection of data on the frequency and duration of human activities that would be associated with inhalation of smoke from burning of site-derived materials would be valuable for the purposes of reducing uncertainties in the baseline HHRA.

10 SUMMARY OF DATA COLLECTION NEEDS

As discussed in the previous section, there are a number of significant limitations and uncertainties associated with the environmental concentration data sets presently available at the site, as well as with a number of human exposure parameters. Tables 10-1 and 10-2 summarize the additional data collection efforts that are needed to support the baseline HHRA and to support risk management decision-making at the UCR Site. These tables are intended to identify general data gaps only. More detailed information on data quality objectives (DQOs), sampling design (number, location, and timing), sample collection procedures, and analytical methods (target analytes, detection limits) will be provided in subsequent sampling and analysis plans (SAPs) and Quality Assurance Project Plans (QAPPs).

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Table 2-1. Demographics of Larger UCR Communities, Indian Reservations, and Adjacent Counties

Community[a]	Total Population (2000)	Median Age (years)	Percent Under 5 yrs	Percent 65 years and over	Percent White[b]	Percent Black or African American[b]	Percent American Indian/Alaska Native[b]	Percent Asian[b]	Per capita income in 1999 (dollars)
Coulee Dam	1,044	44.5	5	20.3	64.6	0.3	29.1	0.5	18,791
Grand Coulee	897	45.3	5.5	23.6	81.3	1.1	12.5	1.3	13,639
Hunters/Cedonia	306	41.5	4.2	15.4	87.6	0.3	4.6	0.3	9,759
Inchelium	389	32.9	5.4	10.5	20.3	0	76.6	0	14,728
Kettle Falls	1,527	34.4	8.3	15.8	91.3	0.1	3.9	0.2	13,614
Marcus	117	43.5	6	14.5	95.7	0	0.9	0.9	10,798
Northport	336	42.8	6	17.3	94.9	0	0.6	0.6	11,679
Colville Indian Reservation	7,587	--	--	--	32.6	0.2	59.7	0.1	--
Spokane Indian Reservation	2,004	--	--	--	18.5	0.3	76.5	0.6	--
Ferry County	7,260	--	4.8	14.5	80.6	0.2	16.6	0.2	15,019
Lincoln County	10,184	--	4.5	20.1	95.8	0.3	2.3	0.3	17,888
Stevens county	40,066	--	5.2	14.1	91.5	0.3	5.4	0.5	15,895

Notes: -- = no data available

[a] Demographic data for towns was obtained from U.S. Census Bureau, American Factfinder website: http://factfinder.census.gov accessed on September 28, 2006 and July 9, 2007. Data for Indian reservations was obtained from Office of Financial Management, State of Washington, 2005 Data Book website: www.ofm.wa.gov/databook/population/pt06.asp accessed on October 10, 2006. Data for counties was obtained from U.S. Census Bureau QuickFacts website: http://quickfacts.census.gov accessed on October 10, 2006.

[b] Percentage data for counties is based upon 2004 census, all other data is based upon 2000 census.

Table 2-2. Active Surface Water Rights within the Study Area with Potential Domestic Uses[a]

Water Rights Document ID	File ID	Type	Year	Purpose	TRS
2095685	S3-163614CL	Claim L		DG IR	T29N/R35E-26
2095691	S3-163620CL	Claim L		DG IR	T34N/R26E-25
2096031	S3-160394CL	Claim L	1910	DG IR ST	T39N/R39E-23
2096376	S3-159759CL	Claim L		DG IR	T27N/R35E-07
2098156	S3-151738CL	Claim S		DG IR	T28N/R32E-07
2101632	S3-134109CL	Claim L	1917	DG	T36N/R37E-14
2103977	S3-120964CL	Claim L	1958	DG	T35N/R37E-10
2104330	S3-120465CL	Claim L	1973	DG	T35N/R37E-10
2106404	S3-110502CL	Claim L	1969	DG	T35N/R37E-10
2109587	S3-095460CL	Claim L	1959	DG	T35N/R37E-10
2112524	S3-080595CL	Claim S		DG IR	T35N/R37E-10
2112525	S3-080596CL	Claim S		DG IR	T35N/R37E-10
2118140	S3-053438CL	Claim S		DG	T30N/R36N-22
2118392	S3-050840CL	Claim S		DG IR ST	T37N/R38E-09
2120101	S3-044916CL	Claim L		DG	T35N/R37E-10
2124756	S3-022700CL	Claim L	1971	DG	T40N/R41E-09
2130228	S3-28591CWRIS	Cert	1989	DS	T27N/R34E-04
2130382	S3-27629CWRIS	Cert	1983	DS FR	T37N/R37E-28
2130601	S3-27202GWRIS	Cert	1982	DS	T28N/R33N-30
2130647	S3-27554GWRIS	Cert	1983	DM IR	T35N/R37E-29
2130836	S3-25471CWRIS	Cert	1977	DS FR	T36N/R37E-14
2131113	S3-25394GWRIS	Cert	1977	DS IR	T36N/R37E-02
2131268	S3-24688CWRIS	Cert	1975	DS	T40N/R40E-31
2132349	S3-01027CWRIS	Cert	1969	DS IR ST	T33N/R37E-30
2132407	S3-01346CWRIS	Cert	1964	DS IR	T35N/R37E-28
2132417	S3-01386CWRIS	Cert	1971	DS IR	T27N/R35E-18
2132610	S3-00822CWRIS	Cert	1971	CI DM	T27N/R35E-21
2135077	S3-*20403CWRIS	Cert	1967	DS	T35N/R37E-32
2135084	S3-*20462CWRIS	Cert	1967	DS FR	T37N/R37E-28
2135146	S3-*21066CWRIS	Cert	1968	DS	T35N/R37E-10
2135162	S3-*21270CWRIS	Cert	1968	DM	T36N/R37E-11
2135257	S3-*19491C	Cert	1966	DS IR	T35N/R37E-21
2135395	S3-*18484CWRIS	Cert	1964	DM IR	T36N/R37E-23
2135397	S3-*18486CWRIS	Cert	1964	DM	T37N/R38E-22
2135466	S3-*19225CWRIS	Cert	1965	DS IR	T32N/R37E-22
2135531	S3-*16460CWRIS	Cert	1960	DS IR	T36N/R37E-11
2135670	S3-*15062CWRIS	Cert	1958	DG IR	T28N/R31E-08
2135673	S3-*15100CWRIS	Cert	1958	DS IR	T37N/R38E-05
2135722	S3-*15256CWRIS	Cert	1959	DS IR	T37N/R38E-05
2135803	S3-*13347CWRIS	Cert	1955	DS IR	T37N/R38E-05
2135824	S3-*13568CWRIS	Cert	1955	DS IR ST	T28N/R32E-24
2135857	S3-*13791ALCWRIS	Cert	1956	DS IR	T28N/R33E-10
2136267	S3-*10256CWRIS	Cert	1951	DS	T33N/R37E-04
2136541	S3-*07143CWRIS	Cert	1946	DS IR	T38N/R38E-32
2136570	S3-*07692CWRIS	Cert	1947	CI DM	T27N/R35E-21
2136769	S3-*05763ALCWRIS	Cert	1942	DS IR ST	T28N/R33E-09
2136776	S3-*05936CWRIS	Cert	1943	DS IR	T35N/R37E-15
2143788	S3-29541	NewApp	1993	DM FR	T27N/R34E-02
2143788	S3-29541	NewApp	1993	DM FR	T27N/R34E-02
2143788	S3-29541	NewApp	1993	DM FR	T27N/R34E-02
2143887	S3-28530	Pmt	1988	DS IR	T28N/R33E-30
2125566	S3-017576CL	Claim L	1910	DG IR	T37N/R37E-17
2130430	S3-27977CWRIS	Cert	1985	DS ST	T38N/R37E-21

Table 2-2. Active Surface Water Rights within the Study Area with Potential Domestic Uses[a]

Water Rights Document ID	File ID	Type	Year	Purpose	TRS
2130447	S3-28079C	Cert	1985	DS	T38N/R37E-21
2130504	S3-28433CWRIS	Cert	1987	DS FR	T37N/R37E-21
2130588	S3-27124GWRIS	Cert	1981	DS IR	T37N/R37E-33
2132493	S3-00176CWRIS	Cert	1968	DS FR	T37N/R37E-33
2136963	S3-*04189CWRIS	Cert	1936	DS	T38N/R37E-21
2098741	S3-147203CL	Claim L	1970	DG IR	T30N/R33E-33
2103455	S3-124892CL	Claim L		DC DG FR IR	T29N/R33E-16
2109377	S3-096741CL	Claim L	1971	DG FR IR	T29N/R33E-16
2109377	S3-01564CWRIS	Cert	1970	DM FR	T29N/R33E-16
2115714	S3-063315CL	Claim S		DG ST	T30N/R33E-28
2115715	S3-063316CL	Claim S		DG ST	T30N/R33E-28
2135396	S3-*18485CWRIS	Cert	1964	DM IR	T29N/R33E-04
2126642	S3-011442CL	Claim L	1972	DG	T28N/R37E-33
2130442	S3-28043CWRIS	Cert	1985	DS	T28N/R37E-33
2130745	S3-26559CWRIS	Cert	1980	DS	T28N/R37E-33
2130926	S3-25993CWRIS	Cert	1978	DS	T28N/R37E-33
2131197	S3-24199CWRIS	Cert	1975	DM	T28N/R37E-33
2131848	S3-22653CWRIS	Cert	1974	DS	T27N/R38E-31
2132074	S3-21008CWRIS	Cert	1973	DS FR	T28N/R37E-33
2132207	S3-20147CWRIS	Cert	1972	DS	T28N/R37E-33
2132317	S3-00851CWRIS	Cert	1971	DS	T28N/R37E-33
2135184	S3-*21464C	Cert	1969	DM IR	T28N/R37E-29
2135271	S3-*19650CWRIS	Cert	1966	DS IR	T27N/R39E-19
2135400	S3-*18572CWRIS	Cert	1964	DS	T27N/R38E-31

Notes:

DG = Domestic General
DM = Domestic Multiple
DS = Domestic Single
IR = Irrigation
ST = Stock water
FR = Fire Protection
CI = Commercial/Industrial

[a] Data provided by WA Department of Ecology
(Emails of June 27, 2007 and July 18, 2007 to S. FitzGerald, Integral Consulting Inc.).

Table 2-3. Public Water Systems Groundwater Wells and Springs within Five Miles of UCR/Lake Roosevelt Shoreline

PWS ID	System Name	Group	System Type	County	Source Type	Use
SPRINGS						
NP280	FORT SPOKANE CAMPGROUND	A	Transient Non-Community	LINCOLN	Spring	Permanent
4490	Upper Columbia RV Park & Campground	A	Transient Non-Community	STEVENS	Spring	Permanent
34737	BISBEE ACRES WATER ASSOCIATION	B	Group B	FERRY	Spring	Permanent
75825	SAN POIL BAY IMPROVEMENT ASSN INC	B	Group B	FERRY	Spring	Emergency
2190	TOWNSHIP CREEK WATER SYSTEM	B	Group B	FERRY	Spring	Permanent
41164	BROUGHER RANCH INC	B	Group B	LINCOLN	Spring	Permanent
26090	FORT SPOKANE STORE	B	Group B	LINCOLN	Spring	Permanent
17710	DAISY WATER SYSTEM	B	Group B	STEVENS	Spring	Permanent
26810	FRUITLAND WATER ASSN	B	Group B	STEVENS	Spring	Permanent
1649	MARBLE WATER SYSTEM	B	Group B	STEVENS	Spring	Permanent
18451	MY PARENTS ESTATE	B	Group B	STEVENS	Spring	Permanent
89080	TRAILS WEST SUBDIVISION	B	Group B	STEVENS	Spring	Permanent
WELLS						
8174	COLUMBIA CEDAR	A	Non-Transient, Non-Community	FERRY	Well(s)	Permanent
NP330	HAAG COVE CAMPGROUND	A	Transient Non-Community	FERRY	Well(s)	Permanent
35550	INCHELIUM WATER DISTRICT	A	Community	FERRY	Well(s)	Permanent and Emergency
NP495	KETTLE RIVER CAMPGROUND	A	Transient Non-Community	FERRY	Well(s)	Permanent
33489	LAKESIDE PARK	A	Community	FERRY	Well(s)	Permanent
51877	MARTIN CREEK COMMUNITY ASSN	A	Community	FERRY	Well(s)	Permanent
33301	NORTH LAKE ROOSEVELT RESORT	A	Transient Non-Community	FERRY	Well(s)	Permanent
73032	RIVERWOOD WATER SYSTEM	A	Community	FERRY	Well(s)	Permanent
7216	WATERING HOLE, THE	A	Transient Non-Community	FERRY	Well(s)	Permanent
15451	COULEE GRANDE-BANKS LK GOLF COURSE	A	Transient Non-Community	GRANT	Well(s)	Seasonal
22850	ELECTRIC CITY, TOWN OF	A	Community	GRANT	Well(s)	Permanent and Seasonal
28700	GRAND COULEE WATER DEPT, CITY OF	A	Community	GRANT	Well(s)	Permanent

Table 2-3. Public Water Systems Groundwater Wells and Springs within Five Miles of UCR/Lake Roosevelt Shoreline

PWS ID	System Name	Group	System Type	County	Source Type	Use
8114	SUNBANKS RESORT	A	Transient Non-Community	GRANT	Well(s)	Permanent
1852	DEER MEADOWS WATER COMPANY INC	A	Community	LINCOLN	Well(s)	Permanent
NP280	FORT SPOKANE CAMPGROUND	A	Transient Non-Community	LINCOLN	Well(s)	Seasonal
19928	HANSON HARBOR HOMEOWNERS ASSN	A	Community	LINCOLN	Well(s)	Permanent
NP335	HAWK CREEK CAMPGROUND	A	Transient Non-Community	LINCOLN	Well(s)	Permanent
NP470	KELLER FERRY CAMPGROUND	A	Transient Non-Community	LINCOLN	Well(s)	Permanent
HD340	KELLER FERRY LANDING	A	Transient Non-Community	LINCOLN	Well(s)	Permanent
NP469	KELLER FERRY MARINA	A	Transient Non-Community	LINCOLN	Well(s)	Permanent
45366	LAKEVIEW TERRACE MHP	A	Community	LINCOLN	Well(s)	Permanent
NP700	PORCUPINE BAY CAMPGROUND	A	Transient Non-Community	LINCOLN	Well(s)	Permanent
20116	RANTZ MARINE PARK	A	Transient Non-Community	LINCOLN	Well(s)	Permanent
23324	RIVER RUE WATER SYSTEM	A	Transient Non-Community	LINCOLN	Well(s)	Permanent
47283	ROOSEVELT LAKE RANCH	A	Community	LINCOLN	Well(s)	Permanent
77651	SEVEN BAYS ESTATES UNLIMITED	A	Community	LINCOLN	Well(s)	Permanent
NP810	SPRING CANYON CAMPGROUND	A	Transient Non-Community	LINCOLN	Well(s)	Permanent
23391	SUNNY HILLS WATER SYSTEM	A	Transient Non-Community	LINCOLN	Well(s)	Permanent
NP070	CAMP NABOR LEE	A	Transient Non-Community	STEVENS	Well(s)	Permanent
NP110	CLOVERLEAF CAMPGROUND	A	Transient Non-Community	STEVENS	Well(s)	Permanent
7664	COLUMBIA SCHOOL DISTRICT 206	A	Non-Transient, Non-Community	STEVENS	Well(s)	Permanent
NP240	EVANS CAMPGROUND	A	Transient Non-Community	STEVENS	Well(s)	Permanent

Table 2-3. Public Water Systems Groundwater Wells and Springs within Five Miles of UCR/Lake Roosevelt Shoreline

PWS ID	System Name	Group	System Type	County	Source Type	Use
23960	EVANS WATER SYSTEM	A	Community	STEVENS	Well(s)	Permanent
24162	EVERGREEN SCHOOL DISTRICT #205	A	Non-Transient, Non-Community	STEVENS	Well(s)	Permanent
26790	FRUITLAND BIBLE CAMP	A	Transient Non-Community	STEVENS	Well(s)	Permanent and Seasonal
NP300	GIFFORD CAMPGROUND	A	Transient Non-Community	STEVENS	Well(s)	Permanent
NP380	HUNTERS CAMPGROUND	A	Transient Non-Community	STEVENS	Well(s)	Permanent
34889	HUNTERS WATER DISTRICT	A	Community	STEVENS	Well(s)	Permanent and Emergency
NP460	KAMLOOPS ISLAND CAMPGROUND	A	Transient Non-Community	STEVENS	Well(s)	Permanent
38400	KETTLE FALLS WATER DEPT	A	Community	STEVENS	Well(s)	Permanent
NP610	MARCUS ISLAND CAMPGROUND	A	Transient Non-Community	STEVENS	Well(s)	Permanent
51550	MARCUS WATER DEPT	A	Community	STEVENS	Well(s)	Seasonal, Permanent, and Emergency
30434	MISSION RIDGE WATER SYSTEM	A	Community	STEVENS	Well(s)	Permanent
NP660	NORTH GORGE CAMPGROUND	A	Transient Non-Community	STEVENS	Well(s)	Permanent
61850	NORTHPORT WATER SYSTEM	A	Community	STEVENS	Well(s)	Permanent
NP780	SNAG COVE CAMPGROUND	A	Transient Non-Community	STEVENS	Well(s)	Permanent
3554	Union Gospel Mission Tshimakain	A	Transient Non-Community	STEVENS	Well(s)	Permanent
41379	WELLPINIT SCHOOL	A	Non-Transient, Non-Community	STEVENS	Well(s)	Permanent
99330	YE OLD COUNTRY STORE	A	Transient Non-Community	STEVENS	Well(s)	Permanent
34014	ANDERSON K. R. LOTS	B	Group B	FERRY	Well(s)	Permanent
AB500	AOY Cascade	B	Group B	FERRY	Well(s)	Permanent
8014	BOYDS TAVERN	B	Group B	FERRY	Well(s)	Permanent
38951	COLUMBIA RIVER WATER ASSOCIATION	B	Group B	FERRY	Well(s)	Permanent
34017	FREDRICKSON SHORT PLAT	B	Group B	FERRY	Well(s)	Permanent
6012	KENT WATER SYSTEM	B	Group B	FERRY	Well(s)	Permanent

Table 2-3. Public Water Systems Groundwater Wells and Springs within Five Miles of UCR/Lake Roosevelt Shoreline

PWS ID	System Name	Group	System Type	County	Source Type	Use
AA644	R GARDEN INTERNATIONAL	B	Group B	FERRY	Well(s)	Permanent and Emergency
6538	BROUGHER RANCH II	B	Group B	LINCOLN	Well(s)	Permanent
8271	BROUGHER RANCH III	B	Group B	LINCOLN	Well(s)	Permanent
8340	CAMPBELL BAY FARMS	B	Group B	LINCOLN	Well(s)	Permanent
AA087	CHAR-DONNIE	B	Group B	LINCOLN	Well(s)	Permanent
4298	COLUMBIA SPRINGS ESTATES	B	Group B	LINCOLN	Well(s)	Permanent
NP190	DETILLION CAMPGROUND	B	Group B	LINCOLN	Well(s)	Permanent
7944	FDR ESTATES #5	B	Group B	LINCOLN	Well(s)	Permanent
7961	FDR ESTATES #6	B	Group B	LINCOLN	Well(s)	Permanent
2484	HUNTER FAMILY WATER SYSTEM	B	Group B	LINCOLN	Well(s)	Permanent
4991	KUNZ WATER SYSTEM	B	Group B	LINCOLN	Well(s)	Permanent
5694	LAKE ROOSEVELT HIDEAWAY	B	Group B	LINCOLN	Well(s)	Permanent
AB219	Lakeview Catering	B	Group B	LINCOLN	Well(s)	Permanent
5403	LAKEVIEW HEIGHTS WATER SYSTEM	B	Group B	LINCOLN	Well(s)	Permanent
7007	LIVINGSTON, GEORGE WATER SYSTEM	B	Group B	LINCOLN	Well(s)	Permanent
24292	LONG LAKE OPERATORS VILLAGE	B	Group B	LINCOLN	Well(s)	Permanent
AB341	Pavlov Water System	B	Group B	LINCOLN	Well(s)	Permanent
6719	PORCUPINE BAY ESTATES	B	Group B	LINCOLN	Well(s)	Permanent
6719	PORCUPINE BAY ESTATES	B	Group B	LINCOLN	Well(s)	Permanent
196	PORTER WELL WATER SYSTEM	B	Group B	LINCOLN	Well(s)	Permanent
56364	ROCKY TOP ESTATES	B	Group B	LINCOLN	Well(s)	Permanent
AA482	ROOSEVELT VIEWS SUBDIVISION	B	Group B	LINCOLN	Well(s)	Permanent
38625	SQUAW CANYON PLAT III	B	Group B	LINCOLN	Well(s)	Permanent
51131	TARBERT WATER SYSTEM	B	Group B	LINCOLN	Well(s)	Permanent
6998	TRANQUIL ESTATES	B	Group B	LINCOLN	Well(s)	Permanent
AA292	WIND WALKER	B	Group B	LINCOLN	Well(s)	Permanent
2525	Azzarito / Fish	B	Group B	STEVENS	Well(s)	Permanent
6870	BISCEGLIA WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
7800	BOSSBURG WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
AA572	BUCK CANYON LODGE	B	Group B	STEVENS	Well(s)	Permanent
33856	CE MINERALS/CALHOUN MILL	B	Group B	STEVENS	Well(s)	Permanent
6224	CHINA BEND VINEYARDS	B	Group B	STEVENS	Well(s)	Permanent
AA168	CLEAR WATER	B	Group B	STEVENS	Well(s)	Permanent
3024	DRAKE S WATER COMPANY	B	Group B	STEVENS	Well(s)	Permanent
5320	ECHO RIDGE VETERINARY HOSPITAL	B	Group B	STEVENS	Well(s)	Permanent
2704	FRONTIER WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent

Table 2-3. Public Water Systems Groundwater Wells and Springs within Five Miles of UCR/Lake Roosevelt Shoreline

PWS ID	System Name	Group	System Type	County	Source Type	Use
AA757	Gold Edge Estates	B	Group B	STEVENS	Well(s)	Permanent
4430	GOLDEN WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
2185	GRAHAM WELL	B	Group B	STEVENS	Well(s)	Permanent
2471	HARSIN/DRISKILL WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
2984	HAYES, LEON WTR. SYS.	B	Group B	STEVENS	Well(s)	Permanent
2539	JAMES WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
1804	JONES, ROBERT D. WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
3719	KINDER, VESTER C. WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
1664	MALONE WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
2491	MOORE WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
1577	PHILLIPS WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
8268	RED S WATER DISTRICT	B	Group B	STEVENS	Well(s)	Permanent
3743	RHOADES WELL	B	Group B	STEVENS	Well(s)	Permanent
2752	RHONDA S WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
7804	RICE CHURCH	B	Group B	STEVENS	Well(s)	Permanent
4112	RICKEY CANYON SUBDIVISION	B	Group B	STEVENS	Well(s)	Permanent
34825	ROBINSON WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
2839	SCRAPER, JOHN WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
NR720	SHEEP CREEK CAMPGROUND	B	Group B	STEVENS	Well(s)	Permanent
5283	SLONIKER & RAGLAND WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
41431	SNAG COVE WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
AA980	Stevens Co Fire District #12	B	Group B	STEVENS	Well(s)	Permanent
3252	VAN SICKLE, FAYE WTR. SYS.	B	Group B	STEVENS	Well(s)	Permanent
2769	VERY DEEP WELL WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
AB381	Victory Baptist Church	B	Group B	STEVENS	Well(s)	Permanent
3135	WEST, ROBERT L. WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
2524	WHITCOMB-DAVIS WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
NR900	WILLIAMS LAKE CAMP GROUND	B	Group B	STEVENS	Well(s)	Permanent

Source: Washington Dept. of Health, 2004 data (WDOH 2006a).

Note: System Name and Use entries are shown as provided by DOH.

Emergency = Any source that is approved by the department for emergency purposes only, is not used for routine or seasonal water demands, is physically disconnected, and is identified in the purveyor's emergency response plan.

Seasonal = A public water system source used on a regular basis, that is not a permanent or emergency source.

Permanent = A public water system supply source that is used regularly each year, and based on expected operational requirements of the system, will be used more than three consecutive months in any twelve-month period. For seasonal water systems that are in operation for less than three consecutive months per year, their sources shall also be considered to be permanent.

Table 2-4. Group A Water Systems with Mapped 10-Year Wellhead Protection Areas

PWSID	System Name	System Type	County	Use
8174	COLUMBIA CEDAR	Non-Transient, Non-Community	FERRY	Permanent
35550	INCHELIUM WATER DISTRICT	Community	FERRY	Permanent
33489	LAKESIDE PARK	Community	FERRY	Permanent
51877	MARTIN CREEK COMMUNITY ASSN	Community	FERRY	Permanent
73032	RIVERWOOD WATER SYSTEM	Community	FERRY	Permanent
22850	ELECTRIC CITY, TOWN OF	Community	GRANT	Permanent
45366	LAKEVIEW TERRACE MHP	Community	LINCOLN	Permanent
77651	SEVEN BAYS ESTATES UNLIMITED	Community	LINCOLN	Permanent
7664	COLUMBIA SCHOOL DISTRICT 206	Non-Transient, Non-Community	STEVENS	Permanent
23960	EVANS WATER SYSTEM	Community	STEVENS	Permanent
24162	EVERGREEN SCHOOL DISTRICT #205	Non-Transient, Non-Community	STEVENS	Permanent
34889	HUNTERS WATER DISTRICT	Community	STEVENS	Permanent
38400	KETTLE FALLS WATER DEPT	Community	STEVENS	Permanent
51550	MARCUS WATER DEPT	Community	STEVENS	Seasonal
30434	MISSION RIDGE WATER SYSTEM	Community	STEVENS	Permanent
61850	NORTHPORT WATER SYSTEM	Community	STEVENS	Permanent

Source: Washington Dept. of Health (WDOH 2006a, b).

Note: System Name and Use entries are shown as provided by DOH.

Table 2-5. Gaging Stations Used to Develop Water Budgets

Station	Gage	Latitude	Longitude	Long-Term Average Gage Flow (cfs)	Cumulative Long-Term Average Columbia River Flow (cfs)	Measured Long-Term Average Columbia River Flow (cfs)	Columbia River Gage[a]	Percent of Grand Coulee Outflow	Period of Record	Count of Daily Flow Values
Columbia River at Castlegar, B.C.	WSC 08NE002	49°19'56" N	117°40'33" W	42,725	42,725	42,725	1	40%	1913–1916 1961–1972	5,478
Kootenay Lake Outflow near Corra Linn, B.C.	WSC 08NJ158	49°28'1" N	117°27'54" W	27,761	70,486	71,101	2	26%	1937–2005	24,929
Pend Oreille River at International Boundary, WA (before entering Canada)	USGS 12398600	48°59'56" N	117°21'09" W	25,938	96,424	99,637	3	24%	1962–2007	15,917
Kettle River near Laurier, WA	USGS 12398600	48°59'56" N	117°21'09" W	2,928	99,352			3%	1929–2007	28,458
Colville River at Kettle Falls, WA	USGS 12409000	48°35'40" N	118°03'41" W	306	99,658			< 1 %	1922–2007	30,802
Spokane River at Long Lake, WA	USGS 12433000	47°50'12" N	117°50'25" W	7,670	107,328			7%	1939–2006	24,656
Sanpoil River near Keller, WA	USGS 12434500	48°05'04" N	118°41'25" W	261	107,589	107,806	4	< 1 %	1952–1974	3,969
Sanpoil River above Jack Creek at Keller, WA	USGS 12434590	48°05'04" N	118°41'25" W	261	107,589	107,806	4	< 1 %	2006–2007	284
Sanpoil River at Keller, WA	USGS 12435000	48°05'04" N	118°41'25" W	261	107,589	107,806	4	< 1 %	1911–1917	1,799

Note:
[a] See Table 2-4.

Table 2-6. Water Budget for the UCR

Columbia River Gage	Station on the Columbia River	Gage	Latitude	Longitude	Long-Term Average Gage Flow (cfs)	Period of Record	Count of Daily Flow Values
1	Columbia River at Castlegar, B.C.	WSC 08NE002	49°19'56" N	117°40'33" W	42,725	1913–1916 1961–1972	5,478
2	Columbia River at Birchbank, B.C.	WSC 08NE049	49°10'40" N	117°42'59" W	71,101	1937–2006	25,294
3	Columbia River at International Boundary, WA[a]	USGS 12399500	49°00'03" N	117°37'42" W	99,637	1938–2007	25,355
4	Columbia River at Grand Coulee, WA	USGS 12436500	47°57'56" N	118°58'54" W	107,806	1923–2006	28,308

Notes: WSC = Water Survey of Canada
USGS = United States Geological Survey
[a] Includes flow from the Pend Oreille River.

Table 2-7. Statistical Measures of Daily Discharge at the U.S.-Canadian Border

	Time Interval		
Statistical Measure	March 1, 1938 to December 21, 2005	March 1, 1938 to December 21, 1972	January 1, 1973 to December 31, 2005
Mean (cfs)	99,544	101,757	97,209
Median (cfs)	82,400	64,800	90,900
Mode (cfs)	101,000	101,000	102,000
Harmonic Mean (cfs)	72,603	62,689	87,154
Minimum (cfs)	21,200	21,200	21,500
Maximum (cfs)	549,000	549,000	302,000
25th Pecentile (cfs)	57,400	44,600	74,500
75th Percentile (cfs)	115,000	127,000	112,000
Average deviation (cfs)	45,676	65,355	25,332
Standard deviation (cfs)	66,239	86,000	34,657
Coefficient of variation (cfs)	0.67	0.85	0.36
Areal mean discharge (cfs/mi^2)	1.67	1.71	1.63
Rainfall equivalent (in/y)	22.65	23.16	22.12

Notes: cfs = cubic feet per second
in. = inch
mi^2 = square mile
y = year

Table 2-8. Terrestrial Animal Species Present in the UCR RI/FS Study Area

Scientific Name	Common Name	Source of Occurrence Information					WDFW USE	Federal Status	State Status	Proposed State Status Listing	Culturally Important
Amphibians											
Ambystoma macrodactylum	Long-toed salamander		BPA	IC							
Ambystoma tigrinum	Tiger salamander	NPS	BPA	IC			IO		SM		
Bufo boreas	Western toad	NPS	BPA	IC				FC	SC		
Bufo woodhousii	Woodhouse's toad		BPA				IO		SM		
Hyla regilla	Pacific treefrog	NPS	BPA	IC							
Spea intermontana	Great basin spadefoot	NPS	BPA	IC							
Rana catesbeiana	Bullfrog		BPA	IC							
Rana clamitans	Green frog		BPA								
Rana pipiens	Northern leopard frog		BPA				IO	FC	SE		
Rana luteiventris	Columbia spotted frog		BPA	IC			IO	FC	SC	PS	
Reptiles											
Chrysemys picta	Painted turtle	NPS	BPA	IC							
Elgaria coerulea	Northern alligator lizard		BPA	IC							
Phrynosoma douglassi	Short-horned lizard	NPS	BPA	IC							
Sceloporus graciosus	Sagebrush lizard	NPS	BPA				IO	FC	SC		
Sceloporus occidentalis	Western fence lizard		BPA								
Uta stansburiana	Side-blotched lizard		BPA	IC							
Eumeces skiltonianus	Western skink		BPA	IC							
Charina bottae	Rubber boa		BPA	IC							
Coluber constrictor	Racer			IC							
Hypsiglena torquata	Night snake		BPA			WDFW	IO		SM		
Pituophis catenifer	Gopher snake	NPS	BPA	IC							
Thamnophis elegans	Western terrestrial garter snake	NPS	BPA	IC							
Thamnophis ordinoides	Northwestern garter snake		BPA								
Thamnophis sirtalis	Common garter snake		BPA	IC							
Crotalus viridis	Western rattlesnake	NPS	BPA	IC							
Birds											
Gavia immer	Common loon	NPS	BPA	xIC	SAS	WDFW	B		SS	PT	
Podilymbus podiceps	Pied-billed grebe		BPA	IC							
Podiceps auritus	Horned grebe		BPA	IC			B		SM		
Podiceps grisegena	Red-necked grebe		BPA	IC			B		SM		
Podiceps nigricollis	Eared grebe		BPA	IC							
Aechmophorus occidentalis	Western grebe	NPS	BPA	IC			B		SC		
Pelecanus erythrorhynchos	American white pelican		BPA	IC			B,RSC		SE		
Phalacrocorax auritus	Double-crested cormorant			IC							
Botaurus lentiginosus	American bittern		BPA	IC							
Ardea herodias	Great blue heron	NPS	BPA	IC		WDFW	B		SM		
Birds (continued)											
Nycticorax nycticorax	Black-crowned night-heron		BPA	IC			B		SM		
Cygnus columbianus	Tundra swan			IC							
Anser albifrons	Greater white-fronted goose		BPA								
Chen caerulescens	Snow goose		BPA	IC							
Chen rossii	Ross' goose		BPA								
Branta canadensis	Canada goose	NPS	BPA	IC							
Aix sponsa	Wood duck		BPA	IC							
Anas crecca	Green-winged teal	NPS?	BPA	IC							
Anas platyrhynchos	Mallard	NPS	BPA	IC							
Anas acuta	Northern pintail	NPS	BPA	IC							
Anas discors	Blue-winged teal	NPS?	BPA	IC							
Anas cyanoptera	Cinnamon teal	NPS?	BPA	IC							
Anas clypeata	Northern shoveler		BPA	IC							
Anas strepera	Gadwall		BPA	IC							
Anas americana	American wigeon		BPA	IC							
Aythya valisineria	Canvasback		BPA	IC							
Aythya americana	Redhead	NPS	BPA	IC							
Aythya collaris	Ring-necked duck		BPA	IC							
Aythya marila	Greater scaup		BPA	xIC	SAS						
Aythya affinis	Lesser scaup	NPS	BPA	IC							
Histrionicus histrionicus	Harlequin duck		BPA	IC							
Melanitta fusca	White-winged scoter		BPA	xIC	SAS						
Bucephala clangula	Common goldeneye	NPS?	BPA	IC							
Bucephala islandica	Barrow's goldeneye	NPS?	BPA	IC							
Bucephala albeola	Bufflehead	NPS	BPA	IC							
Lophodytes cucullatus	Hooded merganser		BPA	IC							
Mergus merganser	Common merganser	NPS	BPA	IC							
Mergus serrator	Red-breasted merganser		BPA	xIC	SAS						
Oxyura jamaicensis	Ruddy duck		BPA	IC							
Cathartes aura	Turkey vulture		BPA	IC			B,CR		SM		
Pandion haliaetus	Osprey	NPS	BPA	IC		WDFW	B		SM		
Haliaeetus leucocephalus	Bald eagle	NPS	BPA	IC		WDFW	B,RSC,CR				CCT
Circus cyaneus	Northern harrier	NPS	BPA	IC							
Accipiter striatus	Sharp-shinned hawk		BPA	IC							
Accipiter cooperii	Cooper's hawk		BPA	IC							

Table 2-8. Terrestrial Animal Species Present in the UCR RI/FS Study Area

Scientific Name	Common Name	Source of Occurrence Information					WDFW USE	Federal Status	State Status	Proposed State Status Listing	Culturally Important
Accipiter gentilis	Northern goshawk		BPA	IC		WDFW	B	FC	SC	PS	
Buteo swainsoni	Swainson's hawk		BPA	IC			B		SM		
Birds (continued)											
Buteo jamaicensis	Red-tailed hawk	NPS	BPA	IC							
Buteo regalis	Ferruginous hawk		BPA	IC			B	FC	ST		
Buteo lagopus	Rough-legged hawk	NPS	BPA	IC							
Aquila chrysaetos	Golden eagle	NPS	BPA	IC		WDFW	B		SC	PS	CCT
Falco sparverius	American kestrel	NPS	BPA	IC							
Falco columbarius	Merlin		BPA	IC			B		SC		
Falco peregrinus	Peregrine falcon	NPS	BPA	IC		WDFW	B,RI	FC	SS		
Falco rusticolus	Gyrfalcon			IC			RI		SM		
Falco mexicanus	Prairie falcon	NPS	BPA	IC			B		SM		
Perdix perdix	Gray partridge	NPSh	BPA	IC							
Alectoris chukar	Chukar	NPS	BPA	xIC	SAS						
Phasianus colchicus	Ring-necked pheasant	NPS	BPA	IC							
Dendragapus canadensis	Spruce grouse		BPA	IC							
Dendragapus obscurus	Blue grouse	NPS	BPA	IC		WDFW					
Bonasa umbellus	Ruffed grouse	NPS	BPA	IC							
Centrocercus urophasianus	Sage-grouse	NPS	BPA	xIC*	xSAS		B,RSC	FC	ST	PS	
Tympanuchus phasianellus	Sharp-tailed grouse	*NPS	BPA	IC		WDFW	B,RSC	FC	ST	PS	CCT
Meleagris gallopavo	Wild turkey		BPA	IC							
Meleagris gallopavo intermedia	Rio Grande wild turkey					WDFW					
Meleagris gallopavo merriami	Merriam's wild turkey					WDFW					
Callipepla californica	California quail	NPS	BPA	xIC	SAS						
Rallus limicola	Virginia rail		BPA	IC							
Porzana carolina	Sora		BPA	IC							
Fulica americana	American coot	NPS	BPA	IC							
Grus canadensis	Sandhill crane		BPA				B,RLC		SE		
Pluvialis squatarola	Black-bellied plover		BPA	xIC	SAS						
Charadrius semipalmatus	Semipalmated plover		BPA	IC							
Charadrius vociferus	Killdeer	NPS	BPA	IC							
Recurvirostra americana	American avocet		BPA	IC							
Tringa melanoleuca	Greater yellowlegs	NPS?	BPA	IC							
Tringa flavipes	Lesser yellowlegs	NPS?	BPA	IC							
Tringa solitaria	Solitary sandpiper	NPS?	BPA	IC							
Actitis macularia	Spotted sandpiper	NPS?	BPA	IC							
Bartramia longicauda	Upland sandpiper	NPS?		IC			B,RI		SE		
Numenius americanus	Long-billed curlew	NPS?	BPA	IC			B,RSC		SM		
Limosa fedoa	Marbled godwit			IC							
Calidris alba	Sanderling		BPA								
Birds (continued)											
Calidris pusilla	Semipalmated sandpiper	NPS?	BPA	IC							
Calidris mauri	Western sandpiper	NPS?	BPA	IC							
Calidris minutilla	Least sandpiper	NPS?	BPA	IC							
Calidris bairdii	Baird's sandpiper	NPS?	BPA	IC							
Calidris melanotos	Pectoral sandpiper	NPS?	BPA	IC							
Calidris alpina	Dunlin		BPA	IC							
Calidris himantopus	Stilt sandpiper	NPS?	BPA	xIC	SAS						
Limnodromus griseus	Short-billed dowitcher			IC							
Limnodromus scolopaceus	Long-billed dowitcher		BPA	IC							
Gallinago gallinago	Common snipe	NPS	BPA	IC							
Phalaropus tricolor	Wilson's phalarope		BPA	IC							
Phalaropus lobatus	Red-necked phalarope			IC							
Larus philadelphia	Bonaparte's gull	NPS?	BPA	IC							
Larus delawarensis	Ring-billed gull	NPS?	BPA	IC							
Larus californicus	California gull	NPS?	BPA	IC							
Larus argentatus	Herring gull	NPS?	BPA	IC							
Larus glaucescens	Glaucous-winged gull	NPS?	BPA	IC							
Sterna hirundo	Common tern		BPA	IC							
Sterna forsteri	Forster's tern		BPA	IC			B		SM		
Chlidonias niger	Black tern		BPA	IC			B	FC	SM		
Columba livia	Rock dove		BPA	IC							
Columba fasciata	Band-tailed pigeon	NPS?	BPA								
Zenaida macroura	Mourning dove	NPS	BPA	IC							
Tyto alba	Barn owl	NPS	BPA	IC							
Otus flammeolus	Flammulated owl		BPA	IC			B,RI		SC	PS	
Otus kennicottii	Western screech owl	NPS	BPA	IC							
Bubo virginianus	Great horned owl	NPS	BPA	IC							
Nyctea scandiaca	Snowy owl		BPA	IC			RI		SM		
Surnia ulula	Northern hawk owl		BPA	IC							
Glaucidium gnoma	Northern pygmy owl		BPA	IC							
Athene cunicularia	Burrowing owl		BPA	IC			B	FC	SC	PS	
Strix varia	Barred owl		BPA	IC			B				
Strix nebulosa	Great gray owl		BPA	IC			IO		SM		

Table 2-8. Terrestrial Animal Species Present in the UCR RI/FS Study Area

Scientific Name	Common Name	Source of Occurrence Information					WDFW USE	Federal Status	State Status	Proposed State Status Listing	Culturally Important
Asio otus	Long-eared owl		BPA	IC							
Asio flammeus	Short-eared owl	NPS	BPA	IC							
Aegolius funereus	Boreal owl		BPA	IC			B		SM		
Aegolius acadicus	Northern saw-whet owl	NPS	BPA	IC							
Birds (continued)											
Chordeiles minor	Common nighthawk		BPA	IC							
Phalaenoptilus nuttallii	Common poorwill		BPA	IC							
Chaetura vauxi	Vaux's swift		BPA	IC			B, CR		SC	PS	
Aeronautes saxatalis	White-throated swift		BPA	IC							
Archilochus alexandri	Black-chinned hummingbird	NPS?	BPA	IC							
Stellula calliope	Calliope hummingbird	NPS?	BPA	IC							
Selasphorus rufus	Rufous hummingbird	NPS?	BPA	IC							
Ceryle alcyon	Belted kingfisher	NPS	BPA	IC							
Melanerpes lewis	Lewis' woodpecker		BPA	IC		WDFW	B		SC	PS	
Sphyrapicus nuchalis	Red-naped sapsucker			IC							
Sphyrapicus thyroideus	Williamson's sapsucker		BPA	IC							
Picoides pubescens	Downy woodpecker	NPS?	BPA	IC							
Picoides villosus	Hairy woodpecker	NPS?	BPA	IC							
Picoides albolarvatus	White-headed woodpecker	NPS?	BPA	IC		WDFW	B,RI		SC	PS	
Picoides tridactylus	Three-toed woodpecker	NPS?	BPA	IC			B,RI		SM		
Picoides arcticus	Black-backed woodpecker	NPS?	BPA	IC			B,RI		SC		
Colaptes auratus	Northern flicker		BPA	IC							
Dryocopus pileatus	Pileated woodpecker	NPS?	BPA	IC			B		SC	PS	
Contopus borealis	Olive-sided flycatcher		BPA	IC				FC			
Contopus sordidulus	Western wood-pewee		BPA	IC							
Empidonax traillii	Willow flycatcher		BPA	IC				FC			
Empidonax minimus	Least flycatcher		BPA	IC							
Empidonax hammondii	Hammond's flycatcher		BPA	IC							
Empidonax oberholseri	Dusky flycatcher		BPA	IC							
Empidonax occidenetalis	Cordilleran flycatcher			IC							
Sayornis saya	Say's phoebe		BPA	IC							
Myiarchus cinerascens	Ash-throated flycatcher		BPA	xIC	xSAS		B		SM		
Tyrannus verticalis	Western kingbird		BPA	IC							
Tyrannus tyrannus	Eastern kingbird		BPA	IC							
Eremophila alpestris	Horned lark		BPA	IC							
Tachycineta bicolor	Tree swallow	NPS?	BPA	IC							
Tachycineta thalassina	Violet-green swallow	NPS?	BPA	IC							
Stelgidopteryx serripennis	Northern rough-winged swallow	NPS?	BPA	IC							
Riparia riparia	Bank swallow	NPS?	BPA	IC							
Hirundo pyrrhonota	Cliff swallow	NPS?	BPA	IC							
Hirundo rustica	Barn swallow	NPS?	BPA	IC							
Perisoreus canadensis	Gray jay	NPS?	BPA	IC							
Birds (continued)											
Cyanocitta stelleri	Steller's jay	NPS?	BPA	IC							
Cyanocitta cristata	Blue jay	NPS?	BPA	xIC	xSAS						
Nucifraga columbiana	Clark's nutcracker		BPA	IC							
Pica pica	Black-billed magpie	NPS	BPA	IC							
Corvus brachyrhynchos	American crow	NPS	BPA	IC							
Corvus corax	Common raven	NPS	BPA	IC							
Poecile atricapillus	Black-capped chickadee	NPS?	BPA	IC							
Poecile gambeli	Mountain chickadee	NPS?	BPA	IC							
Poecile hudsonicus	Boreal chickadee	NPS?	BPA	IC			B		SM		
Poecile rufescens	Chestnut-backed chickadee	NPS?	BPA	IC							
Sitta canadensis	Red-breasted nuthatch		BPA	IC							
Sitta carolinensis	White-breasted nuthatch		BPA	IC							
Sitta pygmaea	Pygmy nuthatch		BPA	IC							
Certhia americana	Brown creeper		BPA	IC							
Salpinctes obscoletus	Rock wren		BPA	IC							
Catherpes mexicanus	Canyon wren		BPA	xIC*	SAS						
Troglodytes aedon	House wren		BPA	IC							
Troglodytes troglodytes	Winter wren		BPA	IC							
Cistothorus palustris	Marsh wren		BPA	IC							
Cinclus mexicanus	American dipper		BPA	IC							
Regulus satrapa	Golden-crowned kinglet		BPA	IC							
Regulus calendula	Ruby-crowned kinglet		BPA	IC							
Sialia mexicana	Western bluebird		BPA	IC			B		SM		
Sialia currucoides	Mountain bluebird		BPA	IC							
Myadestes townsendi	Townsend's solitaire		BPA	IC							
Catharus fuscescens	Veery		BPA	IC							
Catharus ustulatus	Swainson's thrush		BPA	IC							
Catharus guttatus	Hermit thrush		BPA	IC							
Turdus migratorius	American robin	NPS	BPA	IC							
Ixoreus naevius	Varied thrush		BPA	IC							
Dumetella carolinensis	Gray catbird		BPA	xIC	SAS						

Table 2-8. Terrestrial Animal Species Present in the UCR RI/FS Study Area

Scientific Name	Common Name	Source of Occurrence Information					WDFW USE	Federal Status	State Status	Proposed State Status Listing	Culturally Important
Oreoscoptes montanus	Sage thrasher			IC			B		SC	PS	
Anthus rubescens	American pipit		BPA	IC							
Bombycilla garrulus	Bohemian waxwing		BPA	IC							
Bombycilla cedrorum	Cedar waxwing		BPA	IC							
Lanius excubitor	Northern shrike		BPA	IC							
Lanius ludovicianus	Loggerhead shrike		BPA	IC			B	FC	SC	PS	
Birds (continued)											
Sturnus vulgaris	European starling		BPA	IC							
Vireo solitarius	Solitary vireo		BPA	IC							
Vireo gilvus	Warbling vireo		BPA	IC							
Vireo olivaceus	Red-eyed vireo		BPA	IC							
Vermivora peregrina	Tennessee warbler		BPA	xIC	xSAS						
Vermivora celata	Orange-crowned warbler		BPA	IC							
Vermivora ruficapilla	Nashville warbler		BPA	IC							
Dendroica petechia	Yellow warbler		BPA	IC							
Dendroica coronata	Yellow-rumped warbler		BPA	IC							
Dendroica townsendi	Townsend's warbler		BPA	IC							
Setophaga ruticilla	American redstart		BPA	IC							
Seiurus noveboracensis	Northern waterthrush		BPA	IC					SM		
Oporornis tolmiei	Macgillivray's warbler		BPA	IC							
Geothlypis trichas	Common yellowthroat		BPA	IC							
Wilsonia pusilla	Wilson's warbler		BPA	IC							
Icteria virens	Yellow-breasted chat		BPA	IC							
Piranga ludoviciana	Western tanager		BPA	IC							
Pheucticus melanocephalus	Black-headed grosbeak		BPA	IC							
Passerina amoena	Lazuli bunting		BPA	IC							
Passerina cyanea	Indigo bunting		BPA								
Pipilo erythrophthalmus	Rufous-sided towhee		BPA	IC							
Spizella arborea	American tree sparrow	NPS?	BPA	IC							
Spizella passerina	Chipping sparrow	NPS?	BPA	IC							
Spizella pallida	Clay-colored sparrow	NPS?	BPA	xIC	xSAS						
Spizella breweri	Brewer's sparrow	NPS?	BPA	IC							
Pooecetes gramineus	Vesper sparrow	NPS?	BPA	IC							
Chondestes grammacus	Lark sparrow	NPS?	BPA	IC							
Amphispiza belli	Sage sparrow	NPS?		IC			B		SC	PS	
Passerculus sandwichensis	Savannah sparrow	NPS?	BPA	IC							
Ammodramus savannarum	Grasshopper sparrow	NPS?	BPA	IC			B		SM		
Passerella iliaca	Fox sparrow	NPS?	BPA	IC							
Melospiza melodia	Song sparrow	NPS?	BPA	IC							
Melospiza lincolnii	Lincoln's sparrow	NPS?	BPA	IC							
Zonotrichia albicollis	White-throated sparrow	NPS?	BPA	IC							
Zonotrichia atricapilla	Golden-crowned sparrow	NPS?	BPA	xIC	SAS						
Zonotrichia leucophrys	White-crowned sparrow	NPS?	BPA	IC							
Zonotrichia querula	Harris' sparrow	NPS?	BPA	IC							
Birds (continued)											
Junco hyemalis	Dark-eyed junco	NPS	BPA	IC							
Calcarius lapponicus	Lapland longspur			IC							
Plectrophenax nivalis	Snow bunting		BPA	IC							
Dolichonyx oryzivorus	Bobolink		BPA	IC					SM		
Agelaius phoeniceus	Red-winged blackbird	NPS?	BPA	IC							
Sturnella neglecta	Western meadowlark	NPS	BPA	IC							
Xanthocephalus xanthocephalus	Yellow-headed blackbird	NPS?	BPA	IC							
Euphagus carolinus	Rusty blackbird	NPS?	BPA	xIC	xSAS						
Euphagus cyanocephalus	Brewer's blackbird	NPS?	BPA	IC							
Molothrus ater	Brown-headed cowbird		BPA	IC							
Icterus galbula	Northern oriole		BPA	IC							
Leucosticte tephrocotis	Gray-crowned rosy-finch		BPA	IC							
Pinicola enucleator	Pine grosbeak		BPA	IC							
Carpodacus purpureus	Purple finch	NPS?	BPA	xIC	xSAS						
Carpodacus cassinii	Cassin's finch	NPS?	BPA	IC							
Carpodacus mexicanus	House finch	NPS?	BPA	IC							
Loxia curvirostra	Red crossbill		BPA	IC							
Loxia leucoptera	White-winged crossbill		BPA	IC							
Carduelis flammea	Common redpoll		BPA	IC							
Carduelis pinus	Pine siskin		BPA	IC							
Carduelis tristis	American goldfinch	NPS?	BPA	IC							
Coccothraustes vespertinus	Evening grosbeak		BPA	IC							
Passer domesticus	House sparrow	NPS?	BPA	IC							
Mammals											
Sorex cinereus	Masked shrew	NPS?	BPA	IC							
Sorex vagrans	Vagrant shrew	NPS?	BPA	IC							
Sorex monticolus	Dusky shrew	NPS?	BPA								
Sorex palustris	Water shrew	NPS?	BPA	IC							
Sorex bendirii	Pacific water shrew	NPS?	BPA				IO		SM		

Table 2-8. Terrestrial Animal Species Present in the UCR RI/FS Study Area

Scientific Name	Common Name	Source of Occurrence Information					WDFW USE	Federal Status	State Status	Proposed State Status Listing	Culturally Important
Sorex trowbridgii	Trowbridge's shrew	NPS?	BPA	xIC							
Sorex merriami	Merriam's shrew	NPS?	BPA	IC			IO		SC	PS	
Sorex hoyi	Pygmy shrew	NPS?	BPA	IC			IO		SM	PS	
Neurotrichus gibbsii	Shrew-mole		BPA	xIC							
Scapanus townsendii	Townsend's mole		BPA								
Scapanus orarius	Coast mole		BPA	xIC							
Myotis lucifugus	Little brown myotis	NPS?	BPA	IC							
Myotis yumanensis	Yuma myotis	NPS?	BPA	IC			B,CR	FC			
Mammals (continued)											
Myotis evotis	Long-eared myotis	NPS?	BPA	IC			B,CR	FC	SM		
Myotis thysanodes	Fringed myotis	NPS?	BPA	IC			B,CR	FC	SM		
Myotis volans	Long-legged myotis	NPS?	BPA	IC			B,CR	FC	SM		
Myotis californicus	California myotis	NPS?	BPA	IC							
Myotis ciliolabrum	Small-footed myotis	NPS?	BPA	IC			B,CR	FC	SM		
Lasionycteris noctivagans	Silver-haired bat	NPS?	BPA	IC							
Eptesicus fuscus	Big brown bat	NPS?	BPA	IC							
Lasiurus borealis	Red bat	NPS?	BPA				B,IO		SM		
Lasiurus cinereus	Hoary bat	NPS?	BPA	IC							
Euderma maculatum	Spotted bat	NPS?		IC			B,CR		SM	SM	
Coryhorhinus townsendii	Townsend's big-eared bat	NPS?	BPA	IC		WDFW	B,CR	FC	SC	PT	
Coryhorhinus townsendii townsendii	Pacific Townsend's big-eared bat	NPS?				WDFW	B,CR	FC	SC	PT	
Antrozous pallidus	Pallid bat	NPS?	BPA	IC			B,CR		SM		
Ochotona princeps	Pika		BPA	IC							
Brachylagus idahoensis	Pygmy rabbit		BPA	IC			IO	FE	SE		
Sylvilagus nuttallii	Nuttall's cottontail	NPS	BPA	IC							
Lepus americanus	Snowshoe hare		BPA	IC							
Lepus townsendii	White-tailed jack rabbit		BPA	IC			IO		SC		
Tamias minimus	Least chipmunk	NPS?	BPA	IC							
Tamias amoenus	Yellow-pine chipmunk	NPS?	BPA	IC							
Tamias townsendii	Townsend's chipmunk	NPS?	BPA								
Tamias ruficaudus	Red-tailed chipmunk	NPS?	BPA	IC			IO		SM		
Marmota flaviventris	Yellow-bellied marmot	NPS	BPA	IC							
Marmota caligata	Hoary marmot			IC							
Spermophilus washingtoni	Washington ground squirrel		BPA	xIC			IO	FC	SC		
Spermophilus columbianus	Columbian ground squirrel	NPS	BPA	IC							
Spermophilus beecheyi	California ground squirrel		BPA	xIC							
Spermophilus lateralis	Golden-mantled ground squirrel		BPA	IC							
Sciurus niger	Fox squirrel		BPA								
Sciurus griseus	Western gray squirrel		BPA	xIC			IO	FC	ST		
Tamiasciurus hudsonicus	Red squirrel	NPS	BPA	IC							
Tamiasciurus douglasii	Douglas' squirrel		BPA	xIC							
Glaucomys sabrinus	Northern flying squirrel		BPA	IC							
Thomomys talpoides	Northern pocket gopher	NPS?	BPA	IC							
Thomomys mazama	Mazama (Western) pocket gopher	NPS?	BPA				IO	FC	SC		
Perognathus parvus	Great basin pocket mouse		BPA	IC							
Castor canadensis	Beaver	NPS	BPA	IC							CCT
Mammals (continued)											
Reithrodontomys megalotis	Western harvest mouse		BPA	IC							
Peromyscus maniculatus	Deer mouse		BPA	IC							
Neotoma cinerea	Bushy-tailed woodrat		BPA	IC							
Clethrionomys gapperi	Southern red-backed vole	NPS?	BPA	IC							
Clethrionomys californicus	Western red-backed vole	NPS?	BPA	xIC							
Phenacomys intermedius	Heather vole	NPS?	BPA	IC							
Microtus pennsylvanicus	Meadow vole	NPS?	BPA	IC							
Microtus montanus	Montane vole	NPS?	BPA	IC							
Microtus townsendii	Townsend's vole	NPS?	BPA								
Microtus longicaudus	Long-tailed vole	NPS?	BPA	IC							
Microtus oregoni	Creeping vole	NPS?	BPA	xIC							
Microtus richardsoni	Water vole	NPS?	BPA	IC							
Lagurus curtatus	Sagebrush vole	NPS?	BPA	IC			IO		SM		
Ondatra zibethicus	Muskrat	NPS	BPA	IC							
Synaptomys borealis	Northern bog lemming			IC			IO		SM		
Rattus norvegicus	Norway rat	NPS?	BPA								
Mus musculus	House mouse	NPS?	BPA								
Zapus princeps	Western jumping mouse	NPS?	BPA	IC							
Erethizon dorsatum	Porcupine	NPS	BPA	IC							
Canis latrans	Coyote	NPS	BPA	IC							
Canis lupus	Gray wolf					WDFW	IO	FT	SE		
Vulpes vulpes	Red fox		BPA	IC							
Ursus americanus	Black bear	NPS	BPA	IC							CCT
Ursus arctos	Grizzly bear		BPA	xIC		WDFW	IO	FT	SE		CCT
Procyon lotor	Raccoon	NPS	BPA	IC							
Martes americana	Marten		BPA	IC							

Table 2-8. Terrestrial Animal Species Present in the UCR RI/FS Study Area

Scientific Name	Common Name	Source of Occurrence Information					WDFW USE	Federal Status	State Status	Proposed State Status Listing	Culturally Important
Martes pennanti	Fisher		BPA	xIC			IO	FC	SE	PS	
Mustela erminea	Ermine			IC							
Mustela frenata	Long-tailed weasel		BPA	IC							
Mustela vison	Mink	NPS	BPA	IC							
Gulo gulo	Wolverine		BPA	IC			IO	FC	SC		
Taxidea taxus	Badger	NPS	BPA	IC							
Spilogale gracilis	Spotted skunk		BPA								
Mephitis mephitis	Striped skunk	NPS	BPA	IC							
Lutra canadensis	River otter	NPS	BPA	IC							
Felis concolor	Mountain lion	NPS	BPA								
Lynx canadensis	Lynx		BPA	IC			IO	FT	ST		
Mammals (continued)											
Lynx rufus	Bobcat	NPS	BPA	IC							
Cervus elaphus	Elk	NPS									CCT
Cervus elaphus nelsoni	Rocky Mountain elk		BPA	IC		WDFW					CCT
Odocoileus hemionus hemionus	Mule deer	NPS	BPA	IC		WDFW					CCT
Odocoileus virginianus	White-tailed deer	NPS	BPA	IC							CCT
Odocoileus virginianus ochrourus	Northwest white-tailed deer					WDFW					CCT
Alces alces	Moose	NPS	BPA	xIC		WDFW					CCT
Rangifer tarandus	Woodland caribou			IC			IO	FE	SE		
Oreamnos americanus	Mountain goat			IC							
Ovis canadensis	Bighorn sheep					WDFW					

Sources:

CCT (Confederated Tribes of the Colville Reservation)
NPS (National Park Service) = Hebner et al. (2000)
BPA (Bonneville Power Administration) = Creveling and Renfrow (1986)
IC (Interior Columbia Basin Ecosystem Management Project) = Cassidy et al. (1997) and Marcot et al. (2003)
SAS (Seattle Audubon Society) = Seattle Audubon Society (2006)
WDFW (Washington Department of Fish and Wildlife) = WDFW (2006)
USFWS (U.S. Fish and Wildlife Service) = USFWS (2007)
WSDOT (Washington State Department of Transportation) = WSDOT (2007)

Notes:

NPS = specifically identified in NPS document, w/ or w/o scientific name; e.g., northern saw-whet owl.
NPSh = NPS document lists Hungarian partridge, which is a subspecies of gray partridge present in eastern Washington.
NPS? = general species identified in NPS document; e.g., pocket gophers (*Thomomys* spp.). All species within the group identified that were also identified in the BPA document were marked using this code.
BPA = specifically identified in BPA document
IC = species range as shown in GIS coverage from Cassidy et al. 1997 overlaps preliminary analysis area (verified from updated map in Marcot et al. 2003).
xIC = species range as shown in GIS coverage from Cassidy et al. 1997 does not overlap preliminary analysis area (verified from updated map in Marcot et al. 2003).
xIC* = species range as shown in GIS coverage from Cassidy et al. 1997 slightly overlaps preliminary analysis area around Grand Coulee Dam.
SAS = species ranges as shown in Bird Web map overlaps preliminary analysis area. Bird Web was checked for each bird species coded as present in NPS or BPA document and not present in Cassidy et al. 1997 and Marcot et al. 2003.
xSAS = species ranges as shown in Bird Web map does not overlap preliminary analysis area. Bird Web was checked for each bird species coded as present NPS or BPA document and not present in Cassidy et al. 1997 and Marcot et al. 2003.
WDFW = identified in WDFW's Priority Habitats and Species database within the preliminary analysis area.

WDFW Use Codes:
B = breeding
CR = communal roost
IO = individual occurrence
RI = regular occurring individual
RLC = regular large concentration
RSC = regular small concentrations

Federal Status Codes:
FC = federal candidate
FE = federal endangered
FT = federal threatened

State Status Codes:
SC = state candidate
SE = state endangered
SM = state monitor
SS = state sensitive
ST = state threatened

Proposed State Status Codes:
PS = proposed sensitive
PT = proposed threatened

Table 2-9. Aquatic Species Present in the UCR RI/FS Study Area

Scientific Name	Common Name	Source of Occurrence Information	WDFW USE	Federal Status	State Status
Invertebrates					
Anodonta californiensis	California floater	WDFW	IO	FC	SC
Fish					
Acipenser transmontanus	White sturgeon	StreamNet, BPA1			
Acrocheilus alutaceus	Chiselmouth	BPA2			
Catostomus catostomus	Longnose sucker	BPA1			
Catostomus columbianus	Bridgelip sucker	BPA1			
Catostomus macrocheilus	Largescale sucker	BPA1			
Coregonus clupeaformis	Lake whitefish	BPA1			
Cottus spp.	Sculpin	BPA3			
Cyprinus carpio	Carp	BPA1			
Ictalurus natalis	Yellow bullhead	BPA2			
Ictalurus nebulosus	Brown Bullhead	LRF			
Ictalurus punctatus	Channel Catfish	LRF			
Lepomis gibbosus	Pumpkinseed	BPA2			
Lota lota	Burbot	BPA1			
Micropterus dolomieui	Smallmouth bass	BPA1			
Micropterus salmoides	Largemouth bass	BPA1			
Mylocheilus caurinus	Peamouth	BPA1			
Oncorhynchus clarki	Cutthroat	BPA2			
Oncorhynchus mykiss	Rainbow trout	BPA1			
Oncorhynchus nerka	Kokanee (landlocked sockeye)	BPA1			
Oncorhynchus tshawytscha	Chinook salmon (Upper Columbia)	BPA2		FE	SC
Perca flavescens	Yellow perch	BPA1			
Pomoxis nigromaculatus	Black crappie	BPA1			
Prosopium williamsoni	Mountain whitefish	BPA1			
Ptychocheilus oregonensis	Northern pikeminnow	BPA1			
Richardsonius balteatus	Redside shiner	BPA2			
Salmo trutta	Brown trout	BPA1			
Salvelinus confluentus	Bull trout (Columbia Basin)	StreamNet, BPA2		FT	SC
Salvelinus fontinalis	Brook trout	BPA1			
Sander vitreous	Walleye	BPA1			
Tinca tinca	Tench	BPA1			

Sources:

BPA (Bonneville Power Administration) = Lee et al. (2006)
StreamNet = StreamNet (2006)
LRF (Lake Roosevelt Forum) = LRF (2006c)
WDFW (Washington Department of Fish and Wildlife) = WDFW (2006)

Notes: There are no proposed state status listings for aquatic species.

