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Rev. 0

Remedial Investigation Work Plan for Hanford Site Releases to the Columbia River

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Remedial Investigation Work Plan for Hanford Site Releases to the Columbia River

September 2008

United States Department of Energy

P.O. Box 550, Richland, Washington 99352

EXECUTIVE SUMMARY

This document presents a plan for initiating the CERCLA process (a Federal law that establishes how to evaluate and cleanup contamination in the environment) to investigate Hanford Site releases to the Columbia River. The information gained from performing this investigation will ultimately be used to help make final regulatory decisions for cleaning up Hanford Site contamination that exists in and along the Columbia River.

Purpose and Scope

Cleanup of contaminated soil and groundwater at the Hanford Site is under way and is striving to prevent further contaminants from reaching the Columbia River. However, some contaminants have already been released to the Columbia River from past discharges that occurred during the Hanford Site weapons production mission from 1943 to 1989. Waste disposal practices also resulted in release of contaminants to the soil. Some of the contaminants have moved from the soil into groundwater that lies beneath the Hanford Site, then moved with the flow of groundwater into the Columbia River where it comes up through the river bottom, or upwells. It is important to understand what contaminants are present, how concentrated they are, and where they are located at the present time because they may have undesirable effects on humans, animals, and plants that use or live in the Columbia River.

The purpose and scope of this work plan is to describe the initial work to:

- Collect and analyze samples to identify what Hanford Site-related contaminants are present in the Columbia River, what their concentrations are, and where they are located

- Use the sample results to estimate the current risk to humans, animals, and plants if they are exposed to Hanford Site-related contaminants while they use or live in the Columbia River

- Determine whether or not any cleanup actions are needed to lower the risk to humans, animals, and plants from being exposed to Hanford Site-related contaminants.

Depending on evaluation of the results, it is possible that additional investigation or sample collection activities may be needed that are not presently described in the work plan. The purpose and scope of any additional sample collection activities will be documented in a new work plan or a revision to this work plan.

Investigation Area

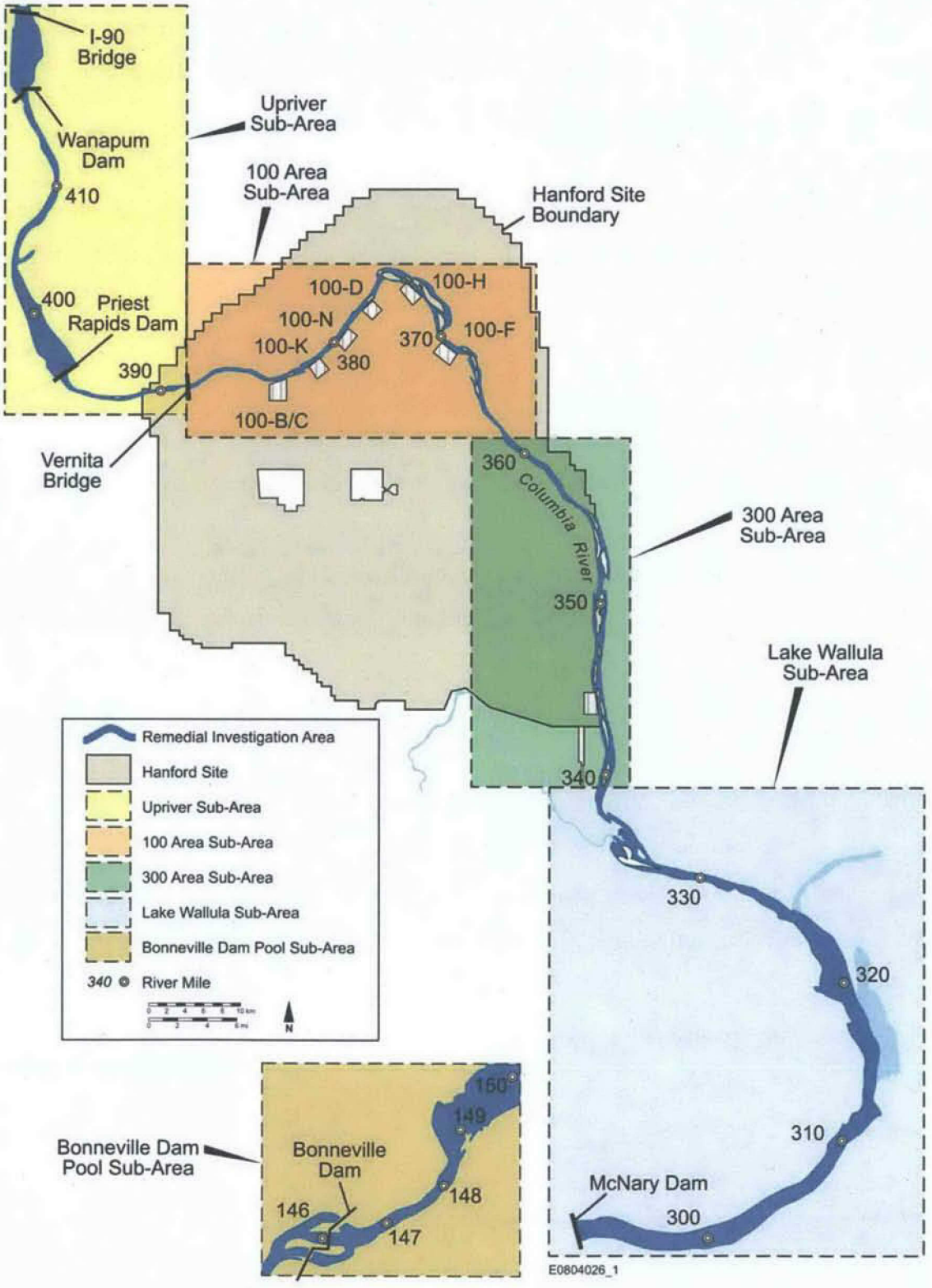
The investigation area was determined from review of existing sample results for the Columbia River from upstream of the Hanford Site to where it empties into the Pacific Ocean. Information relating to how the river flows through the land, the shape of the river bottom, construction periods for dams along the Columbia River, and the Hanford Site operational history were also considered.

