

**Draft**  
**Screening-Level Risk Assessment For Recreational Use Of Beaches**  
**Upper Columbia River**  
**Remedial Investigation and Feasibility Study**

**Prepared by:**  
**U.S. Environmental Protection Agency**  
**Region 10**  
**1200 Sixth Avenue**  
**Seattle, Washington 98101**

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# Executive Summary

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The UCR Site is located in north central Washington, and extends from the U.S.- Canadian international border south and west to the Grand Coulee Dam, a distance of approximately 150 miles down river (see Figure 1-1 in Section 1). The UCR site includes short free-flowing reach of the Columbia River and Franklin D. Roosevelt Lake (Lake Roosevelt), a large reservoir maintained behind the Grand Coulee Dam. EPA prepared this screening assessment in response to public concern regarding the safety of recreating on beaches along the UCR, especially for those beaches which appear to be largely comprised of riverine deposits of slag (Majewski et al., 2003).

Previous investigations by federal and state agencies have identified the presence of contamination within the U.S. portion of the Upper Columbia River (UCR) and surrounding upland areas from the Grand Coulee Dam to the Canadian border (Bortelson et al., 1994; U.S. Environmental Protection Agency Region 10, 2003). Other studies evaluated contaminant source areas and effects north of the Canadian border (Godin & Hagen, 1992; Nener, 1992; Goodarzi, Sanei & Duncan, 2001; Goodarzi et al., 2002; McMartin et al., 2002). Contaminants found by those studies include heavy metals such as cadmium, copper, lead, mercury, and zinc.

In August 1999, the Colville Confederated Tribes petitioned EPA to conduct an assessment of the UCR (The Confederated Tribes of the Colville Reservation, 1999). The petition expressed health and ecological concerns from contamination in the river. Consequently, EPA completed a preliminary assessment and expanded site inspection, which indicated that further data collection and Remedial Investigation and Feasibility Studies (RI/FS) were needed (Ecology and Environment (E&E), 2000; Ecology and Environment (E&E), 2002; U.S. Environmental Protection Agency Region 10, 2003)

Because Franklin D. Roosevelt Lake (Lake Roosevelt) and Grand Coulee Dam are designated as National Recreation Areas, there is a concern that people may be exposed to unsafe levels of contaminants along the river during occasional beach visits. EPA prepared this recreational beach screening assessment in an effort to begin to address concerns expressed over the safety of recreating on beaches in the Upper Columbia River and Lake Roosevelt. This screening level risk assessment is based on beach sediment samples collected in April, 2005 as part of a larger sediment study. The sediment study also involved the collection of a large amount of submerged sediment samples to assess the nature and extent of contamination and to assess risks to the environment (U.S. Environmental Protection Agency Region 10, 2006).

Of the fifteen beaches examined, twelve are safe for recreational use, and the remaining three, northernmost locations ("Black Sand Beach", Northport, and Dalles) will be re-evaluated using the recreational use scenario. If your exposure is limited to ingesting sediment while camping (with young children) along the shoreline for 14 days per year, returning for 30 years, then 12 of the beaches are safe and 3 of the beaches warrant additional study. These beaches present cancer risks on the order of 1 in a million.

Additional studies are planned to occur as part of the Human Health Risk Assessment to address residential, tribal, and other types of exposures and land use.

This screening level risk assessment entailed calculating a safe concentration for each metal of concern for comparison to the maximum level of each metal encountered at each of the 15 beaches. This safe concentration is a Preliminary Remedial Goal (PRG). The PRG was compared to the maximum level of each metal found on each of the 15 beaches. The maximum for arsenic was greater than the PRG at the following 3 of the 15 sites (listed from north to south):

- “Black Sand” Beach at river mile 742
- Northport City Boat Ramp at river mile 735 (this was the only location with a maximum lead concentration above the 400 mg/kg)
- Dalles Orchard at river mile 729

None of the other metals exceeded PRGs at the remaining 12 beaches along the Upper Columbia River or Lake Roosevelt.

Although 12 of the 15 beaches were below the recreational screening levels, these beaches along with the three northernmost locations will be evaluated for other types of uses, including residential or tribal uses. However, no significant health risk to recreational users is posed from exposures to sediment at the three locations with levels of arsenic or lead slightly above screening levels because the screening levels were selected to be very protective for recreational uses.

Although this assessment was developed to prioritize beaches based on limited recreational use, the results suggest that sediments along the beaches would also present minimal risks for residents who frequent the beaches on a daily basis.

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# Abbreviations and Acronyms

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AF	adherence factor
COPC	chemical of potential concern
CSM	conceptual site model
CTE	central tendency estimate
Ecology	Washington State Department of Ecology
HHRA	human health risk assessment
HQ	hazard quotient
MTCA	Washington State Model Toxics Control Act
NOAEL	no-observed adverse effect level
PbB	blood lead levels
PRG	preliminary remediation goal
RBC	risk-based concentration
RI/FS	Remedial Investigation and Feasibility Studies
RfD	reference dose
RME	reasonable maximum exposure
SA	surface area
SF	slope factor

# Introduction

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## 1.1 Background and Site Description

The Upper Columbia River (UCR) site is located in north central Washington, and extends from the U.S. – Canadian international border south and west to the Grand Coulee Dam, a distance of approximately 150 miles down river (Figure 1-1). The UCR site includes a short free-flowing reach of the Columbia River and Franklin D. Roosevelt Lake (Lake Roosevelt), a large reservoir maintained behind the Grand Coulee Dam. EPA prepared this screening assessment in response to public concern regarding the safety of recreating on beaches along the UCR, especially for those beaches which appear to be largely comprised of riverine deposits of slag (Majewski et al., 2003). Because the Upper Columbia River and Lake Roosevelt are a popular destination to camp, boat, swim, or otherwise recreate, there is a concern that people could potentially be exposed to metals in beach sediments along the river.