Occurrence source coding:

BPA1 = fish species captured during 2004 monitoring (Table 29 of source document).
BPA2 = fish species captured during monitoring conducted prior to 2004 but not in 2004 (Table 92 of source document).
BPA3 = sculpins captured during 2004 monitoring (Table 29 of source document), but individuals not identified to specific species.
StreamNet = fish species distribution maintained by StreamNet (migration for white sturgeon; use unknown for bull trout).
WDFW = identified in WDFW's Priority Habitats and Species database within the preliminary analysis area.

WDFW Use Codes:

IO = individual occurrence

Federal Status Codes:

FC = federal candidate
FE = federal endangered
FT = federal threatened

State Status Codes:

SC = state candidate

Proposed State Status Codes:

PS = proposed sensitive
PT = proposed threatened

Table 3-1.
Reported Spills and Permit Limit Exceedances from the Trail Facility to the Columbia River

Year	Constituent	Spill Date	Quantity/Concentration	Permit Limit[a]	Location	Information Source(s)[b]
1980	**Hg**	March 19	7000 kg/day	0.258 kg/day		3
	NH_3HSO_3	July 13	500 gallons			3
	H_2SO_4 (93%)	November 1	30 tonnes			3
	P_2O_5	November 4	24 tonnes			3
1981	**Zn**	April 23	9500 kg/day	9070 kg/day		3
	H_2SO_4 (93%)	May 4	25-30 tonnes			3
	NH_3HSO_3	May 13	4000 gallons			3
	H_2SO_4 (93%)	August 4	53 tonnes			3
	H_2SO_4 (93%)	October 6	40 tonnes			3
1987	**H_2SO_4 (50%)**	September 2	15 tonnes			1
1988	**Zn solution (150 g/L)**	November 25	5 tonnes (surface spill)			1
1989	**As**	July 17	Unknown (surface spill)			1
	Gypsum and H_3PO_4	July 16	Unknown (surface spill)			1
	Neutral thickener	May 1	60,000 L			1
	Yellow substance	August 18	305 meters long			1
1990	**Hg**	March 6	14 kg			1
	Zn	September 4	Unknown (electrolyte)			1
	Sulfuric acid (H_2SO_4)	January 20	unknown (93%)**			1
		April 26	300-400 gal (93%)		Sewer 08	2
		June 11	909 L			1
		August 23	> 30 tonnes		Outfall III	2
		August 24	16,000 L			1
1991	**Cd**	May 7	0.070 mg/L		Outfall III	2
		May 7	0.090 mg/L		Outfall II	2
		November 5	0.07 mg/L	0.05 mg/L		3
	Hg	March 6	0.056 mg/L		Outfall 07	2
		July 18	0.014 mg/L	0.01 mg/L		3
	Pb	February 5	0.53 mg/L		Outfall II	2
		March 6	1.80 mg/L		Outfall 07	2
		March 6	0.56 mg/L		Outfall II	2
		August 14	1.7 mg/L	1 mg/L		3
	Zn	January 30	576 kg			1
		February 11	4,546 L (sulfide residue)			1
		April 21	220 L (solution 160 g/L)			1
		September 17	8.5 mg/L	5 mg/L		3
		October 1	8.2 mg/L	5 mg/L		3
		November 5	5.8 mg/L	5 mg/L		3
		December 3	7.3 mg/L	5 mg/L		3
		December 7	881 L (electrolyte)			1
	Copper Sulfate ($CuSo_4$)	February 5	3,000 L			1
	Sulfuric acid (H_2SO_4)	March 16	4.54 tonnes			1
		April 13	1,000 L (15%)			1
		April 13	Unknown (160 g/L)			1
		September 16	132 to 176 L			1
	Phosphoric acid (H_3PO_4)	February 7	0.9 to 1.8 tonnes			1
		April 2	15 tonnes			1
		April 6	1.35 tonnes			1
		June 15	2 tonnes (weak)			1
		June 21	Unknown			1
		June 24	2.72 to 3.63 tonnes (27%)			1
	Phosphates (PO_4^{3-})	June 21	6.7 tonnes			1
	Total suspended solids (TSS)	December 20	1165.3 kg/day		Outfall III	2
		January 16	157.0 mg/L		Outfall II	2
		September 17	39 mg/L			3
		October 1	12475 mg/L			3
		November 5	10989 mg/L			3
		December 3	18670 mg/L			3
	Flow	June 18	426600 m^3/day		Outfall II	2
	Partially treated slag	August 24	50 tonnes (approximate)		Columbia River	2
	Zinc slurry/ pressure leach slurry	May 13	22.7 L			1
		December 20	2,273 L			1
	$NaHSO_4$	September 16	20 L/min, quantity unknown			1
	NH_3-N	May 13	90.9 L (ammonia)			1
		August 14	45 mg/L			3
		September 17	40 mg/L			3
		November 5	40 mg/L			3
	Coal dust/ water	August 1	220 L			1
	Furnace oil	September 9	50 tonnes			1
1992	**Hg**	June 24	6.8-10 kg/day	1.05 kg/day		3

Table 3-1.
Reported Spills and Permit Limit Exceedances from the Trail Facility to the Columbia River

Year	Constituent	Spill Date	Quantity/Concentration	Permit Limit[a]	Location	Information Source(s)[b]
		September 30	15 kg 60 kg/day	1.05 kg/day		1 3
		October 1	60 kg/day	0.55 kg/day		3
		December 2	0.014 mg/L 0.014 mg/L	0.005 mg/L	Outfall III	2 3
		December 16	0.021 mg/L 0.21 mg/L	0.005 mg/L	Outfall III	2 3
	Zn	April 20	25,000 L (electrolyte)			1
		May 23	350 L (electrolyte) (surface spill) 214.1 kg/day	63.7 kg/day		1 3
	H_2SO_4 (93%)	January 8	100-150 L			3
		March 3	NA			3
		March 7	1 gallon			3
		March 19	20 gallons			3
		April 14	30 gallons			3
		April 18	100 gallons			3
		August 4	5-10 gallons			3
		November 3	434 kg 450 kg			1 3
		December 16	25 to 30 tonnes 2.5 tonnes			1 3
	H_2SO_4 (93.5%)	June 8	20 L			3
	H_2SO_4 (98 %)	September 5	10-15 gallons			3
	Sulfuric acid (H_2SO_4)	February 6	400 L			3
		February 22	250 gallons			3
		July 14	20 L			3
		August 3	Unknown (surface spill)			1
		October 2	20-50 gallons			3
		December 4	10-15 gallons			3
	H_3PO_4 (21 %)	May 25	5 tonnes			3
		May 26	5 tonnes			1
	H_3PO_4 (27%)	May 8	NA			3
	Phosphoric acid (H_3PO_4)	March 1	NA			3
		March 14	NA			3
		April 20	NA			3
		June 26	NA			3
		July 10	1.5 tonnes			3
		July 11	Unknown			1
		August 10	1500 L			3
		September 4	NA			3
	Phosphates (PO_4^{3-})	March 11	Unknown			1
		April 2	Unknown			1
	NH_3SO_4	April 9	150 gallons			3
	SO_3	May 15	40 gallons			3
	Ammonium bisulphite (NH_4HSO_3)	June 4	15 gallons			3
		September 14	30-40 gallons			3
		December 20	15-20 gallons			3
		December 22	400 L			3
	Ammonium sulfate (NH_4SO_4)	December 8	12.3 tonnes 12 tonnes			1 3
		December 11	12 tonnes			1
	SO_4	October 2	50-100 gallons			3
	Sulfide leach residue	April 22	Unknown (surface spill)			1
	Return acid, calcine	July 1	20 gallons			3
	ESSO Teresso 68 oil/ Compressor oil	July 23	25 L			1
		July 28	25-30 L			3
	Transformer oil Voltesso 35	December 17	200 L			3
1993	**As**	September 4	60 to 65 kg (dissolved)			1
		September 5	Unknown		Outfall III	2
		December 9	22 kg (dissolved)			1
	Hg	January 5	up to 7 kg			1
		January 6	0.13 mg/L	0.005 mg/L	Outfall III	2, 3
		January 8	0.013 mg/L	0.005 mg/L	Outfall III	2, 3
		January 12	0.014 mg/L	0.005 mg/L	Outfall III	2, 3
		April 25	0.028 mg/L	0.005 mg/L	Outfall III	2, 3
		May 1	0.012 mg/L	0.005 mg/L	Outfall III	2, 3
		June 4	0.018 mg/L	0.005 mg/L	Outfall III	2, 3
		June 10	18 kg 0.030 mg/L 0.3 mg/L	0.005 mg/L	Outfall III	1 2 3
		June 14	0.014 mg/L	0.005 mg/L	Outfall III	2, 3
		June 15	0.032 mg/L	0.005 mg/L	Outfall III	2, 3
		June 16	0.014 mg/L	0.005 mg/L	Outfall III	2, 3
		June 20	0.014 mg/L	0.005 mg/L	Outfall III	2, 3
		June 21	0.01 mg/L	0.005 mg/L	Outfall III	2, 3
		June 23	0.027 mg/L	0.005 mg/L	Outfall III	2, 3
		June 28	0.011 mg/L	0.005 mg/L	Outfall III	2, 3

Table 3-1.
Reported Spills and Permit Limit Exceedances from the Trail Facility to the Columbia River

Year	Constituent	Spill Date	Quantity/Concentration	Permit Limit[a]	Location	Information Source(s)[b]
		July 6	0.011 mg/L	0.005 mg/L	Outfall III	2, 3
		August 11	0.011 mg/L	0.005 mg/L	Outfall III	2, 3
		August 21	0.023 mg/L	0.005 mg/L	Outfall III	2, 3
	Cd oxide (CdO)	November 3	Unknown			1
	Zn sulfate (150 g/L)	January 7	600 kg			1
	Ammonia (NH_3)	March 14	Unknown			1
	Sulfuric Acid (H_2SO_4)	January 7	13,000 tonnes (50 g/L)			1
		July 30	10 tonnes			1
1994	**As**	February 9	20 kg 21 kg/day	NA		1 3
		February 9	0.22 mg/L 0.02 mg/L; 2.1 kg/day	0.05 mg/L; 5.5 kg/day	Outfall III	2 3
		March 7	0.18 mg/L		Outfall III	2
		June 7	0.06 mg/L		Outfall III	2
		October 17	Unknown		Outfall III	2
		November	0.06 mg/L (once)		Outfall III	2
		"1994"	0.10 tonnes		Outfall II	2
	Cd	March 4	0.09 mg/L		Outfall II	2
		1994	0.19 tonnes		Outfall II	2
		1994	0.02 tonnes		Outfall I	2
	Hg	February 10	1.3 kg			1
		March 4	0.022 mg/L		Outfall II	2
		July 4	< 1 kg < 1 kg/day	0.56 kg/day		1 3
		August 14	0.014 mg/L	0.01 mg/L		3
		October 2	0.006 mg/L		Outfall III	2
		October 18	0.006 mg/L		Outfall III	2
		October 20	0.006 mg/L		Outfall III	2
		November	16 exceedances		Outfall III	2
		December 18	0.011 (units NA)		Outfall III	2
		December 19	0.009 (units NA)		Outfall III	2
		December 21	0.011 (units NA)		Outfall III	2
	Pb	March 4	1.50 mg/L		Outfall II	2
	Chlorine	March 5	< 1 kg			1
	Zn oxide (ZnO)	October 24	unknown			1
	Ammonia (NH_3)	October 5	3,500 kg			1
	Ammonium sulfate (NH_4SO_4)	June 1	2 m^3			1
		June 13	Unknown			1
	TSS	March 4	89.0 mg/L	Outfall II	Outfall II	2
		1994	5791 tonnes	Outfall I	Outfall I	2
	Flow rate	November	all samples exceedances	Outfall I	Outfall I	2
1995	**As**	June 25	12.5 kg/day	11 kg/day		3
	Cd	February 27	NA	3.9 kg/day		3
		March 10	70 kg (dissolved) 102 kg/day 102 kg/day; 0.001 mg/L	60 kg/day, 0.05 mg/L	Outfall III	1 2 3
		June 25	4.2 kg/day	4 kg/day		3
	Cu	June 25	11.5 kg/day	5.5 kg/day		3
	Hg	February 5	0.3375 kg/day 0.34 kg/day; 2.8 E-06 mg/L	0.15 kg/day; 0.005 mg/L	Outfall II	2 3
		February 26	0.1804 kg/day 0.18 kg/day; 1.7 E-06 mg/L	0.55 kg/day; 0.005 mg/L	Outfall II	2 3
		March 9	0.2350 kg/day 0.24 kg/day; 2.2 E-06 mg/L	0.55 kg/day; 0.005 mg/L	Outfall II	2 3
		March 26	0.6768 kg/day 0.68 kg/day; 6.0 E-06 mg L^{-}	0.55 kg/day; 0.005 mg/L	Outfall III	2 3
		March 27	0.7659 kg/day 0.77 kg/day; 7.0 E-06 mg/L	0.55 kg/day; 0.005 mg/L	Outfall III	2 3
		April 3	0.6957 kg/day 0.70 kg/day; 8.0 E-06 mg/L	0.55 kg/day; 0.005 mg/L	Outfall III	2 3
		April 4	0.9636 kg/day 0.96 kg/day; 1.1 E-05 mg/L	0.55 kg/day; 0.005 mg/L	Outfall III	2 3
		April 5	0.6624 kg/day	0.55 kg/day; 0.005 mg/L	Outfall III	2 3
		May 5	0.3496 kg/day	0.55 kg/day; 0.005 mg/L	Outfall II	2
		May 6	0.4440 kg/day 0.35 kg/day	0.55 kg/day; 0.005 mg/L	Outfall II	2 3
		May 7	0.44 kg/day; 3.7 E-06 mg/L	0.15 kg/day; 0.005 mg/L		3
		May 15	0.8280 kg/day 0.83 kg/day; 6.4 E-06 mg/L	0.55 kg/day; 0.005 mg/L	Outfall III	2 3
		May 16	0.7688 kg/day 0.77 kg/day; 5.5 E-06 mg/L	0.55 kg d	Outfall III	2 3
		May 22	1.0413 kg/day 1.04 kg/day; 7.0 E-06 mg/L	0.55 kg d	Outfall III	2 3
		May 31	0.2330 kg/day 0.23 kg/day; 1.3 E-06 mg/L	0.55 kg d	Outfall II	2 3
	Pb	June 25	63.8 kg/day	27.5 kg/day		3
	Zn	June 13	960 kg 960 kg/day 960 kg/day; 0.005 mg/L	150 kg/day; 5 mg/L	Outfall III	1 2 3
		June 13	1321 kg/day	550 kg/day		3
		June 25	407.6 kg/day	150 kg/day		3

Table 3-1.
Reported Spills and Permit Limit Exceedances from the Trail Facility to the Columbia River

Year	Constituent	Spill Date	Quantity/Concentration	Permit Limit[a]	Location	Information Source(s)[b]
	H_2SO_4	June 25	~1,000 L 3000-5000 L 3000-5000 L		Outfall III	1 2 3
	Slag	December 7	75 tonnes			3
	Coal dust (suspected)	May 22	Unknown			1
1996	**As**	January 22	0.32 kg/day	0.1 kg/day	Pond/ cooling water[††]	2, 3
		January 28	0.18 kg/day	0.1 kg/day	pond	2, 3
		February 4	0.14 kg/day	0.1 kg/day	pond	2, 3
	Cd	January 10	0.87 kg/day	0.5 kg/day	Cooling water	2, 3
		January 22	0.14 kg/day,0.82 kg/day	0.1 kg/day, 0.5 kg/day	Pond/ cooling water	2, 3
		February 27	0.01 kg 3.75 kg/day 3.75 kg/day	2.75 kg/day	Outfall II	1 2 3
	Hg	January 26	0.0115 kg/day	0.009 kg/day	Pond	2, 3
		February 26	0.0199 kg/day	0.009 kg/day	Pond	2, 3
	Pb	February 27	0.3 kg			1
	Zn	January 17	40,000 L (& sulfuric acid) 2074 kg 2074 kg/day	150 kg/day	Outfall III	1 2 3
		January 22	39.66 kg/day	20 kg/day	Pond/ cooling water	2, 3
		February 9	31.52 kg/day	20 kg/day	Pond	2, 3
		February 21	16.2 kg/day	5 kg/day	Cooling water	2, 3
		February 21	25 kg/day	20 kg/day		3
		February 27	0.5 kg 35 kg/day	20 kg/day	Pond	1 2, 3
	TSS	January	6431 kg/day		Pond	2
		February	6375 kg/day		Pond	2
		February 15	3459 kg/day		Outfall III	2
		February 21	6987 kg/day		Cooling water	2
	Pb fume slurry	February 26	3 m^3			1
	Slag/slurry	May 10	25 tonnes 35 tons (estimated) 35 tonnes		Columbia	1 2 3
		November 8	35 tonnes (barren) 35 tonnes		River (unknown)	1 2, 3
	Na_2CO_3	February 27	3 m^3			1
	NH_3-N	February 9	30 mg/L			3
	White solution & foam	April 7	Unknown			1
	White discoloration	May 23	Unknown			1
	White oxide dust	December 31	Unknown			1
1997	**Cd**	March 13	3,000 kg (incl. Hg, dissolved) 40 kg 40 kg/day	3 kg/day	Outfall 07	1 2 3
		March 25	22 kg 22 kg/day	3 kg/day		1 3
		March 26	25 kg/day		Outfall III	2
	Hg	March 13	3,000 kg (incl. Cd, dissolved) 8.9 kg 8.9 kg/day	0.55 kg/day	Outfall 07	1 2 3
		December 12	Unknown		Outfall II	2
		December 17	700 L (incl. Zn)			1
	Pb	March 13	1450 kg 1450 kg/day	17.13 kg/day	Outfall 07	2 3
	Zn	July 23	500 kg (as Zn slurry)		Outfall III	1, 2
		December 17	700 L (incl. Hg)			1
	TSS	March 13	3200 kg		Outfall 07	2
	H_2SO_4	May 20	Unknown (as acidic solution) 600 kg 600 kg/day		Outfall III	1 2 3
		July 23	4500 L		Outfall III	2
1998	**As**	March 6	5 m^3 (in slurry) 23 kg/day	15 kg/day	Outfall III	1 2, 3
		March 7	23 kg/day	15 kg/day		3
		June 1	20 kg/day		Outfall II	2
		June 2	20.36 kg (total As) 20.36 kg/day	15 kg/day		1 3
		November 24	20 kg			1
	Cd	May 3	15 kg (in solution) 15 kg/day 15 kg/day; 0.0002 mg/L	2.75 kg/day; 0.022 mg/L	Outfall II	1 2 3
		December 25	3 kg 6.5 kg/day; 0.08 mg/L		Outfall III	1 2
		December 26	4.5 kg/day 6.5 kg/day; 0.08 mg/L	3 kg/day; 0.03 mg/L	Outfall II	2 3
	Cu	July 30	15 kg/day	8 kg/day	Outfall II	2, 3
	Tl	July 21	129 kg/day	NA	Outfall III	2, 3
		October 12	100 kg/day	NA	Unknown	2, 3
	Zn	December 25	87 kg			1
		December 26	177 kg/day ; 2.2 mg/L	90 kg/day ; 0.9 mg/L		3
	Slag cooling water/slag, granulated slag	August 20	~25,000 L (slag, Pb, Zn, H_20) Unknown 1.9 m^3		Outfall II	1 2 3
		October 24	15 min duration		Unknown	1, 2
	Granulated slag/ Barren slag/	January 9	unknown 1-3 m^3		Unknown	2 3

Table 3-1.
Reported Spills and Permit Limit Exceedances from the Trail Facility to the Columbia River

Year	Constituent	Spill Date	Quantity/Concentration	Permit Limit[a]	Location	Information Source(s)[b]
	slurry	April 7	1 tonne 1-1.5 tonnes 1 tonnes		05 sewer	1 2 3
1999	**Cd**	March 24	3.53 kg/day; 0.040 mg/L	3 kg/day; 0.03 mg/L	Outfall III	2, 3
		March 25	4.01 kg/day; 0.045 mg/L	3 kg/day; 0.03 mg/L	Outfall III	2, 3
		March 27	3.32 kg/day; 0.040 mg/L	3 kg/day; 0.03 mg/L	Outfall III	2, 3
		September 22	6.04 kg/day; 0.073 mg/L	2.75 kg/day; 0.061 mg/L	Outfall II	2, 3
		September 24	5.8 kg/day; 0.06 mg/L	3 kg/day; 0.03 mg/L		3
		September 25	5.8 kg/day; 0.061 mg/L	3 kg/day; 0.03 mg/L	Outfall III	2
		October 7	3.48 kg/day	2.75 kg/day	Outfall II	2, 3
		October 11	2.86 kg/day	2.75 kg/day	Outfall II	2, 3
	Tl	April 17	67.2 kg/day; 0.7 mg/L	NA		3
		April 18	67.2 kg		Outfall III	2
		April 18	196 kg 196 kg/day; 2.1 mg/L	NA	Outfall III	2 3
		April 19	201 kg 201 kg/day; 2.1 mg/L	NA	Outfall III	2 3
		April 20	136 kg 136 kg/day; 1.5 mg/L	NA	Outfall III	2 3
		April 21	72.7 kg 72.7 kg/day; 0.8 mg/L	NA	Outfall III	2 3
		April 22	56.0 kg 56 kg/day; 0.6 mg/L	NA	Outfall III	2 3
		April 23	39.0 kg 39 kg/day; 0.4 mg/L	NA	Outfall III	2 3
	Zn	October 4	165 kg/day; 1.90 mg/L 165 kg/day; 1.9 mg/L	75 kg/day; 1.4 mg/L	Outfall II	2 3
		October 7	106 kg/day	90 kg/day		3
	Fume contaminated water	July 23	unknown		Columbia River	2
2000	**Cd**	February 9	3.74 kg/day	2.75 kg/day	Outfall II	2, 3
		February 18	10.5 kg 10.5 kg/day; 0.12 mg/L	2.75 kg/day; 0.06 mg/L	Outfall II	1 2, 3
	Tl	October 8	43 kg 43 kg/day		Outfall III	
		October 10	34 kg 34 kg/day		Outfall III	
		October 11	31 kg 31 kg/day		Outfall III	
	Zn	February 18	350 kg 349 kg/day; 4.0 mg/L 350 kg/day; 4 mg/L	75 kg/day; 1.4 mg/L	Outfall II	1 2 3
		March 31	693 µg/L	900 µg/L		3
		April 4	1810 µg/L	900 µg/L		3
	NH_3/ NH_3-N	March 28	up to 1.9 tonnes 1.9 tonnes		Outfall IV	2 3
	Flow rate	July 25	> 125,000 $m^3 d^{-1}$		Outfall II	2
		July 26	> 125,000 $m^3 d^{-1}$		Outfall II	2
		July 29	> 125,000 $m^3 d^{-1}$		Outfall II	2
		July 30	> 125,000 $m^3 d^{-1}$		Outfall II	2
	Low pH alarm	April 18	NA			3
2001	**Hg**	May 8	1.42 kg/day	0.55 kg/day		3
	Zn	January 31	529.7 kg/day 529.7 kg/day; 6.6 mg/L	75 kg/day; 1.4 mg/L		2 3
		November 26	Unknown	90 kg/day	Unknown	2, 3
	Oil	May 27	10 L 22 L			1 3
	LC50 bioassay	December 3	failed		Outfall II	2
2002	**Cd**	October 21	5.4 kg/day		Outfall II	2
	LC50 bioassay	February 19	failed		Outfall IV	2
		June 19	failed		Outfall II	2
	pH	January 15	8.3		Outfall IV	2
2003	**Zn**	January 8	99.5 kg/day	75 kg/day	Outfall II	2, 3
2008	**As, Zn, Pb, Cd**	April 17	233 kg Zn 66 kg Pb 2.1 kg Cd 3.4 kg As	NA	Not listed	4
	Pb, hydrofluoric acid	May 28	940 kg Pb	NA	Not listed	5

[a] Permit limit listed in Table E1-4, Draft Upper Columbia River RI/FS Work Plan (TCAI, 2007)
[b] Sources:
1 – EPA, 2003. Based on Environment Canada Spilltracker Database, as provided in MacDonald 1997 and personal communication with Environment Canada staff.
2 – CCT, 2004. Based on Freedom of Information and Privacy Act (FOIPA) documents produced by the Canadian Government to CCT.
3 – TCAI, 2007. Based on facility information provided by TCAI and records maintained by the B.C. Ministry of the Environment.
4 - National Response Center report
5 - Environment Canada notice

As – arsenic
Cd – cadmium
Cu – copper
Hg – mercury
Pb – lead
Ti – titanium
TSS – total suspended solids
Zn – zinc

mg/L – milligrams per liter
µg/L – micrograms per liter
kg – kilograms
kg/day – kilograms per day
L – liter
m^3- cubic meter
m^3/day – cubic meters per day
tonne - 1,000 kilograms (also known as a short ton)

Table 3-2. Summary of Permits Issued to the Trail Facility by the B.C. Government Authorizing Onsite Activities and/or Discharges

Permit No.	Applicable Facility Operations	General Description
Air		
PA-02691	Lead Operations	Governs atmospheric emissions from the smelter furnaces and the lead refinery.
PA-02692	Zinc Operations	Governs atmospheric emissions from roasters, acid plants leaching circuit, and electrolytic/melting plants.
PA-02690	Fertilizer Operations	Governs atmospheric emissions from fertilizer operations and other operations located in the Warfield Complex.
Water		
PE-02753	Metallurgical Liquid Effluents	Governs effluent discharges from all on-site operations through Metallurgical Plant Combined Outfalls II, III, and IV.
PE-02407	Waneta Dam Effluent	Governs and permits discharge from a septic system into septic tile fields.
License No. 11790	Water Rights	License to divert water from the Columbia River to Trail Operations (industrial and domestic uses).
Material Management Permits		
PR-11898	Slag Disposal	Permit to store barren slag at the Duncan Flats storage site. Although this permit is active, the storage facility has never been established given that ferrous granules are now sold to the cement industry.
PS-08310	Arsenic Storage	Permit to store arsenic containing materials at Duncan Flats. All wastes are contained in a lined facility (top and bottom), equipped with water collection system.
PS-11532	Thallium and Calomel Storage	Permit to operate an indoor storage facility for mercury and thallium containing materials resulting from on-site metallurgical operations.
AS-16033	Tellurium	Approval to discharge tellurium containing slag from the lead refinery but is now classified as a product (i.e., ferrous granules) and is sold to the cement industry. Therefore no longer applicable.
Landfill Permits		
PR-05175	Warfield Landfill	Permit to operate a non-hazardous waste landfill situated adjacent to the Warfield Operations.
PR-03423	Haley Gully	Permit to operate a non-hazardous waste landfill situated adjacent to the Warfield Operations. This landfill is no longer in use.
Hazardous and Special Waste Management		
PS-08672	Waste Solvent Storage	Permit to operate a waste solvent facility for the collection and safe temporary storage of such materials generated in the Tadanac/Warfield Operations. All materials are appropriately disposed off-site at licensed facilities as required.
PS-08443	Polychlorinated Biphenyl Storage	Permit to operate a storage facility for the temporary storage of PCB-containing materials (e.g., transformers) being phased out of all on-site operations.

Table 3-3. Summary of TRI Facilities and Associated Chemicals in the Vicinity of the Study Area

WRIA	Facility	Facility Reporting Years[a]	County	Reported compounds	Onsite Releases			Other/Offsite Disposal
					Air[b]	Land[c]	Water[d]	
ADDY	NORTHWEST ALLOYS INC	1996-2003	STEVENS	LEAD	x	x		x
				AMMONIA	x	x		x
				COPPER	x			x
				HYDROCHLORIC ACID (1995 AND AFTER "ACID AEROSOLS" ONLY)	x			
ALMIRA	LINCOLN MUTUAL SERVICE INC # 1	1999-2005	LINCOLN	1,2,4-TRIMETHYLBENZENE				
				BENZENE				
				ETHYLBENZENE				
				TOLUENE				
				XYLENE (MIXED ISOMERS)				
COLVILLE	ALADDIN HEARTH PRODS.	1996-1999	STEVENS	CHROMIUM	x			
				COPPER	x			
				LEAD	x			
				MANGANESE	x			
				NICKEL	x			
				TOLUENE	x			x
				ZINC COMPOUNDS	x			
COLVILLE	HEARTH & HOME TECHNOLOGIES	2000-2004	STEVENS	NICKEL	x			x
				CHROMIUM	x			x
COLVILLE	STIMSON LUMBER CO ARDEN OPERATION	2001-2005	STEVENS	LEAD COMPOUNDS	x	x		x
CURLEW	ECHO BAY INC. K2 MINE	2000-2005	FERRY	MERCURY COMPOUNDS		x		
				LEAD COMPOUNDS	x	x		x
INCHELIUM	INCHELIUM TRIBAL WOOD TREATMENT	1996-1997, 2000-2001	FERRY	ARSENIC COMPOUNDS	x			x
				CHROMIUM COMPOUNDS	x			x
				COPPER COMPOUNDS	x			x
				CHROMIUM COMPOUNDS(EXCEPT CHROMITE ORE MINED IN THE TRANSVAAL REGION)				
KETTLE FALLS	BOISE CASCADE LLC KETTLE FALLS PLYWOOD MILL	1998-2005	STEVENS	DIOXIN AND DIOXIN-LIKE COMPOUNDS	x			x
				LEAD	x			x
				METHANOL	x			
KETTLE FALLS	BOISE CASCADE LLC KETTLE FALLS LUMBER	2001-2005	STEVENS	LEAD	x			x
				DIOXIN AND DIOXIN-LIKE COMPOUNDS	x			x
				LEAD COMPOUNDS	x			x
REPUBLIC	KETTLE RIVER OPERATIONS MILL	1998-2005	FERRY	COPPER COMPOUNDS	x	x		
				CYANIDE COMPOUNDS		x		x
				NITRATE COMPOUNDS	x	x		
				AMMONIA	x	x		
				LEAD COMPOUNDS	x	x		
				MANGANESE	x	x		x
				NITRIC ACID	x			

Table 3-3. Summary of TRI Facilities and Associated Chemicals in the Vicinity of the Study Area

WRIA	Facility	Facility Reporting Years[a]	County	Reported compounds	Onsite Releases			Other/Offsite Disposal
					Air[b]	Land[c]	Water[d]	
REPUBLIC	LAMEFOOT MINE	1998, 2000-200	FERRY	NITRATE COMPOUNDS	x	x		x
				MERCURY COMPOUNDS	x	x		
				LEAD COMPOUNDS		x		

Notes:

x = release reported

blank cell = reported value of zero or not reported

The table includes summary listing of all sites in Ferry, Lincoln, and Stevens Counties (1996-2005).

WRIA = Watershed Resources Inventory Areas; definition of these areas is available from Ecology (http://www.ecy.wa.gov/apps/watersheds/wriapages/).

[a] The information provided is a summary of the reporting period; releases indicated may not have occurred in all reporting years.

[b] Air releases are any release from a smoke stack, fugitive emissions, or from a non-point source at a facility. Releases of this type are measured in pounds.

[c] Land releases are any spill on the facility grounds that are not directly connected to a sewer by an impermeable surface, any intentional release applied as a treatment or farm chemical, any surface impoundments, or any on-site landfills.

[d] Water releases include releases to streams, either as direct discharge or as a percentage of storm runoff.

Table 3-4. Current Non-municipal General Permit Facilities That Discharge to WRIAs in UCR Drainage Basin[a]

WRIA	Facility Type	Facility	City	County	Permit	Issue Date	Expiration Date
COLVILLE	Industrial	CHEWELAH BASIN SKI CORPORATION	Chewelah	Stevens	ST0008046C	19-May-04	18-May-09
COLVILLE	Industrial	EQUINOX RESOURCES INC	Colville	Stevens	ST0005287B	11-Dec-98	30-Jun-03
COLVILLE	Industrial	STIMSON LUMBER COMPANY	Colville	Stevens	WA0045527B	3-Dec-03	30-Jun-08
COLVILLE	Industrial	VAAGEN BROS LUMBER INC	Colville	Stevens	ST0008093A	24-Mar-05	23-Mar-10
COLVILLE	Sand And Gravel	B & W EXCAVATING AND CONSTRUCTION	Valley	Stevens	WAG500091A	25-Jun-07	24-Jun-12
COLVILLE	Sand And Gravel	CHEWELAH ASPHALT COMPANY	Chewelah	Stevens	WAG507153B	5-Jan-05	4-Feb-10
COLVILLE	Sand And Gravel	COLVILLE VALLEY CONCRETE 3RD STREET	Colville	Stevens	WAG507015C	5-Jan-05	4-Feb-10
COLVILLE	Sand And Gravel	COLVILLE VALLEY CONCRETE HAWKINS	Colville	Stevens	WAG507139B	5-Jan-05	4-Feb-10
COLVILLE	Sand And Gravel	DAWSON TRUCKING INC	Valley	Stevens	WAG507131B	5-Jan-05	4-Feb-10
COLVILLE	Sand And Gravel	INLAND NORTHWEST COMPANY	Springdale	Stevens	WAG507141B	5-Jan-05	4-Feb-10
COLVILLE	Sand And Gravel	KNIFE RIVER	Colville	Stevens	WAG507047C	5-Jan-05	4-Feb-10
COLVILLE	Sand And Gravel	LANE MT. SILICA COMPANY	Valley	Stevens	WAG507006C	5-Jan-05	4-Feb-10
COLVILLE	Sand And Gravel	LOON LAKE SAND & GRAVEL	Loon Lake	Stevens	WAG507085C	5-Jan-05	4-Feb-10
COLVILLE	Sand And Gravel	PUGH BROTHERS CONSTRUCTION, INC.	Colville	Stevens	WAG500081A	5-Jan-05	4-Feb-10
COLVILLE	Sand And Gravel	WA DOT SP-W-6458 MILL CREEK	Colville	Stevens	WAG507099C	5-Jan-05	4-Feb-10
COLVILLE	Stormwater Industrial	COLMAC COIL MFG INC	Colville	Stevens	SO3000036D	21-Aug-02	20-Sep-07
COLVILLE	Stormwater Industrial	COLMAC INDUSTRIES INC	Colville	Stevens	SO3000037D	21-Aug-02	20-Sep-07
COLVILLE	Stormwater Industrial	UNITED PARCEL SERVICE COLVILLE	Colville	Stevens	SO3003251C	21-Aug-02	20-Sep-07
COLVILLE	Stormwater Industrial	VAAGEN BROS LUMBER INC COLVILLE	Colville	Stevens	SO3002389D	21-Aug-02	20-Sep-07
COLVILLE	Stormwater Industrial	WASTE MGMT OLSONS HAULING CO	Addy	Stevens	SO3003989C	21-Aug-02	20-Sep-07
KETTLE	Sand And Gravel	BUCKHORN MTN BORROW SITE	Curlew	Ferry	WAG507172A	5-Jan-05	4-Feb-10
KETTLE	Sand And Gravel	STOTTS CONSTRUCTION INC	Curlew	Ferry	WAG507010C	5-Jan-05	4-Feb-10
KETTLE	Sand And Gravel	WA DOT PS-FY-63 CURLEW PIT	Curlew	Ferry	WAG507154B	5-Jan-05	4-Feb-10
KETTLE	Stormwater Construction	BUCKHORN MOUNTAIN BORROW AREA	Curlew	Ferry	WAR007756A	16-Nov-05	16-Dec-10
LAKE ROOSEVELT (LOWER)	Sand And Gravel	LINCOLN COUNTY DEPT OF PUBLIC WORKS	Davenport	Lincoln	WAG500017B	5-Jan-05	4-Feb-10
LAKE ROOSEVELT (LOWER)	Sand And Gravel	S AND W ROCK PRODUCTS	Davenport	Lincoln	WAG500056A	25-Jun-99	6-Aug-04
LAKE ROOSEVELT (UPPER)	Industrial	AVISTA CORP KETTLE FALLS GENERATING	Kettle Falls	Stevens	WA0045217C	18-Nov-02	30-Nov-08
LAKE ROOSEVELT (UPPER)	Industrial	BOISE CASCADE KF PLYWOOD MILL	Kettle Falls	Stevens	ST0005262D	1-Jul-03	30-Jun-08
LAKE ROOSEVELT (UPPER)	Industrial	BOISE CASCADE KF SAWMILL	Kettle Falls	Stevens	ST0008007D	24-Mar-05	23-Mar-10
LAKE ROOSEVELT (UPPER)	Sand And Gravel	WA DOT PS-FY-91 TROUT CREEK	Kettle Falls	Stevens	WAG507113C	5-Jan-05	4-Feb-10
LAKE ROOSEVELT (UPPER)	Sand And Gravel	WA DOT QS-W-157 MINGO MT QUARRY	Kettle Falls	Stevens	WAG507169A	5-Jan-05	5-Feb-10
LAKE ROOSEVELT (UPPER)	Stormwater Industrial	KETTLE FALLS LUMBER	Kettle Falls	Stevens	SO3000188D	21-Aug-02	20-Sep-07
SANPOIL	Industrial	HECLA MINING CO	Republic	Ferry	ST0005270D	31-Aug-00	31-Aug-05
SANPOIL	Industrial	KINROSS GOLD CORPORATION	Republic	Ferry	ST0008033C	30-Jun-04	31-Jul-09
SANPOIL	Sand And Gravel	ALPINE CONCRETE - TORBOY PIT	Republic	Ferry	WAG507075C	5-Jan-05	4-Feb-10
SANPOIL	Sand And Gravel	ALPINE CONCRETE & EXCAVATION INC	Republic	Ferry	WAG507059C	5-Jan-05	4-Feb-10
SANPOIL	Sand And Gravel	FERRY COUNTY PUBLIC WORKS	Republic	Ferry	WAG500080A	5-Jan-05	4-Feb-10
SANPOIL	Sand And Gravel	GIDDINGS PIT (NORTH)	Republic	Ferry	WAG507106C	5-Jan-05	4-Feb-10
SANPOIL	Sand And Gravel	KINROSS GOLD CORPORATION PIT	Republic	Ferry	WAG507086C	5-Jan-05	4-Feb-10
SANPOIL	Stormwater Construction	HECLA FILL PROJECT	Republic	Ferry	WAR007461A	16-Nov-05	16-Dec-10
SANPOIL	Stormwater Industrial	HECLA MINING COMPANY REPUBLIC	Republic	Ferry	SO3001539D	21-Aug-02	20-Sep-07
SANPOIL	Stormwater Industrial	KETTLE RIVER JOINT VENTURE	Republic	Ferry	SO3001184D	21-Aug-02	20-Sep-07
SPOKANE (LOWER)	Fish	FORD HATCHERY	Ford	Stevens	WAG137012D	22-Apr-05	1-Jun-10
SPOKANE (LOWER)	Industrial	DAWN MINING COMPANY	Ford	Stevens	ST0005230D	7-Jan-03	30-Jun-07
SPOKANE (LOWER)	Sand And Gravel	ALLIED MINERALS	Springdale	Stevens	WAG507134B	5-Jan-05	4-Feb-10
SPOKANE (LOWER)	Sand And Gravel	CONTINENTAL EXCAVATORS ALLISON PIT	Tumtum	Stevens	WAG507088C	5-Jan-05	4-Feb-10

Notes:

The Sand and Gravel general permit provides coverage for discharges of process water, stormwater, and mine dewatering water associated with sand and gravel operations, rock quarries, and similar mining operations, including stockpiles of mined materials (Ecology 2005).

Industrial stormwater general permits cover a variety of industry types; monitoring requirements vary by industry (Ecology 2007).

WRIA = Watershed Resources Inventory Areas; definition of these areas is available from Ecology (http://www.ecy.wa.gov/apps/watersheds/wriapages/).

[a] Only facilities in Stevens, Ferry, and Lincoln Counties are shown. Data accessed July 27, 2007 from Ecology's Water Quality Permit Life Cycle System (WPLCS), available at:http://www.ecy.wa.gov/programs/wq/permits/wplcs/index.html#WPLCS.

Table 3-5. Ecology Municipal General Permit Facilities That Discharge to WRIAs in UCR Drainage Basin [a]

WRIA	Facility	City	County	Permit #	Issue Date	Expiration Date
COLVILLE	ADDY/BLUE CREEK SEWER SYSTEM	Addy	Stevens	ST0008084A	6-May-02	5-May-07
COLVILLE	CHEWELAH WWTP	Chewelah	Stevens	WA0023604C	4-Apr-06	30-Apr-11
COLVILLE	COLVILLE STP	Colville	Stevens	WA0022616B	29-Jun-01	30-Jun-06
COLVILLE	LOON LAKE SEWER DIST #4	Loon Lake	Stevens	ST0008019D	31-Oct-05	30-Oct-10
COLVILLE	SPRINGDALE WWTP	Springdale	Stevens	ST0005385D	30-Sep-02	29-Sep-07
COLVILLE	WAITTS LAKE SEWER SYSTEM	Valley	Stevens	ST0008056C	12-May-03	11-May-08
KETTLE	CURLEW JOBS CORP CENTER	Curlew	Ferry	ST0005396B	18-Sep-02	17-Sep-07
LAKE ROOSEVELT (LOWER)	DAVENPORT STP	Davenport	Lincoln	WA0045578A	11-Jan-06	31-Jan-11
LAKE ROOSEVELT (LOWER)	SEVEN BAYS ESTATES UNLIMITED	Davenport	Lincoln	ST0005373E	17-May-04	16-May-09
SANPOIL	REPUBLIC STP	Republic	Ferry	ST0008020D	27-Sep-06	30-Oct-11
LAKE ROOSEVELT (UPPER)	KETTLE FALLS STP	Kettle Falls	Stevens	ST0005297D	25-May-06	31-May-11

Notes:

Information in the table above was downloaded from the Ecology Water Quality Permit Life Cycle System (WPLCS) database, available at:http://www.ecy.wa.gov/programs/wq/permits/wplcs/index.html#WPLCS. Data accessed July 27, 2007.

[a] Only facilities in Stevens, Ferry, and Lincoln Counties are included in this table.

STP = Sewage Treatment Plant.

WWTP = Wastewater Treatment Plant.

WRIA = Watershed Resources Inventory Areas; definition of these areas is available from Ecology (http://www.ecy.wa.gov/apps/watersheds/wriapages/).

Table 5-1
List of Chemicals of Interest (COIs)

Chemical Group	Analytes
Common Metals and Metalloids	Aluminum, Antimony, Arsenic, Barium, Beryllium, Boron, Cadmium, Calcium, Chromium, Cobalt, Copper, Fluoride, Iron, Lead, Magnesium, Manganese, Mercury, Molybdenum, Nickel, Potassium, Selenium, Silicon, Silver, Sodium, Sulfur, Tin, Thallium, Uranium, Vanadium, Zinc
Other Metals and Metalloids	Bismuth, Cerium, Cesium, Dysprosium, Erbium, Europium, Gadolinium, Gallium, Germanium, Gold, Holmium, Indium, Lanthanum, Lithium, Lutetium, Neodymium, Niobium, Praseodymium, Rubidium, Samarium, Scandium, Strontium, Tantalum, Tellurium, Thorium, Thulium, Titanium, Tungsten, Ytterbium, Yttrium, Zirconium
Radionuclides	U-238 decay chain radionuclides†
Semivolatile Organic Compounds (SVOCs)	1,1'-Biphenyl, 1,2,4-Trichlorobenzene, 1,2-Dichlorobenzene, 1,3-Dichlorobenzene, 1,4-Dichlorobenzene, 2,2'-oxybis(1-chloropropane), 2,4,5-Trichlorophenol, 2,4,6-Trichlorophenol, 2,4-Dichlorophenol, 2,4-Dimethylphenol, 2,4-Dinitrophenol, 2,4-Dinitrotoluene, 2,6-Dinitrotoluene, 2-Chloronaphthalene, 2-Chlorophenol, 2-Methylphenol (o-cresol), 2-Nitroaniline, 2-Nitrophenol, 3,3'-Dichlorobenzidine, 3-Nitroaniline, 4,6-Dinitro-2-methylphenol, 4-Bromophenyl-phenylether, 4-Chloro-3-methylphenol, 4-Chloroaniline, 4-Chlorophenyl-phenyl ether, 4-Methylphenol (p-cresol), 4-Nitroaniline, 4-Nitrophenol, Acetophenone, Benzaldehyde, Benzoic acid, Benzyl alcohol, bis(2-Chloroethoxy)methane, Bis(2-chloroethyl)ether, Bis(2-ethylhexyl) phthalate, Butyl benzyl phthalate, Caprolactam, Carbazole, Dibenzofuran, Diethyl phthalate, Dimethyl phthalate, Di-n-butyl phthalate, Di-n-octylphthalate, 1-Phenyl-ethanone, Hexachlorocyclopentadiene, Hexachloroethane, Isophorone, Nitrobenzene, NNitrosodi-n-propylamine, N-Nitrosodiphenylamine, Pentachlorophenol, Perchlorocyclopentadiene, Phenol
Polycyclic Aromatic Hydrocarbons (PAHs)	*High Molecular Weight PAHs:* Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(ghi)perylene, Benzo(k)fluoranthene, Chrysene, Dibenzo(a,h)anthracene, Indeno[1,2,3-cd]pyrene *Low Molecular Weight PAHs:* Anthracene, 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Fluoranthene, Fluorene, Naphthalene, Phenanthrene, Pyrene
Pesticides	2,4'-DDD, 2,4'-DDE, 2,4'-DDT, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, Aldrin, alpha-BHC, alpha-Chlordane, Atrazine, beta-BHC, cis-Nonachlor, delta-BHC, Dieldrin, Endosulfan I, Endosulfan II, Endosulfan sulfate, Endrin, Endrin aldehyde, Endrin ketone, gamma-BHC (Lindane), gamma-Chlordane, Heptachlor, Heptachlor epoxide, Hexachlorobenzene, Hexachlorobutadiene, Methoxychlor, Oxychlordane, Toxaphene, trans-Nonachlor
Polychlorinated Biphenyls (PCBs)	Aroclor 1016, Aroclor 1221, Aroclor 1232, Aroclor 1242, Aroclor 1248, Aroclor 1254, Aroclor 1260 PCB congeners*
Polybrominated Diphenylethers (PBDEs)	*PBDE congeners:* PBDE-47, 66, 71, 99, 100, 138, 153, 154, 183, 184, 191, 209
Polychlorinated Dibenzo-p-Dioxins (PCDDs)	PCDD congeners*
Polychlorinated Dibenzofurans (PCDFs)	PCDF congeners*

† See Figure 5-2 for specific radionuclides
* COIs include all congeners

Table 5-2
Dermal Absorbtion Fractions (ABSd) for Chemicals in Soil

Analyte	Dermal Absorption Fraction (ABSd)	Reference
Arsenic	0.03	Wester et al. (1993a)
Cadmium	0.001	Wester et al. (1992a)
Chlordane	0.04	U.S. EPA (1992a)
2,4-Dichlorophenoxyacetic acid (MCPA)	0.05	Wester et al. (1992b)
DDT	0.03	Wester et al. (1996)
TCDD and other dioxins -if soil organic content is >10%	0.03 0.001	Wester et al. (1990) USEPA (1992a)
Lindane	0.04	Duff and Kissel (1996)
Benzo(a)pyrene and other PAHs	0.13	Wester et al. (1990)
Aroclors 1254/1242 and other PCBs	0.14	Wester et al.(1993b)
Pentachlorophenol	0.25	Wester et al. (1993c)
Semivolatile organic compounds	0.1	—

Source: USEPA (2004e) Exhibit 3-4

Table 5-3
Dermal Permeability Coefficients (Kp) for Chemicals in Water

Part A: Inorganics

Analyte	Permeability Coefficient Kp (cm/hr)
Cadmium	1E-03
Chromium (+6)	2E-03
Chromium (+3)	1E-03
Cobalt	4E-04
Lead	1E-04
Mercury (+2)	1E-03
Methyl mercury	1E-03
Mercury vapor	0.24
Nickel	2E-04
Potassium	2E-03
Silver	6E-04
Zinc	6E-04
All other inorganics	1E-03

Source: USEPA (2004e) Exhibit 3-1

Part B: Organics

$\log Kp = -2.80 + 0.66 * \log Kow$

See USEPA (2004e) Appendix B2 for chemical-specific values

TABLE 5-4
RME Human Intake Factors (HIFs) and Inhalation Time-Weighting Factors (TWFs)

			Worker		Recreational Visitor						Subsistence				Resident	
			Contact Intensive	Non-Contact Intensive	Short-Term		Seasonal		Year-Round		Traditional		Modern		Adult	Child
Exposure pathway	**HIF or TWF Type**	**Units**			Adult	Child	Adult	Child	Adult	Child	Adult	Child	Adult	Child		
Inhalation of airborne particulates (PM10) in outdoor air	TWF (non-cancer)	unitless	1.00E-01	2.28E-01	2.24E-02	2.56E-02	2.46E-01	2.81E-01	4.16E-01	4.75E-01	1.67E-01	1.67E-01	8.22E-02	8.22E-02	5.99E-02	2.23E-01
	TWF (cancer)	unitless	3.59E-02	8.15E-02	1.28E-03	1.46E-03	8.44E-02	2.41E-02	1.42E-01	4.07E-02	1.52E-01	1.43E-02	2.82E-02	7.05E-03	2.05E-02	1.91E-02
Incidental ingestion of soil/sediment/dust	HIF (non-cancer)	kg/kg-d	1.42E-06	9.78E-07	8.22E-08	7.67E-07	9.04E-07	8.44E-06	1.53E-06	1.42E-05	4.29E-06	2.00E-05	1.06E-06	9.86E-06	1.37E-06	1.28E-05
	HIF (cancer)	kg/kg-d	5.07E-07	3.49E-07	4.70E-09	4.38E-08	3.10E-07	7.23E-07	5.23E-07	1.22E-06	3.92E-06	1.71E-06	3.62E-07	8.45E-07	4.70E-07	1.10E-06
Incidental ingestion of surface water Total (a)	HIF (non-cancer)	L/kg-d	2.58E-04	5.87E-05	4.66E-05	4.09E-04	4.11E-04	2.60E-03	6.59E-04	3.76E-03	1.71E-03	8.00E-03	8.45E-04	3.95E-03	--	--
	HIF (cancer)	L/kg-d	9.23E-05	2.10E-05	2.66E-06	2.34E-05	1.41E-04	2.23E-04	2.26E-04	3.23E-04	1.57E-03	6.86E-04	2.90E-04	3.38E-04	--	--
Dermal contact with soil/sediment Total (a)	HIF (non-cancer)	kg/kg-d	4.91E-06	9.40E-06	5.64E-07	4.81E-06	3.64E-06	2.78E-05	5.29E-06	3.86E-05	1.63E-05	3.73E-05	2.81E-06	6.44E-06	5.47E-06	2.30E-05
	HIF (cancer)	kg/kg-d	1.75E-06	3.36E-06	3.22E-08	2.75E-07	1.25E-06	2.38E-06	1.81E-06	3.31E-06	1.49E-05	3.20E-06	9.64E-07	5.52E-07	1.87E-06	1.97E-06
Dermal contact with surface water Total (a)	HIF (non-cancer)	L-hr/kg-cm-d	4.91E-02	1.12E-02	1.12E-02	4.81E-02	8.63E-02	2.78E-01	1.34E-01	3.86E-01	3.26E-01	7.47E-01	1.61E-01	3.68E-01	--	--
	HIF (cancer)	L-hr/kg-cm-d	1.75E-02	3.98E-03	6.39E-04	2.75E-03	2.96E-02	2.38E-02	4.58E-02	3.31E-02	2.98E-01	6.40E-02	5.51E-02	3.16E-02	--	--
Inhalation of indoor air	TWF (non-cancer)	unitless	--	--	1.60E-02	1.28E-02	1.76E-01	1.41E-01	--	--	--	--	--	--	8.39E-01	7.36E-01
	TWF (cancer)	unitless	--	--	9.13E-04	7.31E-04	6.03E-02	1.21E-02	--	--	--	--	--	--	2.88E-01	6.31E-02
Inhalation of volatiles in water during showering	TWF (non-cancer)	unitless	--	--	9.32E-04	9.32E-04	1.03E-02	1.03E-02	--	--	--	--	--	--	2.33E-02	2.33E-02
	TWF (cancer)	unitless	--	--	5.33E-05	5.33E-05	3.52E-03	8.79E-04	--	--	--	--	--	--	7.99E-03	2.00E-03
Dermal contact with water during showering	HIF (non-cancer)	L-hr/kg-cm-d	--	--	5.75E-03	9.84E-03	6.33E-02	1.08E-01	--	--	--	--	--	--	1.44E-01	2.46E-01
	HIF (cancer)	L-hr/kg-cm-d	--	--	3.29E-04	5.63E-04	2.17E-02	9.28E-03	--	--	--	--	--	--	4.93E-02	2.11E-02
Ingestion of wild game/waterfowl	HIF (non-cancer)	kg ww/kg-d	--	--	9.32E-05	3.62E-04	5.25E-04	1.03E-03	1.28E-03	2.35E-03	1.43E-03	3.33E-03	1.28E-03	2.35E-03	--	--
	HIF (cancer)	kg ww/kg-d	--	--	5.33E-06	2.07E-05	1.80E-04	8.79E-05	4.37E-04	2.01E-04	1.31E-03	2.86E-04	4.37E-04	2.01E-04	--	--
Ingestion of fish/shellfish	HIF (non-cancer)	kg ww/kg-d	--	--	6.21E-05	2.17E-04	3.71E-04	4.00E-04	9.29E-04	1.73E-03	1.51E-02	3.53E-02	2.00E-03	2.33E-03	--	--
	HIF (cancer)	kg ww/kg-d	--	--	3.55E-06	1.24E-05	1.27E-04	3.43E-05	3.18E-04	1.49E-04	1.38E-02	3.03E-03	6.86E-04	2.00E-04	--	--
Ingestion of drinking water	HIF (non-cancer)	L/kg-d	8.61E-03	9.78E-03	1.10E-03	2.81E-03	1.21E-02	3.09E-02	2.04E-02	5.22E-02	5.71E-02	1.33E-01	1.43E-02	3.67E-02	2.74E-02	7.03E-02
	HIF (cancer)	L/kg-d	3.08E-03	3.49E-03	6.26E-05	1.61E-04	4.13E-03	2.65E-03	6.98E-03	4.48E-03	5.22E-02	1.14E-02	4.90E-03	3.14E-03	9.39E-03	6.03E-03
Ingestion of livestock watered using river water	HIF (non-cancer)	kg ww/kg-d	--	--	--	--	--	--	--	--	7.14E-04	1.67E-03	1.28E-03	2.35E-03	--	--
	HIF (cancer)	kg ww/kg-d	--	--	--	--	--	--	--	--	6.53E-04	1.43E-04	4.37E-04	2.01E-04	--	--
Ingestion of terrestrial/aquatic plants	HIF (non-cancer)	kg ww/kg-d	--	--	--	--	--	--	--	--	1.14E-02	2.40E-02	1.38E-03	3.21E-03	--	--
	HIF (cancer)	kg ww/kg-d	--	--	--	--	--	--	--	--	1.04E-02	2.06E-03	4.71E-04	2.75E-04	--	--
Ingestion of crops grown using river water as irrigation	HIF (non-cancer)	kg ww/kg-d	--	--	--	--	--	--	--	--	1.14E-02	2.40E-02	5.50E-03	1.28E-02	--	--
	HIF (cancer)	kg ww/kg-d	--	--	--	--	--	--	--	--	1.04E-02	2.06E-03	1.89E-03	1.10E-03	--	--

(a) For recreational visitors, includes exposure during both recreational activities (camping, fishing, hunting) and swimming.
-- = pathway not evaluated for this receptor

			Tribal-Specific Scenarios	
Exposure pathway	**HIF Type**	**Units**	Adult	Child
Inhalation of water vapor/aerosols in sweat lodge	TWF (non-cancer)	unitless	8.33E-02	1.04E-02
	TWF (cancer)	unitless	7.62E-02	8.93E-04
Incidental ingestion of terrestrial/aquatic plants during basket weaving	HIF (non-cancer)	kg ww/kg-d	7.05E-06	8.22E-06
	HIF (cancer)	kg ww/kg-d	6.44E-06	7.05E-07
Dermal contact with terrestrial/aquatic plants during basket weaving	HIF (non-cancer)	kg ww/kg-d	1.27E-06	2.30E-06
	HIF (cancer)	kg ww/kg-d	1.16E-06	1.97E-07
Dermal contact with animal tissues during food preparation/preservation	HIF (non-cancer)	kg ww/kg-d	8.03E-06	9.21E-06
	HIF (cancer)	kg ww/kg-d	7.34E-06	7.89E-07
Dermal contact with plant tissues during medicinal/ceremonial activities	HIF (non-cancer)	kg ww/kg-d	2.23E-06	5.11E-06
	HIF (cancer)	kg ww/kg-d	2.04E-06	4.38E-07

TABLE 5-5
EXPOSURE PARAMETERS FOR WORKER POPULATIONS

Exposure Pathway	Exposure Parameter	Units	RME Value and Source				CTE Value and Source			
			Contact Intensive		Non-Contact Intensive		Contact Intensive		Non-Contact Intensive	
General	Body Weight	kg	70	USEPA 1991	70	USEPA 1991	70	USEPA 1991	70	USEPA 1991
	Exposure Duration	years	25	Prof. judgment [14]	25	USEPA 1991	7	Prof. judgment [14]	7	USEPA 1993
GENERAL WORKER ACTIVITIES										
General	Exposure Frequency	days/yr	110	Prof. judgment [16]	250	USEPA 1993	66	Prof. judgment [16]	234	USEPA 1993
Inhalation of outdoor air	Exposure Time	hr/day	8	Prof. judgment [7]	8	Prof. judgment [7]	8	Prof. judgment [7]	8	Prof. judgment [7]
Ingestion of drinking water [3]	Ingestion Rate	L/day	2	USEPA 1991, Prof. judgment [4]	1	USEPA 1991, Prof. judgment [4]	1.4	USEPA 1993, Prof. judgment [4]	0.7	USEPA 1993, Prof. judgment [4]
	Fraction of drinking water from site	unitless	1	[5]	1	[5]	1	[5]	1	[5]
Incidental ingestion of soil/sediment	Ingestion Rate	mg/day	330	USEPA 2002 [2]	100	USEPA 1991 [11]	165	Prof. judgement [2]	50	USEPA 1991 [11]
Dermal contact with soil/sediment	TWA Exposed Skin Surface Area	cm^2/event	5700	Prof. judgment [6]	4802	Prof. judgment [6]	5700	Prof. judgment [6]	4802	Prof. judgment [6]
	October-April	cm^2/event	--		2109	USEPA 2004 [13]	--		2109	USEPA 2004 [13]
	May-September	cm^2/event	5700	USEPA 2004 [12]	5700	USEPA 2004 [12]	5700	USEPA 2004 [12]	5700	USEPA 2004 [12]
	Adherence Factor	mg/cm^2	0.2	USEPA 2004 [10]	0.2	USEPA 2004 [10]	0.02	USEPA 2004 [10]	0.02	USEPA 2004 [10]
	Event Frequency	events/day	1	USEPA 2004	1	USEPA 2004	1	USEPA 2004	1	USEPA 2004
	Dermal Absorption Fraction	unitless	chemical-specific (see Table 5-2)				chemical-specific (see Table 5-2)			
WORKING AT SHORELINE										
General	Exposure Frequency	days/yr	55	Prof. judgment [15]	50	Prof. judgment [15]	33	Prof. judgment [15]	47	Prof. judgment [15]
Incidental ingestion of surface water	Ingestion Rate	mL/hr	30	USEPA 1998 [9]	30	USEPA 1998 [9]	15	USEPA 1998 [9]	15	USEPA 1998 [9]
	Event Frequency	events/day	1	Prof. judgment	1	Prof. judgment	1	Prof. judgment	1	Prof. judgment
	Event Time	hrs/event	4	Prof. judgment	1	Prof. judgment	4	Prof. judgment	1	Prof. judgment
Dermal contact with surface water	Exposed Skin Surface Area	cm^2/event	5700	Prof. judgment [8,1]	5700	Prof. judgment [8,1]	5700	Prof. judgment [8,1]	5700	Prof. judgment [8,1]
	Event Frequency	events/day	1	Prof. judgment	1	Prof. judgment	1	Prof. judgment	1	Prof. judgment
	Event Time	hrs/event	4	Prof. judgment	1	Prof. judgment	4	Prof. judgment	1	Prof. judgment
	Dermal Permeability Coefficient	cm/hr	chemical-specific (see Table 5-3)				chemical-specific (see Table 5-3)			

Note: When combining exposures across receptor populations, total exposure estimates should be time-weighted to avoid double counting exposures.

contact intensive = maintenance/construction worke
non-contact intensive = dock worker, campground employe

References:
USEPA 1989. Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A). Office of Emergency and Remedial Response, Washington, D.C. EPA/540/1-89/002. December.
USEPA 1991. Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. OSWER Directive 9285.6-03. March.
USEPA 1993. Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.
USEPA 1997. Exposure Factors Handbook.
USEPA 1998. Ambient Water Quality Criteria Derivation Methodology.
USEPA 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24. December.
USEPA 2004a. Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part E - Dermal). Office of Solid Waste and Emergency Response, Washington, D.C. EPA/540/R/99/005. July.

Notes:

[1] Assumes all 50 days of shoreline exposure occur in May-September.

[2] RME: Exhibit 5-1. Default value for construction scenario (330 mg/day) is based on the 95th percentile value for adult soil intake rates reported in a soil ingestion mass-balance study.
CTE: Assumed to be 1/2 the RME value.

[3] Water may be either groundwater or surface water; both media will be evaluated as data allow.

[4] Assumes that half of an individual’s daily water intake occurs at work, and all water ingested is assumed to come from the contaminated drinking water source. For the contact intensive scenario, the default drinking water ingestion rate was doubled to account for high-activity outdoor working conditions. RME example provided below:
Contact-intensive -- Default drinking water ingestion rate (2 L/day) * 2 (for high-activity working conditions) * 0.5 (fraction of daily water intake occuring at work) = 2 L/day
Non-contact intensive -- Default drinking water ingestion rate (2 L/day) * 0.5 (fraction ofdaily water intake occuring at work) = 1 L/day

[5] Assumes that while on-site, 100% of drinking water is from site groundwater and/or surface water.

[6] Contact intensive: Time-weighted average (TWA) assumes all days of exposure occur in May-September.
Non-contact intensive: TWA assumes 3/4 of exposure occurs in May-September and 1/4 of exposure occurs in October-April.

[7] Assumes entire work day is outdoors.

[8] Assumes the exposed skin surface is the same as for soil/sediment exposure.

[9] RME: The rate of surface water ingestion by workers (30 mL/hr) is based on the value proposed for a recreational scenario. This value is somewhat lower than the value of 50 mL/hr recommended for swimming (EPA 1989).
CTE: Assumed to be 1/2 the RME value.

[10] Exhibit 3-5, CTE and RME recommendations for an industrial scenario.

[11] Assumed to be equal to the soil ingestion rate for an adult resident.

[12] Assumes the same exposed surface area as a residential adult: exposure of head, hands, forearms, and lower legs (Exhibit 3-5) -- the worker wears a short-sleeved shirt, shorts, and shoes.

[13] Exposed skin surface is assumed to be limited to the head and hands (assumes the worker wears a long-sleeved shirt, pants, and shoes); value is the average of the 50th percentile for males and females greater than 18 years of age (Table 6-2 male, Table 6-3 female).

[14] Assumed to be equal to the non-contact worker.

[15] Contact Intensive: Assumes 50% of time spent at shoreline.
Non-Contact Intensive: Assumes 20% of time spent at shoreline.

[16] Assumes exposure occurs over the course of 22 weeks (5 months; e.g., May to September) --
RME: Assumes exposure frequency of 5 days/week.
CTE: Assumes exposure frequency of 3 days/week.

TABLE 5-6
EXPOSURE PARAMETERS FOR RESIDENTS

Exposure Pathway	Exposure Parameter	Units	RME Value and Source				CTE Value and Source			
			Adult		Child		Adult		Child	
General	Body weight	kg	70	USEPA 1991	15	USEPA 1991	70	USEPA 1991	15	USEPA 1991
	Exposure Duration	yr	24	USEPA 1989, USEPA 1997 [8]	6	USEPA 1989, USEPA 1997 [8]	7	USEPA 1997 [8]	2	USEPA 1997 [8]
	Exposure Frequency	days/yr	350	USEPA 1991	350	USEPA 1991	245	USEPA 1997 [1]	245	USEPA 1997 [1]
Incidental ingestion of soil/dust	Ingestion Rate, total	mg/day	100	USEPA 1991	200	USEPA 1991	50	USEPA 1991	100	USEPA 1991
	Fraction attributable to soil	unitless	0.45			USEPA 1994	0.45			USEPA 1994
	Fraction attributable to indoor dust	unitless	0.55			USEPA 1994	0.55			USEPA 1994
Dermal contact with soil	Exposed Skin Surface Area	cm^2/event	5,700	USEPA 2004 [4]	1,800	USEPA 2004 [4]	5,700	USEPA 2004 [4]	1,800	USEPA 2004 [4]
	Adherence Factor	mg/cm^2	0.07	USEPA 2004	0.2	USEPA 2004	0.01	USEPA 2004	0.04	USEPA 2004
	Event Frequency	events/day	1	USEPA 2004	1	USEPA 2004	1	USEPA 2004	1	USEPA 2004
	Dermal Absorption Fraction	unitless	chemical-specific (see Table 5-2)				chemical-specific (see Table 5-2)			
Inhalation of indoor air	Exposure Time, Indoors	hrs/day	21	USEPA 1997 [2]	18.4	Prof. judgment [7]	21	USEPA 1997 [2]	18.4	Prof. judgment [7]
Inhalation of outdoor air	Exposure Time, Outdoors	hrs/day	1.5	USEPA 1997 [2]	5.6	Prof. judgment [7]	1.5	USEPA 1997 [2]	5.6	Prof. judgment [7]
Ingestion of drinking water	Fraction of drinking water from UCR	unitless	1			Prof. judgment [3]	1			Prof. judgment [3]
	Ingestion rate of drinking water	L/day	2	USEPA 1991, USEPA 1989	1.1	USEPA 2002 [10]	1.4	USEPA 1991, USEPA 1989	0.4	USEPA 2002 [10]
DURING SHOWERING										
General	Shower Frequency	events/day	1	Prof. judgment [5]	1	Prof. judgment [5]	1	Prof. judgment [5]	1	Prof. judgment [5]
	Shower Duration	hr/event	0.58	USEPA 1997 [6]	0.58	USEPA 1997 [6]	0.25	USEPA 1997 [6]	0.25	USEPA 1997 [6]
Dermal contact with water during showering [3]	Exposed Skin Surface Area	cm^2	18,000	USEPA 2004	6,600	USEPA 2004	18,000	USEPA 2004	6,600	USEPA 2004
	Dermal Permeability Coefficient	cm/hr	chemical-specific (see Table 5-3)				chemical-specific (see Table 5-3)			

Note: When combining exposures across receptor populations, total exposure estimates should be time-weighted to avoid double counting exposures.

References:

USEPA 1989. Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A). Office of Emergency and Remedial Response, Washington, D.C. EPA/540/1-89/002. December.

USEPA 1991. Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. OSWER Directive 9285.6-03. March.

USEPA 1994. Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children.

USEPA 1997. Exposure Factors Handbook.

USEPA 2002. Child-Specific Exposure Factors Handbook. Interim Report. Office of Research and Development, National Center for Environmental Assessment, Washington, DC. EPA/600/P/00/002B September 2002.

Notes:

[1] Estimated by taking the percent of time men and women spend at home (67% of time spent at home, see Table 15A-3) and multiplying by 365 days (0.67*365 days = 245 days).

[2] Based on recommended adult values (Table 15-176).

[3] Assumes that 100% of water is from untreated groundwater and/or surface water.

[4] Includes head, hands, forearms, lower legs, and feet (children only).

[5] Assumes one shower with untreated groundwater and/or surface water per each day at the residence.

[6] Utilizes shower duration information for residential scenarios (Section 15.4.1):
RME: equal to 95th percentile - 35 minutes
CTE: equal to 50th percentile - 15 minutes

[7] Based on recommended child values (Table 15-176). Time-weighted value shown (i.e., weekend value * 2/7 + weekday value * 5/7).

[8] Based on population mobility information in Table 15-176:
RME: 95th percentile - 30 years (assumes 6 years as a child and 24 years as an adult)
CTE: average - 9 years (assumes 2 years as a child and 7 years as an adult)

[9] Based on reported values for 3 - < 6 yrs in Table 3-1:
RME = 95th percentile values
CTE = mean values

[10] Based on reported drinking water intake rates for 1-10 year olds Table 4-12:
RME = 95th percentile values
CTE = mean values

TABLE 5-7
EXPOSURE PARAMETERS FOR RECREATIONAL VISITOR POPULATIONS - SHORT-TERM

OUTDOOR RECREATIONAL ACTIVITY-BASED SCENARIOS

Exposure Pathway	Exposure Parameter	Units	RME Value and Source			
			Adult		Child	
General	Body weight	kg	70	USEPA 1991	15	USEPA 1991
	Exposure Duration	yr	4	USEPA 1989	4	USEPA 1989
GENERAL RECREATIONAL ACTIVITIES (FISHING, HUNTING, CAMPING)						
General	Exposure Frequency	days/yr	14	Prof. judgment [1]	14	Prof. judgment [1]
Inhalation of outdoor air	Exposure Time, Outdoors	hrs/day	14	Prof. judgment	16	Prof. judgment
Incidental ingestion of soil/sediment/dust (19)	Ingestion Rate	mg/day	150	USEPA 2002a, Prof. judgment [2]	300	USEPA 2002a, Prof. judgment [2]
Incidental ingestion of surface water	Ingestion Rate	mL/hr	30	USEPA 1998, USEPA 1989 [3]	30	USEPA 1998, USEPA 1989 [3]
	Time spent in contact with water	hrs/day	2	Prof. judgment	2	Prof. judgment
Dermal contact with soil/sediment	Exposed Skin Surface Area	cm^2/event	5700	USEPA 2004 [9]	2800	USEPA 2004 [10]
	Event Frequency	events/day	1	Prof. judgment	1	Prof. judgment
	Adherence Factor	mg/cm^2	0.07	USEPA 2004 [11]	0.2	USEPA 2004 [11]
	Dermal Absorption Fraction	unitless	chemical-specific (see Table 5-2)			
Dermal contact with surface water	Exposed Skin Surface Area	cm^2	5700	USEPA 2004, Prof. judgment [12]	2800	USEPA 2004, Prof. judgment [12]
	Dermal Permeability Coefficient	cm/hr	chemical-specific (see Table 5-3)			
	Time spent in contact with water	hrs/day	2	Prof. judgment	2	Prof. judgment
SWIMMING-SPECIFIC SCENARIO						
General	Exposure Frequency	days/yr	7	Prof. judgment	14	Prof. judgment
	Event Frequency	events/day	1	Prof. judgment	1	Prof. judgment
	Event Time	hrs/event	1	Prof. judgment	2	Prof. judgment
Incidental ingestion of surface water	Ingestion Rate	mL/hr	50	USEPA 1989	50	USEPA 1989
Dermal contact with soil/sediment	Exposed Skin Surface Area	cm^2/event	18000	USEPA 2004, Prof. judgment [18]	6600	USEPA 2004, Prof. judgment [18]
	Adherence Factor	mg/cm^2	0.07	USEPA 2004, Prof. judgment [11]	0.2	USEPA 2004, Prof. judgment [11]
	Dermal Absorption Fraction	unitless	chemical-specific (see Table 5-2)			
Dermal contact with surface water	Exposed Skin Surface Area	cm^2	18000	USEPA 2004	6600	USEPA 2004
	Dermal Permeability Coefficient	cm/hr	chemical-specific (see Table 5-3)			

INDOOR RECREATIONAL SCENARIOS

Exposure Pathway	Exposure Parameter	Units	RME Value and Source			
			Adult		Child	
General	Exposure Frequency	days/yr	14	Prof. judgment [1]	14	Prof. judgment [1]
INSIDE RVs/CAMPERS/TENTS						
Inhalation of indoor air	Exposure Time, Indoors	hrs/day	10	Prof. judgment [17]	8	Prof. judgment [17]
SHOWERING AT SITE FACILITIES [13]						
General	Shower Frequency	events/day	1	Prof. judgment [15]	1	Prof. judgment [15]
	Shower Duration	hr/event	0.58	USEPA 1997 [16]	0.58	USEPA 1997 [16]
Dermal contact with water during showering	Exposed Skin Surface Area	cm^2	18000	USEPA 2004	6600	USEPA 2004
	Dermal Permeability Coefficient	cm/hr	chemical-specific (see Table 5-3)			

INGESTION SCENARIOS

Exposure Pathway	Exposure Parameter	Units	RME Value and Source			
			Adult		Child	
INGESTION OF FISH/SHELLFISH/GAME/WATERFOWL FROM UCR SITE						
General	Exposure Frequency	days/yr	365	[7]	365	[7]
Ingestion of wild game/ waterfowl	Average Intake Rate	g/day	6.52	Prof. judgment [14]	5.4	Prof. judgment [14]
Ingestion of fish/shellfish	Average Intake Rate	g/day	4.35	Patrick 1997, Prof. judgment [6, 8]	3.26	Patrick 1997, Prof. judgment [6, 8]
INGESTION OF DRINKING WATER [13]						
General	Exposure Frequency	days/yr	14	Prof. judgment [1]	14	Prof. judgment [1]
Ingestion of drinking water	Fraction of drinking water from UCR	unitless	1			Prof. judgment [5]
	Ingestion rate of drinking water	L/day	2	USEPA 1991, USEPA 1989	1.1	USEPA 2002a [4]

Note: When combining exposures across receptor populations, total exposure estimates should be time-weighted to avoid double counting exposures.

TABLE 5-7
EXPOSURE PARAMETERS FOR RECREATIONAL VISITOR POPULATIONS - SHORT-TERM

References:

Patrick 1997. Consumption Patterns of Anglers Who Frequently Fish Lake Roosevelt.

USEPA 1989. Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A). Office of Emergency and Remedial Response, Washington, D.C. EPA/540/1-89/002. December.

USEPA 1991. Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. OSWER Directive 9285.6-03. March.

USEPA 1997. Exposure Factors Handbook.

USEPA 1998. Ambient Water Quality Criteria Derivation Methodology.

USEPA 2002a. Child-Specific Exposure Factors Handbook. Interim Report. Office of Research and Development, National Center for Environmental Assessment, Washington, DC. EPA/600/P/00/002B September 2002.

USEPA 2002b. Estimated per capita fish consumption in the United States, Volume 1.

USEPA 2004. Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part E - Dermal). Office of Solid Waste and Emergency Response, Washington, D.C. EPA/540/R/99/005. July.

Notes:

[1] Short-term use: Includes individuals (both local and non-local) that visit the river as part of occasional recreational activities; assumes exposure occurs for 14 days/year.

[2] For exposures at the beach, children are assumed to potentially ingest greater amounts of soil/sediment than they would at home. The RME value for a child visitor of 300 mg/day is the 90th percentile from a study of 78 children camping adjacent to a lake (van Wijnen et al., 1990); it is 1.5 times higher than the recommended RME value for a child resident (200 mg/day). This same factor was applied to the recommended value for an adult resident (100 mg/day), yielding 150 mg/day for adult recreational visitors.

[3] The RME rate of surface water ingestion by recreational visitors (30 mL/hr) is based on the value proposed for a recreational scenario. This value is somewhat lower than the value of 50 mL/hr recommended for swimming (USEPA 1989).

[4] RME value of 1.1 L/day is the 95th percentile drinking water intake rate for 1-10 year olds (Table 4-12).

[5] Assumes that while on-site, 100% of drinking water is from untreated groundwater and/or surface water.

[6] Fish intake rates based on assumption of 7 fish meals from UCR, and a meal size of 8 oz and 6 oz for adults and children, respectively.
[Adult average intake rate (g/day) = 7 meals * 8 oz * 28.35 g per oz / 365 days per year = 4.35 g/day]

[7] Intake rates for fish and game are representative of a daily intake (g/day) averaged across a year; therefore, the exposure frequency is set to 365 days/yr.

[8] Assumes all fish consumed while at the UCR site were caught at the UCR site.

[9] Assumes the same exposed surface area as a residential adult: exposure of head, hands, forearms, and lower legs (Exhibit 3-5).

[10] Assumes the same exposed surface area as a residential child: exposure of head, hands, forearms, lower legs, and feet (Exhibit 3-5).

[11] Assumes soil/sediment adherence factor equal to the recommended default soil adherence factors for residents (Exhibit 3-3).

[12] Assumes same exposed surface area as for soil/sediment exposure.

[13] Water may be either groundwater or surface water; both media will be evaluated as data allow.

[14] Game/waterfowl intake rates based on assumption of 7 game meals from UCR, and a meal size of 12 oz and 8 oz for adults and children, respectively.
[Adult average intake rate (g/day) = 7 meals * 12 oz * 28.35 g per oz / 365 days per year = 6.52 g/day]

[15] For short-term and seasonal use scenarios, assumes one shower with untreated groundwater and/or surface water per each day on-site. For the long-term use scenario, it is assumed that visitors do not utilize showering facilities.

[16] Assumes shower duration equal to 95th percentile (35 minutes) for residential scenarios (Section 15.4.1).

[17] For short-term and seasonal use scenarios, it is assumed that visitors are on-site 24 hrs/day; "indoors" includes inside tents/campers/RVs. For the long-term use scenario, it is assumed that visitors only use the site during the day but do not stay overnight.

[18] Assumes same exposed surface area as for surface water exposure.

[19] Assumes soil ingestion rate includes contribution from "indoor" dust in campers, RVs, and tents.

TABLE 5-8
EXPOSURE PARAMETERS FOR RECREATIONAL VISITOR POPULATIONS - SEASONAL

OUTDOOR RECREATIONAL ACTIVITY-BASED SCENARIOS

Exposure Pathway	Exposure Parameter	Units	RME Value and Source			
			Adult		Child	
General	Body weight	kg	70	USEPA 1991	15	USEPA 1991
	Exposure Duration	yr	24	USEPA 1989	6	USEPA 1989
GENERAL RECREATIONAL ACTIVITIES (FISHING, HUNTING, CAMPING)						
General	Exposure Frequency	days/yr	154	Prof. judgment [2]	154	Prof. judgment [2]
Inhalation of outdoor air	Exposure Time, Outdoors	hrs/day	14	Prof. judgment	16	Prof. judgment
Incidental ingestion of soil/sediment/dust (15)	Ingestion Rate	mg/day	150	USEPA 2002a, Prof. judgment [4]	300	USEPA 2002a, Prof. judgment [4]
Incidental ingestion of surface water	Ingestion Rate	mL/hr	30	USEPA 1998, USEPA 1989 [5]	30	USEPA 1998, USEPA 1989 [5]
	Time spent in contact with water	hrs/day	2	Prof. judgment	2	Prof. judgment
Dermal contact with soil/sediment	Exposed Skin Surface Area	cm^2/event	5700	USEPA 2004 [11]	2800	USEPA 2004 [12]
	Event Frequency	events/day	1	Prof. judgment	1	Prof. judgment
	Adherence Factor	mg/cm^2	0.07	USEPA 2004 [13]	0.2	USEPA 2004 [13]
	Dermal Absorption Fraction	unitless	chemical-specific (see Table 5-2)			
Dermal contact with surface water	Exposed Skin Surface Area	cm^2	5700	USEPA 2004, Prof. judgment [14]	2800	USEPA 2004, Prof. judgment [14]
	Dermal Permeability Coefficient	cm/hr	chemical-specific (see Table 5-3)			
	Time spent in contact with water	hrs/day	2	Prof. judgment	2	Prof. judgment
SWIMMING-SPECIFIC SCENARIO						
General	Exposure Frequency	days/yr	25	Prof. judgment	50	Prof. judgment
	Event Frequency	events/day	1	Prof. judgment	1	Prof. judgment
	Event Time	hrs/event	1	Prof. judgment	2	Prof. judgment
Incidental ingestion of surface water	Ingestion Rate	mL/hr	50	USEPA 1989	50	USEPA 1989
Dermal contact with soil/sediment	Exposed Skin Surface Area	cm^2/event	18000	USEPA 2004, Prof. judgment [19]	6600	USEPA 2004, Prof. judgment [19]
	Adherence Factor	mg/cm^2	0.07	USEPA 2004, Prof. judgment [13]	0.2	USEPA 2004, Prof. judgment [13]
	Dermal Absorption Fraction	unitless	chemical-specific (see Table 5-2)			
Dermal contact with surface water	Exposed Skin Surface Area	cm^2	18000	USEPA 2004	6600	USEPA 2004
	Dermal Permeability Coefficient	cm/hr	chemical-specific (see Table 5-3)			

INDOOR RECREATIONAL SCENARIOS

Exposure Pathway	Exposure Parameter	Units	RME Value and Source			
			Adult		Child	
General	Exposure Frequency	days/yr	154	Prof. judgment [2]	154	Prof. judgment [2]
INSIDE RVs/CAMPERS/TENTS						
Inhalation of indoor air	Exposure Time, Indoors	hrs/day	10	Prof. judgment [21]	8	Prof. judgment [21]
SHOWERING AT SITE FACILITIES [16]						
General	Shower Frequency	events/day	1	Prof. judgment [18]	1	Prof. judgment [18]
	Shower Duration	hr/event	0.58	USEPA 1997 [20]	0.58	USEPA 1997 [20]
Dermal contact with water during showering	Exposed Skin Surface Area	cm^2	18000	USEPA 2004	6600	USEPA 2004
	Dermal Permeability Coefficient	cm/hr	chemical-specific (see Table 5-3)			

INGESTION SCENARIOS

Exposure Pathway	Exposure Parameter	Units	RME Value and Source			
			Adult		Child	
INGESTION OF FISH/SHELLFISH/GAME/WATERFOWL FROM UCR SITE						
General	Exposure Frequency	days/yr	365	[1]	365	[1]
Ingestion of wild game/ waterfowl	Average Intake Rate	g/day	37	USEPA 1997 [3]	15	USEPA 2002a [17]
Ingestion of fish/shellfish	Average Intake Rate	g/day	26	Patrick 1997, Prof. judgment [9, 10]	6	USEPA 2002b [8, 10]
INGESTION OF DRINKING WATER [16]						
General	Exposure Frequency	days/yr	154	Prof. judgment [2]	154	Prof. judgment [2]
Ingestion of drinking water	Fraction of drinking water from UCR	unitless	1			Prof. judgment [7]
	Ingestion rate of drinking water	L/day	2	USEPA 1991, USEPA 1989	1.1	USEPA 2002a [6]

Note: When combining exposures across receptor populations, total exposure estimates should be time-weighted to avoid double counting exposures.

TABLE 5-8
EXPOSURE PARAMETERS FOR RECREATIONAL VISITOR POPULATIONS - SEASONAL

References:

Patrick 1997. Consumption Patterns of Anglers Who Frequently Fish Lake Roosevelt.

USEPA 1989. Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A). Office of Emergency and Remedial Response, Washington, D.C. EPA/540/1-89/002. December.

USEPA 1991. Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. OSWER Directive 9285.6-03. March.

USEPA 1997. Exposure Factors Handbook.

USEPA 1998. Ambient Water Quality Criteria Derivation Methodology.

USEPA 2002a. Child-Specific Exposure Factors Handbook. Interim Report. Office of Research and Development, National Center for Environmental Assessment, Washington, DC. EPA/600/P/00/002B September 2002.

USEPA 2002b. Estimated per capita fish consumption in the United States, Volume 1.

USEPA 2004. Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part E - Dermal). Office of Solid Waste and Emergency Response, Washington, D.C. EPA/540/R/99/005. July.

Notes:

[1] Intake rates for fish and game are representative of a daily intake (g/day) averaged across a year; therefore, the exposure frequency is set to 365 days/yr.

[2] Seasonal use: Includes individuals that reside seasonally within the site boundary and frequently engage in recreational activities; assumes exposure occurs over the course of 22 weeks (5 months; e.g., May to September) at a frequency of 7 days/week.

[3] Table 11-30, Total meat intake mean (2.1 g/kg-d) adjusted to a body weight of 70 kg. Assumed that one-quarter of all meat ingested is derived from wild game/waterfowl.

[4] For exposures at the beach, children are assumed to potentially ingest greater amounts of soil/sediment than they would at home. The RME value for a child visitor of 300 mg/day is the 90th percentile from a study of 78 children camping adjacent to a lake (van Wijnen et al., 1990); it is 1.5 times higher than the recommended RME value for a child resident (200 mg/day). This same factor was applied to the recommended value for an adult resident (100 mg/day), yielding 150 mg/day for adult recreational visitors.

[5] The RME rate of surface water ingestion by recreational visitors (30 mL/hr) is based on the value proposed for a recreational scenario. This value is somewhat lower than the value of 50 mL/hr recommended for swimming (USEPA 1989).

[6] RME value of 1.1 L/day is the 95th percentile drinking water intake rate for 1-10 year olds (Table 4-12).

[7] Assumes that while on-site, 100% of drinking water is from untreated groundwater and/or surface water.

[8] CTE value mean from USDA survey.

[9] CTE value mean from the WDOH survey, based on 42 meals per year, 8 oz per meal.

[10] Assumes all fish consumed while at the UCR site were caught at the UCR site.

[11] Assumes the same exposed surface area as a residential adult: exposure of head, hands, forearms, and lower legs (Exhibit 3-5).

[12] Assumes the same exposed surface area as a residential child: exposure of head, hands, forearms, lower legs, and feet (Exhibit 3-5).

[13] Assumes soil/sediment adherence factor equal to the recommended default soil adherence factors for residents (Exhibit 3-3).

[14] Assumes same exposed surface area as for soil/sediment exposure.

[15] Assumes soil ingestion rate includes contribution from "indoor" dust in campers, RVs, and tents.

[16] Water may be either groundwater or surface water; both media will be evaluated as data allow.

[17] Table 3-50, Total meat intake mean for children 3-5 years old (4.1 g/kg-d) adjusted to a body weight of 15 kg. Assumed that one-quarter of all meat ingested is derived from wild game/waterfowl.

[18] For short-term and seasonal use scenarios, assumes one shower with untreated groundwater and/or surface water per each day on-site. For the long-term use scenario, it is assumed that visitors do not utilize showering facilities.

[19] Assumes same exposed surface area as for surface water exposure.

[20] Assumes shower duration equal to 95th percentile (35 minutes) for residential scenarios (Section 15.4.1).

[21] For short-term and seasonal use scenarios, it is assumed that visitors are on-site 24 hrs/day; "indoors" includes inside tents/campers/RVs. For the long-term use scenario, it is assumed that visitors only use the site during the day but do not stay overnight.

TABLE 5-9
EXPOSURE PARAMETERS FOR RECREATIONAL VISITOR POPULATIONS - YEAR-ROUND

OUTDOOR RECREATIONAL ACTIVITY-BASED SCENARIOS

Exposure Pathway	Exposure Parameter	Units	RME Value and Source			
			Adult		Child	
General	Body weight	kg	70	USEPA 1991	15	USEPA 1991
	Exposure Duration	yr	24	USEPA 1989	6	USEPA 1989
GENERAL RECREATIONAL ACTIVITIES (FISHING, HUNTING, CAMPING)						
General	Exposure Frequency	days/yr	260	Prof. judgment [3]	260	Prof. judgment [3]
Inhalation of outdoor air	Exposure Time, Outdoors	hrs/day	14	Prof. judgment	16	Prof. judgment
Incidental ingestion of soil/sediment	Ingestion Rate	mg/day	150	USEPA 2002a, Prof. judgment [4]	300	USEPA 2002a, Prof. judgment [4]
Incidental ingestion of surface water	Ingestion Rate	mL/hr	30	USEPA 1998, USEPA 1989 [5]	30	USEPA 1998, USEPA 1989 [5]
	Time spent in contact with water	hrs/day	2	Prof. judgment	2	Prof. judgment
Dermal contact with soil/sediment	Exposed Skin Surface Area	cm^2/event	5700	USEPA 2004 [11]	2800	USEPA 2004 [12]
	Event Frequency	events/day	1	Prof. judgment	1	Prof. judgment
	Adherence Factor	mg/cm^2	0.07	USEPA 2004 [13]	0.2	USEPA 2004 [13]
	Dermal Absorption Fraction	unitless	chemical-specific (see Table 5-2)			
Dermal contact with surface water	Exposed Skin Surface Area	cm^2	5700	USEPA 2004, Prof. judgment [14]	2800	USEPA 2004, Prof. judgment [14]
	Dermal Permeability Coefficient	cm/hr	chemical-specific (see Table 5-3)			
	Time spent in contact with water	hrs/day	2	Prof. judgment	2	Prof. judgment
SWIMMING-SPECIFIC SCENARIO						
General	Exposure Frequency	days/yr	25	Prof. judgment	50	Prof. judgment
	Event Frequency	events/day	1	Prof. judgment	1	Prof. judgment
	Event Time	hrs/event	1	Prof. judgment	2	Prof. judgment
Incidental ingestion of surface water	Ingestion Rate	mL/hr	50	USEPA 1989	50	USEPA 1989
Dermal contact with soil/sediment	Exposed Skin Surface Area	cm^2/event	18000	USEPA 2004, Prof. judgment [15]	6600	USEPA 2004, Prof. judgment [15]
	Adherence Factor	mg/cm^2	0.07	USEPA 2004, Prof. judgment [13]	0.2	USEPA 2004, Prof. judgment [13]
	Dermal Absorption Fraction	unitless	chemical-specific (see Table 5-2)			
Dermal contact with surface water	Exposed Skin Surface Area	cm^2	18000	USEPA 2004	6600	USEPA 2004
	Dermal Permeability Coefficient	cm/hr	chemical-specific (see Table 5-3)			

INGESTION SCENARIOS

Exposure Pathway	Exposure Parameter	Units	RME Value and Source			
			Adult		Child	
INGESTION OF FISH/SHELLFISH/GAME/WATERFOWL FROM UCR SITE						
General	Exposure Frequency	days/yr	365	[1]	365	[1]
Ingestion of wild game/ waterfowl	Average Intake Rate	g/day	89	USEPA 1997 [2]	35	USEPA 2002a [17]
Ingestion of fish/shellfish	Average Intake Rate	g/day	65	Patrick 1997, Prof. judgment [9, 10]	26	Patrick 1997 [8, 10]
INGESTION OF DRINKING WATER [16]						
General	Exposure Frequency	days/yr	260	Prof. judgment [3]	260	Prof. judgment [3]
Ingestion of drinking water	Fraction of drinking water from UCR	unitless	1			Prof. judgment [7]
	Ingestion rate of drinking water	L/day	2	USEPA 1991, USEPA 1989	1.1	USEPA 2002a [6]

Note: When combining exposures across receptor populations, total exposure estimates should be time-weighted to avoid double counting exposures.

References:

Patrick 1997. Consumption Patterns of Anglers Who Frequently Fish Lake Roosevelt.

USEPA 1989. Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A). Office of Emergency and Remedial Response, Washington, D.C. EPA/540/1-89/002. December.

USEPA 1991. Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. OSWER Directive 9285.6-03. March.

USEPA 1997. Exposure Factors Handbook.

USEPA 1998. Ambient Water Quality Criteria Derivation Methodology.

USEPA 2002a. Child-Specific Exposure Factors Handbook. Interim Report. Office of Research and Development, National Center for Environmental Assessment, Washington, DC. EPA/600/P/00/002B September 2002.

USEPA 2002. Estimated per capita fish consumption in the United States, Volume 1.

USEPA 2004. Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part E - Dermal). Office of Solid Waste and Emergency Response, Washington, D.C. EPA/540/R/99/005. July.

TABLE 5-9
EXPOSURE PARAMETERS FOR RECREATIONAL VISITOR POPULATIONS - YEAR-ROUND

Notes:

[1] Intake rates for fish and game are representative of a daily intake (g/day) averaged across a year; therefore, the exposure frequency is set to 365 days/yr.

[2] Table 11-30, Total meat intake RME 95th percentile (5.1 g/kg-d) adjusted to a body weight of 70 kg. Assumed that one-quarter of all meat ingested is derived from wild game/waterfowl.

[3] Long-term use: Includes individuals that reside locally and may engage in year-round recreational activities; assumes exposure occurs year-round at a frequency of 5 days/week.

[4] For exposures at the beach, children are assumed to potentially ingest greater amounts of soil/sediment than they would at home. The RME value for a child visitor of 300 mg/day is the 90th percentile from a study of 78 children camping adjacent to a lake (van Wijnen et al., 1990); it is 1.5 times higher than the recommended RME value for a child resident (200 mg/day). This same factor was applied to the recommended value for an adult resident (100 mg/day), yielding 150 mg/day for adult recreational visitors.

[5] The RME rate of surface water ingestion by recreational visitors (30 mL/hr) is based on the value proposed for a recreational scenario. This value is somewhat lower than the value of 50 mL/hr recommended for swimming (USEPA 1989).

[6] RME value of 1.1 L/day is the 95th percentile drinking water intake rate for 1-10 year olds (Table 4-12).

[7] Assumes that while on-site, 100% of drinking water is from untreated groundwater and/or surface water.

[8] RME value 40% of the >90th from the WDOH survey.

[9] RME value >90th from the WDOH survey, based on 2 meals per week, 8 oz per meal.

[10] Assumes all fish consumed while at the UCR site were caught at the UCR site.

[11] Assumes the same exposed surface area as a residential adult: exposure of head, hands, forearms, and lower legs (Exhibit 3-5).

[12] Assumes the same exposed surface area as a residential child: exposure of head, hands, forearms, lower legs, and feet (Exhibit 3-5).

[13] Assumes soil/sediment adherence factor equal to the recommended default soil adherence factors for residents (Exhibit 3-3).

[14] Assumes same exposed surface area as for soil/sediment exposure.

[15] Assumes same exposed surface area as for surface water exposure.

(16) Water may be either groundwater or surface water; both media will be evaluated as data allow.

(17) Table 3-50, Total meat intake RME 95th percentile for children 3-5 years old (9.4 g/kg-d) adjusted to a body weight of 15 kg. Assumed that one-quarter of all meat ingested is derived from wild game/waterfowl.

TABLE 5-10
EXPOSURE PARAMETERS FOR SUBSISTENCE POPULATIONS - MODERN

SUBSISTENCE ACTIVITY-BASED SCENARIOS (FISHING, HUNTING, GATHERING)

Exposure Pathway	Exposure Parameter	Units	RME Value and Source			
			Adult		Child	
General	Body weight	kg	70	USEPA 1991	15	USEPA 1991
	Exposure Frequency at UCR site	days/yr	180	Prof. judgment	180	Prof. judgment
	Event Frequency	events/day	1	Prof. judgment	1	Prof. judgment
	Exposure Time	hrs/event	4	Prof. judgment	4	Prof. judgment
	Exposure Duration	years	24	USEPA 1989	6	USEPA 1989
Incidental ingestion of soil/sediment	Ingestion rate of soil/sediment	mg/day	150	Prof. judgment [2]	300	Prof. judgment [2]
Incidental ingestion of surface water	Ingestion rate of surface water	ml/hr	30	USEPA 1998 [3]	30	USEPA 1998 [3]
Dermal contact with soil/sediment	Soil/Sediment Adherence Factor	mg/cm^2	0.07	USEPA 2004 [4]	0.07	USEPA 2004 [4]
	Exposed Skin Surface Area	cm^2/event	5,700	USEPA 2004 [5]	2,800	USEPA 2004 [5]
	Dermal Absorption Fraction	unitless	chemical-specific (see Table 5-2)			
Dermal contact with surface water	Exposed Skin Surface Area	cm^2	5,700	USEPA 2004 [5]	2,800	USEPA 2004 [5]
	Dermal Permeability Coefficient	cm/hr	chemical-specific (see Table 5-3)			

INGESTION SCENARIOS

Exposure Pathway	Exposure Parameter	Units	RME Value and Source			
			Adult		Child	
General	Body weight	kg	70	USEPA 1991	15	USEPA 1991
	Exposure Frequency	days/yr	365	[1]	365	[1]
	Exposure Duration	years	24	USEPA 1989	6	USEPA 1989
Ingestion of wild game/waterfowl	Fraction of meals from UCR	unitless	0.5			Prof. judgment
	Average ingestion rate	g game/day	179	USEPA 1997 [6]	70.5	Prof. judgment [6]
Ingestion of livestock watered using river water [10]	Average ingestion rate	g livestock/day	89	USEPA 1997 [6]	35	Prof. judgment [6]
Ingestion of fish/shellfish	Fraction of meals from UCR	unitless	0.5			Prof. judgment
	Average ingestion rate	g fish/day	280	USEPA 2002a [7]	70	USEPA 2002b [7]
Ingestion of terrestrial/ aquatic plants	Fraction of meals from UCR	unitless	0.25			Prof. judgment
	Fraction of plants that are aquatic	unitless	0.5			Prof. judgment
	Fraction of plants that are terrestrial	unitless	0.5			Prof. judgment
	Average ingestion rate	g plant/day	385	USEPA 1997 [8]	192.5	Prof. judgment [12]
Ingestion of crops grown using river water as irrigation [11]	Average ingestion rate	g crop/day	385	USEPA 1997 [8]	192.5	Prof. judgment [12]
Ingestion of drinking water	Fraction of drinking water from UCR	unitless	0.5			Prof. judgment
	Ingestion rate of drinking water	L/day	2	USEPA 1989, USEPA 1991	1.1	USEPA 2002b [9]

Note: When combining exposures across receptor populations, total exposure estimates should be time-weighted to avoid double counting exposures.

References:

USEPA 1989. Risk Assessment Guidance for Superfund (RAGS), Part A.

USEPA 1991. Supplemental Guidance: Standard Default Exposure Factors.

USEPA 1993. Default Exposure Factors for CTE and RME.

USEPA 1996. Soil Screening Guidance.

USEPA 1997. Exposure Factors Handbook.

USEPA 1998. Ambient Water Quality Criteria Derivation Methodology.

USEPA 2002a. Estimated per capita fish consumption in the United States, Volume 1.

USEPA 2002b. Child-Specific Exposure Factors Handbook. Interim Report. Office of Research and Development, National Center for Environmental Assessment, Washington, DC. EPA/600/P/00/002B September 2002.

USEPA 2004. Risk Assessment Guidance for Superfund (RAGS), Part E Dermal.

Notes:

[1] Dietary intake rates are representative of a daily intake (g/day) averaged across a year; therefore, the exposure frequency is set to 365 days/yr.

[2] Assumed to be similar to soil/sediment ingestion rate for recreational activities. The recreational sediment ingestion rate was calculated as 1.5 times higher than the recommended value (USEPA 1991) for an adult resident (100 mg/day), yielding 150 mg/day.

[3] The RME surface water ingestion rate is based on the value proposed in USEPA (1998) for a recreational scenario (30 mL/hr). This value is somewhat lower than the value of 50 mL/hr recommended for swimming (USEPA 1989).

[4] Assumes soil/sediment adherence factor equal to the recommended default soil adherence factors for residents (Exhibit 3-3).

[5] Assumes the same exposed surface area as a resident. Exhibit 3-5: includes head, hands, forearms, lower legs, and feet (children only).

[6] Assumed that one-half of all meat ingested is derived from wild game/waterfowl and one-quarter of all meat ingested is derived from livestock.
Adult: Table 11-30, Total meat intake RME 95th percentile (5.1 g/kg-d) adjusted to a body weight of 70 kg.
Child: Table 3-50, Total meat intake RME 95th percentile for children 3-5 years old (9.4 g/kg-d) adjusted to a body weight of 15 kg.

[7] Adult: 95th percentile, adult consumers only
Child: 95th percentile, consumers and non-consumers - based on 1991-1992 study by Columbia River Inter-Tribal Fish Commission (CRITFC)

[8] Assumed one-quarter of all fruits/vegetables are derived from crops and one-quarter is derived from gathered plants.
Adult: Table 9-29, Total fruit & vegetable intake RM 95th percentile (12 g/kg-d + 10 g/kg-d) adjusted to a body weight of 70 kg.

[9] RME value of 1.1 L/day is the 95th percentile drinking water intake rate for 1-10 year olds (Table 4-12).A25

[10] Restricted to livestock that utilized water derived from UCR as drinking water

[11] Restricted to crops that have been grown using irrigation water derived from UCR

[12] Child values assumed to be 1/2 adult.

TABLE 5-11
EXPOSURE PARAMETERS FOR SUBSISTENCE POPULATIONS - TRADITIONAL

SUBSISTENCE ACTIVITY-BASED SCENARIOS (FISHING, HUNTING, GATHERING)

Exposure Pathway	Exposure Parameter	Units	Upper-Bound Value and Source			
			Adult		Child	
General	Body weight	kg	70	USEPA 1991; 2005	15	USEPA 1991; 2005
	Exposure Frequency at UCR site	days/yr	365	Prof. judgment, Harper et al. 2002	365	Prof. judgment, Harper et al. 2002
	Event Frequency	events/day	1	Prof. judgment	1	Prof. judgment
	Exposure Time	hrs/event	4	Prof. judgment	4	Prof. judgment
	Exposure Duration	years	64	Harper et al. 2002	6	Harper et al. 2002
Incidental ingestion of soil/sediment	Ingestion rate of soil/sediment	mg/day	300	Harper et al. 2002 [2]	300	Harper et al. 2002 [2]
Incidental ingestion of surface water	Ingestion rate of surface water	ml/hr	30	USEPA 1998 [3]	30	USEPA 1998 [3]
Dermal contact with soil/sediment	Soil/Sediment Adherence Factor	mg/cm^2	0.2	USEPA 2005 [4]	0.2	USEPA 2005 [4]
	Exposed Skin Surface Area	cm^2/event	5,700	USEPA 2005 [5]	2,800	USEPA 2005 [5]
	Dermal Absorption Fraction	unitless	chemical-specific (see Table 5-2)			
Dermal contact with surface water	Exposed Skin Surface Area	cm^2	5,700	USEPA 2005 [5]	2,800	USEPA 2005 [5]
	Dermal Permeability Coefficient	cm/hr	chemical-specific (see Table 5-3)			

INGESTION SCENARIOS

Exposure Pathway	Exposure Parameter	Units	Upper-Bound Value and Source			
			Adult		Child	
General	Body weight	kg	70	USEPA 2005	15	USEPA 1991; 2005
	Exposure Frequency	days/yr	365	Prof. judgment, Harper et al. 2002	365	Prof. judgment, Harper et al. 2002
	Exposure Duration	years	64	Harper et al. 2002	6	Harper et al. 2002
Ingestion of wild game/waterfowl	Fraction of meals from UCR	unitless	1			Prof. judgment
	Average ingestion rate	g game/day	100	Harper et al. 2002 [6]	50	Prof. judgment [6]
Ingestion of livestock watered using river water [10]	Average ingestion rate	g livestock/day	50	Harper et al. 2002 [6]	25	Prof. judgment [6]
Ingestion of fish/shellfish	Fraction of meals from UCR	unitless	1			Prof. judgment
	Average ingestion rate	g fish/day	1060	USEPA 2005 [7]	530	Prof. judgment [7]
Ingestion of terrestrial/ aquatic plants	Fraction of meals from UCR	unitless	1			Prof. judgment
	Fraction of plants that are aquatic	unitless	0.5			Prof. judgment
	Fraction of plants that are terrestrial	unitless	0.5			Prof. judgment
	Average ingestion rate	g plant/day	800	Harper et al. 2002 [8]	360	USEPA 2005 [8]
Ingestion of crops grown using river water as irrigation [1]	Average ingestion rate	g crop/day	800	Harper et al. 2002 [8]	360	USEPA 2005 [8]
Ingestion of drinking water	Fraction of drinking water from UCR	unitless	1			Prof. judgment
	Ingestion rate of drinking water	L/day	4	Harper et al. 2002, Harris & Harper 1997 [9]	2	USEPA 2005 [9]

Note: When combining exposures across receptor populations, total exposure estimates should be time-weighted to avoid double counting exposures.

References:

Harris and Harper 1997. Umatilla Tribe Exposure Scenarios.
Harper et al. 2002. Spokane Tribe RME Exposure Parameters.
USEPA 1989. Risk Assessment Guidance for Superfund (RAGS), Part A.
USEPA 1991. Supplemental Guidance: Standard Default Exposure Factors.
USEPA 1993. Default Exposure Factors for CTE and RME.
USEPA 1996. Soil Screening Guidance.
USEPA 1997. Exposure Factors Handbook.
USEPA 1998. Ambient Water Quality Criteria Derivation Methodology.
USEPA 2004. Risk Assessment Guidance for Superfund (RAGS), Part E Dermal.
USEPA 2005. Midnite Mine HHRA.

Notes:

[1] Restricted to crops that have been grown using irrigation water derived from UCR

[2] Table 1. Soil intake rate is reported as 400 mg/d (100 mg/d from indoor sources + 300 mg/d for outdoor scenarios). Assumed that UCR site exposures were restricted to outdoor scenarios only (300 mg/d). Reported soil intake rates were assumed to apply to sediment exposures. Intake rates for child assumed to be equal to adult. This is supported by Section 3.7 in Harper et al. (2002) which identifies soil intake rates for child and adult as being equal.

[3] The RME surface water ingestion rate is based on the value proposed in USEPA (1998) for a recreational scenario (30 mL/hr). This value is somewhat lower than the value of 50 mL/hr recommended for swimming (USEPA 1989).

[4] From EPA 2001a, Kissel et al. 1998a

[5] Includes head, hands, forearms, lower legs, and feet (children only).

[6] Adult: Table I, high fish diet -- big game 100 g/d + small game/fowl 50 g/d (assumed 1/2 of big game from hunting, 1/2 from raised livestock)
Child: assumed to be 1/2 the adult

[7] Adult: Table I, high fish diet -- 885 g/d fish and 175 g/d shellfish
Child: assumed to be 1/2 the adult

[8] Adult: Table I - Vegetable ingestion subsistence value 1,600 g/d (assumed 1/2 from crops, 1/2 from gathering activities)
Child: Midnite Mine HHRA Table 3-9 - Plant ingestion value 720 g/d (assumed 1/2 from crops, 1/2 from gathering activities)

[9] Includes extra 1 L/day for sweat lodge use

[10] Restricted to livestock that utilized water derived from UCR as drinking water

TABLE 5-12
EXPOSURE PARAMETERS FOR TRIBAL-SPECIFIC EXPOSURE SCENARIOS

Exposure Pathway	Exposure Parameter	Units	Upper-Bound Value and Source			
			Adult		Child	
General	Body weight	kg	70	USEPA 1991; 2005	15	USEPA 1991; 2005
	Exposure Duration	years	64	Harper et al. 2002	6	Harper et al. 2002
SWEAT LODGE SCENARIO						
General	Sweat lodge Exposure Frequency	events/yr	365	Harper et al. 2002	365	Harper et al. 2002
	Sweat lodge Exposure Time	hrs/event	2	Harper et al. 2002	0.25	USEPA 2005 [1]
	Fraction of water from site	unitless	1			Prof. judgment
BASKET-WEAVING SCENARIO						
General	Basket-weaving Exposure Frequency	events/yr	180	Prof. judgment	90	Prof. judgment
	Fraction of plants from site	unitless	1			Prof. judgment
Incidental ingestion of terrestrial/aquatic plants	Ingestion rate of plant tissue	mg/event	1000	Prof. judgment	500	Prof. judgment [2]
Dermal contact with terrestrial/aquatic plants	Plant Adherence Factor	mg/cm^2	0.2	USEPA 2005 [3]	0.2	USEPA 2005 [3]
	Exposed Skin Surface Area	cm^2/event	904	USEPA 2004 [4]	700	USEPA 2004 [4]
	Dermal Absorption Fraction from plants	unitless	chemical-specific (see Table 5-2)			[4]
FOOD PREPARATION/PRESERVATION ACTIVITIES						
General	Exposure frequency	events/yr	180	Prof. judgment	90	Prof. judgment
	Fraction of animal tissue from site	unitless	1			Prof. judgment
Dermal contact with animal tissues during preparation/preservation activities	Tissue Adherence Factor	mg/cm^2	0.2	USEPA 2005 [3]	0.2	USEPA 2005 [3]
	Exposed Skin Surface Area	cm^2/event	5,700	USEPA 2004 [5]	2,800	USEPA 2004 [6]
	Dermal Absorption Fraction from tissue	unitless	chemical-specific (see Table 5-2)			[4]
MEDICINAL/CEREMONIAL PRACTICES						
General	Exposure frequency	events/yr	50	Prof. judgment	50	Prof. judgment
	Fraction of plant tissue from site	unitless	1			Prof. judgment
Dermal contact with plant tissues during medicinal/ceremonial activities	Tissue Adherence Factor	mg/cm^2	0.2	USEPA 2005 [3]	0.2	USEPA 2005 [3]
	Exposed Skin Surface Area	cm^2/event	5,700	USEPA 2004 [5]	2,800	USEPA 2004 [6]
	Dermal Absorption Fraction from tissue	unitless	chemical-specific (see Table 5-2)			[3]

Note: When combining exposures across receptor populations, total exposure estimates should be time-weighted to avoid double counting exposures.

References:

Harris and Harper 1997. Umatilla Tribe Exposure Scenarios.
Harper et al. 2002. Spokane Tribe RME Exposure Parameters.
USEPA 1989. Risk Assessment Guidance for Superfund (RAGS), Part A.
USEPA 1991. Supplemental Guidance: Standard Default Exposure Factors.
USEPA 1993. Default Exposure Factors for CTE and RME.
USEPA 1996. Soil Screening Guidance.
USEPA 1997. Exposure Factors Handbook.
USEPA 1998. Ambient Water Quality Criteria Derivation Methodology.
USEPA 2004. Risk Assessment Guidance for Superfund (RAGS), Part E Dermal.
USEPA 2005. Midnite Mine HHRA.

Notes:

[1] Child value based on heat stress recommendations from American Academy of Pediatrics (2000)
[2] Child value assumed to be 1/2 the adult value
[3] Assumed to be same as soil
[4] Exhibit C-1, hands only - children: <7-<18, adult: avg
[5] Assumes the same exposed surface area as a residential adult: exposure of head, hands, forearms, and lower legs (Exhibit 3-5).
[6] Assumes the same exposed surface area as a residential child: exposure of head, hands, forearms, lower legs, and feet (Exhibit 3-5).

Table 5-13 IEUBK Model Inputs

CONSTANT MODEL INPUTS

PARAMETER	VALUE
Absorption Fractions: Air Diet Water Soil/Sediment/Dust	 32% 50% 50% 30% [1]
Fraction of intake as soil	45%
GSD	1.6

BASELINE AGE-DEPENDENT MODEL INPUTS [2]

	AIR		DIET	WATER	SOIL
Age (yrs)	Time Outdoors (hrs)	Ventilation Rate (m^3/day)	Dietary Intake [3] (μg/day)	Intake (L/day)	Intake (mg/day)
0-1	1.0	2.0	3.16	0.20	85
1-2	2.0	3.0	2.6	0.50	135
2-3	3.0	5.0	2.87	0.52	135
3-4	4.0	5.0	2.74	0.53	135
4-5	4.0	5.0	2.61	0.55	100
5-6	4.0	7.0	2.74	0.58	90
6-7	4.0	7.0	2.99	0.59	85

[1] If available, site-specific data on absorption from soil/sediment may be used in place of default values.

[2] See Appendix D.2 for detailed model inputs for site-specific exposures

[3] Revised USEPA (2006g) recommended dietary intake parameters, based on updated dietary lead intake estimates from the Food and Drug Administration Total Diet Study (FDA 2001) and food consumption data from NHANES III (CDC 1997) .

TABLE 5-14
ADULT LEAD MODEL (ALM) INPUTS

Parameter	Units	Value	Source	Notes
Baseline Blood Lead (PbB0)	µg/dL	1.0	SRC 2006	b
Biokinetic Slope Factor (BKSF)	µg/dL per µg/day	0.4	EPA 2003	a
Absorption Fraction (AF)	(unitless)			
sediment		0.12	EPA 2003	a,c
other media		0.2	EPA 2003	a
PbB $\text{Ratio}_{\text{fetal/maternal}}$	(unitless)	0.9	EPA 2003	b
GSD	(unitless)	1.8	SRC 2006	b
Intake Rate (IR)	Population, exposure scenario, and media-specific; see Tables 5-5 to 5-12.			
Exposure Frequency (EF)				
Averaging Time (AT)	(days)			
Worker		365	EPA 2003	a
Resident		350	EPA 1991	a
Rec. Vis. - Short-term		90		d,e
Rec. Vis. - Seasonal		154		e
Rec. Vis. - Year-Round		260		e
Subsist. - Traditional		365		e
Subsist. - Modern		180		e

SRC 2006. Update of the Adult Lead Methodology’s Default Baseline Blood Lead Concentration and Geometric Standard Deviation Parameters. Peer Review Draft for EPA OSRTI. November.

EPA 2003. Recommendations of the Technical Review Workgroup for Lead - an approach for assessing risks associated with adult exposure to lead in soil. EPA-540-R-03-001.

EPA 1991. Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. OSWER Directive 9285.6-03. March.

Notes:

(a) default EPA recommendation

(b) Table ES-1: all census regions

(c) absorption fraction for soil (AFs) of 0.2 * default lead RBA for soil of 0.6

(d) set equal to 90-days to estimate upper-bound exposure (see Section 5.5.3)

(e) set equal to exposure frequency (EF)

TABLE 6-1 NON-CANCER AND CANCER TOXICITY VALUES FOR HUMAN HEALTH

Analyte	CASRN	oRfD	source	oSF	source	iRfC	source	iUR	source	VOC	ADAF note
		(mg/kg-day)		(mg/kg-day)$^{-1}$		(mg/m^3)		(ug/m^3)$^{-1}$			
Common Metals/Metalloids											
Aluminum	7429-90-5	1.0E+00	P	--		5.0E-03	P	--			
Antimony:											
Antimony (metallic)	7440-36-0	4.0E-04	I	--		--		--			
Antimony Pentoxide	1314-60-9	5.0E-04	H	--		--		--			
Antimony Potassium Tartrate	11071-15-1	9.0E-04	H	--		--		--			
Antimony Tetroxide	1332-81-6	4.0E-04	H	--		--		--			
Antimony Trioxide	1309-64-4	4.0E-04	H	--		2.0E-04	I	--			
Arsenic, Inorganic	7440-38-2	3.0E-04	I	1.5E+00	I	3.0E-05	C	4.3E-03	I		
Barium	7440-39-3	2.0E-01	I	--		5.0E-04	H	--			
Beryllium and compounds	7440-41-7	2.0E-03	I	--		2.0E-05	I	2.4E-03	I		
Boron And Borates Only	7440-42-8	2.0E-01	I	--		2.0E-02	H	--			
Cadmium:											
Cadmium (Diet)	7440-43-9	1.0E-03	I	--		--		1.8E-03	I		
Cadmium (Water)	7440-43-9	5.0E-04	I	--		--		1.8E-03	I		
Calcium	7440-70-2	--	[4]	--		--		--			
Chromium:											
Chromium III (Insoluble Salts)	16065-83-1	1.5E+00	I	--		--		--			
Chromium VI (chromic acid mists)	18540-29-9	3.0E-03	I	--		8.0E-06	I	8.4E-02	I [1]		
Chromium VI (particulates)	18540-29-9	3.0E-03	I	--		1.0E-04	I	8.4E-02	I [1]		
Cobalt	7440-48-4	3.0E-04	P	--		6.0E-06	P	9.0E-03	P		
Copper	7440-50-8	4.0E-02	H	--		--		--			
Fluorine (Soluble Fluoride)	7782-41-4	6.0E-02	I	--		--		--			
Iron	7439-89-6	7.0E-01	P	--		--		--			
Lead:											
Lead and Compounds	7439-92-1	--	L	--		--		--			
Tetraethyl Lead	78-00-2	1.0E-07	I	--		--		--			
Magnesium	7439-95-4	--	[4]	--		--		--			
Manganese:											
Manganese (Food)	7439-96-5	1.4E-01	I	--		5.0E-05	I	--			
Manganese (Water or Soil)	7439-96-5	4.7E-02	I [2]	--		5.0E-05	I	--			
Molybdenum	7439-98-7	5.0E-03	I	--		--		--			
Nickel:											
Nickel Soluble Salts	7440-02-0	2.0E-02	I	--		--		--			
Nickel Refinery Dust	NA	--		--		--		2.4E-04	I		
Nickel Subsulfide	12035-72-2	--		--		--		4.8E-04	I		
Potassium	7440-09-7	--	[4]	--		--		--			
Selenium	7782-49-2	5.0E-03	I	--		--		--			
Silica	7631-86-9	--		--		--		--			
Silver	7440-22-4	5.0E-03	I	--		--		--			
Sodium	7440-23-5	--	[4]	--		--		--			
Thallium:											
Thallium (Soluble Salts)	7440-28-0	6.5E-05	S	--		--		--			
Thallium (I) Nitrate	10102-45-1	9.0E-05	I	--		--		--			
Thallium Acetate	563-68-8	9.0E-05	I	--		--		--			
Thallium Carbonate	6533-73-9	8.0E-05	I	--		--		--			
Thallium Chloride	7791-12-0	8.0E-05	I	--		--		--			
Thallium Sulfate	7446-18-6	8.0E-05	I	--		--		--			
Tin	7440-31-5	6.0E-01	H	--		--		--			
Uranium:											
Uranium (Soluble Salts) - IRIS	7440611_I	3.0E-03	I	--		--		--			
Uranium (Soluble Salts) - MCL	7440611_O	6.0E-04	[5]	--		--		--			
Vanadium:											
Vanadium and Compounds	NA	5.0E-03	S	--		--		--			
Vanadium (Metallic)	7440-62-2	7.0E-03	H	--		--		--			
Vanadium Pentoxide	1314-62-1	9.0E-03	I	--		7.0E-06	P	8.3E-03	P		
Vanadium Sulfate	36907-42-3	2.0E-02	H	--		--		--			
Zinc (Metallic)	7440-66-6	3.0E-01	I	--		--		--			
Other Metals and Metalloids											
Bismuth	7440-69-9	--		--		--		--			
Cerium	7440-45-1	--		--		--		--			
Cesium	7440-46-2	--		--		--		--			
Gallium	7440-55-3	--		--		--		--			
Lanthanum	7439-91-0	--		--		--		--			
Lithium	7439-93-2	2.0E-03	P	--		--		--			
Niobium	7440-03-1	--		--		--		--			
Rubidium	7440-17-7	--		--		--		--			
Scandium	7440-20-2	--		--		--		--			
Strontium, Stable	7440-24-6	6.0E-01	I	--		--		--			
Thorium	7440-29-1	--		--		--		--			
Titanium	7440-32-6	--		--		--		--			
Ytterbium	7440-64-4	--		--		--		--			
Zirconium	7440-67-7	--		--		--		--			
Mercury Compounds											
Mercuric Chloride	7487-94-7	3.0E-04	I	--		--		--			
Mercuric Sulfide	1344-48-5	3.0E-04	S	--		--		--			

TABLE 6-1 NON-CANCER AND CANCER TOXICITY VALUES FOR HUMAN HEALTH

Analyte	CASRN	oRfD (mg/kg-day)	source	oSF (mg/kg-day)$^{-1}$	source	iRfC (mg/m^3)	source	iUR (ug/m^3)$^{-1}$	source	VOC	ADAF note
Mercury (elemental)	7439-97-6	--		--		3.0E-04	I	--		V	
Mercury, Inorganic Salts	NA	3.0E-04	I	--		--		--			
Methyl Mercury	22967-92-6	1.0E-04	I	--		--		--			
Phenylmercuric Acetate	62-38-4	8.0E-05	I	--		--		--			
Pesticides											
Aldrin	309-00-2	3.0E-05	I	1.7E+01	I	--		4.9E-03	I		
Atrazine	1912-24-9	3.5E-02	I	2.3E-01	C	--		--			
Benzenehexachloride (BHC), Delta-	319-86-8	--		--		--		--			
Chlordane	12789-03-6	5.0E-04	I	3.5E-01	I	7.0E-04	I	1.0E-04	I		
Chlordane, alpha-	5103-71-9	--		--		--		--			
Chlordane, gamma-	5566-34-7	--		--		--		--			
DDT and metabolites:											
DDD, 4,4'-	72-54-8	--		2.4E-01	I	--		--			
DDD, 2,4-	53-19-0	--		--		--		--			
DDE, 2,4-	3424-82-6	--		--		--		--			
DDE, 4,4'-	72-55-9	--		3.4E-01	I	--		--			
DDT, 2,4-	789-02-6	--		--		--		--			
DDT, 4,4'-	50-29-3	5.0E-04	I	3.4E-01	I	--		9.7E-05	I		
Dieldrin	60-57-1	5.0E-05	I	1.6E+01	I	--		4.6E-03	I		
Endosulfan	115-29-7	6.0E-03	I	--		--		--			
Endosulfan I	959-98-8	--		--		--		--			
Endosulfan II	33213-65-9	--		--		--		--			
Endosulfan sulfate	1031-07-8	--		--		--		--			
Endrin	72-20-8	3.0E-04	I	--		--		--			
Endrin aldehyde	7421-93-4	--		--		--		--			
Endrin ketone	53494-70-5	--		--		--		--			
Heptachlor	76-44-8	5.0E-04	I	4.5E+00	I	--		1.3E-03	I		
Heptachlor Epoxide	1024-57-3	1.3E-05	I	9.1E+00	I	--		2.6E-03	I		
Hexachlorobenzene	118-74-1	8.0E-04	I	1.6E+00	I	--		4.6E-04	I		
Hexachlorobutadiene	87-68-3	1.0E-03	P	7.8E-02	I	--		2.2E-05	I		
Hexachlorocyclohexane, Alpha-	319-84-6	--		6.3E+00	I	--		1.8E-03	I		
Hexachlorocyclohexane, Beta-	319-85-7	--		1.8E+00	I	--		5.3E-04	I		
Hexachlorocyclohexane, Gamma- (Lindane)	58-89-9	3.0E-04	I	1.1E+00	C	--		3.1E-04	C		
Methoxychlor	72-43-5	5.0E-03	I	--		--		--			
Nonachlor, cis-	5103-73-1	--		--		--		--			
Nonachlor, trans-	39765-80-5	--		--		--		--			
Oxychlordane	27304-13-8	--		--		--		--			
Toxaphene	8001-35-2	--		1.1E+00	I	--		3.2E-04	I		
Semi-Volatile Organic Chemicals (SVOCs)											
Acetophenone	98-86-2	1.0E-01	I	--		--		--		V	
Benzaldehyde	100-52-7	1.0E-01	I	--		--		--		V	
Benzoic Acid	65-85-0	4.0E+00	I	--		--		--			
Benzyl Alcohol	100-51-6	5.0E-01	P	--		--		--			
Biphenyl, 1,1'-	92-52-4	5.0E-02	I	--		--		--		V	
Bis(2-chloro-1-methylethyl) ether	108-60-1	4.0E-02	I	7.0E-02	H	--		1.0E-05	H	V	
Bis(2-chloroethoxy)methane	111-91-1	3.0E-03	P	--		--		--			
Bis(2-chloroethyl)ether	111-44-4	--		1.1E+00	I	--		3.3E-04	I	V	
Bis(2-ethylhexyl)phthalate	117-81-7	2.0E-02	I	1.4E-02	I	--		--			
Bromophenyl-phenylether, 4-	101-55-3	--		--		--		--			
Butyl Benzyl Phthlate	85-68-7	2.0E-01	I	1.9E-03	P	--		--			
Caprolactam	105-60-2	5.0E-01	I	--		--		--			
Carbazole	86-74-8	--		--		--		--			
Chloro-3-methylphenol, 4-	59-50-7	--		--		--		--			
Chloroaniline, p-	106-47-8	4.0E-03	I	5.4E-02	P	--		--			
Chloronaphthalene, Beta-	91-58-7	8.0E-02	I	--		--		--		V	
Chlorophenol, 2-	95-57-8	5.0E-03	I	--		--		--		V	
Chlorophenylphenyl ether, 4-	7005-72-3	--		--		--		--			
Cresol, o-	95-48-7	5.0E-02	I	--		--		--			
Cresol, p-	106-44-5	5.0E-03	H	--		--		--			
Dibenzofuran	132-64-9	--		--		--		--			
Dibutyl Phthalate	84-74-2	1.0E-01	I	--		--		--			
Dichlorobenzene, 1,2-	95-50-1	9.0E-02	I	--		2.0E-01	H	--		V	
Dichlorobenzene, 1,3-	541-73-1	--		--		--		--			
Dichlorobenzene, 1,4-	106-46-7	--		5.4E-03	C	8.0E-01	I	1.1E-05	C	V	
Dichlorobenzidine, 3,3'-	91-94-1	--		4.5E-01	I	--		--			
Dichlorophenol, 2,4-	120-83-2	3.0E-03	I	--		--		--			
Diethyl Phthalate	84-66-2	8.0E-01	I	--		--		--			
Dimethylphenol, 2,4-	105-67-9	2.0E-02	I	--		--		--			
Dimethylphthalate	131-11-3	--		--		--		--			
Dinitro-2-methylphenol, 4,6-	534-52-1	1.0E-04	P	--		--		--			
Dinitrophenol, 2,4-	51-28-5	2.0E-03	I	--		--		--			
Dinitrotoluene, 2,4-	121-14-2	2.0E-03	I	--		--		--			
Dinitrotoluene, 2,6-	606-20-2	1.0E-03	P	--		--		--			
Di-n-octylphthalate	117-84-0	--		--		--		--			
Hexachlorocyclopentadiene	77-47-4	6.0E-03	I	--		2.0E-04	I	--			
Hexachloroethane	67-72-1	1.0E-03	I	1.4E-02	I	--		4.0E-06	I		