## 1.2 Purpose

This report documents a screening evaluation of contaminant concentrations in beach sediment along the banks of the Upper Columbia River and Lake Roosevelt from the Canadian border to the Grand Coulee Dam. Fifteen beaches along the Upper Columbia River and Lake Roosevelt were sampled as representative of popular recreational sites based on comments received from The Confederated Tribes of the Colville Reservation (CCT), the Spokane Tribe of Indians (STI), the National Parks Service, and the Washington Departments of Ecology and Health. The purpose of performing a screening level risk assessment is to provide a high degree of confidence that a health threat does not exist or, alternatively, to determine if further evaluation is warranted in the RI/FS.

## 1.3 Site Description

The Upper Columbia River (UCR) site is located in north central Washington, and extends from the U.S.–Canadian international border south and west to the Grand Coulee Dam, a distance of approximately 150 miles down river (see Figure 1-1). The UCR site includes a free-flowing reach of the Columbia River and Franklin D. Roosevelt Lake (Lake Roosevelt), a large reservoir maintained behind the Grand Coulee Dam. EPA prepared this screening risk assessment in response to public concern regarding the safety of recreating on beaches along the UCR, especially for those beaches which appear to be largely comprised of riverine deposits of slag (Majewski et al., 2003).

## 1.4 Methods

### 1.4.1 Field Sampling

Sediment samples were collected from the upper 15 cm at three elevations (1250, 1260, and 1280 feet above mean sea level) along the shoreline, and analyzed for metals, PCB arochlors, dioxins, furans, and pesticides. The sample elevations were selected to be exposed between 20 and 100 percent of the time during a typical water year. Samples were collected along beaches where exposure is expected from the surface to a depth 15 cm.

### 1.4.2 Selection of Contaminants for Screening

The following seven contaminants were selected because the maximum concentrations of at least one beach sample exceeded the residential Preliminary Remedial Goals (PRG) developed by Region 9 (Smucker, 2004) <http://www.epa.gov/region09/waste/sfund/prg/index.html>. Because the residential PRGs are based on exposures of 350 days per year for 30 years, they are protective for 14 days of intense recreation use per year. None of the other chemicals (e.g., PCB arochlors, dioxins, furans, and pesticides) exceeded the Region 9 Residential PRGs.

The following seven metals were selected for evaluation because the maximum levels exceeded the Region 9 PRG:

- Antimony
- Arsenic
- Copper
- Iron
- Lead
- Manganese
- Uranium

After comparison of maximum sample concentrations with recreational PRGs, exceedances were limited to arsenic and lead.

### 1.4.3 Screening Process

The screening level risk assessment entailed calculating a safe concentration for each metal of concern for comparison to the maximum level of each metal encountered at each of the 15 beaches (Table 1-1). This safe concentration is Preliminary Remedial Goal (PRG) (U.S. Environmental Protection Agency, 2005a). The PRGs were developed for screening purposes; they are not clean-up levels (U.S. Environmental Protection Agency, 2005a). Based on this comparison, sites were grouped into one of the following categories:

- Excluded from further consideration because they are unlikely to pose a threat to human health from recreational use, or
- Evaluated further in the RI/FS

Because young children are the most vulnerable, because of their high potential for sediment ingestion and their low body weight, PRGs developed to ensure protection of children are protective of older children and adults. PRGs developed for beach sediment

TABLE 1-1

Values for Selected Contaminants of Concern on UCR Beaches (all values are expressed in mg/kg dry weight)  
Upper Columbia River RI/FS

<b>Metal</b>	<b>Maximum (mg/kg dry wt)</b>	<b>Region 9 Residential PRG</b>	<b>Recreational PRG</b>
Antimony	53	31	521
Arsenic	36	0.4	13 <sup>a</sup>
Copper	3,290	3,129	52,143
Iron	254,000	23,463	782,143
Lead	535	400	400
Manganese	4,780	1,762	60,833
Uranium	84	16	261

<sup>a</sup>13 mg/kg is the risk-based PRG for arsenic, but this value was increased to account for naturally occurring arsenic at approximately 3 mg/kg for an adjusted PRG of 16 mg/kg (associated with an incremental risk of 10–6 see discussion on background levels).

assume children will be exposed to beach sand sediment through ingestion and dermal contact and will ingest more sediment (i.e., eat more dirt) while playing at the beach than they would in their home setting on a per day basis because of greater access to uncovered sand or sediment and more limited access to washrooms compared with a home or school. Consistent with EPA dermal exposure guidance, the dermal pathway was evaluated for arsenic only because absorption factors are not currently available for other metals (U.S. Environmental Protection Agency, 2004b). Children were assumed to visit the beaches for up to 14 days per year. For arsenic, the only carcinogen evaluated, the 14-day exposure was repeated annually for 30 consecutive years. For children, the PRG was based on a high rate of sediment ingestion equal to 300 mg/day based on the 90<sup>th</sup> percentile from a soil ingestion study of children camping (van Wijnen, Clausing & Brunekreef, 1990). The adult sediment ingestion rate was 100 mg/day, equivalent to a full-time residential rate (U.S. Environmental Protection Agency, 1991a).

#### 1.4.4 Preliminary Remediation Goal for Lead

PRGs are developed differently for lead than for the other metals. EPA uses a mathematical model to estimate blood lead levels in children up to 84 months of age (U.S. Environmental Protection Agency, 2005b). The model was used to calculate the national residential soil lead screening level of 400 mg/kg. This level associated with 5% risk of attaining an *elevated* blood lead level of 10 µg/dL (U.S. Environmental Protection Agency, 1998b). Currently, 10 µg/dL is recognized as an elevated blood level for children by EPA and the Centers for Disease Control and Prevention (Centers for Disease Control and Prevention, 1991; U.S. Environmental Protection Agency, 1998b). The 400 mg/kg national screening level was selected as a protective recreational PRG for this screening assessment. Alternative scenarios or assumptions may be used to assess risks for other types of activities in the forthcoming RI/FS.