TABLE 6-1 NON-CANCER AND CANCER TOXICITY VALUES FOR HUMAN HEALTH

Analyte	CASRN	oRfD (mg/kg-day)	source	oSF (mg/kg-day)$^{-1}$	source	iRfC (mg/m^3)	source	iUR (ug/m^3)$^{-1}$	source	VOC	ADAF note
Isophorone	78-59-1	2.0E-01	I	9.5E-04	I	2.0E+00	C	--			
Nitroaniline, 2-	88-74-4	--		--		--		--			
Nitroaniline, 3-	99-09-2	3.0E-04	P	2.1E-02	P	1.0E-03	P	--			
Nitroaniline, 4-	100-01-6	3.0E-03	P	2.1E-02	P	4.0E-03	P	--			
Nitrobenzene	98-95-3	5.0E-04	I	--		2.0E-03	H	--		V	
Nitrophenol, 2-	88-75-5	--		--		--		--			
Nitrophenol, 4-	100-02-7	--		--		--		--			
Nitroso-di-N-propylamine, N-	621-64-7	--		7.0E+00	I	--		--			
Nitrosodiphenylamine, N-	86-30-6	--		4.9E-03	I	--		--			
Pentachlorophenol	87-86-5	3.0E-02	I	1.2E-01	I	--		--			
Phenol	108-95-2	3.0E-01	I	--		2.0E-01	C	--			
Trichlorobenzene, 1,2,4-	120-82-1	1.0E-02	I	3.6E-03	C	4.0E-03	P	--		V	
Trichlorophenol, 2,4,5-	95-95-4	1.0E-01	I	--		--		--			
Trichlorophenol, 2,4,6-	88-06-2	1.0E-03	P	1.1E-02	I	--		3.1E-06	I		
Polycyclic Aromatic Hydrocarbons (PAHs)											
Acenaphthene	83-32-9	6.0E-02	I	--		--		--		V	
Acenaphthylene	208-96-8	--		--		--		--			
Anthracene	120-12-7	3.0E-01	I	--		--		--		V	
Benz[a]anthracene	56-55-3	--		7.3E-01	[3]	--		1.1E-04	[3]		m
Benzo[ghi]perylene	191-24-2	--		--		--		--			
Benzo[a]pyrene	50-32-8	--		7.3E+00	I	--		1.1E-03	C		m
Benzo[b]fluoranthene	205-99-2	--		7.3E-01	[3]	--		1.1E-04	[3]		m
Benzo[k]fluoranthene	207-08-9	--		7.3E-02	[3]	--		1.1E-04	[3]		m
Chrysene	218-01-9	--		7.3E-03	[3]	--		1.1E-05	[3]		m
Dibenz[a,h]anthracene	53-70-3	--		7.3E+00	[3]	--		1.2E-03	[3]		m
Fluoranthene	206-44-0	4.0E-02	I	--		--		--			
Fluorene	86-73-7	4.0E-02	I	--		--		--		V	
Indeno[1,2,3-cd]pyrene	193-39-5	--		7.3E-01	[3]	--		1.1E-04	[3]		m
Methylnaphthalene, 1-	90-12-0	7.0E-03	P	2.9E-02	P	--		--		V	
Methylnaphthalene, 2-	91-57-6	4.0E-03	I	--		--		--		V	
Naphthalene	91-20-3	2.0E-02	I	--		3.0E-03	I	3.4E-05	C	V	
Phenanthrene	85-01-8	--		--		--		--			
Pyrene	129-00-0	3.0E-02	I	--		--		--		V	
Dioxins											
TCDD, 2,3,7,8- (Dioxin)	1746-01-6	1.0E-09	A	1.3E+05	C	--		3.8E+01	C		
PeCDD, 1,2,3,7,8-	40321-76-4	--		1.3E+05	[6]	--		3.8E+01	[6]		
HxCDD, 1,2,3,4,7,8-	39227-28-6	--		1.3E+04	[6]	--		3.8E+00	[6]		
HxCDD, 1,2,3,6,7,8-	57653-85-7	--		1.3E+04	[6]	--		3.8E+00	[6]		
HxCDD, 1,2,3,7,8,9-	19408-74-3	--		1.3E+04	[6]	--		3.8E+00	[6]		
HxCDD, Mixture	NA	--		6.2E+03	I	--		1.3E+00	I		
HpCDD, 1,2,3,4,6,7,8-	35822-46-9	--		1.3E+03	[6]	--		3.8E-01	[6]		
OCDD	3268-87-9	--		3.9E+01	[6]	--		1.1E-02	[6]		
Furans											
Furan	110-00-9	1.0E-03	I	--		--		--		V	
TCDF, 2,3,7,8-	51207-31-9	--		1.3E+04	[6]	--		3.8E+00	[6]		
PeCDF, 1,2,3,7,8-	57117-41-6	--		3.9E+03	[6]	--		1.1E+00	[6]		
PeCDF, 2,3,4,7,8-	57117-31-4	--		3.9E+04	[6]	--		1.1E+01	[6]		
HxCDF, 1,2,3,4,7,8-	70648-26-9	--		1.3E+04	[6]	--		3.8E+00	[6]		
HxCDF, 1,2,3,6,7,8-	57117-44-9	--		1.3E+04	[6]	--		3.8E+00	[6]		
HxCDF, 1,2,3,7,8,9-	72918-21-9	--		1.3E+04	[6]	--		3.8E+00	[6]		
HxCDF, 2,3,4,6,7,8-	60851-34-5	--		1.3E+04	[6]	--		3.8E+00	[6]		
HpCDF, 1,2,3,4,6,7,8-	67562-39-4	--		1.3E+03	[6]	--		3.8E-01	[6]		
HpCDF, 1,2,3,4,7,8,9-	55673-89-7	--		1.3E+03	[6]	--		3.8E-01	[6]		
OCDF	39001-02-0	--		3.9E+01	[6]	--		1.1E-02	[6]		
Polychlorinated Biphenyls (PCBs)											
Polychlorinated Biphenyls (high risk)	1336-36-3	--		2.0E+00	I	--		5.7E-04	C		
Polychlorinated Biphenyls (low risk)	1336-36-3	--		4.0E-01	I	--		1.0E-04	I		
Polychlorinated Biphenyls (lowest risk)	1336-36-3	--		7.0E-02	I	--		--			
As Aroclor:											
Aroclor 1016	12674-11-2	7.0E-05	I	7.0E-02	I	--		2.0E-05	I		
Aroclor 1221	11104-28-2	--		2.0E+00	I	--		5.7E-04	I	V	
Aroclor 1232	11141-16-5	--		2.0E+00	I	--		5.7E-04	I	V	
Aroclor 1242	53469-21-9	--		2.0E+00	I	--		5.7E-04	I		
Aroclor 1248	12672-29-6	--		2.0E+00	I	--		5.7E-04	I		
Aroclor 1254	11097-69-1	2.0E-05	I	2.0E+00	I	--		5.7E-04	I		
Aroclor 1260	11096-82-5	--		2.0E+00	I	--		5.7E-04	I		
Congener-specific:											
Tetrachlorobiphenyl, 3,3',4,4'- (PCB 77)	32598-13-3	--		1.3E+01	[6]	--		3.8E-03	[6]		
Tetrachlorobiphenyl, 3,4,4',5- (PCB 81)	70362-50-4	--		3.9E+01	[6]	--		1.1E-02	[6]		
Pentachlorobiphenyl, 2',3,4,4',5- (PCB 123)	65510-44-3	--		3.9E+00	[6]	--		1.1E-03	[6]		
Pentachlorobiphenyl, 2,3',4,4',5- (PCB 118)	31508-00-6	--		3.9E+00	[6]	--		1.1E-03	[6]		
Pentachlorobiphenyl, 2,3,3',4,4'- (PCB 105)	32598-14-4	--		3.9E+00	[6]	--		1.1E-03	[6]		
Pentachlorobiphenyl, 2,3,4,4',5- (PCB 114)	74472-37-0	--		3.9E+00	[6]	--		1.1E-03	[6]		
Pentachlorobiphenyl, 3,3',4,4',5- (PCB 126)	57465-28-8	--		1.3E+04	[6]	--		3.8E+00	[6]		
Hexachlorobiphenyl, 2,3',4,4',5,5'- (PCB 167)	52663-72-6	--		3.9E+00	[6]	--		1.1E-03	[6]		
Hexachlorobiphenyl, 2,3,3',4,4',5'- (PCB 157)	69782-90-7	--		3.9E+00	[6]	--		1.1E-03	[6]		

TABLE 6-1 NON-CANCER AND CANCER TOXICITY VALUES FOR HUMAN HEALTH

Analyte	CASRN	oRfD	source	oSF	source	iRfC	source	iUR	source	VOC	ADAF note
		(mg/kg-day)		$(mg/kg\text{-}day)^{-1}$		(mg/m^3)		$(ug/m^3)^{-1}$			
Hexachlorobiphenyl, 2,3,3',4,4',5- (PCB 156)	38380-08-4	--		3.9E+00	[6]	--		1.1E-03	[6]		
Hexachlorobiphenyl, 3,3',4,4',5,5'- (PCB 169)	32774-16-6	--		3.9E+03	[6]	--		1.1E+00	[6]		
Heptachlorobiphenyl, 2,2',3,3',4,4',5- (PCB 170)	35065-30-6	--		--	[7]	--		--	[7]		
Heptachlorobiphenyl, 2,2',3,4,4',5,5'- (PCB 180)	35065-29-3	--		--	[7]	--		--	[7]		
Heptachlorobiphenyl, 2,3,3',4,4',5,5'- (PCB 189)	39635-31-9	--		3.9E+00	[6]	--		1.1E-03	[6]		
Polybrominated Diphenyl Ethers (PBDEs)											
Congener-specific:											
Decabromodiphenyl ether, 2,2',3,3',4,4',5,5',6,6'- (PBDE-209)	1163-19-5	7.0E-03	I	7.0E-04	I	--		--			
Hexabromodiphenyl ether, 2,2',4,4',5,5'- (PBDE-153)	68631-49-2	2.0E-04	I	--		--		--			
Pentabromodiphenyl ether, 2,2',4,4',5- (PBDE-99)	60348-60-9	1.0E-04	I	--		--		--			
Tetrabromodiphenyl ether, 2,2',4,4'- (PBDE-47)	5436-43-1	1.0E-04	I	--		--		--			

Source: Regional Screening Levels for Chemical Contaminants at Superfund Sites (September 12, 2008)

Sources: I = IRIS; P = PPRTV; A = ATSDR; C = Cal EPA; H = HEAST; W = WHO; E = EPA-NCEA provisional value; S = see user guide Section 5; L = see user guide on lead

ADAF Note: m = Default ADAFs applied, carcinogenic via mutagenic mode of action

[1] According to IRIS, chromium VI values based on an assumed ratio of 6:1 (Cr+3 : Cr+6).

[2] oRfD (1.4E-01 mg/kg-day) adjusted by a modifying factor of 3, in accord with IRIS recommendations.

[3] oSF adjusted based on the EOP weighting factors in Table 6-6.

[4] Essential nutrients

[5] Based on recommended RfD for uranium (0.6 g/kg-day) provided in the National Primary Drinking Water Regulations for Radionuclides.

[6] oSF adjusted based on the TEF values in Table 6-4.

[7] Mammalian TEF withdrawn in Van den Berg et al. (1998). *In vivo* studies did not confirm the weak Ah receptor agonist properties of di-ortho PCBs reported from *in vitro* experiments. Therefore, these congeners are not evaluated based on a TEQ approach. Instead, these congeners are included in the estimate of total non-dioxin-like PCBs.

Table 6-2
List of Chemicals of Interest (COIs) without Toxicity Values

Chemical Group	Analytes
Common Metals and Metalloids	Calcium[a], Magnesium[a], Potassium[a], Silicon, Sodium[a], Sulfur
Other Metals and Metalloids	Bismuth, Cerium, Cesium, Dysprosium, Erbium, Europium, Gadolinium, Gallium, Germanium, Gold, Holmium, Indium, Lanthanum, Lutetium, Neodymium, Niobium, Praseodymium, Rubidium, Samarium, Scandium, Tantalum, Tellurium, Thorium, Thulium, Titanium, Tungsten, Ytterbium, Yttrium, Zirconium
Semi-volatile Organic Compounds (SVOCs)	2-Nitroaniline, 2-Nitrophenol, 3-Nitroaniline, 4,6-Dinitro-2-methylphenol, 4-Bromophenyl-phenylether, 4-Chloro-3-methylphenol, 4-Chlorophenyl-phenyl ether, 4-Nitroaniline, 4-Nitrophenol, bis(2-Chloroethoxy)methane, Dimethyl phthalate, Di-n-octylphthalate
Polycyclic Aromatic Hydrocarbons (PAHs)	*High Molecular Weight PAHs:* Benzo(ghi)perylene *Low Molecular Weight PAHs:* Acenaphthylene, Phenanthrene
Pesticides	2,4'-DDD[b], 2,4'-DDE[b], 2,4'-DDT[b], alpha-Chlordane[c], gamma-Chlordane[c], cis-Nonachlor, trans-Nonachlor, delta-BHC, Endosulfan I[d], Endosulfan II[d], Endosulfan sulfate[d], Endrin aldehyde, Endrin ketone, Oxychlordane
Polychlorinated Dibenzo-dioxins and furans (PCDDs and PCDFs)	[e]
Polybrominated Diphenylethers (PBDEs)	*PBDE congeners:* PBDE-66, 71, 100, 138, 154, 183, 184, 191

[a] Essential nutrients

[b] Will be evaluated using toxicity values for 4,4'-DDT (CASRN: 50-29-3).

[c] Will be evaluated using toxicity values for Chlordane (CASRN: 57-74-9).

[d] Will be evaluated using toxicity values for Endosulfan (CASRN: 115-29-7).

[e] Toxicity information is only available for the congeners listed in Table 6-4.

TABLE 6-3
GASTROINTESTINAL ABSORPTION EFFICIENCIES FOR ADJUSTMENT OF ORAL TOXICITY FACTORS

Chemical	ABS_{GI}	Toxicity Factor	Reference
Antimony	15%	RfD	Waitz, 1965
Barium	7%	RfD	Cuddihy & Griffith, 1972; Taylor, 1962
Beryllium	0.7%	RfD	Reeves, 1965
Cadmium (diet)	2.5%	RfD	IRIS, 1999
Cadmium (water)	5%		
Chromium (III)	1.30%	RfD	Donaldson & Barreras, 1996; Keim, 1987
Chromium (VI)	2.50%	RfD	Donaldson & Barreras, 1996; MacKenzie, 1959; Sayato, 1980
Manganese	4%	RfD	Davidsson, 1989; IRIS, 1999; Ruoff, 1995
Mercuric chloride (other soluble salts)	7%	RfD	IRIS, 1999
Nickel	4%	RfD	Elakhovskaya, 1972
Silver	4%	RfD	Furchner, 1968; IRIS, 1999
Vanadium	2.60%	RfD	Conklin, 1982

Source: EPA (2004e) RAGS Part E: Dermal, Exhibit 4-1

TABLE 6-4
TOXICITY EQUIVALENCE FACTORS FOR PCB, DIOXIN, AND FURAN CONGENERS

Class	Congener	CASRN	Mammal Toxicity Equivalence Factor (TEF)
Co-planar PCBs	3,3',4,4'-TCB (77)	32598133	0.0001
	3,4,4',5-TCB (81)	70362504	**0.0003**
	3,3',4,4'-5-PeCB (126)	57465288	0.1
	3,3',4,4',5,5'-HxCB (169)	32774166	**0.03**
Mono-ortho PCBs	2,3,3',4,4'-PeCB (105)	32598144	**0.00003**
	2,3,4,4',5-PeCB (114)	74472370	**0.00003**
	2,3',4,4',5-PeCB (118)	31508006	**0.00003**
	2',3,4,4',5-PeCB (123)	65510443	**0.00003**
	2,3,3',4,4',5-HxCB (156)	38380084	**0.00003**
	2,3,3',4,4',5'-HxCB (157)	69782907	**0.00003**
	2,3',4,4',5,5'-HxCB (167)	52663726	**0.00003**
	2,3,3',4,4',5,5'-HpCB (189)	39635319	**0.00003**
Dibenzo-p-dioxins (PCDDs)	2,3,7,8-TCDD	1746016	1
	1,2,3,7,8-PeCDD	40321764	1
	1,2,3,4,7,8-HxCDD	39227286	0.1
	1,2,3,6,7,8-HxCDD	57653857	0.1
	1,2,3,7,8,9-HxCDD	19408743	0.1
	1,2,3,4,6,7,8-HpCDD	35822469	0.01
	OCDD	3268879	**0.0003**
Dibenzofurans (PCDFs)	2,3,7,8-TCDF	51207319	0.1
	1,2,3,7,8-PeCDF	57117416	**0.03**
	2,3,4,7,8-PeCDF	57117314	**0.3**
	1,2,3,4,7,8-HxCDF	70648269	0.1
	1,2,3,6,7,8-HxCDF	57117449	0.1
	1,2,3,7,8,9-HxCDF	72918219	0.1
	2,3,4,6,7,8-HxCDF	60851345	0.1
	1,2,3,4,6,7,8-HpCDF	67562394	0.01
	1,2,3,4,7,8,9-HpCDF	55673897	0.01
	OCDF	39001020	**0.0003**

Data source: Van den Berg et al. (2006) **updated in 2006**

Table 6-5
Slope Factor Tiers for Assessing Oral Exposures to PCBs

Tier	oSF	Criteria for Use:
High Risk and Persistence	Upper Bound: 2.0 $(mg/kg/d)^{-1}$ CTE: 1.0 $(mg/kg/d)^{-1}$	-Food chain exposure -Sediment or soil ingestion -Dust or aerosol inhalation -Dermal exposure, if an absorption fractor has been applied -Presence of dioxin-like, tumor-promoting, or persistent congeners -Early-life exposure (all pathways and mixtures)
Low Risk and Persistence	Upper Bound: 0.4 $(mg/kg/d)^{-1}$ CTE: 0.3 $(mg/kg/d)^{-1}$	-Ingestion of water-soluble congeners -Inhalation of evaporated congeners -Dermal exposure, if no absorption fractor has been applied
Lowest Risk and Persistence	Upper Bound: 0.07 $(mg/kg/d)^{-1}$ CTE: 0.04 $(mg/kg/d)^{-1}$	-Congener or isomer analyses verify that congeners with more than 4 chlorines comprise less that 0.5% of total PCBs

Source: IRIS (http://www.epa.gov/iris/subst/0294.htm)

TABLE 6-6
TOXICITY WEIGHTING FACTORS FOR PAHs

PAH	CASRN	Estimated Order of Potency (EOP)	Source	Primary Reference(s)
Benzo[a]pyrene	50328	1	[1]	
Benz[a]anthracene	56553	0.1	[1]	Bingham and Falk (1969)
Benzo[b]fluoranthene	205992	0.1	[1]	Habs et al. (1980)
Benzo[j]fluoranthene	205823	0.1	[2]	Habs et al. (1980)
Benzo[k]fluoranthene	207089	0.01	[1]	Habs et al. (1980)
Dibenz[a,j]acridine	224420	0.1	[2]	Warshawsky et al. (1992)
Dibenz[a,h]acridine	226368	0.1	[2]	Warshawsky et al. (1992)
Dibenz[a,h]anthracene	53703	1	[1]	Wynder and Hoffman (1959)
7H-Dibenzo[c,g]carbazole	194592	1	[2]	Warshawsky et al. (1992)
Dibenzo[a,e]pyrene	192654	1	[2]	Cavalieri et al. (1989, 1991)
Dibenzo[a,h]pyrene	189640	10	[2]	Cavalieri et al. (1989, 1991)
Dibenzo[a,i]pyrene	189559	10	[2]	Cavalieri et al. (1989, 1991)
Dibenzo[a,l]pyrene	191300	10	[2]	Cavalieri et al. (1989, 1991)
Indeno[1,2,3-c,d]pyrene	193395	0.1	[1]	Habs et al. (1980); Hoffman & Wyner (1966)
5-Methylchrysene	3697243	1	[2]	Hecht et al. (1976)
1-Nitropyrene	5522430	0.1	[2]	Wislocki et al. (1986)
4-Nitropyrene	57835924	0.1	[2]	Wislocki et al. (1986)
1,6-Dinitropyrene	42397648	10	[2]	Takayama et al. 1985
1,8-Dinitropyrene	42397659	1	[2]	Wislocki et al. (1986)
6-Nitrochrysene	7496028	10	[2]	Wislocki et al. (1986), Busby et al. (1988, 1989)
2-Nitrofluorene	607578	0.01	[2]	Miller et al. (1955)
Chrysene	218019	0.001	[1]	Wynder and Hoffman (1959)

<u>Sources:</u>

[1] EPA (1993) - Provisional Guidance for Quantitative Risk Assessment of PAHs. EPA/600/R-93/089.

[2] Collins et al. (1998) - Potency Equivalency Factors for Some PAHs and PAH Derivatives. *Reg Tox Pharm* 28:45-54.

Table 6-7
Cancer Slope Factors for Radionuclide COIs

Element (Atomic No.)	Pricinpal Radionuclide [1]	Associated Decay Chain [2]	Terminal Radionuclide [3]	Cancer Slope Factors				
				Soil Ingestion (risk/pCi)	Water Ingestion (risk/pCi)	Food Ingestion (risk/pCi)	Inhalation (risk/pCi)	External Exposure (risk/y per pCi/g)
Radon (86)	Rn-222	--	--	--	--	--	--	1.74E-09
Lead (82)	Pb-214	--	--	8.51E-13	3.44E-13	4.85E-13	3.63E-11	9.82E-07
	Pb-210+D	Bi-210 (5 d) Po-210 (138 d)	Pb-206 [stable]	2.66E-09	1.27E-09	3.44E-09	1.39E-08	4.21E-09
	Pb-210	--	--	1.84E-09	8.81E-10	1.18E-09	2.77E-09	1.41E-09
Bismuth (83)	Bi-214	--	--	4.33E-13	1.92E-13	2.65E-13	2.90E-11	7.48E-06
	Bi-210	--	--	2.55E-11	8.92E-12	1.30E-11	3.17E-10	2.76E-09
	Bi-210m	--	--	1.45E-10	5.51E-11	7.77E-11	1.17E-08	1.01E-06
Polonium (84)	Po-218	--	--	--	--	--	--	4.26E-11
	Po-214	--	--	--	--	--	--	3.86E-10
	Po-210	--	--	7.96E-10	3.77E-10	2.25E-09	1.08E-08	3.95E-11
Radium (88)	Ra-226+D	Rn-222 (4 d) Po-218 (3 min) [Pb-214 (99.98%, 27 min) At-218 (0.02%, 2 s)] Bi-214 (99.99%, 20 min) [Po-214 (99.98%, 1.64 x 10-4 s) Tl-210 (0.02%, 1 min)]	Pb-210	7.30E-10	3.86E-10	5.15E-10	1.16E-08	8.49E-06
	Ra-226	--	--	7.29E-10	3.85E-10	5.14E-10	1.15E-08	2.29E-08
Thorium (90)	Th-234	--	--	6.70E-11	2.31E-11	3.40E-11	3.07E-11	1.63E-08
	Th-230	--	--	2.02E-10	9.10E-11	1.19E-10	2.85E-08	8.19E-10
Protactinium (91)	Pa-234	--	--	7.03E-12	2.56E-12	3.70E-12	1.46E-12	8.71E-06
Uranium (92)	U-238+D	Th-234 (24 d) [Pa-234m (99.80%, 1 min) Pa-234 (0.33%, 7 h)]	U-234	2.10E-10	8.71E-11	1.21E-10	9.35E-09	1.14E-07
	U-238	--	--	1.43E-10	6.40E-11	8.66E-11	9.32E-09	4.99E-11
	U-234	--	--	1.58E-10	7.07E-11	9.55E-11	1.14E-08	2.52E-10

[1] "+D" designates principal radionuclides with associated decay chains.

[2] The chain of decay products of a principal radionuclide extending to (but not including) the next principal radionuclide or a stable radionuclide. Half-lives are given in parentheses. Branches are indicated by square brackets with branching percentages in parentheses.

[3] The principal radionuclide or stable nuclide that terminates an associated decay chain.

Source: HEAST (http://www.epa.gov/radiation/heast/index.htm)

TABLE 7-1
ADJUSTMENT OF HUMAN INTAKE FACTORS FOR AGE INTERVALS

Receptor	**Age Dependant Adjustment Factors (ADAF = ED_i/ ED_{total})**			
	Child		**Adult**	
	0-<2 yrs	2-<6 yrs	6-<16 yrs	16+ yrs
Worker				
Contact Intensive and Non-Contact Intensive	--	--	--	25 yrs/25 yrs (1.00)
Recreational Visitor				
Short-term	2 yrs/4 yrs (0.50)	2 yrs/4 yrs (0.50)	4 yrs/4 yrs (1.00)[a]	--
Seasonal	2 yrs/6 yrs (0.33)	4 yrs/6 yrs (0.67)	10 yrs/24 yrs (0.42)	14 yrs/24 yrs (0.58)
Year-Round	2 yrs/6 yrs (0.33)	4 yrs/6 yrs (0.67)	10 yrs/24 yrs (0.42)	14 yrs/24 yrs (0.58)
Subsistence				
Traditional	2 yrs/6 yrs (0.33)	4 yrs/6 yrs (0.67)	10 yrs/64 yrs (0.16)	54 yrs/64 yrs (0.84)
Modern	2 yrs/6 yrs (0.33)	4 yrs/6 yrs (0.67)	10 yrs/64 yrs (0.16)	54 yrs/64 yrs (0.84)
Resident				
Resident	2 yrs/6 yrs (0.33)	4 yrs/6 yrs (0.67)	10 yrs/24 yrs (0.42)	14 yrs/24 yrs (0.58)
Tribal				
Tribal	2 yrs/6 yrs (0.33)	4 yrs/6 yrs (0.67)	10 yrs/64 yrs (0.16)	54 yrs/64 yrs (0.84)

[a] conservative assumption

CALCULATION EXAMPLE:
INCIDENTAL INGESTION OF SEDIMENT BY TRADITIONAL SUBSISTENCE RECEPTORS

$$\begin{aligned}\text{Excess Cancer Risk} = {} & [C_{sed} \cdot (HIF_{sed,\ child} \cdot ED_{0\text{-}<2yrs} / ED_{child}) \cdot oSF \cdot ADAF_{0\text{-}<2yrs}] + \\ & [C_{sed} \cdot (HIF_{sed,\ child} \cdot ED_{2\text{-}<6yrs} / ED_{child}) \cdot oSF \cdot ADAF_{2\text{-}<6yrs}] + \\ & [C_{sed} \cdot (HIF_{sed,\ adult} \cdot ED_{6\text{-}<16yrs} / ED_{adult}) \cdot oSF \cdot ADAF_{6\text{-}<16yrs}] + \\ & [C_{sed} \cdot (HIF_{sed,\ adult} \cdot ED_{16+yrs} / ED_{adult}) \cdot oSF \cdot ADAF_{16+yrs}]\end{aligned}$$

When the receptor-specific exposure parameter values are substituted (see Table 5-11), the equation becomes:

$$\begin{aligned}\text{Excess Cancer Risk} = {} & [C_{sed} \cdot (1.7\text{E-}06 \text{ kg/kg-d} \cdot 2 \text{ yrs} / 6 \text{ yrs}) \cdot oSF \cdot 10] + \\ & [C_{sed} \cdot (1.7\text{E-}06 \text{ kg/kg-d} \cdot 4 \text{ yrs} / 6 \text{ yrs}) \cdot oSF \cdot 3] + \\ & [C_{sed} \cdot (3.9\text{E-}06 \text{ kg/kg-d} \cdot 10 \text{ yrs} / 64 \text{ yrs}) \cdot oSF \cdot 3] + \\ & [C_{sed} \cdot (3.9\text{E-}06 \text{ kg/kg-d} \cdot 54 \text{ yrs} / 64 \text{ yrs}) \cdot oSF \cdot 1]\end{aligned}$$

This equation can be combined and simplified as follows:

$$\text{Excess Cancer Risk} = C_{sed} \text{ (mg/kg)} \cdot 1.4\text{E-}05 \text{ (kg/kg-d)} \cdot oSF \text{ (mg/kg-d)}^{-1}$$

TABLE 9-1
ASSIGNMENT OF DATA NEEDS PRIORITY RANKINGS

Data Needs Priority	Preliminary Risk Estimates [1]	Description
None	Cancer: < 1E-06 Non-cancer: < 0.1	No additional data collection is necessary. Baseline HHRA will present risks based on available data.
Low	Cancer: 1E-06 to 1E-05 Non-cancer: 0.1 to 0.3	Additional data collection is unlikely. Final decision to collect data will be deferred until other exposure scenarios have been adequately characterized.
Moderate	UCL > 2 times mean Cancer: 1E-05 to 1E-04 Non-cancer: 0.4 to 1	Additional data collection may be needed. Decisions to collect data or to defer data collection will be made on a case-by-case basis.
High	UCL > 2 times mean Cancer: > 1E-04 Non-cancer: > 1	Additional data collection is needed to reduced uncertainty and increase accuracy.
Deferred	n/a	Data collection may be deferred in the following cases: • If the data set for the primary medium is poor, collection of associated secondary or tertiary media may be deferred until the primary medium has been adequately characterized. • If tertiary media exposure estimates are based on estimated (rather than measured) concentration values in a secondary media, collection of the tertiary medium may be deferred until the secondary medium has been adequately characterized.

[1] Pathway-specific risk estimates calculated based on 95% UCL of the mean for the maximally exposed RME receptor. If measured data are not available, screening level concentration estimates are derived using conservative uptake models.

TABLE 9-2
SURFACE WATER SAMPLE SUMMARY FOR EACH COI BY EXPOSURE REACH

Chemicals of Interest (COIs)			N Samples Analyzed for the Chemical of Interest						
Analyte Group	Analyte	CASRN	Reach 1	Reach 2	Reach 3	Reach 4a	Reach 4b	Reach 5	Reach 6
Metals	Aluminum	7429905			4		3	4	4
	Antimony	7440360			2		2	4	4
	Arsenic	7440382	65		4		3	4	4
	Barium	7440393			2		2	4	4
	Beryllium	7440417			2		2	4	4
	Boron	7440428							
	Cadmium	7440439	55		4		3	4	4
	Calcium	7440702			4		3	4	4
	Chromium	7440473	54		2		2	4	4
	Cobalt	7440484			2		2	4	4
	Copper	7440508	54		2		2	4	4
	Fluoride	16984488							
	Iron	7439896			4		3	4	4
	Lead	7439921	54						1
	Magnesium	7439954			4		3	4	4
	Manganese	7439965			4		3	4	4
	Mercury	7439976	55		2		2	4	4
	Molybdenum	7439987							
	Nickel	7440020	31		2		2	4	4
	Potassium	7440097			4		3	4	4
	Selenium	7782492			2		2	4	4
	Silica	7631869			4		3	4	3
	Silver	7440224	29		2		2	4	4
	Sodium	7440235			4		3	4	4
	Thallium	7440280							1
	Tin	7440315							
	Uranium	7440611							
	Vanadium	7440622							1
	Zinc	7440666	55		4		3	4	4
PAHs	2-Methylnaphthalene	91576							1
	Acenaphthene	83329							1
	Acenaphthylene	208968							1
	Anthracene	120127							1
	Benzo(a)anthracene	56553							1
	Benzo(a)pyrene	50328							1
	Benzo(b)fluoranthene	205992							1
	Benzo(ghi)perylene	191242							1
	Benzo(k)fluoranthene	207089							1
	Chrysene	218019							1
	Dibenz(a,h)anthracene	53703							1
	Fluoranthene	206440							1
	Fluorene	86737							1
	Indeno(1,2,3-cd)pyrene	193395							1
	Naphthalene	91203							1
	Phenanthrene	85018							1
	Pyrene	129000							1
Pesticides	2,4'-DDD	53190							
	2,4'-DDE	3424826							
	2,4'-DDT	789026							
	4,4'-DDD	72548							1
	4,4'-DDE	72559							1
	4,4'-DDT	50293							1
	Aldrin	309002							1
	alpha-BHC	319846							1
	alpha-Chlordane	5103719							1
	Atrazine	1912249							
	beta-BHC	319857							1
	cis-Nonachlor	5103731							

TABLE 9-2
SURFACE WATER SAMPLE SUMMARY FOR EACH COI BY EXPOSURE REACH

Chemicals of Interest (COIs)			N Samples Analyzed for the Chemical of Interest						
Analyte Group	Analyte	CASRN	Reach 1	Reach 2	Reach 3	Reach 4a	Reach 4b	Reach 5	Reach 6
Pesticides (cont.)	delta-BHC	319868							1
	Dieldrin	60571							1
	Endosulfan I	959988							1
	Endosulfan II	33213659							1
	Endosulfan sulfate	1031078							1
	Endrin	72208							1
	Endrin aldehyde	7421934							1
	Endrin ketone	53494705							1
	gamma-BHC	58899							1
	gamma-Chlordane	5566347							1
	Heptachlor	76448							1
	Heptachlor epoxide	1024573							1
	Hexachlorobenzene	118741							1
	Hexachlorobutadiene	87683							1
	Methoxychlor	72435							1
	Oxychlordane	27304138							
	Toxaphene	8001352							1
	trans-Nonachlor	39765805							
SVOCs	1,1'-Biphenyl	92524							1
	1,2,4-Trichlorobenzene	120821							1
	1,2-Dichlorobenzene	95501							1
	1,3-Dichlorobenzene	541731							1
	1,4-Dichlorobenzene	106467							1
	2,2'-oxybis(1-chloropropane)	108601							1
	2,4,5-Trichlorophenol	95954							1
	2,4,6-Trichlorophenol	88062							1
	2,4-Dichlorophenol	120832							1
	2,4-Dimethylphenol	105679							1
	2,4-Dinitrophenol	51285							1
	2,4-Dinitrotoluene	121142							1
	2,6-Dinitrotoluene	606202							1
	2-Chloronaphthalene	91587							1
	2-Chlorophenol	95578							1
	2-Methylphenol	95487							1
	2-Nitroaniline	88744							1
	2-Nitrophenol	88755							1
	3,3'-Dichlorobenzidine	91941							1
	3-Nitroaniline	99092							1
	4,6-Dinitro-2-methylphenol	534521							1
	4-Bromophenyl-phenylether	101553							1
	4-Chloro-3-methylphenol	59507							1
	4-Chloroaniline	106478							1
	4-Chlorophenylphenyl ether	7005723							1
	4-Methylphenol	106445							1
	4-Nitroaniline	100016							1
	4-Nitrophenol	100027							1
	Acetophenone	98862							1
	Benzaldehyde	100527							1
	Benzoic acid	65850							
	Benzyl alcohol	100516							
	bis(2-Chloroethoxy)methane	111911							1
	Bis(2-chloroethyl)ether	111444							1
	Bis(2-ethylhexyl)phthalate	117817							1
	Butyl benzyl phthalate	85687							1
	Caprolactam	105602							1
	Carbazole	86748							1
	Dibenzofuran	132649							1
	Diethylphthalate	84662							1

TABLE 9-2
SURFACE WATER SAMPLE SUMMARY FOR EACH COI BY EXPOSURE REACH

Chemicals of Interest (COIs)			N Samples Analyzed for the Chemical of Interest						
Analyte Group	Analyte	CASRN	Reach 1	Reach 2	Reach 3	Reach 4a	Reach 4b	Reach 5	Reach 6
SVOCs (cont.)	Dimethylphthalate	131113							1
	Di-n-butylphthalate	84742							1
	Di-n-octylphthalate	117840							1
	Hexachloroethane	67721							1
	Isophorone	78591							1
	Nitrobenzene	98953							1
	N-Nitrosodi-n-propylamine	621647							1
	N-Nitrosodiphenylamine	86306							1
	Pentachlorophenol	87865							1
	Perchlorocyclopentadiene	77474							1
	Phenol	108952							1
PCB Aroclor	Total Aroclor	1336363_a							1

TABLE 9-3
SURFACE SEDIMENT SAMPLE SUMMARY FOR EACH COI BY EXPOSURE REACH

Chemicals of Interest (COIs)			N Samples Analyzed for the Chemical of Interest						
Analyte Group	Analyte	CASRN	Reach 1	Reach 2	Reach 3	Reach 4a	Reach 4b	Reach 5	Reach 6
Metals	Aluminum	7429905	68	39	28	36	49	17	24
	Antimony [1]	7440360	67	35	21	28	28	1	4
	Arsenic	7440382	71	41	33	36	49	17	24
	Barium	7440393	68	39	28	36	49	17	24
	Beryllium	7440417	68	39	28	36	49	17	24
	Boron	7440428							
	Cadmium	7440439	71	41	33	36	49	17	24
	Calcium	7440702	68	39	28	36	49	17	24
	Chromium	7440473	68	39	28	36	49	17	24
	Cobalt	7440484	68	39	28	36	49	17	24
	Copper	7440508	71	41	33	36	49	17	24
	Fluoride	16984488							
	Iron	7439896	68	39	28	36	49	17	24
	Lead	7439921	71	41	33	36	49	17	24
	Magnesium	7439954	68	39	28	36	49	17	24
	Manganese	7439965	68	39	28	36	49	17	24
	Mercury	7439976	66	39	28	36	46	17	24
	Molybdenum	7439987	1						
	Nickel	7440020	68	39	28	36	49	17	24
	Potassium	7440097	68	39	28	36	49	17	24
	Selenium	7782492	48	22	10	22	21	14	21
	Silica	7631869							
	Silver [1]	7440224	67	39	28	36	41	12	18
	Sodium	7440235	68	39	28	36	49	17	24
	Thallium	7440280	68	39	28	36	49	17	24
	Tin	7440315							
	Uranium	7440611	46	30	27	29	49	17	24
	Vanadium	7440622	68	39	28	36	49	17	24
	Zinc	7440666	71	41	33	36	49	17	24
Other Metals	Bismuth	7440699	1						
	Cerium	7440451	1						
	Cesium	7440462	1						
	Gallium	7440553	1						
	Lanthanum	7439910	1						
	Lithium	7439932	1						
	Niobium	7440031							
	Rubidium	7440177	1						
	Scandium	7440202	1						
	Strontium	7440246	1						
	Thorium	7440291	1						
	Titanium	7440326	1						
	Ytterbium	7440644							
	Zirconium	7440677							
PAHs	2-Methylnaphthalene	91576	45	30	27	29	49	17	24
	Acenaphthene	83329	45	30	27	29	49	17	24
	Acenaphthylene	208968	45	30	27	29	49	17	24
	Anthracene	120127	45	30	27	29	49	17	24
	Benzo(a)anthracene	56553	45	30	27	29	49	17	24
	Benzo(a)pyrene	50328	45	30	27	29	49	17	24
	Benzo(b)fluoranthene	205992	45	30	27	29	49	17	24
	Benzo(ghi)perylene	191242	45	30	27	29	49	17	24
	Benzo(k)fluoranthene	207089	45	30	27	29	49	17	24
	Chrysene	218019	45	30	27	29	49	17	24
	Dibenz(a,h)anthracene	53703	45	30	27	29	49	17	24
	Fluoranthene	206440	45	30	27	29	49	17	24
	Fluorene	86737	45	30	27	29	49	17	24
	Indeno(1,2,3-cd)pyrene	193395	45	30	27	29	49	17	24
	Naphthalene	91203	45	30	27	29	49	17	24
	Phenanthrene	85018	45	30	27	29	49	17	24
	Pyrene	129000	45	30	27	29	49	17	24

TABLE 9-3
SURFACE SEDIMENT SAMPLE SUMMARY FOR EACH COI BY EXPOSURE REACH

Chemicals of Interest (COIs)			N Samples Analyzed for the Chemical of Interest						
Analyte Group	Analyte	CASRN	Reach 1	Reach 2	Reach 3	Reach 4a	Reach 4b	Reach 5	Reach 6
Pesticides	2,4'-DDD	53190	45	30	27	29	49	17	24
	2,4'-DDE	3424826	45	30	27	29	49	17	24
	2,4'-DDT	789026	45	30	27	29	49	17	24
	4,4'-DDD	72548	58	39	28	36	49	17	24
	4,4'-DDE	72559	58	39	28	36	49	17	24
	4,4'-DDT	50293	58	39	28	36	49	17	24
	Aldrin	309002	58	39	28	36	49	17	24
	alpha-BHC	319846	58	39	28	36	49	17	24
	alpha-Chlordane	5103719	58	39	28	36	49	17	24
	Atrazine	1912249	45	30	27	29	49	17	24
	beta-BHC	319857	58	39	28	36	49	17	24
	cis-Nonachlor	5103731	45	30	27	29	49	17	24
	delta-BHC	319868	58	39	28	36	49	17	24
	Dieldrin	60571	58	39	28	36	49	17	24
	Endosulfan I	959988	58	39	28	36	49	17	24
	Endosulfan II	33213659	58	39	28	36	49	17	24
	Endosulfan sulfate	1031078	58	39	28	36	49	17	24
	Endrin	72208	58	39	28	36	49	17	24
	Endrin aldehyde	7421934	58	39	28	36	49	17	24
	Endrin ketone	53494705	58	39	28	36	49	17	24
	gamma-BHC	58899	58	39	28	36	49	17	24
	gamma-Chlordane	5566347	58	39	28	36	49	17	24
	Heptachlor	76448	58	39	28	36	49	17	24
	Heptachlor epoxide	1024573	58	39	28	36	49	17	24
	Hexachlorobenzene	118741	45	30	27	29	49	17	24
	Hexachlorobutadiene	87683	45	30	27	29	49	17	24
	Methoxychlor	72435	58	39	28	36	49	17	24
	Oxychlordane	27304138	45	30	27	29	49	17	24
	Toxaphene	8001352	58	39	28	36	49	17	24
	trans-Nonachlor	39765805	45	30	27	29	49	17	24
SVOCs	1,1'-Biphenyl	92524	45	30	27	29	49	17	24
	1,2,4-Trichlorobenzene	120821	45	30	27	29	49	17	24
	1,2-Dichlorobenzene	95501	45	30	27	29	49	17	24
	1,3-Dichlorobenzene	541731	45	30	27	29	49	17	24
	1,4-Dichlorobenzene	106467	45	30	27	29	49	17	24
	2,2'-oxybis(1-chloropropane)	108601	45	30	27	29	49	17	24
	2,4,5-Trichlorophenol	95954	45	30	27	29	49	17	24
	2,4,6-Trichlorophenol	88062	45	30	27	29	49	17	24
	2,4-Dichlorophenol	120832	45	30	27	29	49	17	24
	2,4-Dimethylphenol	105679	45	30	27	29	49	17	24
	2,4-Dinitrophenol	51285	32	29	19	20	41	14	18
	2,4-Dinitrotoluene	121142	45	30	27	29	49	17	24
	2,6-Dinitrotoluene	606202	45	30	27	29	49	17	24
	2-Chloronaphthalene	91587	45	30	27	29	49	17	24
	2-Chlorophenol	95578	45	30	27	29	49	17	24
	2-Methylphenol	95487	45	30	27	29	49	17	24
	2-Nitroaniline	88744	45	30	27	29	49	17	24
	2-Nitrophenol	88755	45	30	27	29	49	17	24
	3,3'-Dichlorobenzidine	91941	45	30	27	29	49	17	24
	3-Nitroaniline	99092	45	30	27	29	49	17	24
	4,6-Dinitro-2-methylphenol	534521	45	30	27	29	49	17	24
	4-Bromophenyl-phenylether	101553	45	30	27	29	49	17	24
	4-Chloro-3-methylphenol	59507	45	30	27	29	49	17	24
	4-Chloroaniline	106478	45	30	27	29	49	17	24
	4-Chlorophenylphenyl ether	7005723	45	30	27	29	49	17	24
	4-Methylphenol	106445	45	30	27	29	49	17	24
	4-Nitroaniline	100016	45	30	27	29	49	17	24
	4-Nitrophenol	100027	45	30	27	29	49	17	24
	Acetophenone	98862	45	30	27	29	49	17	24
	Benzaldehyde	100527	45	30	27	29	49	17	24

TABLE 9-3
SURFACE SEDIMENT SAMPLE SUMMARY FOR EACH COI BY EXPOSURE REACH

Chemicals of Interest (COIs)			N Samples Analyzed for the Chemical of Interest						
Analyte Group	Analyte	CASRN	Reach 1	Reach 2	Reach 3	Reach 4a	Reach 4b	Reach 5	Reach 6
SVOCs (cont.)	Benzoic acid	65850	32	20	20	19	20	2	
	Benzyl alcohol	100516	45	30	27	29	49	17	24
	bis(2-Chloroethoxy)methane	111911	45	30	27	29	49	17	24
	Bis(2-chloroethyl)ether	111444	45	30	27	29	49	17	24
	Bis(2-ethylhexyl)phthalate	117817	45	30	27	29	49	17	24
	Butyl benzyl phthalate	85687	45	30	27	29	49	17	24
	Caprolactam	105602	45	30	27	29	49	17	24
	Carbazole	86748	45	30	27	29	49	17	24
	Dibenzofuran	132649	45	30	27	29	49	17	24
	Diethylphthalate	84662	45	30	27	29	49	17	24
	Dimethylphthalate	131113	45	30	27	29	49	17	24
	Di-n-butylphthalate	84742	45	30	27	29	49	17	24
	Di-n-octylphthalate	117840	45	30	27	29	49	17	24
	Hexachloroethane	67721	45	30	27	29	49	17	24
	Isophorone	78591	45	30	27	29	49	17	24
	Nitrobenzene	98953	45	30	27	29	49	17	24
	N-Nitrosodi-n-propylamine	621647	45	30	27	29	49	17	24
	N-Nitrosodiphenylamine	86306	45	30	27	29	49	17	24
	Pentachlorophenol	87865	45	30	27	29	49	17	24
	Perchlorocyclopentadiene	77474	45	30	27	29	49	17	24
	Phenol	108952	45	30	27	29	49	17	24
PCB Aroclor	Total Aroclor	1336363_a	58	39	28	37	49	17	24
PCB TEQ	2006 TEQ_PCB	TEQ_PCB							
DF TEQ	2006 TEQ_D/F	TEQ_DF	7	6	7	6	13	3	6
PBDE	PBDE	PBDE							

[1] Several samples had analytical results that were rejected (R-qualified) by the data validator.

TABLE 9-4
BEACH SEDIMENT DATA STRATIFIED BY ELEVATION

Beach	River Mile	Sediment Concentration (mg/kg)																	
		Aluminum			Antimony			Arsenic			Barium			Beryllium			Cadmium		
		Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper
Black Sand Beach	742	19,000	18,600	18,600	18.6	52.3	47.7	16.1	25.2	27.3	1,280	1,680	1,750	1.2	1.3	1.3	1.0	1.2	1.4
Northport Boat Launch	735*	11,923	12,493	9,843	22.9	27.2	21.5	17.3	14.3	10.7	1,062	1,036	848	0.9	0.9	0.8	3.0	2.4	2.2
Dalles Orchard	729	11,300	11,900	10,700	24.8	32.4	11.2	18.1	22.5	13.7	1,020	1,070	686	0.8	0.9	0.8	2.1	1.9	2.5
North Gorge Campground	718	7,060	7,880	4,350	6.4 J	3.6 J	0.47 J	10.7	9.6	5.0	407	315	102	0.48 J	0.53 J	0.28 J	4.2	4.2	1.1
Marcus Island Campground	708	8,600	9,890	7,310	8.1 U	2 J	6.2 U	6.5	8.6	3.9	258	264	101	0.48 J	0.56 J	0.36 J	7.3	5.6	1.6
Kettle Falls Swim Beach	700*	10,277	5,137	4,900	0.7	1.5	1.2	1.9	1.3	1.6	104	40	43	0.9	0.4	0.3	0.3	0.2	0.1
Haag Cove	697	13,000	7,660	3,000	1.8 J	1.8 J	0.29 J	2.3	1.4	1.0	232	102	30	1.2 E	0.7	0.28 J	7.8	4.4	0.32 J
French Rocks Boat Launch	690	6,370	6,050	6,550	0.95 J	1 J	0.42 J	2.6	2.4	2.4	56	58	62	0.52 J	0.51 J	0.5	0.45 J	0.33 J	0.5
Cloverleaf Branch	675	12,300	7,520	7,780 E	1.6 J	1.1 J	1 J	7.0	3.6	2.3	152	80	66	0.93 E	0.59 E	0.6	2.4	0.6	3.1
AA Campground	673	10,200 E	12,200 E	9,080 E	1.1 J	1.5 J	1.2 J	3.6	5.3	4.1	78	117	78	0.7	0.9	0.7	1.0	0.7	0.17 J
Rogers Bar Campground	658	2,760	5,810	4,810	--	--	--	0.97 U	1.9	2.2	21	53	38	0.21 E	0.44 E	0.37 E	0.056 J	0.11 J	0.22 J
Columbia Campground	642*	11,617	10,660	8,947	1.1	1.0	1.0	4.7	5.4	3.8	116	100	81	0.9	0.7	0.6	1.6	0.4	0.3
Lincoln Mill Boat Ramp	633	5,070	6,900	7,160	--	--	--	5.9	6.7	5.9	35	34	61	0.32 J	0.43 J	0.5	0.47 U	0.058 J	0.064 J
Keller Ferry No. 2	615	8,620	8,030	6,270	--	--	--	4.7	4.9	4.0	69	59	46	0.7	0.7	0.5	0.5 U	0.48 U	0.5 U
Spring Canyon Campground	600	8,310	7,800	7,150	0.79 J	1.1 J	1 J	10.3	7.5	8.5	51	52	41	0.6	0.6	0.5	0.52 U	0.51 U	0.52 U

Beach	River Mile	Sediment Concentration (mg/kg)																	
		Calcium			Chromium			Cobalt			Copper			Iron			Lead		
		Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper
Black Sand Beach	742	58,700	63,300	66,900	101	123	128	29.5	48.6	51.0	1,620	2,240	2,350	197,000 D	187,000 D	211,000 D	276	231	266
Northport Boat Launch	735*	52,267	49,967	37,967	68.4	66.2	50.7	27.4	27.5	21.5	1,382	1,182	833	113,367	108,233	75,267	309	256	186
Dalles Orchard	729	37,700	39,900	35,100	71.9	77.6	51.3	35.1	36.8	22.4	1,300	1,380	802	108,000 D	110,000 D	82,100 D	205	190	214
North Gorge Campground	718	24,700	15,400	6,090	24.9	22.8	15.1	9.8	8.5	4.3 J	216	132	22.9	29,500	23,500	16,000	216	223	68.8
Marcus Island Campground	708	7,520	6,920	7,110	19.7	19.9	14.0	6.8 J	7.1	5.2	50.3	57.8	14.1	17,600	23,400	12,700	297	202	52.3
Kettle Falls Swim Beach	700*	8,840	2,470	2,023	22.9	9.8	9.8	8.0	3.6	3.4	17.6	9.5	10.1	17,433	9,647	9,530	8.9	6.0	5.2
Haag Cove	697	5,670	2,550	879	24.8	14.6	5.6	8.7	5.2 J	2.3 J	34.0	16.5	4.2	18,100	11,800	5,180	222	136	16.5
French Rocks Boat Launch	690	3,050	2,430	4,830	12.7	12.4	12.8	4.9 J	4.3 J	4.5	13.8	14.5	10.9	12,000	9,960	11,000	21.9	18.7	20.7
Cloverleaf Branch	675	5,200	6,050	3,100	28.0	17.7	19.5	10.0	6.7	5.6 J	28.7	16.1	14.8	22,600 E	15,200 E	13,300	102	15.8	51.1
AA Campground	673	2,520	4,120	2,990	18.0	24.2	14.8	6.9	10.4	6.4	14.7	20.0	12.1	16,000	21,100	14,800	33.7	19.7	6.7
Rogers Bar Campground	658	1,670	1,700	1,580	5.7	13.2	9.6	2.1 J	4.1 J	3.7 J	4.9	9.0	7.4	4,930	9,800	9,720	3.1	5.4	5.1
Columbia Campground	642*	2,980	2,333	2,017	16.9	14.3	12.1	7.7	6.3	5.4	19.1	11.4	8.7	16,700	15,933	14,400	58.2	18.5	10.6
Lincoln Mill Boat Ramp	633	10,300	15,100	11,500	6.2	9.1	9.6	3 J	3.5 J	14.2	7.3	10.0	11.5	10,200	12,600	14,200	4.4	4.7	6.2
Keller Ferry No. 2	615	1,940	1,760	3,880	12.5	11.2	9.8	5.4	5.0	3.9 J	9.1	8.6	6.7	15,600	15,500	13,100	5.9	6.3	4.5
Spring Canyon Campground	600	1,960	1,810	5,990	9.6	9.7	9.0	4.4 J	4.1 J	3.7 J	7.1	5.5	6.5	15,400	14,900	14,300	6.7	7.1	6.1

TABLE 9-4
BEACH SEDIMENT DATA STRATIFIED BY ELEVATION

Beach	River Mile	Sediment Concentration (mg/kg)																	
		Magnesium			Manganese			Mercury			Nickel			Potassium			Selenium		
		Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper
Black Sand Beach	742	6,670	7,070	8,290	3,080	3,680 D	3,680 D	0.028 J	0.03 J	0.650	9.3	12.1	12.4	3,500	3,610	3,750	--	--	3.4 U
Northport Boat Launch	735*	12,000	12,357	11,447	2,138	2,004	1,446	0.102	0.099	0.075	13.3	13.0	12.8	2,410	2,403	1,943	3.6 U	3.5 U	3.8 U
Dalles Orchard	729	5,640	6,450	9,090	2,110	2,200	1,660	0.034 J	0.044 J	0.073 J	10.4	12.1	10.4	2,270	2,300	2,030	--	--	--
North Gorge Campground	718	13,900	10,200	4,140	434	270	171	0.370	0.400	0.068 J	15.3	17.2	9.6	1,190	1,220	624	3 J	2.7 J	1.1 J
Marcus Island Campground	708	6,070	5,390	4,220	214	246	170	0.810	0.470	0.078 J	16.3	16.8	12.9	1,010	1,020	1,070	2.3 J	4.3 J	3.6 U
Kettle Falls Swim Beach	700*	6,343	2,883	2,887	381	151	177	0.006	0.1 U	0.1 U	18.7	7.8	7.8	1,804	624	555	--	--	--
Haag Cove	697	5,220	3,210	1,390	267	158	111	0.800	0.290	0.099 U	19.7	11.2	4.1	2,260	1,120	483	--	--	--
French Rocks Boat Launch	690	3,980	2,770	4,590	260	171	208	0.03 J	0.019 J	0.099 U	10.9	9.6	15.0	775	843	749	--	--	--
Cloverleaf Branch	675	6,530	4,520	4,040	526	194	145	0.210	0.03 J	0.062 J	23.8	15.9	14.0	2,190	1,210	1,200	--	--	--
AA Campground	673	3,700	4,970	3,550	167	383	248	0.053 J	0.031 J	0.01 J	15.5	21.1	12.8	1,220	2,020	1,160	--	--	--
Rogers Bar Campground	658	1,540	2,590	2,390	95	157	134	0.1 U	0.11 U	0.1 U	5.1	10.2	9.0	317 J	719	519	--	--	--
Columbia Campground	642*	4,107	3,890	3,487	283	190	167	0.136	0.029	0.017	14.6	11.8	10.2	2,210	1,840	1,413	--	--	--
Lincoln Mill Boat Ramp	633	5,320	6,240	6,530	217	224	334	0.098 U	0.11 U	0.1 U	6.1	7.8	8.5	1,140	1,410	1,350	--	--	--
Keller Ferry No. 2	615	4,210	4,390	4,330	248	230	214	0.11 U	0.11 U	0.11 U	10.1	9.4	8.5	1,640	1,410	1,080	--	--	--
Spring Canyon Campground	600	5,880	5,590	5,360	227	208	226	0.11 U	0.11 U	0.1 U	8.2	7.5	7.5	1,610	1,470	1,230	3.6 U	3.6 U	3.6 U

Beach	River Mile	Sediment Concentration (mg/kg)																	
		Silver			Sodium			Thallium			Uranium			Vanadium			Zinc		
		Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper
Black Sand Beach	742	1.1 U	0.93 U	0.97 U	1,300	1,770	1,840	2.7 U	2.3 U	2.4 U	64.8	84.3	81.6	36.6	38.3	39.8	14,900 D	15,200 D	16,900
Northport Boat Launch	735*	1.1 U	1 U	1.1 U	1,130	1,147	767	2.6 U	2.5 U	2.7 U	20.9 U	20.2 U	21.8 U	28.4	31.2	27.9	9,623	8,543	5,947
Dalles Orchard	729	1 U	0.97 U	1 U	1,200	1,300	811	0.83 J	1.1 J	1.3 J	20.4 U	19.4 U	21 U	28.2	29.2	27.2	8,700 D	8,410 D	6,560 D
North Gorge Campground	718	1.2 U	1.4 U	1 U	170 J	134 J	88.5 J	3.1 U	3.4 U	2.6 U	14.2 J	11.2 J	5.7 J	26.9	27.4	27.9	1,700	1,060	352
Marcus Island Campground	708	1.4 U	1.3 U	1 U	86.4 J	134 J	95.9 J	3.4 U	3.2 U	2.6 U	27.1 U	6.7 J	7.5 J	24.4	28.5	18.6	915	620	186
Kettle Falls Swim Beach	700*	1 U	0.91 U	0.93 U	262	115	97	2.6 U	2.3 U	2.3 U	20.8 U	17.9 U	18.7 U	33.7	20.4	20.7	55	36	34
Haag Cove	697	1.5 U	1.2 U	0.86 U	242 J	125 J	60.4 J	3.8 U	2.9 U	2.2 U	30.2 U	23.1 U	17.3 U	29.0	19.8	9.1	700	391	54
French Rocks Boat Launch	690	1.1 U	1 U	0.89 U	155 J	131 J	134 J	2.8 U	2.6 U	2.2 U	22.1 U	8.4 J	17.7 U	21.7	19.6	21.9	97	67	92
Cloverleaf Branch	675	1.2 U	1.1 U	1.2 U	245 J	147 J	94 J	3.1 U	2.7 U	3.1 U	24.6 U	21.4 U	24.4 U	35.6	26.6	21.9	295	90	220
AA Campground	673	1.2 U	1.2 U	1.1 U	115 J	173 J	129 J	3 U	3.1 U	2.9 U	23.9 U	24.6 U	22.8 U	27.2	32.6	26.3	158	118	49
Rogers Bar Campground	658	0.97 U	1.1 U	1 U	58.3 J	97.8 J	87.7 J	2.4 U	2.7 U	2.5 U	19.4 U	9.8 J	20.2 U	8.7	16.2	16.7	21	33	47
Columbia Campground	642*	1.1 U	1 U	1.1 U	144	103	93	2.7 U	2.6 U	2.7 U	10.2	21 U	21.2 U	23.0	21.0	18.0	233	143	120
Lincoln Mill Boat Ramp	633	0.94 U	0.97 U	0.93 U	57.2 J	97.2 J	97.6 J	2.3 U	2.4 U	2.3 U	6.3 J	6.4 J	6.9 J	8.4	10.8	13.4	27	30	36
Keller Ferry No. 2	615	1 U	0.96 U	1 U	74.7 J	57.7 J	49.3 J	2.5 U	2.4 U	2.5 U	5.4 J	4.6 J	20.2 U	19.5	17.2	14.0	39	44	37
Spring Canyon Campground	600	1 U	1 U	1 U	65.7 J	53.8 J	73.5 J	2.6 U	2.6 U	2.6 U	20.8 U	5.2 J	20.6 U	14.8	14.0	13.9	48	55	40

Lower = 1,255 ft above mean sea level

Middle = 1,270 ft above mean sea level

Upper = 1,285 ft above mean sea level

*Mean concentration of left (L), center (C), and right (R) grab sub-samples is shown (non-detects evaluated at 1/2 the detection limit)

-- = no data available (results rejected by data validator)

Table 9-5
EPA 2005 Phase I Size-Fractioned Sediment Sample Results for Metals

Analyte Type	Analyte	Units	Northport Boat Launch (RM735BSF)				Kettle Falls Swim Beach (RM700BSF)				Columbia Campground (RM642BSF)			
			Fraction > 75 µm		Fraction < 75 µm		Fraction > 75 µm		Fraction < 75 µm		Fraction > 75 µm		Fraction < 75 µm	
Metals	Aluminum	mg/kg	12300		8400		6430		14000		8350		16400	
	Antimony	mg/kg	47.4		3.9	J	--		--		--		--	
	Arsenic	mg/kg	10.1		10.4		1.2		2		2.6		3.9	
	Barium	mg/kg	1230		1030		59.2		182		92.3		175	
	Beryllium	mg/kg	0.71	E	0.59	E	0.33	E	0.76	E	0.42	E	0.85	E
	Cadmium	mg/kg	4.8		5.5		0.34	J	0.82		0.81		1.6	
	Calcium	mg/kg	55000		27700		3740		14000		2080		3900	
	Chromium	mg/kg	80.3		29.4		14.1		33		13.2		21	
	Cobalt	mg/kg	34.3		12.7		5.3		11.4		6.2		10.2	
	Copper	mg/kg	1530	E	278	E	11.9	E	26.7	E	9.8	E	24.1	E
	Iron	mg/kg	126000	D	35100		12800		24600		14100		21000	
	Lead	mg/kg	267		325		7.5		21.8		26.1		47.4	
	Magnesium	mg/kg	13100		14200		4250		9380		3670		4750	
	Manganese	mg/kg	2380		690		211		568		187		389	
	Mercury	mg/kg	0.072	J	0.32		0.008	J	0.031	J	0.043	J	0.078	J
	Nickel	mg/kg	14.7		21.1		13		27		11.3		18.8	
	Potassium	mg/kg	2970		1630		955		2850		1730		2800	
	Selenium	mg/kg	8		3.9		1.3	J	2.5	J	0.94	J	1.5	J
	Silver	mg/kg	--		--		--		--		--		--	
	Sodium	mg/kg	1210		214	J	147	J	355	J	77.2	J	226	J
	Thallium	mg/kg	2.3	U	2.4	U	2	U	2.5	U	1.9	U	2.6	U
	Uranium	mg/kg	18.8	U	19.2	U	16.3	U	19.8	U	15.5	U	20.4	U
	Vanadium	mg/kg	38.5		39.4		27.5		47.3		19.7		32.4	
	Zinc	mg/kg	10100	D	1860		44.6		106		154		222	

-- = no data available; results were rejected by the data validator

Analyte Type	Analyte	Units	RM735BSF	RM700BSF	RM642BSF
Size Fraction	Colloids	%	0.1	0.2	0.3
	Silt	%	11.4	11.0	28.9
	Clay	%	0.1	0.6	2.2
	Gravel	%	0.3	15	3
	Med. Sand	%	30.5	34.1	21
	Fine Sand	%	56.9	34.3	37.2
	Co. Sand	%	0.7	4.8	7.4
	Sand Total	%	88.1	73.2	65.6
	<200 Total	%	11.6	11.8	31.4

TABLE 9-6
SUBSURFACE SEDIMENT SAMPLE SUMMARY FOR EACH COI BY EXPOSURE REACH

Chemicals of Interest (COIs)			N Samples Analyzed for the Chemical of Interest						
Analyte Group	Analyte	CASRN	Reach 1	Reach 2	Reach 3	Reach 4a	Reach 4b	Reach 5	Reach 6
Metals	Aluminum	7429905			1	1			
	Antimony	7440360			1	1			
	Arsenic	7440382			1	1			
	Barium	7440393			1	1			
	Beryllium	7440417			1	1			
	Boron	7440428							
	Cadmium	7440439			1	1			
	Calcium	7440702			1	1			
	Chromium	7440473			1	1			
	Cobalt	7440484			1	1			
	Copper	7440508			1	1			
	Fluoride	16984488							
	Iron	7439896			1	1			
	Lead	7439921			1	1			
	Magnesium	7439954			1	1			
	Manganese	7439965			1	1			
	Mercury	7439976			1	1			
	Molybdenum	7439987							
	Nickel	7440020			1	1			
	Potassium	7440097			1	1			
	Selenium	7782492			1	1			
	Silica	7631869							
	Silver	7440224			1	1			
	Sodium	7440235			1	1			
	Thallium	7440280			1	1			
	Tin	7440315							
	Uranium	7440611							
	Vanadium	7440622			1	1			
	Zinc	7440666			1	1			
Pesticides	2,4'-DDD	53190							
	2,4'-DDE	3424826							
	2,4'-DDT	789026							
	4,4'-DDD	72548			1	1			
	4,4'-DDE	72559			1	1			
	4,4'-DDT	50293			1	1			
	Aldrin	309002			1	1			
	alpha-BHC	319846			1	1			
	alpha-Chlordane	5103719			1	1			
	Atrazine	1912249							
	beta-BHC	319857			1	1			
	cis-Nonachlor	5103731							
	delta-BHC	319868			1	1			
	Dieldrin	60571			1	1			
	Endosulfan I	959988			1	1			
	Endosulfan II	33213659			1	1			
	Endosulfan sulfate	1031078			1	1			
	Endrin	72208			1	1			
	Endrin aldehyde	7421934			1	1			
	Endrin ketone	53494705			1	1			
	gamma-BHC	58899			1	1			
	gamma-Chlordane	5566347			1	1			
	Heptachlor	76448			1	1			
	Heptachlor epoxide	1024573			1	1			
	Hexachlorobenzene	118741							
	Hexachlorobutadiene	87683							
	Methoxychlor	72435			1	1			
	Oxychlordane	27304138							
	Toxaphene	8001352			1	1			
	trans-Nonachlor	39765805							
PCB Aroclor	Total Aroclor	1336363_a			1	1			

Table 9-7
UCR EPA Expanded Site Investigation (ESI) Subsurface Sediment Locations

Station:			**CS017**		**CS024**	
Station Location:			UCR, on flats fronting Haag Cove		Marcus Flats, near Pingston Creek	
River Mile:			RM 697		RM 705	
Sample Date(s):			5/18/2001		6/8/2001	
Sample ID:			**CR-018-SD**	**CR-066-SD**	**not collected**	**CR-062-SD**
Collection Depth:			0-6 inches	18-24 inches	0-6 inches	18-24 inches
Analyte Group	**Analyte**	**Units**				
Metals	Aluminum	mg/kg	9540	9540		6810
	Antimony	mg/kg	2.4 BJL	0.72 UJK		1.6 UJK
	Arsenic	mg/kg	13.1	2.8		5.8
	Barium	mg/kg	1030	175		147
	Beryllium	mg/kg	0.53 BJK	0.53 BJK		0.29 B
	Cadmium	mg/kg	8.6	0.43 B		0.1 U
	Calcium	mg/kg	34900	5560		162000
	Chromium	mg/kg	25.2	9.4		12.9
	Cobalt	mg/kg	6.5 BJK	4 B		4.7 B
	Copper	mg/kg	67.7 JL	15.6 JL		18.1 JL
	Iron	mg/kg	25900	11500		11700
	Lead	mg/kg	439	26.8		6.7 JL
	Magnesium	mg/kg	21400	2970		5090
	Manganese	mg/kg	420	315		327
	Mercury	mg/kg	0.93	0.06 U		0.08 U
	Nickel	mg/kg	22.7	9.2 B		14.3
	Potassium	mg/kg	1590 JL	1060 B		1330 B
	Selenium	mg/kg	0.86 U	0.82 U		1.2 U
	Silver	mg/kg	1.8 BJK	0.32 B		0.32 U
	Sodium	mg/kg	276 BJK	276 BJK		337 U
	Thallium	mg/kg	0.98 U	0.94 U		1.3 U
	Vanadium	mg/kg	33.9	19.2		16.6 B
	Zinc	mg/kg	1180	84.2		42.3
PCB	As Aroclor	mg/kg	0.085 U (a)	0.083 U (a)		0.1 U (a)
Pesticides	4,4'-DDD	mg/kg	0.0042 U	0.0041 U		0.005 U
	4,4'-DDE	mg/kg	0.0042 U	0.0041 U		0.005 U
	4,4'-DDT	mg/kg	0.0042 U	0.0041 U		0.005 U
	Aldrin	mg/kg	0.0022 U	0.0021 U		0.0026 U
	alpha-BHC	mg/kg	0.0022 U	0.0021 U		0.0026 U
	alpha-Chlordane	mg/kg	0.0022 U	0.0021 U		0.0026 U
	beta-BHC	mg/kg	0.0022 U	0.0021 U		0.0026 U
	delta-BHC	mg/kg	0.0022 U	0.0021 U		0.0026 U
	Dieldrin	mg/kg	0.0042 U	0.0041 U		0.005 U
	Endosulfan I	mg/kg	0.0022 U	0.0021 U		0.0026 U
	Endosulfan II	mg/kg	0.0042 U	0.0041 U		0.005 U
	Endosulfan sulfate	mg/kg	0.0042 U	0.0041 U		0.005 U
	Endrin	mg/kg	0.0042 U	0.0041 U		0.005 U
	Endrin aldehyde	mg/kg	0.0042 U	0.0041 U		0.005 U
	Endrin ketone	mg/kg	0.0042 U	0.0041 U		0.005 U
	gamma-BHC	mg/kg	0.0022 U	0.0021 U		0.0026 U
	gamma-Chlordane	mg/kg	0.0022 U	0.0021 U		0.0026 U
	Heptachlor	mg/kg	0.0022 U	0.0021 U		0.0026 U
	Heptachlor epoxide	mg/kg	0.0022 U	0.0021 U		0.0026 U
	Methoxychlor	mg/kg	0.022 U	0.021 U		0.026 U
	Toxaphene	mg/kg	0.22 U	0.21 U		0.26 U
Sediment Characterization	Clay	%	30	30		10 <
	Gravel	%	0	0		1
	Percent Sand	%	20	20		45
	Silt	%	50	40		45
	TOC	%	1.66	1.04		1.58

(a) maximum detection limit for reported Aroclor mixtures

TABLE 9-8
OUTDOOR AIR SAMPLE SUMMARY FOR EACH COI BY EXPOSURE REACH

Chemicals of Interest (COIs)			N Samples Analyzed for the Chemical of Interest						
Analyte Group	Analyte	CASRN	Reach 1	Reach 2	Reach 3	Reach 4a	Reach 4b	Reach 5	Reach 6
Metals	Aluminum	7429905							
	Antimony	7440360			127		124	120	
	Arsenic	7440382	770		119		119	109	
	Barium	7440393			79		88	72	
	Beryllium	7440417			103		117	100	
	Boron	7440428							
	Cadmium	7440439	770		134		127	124	
	Calcium	7440702							
	Chromium	7440473			108		105	100	
	Cobalt	7440484			129		131	128	
	Copper	7440508			135		136	132	
	Fluoride	16984488							
	Iron	7439896			129		126	122	
	Lead	7439921	769		127		127	123	
	Magnesium	7439954							
	Manganese	7439965			131		128	124	
	Mercury	7439976			23		22	21	
	Molybdenum	7439987			74		71	69	
	Nickel	7440020			114		114	105	
	Potassium	7440097							
	Selenium	7782492							
	Silica	7631869							
	Silver	7440224			109		108	105	
	Sodium	7440235							
	Thallium	7440280			107		106	94	
	Tin	7440315							
	Uranium	7440611			75		79	72	
	Vanadium	7440622			130		132	125	
	Zinc	7440666	769		131		131	124	
Other Metals	Bismuth	7440699			112		110	98	
	Cerium	7440451			115		123	114	
	Cesium	7440462			117		120	113	
	Gallium	7440553			105		110	99	
	Lanthanum	7439910			122		127	117	
	Lithium	7439932			113		117	108	
	Niobium	7440031			103		109	98	
	Rubidium	7440177			123		126	117	
	Scandium	7440202			104		116	110	
	Strontium	7440246			127		125	122	
	Thorium	7440291			86		101	95	
	Titanium	7440326			105		115	103	
	Ytterbium	7440644			104		105	100	
	Zirconium	7440677							

Note: Measured data for Reach 1 are based on samples collected post-1999.

Table 9-9
Calculation of the Particulate Emission Factor (PEF)

Equation:

$$\text{PEF (kg/m}^3\text{)} = \frac{0.036 \cdot (1\text{-}V) \cdot (U_m/U_t)^3 \cdot F(x) \cdot FEF}{Q/C \cdot 3{,}600 \text{ s/hr}}$$

Exposure Parameter		Units	Value	Notes
Fraction of vegetative cover	*V*	unitless	0	[1]
Mean annual windspeed	*Um*	m/sec	6.17	[2]
Windspeed threshold @ 7m	*Ut*	m/sec	11.32	[3]
Um/Ut function	*Fx*	unitless	0.194	[3]
Unit emission rate/mean conc	*Q/C*	g/m^2-sec per kg/m^3	46.8	[4]
Fines enrichment factor	*FEF*	unitless	2	[5]

Particulate Emission Factor	***PEF***	**kg soil/m^3 air**	**1.3E-08**

[1] Adjusted from default (0.5) based on assumption of no vegetative cover on beaches and shorelines.

[2] Adjusted from default (4.69 m/s) based on assumed of mean annual wind speed of 12 knots (6.17 m/s).

[3] Recommended default (EPA 1996b)

[4] Adjusted from default (90.8 - based on 0.5 $acre^2$ source area scenario) to a 30 $acre^2$ source scenario (EPA 1996b).

[5] Assumption; based on comparison of coarse & fine sediment data from EPA 2005 Phase I Sediment Study.

For more information on PEF adjustments:

http://www.epa.gov/superfund/health/conmedia/soil/pdfs/appd_d.pdf

TABLE 9-10a
FISH TISSUE (FILLET) SAMPLE SUMMARY FOR EACH COI BY EXPOSURE REACH

Chemicals of Interest (COIs)			N Samples Analyzed for the Chemical of Interest						
Analyte Group	Analyte	CASRN	Reach 1	Reach 2	Reach 3	Reach 4a	Reach 4b	Reach 5	Reach 6
Metals	Aluminum	7429905	10		10				10
	Antimony	7440360	10		10				10
	Arsenic	7440382	12		12				11
	Barium	7440393	10		10				10
	Beryllium	7440417	10		10				10
	Boron	7440428							
	Cadmium	7440439	10		10				10
	Calcium	7440702	10		10				10
	Chromium	7440473	10		10				10
	Cobalt	7440484	10		10				10
	Copper	7440508	10		10				10
	Fluoride	16984488							
	Iron	7439896	10		10				10
	Lead	7439921	10		10				10
	Magnesium	7439954	10		10				10
	Manganese	7439965	10		10				10
	Mercury	7439976	10		18				18
	Molybdenum	7439987							
	Nickel	7440020	10		10				10
	Potassium	7440097	10		10				10
	Selenium	7782492	10		10				10
	Silica	7631869							
	Silver	7440224	10		10				10
	Sodium	7440235	10		10				10
	Thallium	7440280	10		10				10
	Tin	7440315							
	Uranium	7440611	10		10				10
	Vanadium	7440622	10		10				10
	Zinc	7440666	10		10				10
PBDE	PBDE-153	68631492			4				
	PBDE-209	1163195			4				
	PBDE-47	5436431			4				
	PBDE-99	60348609			4				
PCB Aroclor	Aroclor-1016	12674112							
	Aroclor-1221	11104282							
	Aroclor-1232	11141165							
	Aroclor-1242	53469219			8				16
	Aroclor-1248	12672296							
	Aroclor-1254	11097691			8				16
	Aroclor-1254/1260	E-15009							
	Aroclor-1260	11096825			8				16
PCB	As Aroclor	1336363_as	10		10				10
PCB TEQ (a)	2006 TEQ_PCB	TEQ_PCB	10		18				26
DF TEQ	2006 TEQ_D/F	TEQ_DF	10		23				26

(a) PCB TEQ results estimated from Aroclor

TABLE 9-10b
FISH TISSUE (WHOLE BODY) SAMPLE SUMMARY FOR EACH COI BY EXPOSURE REACH

Chemicals of Interest (COIs)			N Samples Analyzed for the Chemical of Interest						
Analyte Group	Analyte	CASRN	Reach 1	Reach 2	Reach 3	Reach 4a	Reach 4b	Reach 5	Reach 6
Metals	Aluminum	7429905	38	22	34	22		25	34
	Antimony	7440360	38	22	34	22		25	34
	Arsenic	7440382	50	26	40	26		29	38
	Barium	7440393	38	22	34	22		25	34
	Beryllium	7440417	38	22	34	22		25	34
	Cadmium	7440439	38	22	34	22		25	34
	Calcium	7440702	38	22	34	22		25	34
	Chromium	7440473	38	22	34	22		25	34
	Cobalt	7440484	38	22	34	22		25	34
	Copper	7440508	38	22	34	22		25	34
	Iron	7439896	38	22	34	22		25	34
	Lead	7439921	38	22	34	22		25	34
	Magnesium	7439954	38	22	34	22		25	34
	Manganese	7439965	38	22	34	22		25	34
	Mercury	7439976	18	22	24	22		25	24
	Nickel	7440020	38	22	34	22		25	34
	Potassium	7440097	38	22	34	22		25	34
	Selenium	7782492	38	22	34	22		25	34
	Silver	7440224	38	22	34	22		25	34
	Sodium	7440235	38	22	34	22		25	34
	Thallium	7440280	38	22	34	22		25	34
	Uranium	7440611	38	22	34	22		25	34
	Vanadium	7440622	38	22	34	22		25	34
	Zinc	7440666	38	22	34	22		25	34
PCB	As Aroclor	1336363_a	18	22	24	22		25	24
PCB TEQ (a)	2006 TEQ_PCB	TEQ_PCB	18	22	24	22		25	24
DF TEQ	2006 TEQ_D/F	TEQ_DF	18	22	24	22		25	24

(a) PCB TEQ results estimated from Aroclor

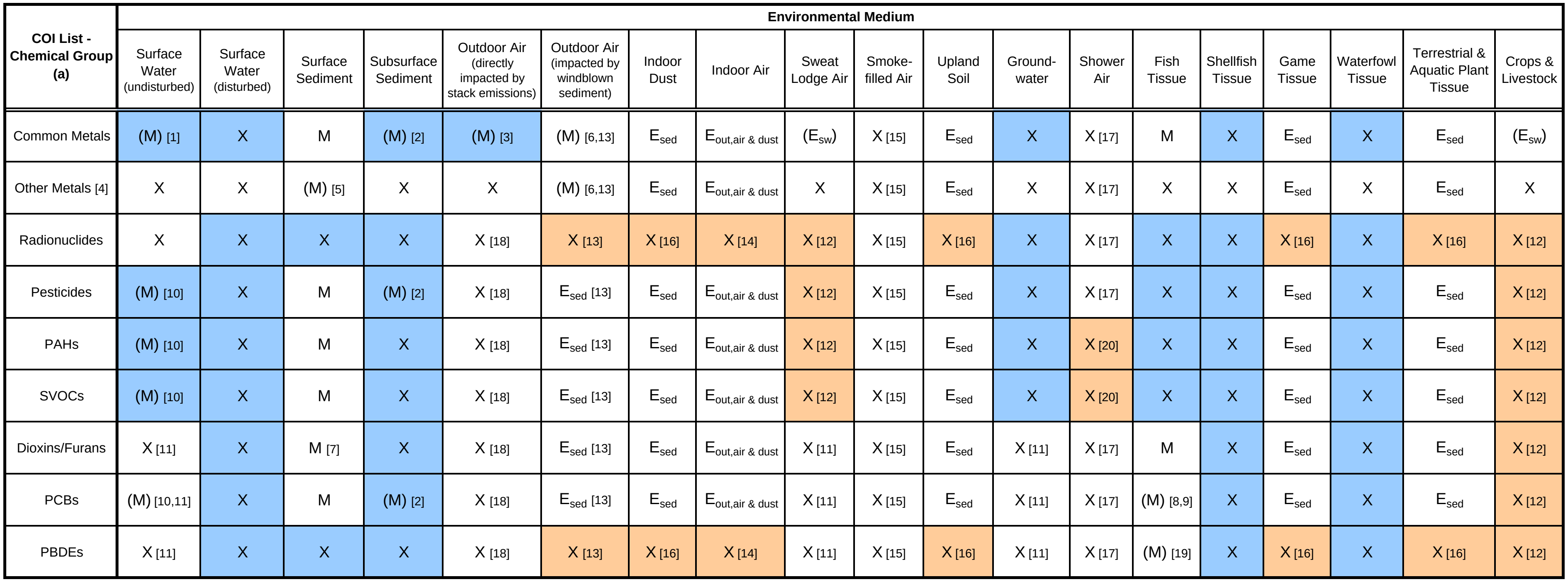
TABLE 9-11
NON-LEAD PRELIMINARY RISK ESTIMATES AND DATA NEEDS PRIORITY

Data Adequacy Evaluation Section	Exposure Medium	Exposure Pathway	COI(s) ≥ LOPC	Magnitude of LOPC Exceedance [1]	Data Needs Priority
9.5.1	**Surface Water**	Incidental Ingestion of Surface Water	Arsenic	LOW [18]	HIGH [7]
		Dermal Contact with Surface Water	--	NONE	
		Ingestion of Surface Water as Drinking Water	Arsenic	MODERATE [17]	
9.5.2	**Surface Sediment**	Incidental Ingestion of Sediment	Metals	HIGH [12,13]	HIGH
			Dioxins/Furans	LOW [13]	
		Dermal Contact with Sediment	Arsenic	LOW-MODERATE	
9.5.3	**Subsurface Sediment**	Incidental Ingestion of Subsurface Sediment	***	***	HIGH
		Dermal Contact with Subsurface Sediment	***	***	
9.5.4	**Outdoor Air** (directly impacted by stack emissions)	Inhalation of Airborne Particulates in Outdoor Air	Arsenic	LOW	MODERATE [15]
9.5.5	**Outdoor Air** (impacted by windblown sediments)	Inhalation of Airborne Particulates in Outdoor Air (under routine conditions)	Barium, Manganese	LOW	*Deferred*
		Inhalation of Airborne Particulates in Outdoor Air (under windstorm conditions)	--	NONE	LOW [16]
9.5.6	**Indoor Dust [2]**	Incidental Ingestion of Indoor Dust	Metals	LOW-MODERATE	*Deferred*
9.5.7	**Indoor Air [3]**	Inhalation of Airborne Particulates in Indoor Air	Metals	LOW-HIGH	*Deferred*
9.5.8	**Sweat Lodge Air**	Inhalation of Surface Water During Sweat Lodge Use	Arsenic	MODERATE [7,11]	*Deferred*
			Cadmium	LOW [7,8,11]	
9.5.9	**Smoke-filled Air**	Inhalation of Smoke-filled Air	***	***	*Deferred*
9.5.10	**Upland Soil [20]**	Incidental Ingestion of Soil	Metals	MODERATE [12]	MODERATE
		Dermal Contact with Soil	Arsenic	LOW-MODERATE	
9.5.11	**Groundwater**	Ingestion of Drinking Water	***	***	MODERATE [7]
		Inhalation of SVOCs in Shower Water	***	***	
		Dermal Contact with Shower Water	***	***	
9.5.12	**Fish**	Ingestion of Fish (fillet and whole body)	Metals	HIGH [13]	HIGH
			Dioxins/Furans	HIGH	
			PBDEs	HIGH	
			PCBs	HIGH [13]	
9.5.12	**Shellfish**	Ingestion of Shellfish	***	***	HIGH
9.5.13	**Game [4,14]**	Ingestion of Hunted Large Game from the Site	Metals	HIGH	*Deferred*
			Dioxins/Furans	HIGH	
			PCBs	HIGH [9]	
			PAHs	LOW-MODERATE	
			Pesticides	LOW-MODERATE [9]	
			Bis(2-ethylhexyl)phthalate	LOW [9]	
		Dermal Contact with Large Game During Preparation/ Preservation Activities	Dioxins/Furans	MODERATE	
			PCBs	LOW [9]	
9.5.13	**Waterfowl**	Ingestion of Waterfowl from the Site	***	***	HIGH [21]
		Dermal Contact with Waterfowl During Preparation/ Preservation Activities	***	***	
9.5.14	**Terrestrial (Upland) Plants [4,14]**	Ingestion of Terrestrial Plants Gathered from the Site	Metals	HIGH	*Deferred*
			Dioxins/Furans	LOW	
			PCBs	LOW [9]	
			PAHs	LOW-MODERATE	
			Pesticides	LOW [9]	
			Bis(2-chloroethyl) ether	HIGH [9,10]	
		Dermal Contact with Terrestrial Plant Materials During Ceremonial/Medicinal Activities	--	NONE	
9.5.15	**Aquatic (Riparian) Plants [19]**	Ingestion of Aquatic Plants	Metals	HIGH	*Deferred*
			Dioxins/Furans	LOW	
			PCBs	LOW [9]	
			PAHs	LOW-MODERATE	
			Pesticides	LOW [9]	
			Bis(2-chloroethyl) ether	HIGH [9,10]	
		Incidental Ingestion of Aquatic Plant Materials Used in Basket weaving	Arsenic	LOW	
			Bis(2-chloroethyl) ether	LOW [9,10]	
		Dermal Contact with Aquatic Plant Materials Used in Basket weaving	--	NONE	
9.5.16	**Crops [5]**	Ingestion of Crops Irrigated with Surface Water	Metals	HIGH [6,7]	*Deferred*
9.5.17	**Livestock [5]**	Ingestion of Livestock Watered with Surface Water and Fed Irrigated Crops	Metals	MODERATE [6,7]	*Deferred*

[1] non-cancer -- NONE: HQ < 0.1, LOW: HQ > 0.1 - 0.3, MODERATE: HQ > 0.3 - 1, HIGH: HQ > 1
[2] assumed to be 70% of sediment concentrations
[3] estimated from indoor dust and outdoor air
[4] estimated using soil to biota uptake models (Csoil assumed to be equal to Csediment)
[5] estimated from surface water using uptake models
[6] risk estimates based on "background" conditions were also above the LOPC
[7] surface water data set is extremely limited (only one location and a subset of metals analyzed)
[8] detection frequency was only 13% (7/55) in surface water; achieved surface water DLs were not adequate to assess risks based on modeled sweat lodge air data
[9] detection frequency was usually less than 10% in sediment
[10] uptake factor may be biased high as bioaccumulation in food chain is unlikely (ATSDR Toxicological Profile for Bis(2-chloroethyl) ether, http://www.atsdr.cdc.gov/toxprofiles/tp127.html).
[11] sweat lodge estimation method based on a bulk transfer approach is likely to overestimate air concentrations
[12] based on bulk sediment concentrations and default RBA
[13] uncertainty in the EPCs (either due to limited number of samples, 95UCL higher than max, and/or ratio of 95UCL to the mean > 2.0)
[14] tissue estimation approach is likely to overestimate tissue concentrations
[15] measured data set is limited (subset of COIs analyzed)
[16] measured data set is limited (few samples are available that are identified as being collected during a high wind event)
[17] measured arsenic concentrations in surface water are below drinking water MCL
[18] data set is not representative of water during disturbance activities; risks based on disturbed surface water are likely to be higher
[19] estimated using sediment to biota uptake models
[20] Csoil assumed to be equal to Csediment
[21] sampling may be deferred if a conservative method to estimate waterfowl tissue concentrations demonstrates that risks will not exceed the LOPC

*** = preliminary risk calculations could not be performed

TABLE 9-12
ANALYTICAL SUITE ADEQUACY FOR EACH ENVIRONMENTAL MEDIUM



COI List - Chemical Group (a)	**Environmental Medium**																		
	Surface Water (undisturbed)	Surface Water (disturbed)	Surface Sediment	Subsurface Sediment	Outdoor Air (directly impacted by stack emissions)	Outdoor Air (impacted by windblown sediment)	Indoor Dust	Indoor Air	Sweat Lodge Air	Smoke-filled Air	Upland Soil	Ground-water	Shower Air	Fish Tissue	Shellfish Tissue	Game Tissue	Waterfowl Tissue	Terrestrial & Aquatic Plant Tissue	Crops & Livestock
Common Metals	(M) [1]	X	M	(M) [2]	(M) [3]	(M) [6,13]	E_{sed}	$E_{out,air\ \&\ dust}$	(E_{sw})	X [15]	E_{sed}	X	X [17]	M	X	E_{sed}	X	E_{sed}	(E_{sw})
Other Metals [4]	X	X	(M) [5]	X	X	(M) [6,13]	E_{sed}	$E_{out,air\ \&\ dust}$	X	X [15]	E_{sed}	X	X [17]	X	X	E_{sed}	X	E_{sed}	X
Radionuclides	X	X	X	X	X [18]	X [13]	X [16]	X [14]	X [12]	X [15]	X [16]	X	X [17]	X	X	X [16]	X	X [16]	X [12]
Pesticides	(M) [10]	X	M	(M) [2]	X [18]	E_{sed} [13]	E_{sed}	$E_{out,air\ \&\ dust}$	X [12]	X [15]	E_{sed}	X	X [17]	X	X	E_{sed}	X	E_{sed}	X [12]
PAHs	(M) [10]	X	M	X	X [18]	E_{sed} [13]	E_{sed}	$E_{out,air\ \&\ dust}$	X [12]	X [15]	E_{sed}	X	X [20]	X	X	E_{sed}	X	E_{sed}	X [12]
SVOCs	(M) [10]	X	M	X	X [18]	E_{sed} [13]	E_{sed}	$E_{out,air\ \&\ dust}$	X [12]	X [15]	E_{sed}	X	X [20]	X	X	E_{sed}	X	E_{sed}	X [12]
Dioxins/Furans	X [11]	X	M [7]	X	X [18]	E_{sed} [13]	E_{sed}	$E_{out,air\ \&\ dust}$	X [11]	X [15]	E_{sed}	X [11]	X [17]	M	X	E_{sed}	X	E_{sed}	X [12]
PCBs	(M) [10,11]	X	M	(M) [2]	X [18]	E_{sed} [13]	E_{sed}	$E_{out,air\ \&\ dust}$	X [11]	X [15]	E_{sed}	X [11]	X [17]	(M) [8,9]	X	E_{sed}	X	E_{sed}	X [12]
PBDEs	X [11]	X	X	X	X [18]	X [13]	X [16]	X [14]	X [11]	X [15]	X [16]	X [11]	X [17]	(M) [19]	X	X [16]	X	X [16]	X [12]

(a) See Table 5-1 for a detailed list of COIs for each Chemical Group

M	Measured data are available - shown in parentheses if available data are limited or do not encompass all reaches
E_i	Estimated data available (from medium i)
X	No data available
🟧	Preliminary risk estimates could not be performed due to lack of environmental data; however, it may be possible to estimate concentrations based on media collected as part of future sampling efforts; analysis of this chemical group in this media is deferred
🟦	Preliminary risk estimates could not be performed due to lack of environmental data; additional sample collection is likely to be needed for this chemical group in this media

Notes:

[1] Available surface water data are limited (not all metals analyzed or reaches represented); data are not representative of disturbed conditions
[2] Only 1 sample in Reach 3 and 1 sample in Reach 4a
[3] Only a subset of metals (As, Cd, Pb, Zn) were analyzed in Reach 1
[4] Limited toxicity data are available for most "other" trace elements; it is anticipated that these analytes are likely to be minor relative to the common metals
[5] Only 1 sample in Reach 1
[6] No samples in Reach 2, 4a, or 6
[7] Only 20% of samples analyzed for dioxin/furan
[8] PCB TEQ estimated based on Aroclor measurements for some samples
[9] No fillet samples in Reach 2, 4a, 4b, or 5; no whole body samples in Reach 4b
[10] Only 1 sample in Reach 6
[11] Dioxin/furans, PCBs, PBDEs would be expected to be sorbed to organic materials in sediment/soil and in biotic tissues in preference to water
[12] May be estimated from surface water
[13] Metals, pesticides, PAHs, SVOCs, dioxin/furans, PCBs, and PBDEs have relatively low volatility; presence in air can be predicted from PM10 measures
[14] May be estimated from outdoor air and indoor dust
[15] Collection deferred pending additional information on this exposure scenario
[16] May be estimated from sediment and/or soil
[17] Volatile COIs only
[18] Metals are the principle COIs
[19] Only 4 fillet samples in Reach 3
[20] May be estimated from groundwater

COI Check v6.xls, COI Data Gap Matrix

TABLE 9-13
SUMMARY OF HUMAN EXPOSURE PARAMETER ADEQUACY

Exposure Medium	**Exposure Route**	**Exposed Population**							
		Worker		Recreational Visitor			Subsistence		Residential
		Contact Intensive	Non-Contact Intensive	Short-Term	Seasonal	Year-Round	Traditional	Modern	
Surface water	Incidental ingestion	❍	❍	❍	❍	❍	●	❍	
	Ingestion as drinking water	❍(a)	❍(a)	❍	❍(a)	❍(a)	✓	❍(a)	❍(a)
	Dermal Contact	❍	❍	❍	❍	❍	❍	❍	
Sediment/Soil	Incidental ingestion	●	●	●	●	●	✓	●	●
	Dermal contact	❍	●	❍	●	●	●	●	●
Outdoor air	Inhalation	❍	●	❍	●	●	●	●	●
Indoor dust	Ingestion								●
Indoor air	Inhalation			❍	●				●
Groundwater	Ingestion			(c)	(c)				(c)
	Inhalation (b)			(c)	(c)				(c)
	Dermal Contact (b)			(c)	(c)				(c)
Fish/Game	Ingestion			●	●	●	✓	●	
Shellfish/ Waterfowl	Ingestion			(c)	(c)	(c)	(c)	(c)	
Plants/Crops/ Livestock	Ingestion						✓	●	
Amphibians/ Reptiles	Ingestion						(c)	(c)	

(a) Below drinking water MCLs

(b) During showering

(c) Available data are insufficient to evaluate this exposure scenario

Tribal-Specific Exposure Scenarios:	STI	CCT
Inhalation of water vapor/aerosols in sweat lodge air	✓	●
Incidental ingestion of terrestrial/aquatic plants during basket weaving	●	●
Dermal contact with terrestrial/aquatic plants during basket weaving	❍	❍
Dermal contact with animal tissues during food preparation/preservation	●	●
Dermal contact with plant tissues during medicinal/ceremonial activities	❍	❍
Inhalation of smoke/ash from burning materials during food preparation/preservation	(c)	(c)

STI = Spokane Tribe of Indians

CCT = Confederated Colville Tribes

(a) Below drinking water MCLs

(b) During showering

(c) Available data are insufficient to evaluate this exposure scenario

KEY:

	Exposure pathway is not complete for this receptor population
✓	Adequate site-specific exposure parameters are presently available
❍	Only defaults or judgement-based exposure parameters are available; initial risk estimates are below the LOPC in all exposure reaches
●	Only defaults or judgement-based exposure parameters are available; initial risk estimates are at or above the LOPC in one or more exposure reaches

TABLE 10-1
ENVIRONMENTAL MEDIUM-SPECIFIC DATA NEEDS CONCLUSIONS

Exposure Medium	Data Need Conclusion [PRIORITY]	Discussion
Surface Water (disturbed conditions)	**Data Needed [HIGH]**	Available measured data are not representative of disturbed conditions (*i.e.*, sediment suspended in water due to human activities); concentrations under disturbed conditions are likely to be higher than undisturbed. **Data Collection Needed:** • Unfiltered surface water samples representative of disturbed scenarios (*e.g.*, wading in shallow water). • Multiple samples from sampling locations across the entire site. • Multiple samples from time periods with highest potential for human contact (spring/summer/fall). • COIs: metals, radionuclides, pesticides, dioxins/furans, PCBs, PAHs, SVOCs, and PBDEs
Surface Water (undisturbed conditions)	**Data Needed [LOW]**	Available measured data are not spatially or temporally representative and list of analyzed COIs is limited; measured data indicate low potential for significant risks from metals. **Data Collection Needed:** • Unfiltered surface water samples representative of undisturbed scenarios (*e.g.*, swimming in open water). • Multiple samples from sampling locations across the entire site. • Multiple samples from time periods with highest potential for human contact (spring/summer/fall). • COIs: metals, pesticides, PAHs, and SVOCs
Surface Sediment	**Data Needed [HIGH]**	Not all areas of interest have been sampled; measured data for surface sediment indicate potential for significant risks from metals. **Data Collection Needed:** • Sediment (0-6”) from un-sampled beaches with highest potential for human contact. • Site-specific relative bioavailability (RBA) for metals. • Size-fractioning data for metals. • COIs: metals, radionuclides, PBDEs
Subsurface Sediment	**Data Needed [HIGH]**	Available measured data too limited to perform risk calculations; measured data for surface sediment indicate potential for significant risks. **Data Collection Needed:** • Sediment (6-30”) from beaches with highest potential for human contact. • COIs: metals, radionuclides, pesticides, dioxins/furans, PCBs, PAHs, SVOCs, and PBDEs

Exposure Medium	Data Need Conclusion [PRIORITY]	Discussion
Outdoor Air (impacted stack emissions from Trail)	**Data Needed [MODERATE]**	Available measured data from Northport sampling station analyzed for only a subset of metals; measured data indicate low potential for significant risks from analyzed metals. **Data Collection Needed:** • Expand analysis of Northport air samples to include all metal COIs.
Outdoor Air (impacted by windborne sediments under routine conditions)	*Deferred*	Available measured data are spatially limited (only 3 stations) but include areas with large expanses of exposed sediment (*e.g.*, Marcus Flats); measured data indicate low potential for significant risks from metals; PEF-estimated data **<** measured data which suggests that contribution of windborne sediments is likely to be minor under routine conditions; PEF-estimated data indicate very low potential for risk from non-metals. **Data Collection Pending:** • Information on measured concentrations of metals in background outdoor air.
Outdoor Air (impacted by windborne sediments under wind storm events)	**Data Needed [LOW]**	Limited measured data set; cannot use PEF approach; risks based on maximum detected measured concentration indicate low potential for significant risks. **Data Collection Needed:** • Focus sample collection on locations where there are large expanses of exposed contaminated sediments and the potential for windblown erosion and transport is high during high wind conditions. • COIs: metals, radionuclides
Indoor Dust	*Deferred*	**Data Collection Pending:** • Adequate characterization of on-site exposure scenarios and measured data on upland soil.
Indoor Air	*Deferred*	**Data Collection Pending:** • Adequate characterization of on-site exposure scenarios and measured data on site-specific background levels of metals in environmental media of interest.
Sweat Lodge Air	*Deferred*	**Data Collection Pending:** • Improved surface water data set.
Smoke-filled Air	*Deferred*	**Data Collection Pending:** • Measured plant data and information on exposure scenario from site-specific surveys.
Upland Soil	**Data Needed [MODERATE]**	No measured data available; preliminary risk estimates based on sediment indicate potential for significant risks; upland soil concentrations (outside of historical floodplain) are likely to be lower than sediment. **Data Collection Needed:** • Focus sample collection on areas most likely to be impacted by air and floodplain deposition. • COIs: metals, radionuclides, pesticides, dioxins/furans, PCBs, PAHs, SVOCs, and PBDEs

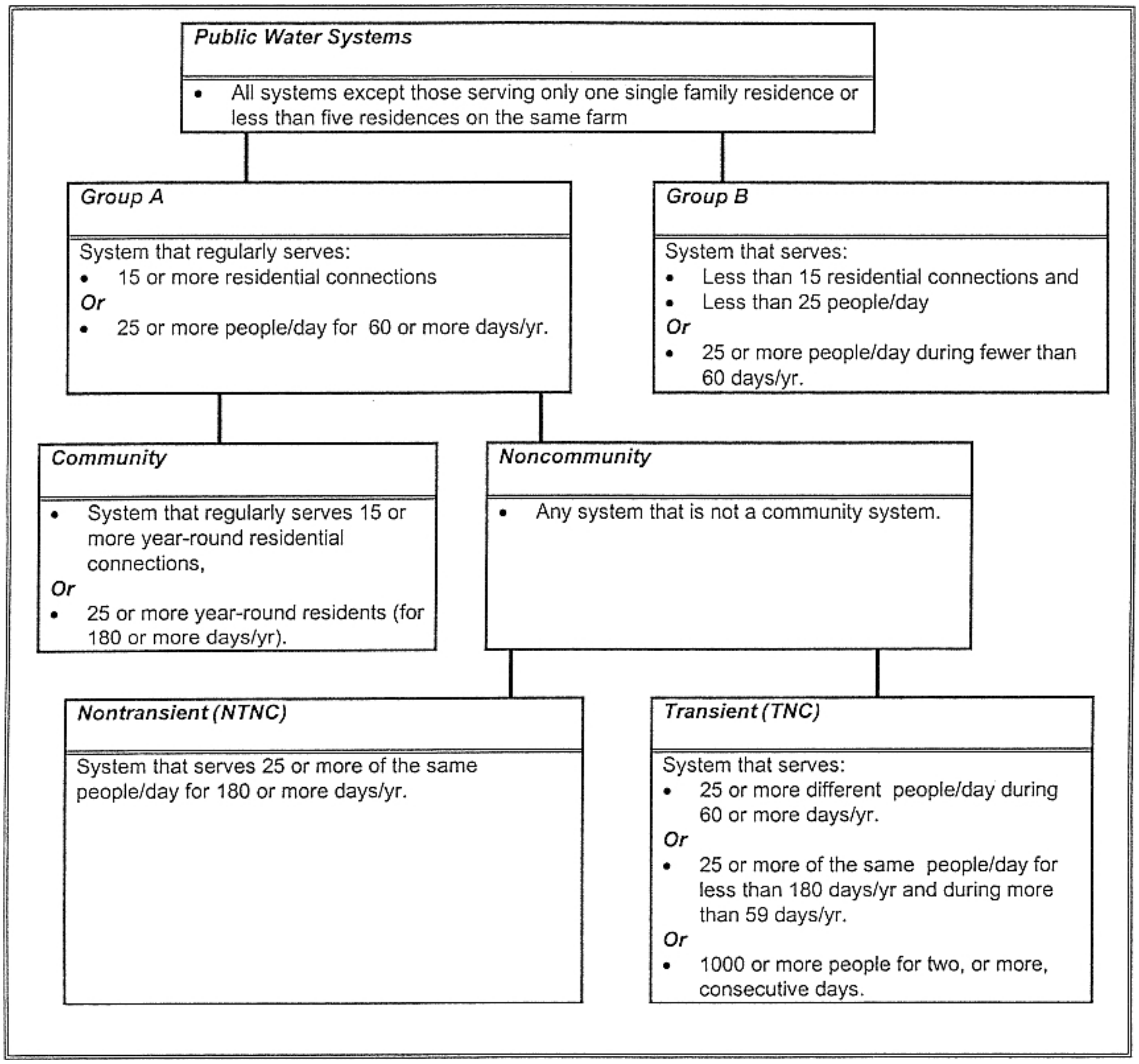
Exposure Medium	Data Need Conclusion [PRIORITY]	Discussion
Groundwater	**Data Needed [MODERATE]**	No measured data available. **Data Collection Needed:** • Focus sample collection on wells most likely to be influenced by site which are currently being utilized as a potable water source. • COIs: metals, radionuclides, pesticides, PAHs, and SVOCs
Shower Air	*Deferred*	**Data Collection Pending:** • Measured data of volatiles in groundwater.
Fish	**Data Needed [HIGH]**	Measured data for fish indicate potential for significant risk; not all species of interest have been evaluated; not all COIs have been analyzed. **Data Collection Needed:** • Fillet and whole body tissue concentrations in species that are important in the diet of recreational and/or subsistence populations, specifically including white sturgeon and kokanee. • COIs: metals, arsenic speciation, radionuclides, pesticides, dioxins/furans, PCBs (congener data preferred over Aroclor), PAHs, SVOCs, PBDEs
Shellfish	**Data Needed [HIGH]**	No measured data available for shellfish; no uptake models available to estimate tissue levels; measured data for fish indicate potential for significant risk from ingestion of aquatic species. **Data Collection Needed:** • Tissue concentrations in shellfish species targeted by humans. (Note: collection may be deferred until information on targeted species provided by site-specific surveys.) • COIs: metals, arsenic speciation, radionuclides, pesticides, dioxins/furans, PCBs (congener data preferred over Aroclor), PAHs, SVOCs, PBDEs
Game	*Deferred*	**Data Collection Pending:** • Measured upland soil data
Waterfowl	**Data Needed [HIGH]**	No measured data available; no uptake models available to estimate tissue levels; high potential for waterfowl exposure to contaminated media (e.g., surface water, sediment, aquatic prey items). **Data Collection Needed:** • Tissue concentrations in waterfowl species targeted by humans. (Note: collection of measured data may be deferred if a conservative method to estimate waterfowl tissue concentrations demonstrates that estimated risks will not exceed the LOPC.) • COIs: metals, radionuclides, pesticides, dioxins/furans, PCBs, PAHs, SVOCs, and PBDEs

Exposure Medium	**Data Need Conclusion [PRIORITY]**	**Discussion**
Upland (Terrestrial) Plants	*Deferred*	**Data Collection Pending:** • Measured upland soil data and information on exposure potential and species of interest from site-specific surveys.
Riparian (Aquatic) Plants	*Deferred*	**Data Collection Pending:** • Information on exposure potential and species of interest from site-specific surveys.
Amphibians/Reptiles	*Deferred*	**Data Collection Pending:** • Information on exposure potential and species of interest from site-specific surveys.
Irrigated Crops	*Deferred*	**Data Collection Pending:** • Improved surface water data set and measured upland soil data.
Watered Livestock	*Deferred*	**Data Collection Pending:** • Improved surface water data set and measured upland soil data.

TABLE 10-2
HUMAN EXPOSURE PARAMETERS DATA NEEDS CONCLUSIONS

Exposure Medium	Exposure Pathway	Data Need Conclusion
Surface water	Ingestion	Need site-specific data on the types of behaviors that may lead to surface water ingestion, along with site-specific data on actual exposure frequency and duration to surface water.
	Dermal Contact	
Sediment/Soil	Ingestion	Need site-specific data on the types of behaviors that may lead to sediment/soil ingestion, along with site-specific data on actual exposure frequency and duration to sediment/soil.
	Dermal Contact	
Outdoor air	Inhalation	Need site-specific data on the frequency and duration of outdoor activities.
Indoor dust	Ingestion	*No Site-Specific Data Needed*
Indoor air	Inhalation	*No Site-Specific Data Needed*
Sweat Lodge Air	Inhalation	Need frequency and duration of sweat lodge use by CCT tribal members.
Smoke-filled Air	Inhalation	Need site-specific data for tribal populations on the frequency and duration of activities associated with smoke inhalation, along with data on the type of materials being burned
Groundwater	Ingestion	*No Site-Specific Data Needed*
	Dermal Contact (a)	
	Inhalation (a)	
Biota (b)	Ingestion	Need site-specific data for recreational visitor and/or subsistence populations on frequency of meals from the site, size of each meal, and the type of material (species, tissue type) ingested
Plant Materials	Ingestion (c)	Need site-specific data for tribal populations on frequency and duration of basket weaving activities, along with data on the type of plant materials utilized. *Note: Not a Critical Data Need*
	Dermal contact (d)	
Food Materials	Dermal contact (e)	*No Site-Specific Data Needed*

(a) during showering
(b) includes fish, shellfish, game, waterfowl, plants, crops, and livestock
(c) during basket weaving
(d) during basket weaving, preparation and application of medicines, and ceremonial activities
(e) during preparation/preservation activities



Public Water Systems

- All systems except those serving only one single family residence or less than five residences on the same farm

Group A

System that regularly serves:

- 15 or more residential connections

Or

- 25 or more people/day for 60 or more days/yr.

Group B

System that serves:

- Less than 15 residential connections and
- Less than 25 people/day

Or

- 25 or more people/day during fewer than 60 days/yr.

Community

- System that regularly serves 15 or more year-round residential connections,

Or

- 25 or more year-round residents (for 180 or more days/yr).

Noncommunity

- Any system that is not a community system.

Nontransient (NTNC)

System that serves 25 or more of the same people/day for 180 or more days/yr.

Transient (TNC)

System that serves:

- 25 or more different people/day during 60 or more days/yr.

Or

- 25 or more of the same people/day for less than 180 days/yr and during more than 59 days/yr.

Or

- 1000 or more people for two, or more, consecutive days.

Figure 2-1. Definitions of Group A and Group B Water Systems.
Source: WAC 246-290-020

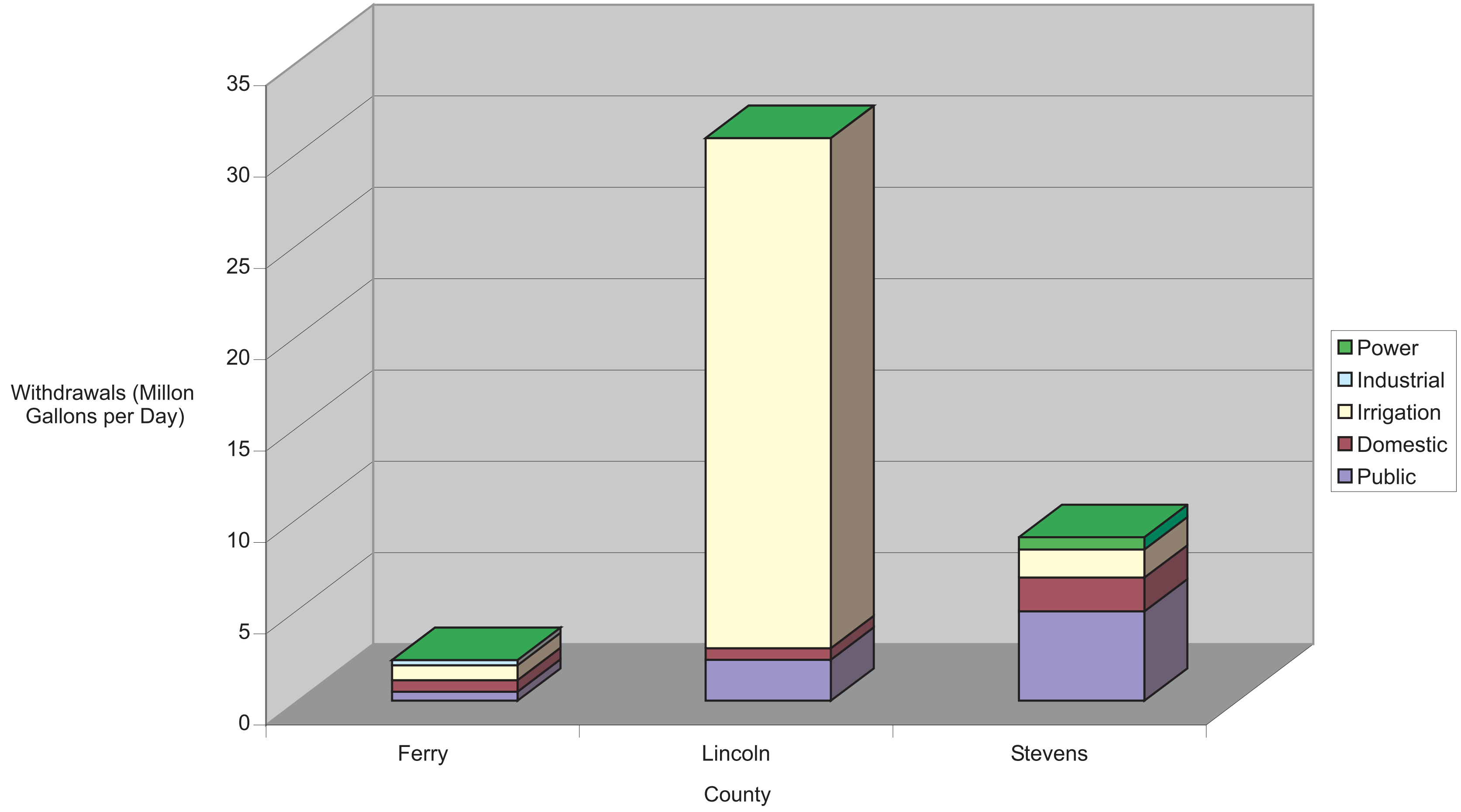


Figure 2-2. Groundwater Withdrawals by County in 2000.
Source: Lane (2004)
Note: Data from 2000 are the most currently available data set.

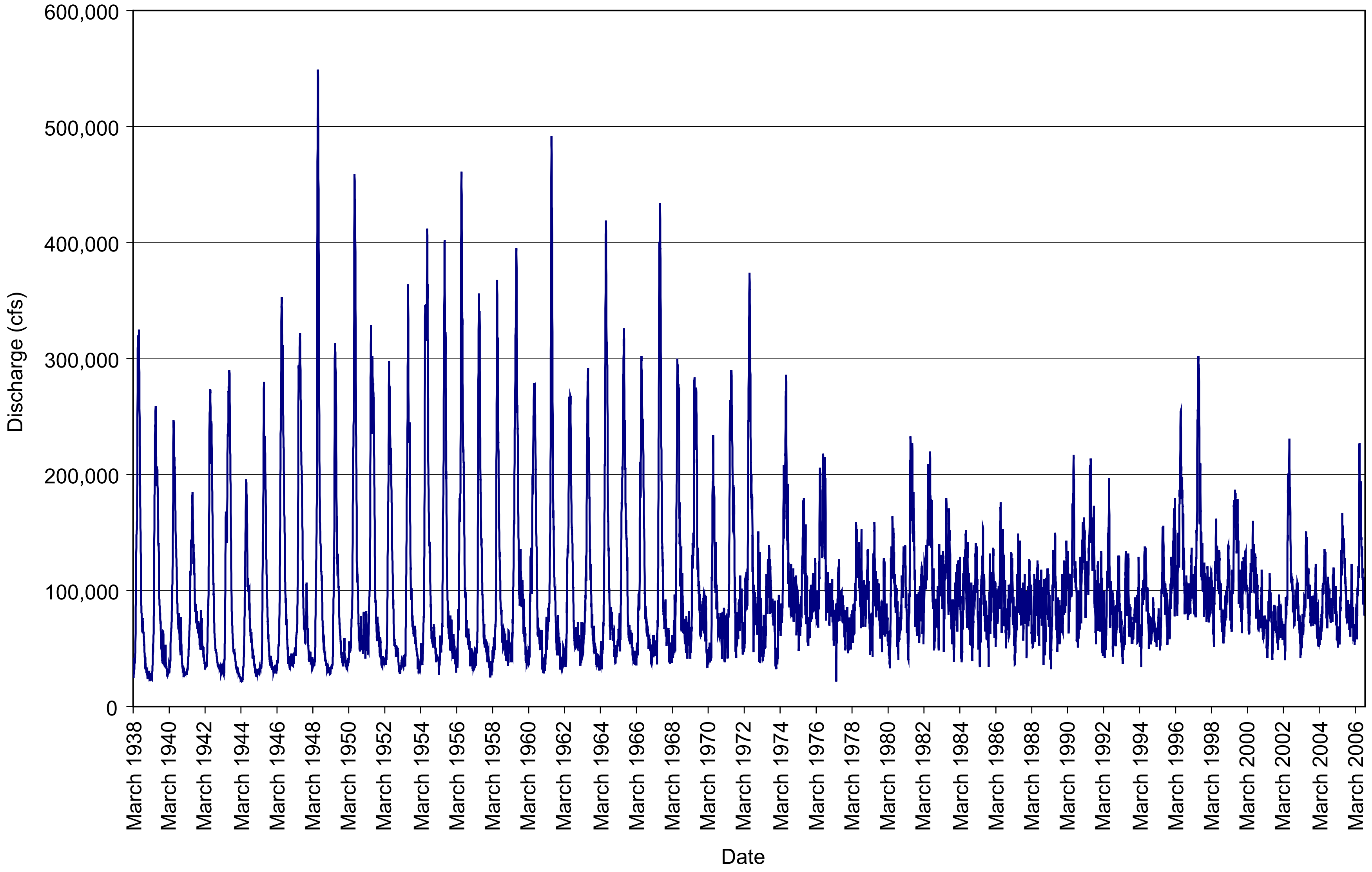


Figure 2-3. Mean Columbia River Daily Discharge Hydrograph at the U.S.-Canadian Border as Recorded at USGS Station No. 12399500.

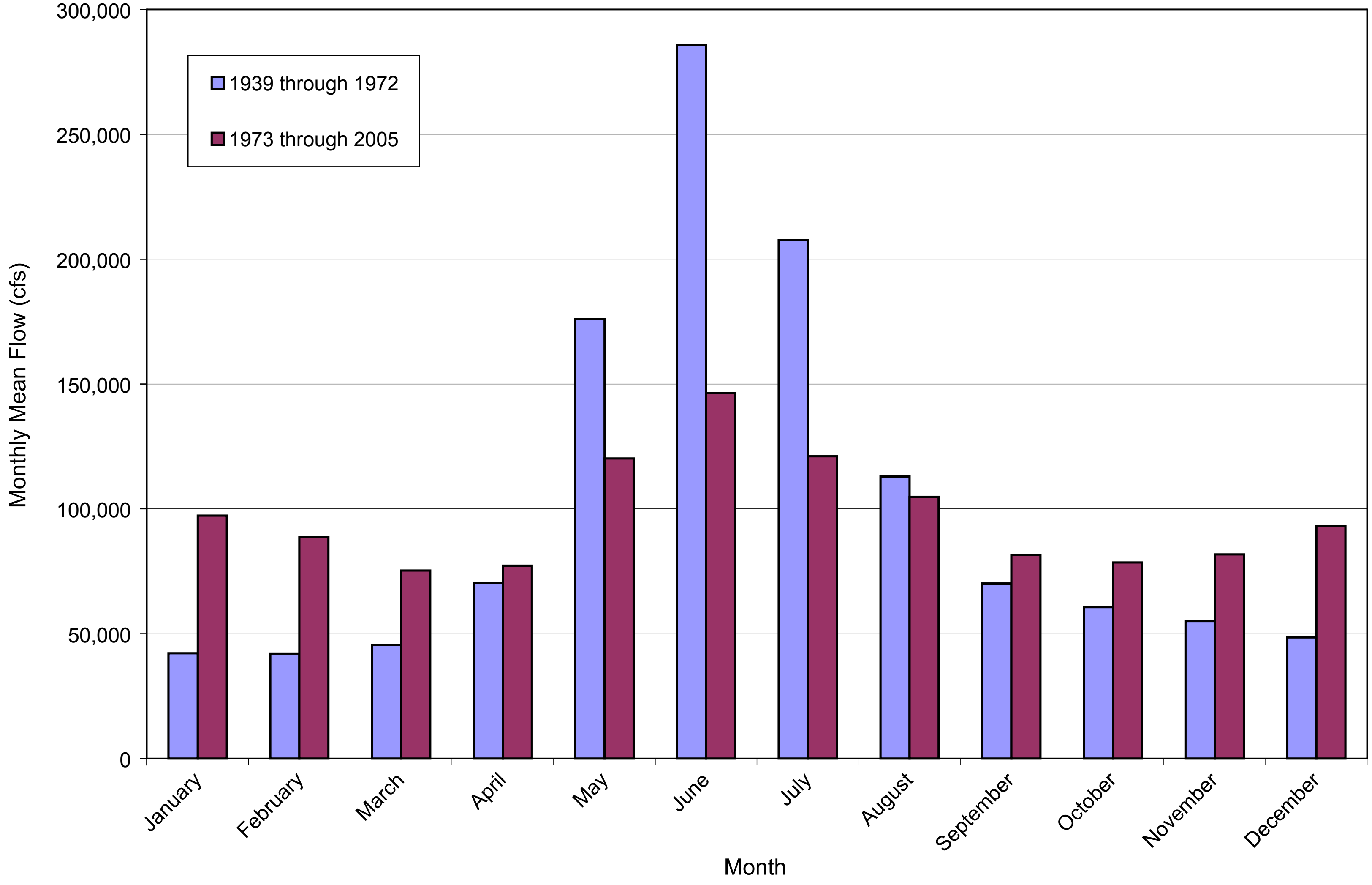


Figure 2-4. Monthly Mean Flow Across the U.S.-Canadian Border for Two Time Intervals as Recorded at USGS Station No. 12399500.

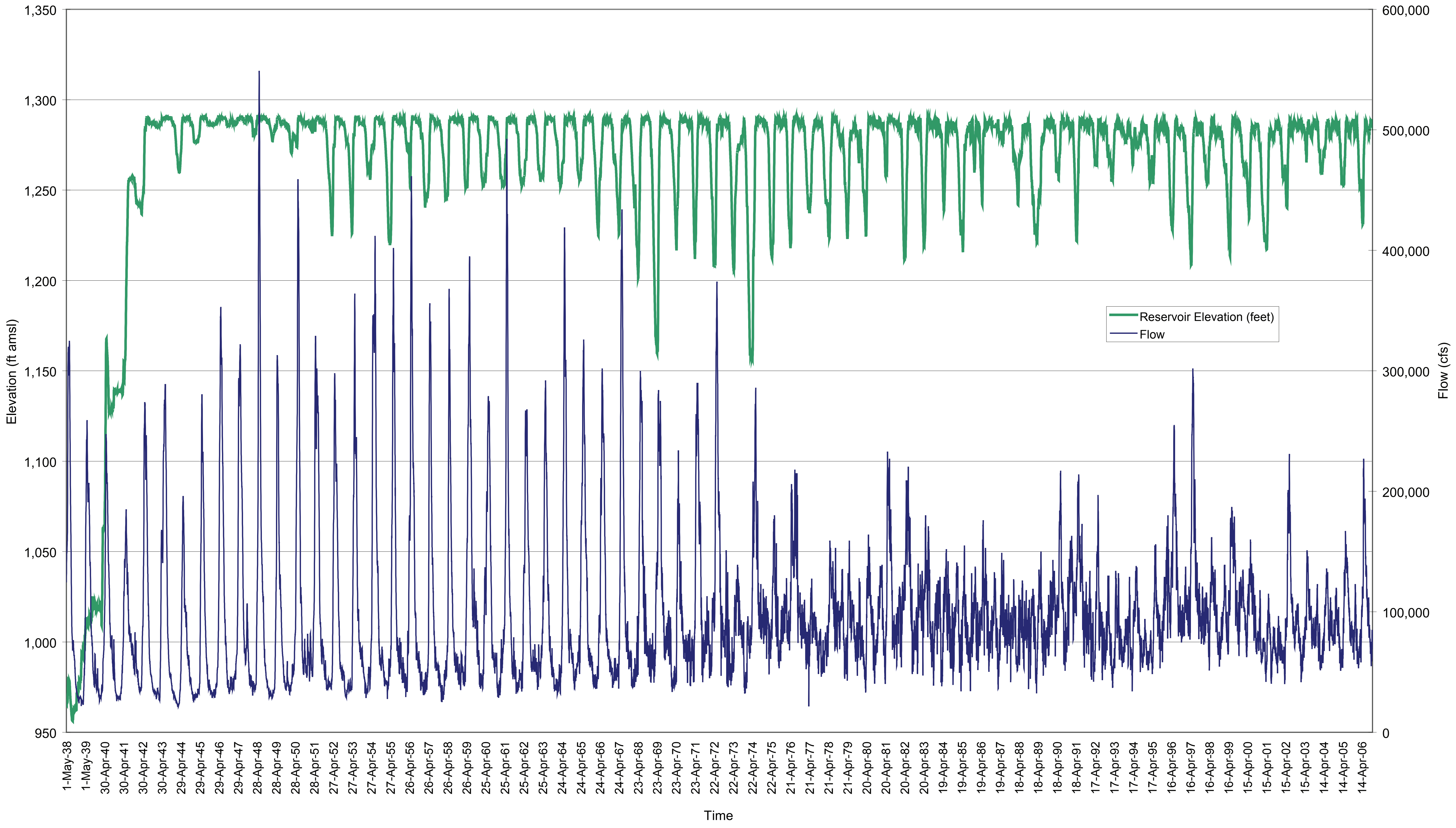


Figure 2-5. Plot of Water Elevation in Lake Roosevelt as a Function of Time.
Notes: Flow recorded at USGS station No. 12399500.
Water elevation recorded at Grand Coulee.

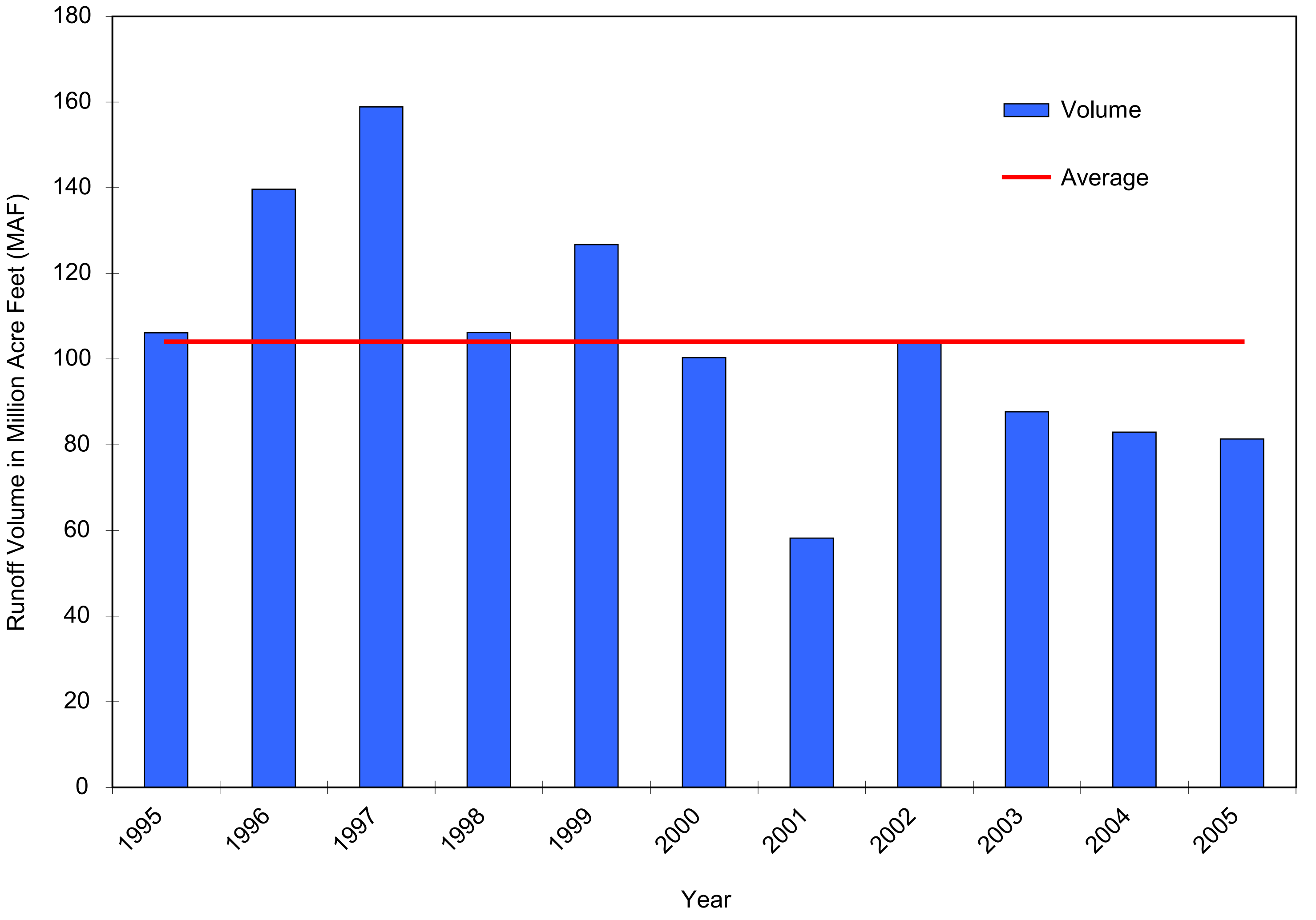


Figure 2-6. Actual January through June Runoff Volume from 1995-2005 at the Dalles, OR Compared to the 1961-2005 Average.
Source: http://www.cbr.washington.edu/dart/dart.html (September 2006).