### 1.4.5 Preliminary Remediation Goal for Metals Other Than Lead

PRGs were calculated using standard EPA risk equations and solving for concentration (U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response, 1996b). Target risk goals and equations differ for carcinogenic or non-carcinogenic effects. PRGs are calculated by defining a target cancer risk or hazard goals, a set of exposure assumptions, and then solving sediment concentration. Arsenic was the only carcinogen evaluated. The arsenic PRG is based on the low end of EPA's acceptable cancer range, which is an increased cancer risk of one in a million ( $10^{-6}$ ). This level was adjusted to account for local levels of naturally occurring arsenic at approximately 3 mg/kg. Based solely on cancer risk, PRG would be 13 mg/kg, but the average background level is 3 mg/kg, these levels were added to realize an adjusted PRG of 16 mg/kg. A PRG based on non-cancer arsenic effects would be substantially higher at 540 mg/kg. The target risk goal for non-carcinogenic hazards is a hazard quotient (HQ) of 1. An HQ of 1 is the point at which the estimated dose equals the protective dose or Reference Dose (RfD).

### 1.4.6 Beach Recreation

Typical recreational uses on the beach areas are:

- Dry beach play – playing and digging in the sand,
- Shallow water play – wading, splashing, or swimming
- Camping, picnicking, or cooking
- Boat launching and retrieval

These recreational activities may include intensive contact with sediments, especially when individuals are moving in and out of the water and in contact with beach sand. Of particular interest is a young child playing on the sand, where wet materials are more likely to adhere to skin, and a large proportion of skin is exposed (Finley & Scott, 1996; Kissel, Richter & Fenske, 1996). Under these conditions, adhered materials are available for hand-to-mouth ingestion and, to a lesser extent, for dermal absorption.

### 1.4.7 Limitations of this Assessment

The focus of this screening level risk assessment is the sediment ingestion pathway by children; however, examples of other receptors and exposure pathways that will be part of the forthcoming RI/FS work include-exposures that occur during fishing, hunting, or gathering of other food items from the Upper Columbia River and Lake Roosevelt. This assessment does not address risks associated with wind blown sediment. Dust storms are currently being investigated by the U.S. Geological Survey, but results are not yet available (Majewski et al., 2003). These exposures will be addressed in the forthcoming baseline risk assessment.

Mercury is the primary concern from fish consumption. EPA is currently analyzing fish tissue for an extensive array of potential contaminants, but the fish consumption pathway is not included in this screening assessment. This pathway will be investigated in the near future by both the Washington Department of Health and EPA.

It is also possible that park maintenance workers could be exposed to contaminants in sediment during the course of their work activities. Because the screening levels are

protective of children during beach play, the screening concentrations are likely protective of adult maintenance workers at the depths sampled. However, it is possible that contamination may be present below samples depth used in this assessment which could expose excavation workers.

The focus of this expedited risk assessment is the development of screening levels for beach sediment that will protect all visitors recreating along the Upper Columbia River and Lake Roosevelt. Recreational exposure was evaluated based on children ingesting sediment and getting sediment on their skin (dermal contact). Children were selected as the most sensitive population based on their potentially higher ingestion of sediment and lower body weight.

This report was prepared in accord with EPA's current risk assessment guidelines (U.S. Environmental Protection Agency Office of Solid Waste And Emergency Response, 1989; U.S. Environmental Protection Agency, 1991c; U.S. Environmental Protection Agency, 2000; U.S. Environmental Protection Agency, 2002b; U.S. Environmental Protection Agency Office of Emergency and Remedial Response, 2002; U.S. Environmental Protection Agency, 2004a; U.S. Environmental Protection Agency, 2004b; U.S. Environmental Protection Agency, 2006). The evaluation follows the best available science and professional judgment to reflect site-specific conditions that are not specifically addressed in appropriate regulatory guidance.

The accuracy of this report depends in part on the quality and representativeness of the available sampling, exposure, and toxicological data. Where information is incomplete, health-protective assumptions were made so that public health risks were not underestimated. Section 4 presents a discussion of uncertainties in the risk assessment resulting from data limitations.