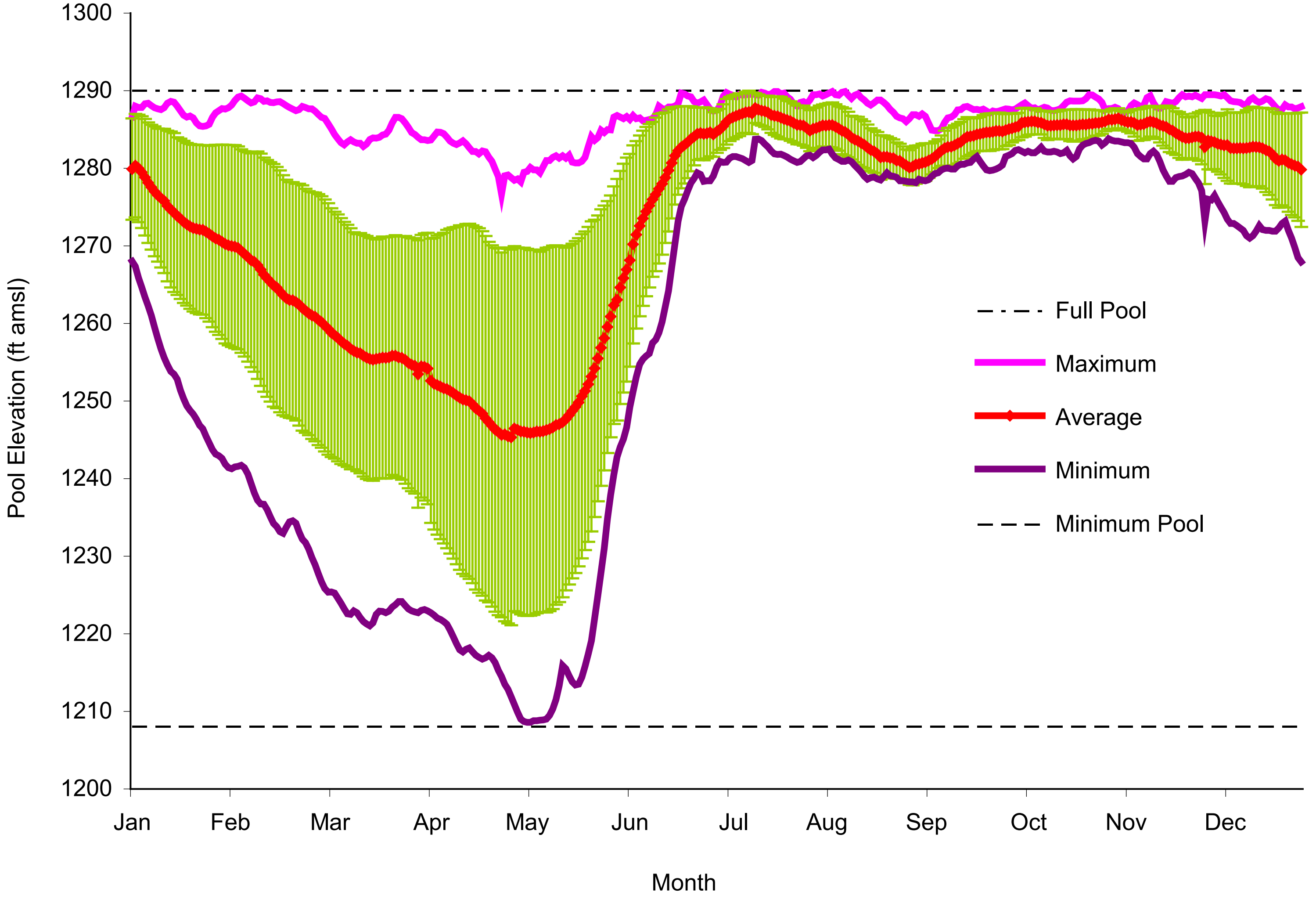


Figure 2-7. Daily Pool Elevations over the Period 1995-2005.
Source: http://www.cbr.washington.edu/dart/dart.html (September 2006).
Note: The shaded area around the average represents one standard deviation.

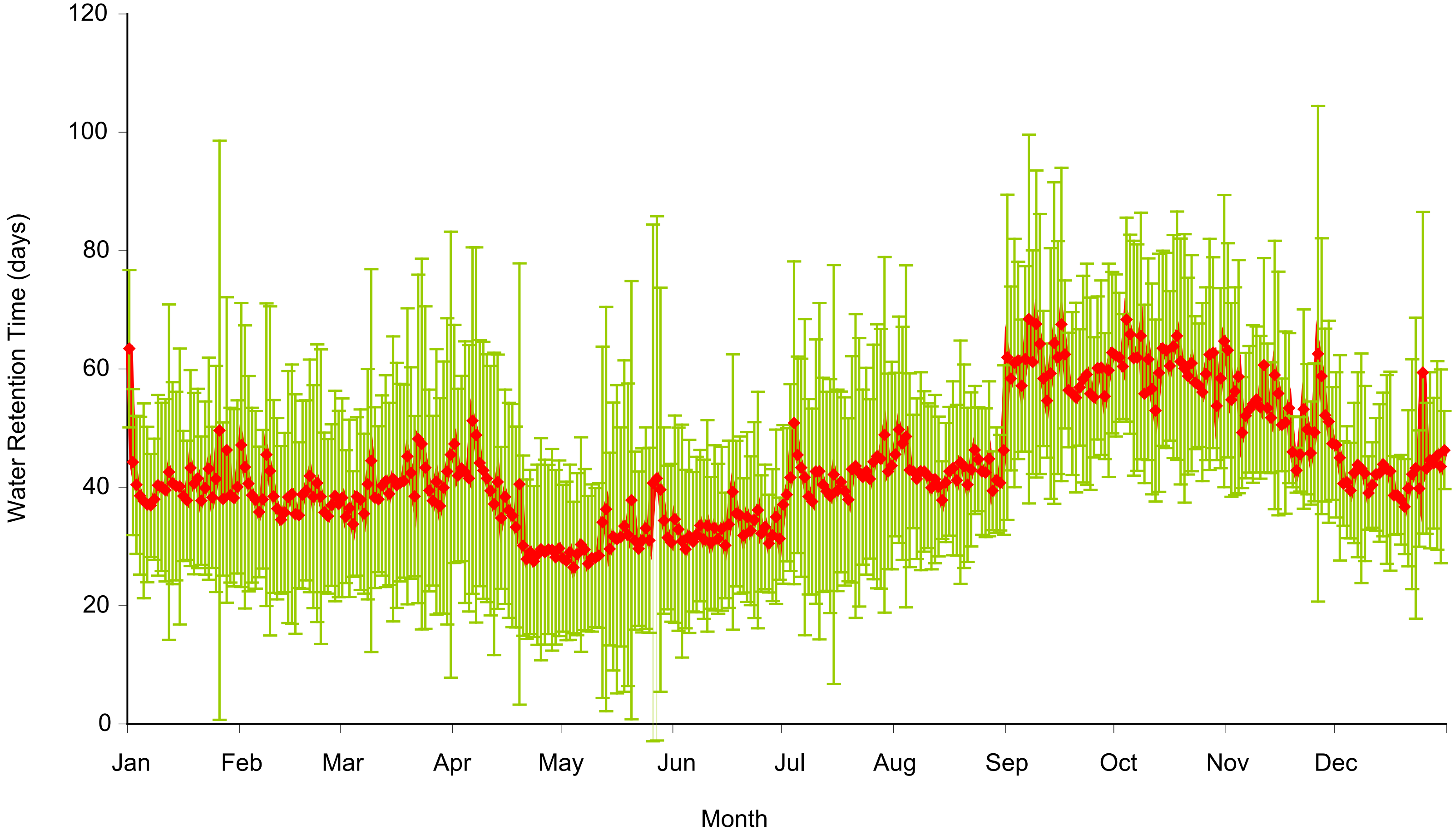


Figure 2-8. Daily Average Lake Roosevelt Water Retention Time Over the Period of 1995-2005.
Source: http://www.cbr.washington.edu/dart/dart.html (September 2006).
Note: The shaded area around the average represents one standard deviation.

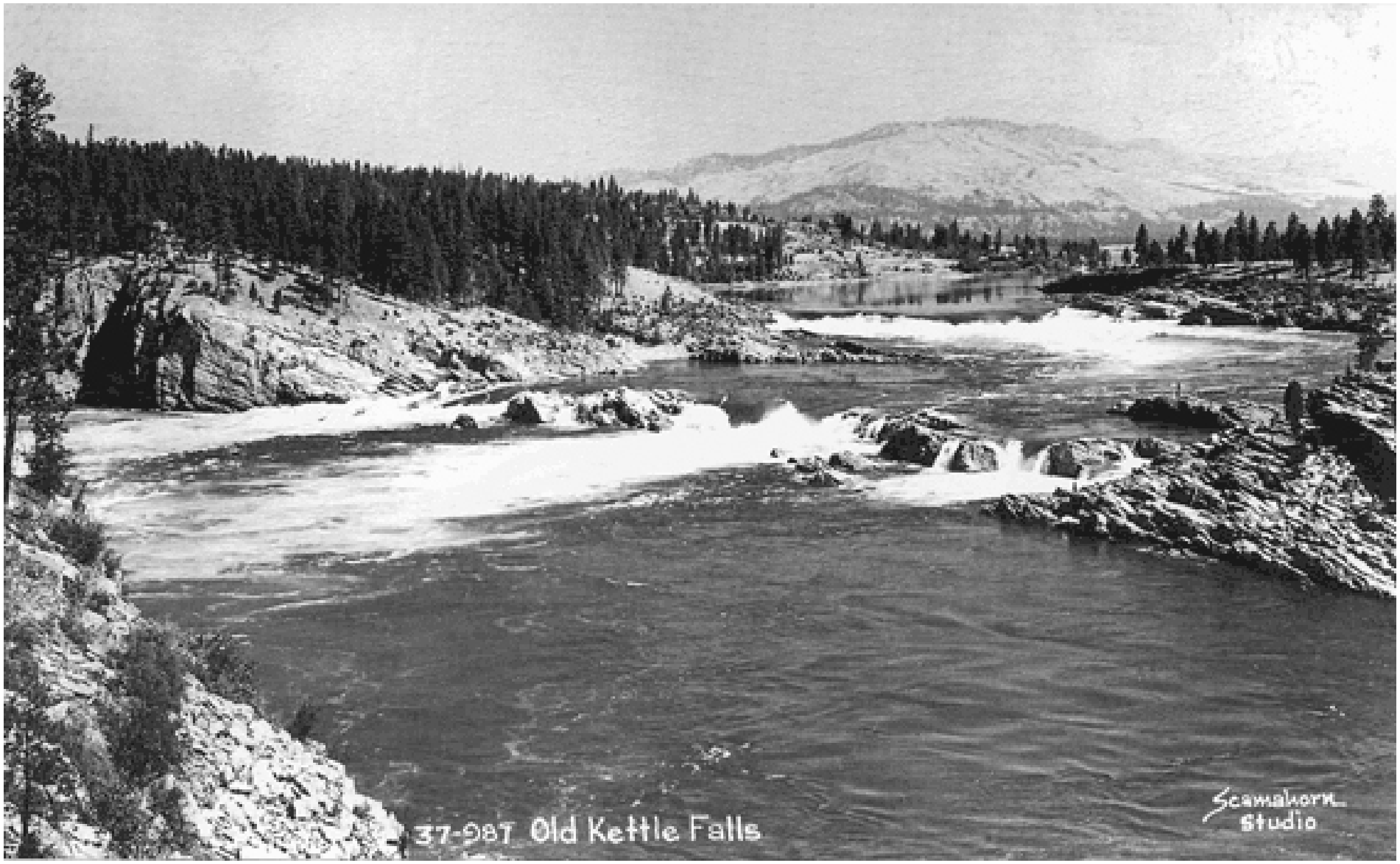
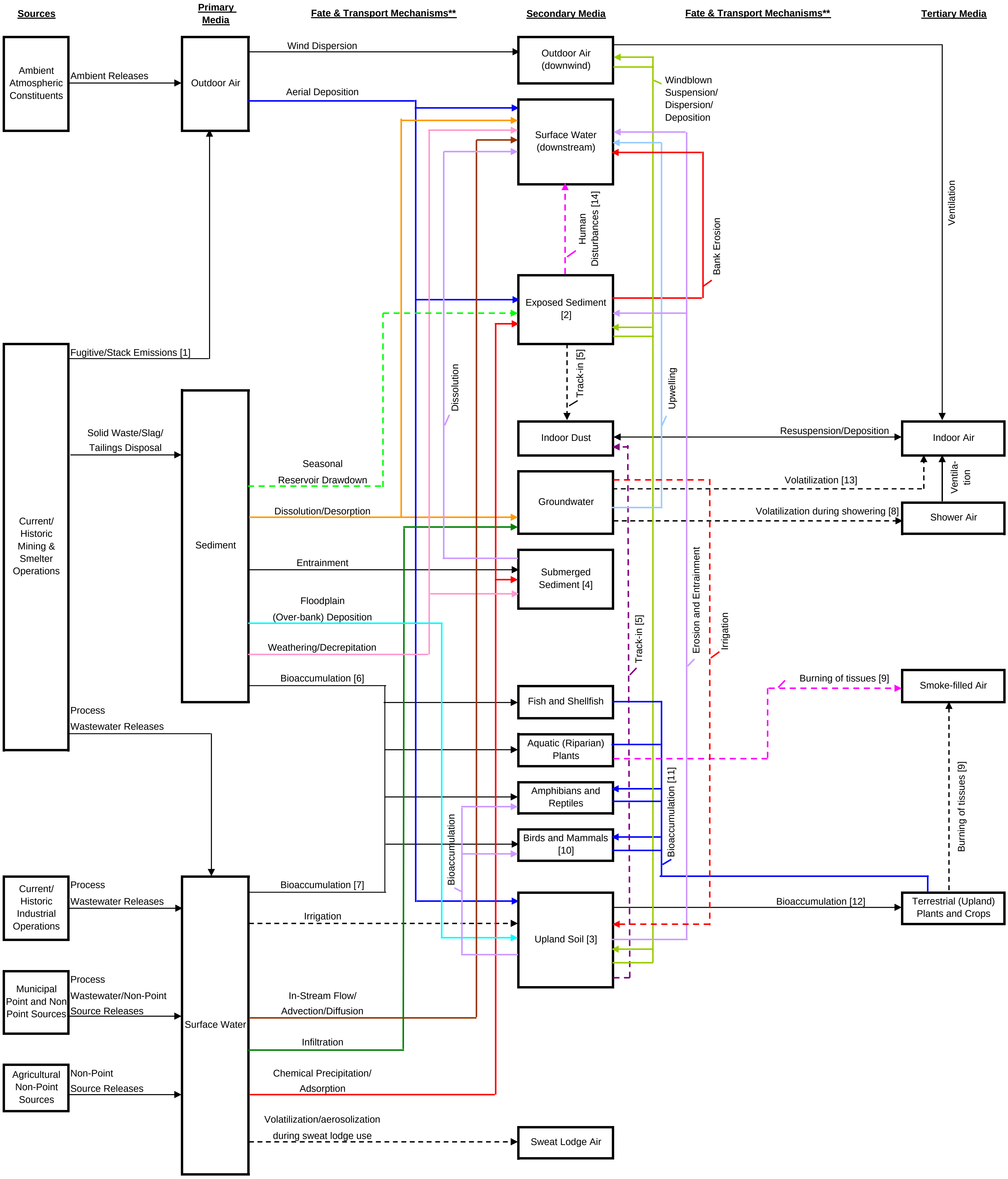


Figure 2-9. Photograph of UCR at Kettle Falls Prior to the Inundation of Lake Roosevelt, circa 1937.
Source: Old Kettle Falls, photo postcard, Scamahorn Studio.

FIGURE 5-1. SOURCES, FATE AND TRANSPORT MECHANISMS FOR HUMAN EXPOSURE MEDIA



** Different arrow colors have no technical meaning and are used solely to distinguish between arrows when lines cross.
Fate and transport mechnisms associated with environmental processes are shown as solid line arrows.
Transport mechnisms associated with human behaviors are shown as dotted line arrows.

Footnotes:

[1] impacts to outdoor air due to fugitive/stack emissions from the Trail facility restricted to locations near the U.S.-Canada border

[2] 'exposed sediment' includes solid materials from beaches, wetlands, and riparian areas (i.e., within the current high water mark) that become exposed at some time during the year (e.g., during reservoir draw-down or low-flow conditions)

[3] 'upland soil' includes solid materials from areas that are above the current high water mark (but may be within the historical floodplain)

[4] 'submerged sediment' includes solid materials within the thalweg (i.e., the pre-reservoir channel) and sediments at depth that are always covered by water
Note: because humans are not expected to come into direct contact with submerged sediments, it is not an exposure medium of interest for human health

[5] track-in on shoes or clothing, or by other vectors (e.g., pets)

[6] bioaccumulation as a result of direct uptake from sediment (e.g., aquatic plants) and incidental ingestion of sediment (e.g., birds, mammals)

[7] bioaccumulation as a result of direct uptake from surface water (e.g., aquatic plants) and ingestion of surface water (e.g., birds and mammals)

[8] semi-volatile and volatile organic chemicals only

[9] burning of plant materials during food preparation/preservation and/or ceremonial/medicinal activities

[10] includes wild game, waterfowl, and livestock

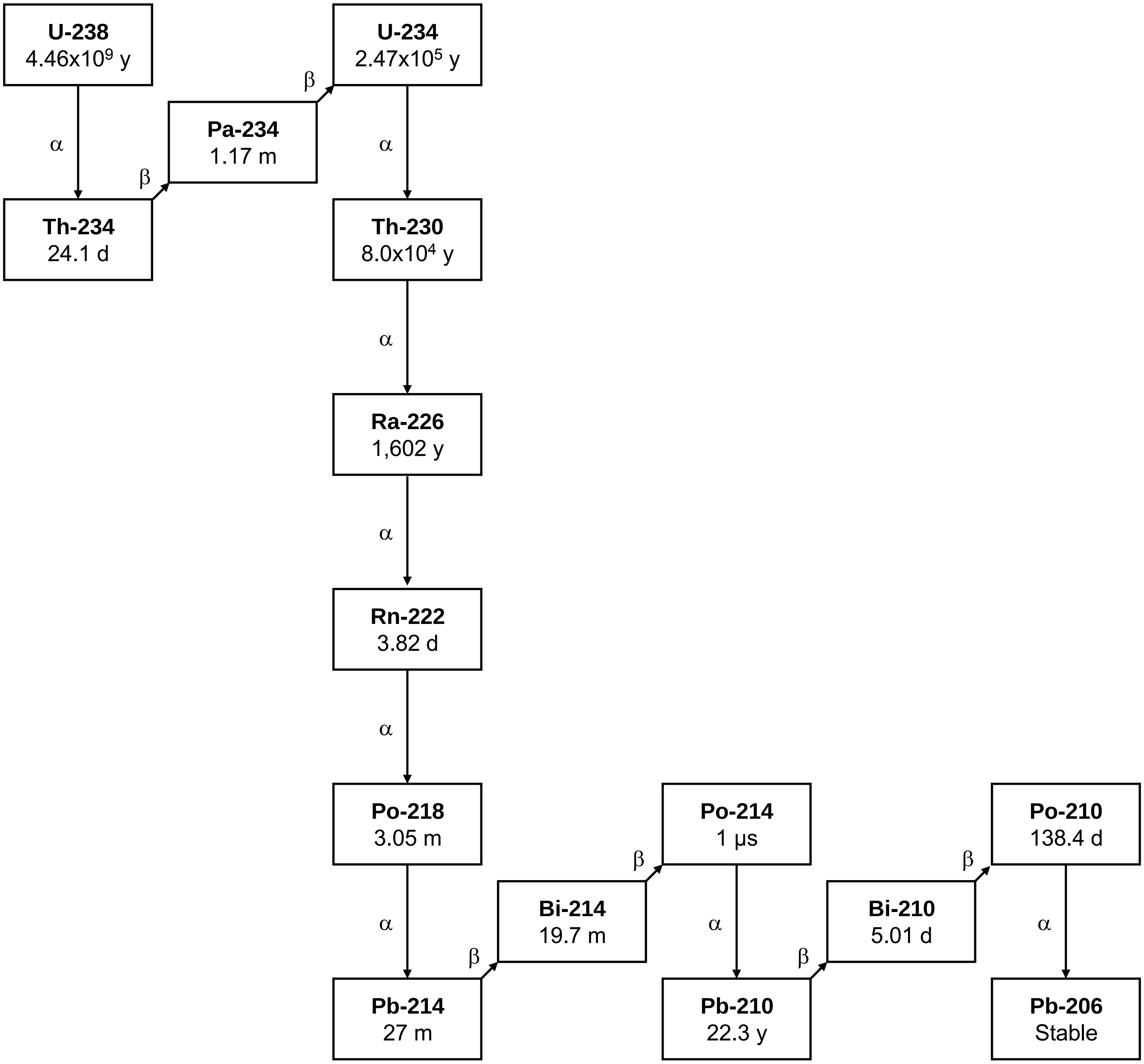
[11] bioaccumulation as a result of ingestion of biota (including aquatic and terrestrial plants and prey)

[12] bioaccumulation as a result of direct uptake from upland soil

[13] includes volatilization of semi-volatile and volatile organic chemicals as a result of residential water use (e.g., dishwasher, toilets, etc.)

[14] disturbances of exposed and shallow submerged sediments as a result of human activities (e.g., wading, swimming, etc.)

Figure 5-2
Uranium-238 Decay Chain



Source: http://www.health.state.ny.us/environmental/radiological/radon/chain.htm

Figure 5-3
Human Health Exposure Pathways and Populations

Exposure Media	Exposure Route	Exposed Populations			
		Recreational - Child & Adult (a)	Occupational - Adult (b) (4)	Subsistence - Child & Adult (c)	Resident - Child & Adult (d)
Primary Media:					
Sediment (13)	Ingestion	✓	✓	✓	
	Dermal (2)	✓	✓	✓	
Surface Water	Ingestion (18)	✓	✓	✓	? (19)
	Dermal (2)	✓	✓	✓	
Outdoor Air (directly impacted by emissions)	Inhalation	✓	✓	✓	✓
Secondary Media:					
Outdoor Air (impacted by windblown sediment/soil)	Inhalation (1)	✓	✓	✓	✓
Upland Soil	Ingestion	✓	✓	✓	✓
	Dermal (2)	✓	✓	✓	✓
Indoor Dust	Ingestion	✓ (3,7)			✓
Sweat Lodge Air	Inhalation (5)			✓	
Groundwater	Ingestion	?	?	?	?
	Dermal (2)	? (3,16)			? (16)
Terrestrial/ Aquatic Plants	Ingestion			✓ (11)	
	Dermal (2)			✓ (9)	
Birds/Mammals (12)	Ingestion	✓		✓	
	Dermal (2)			✓ (10)	
Amphibians/Reptiles	Ingestion			? (17)	
	Dermal (2)			? (10,17)	
Fish/Shellfish	Ingestion	✓		✓	
	Dermal (2)			✓ (10)	
Tertiary Media:					
Indoor Air	Inhalation	✓ (3,15)			✓? (20)
Smoke-filled Air	Inhalation (8)			✓	
Shower Air	Inhalation (6)	? (3)			?
Crops (14)	Ingestion			✓	
	Dermal (2)			✓ (9)	

LEGEND:

	Exposure pathway is not complete for this population or potential exposures are negligible
?	Exposure pathway is potentially complete for this population
✓	Exposure pathway is complete for this population

Figure 5-3
Human Health Exposure Pathways and Populations

Receptor Population Descriptions:

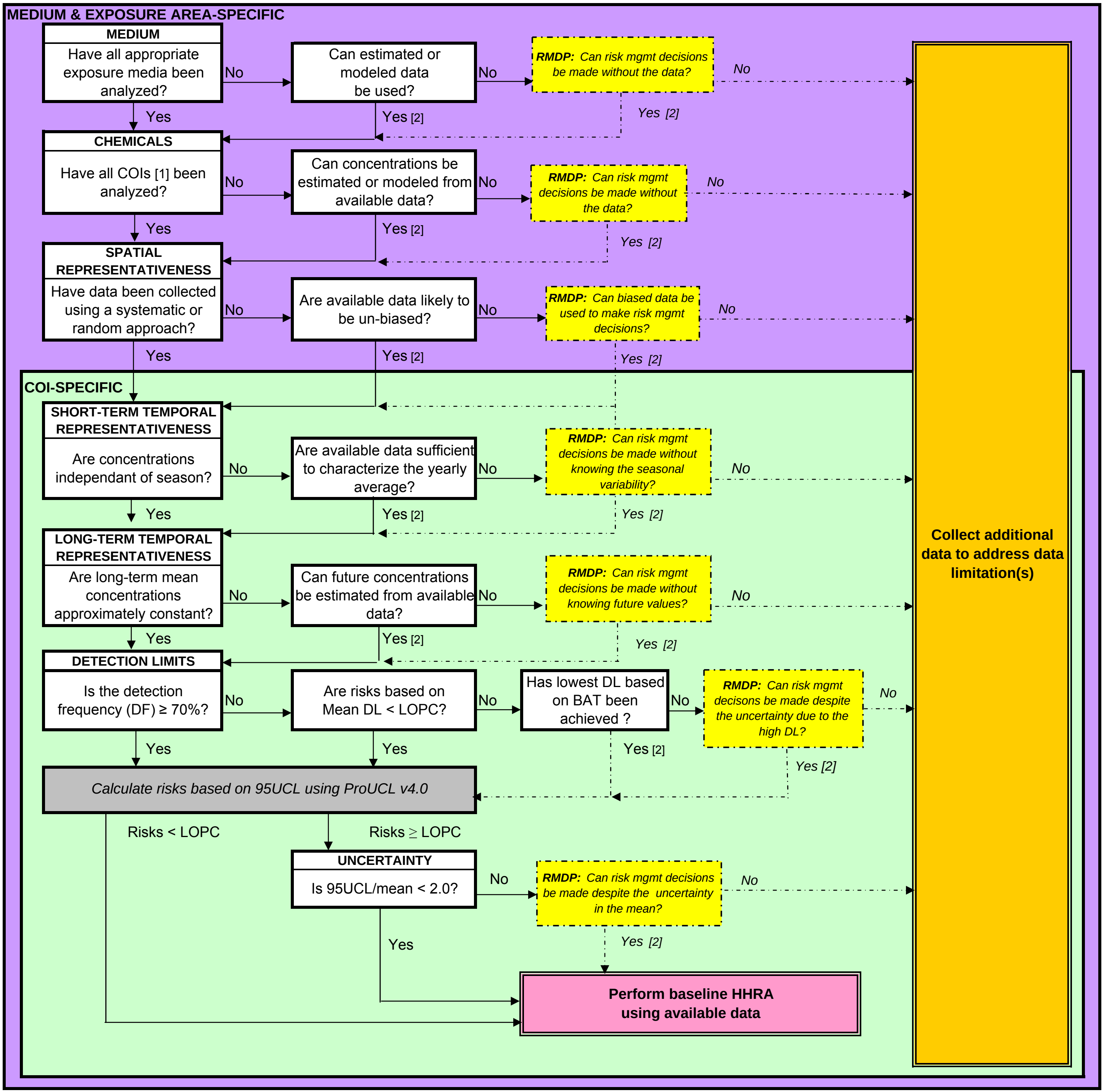
(a) Recreational activities include fishing, hunting, swimming, camping, etc.
  Three recreational visitor exposure scenarios will be evaluated --
    Short-term: Individuals (both local and non-local) that visit the river as part of occasional recreational activities
    Seasonal: Individuals that reside seasonally within the site boundary and frequently engage in recreational activitie
    Year-round: Individuals that reside locally and may engage in year-round recreational activities
(b) Individuals that work along the river banks (e.g., park employees, construction workers, ferry boat workers, etc.).
  Two worker exposure scenarios will be evaluated --
    Contact Intensive: Workers that engage in activities with a high opportunity for contact with sediments
    Non-contact Intensive: Workers that engage in activities that do not usually have extensive contact with sediments
(c) Individuals that reside outside of the site boundary and fish/hunt/gather plants along the river.
  Two subsistence exposure scenarios will be evaluated --
    Modern: Intake and use rates represent modern subsistence scenarios
    Traditional: Intake and use rates represent traditional subsistence scenarios
(d) Individuals that reside outside of the site boundary, but residence proximity to the river may result in site-related exposures
  (e.g., windborne impacts to indoor air, or sediment track-in into indoor dust, etc.)

Notes:

(1) includes both chronic exposure to long-term average concentrations and short-term exposures during windstorm events
(2) dermal exposures will be evaluated for COIs with dermal absorption coefficients
(3) evaluated for short-term and seasonal visitors staying within the site boundary during recreational activities
(4) it is expected that exposure is likely to be lower for indoor workers than for outdoor workers,
  therefore occupational exposures are assumed occur entirely outdoors
(5) exposure to aerosols and water vapor
(6) inhalation exposures during showering, will be evaluated for semi-volatile and volatile COIs only
(7) dust ingestion is included in the total ingestion rates for soil/sediment
(8) inhalation of smoke/ash particulates from burning plant materials
(9) dermal exposures from plants used medicinally and/or ceremonially and contact during basket weaving activities
(10) dermal exposures from animal tissues used medicinally and/or ceremonially and contact during preservation activities
(11) includes ingestion of gathered plants as food and incidental ingestion of plants during basket weaving activities
(12) wild game, waterfowl, and livestock that have been watered with UCR water and/or fed irrigated plants
(13) includes solid materials from beaches, wetlands, and riparian areas (i.e., within the current high water mark)
  that become exposed at some time during the year (e.g., during reservoir draw-down or low-flow conditions)
(14) crops that have been irrigated with UCR water
(15) indoor exposures (inside RVs, campers, tents) evaluated for short-term and seasonal visitors only;
  year-round visitors are assumed to reside off-site (evaluated under the residential scenario)
(16) during showering
(17) a determination of exposures to amphibians/reptiles will be based on site-specific survey results
(18) includes incidental ingestion exposures for on-site receptors (e.g., during swimming, wading, fishing, etc.)
  and ingestion of untreated surface water as drinking water
(19) assumes that untreated surface water is used as the source for residential drinking water
(20) inhalation of chemicals in indoor air derived from outdoor air and indoor dust is a complete exposure pathway; inhalation of chemicals
  in indoor air derived from groundwater (e.g., SVOCs released from residential water use) is a potentially complete pathway

FIGURE 9-1

ENVIRONMENTAL CONCENTRATION DATA ADEQUACY EVALUATION IN SUPPORT OF THE HUMAN HEALTH RISK ASSESSMENT

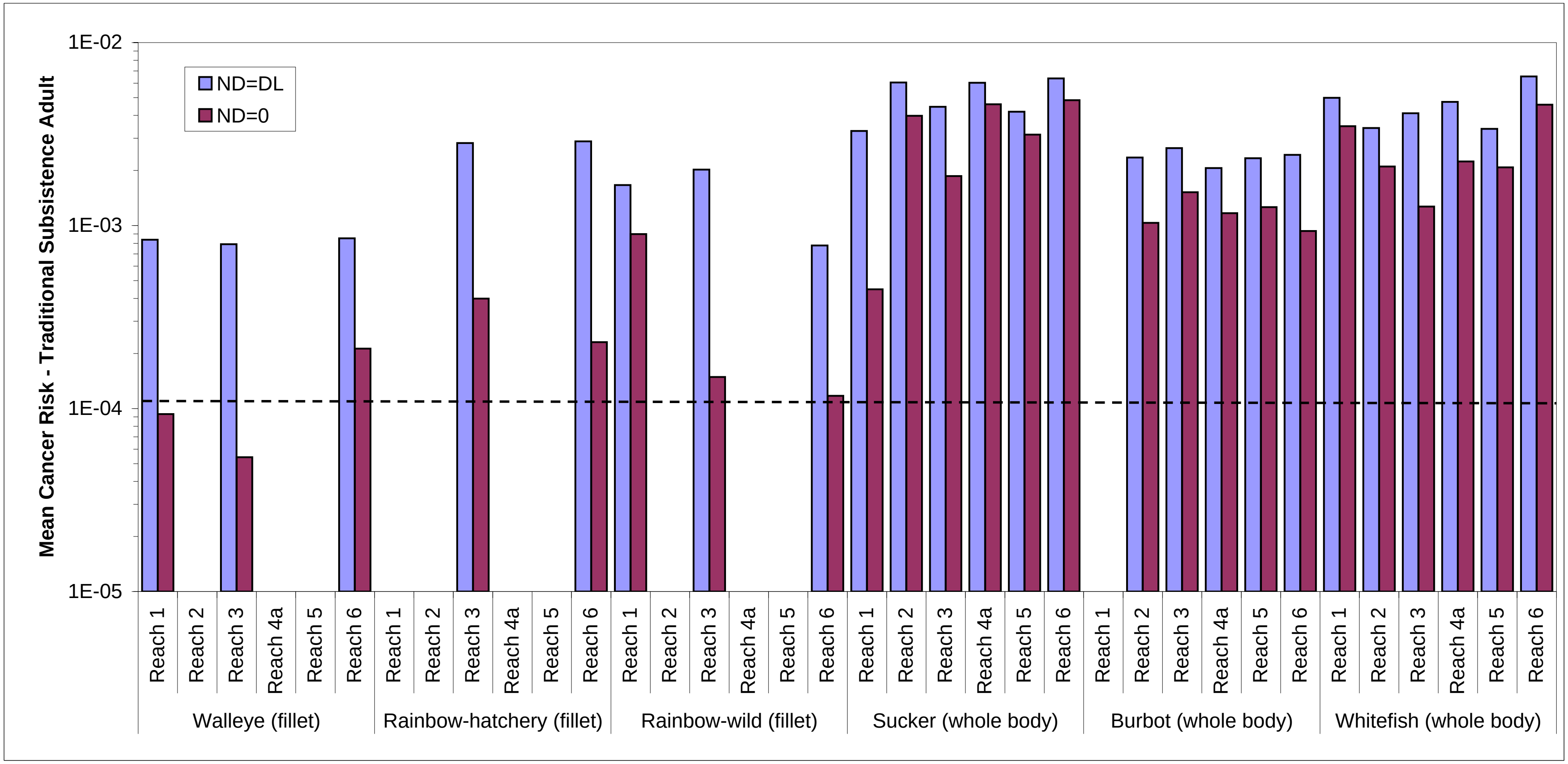


DF = detection frequency (N detects / N total samples)	LOPC = level of potential concern
DL = detection limit	BAT = best available techniques
95UCL = 95% upper confidence limit on the mean	RMDP = risk management decision point

[1] For a medium, the COI list may be limited to those COIs reasonably expected to occur based on fate and transport processes (i.e., dioxin/furans are more likely to be present in tissues and sediment relative to water). For the purposes of risk assessment support, the COI list may also be limited to those COIs with available toxicity data.

[2] Uncertainty section of baseline HHRA should include a discussion of data limitations and the direction and magnitude of any potential data biases.

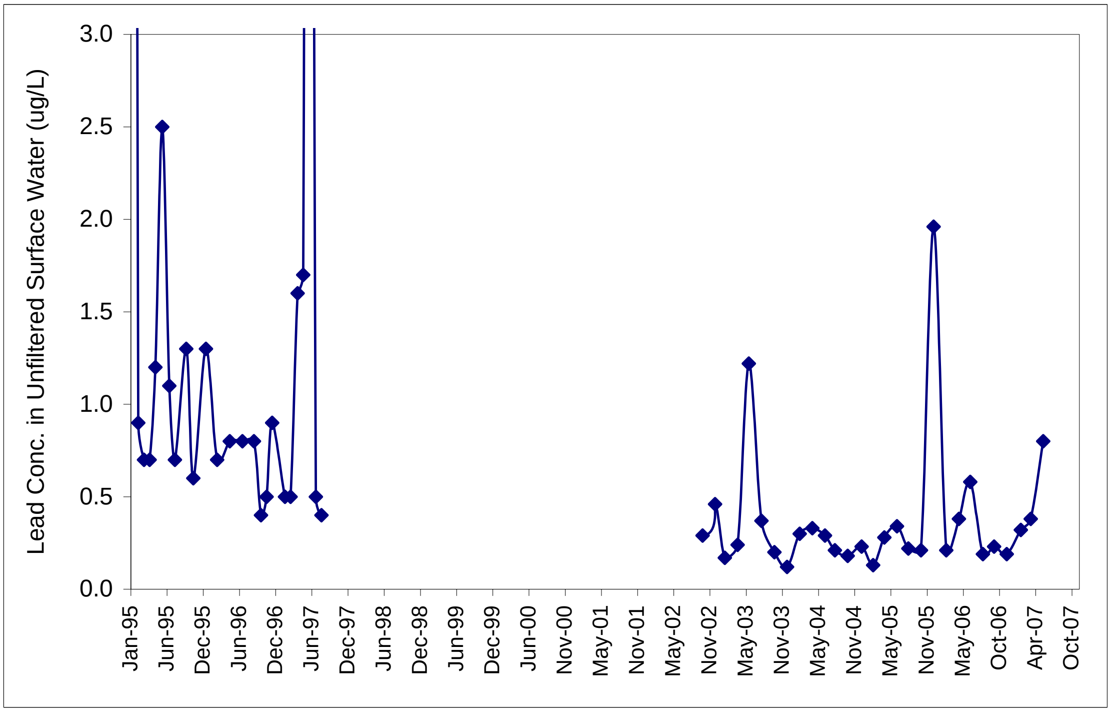
FIGURE 9-13. DETECTION LIMIT ADEQUACY OF DIOXIN-LIKE CONGENERS IN FISH TISSUE



I:\Upper Columbia River\HHRA Workplan\Risk Calcs\Non-Lead\DL check\Fish TEQ DL Evaluation_12-08.xlsGraph_TradSubsist

FIGURE 9-2
TEMPORAL EVALUATION OF LEAD CONCENTRATIONS IN SURFACE WATER

PANEL A: NORTHPORT, WA WATER QUALITY MONITORING STATION (61A070)



Note: Two samples not shown (off-scale): 1/10/1995 - 20U ug/L, 6/4/1997 - 12.1 ug/L

PANEL B: WANETA, BC WATER QUALITY MONITORING STATION (BC08NE0001)

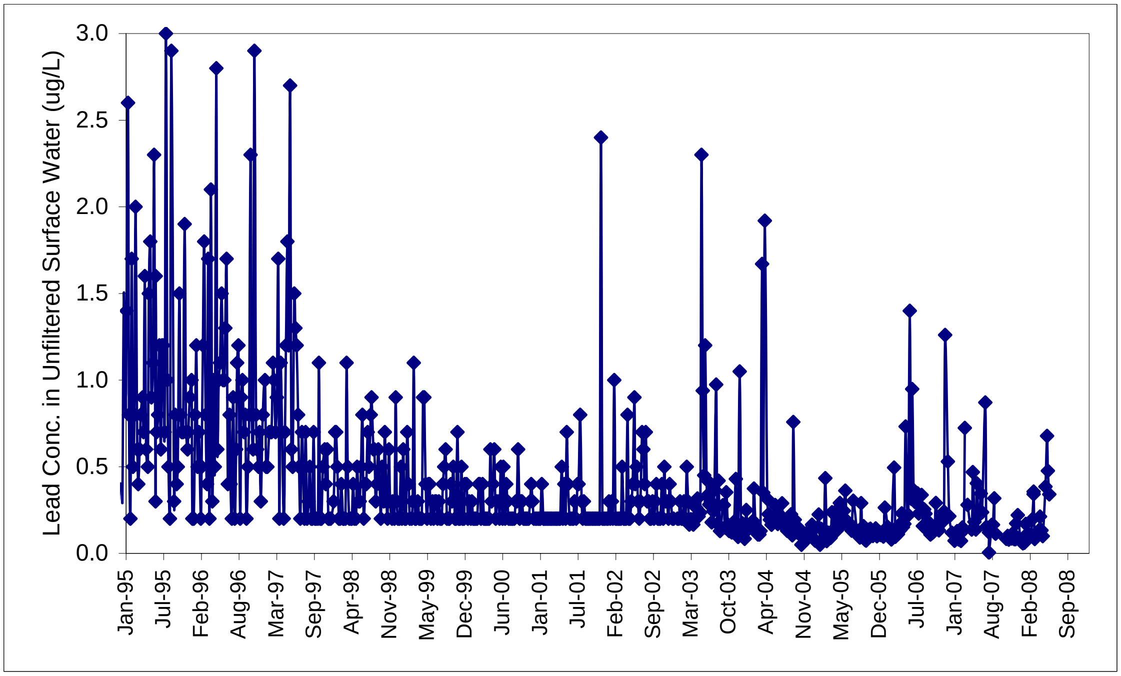
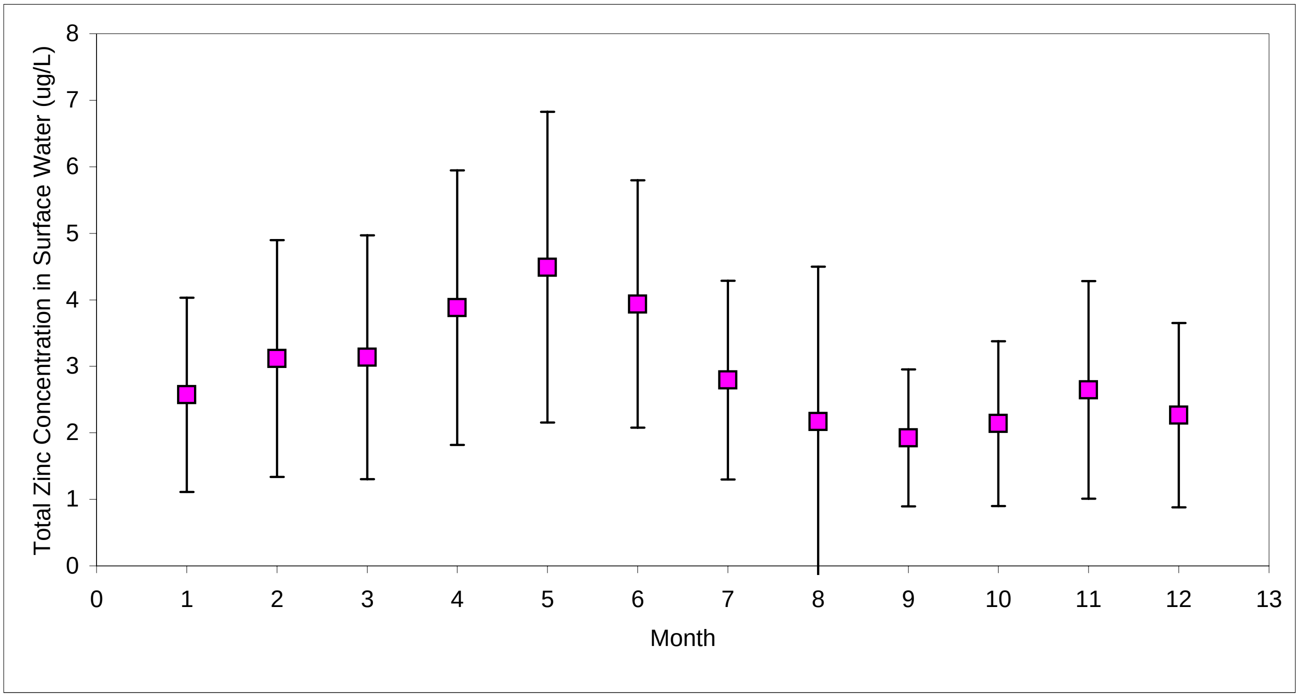


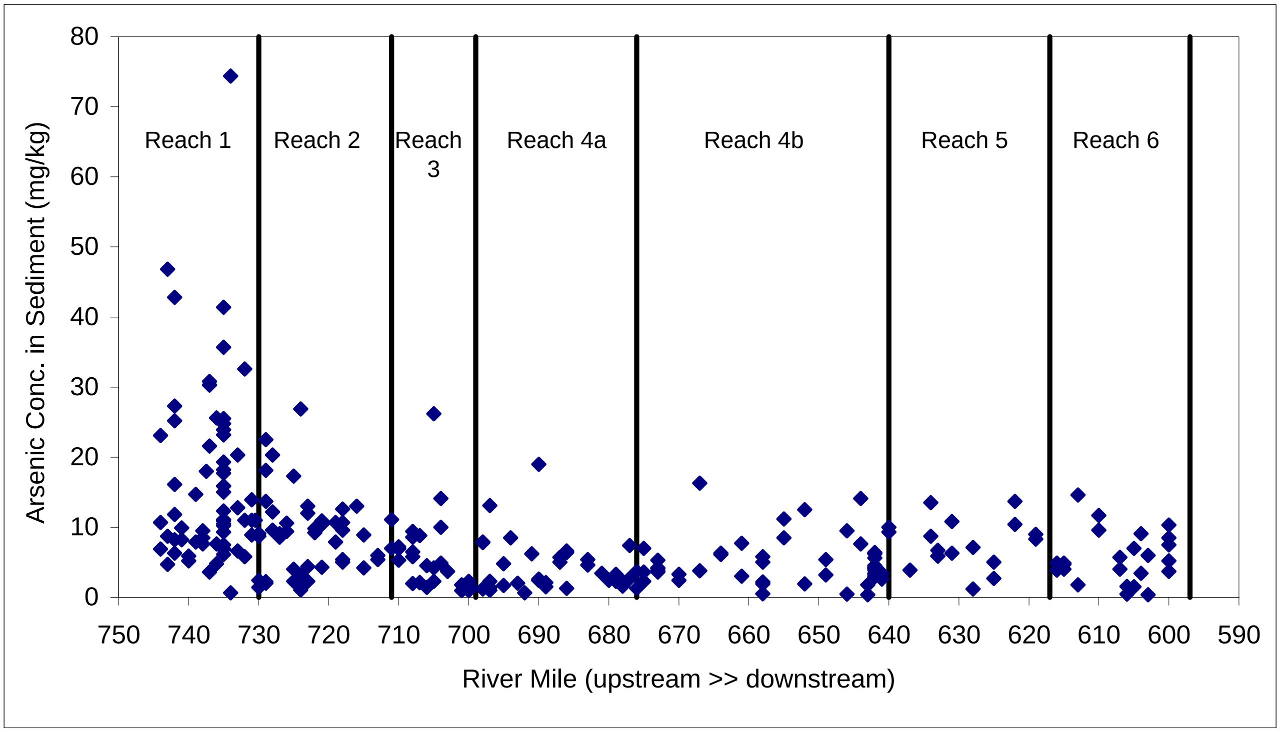
FIGURE 9-3
AVERAGE MONTHLY ZINC CONCENTRATIONS IN SURFACE WATER AT WANETA



Includes samples collected from January 1995 to July 2008.
Error bars represent ± 1 standard deviation.

FIGURE 9-4
SPATIAL EVALUATION OF ARSENIC AND LEAD CONCENTRATIONS IN SEDIMENT

ARSENIC



LEAD

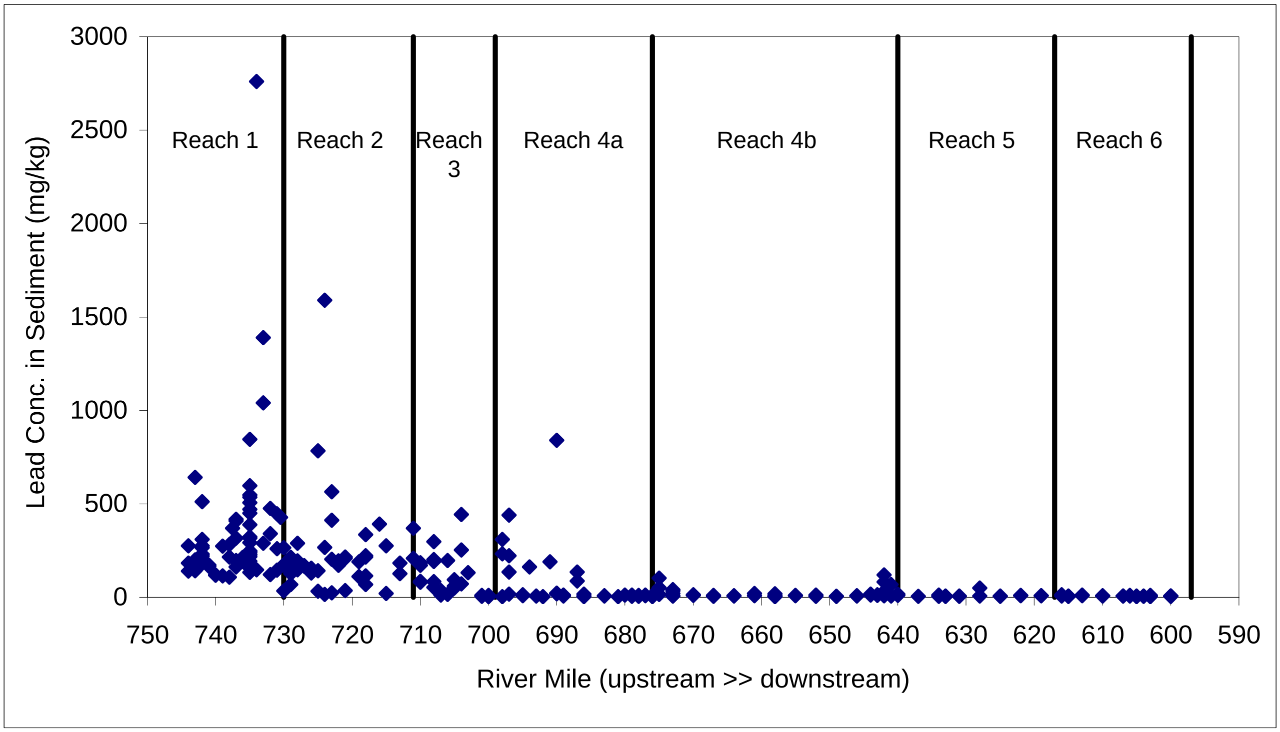


FIGURE 9-5
COMPARISON OF BEACH SEDIMENT CONCENTRATIONS FROM THREE ELEVATIONS

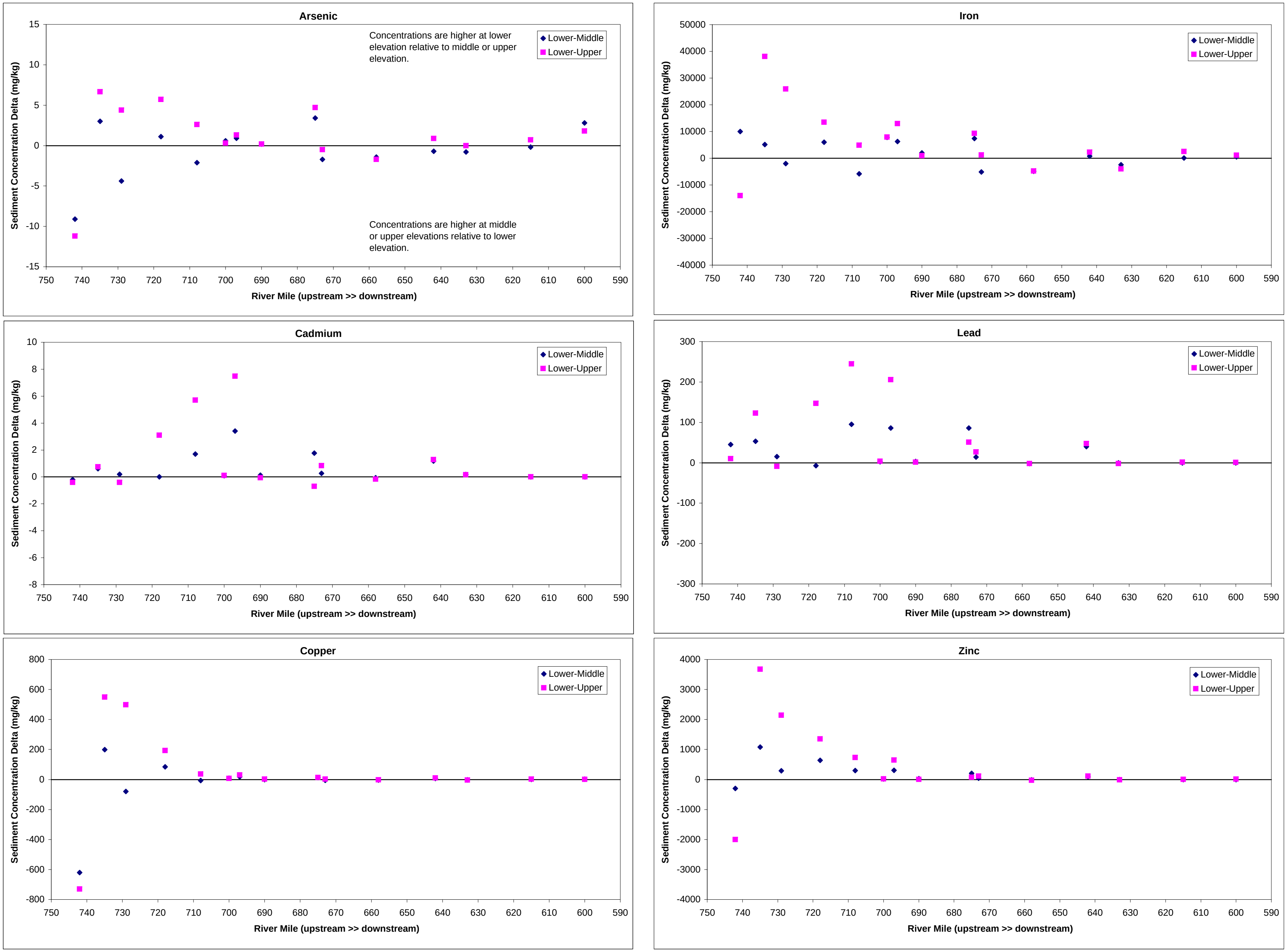
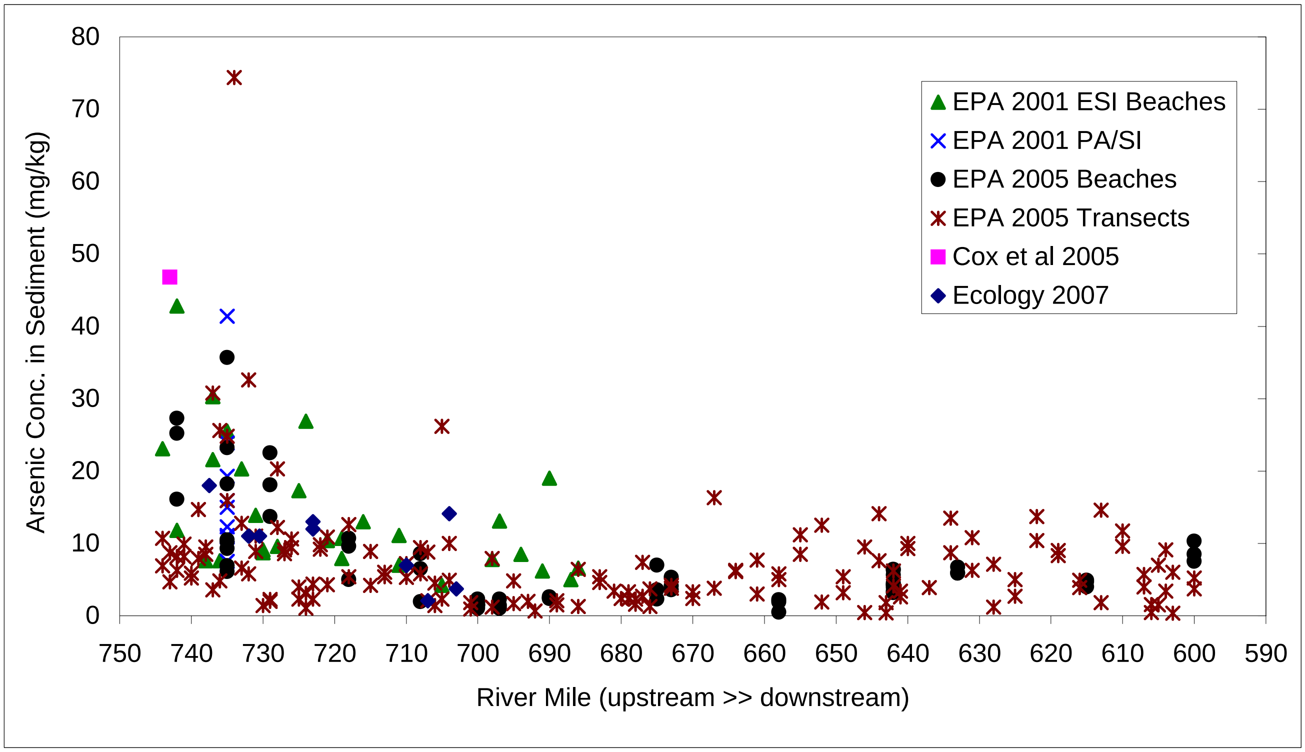


FIGURE 9-6
EVALUATION OF ARSENIC AND LEAD CONCENTRATIONS IN SEDIMENT BY STUDY

ARSENIC



LEAD

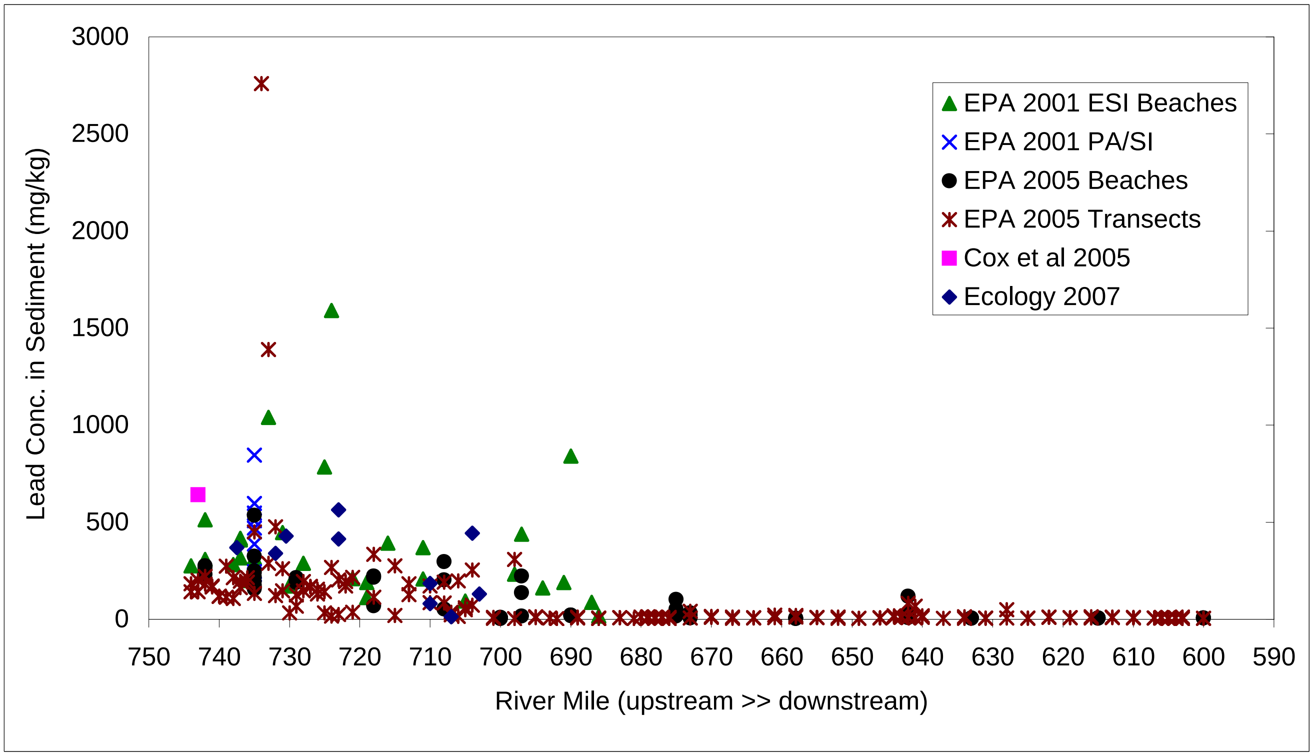


FIGURE 9-7
COMPARISON OF METAL CONCENTRATIONS IN SIZE-FRACTIONED SURFACE SEDIMENT SAMPLES

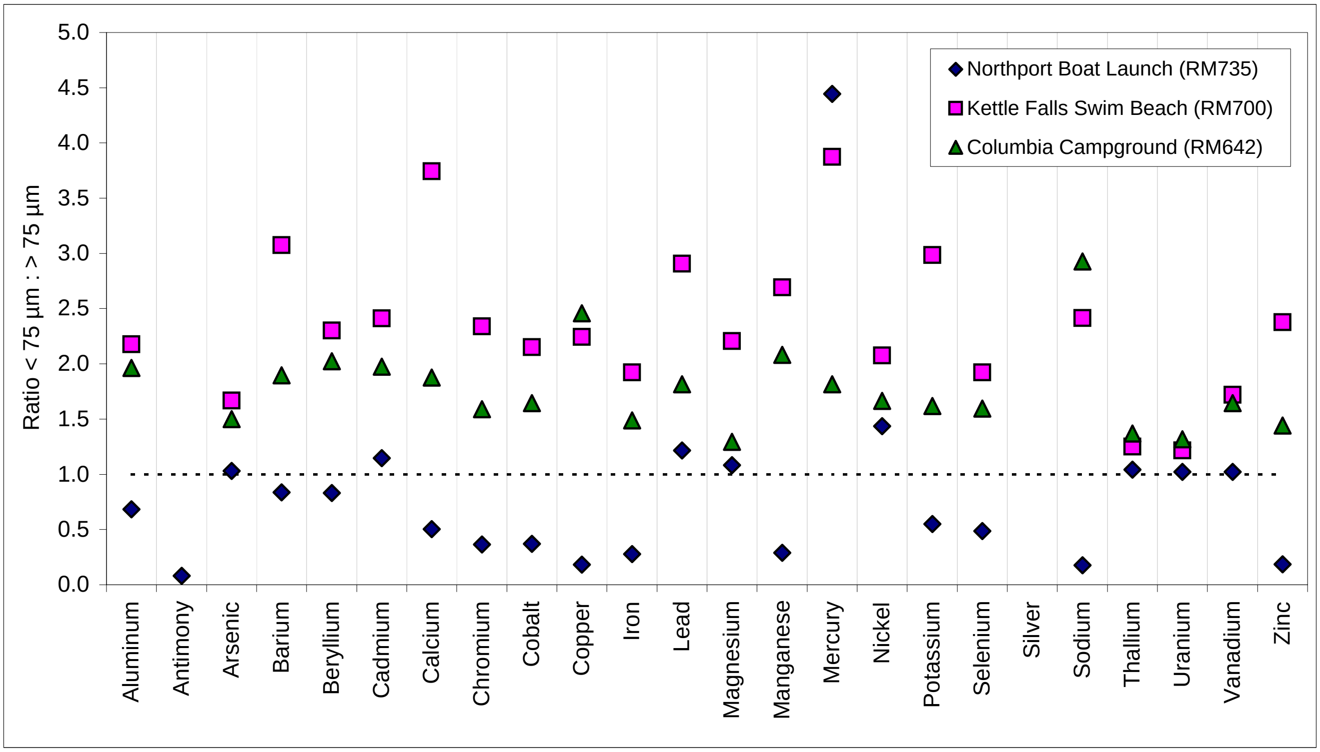
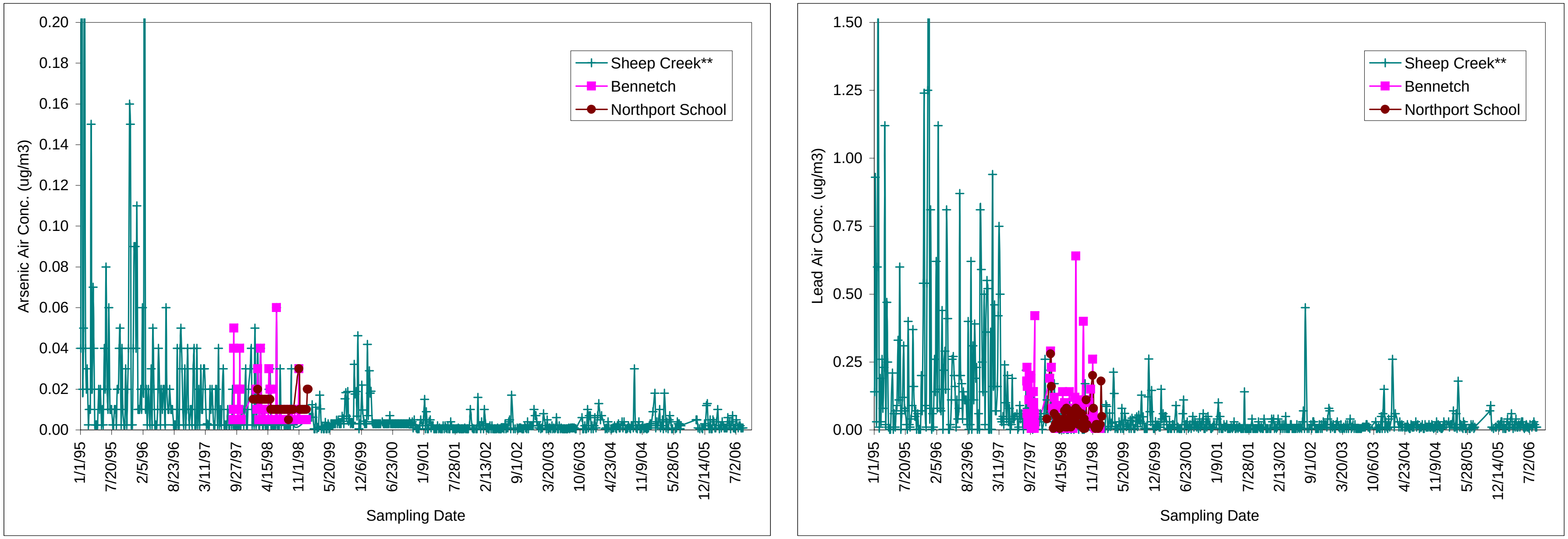
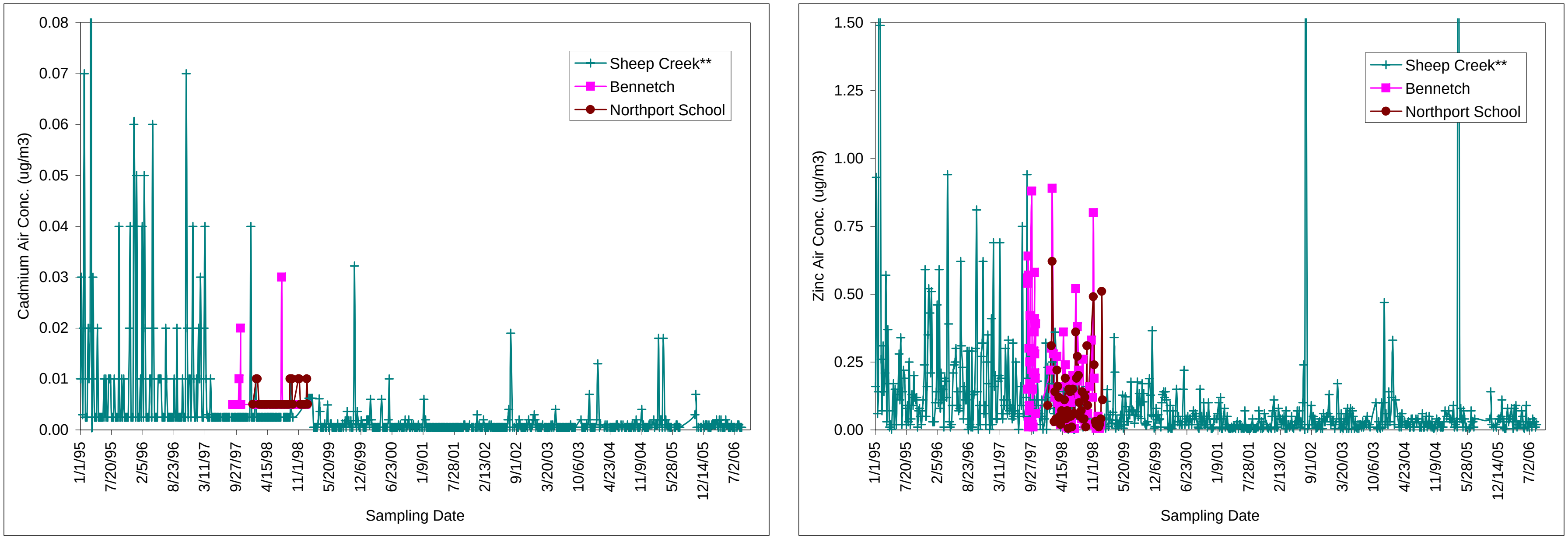


FIGURE 9-8 TEMPORAL EVALUATION OF OUTDOOR AIR CONCENTRATIONS IN NORTHPORT



Arsenic

Lead



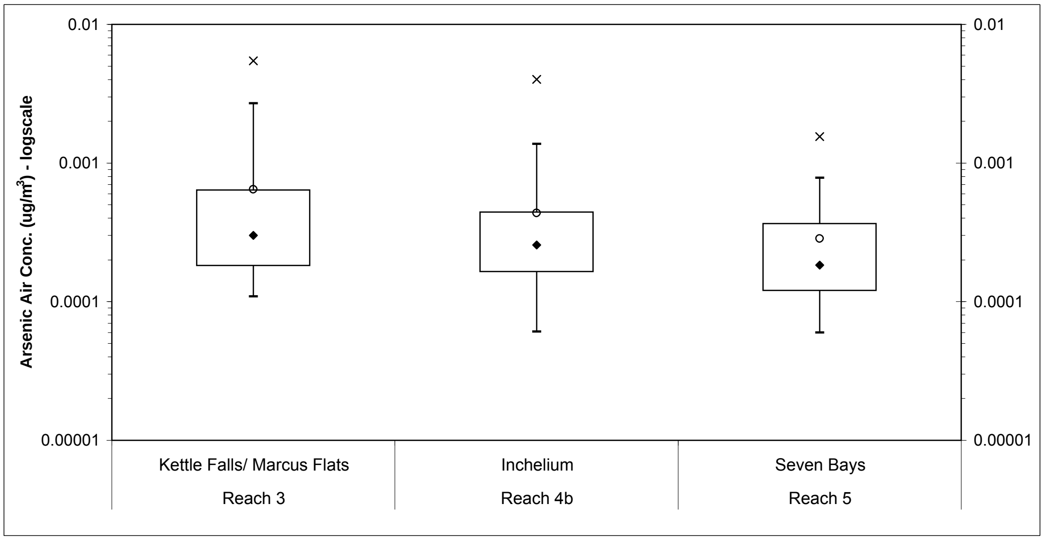
Cadmium

Zinc

***Air monitoring data from the TCM Sheep Creek air monitoring station had not been verified at the time of this document. These data will be reviewed and any necessary corrections will be incorporated into the air data set prior to the baseline HHRA.*

FIGURE 9-9

SPATIAL EVALUATION OF ARSENIC CONCENTRATIONS IN OUTDOOR AIR NEAR BEACHES



Arsenic Air Concentration (ug/m^3) Summary Statistics:

Statistic	Kettle Falls/ Marcus Flats	Inchelium	Seven Bays
Maximum	0.0055	0.0040	0.0016
Mean	0.0006	0.0004	0.0003
95th %tile	0.0027	0.0014	0.0008
75th %tile	0.0006	0.0004	0.0004
Median	0.0003	0.0003	0.0002
25th %tile	0.0002	0.0002	0.0001
5th %tile	0.0001	0.0001	0.0001

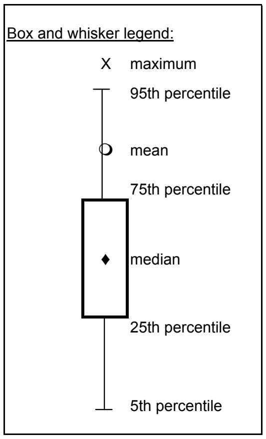


FIGURE 9-10

TEMPORAL EVALUATION OF OUTDOOR AIR CONCENTRATIONS NEAR BEACHES

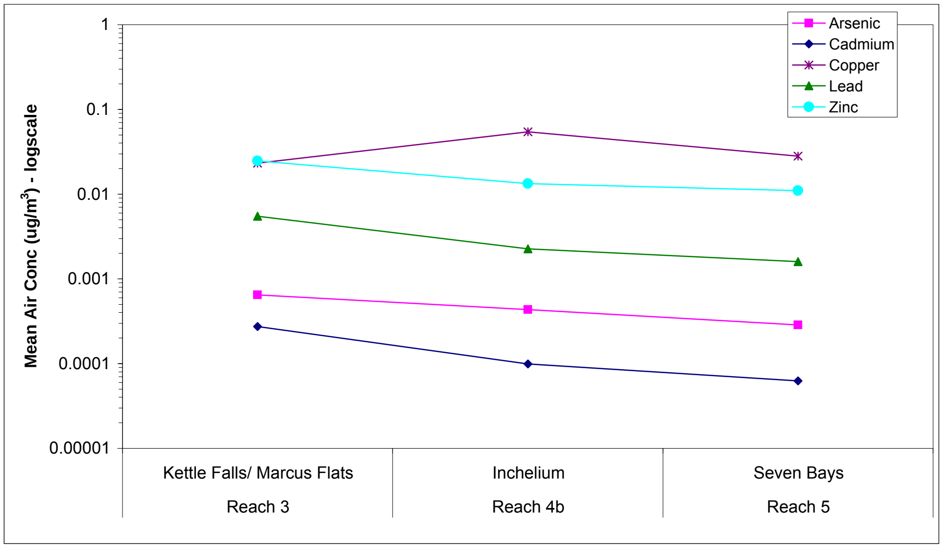
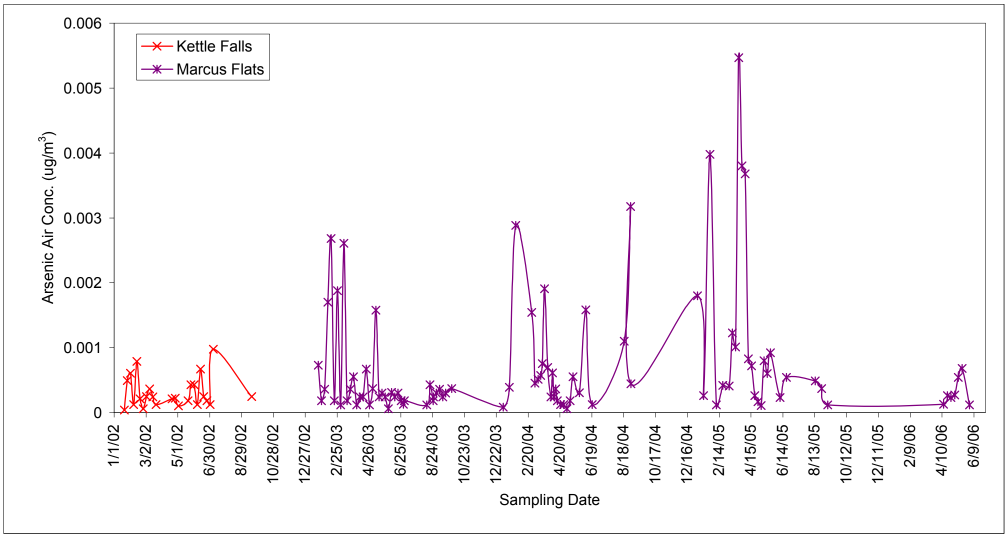


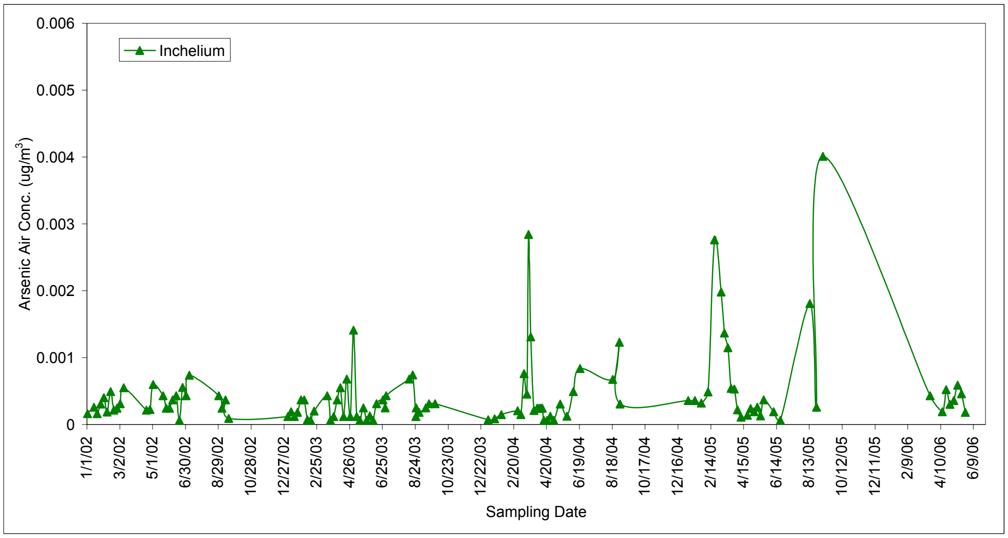
FIGURE 9-11

TEMPORAL EVALUATION OF ARSENIC CONCENTRATIONS IN OUTDOOR AIR NEAR BEACHES

Reach 3



Reach 4b



Reach 5

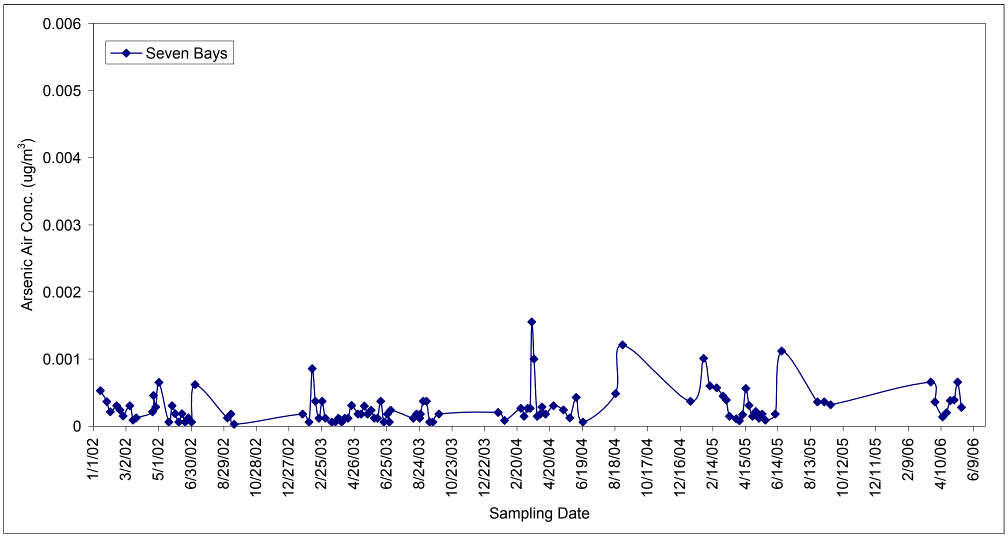
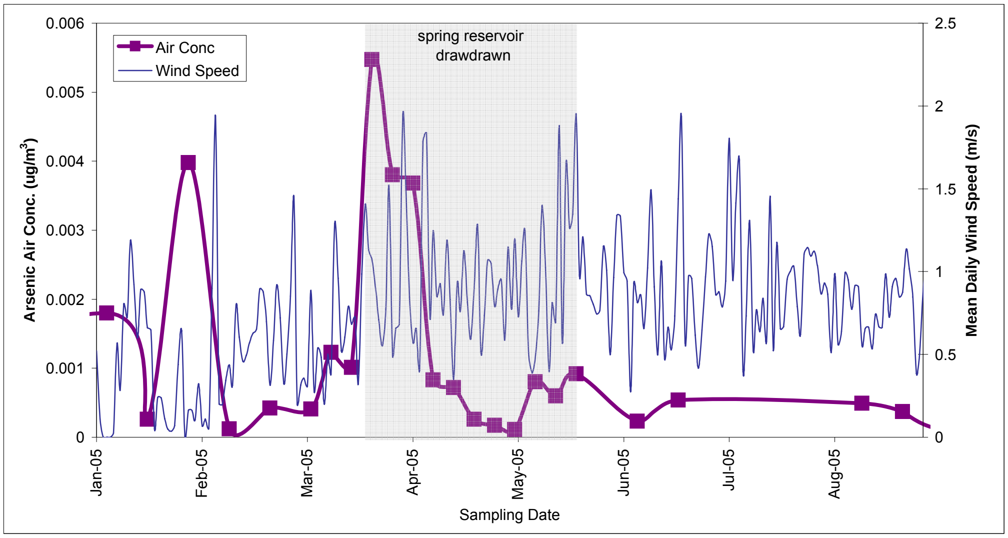


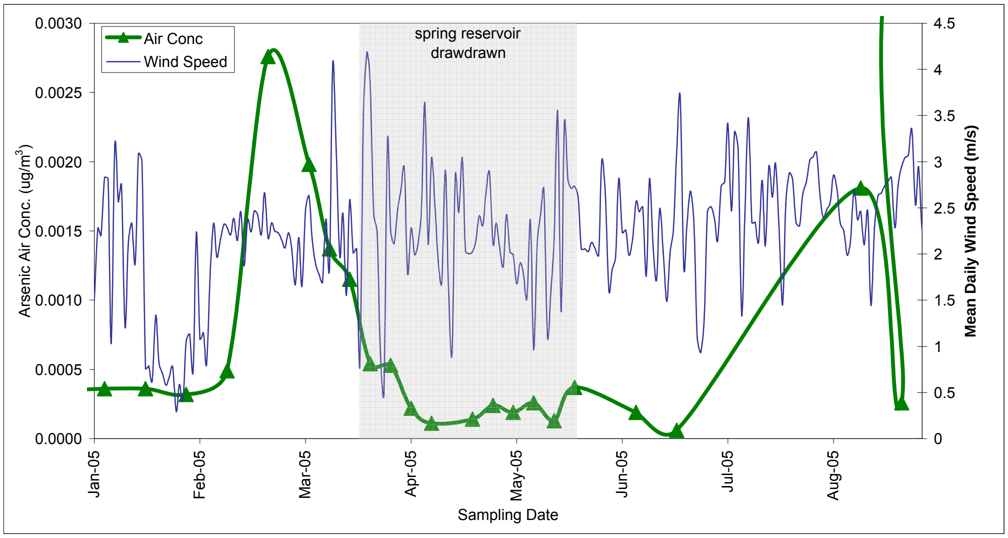
FIGURE 9-12

EXAMPLE OF SEASONAL VARIABILITY IN OUTDOOR AIR ARSENIC CONCENTRATIONS AND WIND SPEED IN 2005

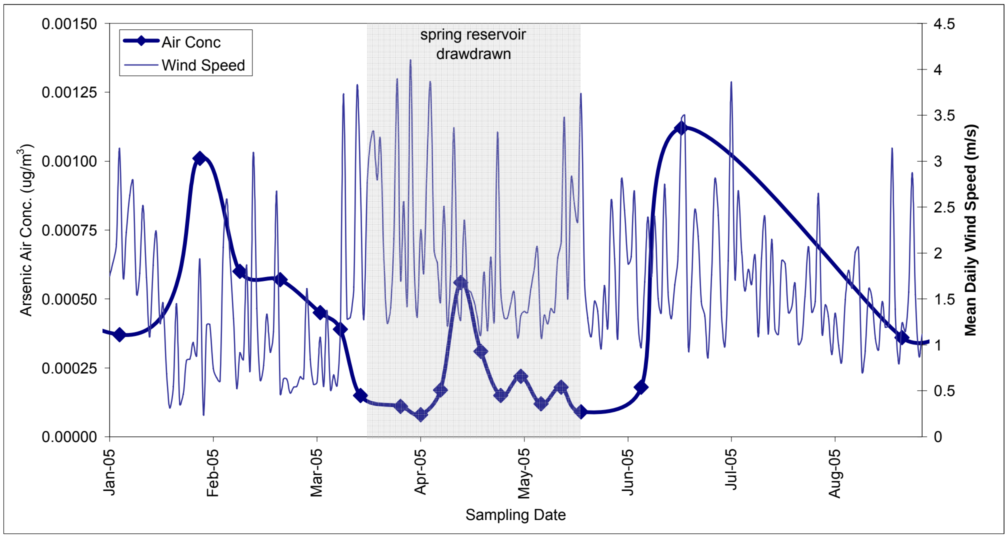
Reach 3 - Marcus Flats



Reach 4b - Inchelium



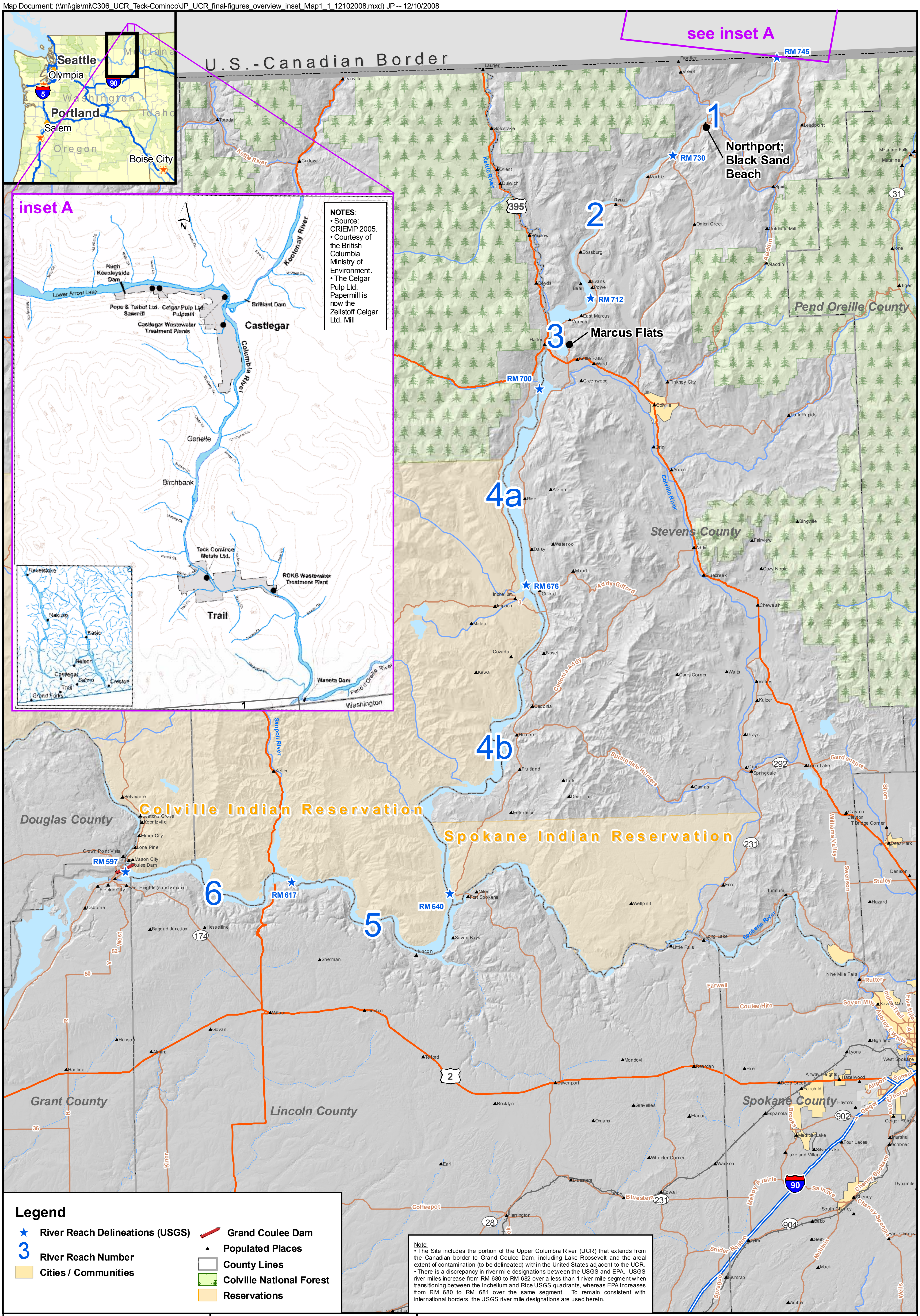
Reach 5 - Seven Bays



spring reservoir drawdown = lake elevation < 1260 ft amsl

Note: Concentration scales (x-axis) differ across graphs.

Map Document: (\\mi\gis\mi\C306_UCR_Teck-Cominco\JP_UCR_final-figures_overview_inset_Map1_1_12102008.mxd) JP -- 12/10/2008



Legend

- ★ River Reach Delineations (USGS)
- 3 River Reach Number
- ▨ Cities / Communities
- Grand Coulee Dam
- ▲ Populated Places
- ☐ County Lines
- 🟩 Colville National Forest
- ▨ Reservations

Note:
• The Site includes the portion of the Upper Columbia River (UCR) that extends from the Canadian border to Grand Coulee Dam, including Lake Roosevelt and the areal extent of contamination (to be delineated) within the United States adjacent to the UCR.
• There is a discrepancy in river mile designations between the USGS and EPA. USGS river miles increase from RM 680 to RM 682 over a less than 1 river mile segment when transitioning between the Inchelium and Rice USGS quadrants, whereas EPA increases from RM 680 to RM 681 over the same segment. To remain consistent with international borders, the USGS river mile designations are used herein.

Integral **Parametrix**

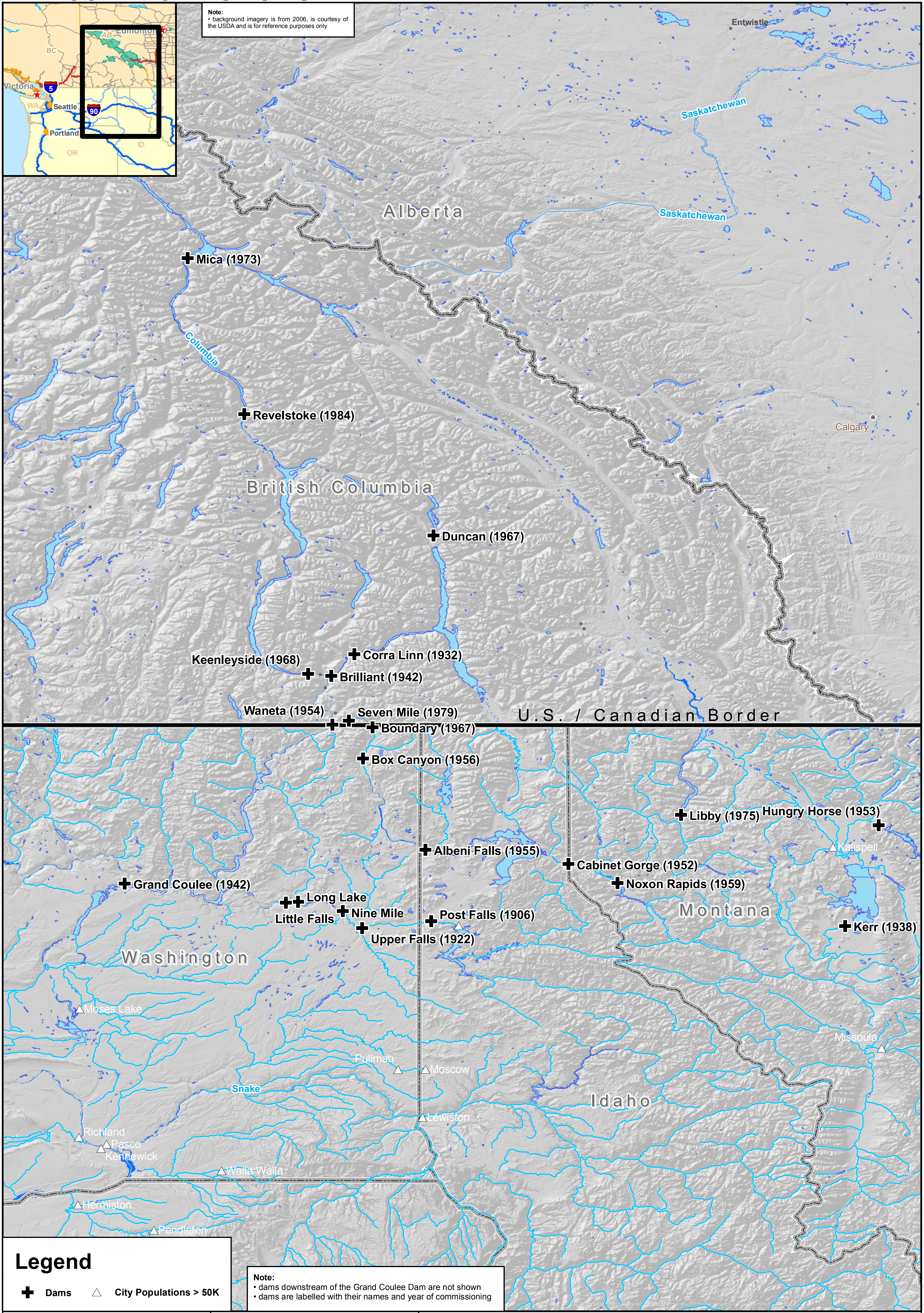
Km 0 5 10
Miles 0 5 10

N

Map 2-1

Site Location and River Reach Delineations

Upper Columbia River, WA



Note:
- background imagery is from 2006, is courtesy of the USDA and is for reference purposes only

Note:
- dams downstream of the Grand Coulee Dam are not shown
- dams are labelled with their names and year of commissioning

Integral **Parametrix**

Km 0 50 100

Miles 0 25 50

N

Map 2-10

Major Dams Upstream of the Study Area

Upper Columbia River, WA

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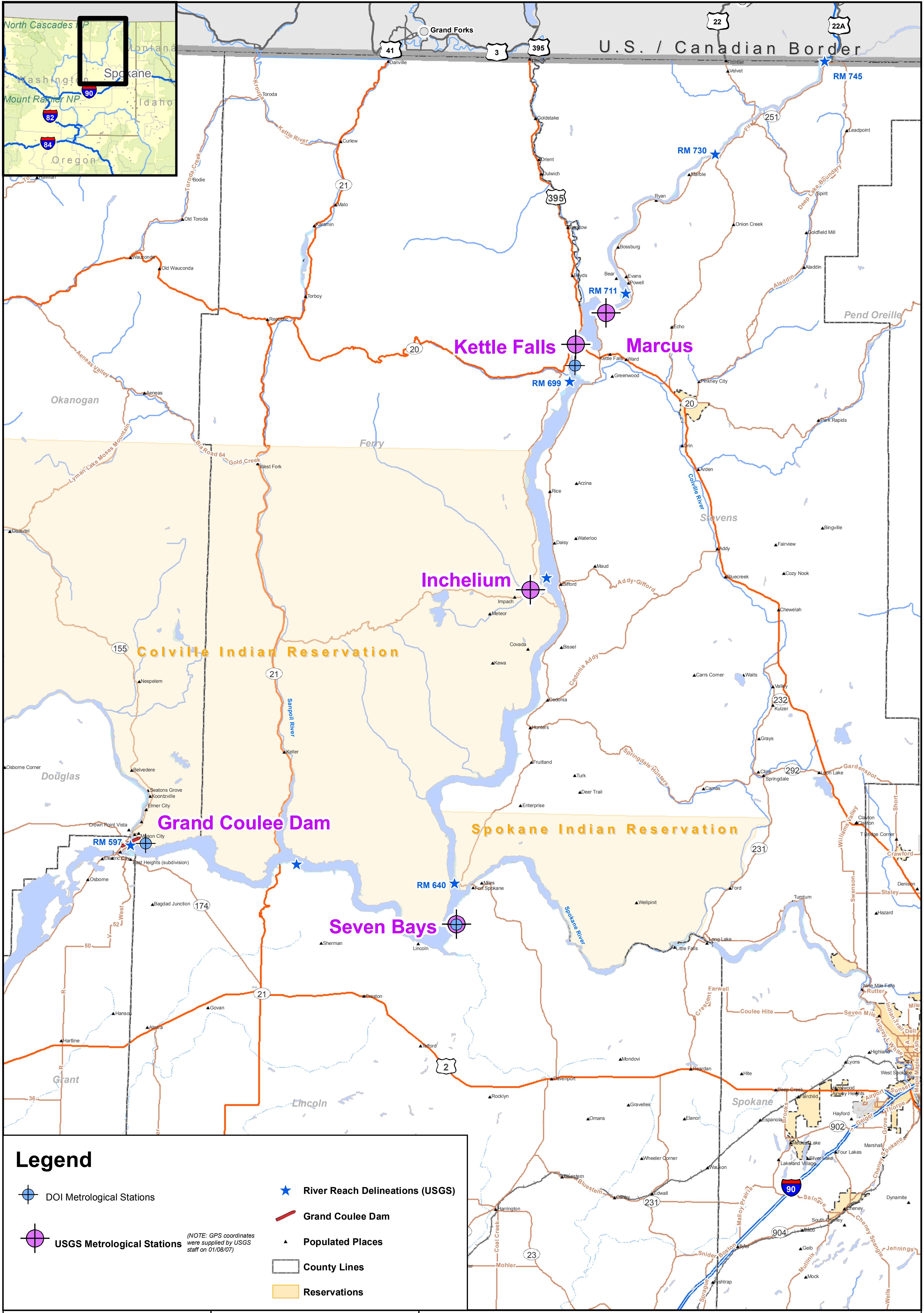


Integral **Parametrix**

0 5 10 Km

0 5 10 Miles

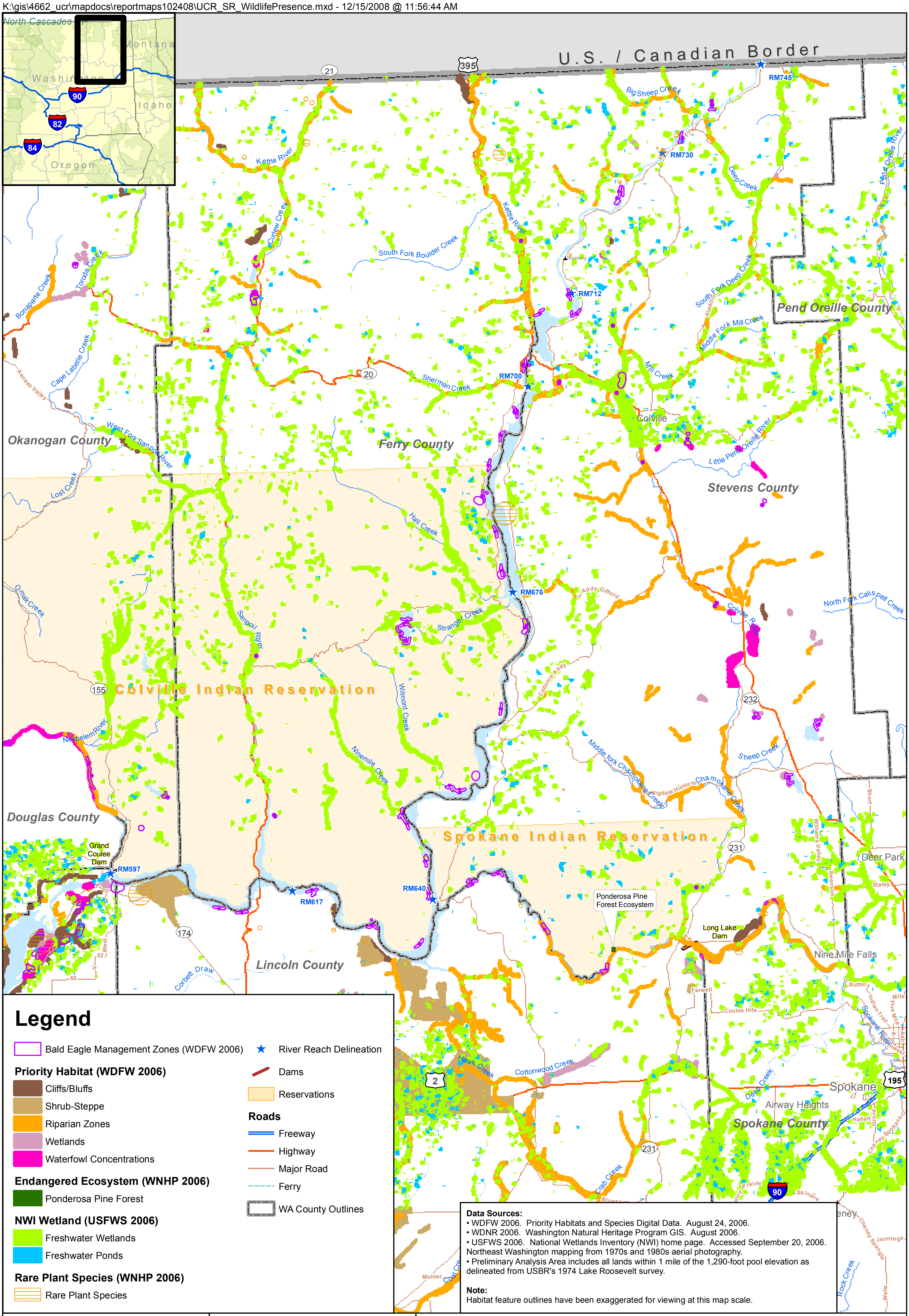
N

Map 2-11

Meteorological Stations Within the Study Area

Upper Columbia River, WA

K:\gis\4662_ucr\mapdocs\reportmaps102408\UCR_SR_WildlifePresence.mxd - 12/15/2008 @ 11:56:44 AM



Legend

- ☐ Bald Eagle Management Zones (WDFW 2006)

Priority Habitat (WDFW 2006)

- 🟫 Cliffs/Bluffs
- ▨ Shrub-Steppe
- 🟧 Riparian Zones
- ▨ Wetlands
- ▨ Waterfowl Concentrations

Endangered Ecosystem (WNHP 2006)

- 🟩 Ponderosa Pine Forest

NWI Wetland (USFWS 2006)

- 🟩 Freshwater Wetlands
- 🟦 Freshwater Ponds

Rare Plant Species (WNHP 2006)

- ▤ Rare Plant Species

- ★ River Reach Delineation
- ／ Dams
- ▨ Reservations

Roads

- ═ Freeway
- ― Highway
- ― Major Road
- - - Ferry
- ▭ WA County Outlines

Data Sources:
- WDFW 2006. Priority Habitats and Species Digital Data. August 24, 2006.
- WDNR 2006. Washington Natural Heritage Program GIS. August 2006.
- USFWS 2006. National Wetlands Inventory (NWI) home page. Accessed September 20, 2006. Northeast Washington mapping from 1970s and 1980s aerial photography.
- Preliminary Analysis Area includes all lands within 1 mile of the 1,290-foot pool elevation as delineated from USBR's 1974 Lake Roosevelt survey.

Note:
Habitat feature outlines have been exaggerated for viewing at this map scale.

Integral **Parametrix**

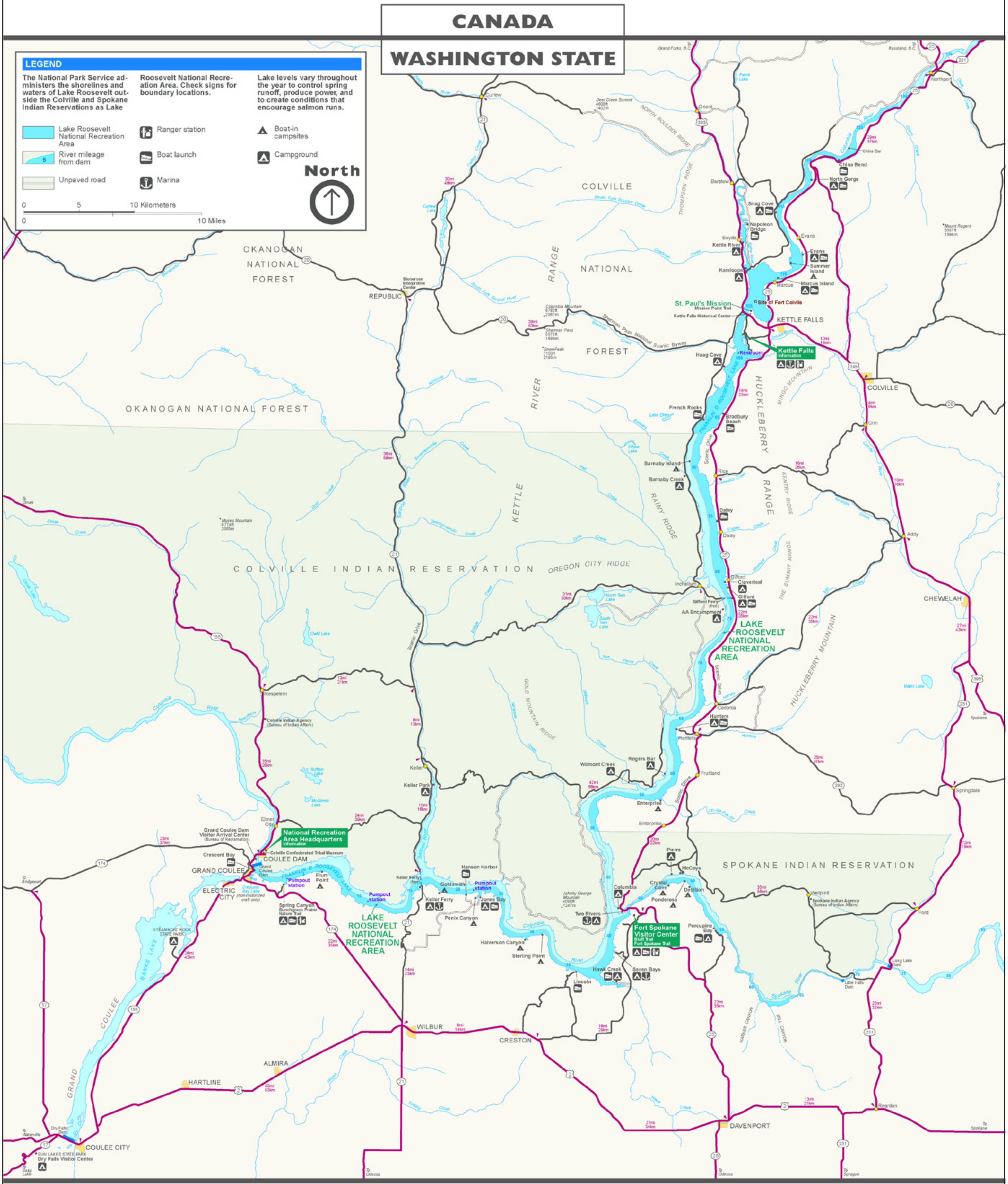
N

Km
0 5 10

Miles
0 2.5 5

Map 2-12 **Priority, Wetland, and Endangered Habitats within the UCR Study Area**

Upper Columbia River, WA



Map 2-2. NPS Recreational Facilities, Upper Columbia River, WA.
Map Source: LRF (2007a).
Note: Not to a set scale.

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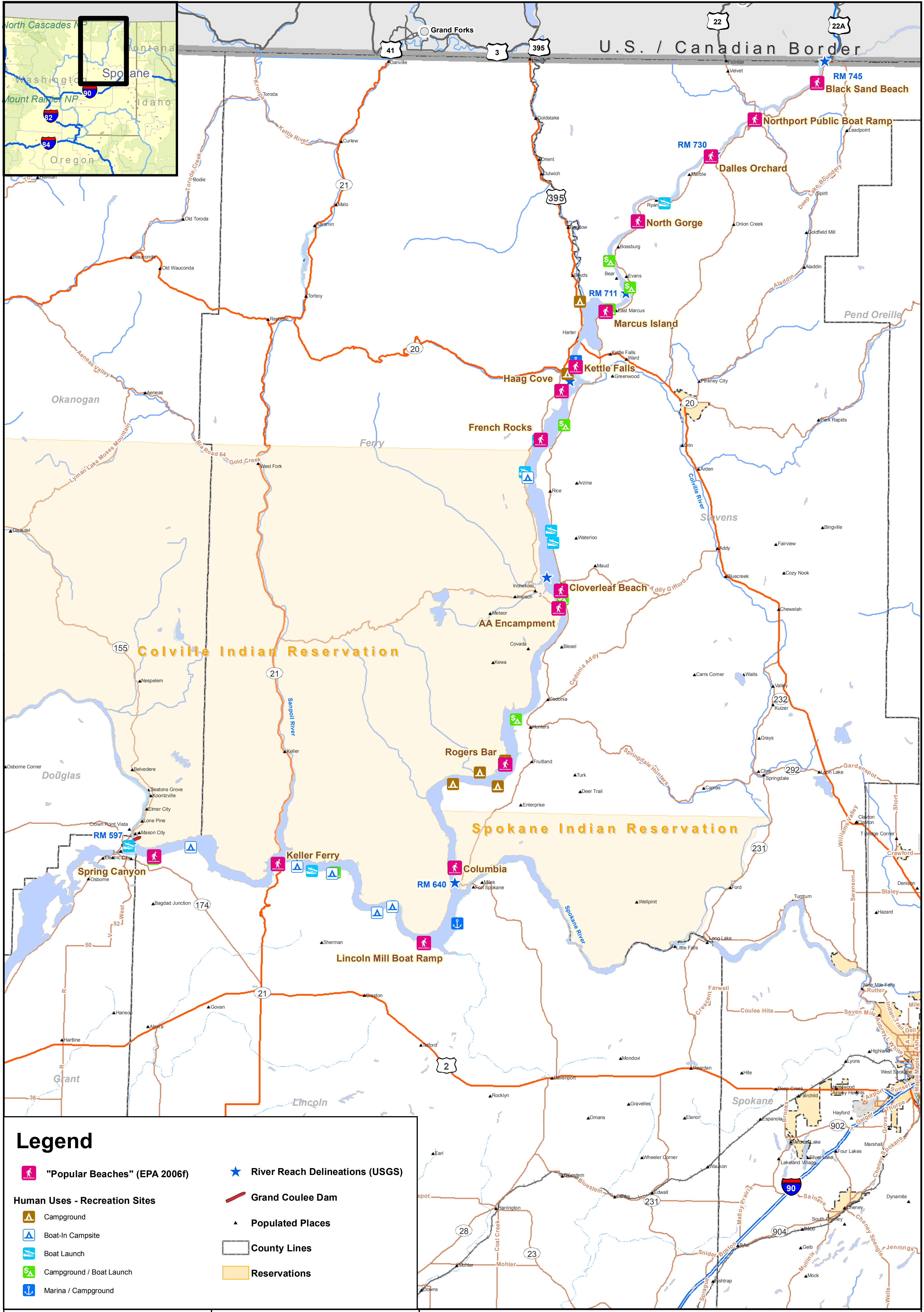

Legend

- "Popular Beaches" (EPA 2006f)
- River Reach Delineations (USGS)
- Grand Coulee Dam
- Populated Places
- County Lines
- Reservations

Human Uses - Recreation Sites

- Campground
- Boat-In Campsite
- Boat Launch
- Campground / Boat Launch
- Marina / Campground

Integral **Parametrix**

Km 0 5 10

Miles 0 5 10

N

Map 2-3

High Use Beach and Developed Recreational Areas

Upper Columbia River, WA

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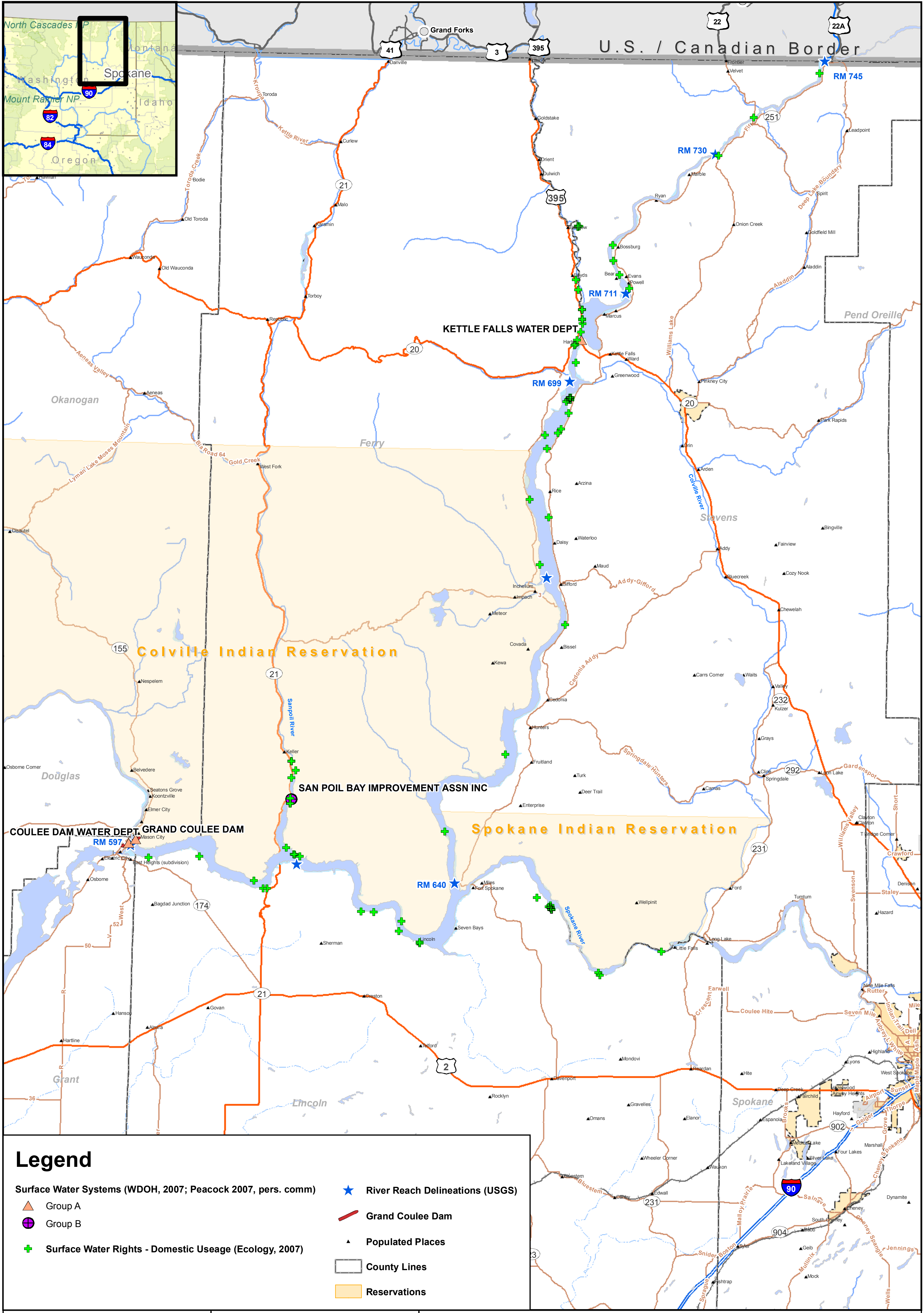
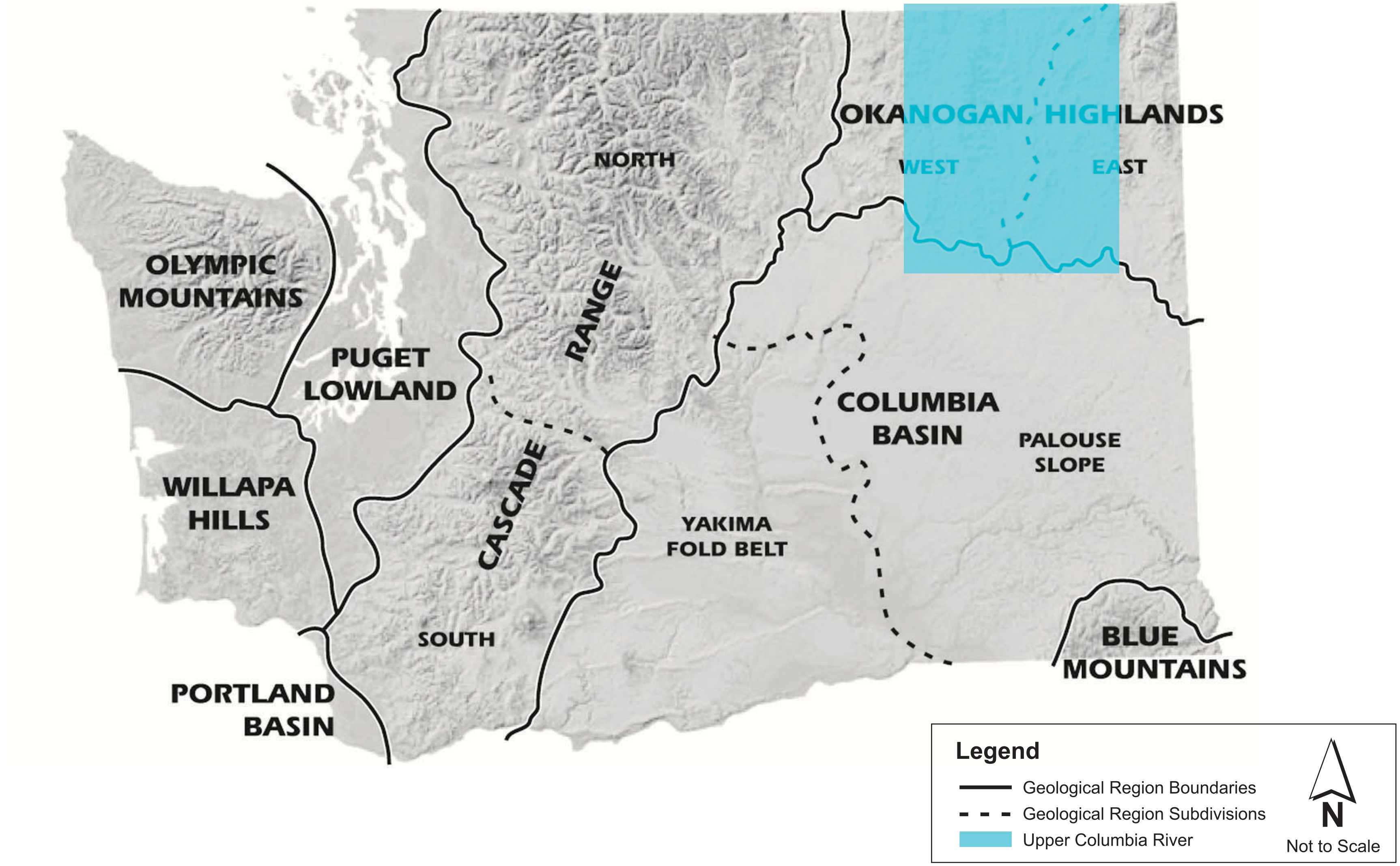


Integral **Parametrix**

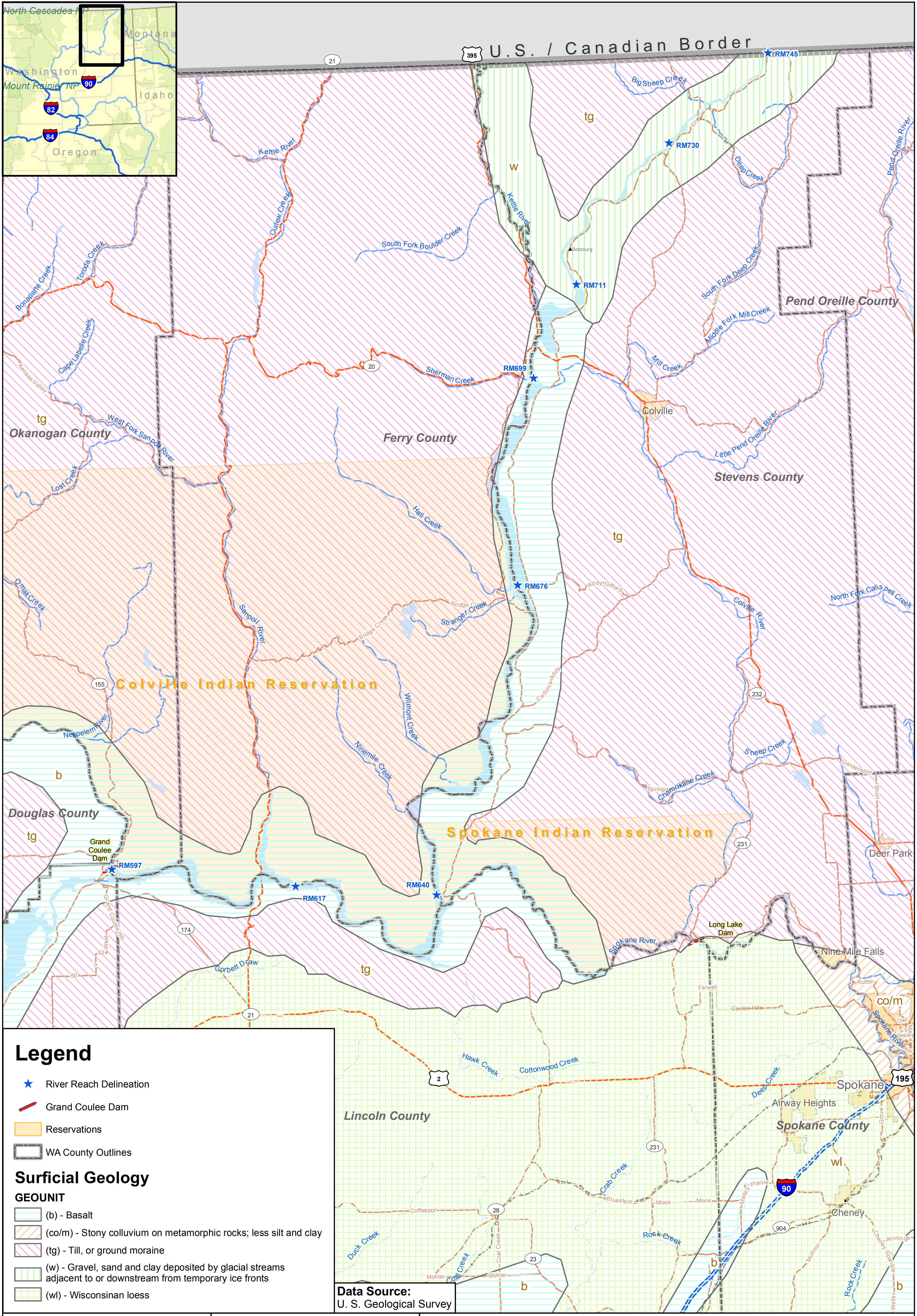
Km
0 5 10
Miles
0 5 10
N

Map 2-4 **Public Surface Water Systems and Domestic Supply Surface Water Rights**

Upper Columbia River, WA



Map 2-5. Geological Regions of Washington State.
Source: WDGER (2002).