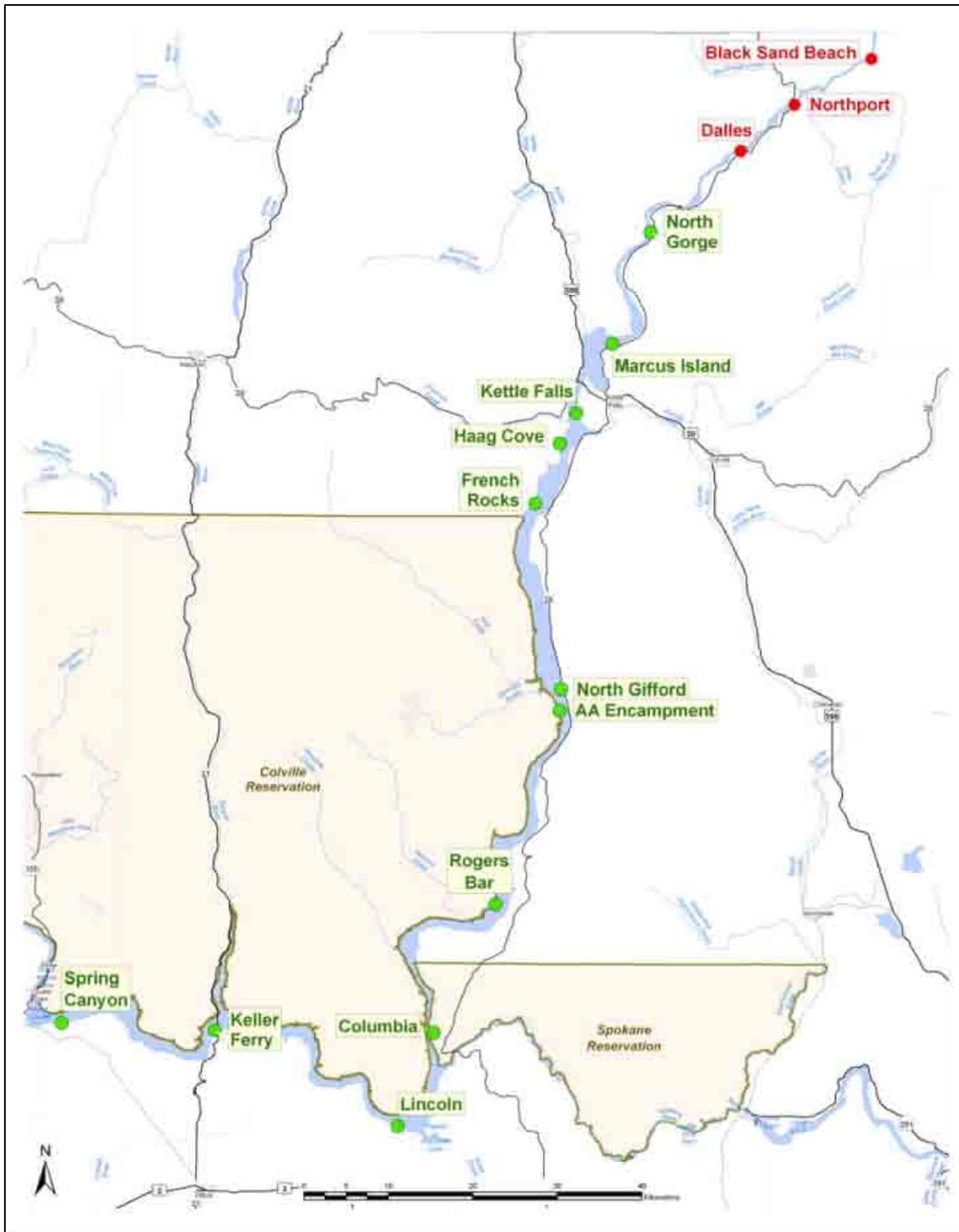


FIGURE 1-1  
Upper Columbia River and Lake Roosevelt Beach Area Sampling Sites

## SECTION 2

# Data Evaluation

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This section provides a summary of the sampling and analysis completed to support this screening assessment. Samples were collected from sediment (i.e., beach sand) on the portions of the beach used by people for recreation. Ortho photographs showing the sample locations are presented in Appendix B. Sections below describe the numbers and types of samples collected at each beach and present analytical results. Also described are the chemicals of potential concern (COPCs) and the background concentrations of metals in sediment for the Upper Columbia River and Lake Roosevelt.

Data were gathered for this screening level analysis as described in the Sediment Sampling Approach and Rationale report prepared by CH2MHill (U.S. Environmental Protection Agency Region 10, 2006). Overall objectives for the Phase I sediment sampling include the following:

- Evaluate human health risks from recreational exposure at 15 high-use locations dispersed along the Upper Columbia River and Lake Roosevelt
- Define nature and extent of sediment contamination
- Describe longitudinal and transverse spatial trends of sediment contamination
- Collect concentration depth data from sediment cores
- Describe temporal trends by comparing data collected in 2005 with prior sediment data

After screening maximum beach samples against Region 9 Residential PRGs, the following chemicals of potential concern were identified. Maximum beach sample concentrations were then screened against recreational PRGs for these metals, with the exception of lead – where a residential PRG was used as the recreational PRG. See Appendix A for results of the COPC screening.

- Antimony
- Arsenic
- Copper
- Iron
- Lead
- Manganese
- Uranium

## 2.1 Sampling Investigations

For this recreational screening risk assessment, samples were collected from beach sediment at 15 locations along the Upper Columbia River and Lake Roosevelt based on input from the Confederated Tribes of the Colville Reservation, the Spokane Tribe of Indians, Washington State, and the National Parks Service. Beach locations were distributed along the entire

length of the site. Additionally, within each location, samples were located based on local knowledge (gleaned during discussions with staff from the Tribes and National Parks Service) of high use areas based on proximity to swim beaches, campgrounds, play equipment, boat ramps, and other amenities.

## 2.2 Sediment Sampling

Appendix A summarizes the results of COPCS at each location. The objective of the sampling was to produce sufficient data for screening against PRGs. Surface samples were collected from the upper 10-15 cm at three locations and three elevations for a total of 9 sub-samples. These sub-samples were combined at each of the three elevations to yield three composite samples at 12 locations. The 9 sub-samples collected at the Northport, Kettle Falls, and Columbia Campground beaches were not combined. At these beaches, all 9 samples were analyzed separately to measure variability between sub-samples. Ratios of the maximum to mean concentrations were relatively small, (i.e., generally less than 2x for the composites and less than 3x for the discreet samples).

## 2.3 Sediment Laboratory Analyses

The laboratory had problems with the analyses for antimony and uranium. In the case of antimony, the many results were rejected due to low matrix spike recoveries (i.e., recovery below 30 percent) that indicated low bias in the measurement. This was not caused by laboratory or field error, but is intrinsic to the nature of the sediments collected. Despite uncertainties in the antimony results, the highest value encountered was one tenth of the PRG and it is unlikely that antimony poses a risk to people on the beaches. More than 75% of the uranium analyses were below the detection limit which varied between 5 and 129 mg/kg depending on the lab result and the moisture content of the sediment. However, even the maximum non-detect value was below the PRG of 261 mg/kg.

## 2.4 Results

After a comparison of the full suite of chemicals, including pesticides, organic compounds, PCBs, dioxins, furans, and metals, seven metals had maximum concentrations which exceeded residential land use soil screening values (Smucker, 2004). Recreational PRGs were developed to screen beaches based on 14 days of use per year instead of 350 days of use per year for residential land use PRGs. For children, the PRG was based on a high rate of sediment ingestion equal to 300 mg/day based on the 90<sup>th</sup> percentile from a soil ingestion study of children camping (van Wijnen, Clausing & Brunekreef, 1990). The adult sediment ingestion rate was 100 mg/day, equivalent to a full-time residential rate (U.S. Environmental Protection Agency, 1991a). When compared with recreational PRGs, three of the fifteen locations had concentrations above the arsenic PRG and one sample exceeded the lead PRG (Table 2-1). Levels for these metals exceeded the residential PRGs by a small margin. The maximum concentration for arsenic was greater than the PRG at the following 3 of the 15 sites (listed from north to south):

TABLE 2-1  
Summary of Beach Screening Results  
*Upper Columbia River RI/FS*

Beach (listed from North to South)	Bank – River Mile	Exceeds PRG
“Black Sand” Beach	East – 742	Arsenic
Northport Boat Ramp	East – 735	Arsenic      Lead
Dalles Orchard	East – 729	Arsenic
North Gorge Campground	East – 718	Pass
Marcus Island Campground	East – 708	Pass
Kettle Falls Swim Beach	East – 700	Pass
Haag Cove	West – 697	Pass
French Rocks Boat Ramp	West – 690	Pass
North Gifford	East – 675	Pass
AA Campground	East – 673	Pass
Roger’s Bar	West – 658	Pass
Columbia Campground	East – 642	Pass
Lincoln Mills Boat Ramp	East – 633	Pass
Keller Ferry No. 2	East – 615	Pass
Spring Canyon Campground	East – 600	Pass

- “Black Sand” Beach at river mile 742
- Northport City Boat Ramp at river mile 735 (this was the only location with a maximum lead concentration above the 400 mg/kg)
- Dalles Orchard at river mile 729

None of the other chemicals (e.g., PCB arochlors, dioxins, furans, and pesticides) exceeded recreational PRGs. Although this screening risk assessment was based on recreational use of the beaches, because the arsenic recreational PRG was based on a 1 in a million cancer risk and the lead recreational PRG was equal to the residential PRG, risks from sediment exposure would still be modest, even under a full-time residential land-use scenario.

## 2.5 Sediment Background Concentrations

Background concentrations for the seven metals of concern are presented in Table 2-2. These background concentrations are based on results from sediment reference samples collected in 2005 by EPA, the U.S. Geological Survey in 1995 and 1990, and Ecology’s Natural Background Soil Metals Concentrations in Washington State (Washington State Department of Ecology, 1994; Majewski et al., 2003).

**TABLE 2-2**  
Reference Concentrations for Metals of Potential Concern  
*Upper Columbia River RI/FS*

<b>Metal</b>	<b>Reference Concentration Range (mg/kg)</b>
Antimony	0.1 – 1.4
Arsenic	1 – 10
Copper	10 – 25
Iron	5,100 – 34,000
Lead	8 – 47
Manganese	129 – 1,000
Uranium	0.5

## SECTION 3

# Development of PRGs

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The purpose of establishing a PRG is to provide a point of comparison below which there is a high degree of confidence that a health threat does not exist. *Alternatively, a health threat may not exist at beaches where metals occur above the PRG.* To develop a PRG, the amount of exposure to a given chemical must be defined, an estimate of the toxicity of each chemical must be available, and target cancer risk and other health hazard goals must be established. Each of these three categories: exposure, toxicity, and target risk, are included in equations to calculate the PRG. Although, true for all metals examined, the lead PRG was based on a the national soil PRG for lead, which is based on limiting lead exposure, based on a modeled 5% target risk of attaining a blood level of 10 µg/dL for a child aged 6-84 months (U.S. Environmental Protection Agency, 1998b). Toxicity data was based on EPA sources, primarily the online Integrated Risk Information System (IRIS) <http://www.epa.gov/iris/> (Cook, 2003).

## 3.1 Exposure Assessment

In a screening risk assessment, exposure is defined conditionally to calculate the PRGs. A screening assessment is an “If - Then” statement created to prioritize areas based on a clearly defined exposure scenario. For this assessment, the statement is:

If your exposure is limited to ingesting sediment while camping (with young children) along the shoreline for 14 days per year, returning for 30 years, then 12 of the beaches are safe and 3 of the beaches warrant additional study. These 3 beaches present cancer risks on the order of 1 in a million.

EPA defined the target population as young children because they are the most sensitive to potential risks from ingesting beach sediment. Young children typically ingest more sediment than older children, or adults, because they are often on the ground, have greater hand-to-mouth contact, and ingest more material normalized to their lighter body weight (Simon, 1998). In addition to their greater potential for exposure, children are more sensitive to lead because their brains are still developing (National Academy of Sciences, 1993). Recent research suggests that early life exposures may contribute to the onset of diseases in later life (Barker, 2004; Smith et al., 2006).

Exposure was defined as a 14-day camping scenario with young children and associated high rates of sediment ingestion and dermal exposure, reoccurring over 30 years. The 14-day exposure frequency was based on National Park Service limits to camping. Repeating exposure over 30 years makes for a more protective PRG for arsenic, the only carcinogen evaluated, but does not effect the PRGs for other metals.

### 3.1.1 Ingestion of Soil

Incidental ingestion of soil is believed to be the primary route of exposure for metals in outdoor settings (Duggan & Inskip, 1985; Duggan et al., 1985). Young children are more

likely to ingest soil during outdoor play than adults because of their more frequent hand-to-mouth actions and tendency to play in sand (U.S. Environmental Protection Agency, 1997a; U.S. Environmental Protection Agency, 2002a). Although adults also ingest soil, they typically ingest less soil than children (Stanek et al., 1997). Because adults ingest less soil than children, PRGs protective of children will protect adults.

The best estimates of soil ingestion rates in children are from mass balance tracer studies which estimate soil ingestion based on elements found in soil and feces, and even these studies reflect a high degree of uncertainty (previous studies have been published without any measurements at all) (Hawley, 1985). Ideally, soil tracers have a low content in the diet and low gastrointestinal absorption. Tracer studies measure all sources of tracers that were ingested, including outdoor soil, indoor house dust, airborne dust that is trapped in the upper respiratory tract and swallowed, food, medicines, vitamins, paint chips, baby powder, and toothpaste. The most reliable studies have attempted to correct for the contribution of tracers from the diet and from medicines (U.S. Environmental Protection Agency, 1997a).

For residential exposure scenarios, EPA has recommended a Reasonable Maximum Exposure soil (i.e., the highest value that is reasonably expected to occur within a population) ingestion rates of 200 mg/day for young children (ages 1 through 6) and 100 mg/day for older groups (U.S. Environmental Protection Agency, 1991a). These values are protective estimates of average values for soil and dust ingestion over a chronic period of exposure based on EPA's subsequent review of soil ingestion studies (U.S. Environmental Protection Agency, 1997a).