Legend

★ River Reach Delineation

— Grand Coulee Dam

🟧 Reservations

▭ WA County Outlines

Surficial Geology

GEOUNIT

▨ (b) - Basalt

▨ (co/m) - Stony colluvium on metamorphic rocks; less silt and clay

▨ (tg) - Till, or ground moraine

▨ (w) - Gravel, sand and clay deposited by glacial streams adjacent to or downstream from temporary ice fronts

▨ (wl) - Wisconsinan loess

Data Source:
U. S. Geological Survey

Integral **Parametrix**

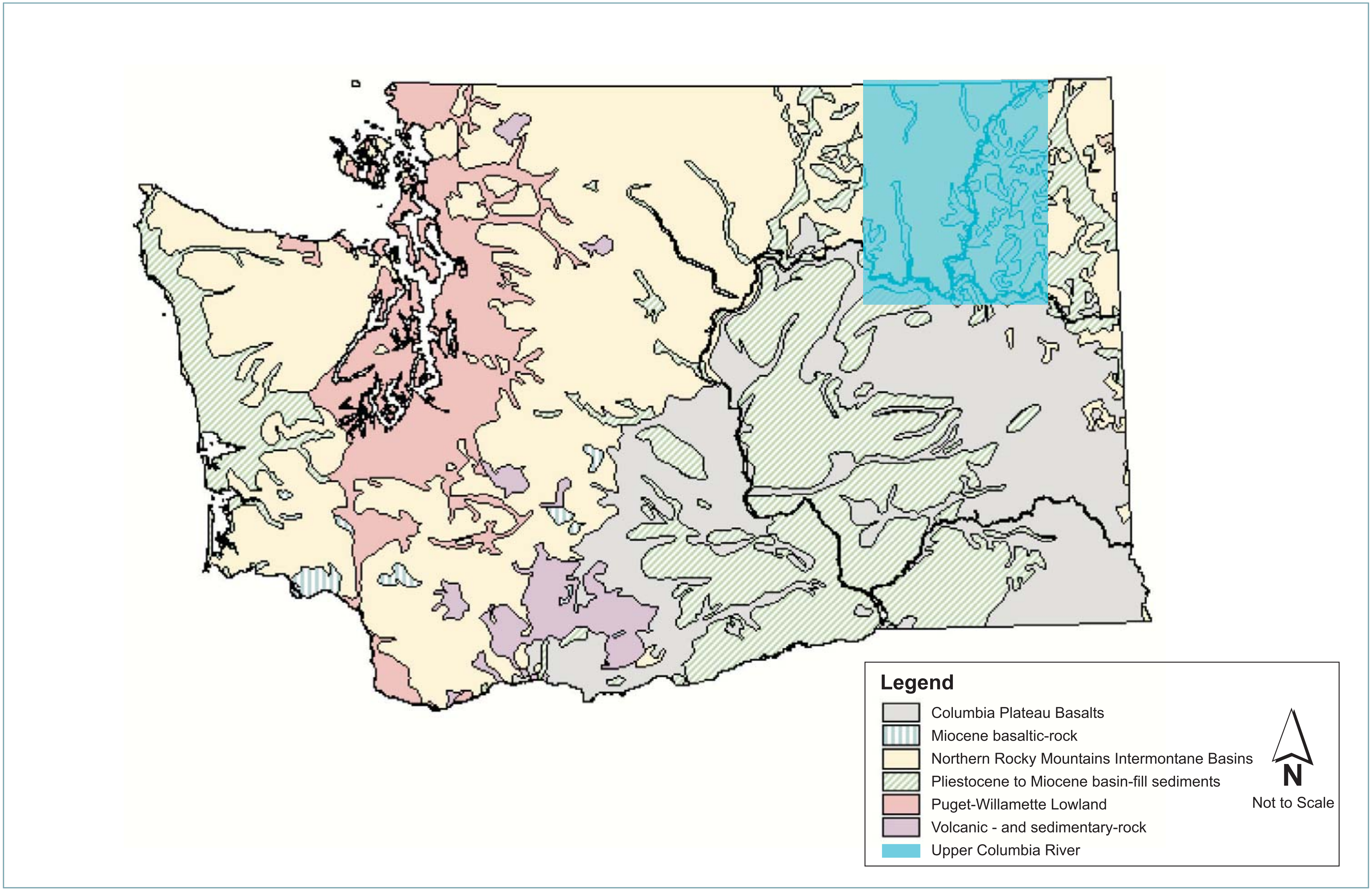
N

Km
0 5 10

Miles
0 2.5 5

Map 2-6 **Surficial Geology**

Upper Columbia River, WA



Map 2-7. Principal Surficial Aquifiers of Washington State.
Source: USGS (1985)

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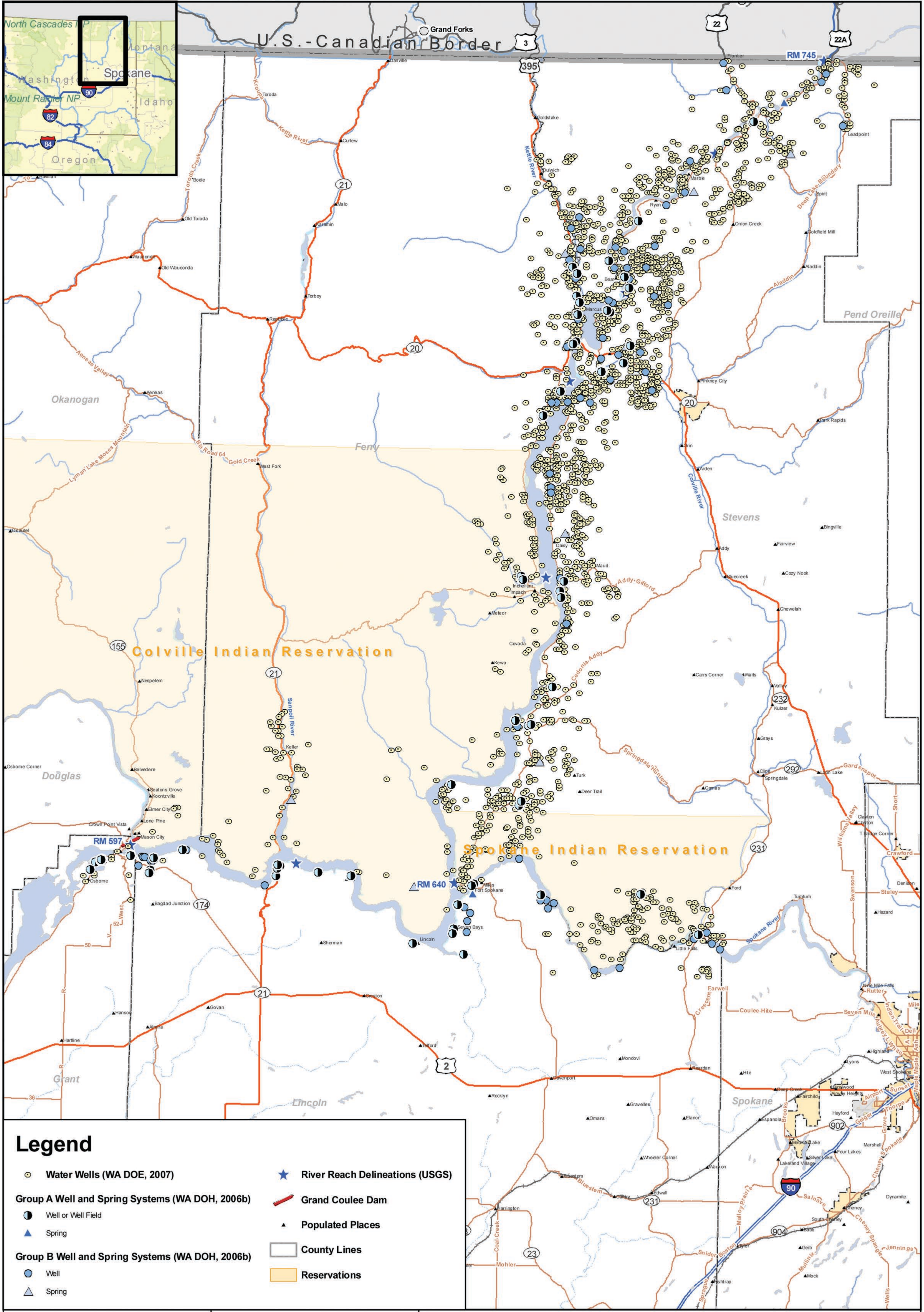


Integral **Parametrix**

0 5 10 Km

0 5 10 Miles

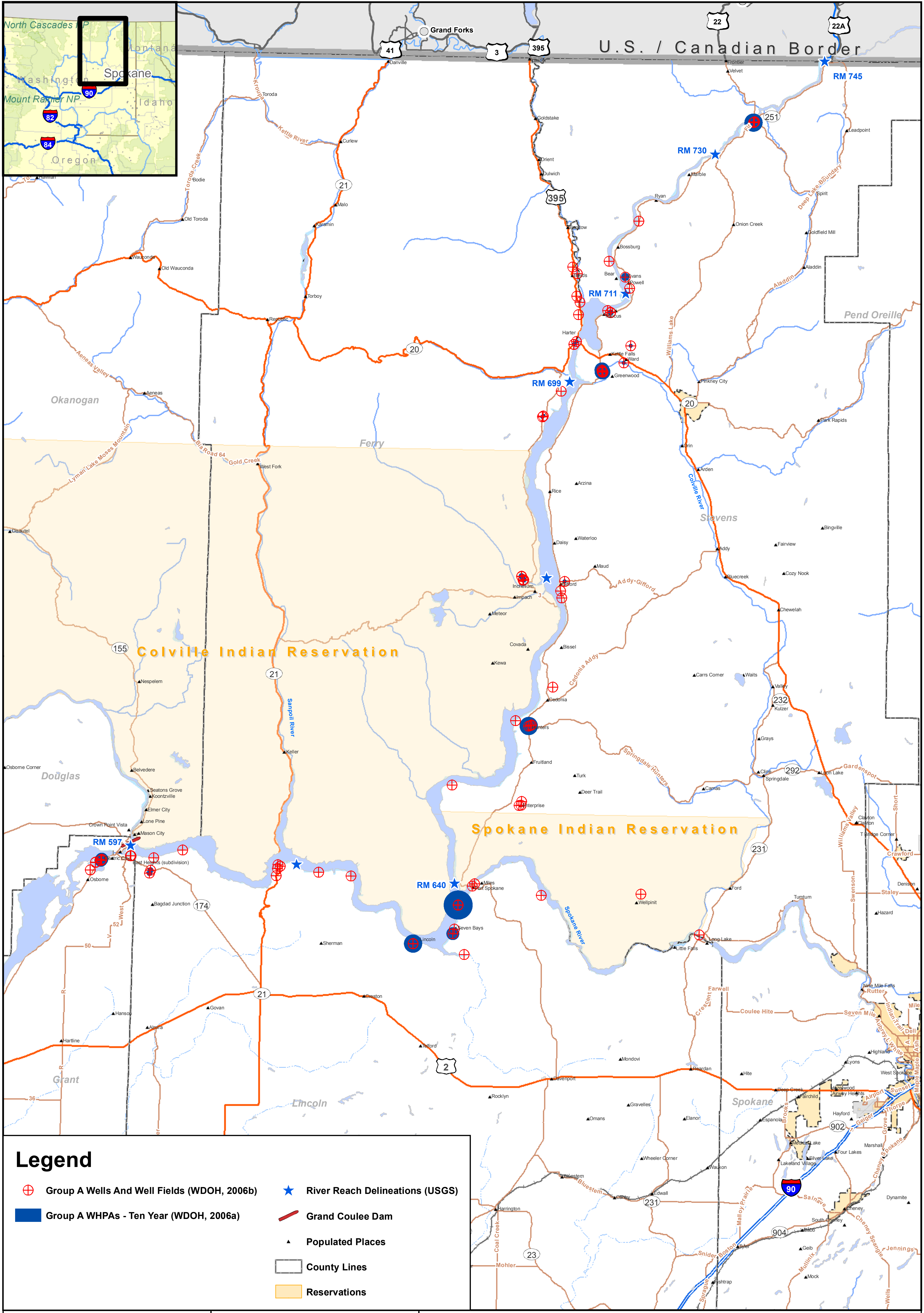
N

Map 2-8

Residential and Non-residential Wells and Springs Within Five Miles of the Study Area Shoreline

Upper Columbia River, WA

\\Mi\gis\mi\C306_UCR_Teck-Cominco\UCR_final-figures_overview_20060816.mxd TWC @ 08-30-07



Integral **Parametrix**

Km
0 5 10

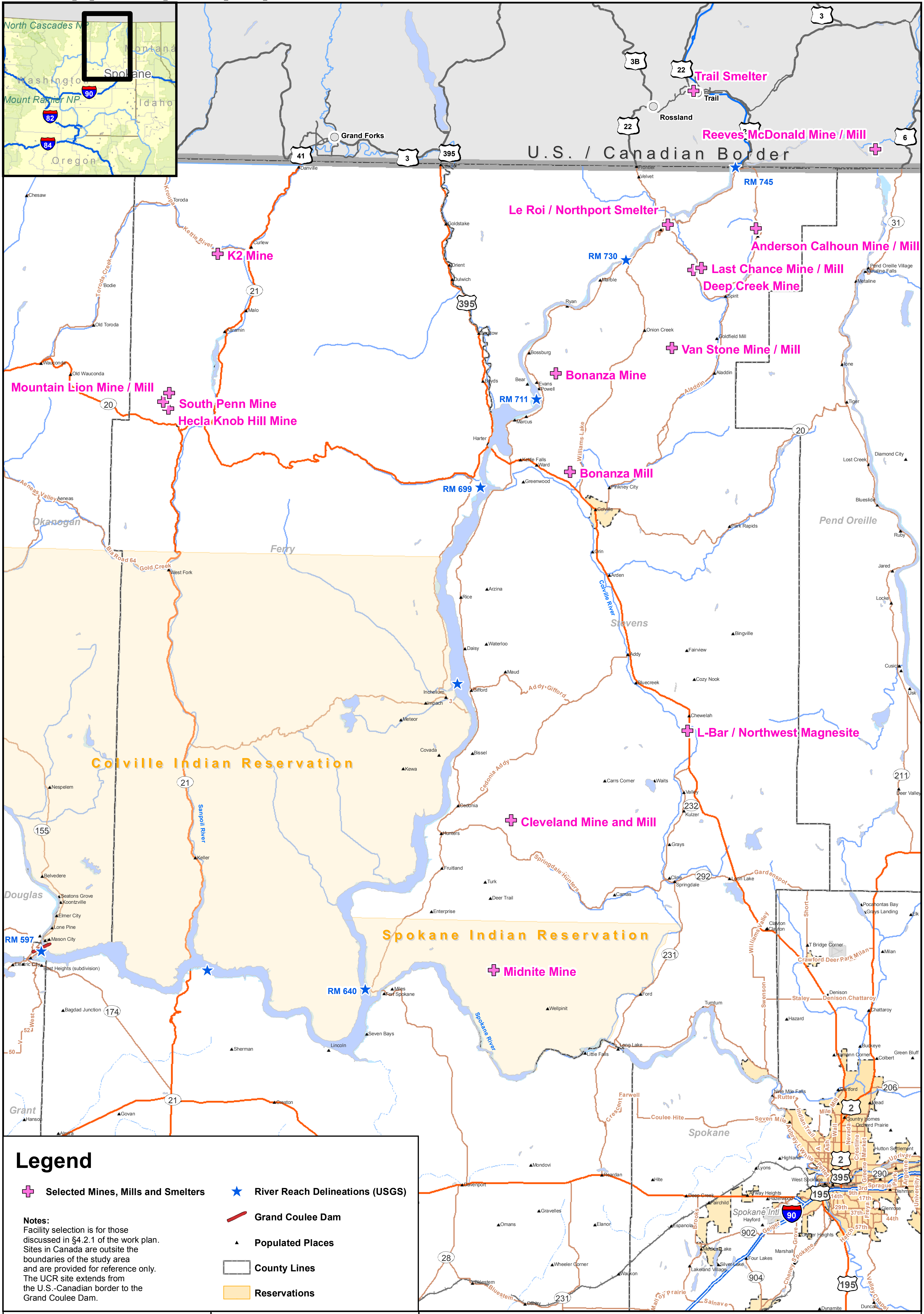
Miles
0 5 10

N

Map 2-9

Ten Year Well Head Protection Areas (WHPAs)
Within Five Miles of the Study Area Shoreline
Upper Columbia River, WA

\\Mi\gis\mi\C306_UCR_Teck-Cominco\UCR_final-figures_overview_20060816.mxd TWC @ 08-30-07



Legend

- ✚ Selected Mines, Mills and Smelters
- ★ River Reach Delineations (USGS)
- Grand Coulee Dam
- ▲ Populated Places
- ▭ County Lines
- ▭ Reservations

Notes:
Facility selection is for those discussed in §4.2.1 of the work plan. Sites in Canada are outside the boundaries of the study area and are provided for reference only. The UCR site extends from the U.S.-Canadian border to the Grand Coulee Dam.

Integral **Parametrix**

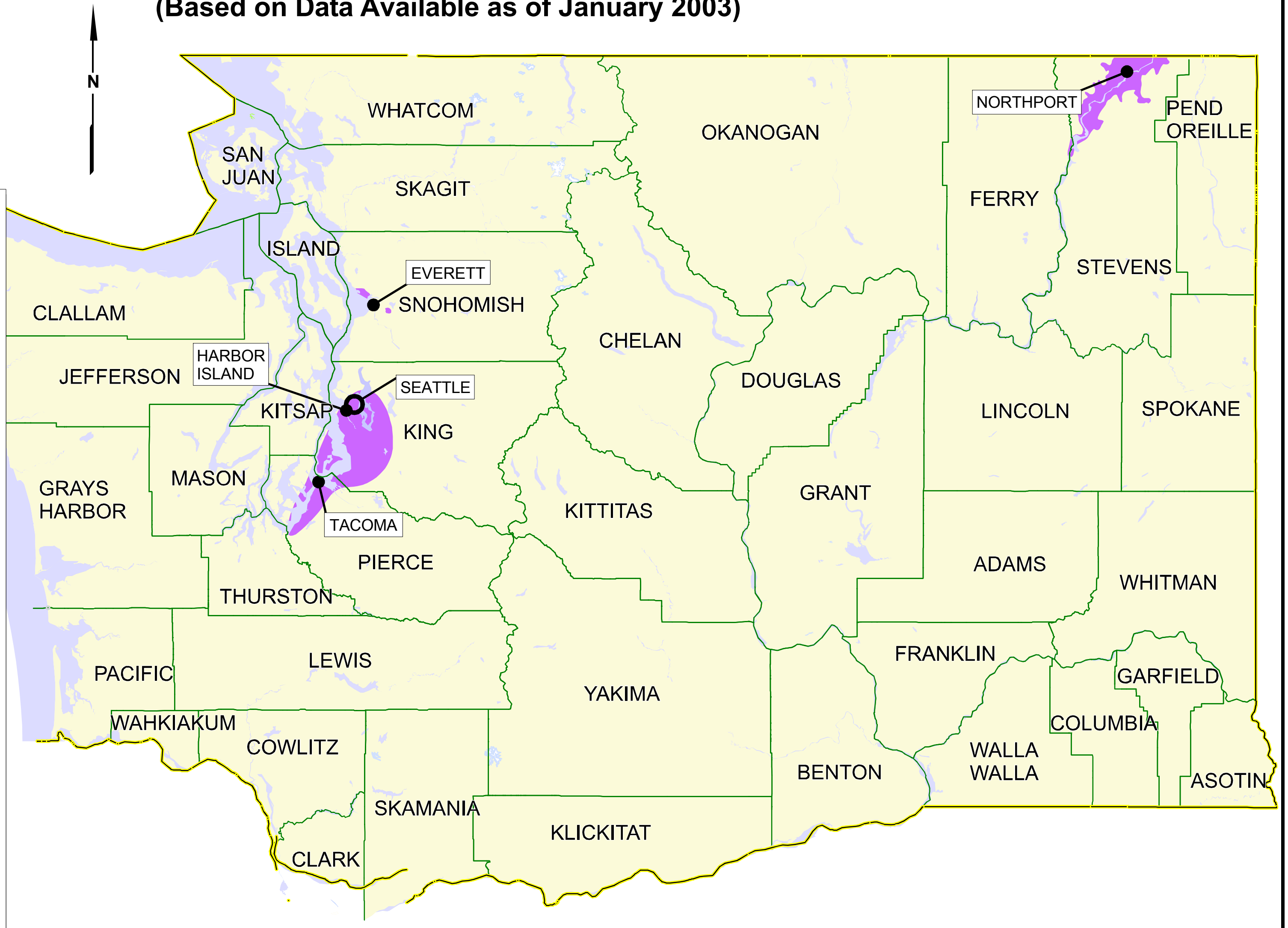
Km 0 5 10
Miles 0 5 10
N

Map 3-1

Mine, Mill, and Smelting Facilities in the Vicinity of the Study Area
Upper Columbia River, WA

Map 3 - 2 : Estimate of Areas Potentially Affected by Historical Smelter Emissions

(Based on Data Available as of January 2003)



Legend

🟪 Area potentially affected by smelter emissions

● Smelter locations

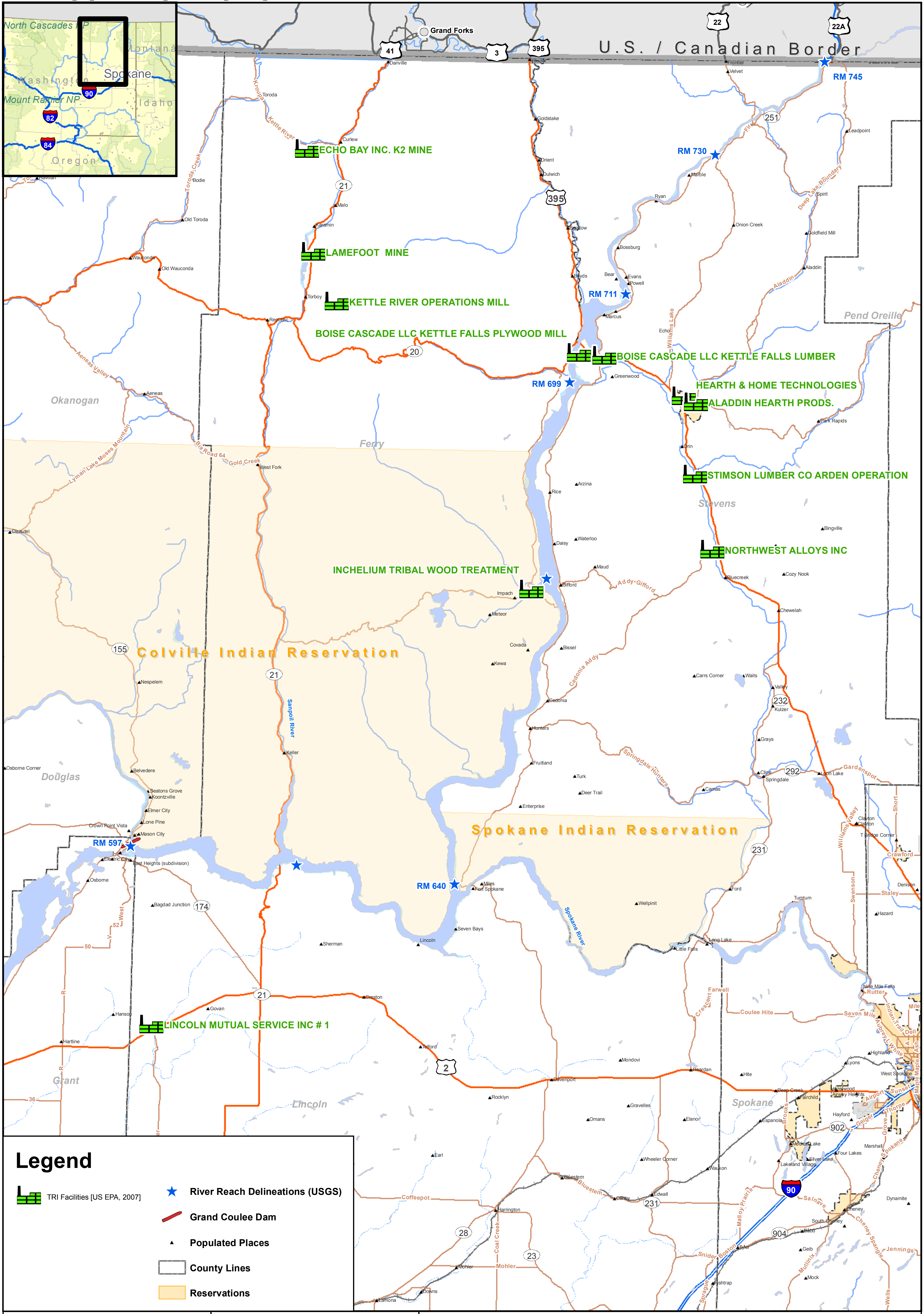
Disclaimer

This map should not substitute for a site-specific assessment. Not all of the areas identified on the map will actually have elevated levels of arsenic and lead in soil. Some properties outside of the identified areas may have elevated levels of arsenic and lead in soil.

This map was developed in 2003 to support the Area-Wide Soil Contamination Task Force. It is based on information available at that time and is intended to provide a general indication of where elevated levels of arsenic and lead in soil may be present due to historical smelter emissions, so individuals and communities can assess whether to look in to additional information on area-wide soil contamination. The areas potentially affected by smelter emissions in these maps were derived from actual soil sampling results for the Tacoma and Harbor Island smelters, sampling and air modeling for the Everett smelter, and maps of sulfur dioxide injury to vegetation from the Northport and Trail, BC smelters. The areas indicated as potentially affected by smelter emissions do not necessarily include all affected areas, because the complete extent of effects has not been determined.

Source: Ecology, 2008

\\Mi\gis\mi\C306_UCR_Teck-Cominco\UCR_final-figures_overview_20060816.mxd TWC @ 08-30-07



Integral Parametrix

Km
0 5 10

Miles
0 5 10

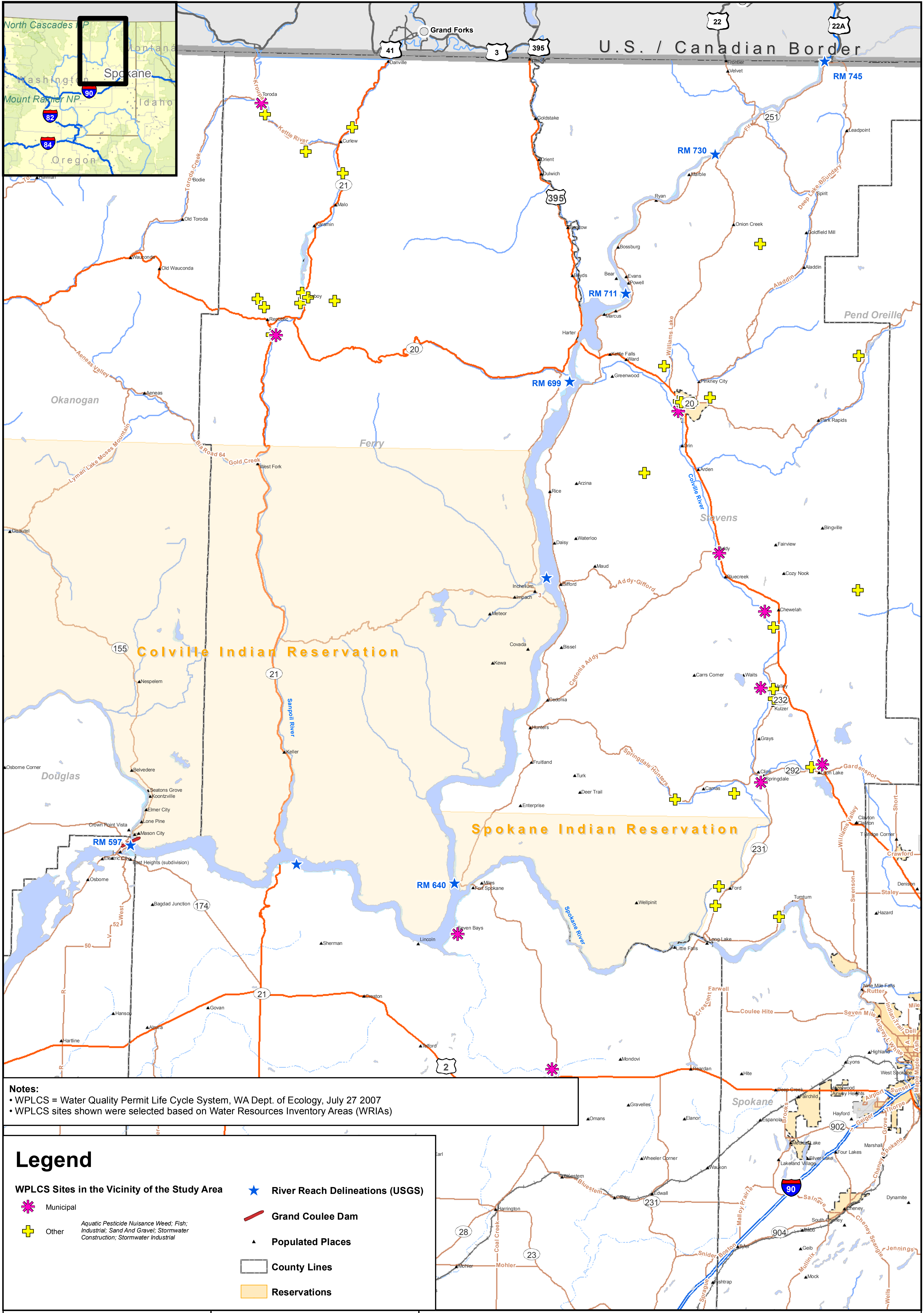
N

Map 3-3

TRI Reporting Facilities (1996 to 2005) in the Vicinity of the Study Area

Upper Columbia River, WA

\\Mi\gis\mi\C306_UCR_Teck-Cominco\UCR_final-figures_overview_20060816.mxd TWC @ 08-30-07



Notes:
- WPLCS = Water Quality Permit Life Cycle System, WA Dept. of Ecology, July 27 2007
- WPLCS sites shown were selected based on Water Resources Inventory Areas (WRIAs)

Legend

WPLCS Sites in the Vicinity of the Study Area

✳ Municipal

✚ Other *Aquatic Pesticide Nuisance Weed; Fish; Sand And Gravel; Stormwater Construction; Stormwater Industrial*

★ **River Reach Delineations (USGS)**

▬ **Grand Coulee Dam**

▲ **Populated Places**

☐ **County Lines**

▨ **Reservations**

Integral **Parametrix**

Km 0 5 10

Miles 0 5 10

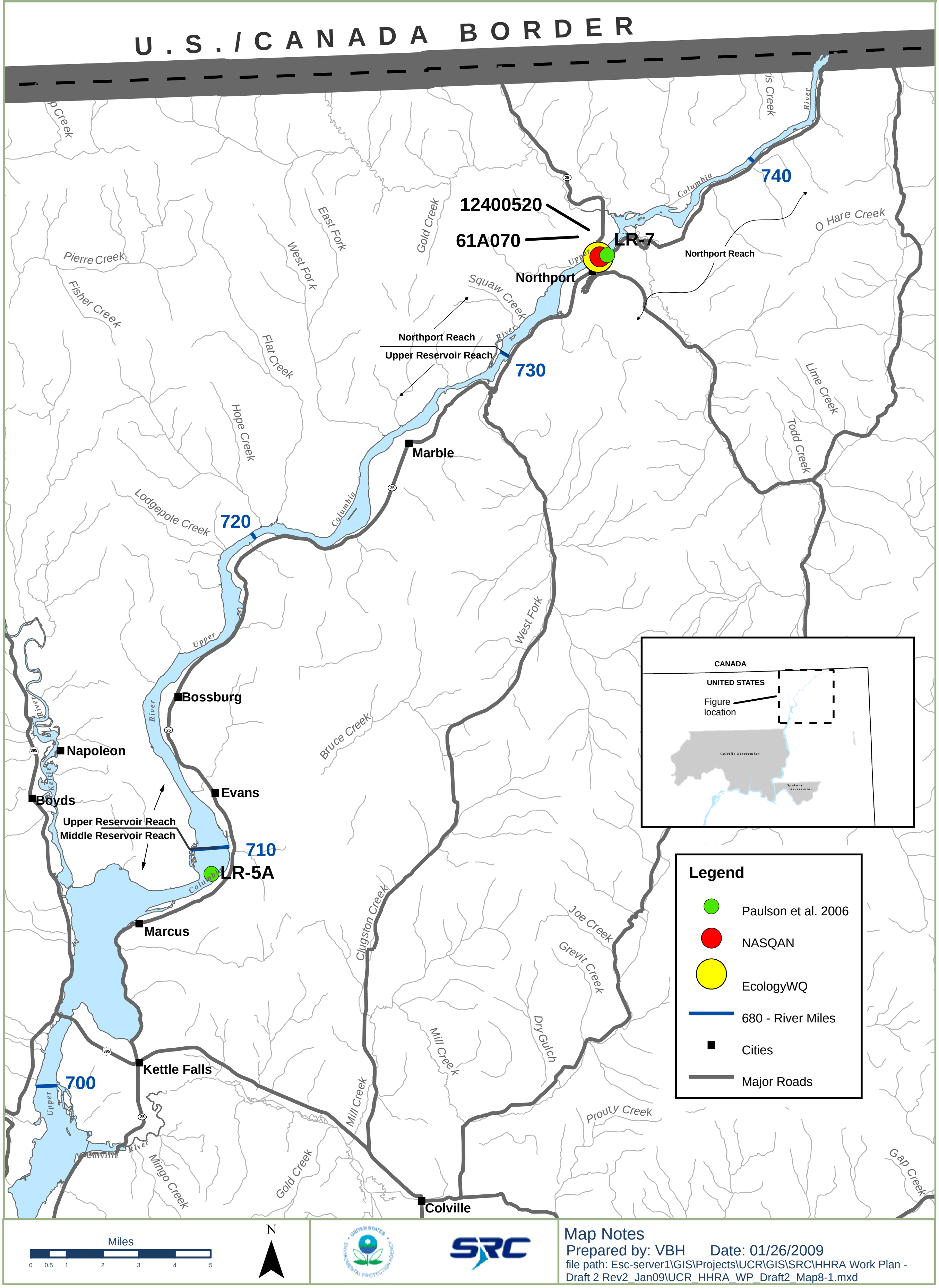
N

Map 3-4

WPLCS Sites in the Vicinity of the Study Area

Upper Columbia River, WA

Map 8-1. Northport Monitors and Paulson et al. (2006) Surface Water Sampling Locations

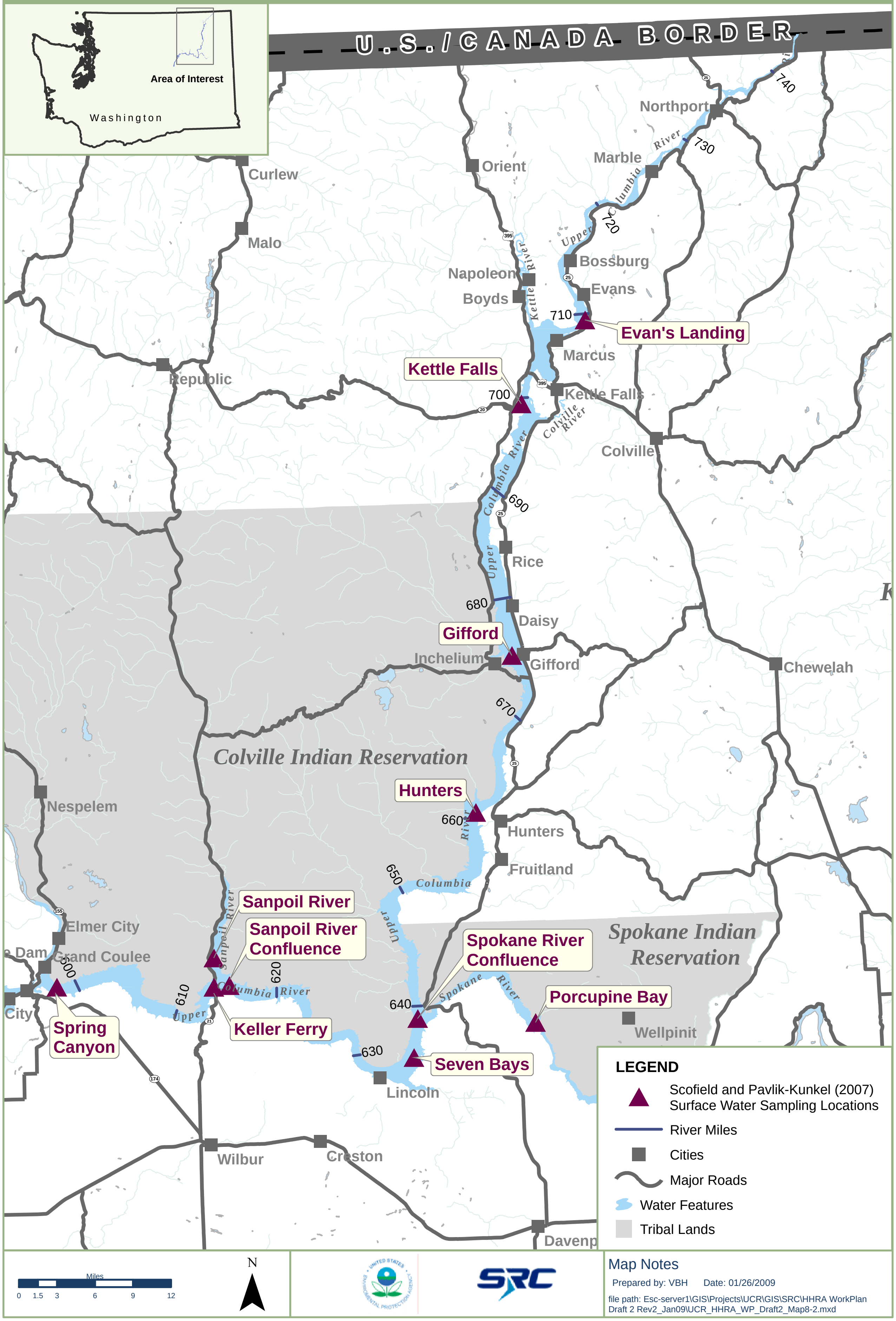


Map Notes

Prepared by: VBH Date: 01/26/2009

file path: Esc-server1\GIS\Projects\UCR\GIS\SRC\HHRA Work Plan - Draft 2 Rev2_Jan09\UCR_HHRA_WP_Draft2_Map8-1.mxd

Map 8-2. Scofield and Pavlik-Kunkel (2007) Surface Water Sampling Locations

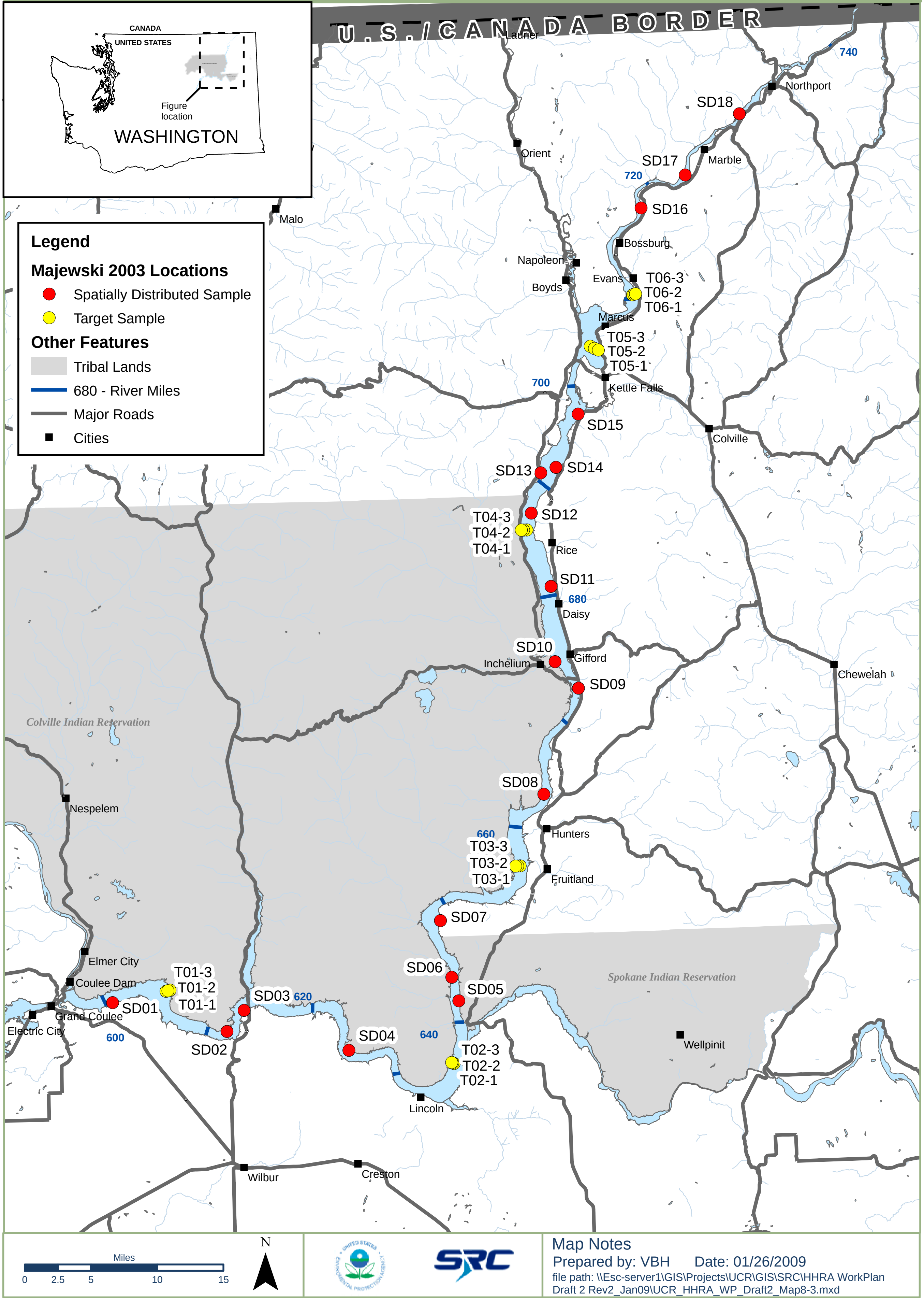


Map Notes

Prepared by: VBH Date: 01/26/2009

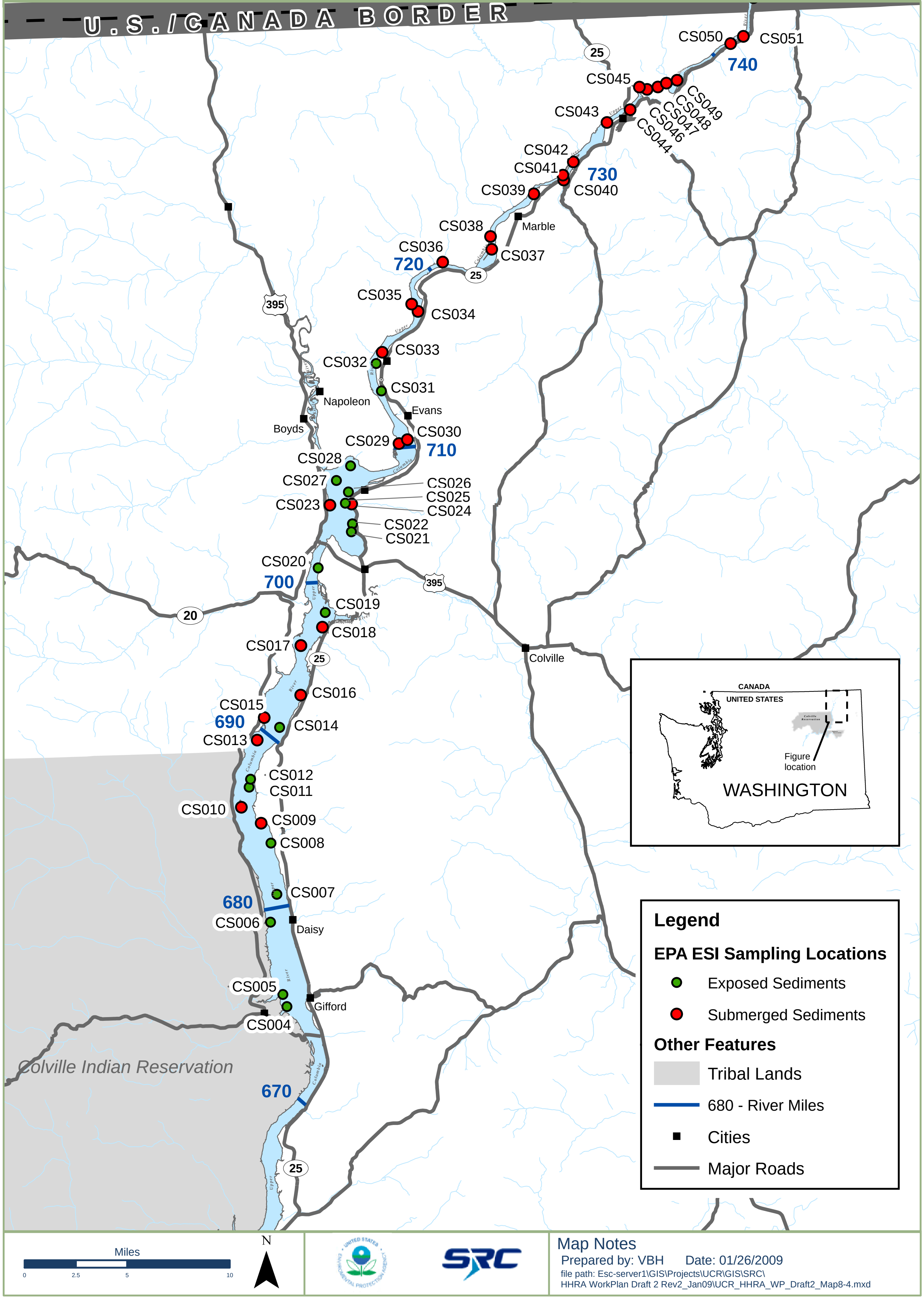
file path: Esc-server1\GIS\Projects\UCR\GIS\SRC\HHRA WorkPlan Draft 2 Rev2_Jan09\UCR_HHRA_WP_Draft2_Map8-2.mxd

Map 8-3. Majewski et al. (2003) Sediment Sampling Locations



Map Notes
Prepared by: VBH Date: 01/26/2009
file path: \\Esc-server1\GIS\Projects\UCR\GIS\SRC\HHRA WorkPlan Draft 2 Rev2_Jan09\UCR_HHRA_WP_Draft2_Map8-3.mxd

Map 8-4. EPA ESI Sediment Sampling Locations



Map Notes
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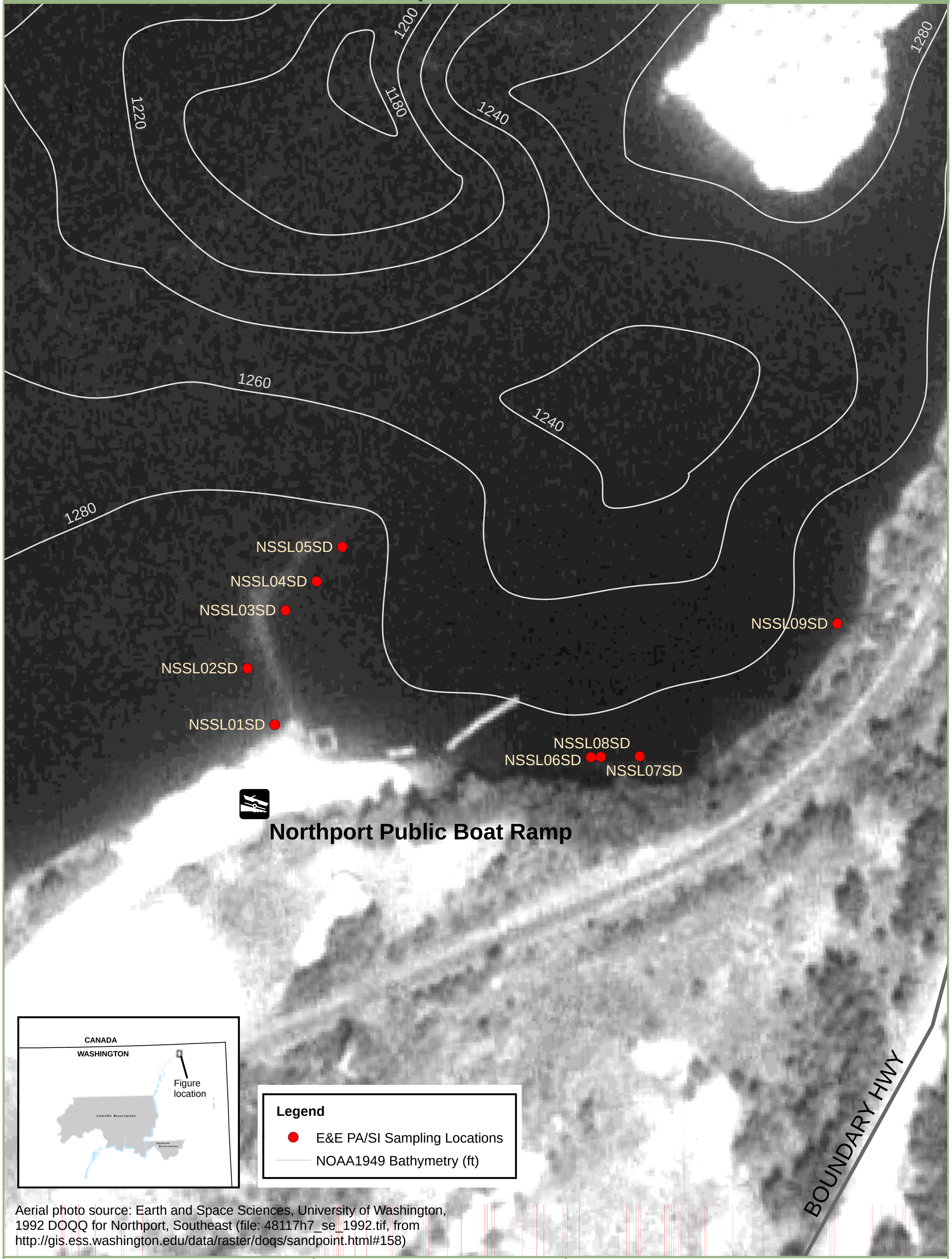
file path: Esc-server1\GIS\Projects\UCR\GIS\SRC\
HHRA WorkPlan Draft 2 Rev2_Jan09\UCR_HHRA_WP_Draft2_Map8-4.mxd

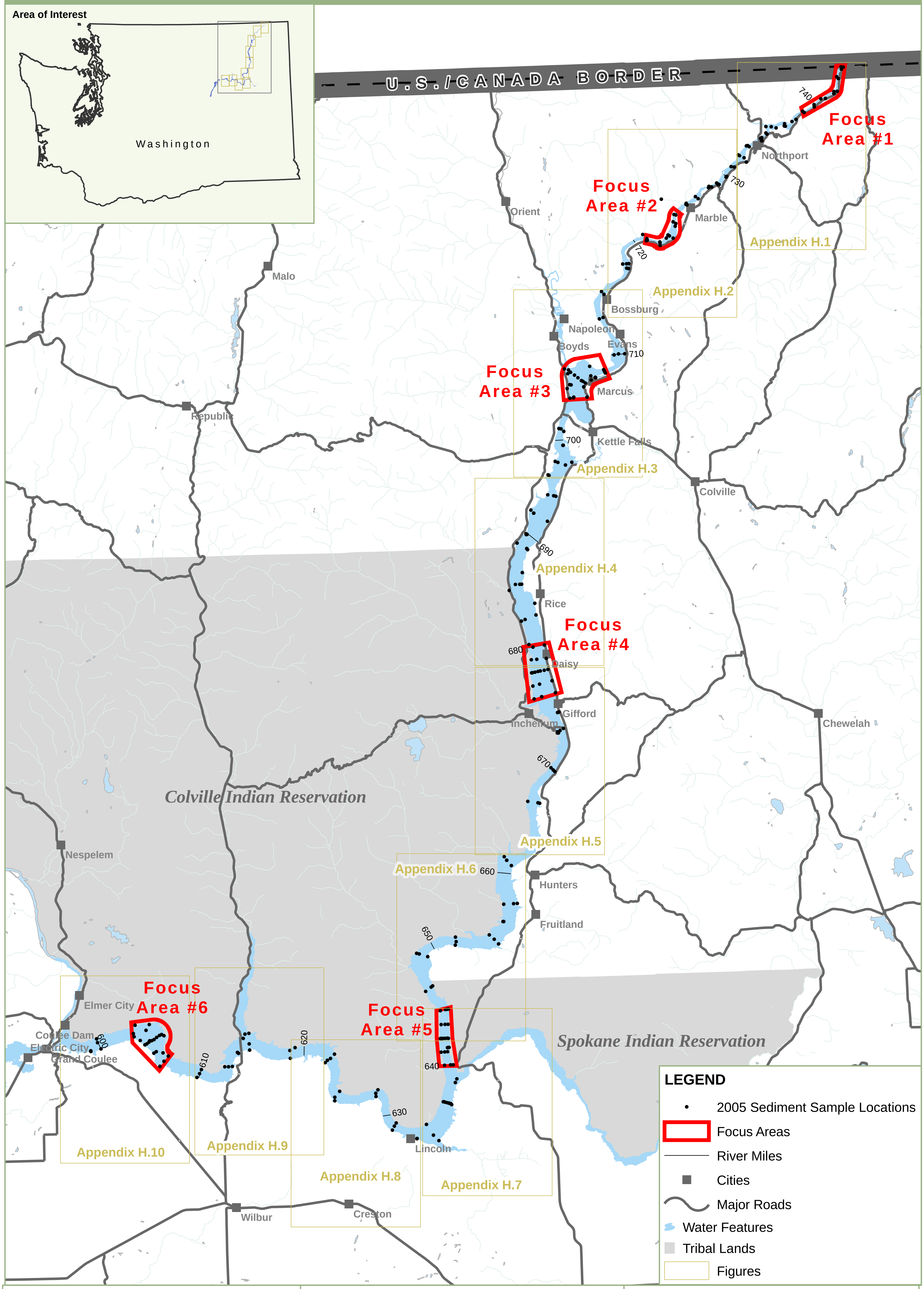
Map 8-5. E&E PA/SI Sediment Sampling Locations Near LeRoi/Northport Smelter



Aerial photo source: Earth and Space Sciences, University of Washington, 1992 DOQQ for Northport, Southeast (file: 48117h7_se_1992.tif, from http://gis.ess.washington.edu/data/raster/doqs/sandpoint.html#158)

Map Notes
Prepared by: VBH Date: 01/26/2009
file path: Esc-server1\GIS\Projects\UCR\GIS\SRC\HHRA WorkPlan Draft 2 Rev2_Jan09\UCR_HHRA_WP_Draft2_Map8-5.mxd

Map 8-6. EPA 2005 Phase 1 Sediment Sampling Locations



Miles
0 2 4 8 12 16

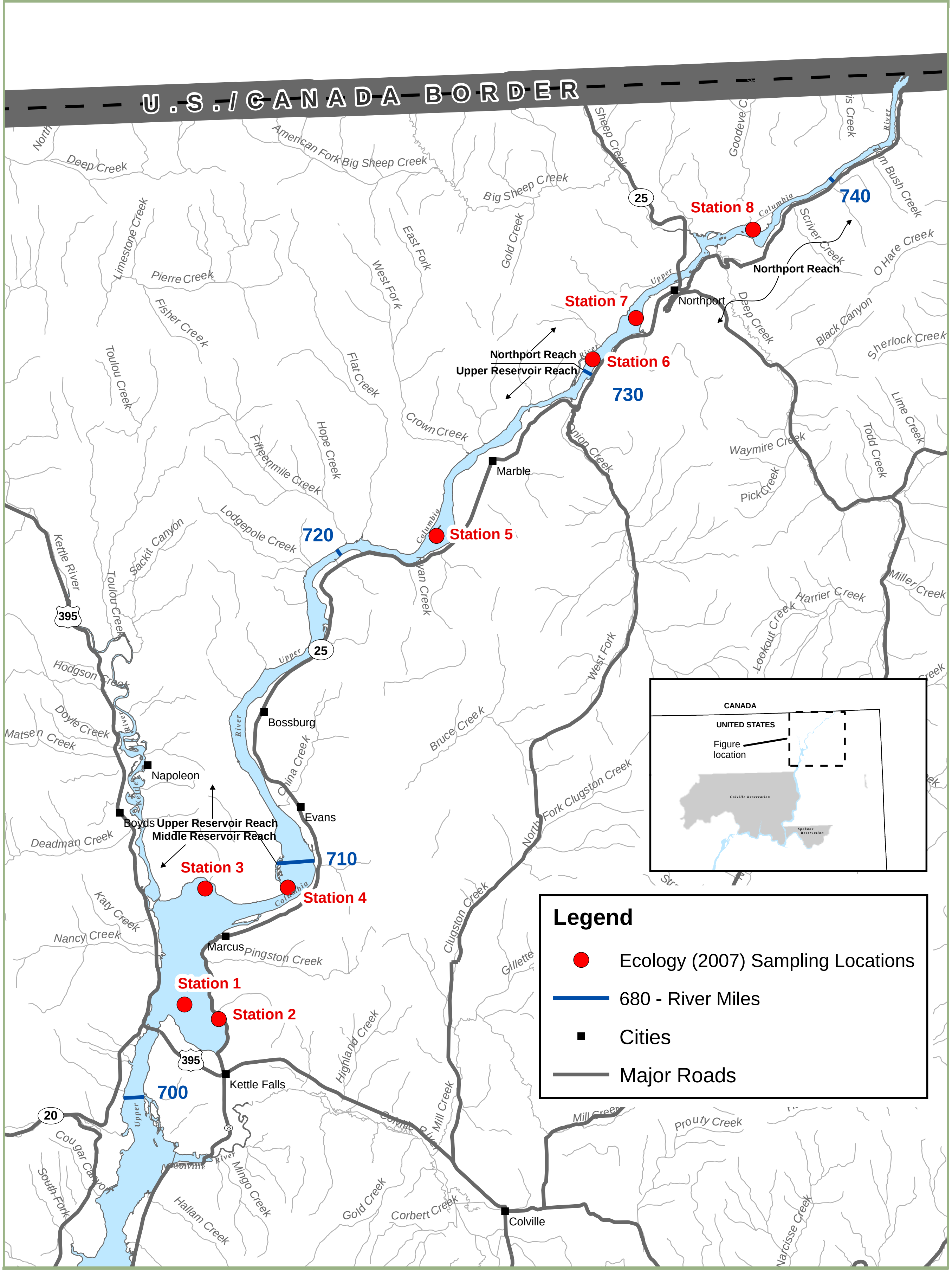
N

Map Notes

Prepared by: VBH Date: 01/26/2009

file path: Esc-server1\GIS\Projects\UCR\GIS\SRC\HHRA WorkPlan Draft 2 Rev2_Jan09\UCR_HHRA_WP_Draft2_Map 8-6.mxd

Map 8-7. Ecology (2007) Sediment Sampling Locations

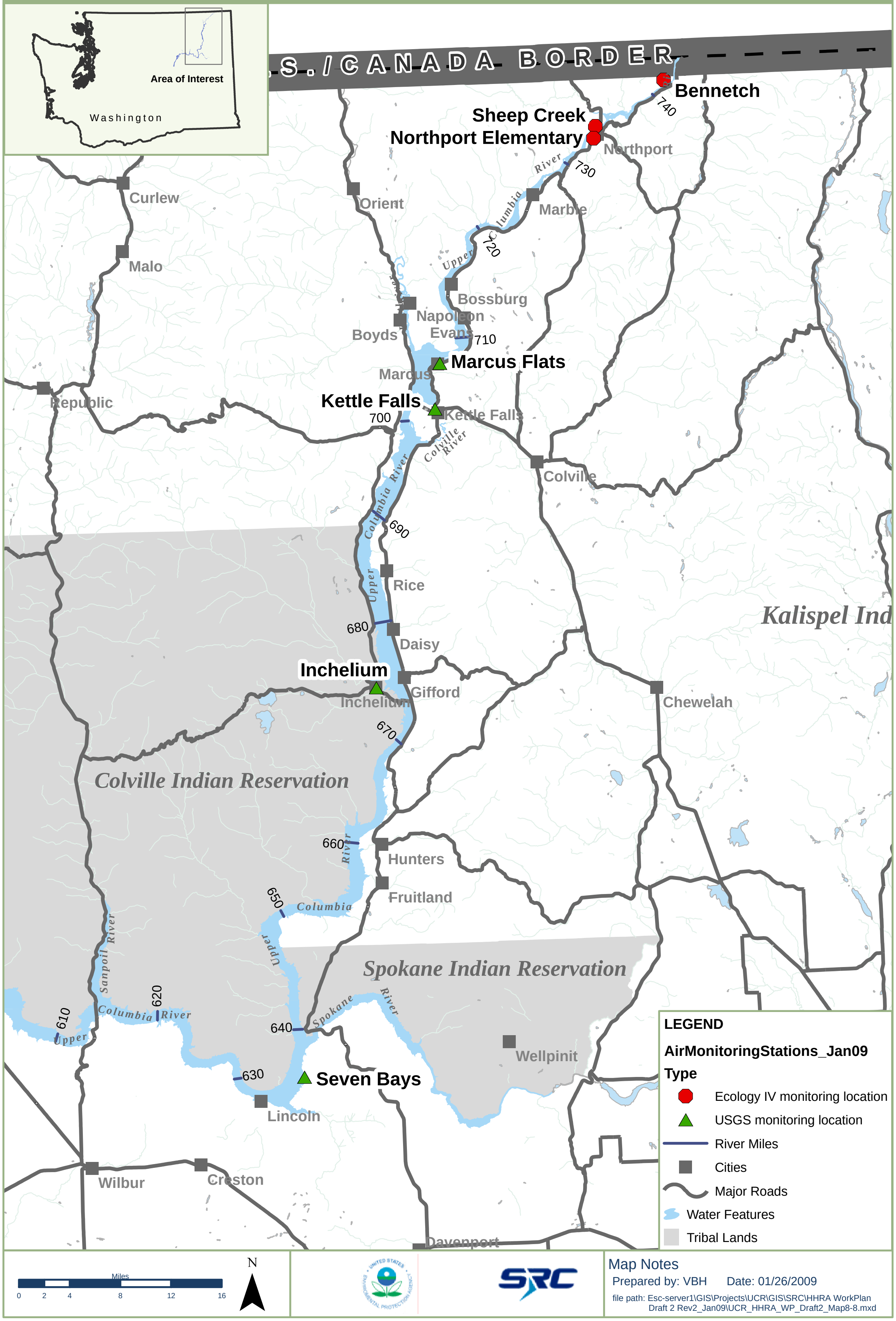


Miles
0 0.5 1 2 3 4 5

N

Map Notes
Prepared by: VBH Date: 01/26/2009
file path: Esc-server1\gis\Projects\UCR\GIS\SRC\HHRA Work Plan Draft2 Rev2_Jan09\UCR_HHRA_WP_Draft2_Map8-7.mxd

Map 8-8. Outdoor Air Monitoring Stations

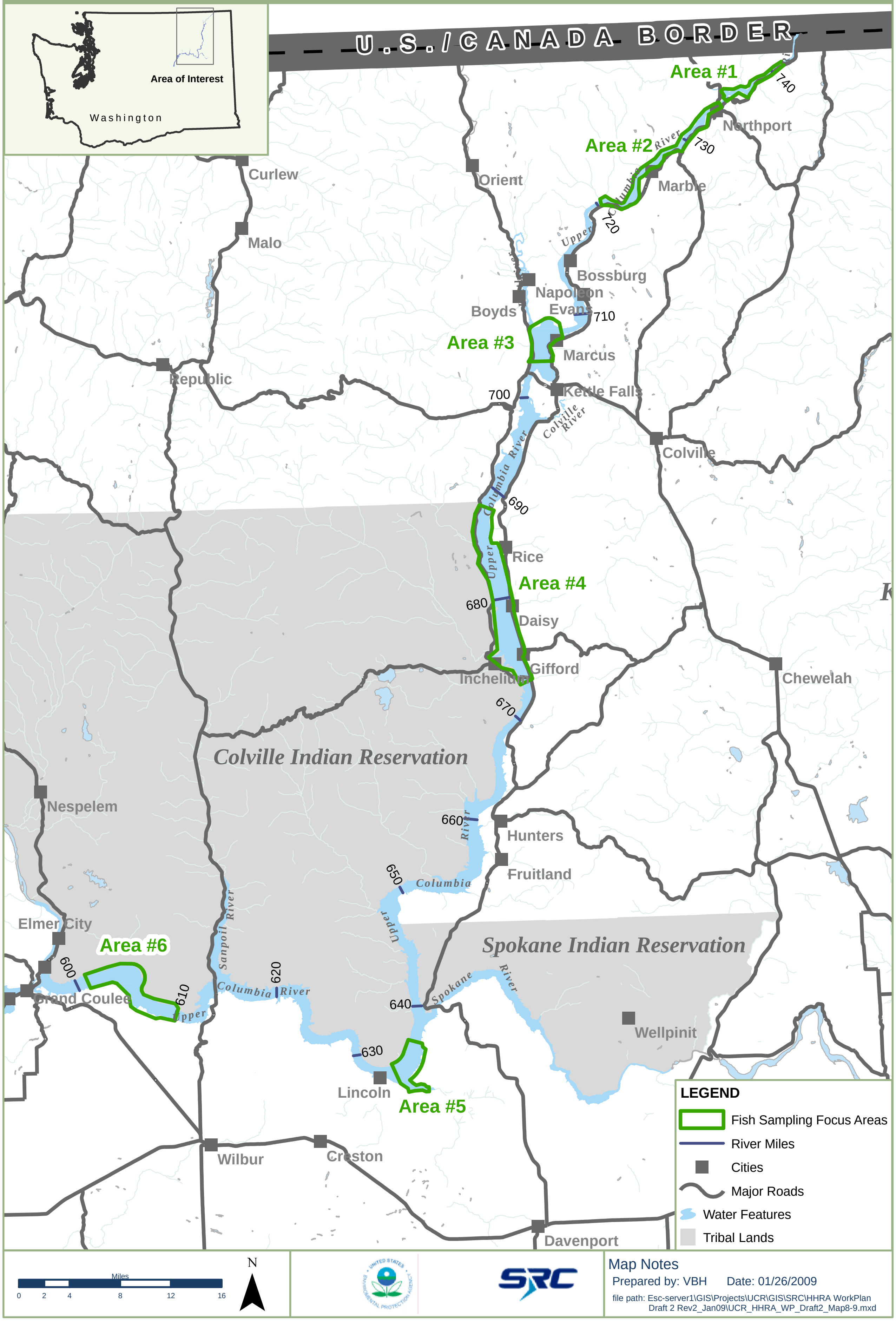


Map Notes

Prepared by: VBH Date: 01/26/2009

file path: Esc-server1\GIS\Projects\UCR\GIS\SRC\HHRA WorkPlan Draft 2 Rev2_Jan09\UCR_HHRA_WP_Draft2_Map8-8.mxd

Map 8-9. EPA 2005 Phase I Fish Tissue Sampling Locations



Map Notes
Prepared by: VBH Date: 01/26/2009
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