For exposures at the beach, children are assumed to potentially ingest greater amounts of soil/sediment than they would at home; consequently, the soil/sediment ingestion rate selected for the PRG calculations is 300 mg/day, rather than 200 mg/day. EPA selected this value because EPA believes it is based on the most relevant soil ingestion study for a camping scenario. The value is the 90<sup>th</sup> percentile from a study of 78 children camping adjacent to a lake (van Wijnen, Clausing & Brunekreef, 1990).

### 3.1.2 Dermal Contact With Soil

Dermal contact with soil is a complete pathway and was included in the PRG calculations concurrent with soil ingestion. However, a dermal absorption factor is available to quantify the dermal pathway for arsenic only (U.S. Environmental Protection Agency, 2004b).

EPA recommends the use of oral toxicity criteria for the dermal pathway, with a conversion factor to convert the orally administered toxicity criteria to an internally absorbed dose, and an absorption factor for the amount of chemicals which cross the skin and enter the blood stream (U.S. Environmental Protection Agency, 2004b). The importance of dermal exposures relative to ingestion exposures for soil depends on the chemical-specific absorption fraction and relative bioavailability factors associated with the dermal and ingestion routes. In this assessment, dermal absorption of arsenic is insignificant relative to ingestion (Lorenzana et al., 1996).

### 3.1.3 Gastrointestinal Absorption

The dose calculated by the exposure assessment is an “administered” dose unless it is adjusted to account for systemic absorption into the blood stream (“absorbed” dose). Absorption should be adjusted if the form of the chemical for the exposed population differs from the form of the chemical used to develop the toxicity criteria. In this assessment, EPA adjusted the arsenic absorption by a factor of 0.6 to account for reduced absorption of arsenic in sediment relative to arsenic in drinking water because the toxicity criteria for arsenic are based on drinking water exposures (U.S. Environmental Protection Agency Office of Solid Waste And Emergency Response, 1989; U.S. Environmental Protection Agency, 1998a).

### 3.1.4 Dermal Absorption

Because arsenic is the only metal with an available dermal absorbed fraction, dermal exposure calculations were limited exclusively to arsenic (U.S. Environmental Protection Agency, 2004b). The dermal absorption factor for arsenic is 3% (U.S. Environmental Protection Agency, 2004b).

### 3.1.5 Intake Calculations

For each exposure pathway and age group, the following equation calculates unit exposure, as dose per mg/kg of chemical in soil per day based on the exposure assumptions (see Table 3-1 below and Appendix D for detailed calculations).

#### Non-carcinogens

Soil Ingestion:

$$\text{Summary Intake Factor (SIF)} = CF \times IRS_c \times EF_c \times ED_q / (BW_c \times AT_n)$$

Dermal Soil Contact:

$$SIF = CF \times SA_c \times EF_c \times ED_c \times AF_c / (BW_c \times AT_n)$$

#### Carcinogens

Exposure is calculated differently for assessing carcinogenic risks than non-carcinogenic hazards. The averaging time for non-carcinogenic effects is the same as the exposure period (i.e., 6 years for children), whereas for carcinogenic effects the averaging time is equivalent to a lifetime, or 70 years (U.S. Environmental Protection Agency Office of Solid Waste And Emergency Response, 1989).

For evaluation of carcinogenic exposure, pathways with different exposures for two age groups (e.g., child soil ingestion and dermal contact), the total dose is calculated by:

1. Weighting the intake of each age group (e.g., 1- to 6-year-olds) by the length of time spent in that age group (e.g., 6 years)

TABLE 3-1  
Exposure Parameter Definitions  
*Upper Columbia River RI/FS*

Abbreviation	Name	Value and Units
CF	Sediment Conversion Factor	10 <sup>6</sup> mg per kg
IRS <sub>c</sub>	Sediment Ingestion Rate – Child	300 mg per day
IRS <sub>a</sub>	Sediment Ingestion Rate – Adult	100 mg per day
EF	Exposure Frequency	14 days per year
ED <sub>c</sub>	Exposure Duration – Child	6 years
ED <sub>a</sub>	Exposure Duration – Adult	24 years
AF <sub>c</sub>	Adherence Factor – Child	0.2 mg/cm <sup>2</sup>
AF <sub>a</sub>	Adherence Factor – Adult	0.07 mg/cm <sup>2</sup>
SA <sub>c</sub>	Exposed Surface Area – Child	6,600 cm <sup>2</sup>
SA <sub>a</sub>	Exposed Surface Area – Adult	15,000 cm <sup>2</sup>
BW <sub>c</sub>	Body Weight – Child	15 kg
BW <sub>a</sub>	Body Weight – Adult	70 kg
AT <sub>c</sub>	Averaging Time – Carcinogens	25,500 days
AT <sub>nc</sub>	Averaging Time – Non-Carcinogens	2,190 days

2. Summing the time-weighted doses from all age groups

3. Dividing by the averaging time, as follows:

Soil Ingestion:

$$SIF_{soil} = CF \times EF_c \times \{ (ED_c \times IRS_c / BW_c) + (ED_a \times IRS_a / BW_a) \} / AT_c$$

Dermal Soil Contact:

$$SIF_{dermal} = CF \times EF_c \times \{ (ED_c \times SA_c \times AF_c / BW_c) + (ED_a \times SA_a \times AF_a / BW_a) \} / AT_c$$

The dose for each pathway of exposure (ingestion of soil, dermal contact) is combined with the toxicity criteria and target health goals to estimate PRGs. Appendix D contains the spreadsheets with calculation details and a presentation of each formula used.

## 3.2 Toxicity Criteria

This section summarizes toxicity criteria used to calculate PRGs. A fundamental principle of toxicology is that the dose determines whether a chemical is toxic. For example, very high doses of iron or manganese are toxic, but both metals are essential nutrients at lower doses. Accordingly, the toxicity criteria describe the quantitative relationship between a chemical's dose and magnitude of toxic effect. The criteria are described below; toxicity

criteria used in this assessment are summarized in Table 3-2. It is noteworthy that for arsenic and lead, the only two metals which exceeded the PRG, the toxicity criteria are based on extensive studies of human populations exposed to these metals (National Academy of Sciences, 1993; National Academy of Sciences, 1999; National Academy of Sciences, 2001).

### 3.2.1 Oral Toxicity Parameters

Key dose-response parameters are EPA slope factors for assessing cancer risks, and EPA-verified reference dose (RfD) values for evaluating non-carcinogenic effects (Table 3-2). Most of these criteria are from the EPA's online data base Integrated Risk Information System (IRIS) <http://www.epa.gov/iris/>, but other sources of toxicity parameters are available from the Risk Assessment Information System [http://risk.lsd.ornl.gov/tox/tox\\_values.shtml](http://risk.lsd.ornl.gov/tox/tox_values.shtml).

#### Carcinogenic Effects of Arsenic

The cancer slope factor (SF) expressed as the inverse of dose units of mg/kg-day relates an increase in cancer risk as a function of dose. The dose response assumes that there is no threshold. In other words, any exposure to arsenic greater than zero is associated with a proportional increase in cancer risk, such that no dose is without some risk of cancer.

Arsenic's SF, the only carcinogen in this assessment, is based on human epidemiological studies and real environmental exposures. In Taiwan, a correlation has been made between high arsenic concentrations in drinking water and the increased incidence of skin cancer in humans (Tseng, 1977; Tseng, 1989). Therefore, EPA has classified arsenic as a proven human carcinogen (U.S. Environmental Protection Agency, 2003). Currently, the SF for arsenic is under review to incorporate findings from more recent studies including drinking water reviews (National Academy of Sciences, 1999; National Academy of Sciences, 2001). There are no cancer toxicity criteria for the other metals of concern, because there is no evidence to suggest that they are carcinogenic.

#### Non-carcinogenic Effects

The chronic RfD (expressed in units of mg/kg-day) is an estimated daily chemical intake rate for the human population, including sensitive subgroups, that appears to be without appreciable risk of non-carcinogenic effects if ingested over a lifetime. Because chronic criteria are based on lifetime average body weight and intake assumptions, they are likely to be protective when compared to child's exposure, with their lower body weight and greater sediment ingestion rate.

RfD values are derived from experimental data on a no-observed-adverse-effect level (NOAEL) or lowest-observed-adverse-effect level (LOAEL) in animals or humans. A NOAEL is the highest tested chemical dose given to animals or humans that has not been associated with any adverse health effects. A LOAEL is the lowest chemical dose at which health effects have been reported. RfDs are calculated by dividing a NOAEL or LOAEL by a total uncertainty factor, which represents a combination of individual factors for various sources of uncertainty in the data base for a particular chemical or in extrapolating animal data to humans. RfDs and associated uncertainty factors are summarized in Table 3-2 for each chemical. IRIS also assigns a level of confidence in the RfD. The level of confidence is

rated as either high, medium, or low based on the confidence in the critical study and underlying data.

TABLE 3-2  
Toxicity Criteria  
*Upper Columbia River RI/FS*

Chemical	Cancer SF (mg/kg-day) <sup>-1</sup>	Noncancer: RfD (mg/kg-day)	Health Endpoint	Uncertainty Factor Confidence in RfD	Reference
Antimony	None	0.0004	Reduced lifespan, altered glucose and cholesterol	1,000 Low confidence	(U.S. Environmental Protection Agency, 1991b)
Arsenic	1.5	0.0003	Skin cancer (SF), hyper pigmentation and hyperkeratosis of the skin (RfD)	3 Medium confidence	(U.S. Environmental Protection Agency, 1998a)
Copper	None	0.04	Renal, proteinuria	10 High confidence	(U.S. Environmental Protection Agency, 1997b)
Iron	None	0.6	Hematological effects	1 High	(Institute of Medicine, 2001; Stifelman <i>et al.</i> , 2005)
Lead	None	10 µg/dL in blood	CNS IQ and cognitive function	High	(Centers for Disease Control and Prevention, 1991; U.S. Environmental Protection Agency, 1998b)
Manganese	None	0.047*	CNS Motor Effects	1 Medium confidence	(U.S. Environmental Protection Agency, 1996)
Uranium	None	0.0002	Renal damage	1,000 Low confidence	(U.S. EPA National Center for Exposure Assessment, 2001)

Notes:  
RfD – Reference Dose  
SF – Slope Factor

\*Mn RfD is 0.14 with a MF of 3 for non-dietary assessments ( $0.14/3 = .047$ ) based on (U.S. Environmental Protection Agency, 1996)

### 3.2.2 Essential Nutrients

Of the seven chemicals of concern, three are essential nutrients: iron, copper, and manganese. RfDs for essential elements are developed to be protective against deficiency as well as toxicity. Therefore, RfDs for essential metals are protective against the toxic effects of over-exposure to these metals, and the RfDs supply adequate levels of the metal to meet the Recommended Daily Allowance guidelines (Institute of Medicine, 2001; U.S. Environmental Protection Agency, 2004a; Stifelman *et al.*, 2005).

### 3.3 Calculation of PRGs

This section calculates health-based PRGs for beach sediment. Preceding sections quantified exposure in terms of a unit dose of chemical along with the relative toxicity associated with exposure. This section uses this information to calculate sediment PRGs that are protective of health for sediment ingestion and dermal absorption for arsenic.

PRGs are calculated by defining a exposure parameters and a target risk level, then solving the equations for a sediment concentration (U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response, 1996a). The target cancer risk for arsenic, the only carcinogen assessed, is 1 in a million ( $10^{-6}$ ). This is the low end of EPA's cancer risk range spanning  $10^{-6}$  to  $10^{-4}$ . For lead, EPA relied on the EPA's national PRG of 400 mg/kg, instead of calculating a site-specific concentration (U.S. Environmental Protection Agency, 1994; U.S. Environmental Protection Agency, 1998b). The target risk for the remaining metals was a Hazard Quotient of 1.

The following equation was used for calculation of PRGs for oral and dermal exposure to arsenic (the only carcinogen in this assessment):

$$\text{Soil/Sediment PRG} = \text{Target Risk} / \{SF \times \{(SIF_{\text{sediment}}) + (SIF_{\text{dermal}} \times ABS_d)\}\}$$

The target risk goal for non-carcinogenic hazards is a hazard quotient (HQ) of 1. An HQ of 1.0 is the point at which the estimated dose equals the RfD.

PRGs based on noncancer effects for each the remaining metals, were calculated using the following equation for each pathway.

$$\text{Soil PRG} = \text{HQ} \times \text{RfD} / (SIF_{\text{soil}})$$

PRG calculations are included as Appendix D.

## SECTION 4

# Uncertainties in the Beach Screening Assessment

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The purpose of the screening level risk assessment was to prioritize beaches into two categories:

1. Excluded from further consideration because they are unlikely to pose a threat to human health from recreational use, or
2. Evaluated further in the Remedial Investigation and Feasibility Studies

The screening assessment produces the potential for two kinds of errors. The first is the potential to falsely retain a site for additional evaluation when, in fact, the site need not be considered a concern (false positive conclusion). The second is to falsely eliminate a site from further consideration when, in fact, there should be a concern (false negative conclusion). The assessment was designed to limit the potential for false negative errors in favor of the potential for false positive errors, which can be addressed during planned re-evaluations. Countering false positive errors is important to prevent response actions where they are not necessary. EPA wishes to limit the potential for false negative errors to avoid missing a potentially hazardous situation. Therefore, uncertainties were handled protectively in this screening assessment to reduce the potential for false negative conclusions (e.g., maximum concentrations from each of the beaches were used for screening).

EPA recognizes that perhaps the greatest uncertainty was caused limiting the sampling to 15 locations. During public meetings held in June 2006, EPA learned that the Agency did not include two popular beaches, namely Bradbury Beach and Colville Flats. Sampling at these locations will be recommended during the next phase of field work. Sampling at additional beaches in the vicinity of Dalles Orchard, Northport, and "Black Sand" beaches will also be considered.

PRG development requires assumptions about exposure and toxicity as well as defining a target level of risk. Assumptions about exposure are generally site-specific, in this assessment, 14 days was based on Park Service limits to camping and a high sediment ingestion rate was selected based on a study of children camping near a lake (van Wijnen, Clausing & Brunekreef, 1990; National Parks Service, 2006). Assumptions about toxicity are independent of the site, and depend on the standardized values (Cook, 2003).

PRGs for sediment included an assumption that ingestion of sediment during recreational activities was 300 mg/day for children up to six years old, and 100 mg/day for children older than six and adults. The 300 mg per day ingestion day is the 90th percentile value from a study of soil ingested by children while camping (van Wijnen, Clausing & Brunekreef, 1990). The average value from this study was 120 mg/day. Recreational users of the rivers may have a shorter exposure duration than 30 years assumed for the PRG calculation for arsenic or the 6-year total assumed for other metals. Shorter exposure

durations would produce proportionally less stringent PRGs. In addition to exposure parameters, PRG development required selection of a target acceptable risk level. For arsenic, the only carcinogen evaluated, the PRG was based on a  $1 \times 10^{-6}$  increased cancer risk, which represents the low end of EPA's cancer risk range of  $10^{-6}$  to  $10^{-4}$ . The lead PRG was based on the national soil screening value for lead (U.S. Environmental Protection Agency, 1998b). Because this value is typically used in residential settings, it is considered protective in a recreational setting. For the other metals, the target risk was a HQ of 1, which is considered a protective threshold for adverse health effects (U.S. Environmental Protection Agency Office of Solid Waste And Emergency Response, 1989).

The effects of simultaneous exposure to multiple chemicals can be additive, antagonistic (less than additive), or synergistic (more than additive). Whether and how chemicals interact depends on the level of exposure and characteristics of the individual chemicals. Adverse health interactions are unlikely to occur from beach sediment exposure because the exposure levels are low and the interactions are likely to be less than additive because copper, iron, manganese and zinc are essential minerals (Goyer, 1995). For example, iron and zinc decrease absorption and toxicity from exposure to lead (Goyer, 1997).

## SECTION 5

# Summary and Conclusions

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EPA has completed a screening level risk assessment for sediment exposure from limited recreational use at fifteen popular beaches along Lake Roosevelt and the Upper Columbia River. Twelve of the fifteen beaches are safely below health-based risk standards for all the contaminants EPA tested for, including arsenic, lead, pesticides, and PCBs. At three beaches EPA found levels of arsenic and/or lead that were slightly above EPA screening levels, but those beaches remain safe for seasonal recreation as well. This screening was limited to recreational use only, such as a family that camps for up to two weeks per year, returning for 30 years. More intensive uses of the beaches, such as year-round food gathering or camping for extended periods of several months or more were not addressed by this assessment, but will be addressed in the Upper Columbia River RI/FS.

The beach screening is a first step in evaluating potential risks from contamination. EPA will be using all of the sediment and fish tissue data EPA collected in 2005 to conduct an in-depth risk assessment for people living in the area and using the beaches year-round. That risk assessment may take several years to complete.

The highest levels of arsenic in beach sediments were found at the three most northern beaches EPA sampled (Black Sand, Northport, and Dalles). Arsenic levels at these beaches were still very low, but slightly higher than the screening level. Lead was also slightly higher than the screening level at Northport only. Since these three locations did not pass EPA's screening, EPA will re-evaluate them for recreational use during the full risk assessment. However, because the risks are low, these beaches are still safe for visitors to use.

The following is a summary of findings:

- Higher metal concentrations were found at the northern reach of the river.
- There was little difference between metals levels at different beach elevations.
- Three sites ("Black Sand" Beach, Northport, and Dalles) were selected for further evaluation based on the concentration of arsenic above screening levels. One of these sites, at Northport, also exceeded the screening level for lead.

## SECTION 6

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