The investigation area begins upriver from the Hanford Site above the Wanapum Dam and continues to McNary Dam, the first downriver dam from the Hanford Site. Limited sampling is also planned in the vicinity of Bonneville Dam because the Hanford Site operated for a short period of time before McNary Dam was constructed. During that time period, the Bonneville Dam was the first dam downriver of the Hanford Site. As a starting point to manage the work, the investigation area has been divided into five sub-areas. These five sub-areas are shown in Figure ES-1 and identified as upriver, 100 Area, 300 Area, Lake Wallula, and Bonneville Dam Pool.

Sample Collection

Thousands of samples have been collected previously in and around the Columbia River to measure the concentration of chemicals in river water, the river bottom and shoreline, fish and other animals, and plants. Results from previous samples and new samples that will be collected under this work plan will be used together to help address these questions and make better conclusions about the need for additional investigations or cleanup activities.

Figure ES-1. Remedial Investigation Area.



The results from previous samples, information about where the contaminants came from, and an understanding of the different ways contaminants can move around in nature were used to help prepare the plan for collecting new samples. More than 1,100 samples will be collected as part of this work, with an emphasis on areas where:

- Hanford Site contaminants are most likely to be present. Examples include locations where build up of sediments exist on the river bottom downstream of Hanford Site reactors and behind the first downstream dam, islands, and areas where contaminated groundwater is upwelling in the river bottom.

- People use the Columbia River for recreational and other activities. Examples include islands, shoreline parks and beaches, boat launches, and other public access points.

Areas where non-Hanford Site contaminants are most likely to be present will also be sampled because it is important to help understand background conditions that are introduced into the investigation area. Examples include areas upriver from the Hanford Site, irrigation returns, and locations where other rivers enter the Columbia River.

The total number of samples collected will be split among various types of material, or media:

- Pore water (groundwater that is upwelling beneath the surface of the river bottom in the space between rocks and sediment)
- Sediment
- Surface water (river water)
- Fish
- Island soil.

Most sediment samples will consist of material collected from the upper 4 inches of the river bottom. A smaller number of sediment samples will consist of a "core" of material from the upper surface of material built up on the river bottom to the base of the river bed. Sediment

cores will be divided into multiple pieces representing different depths of the river bottom. Each individual piece will be sampled and tested separately to get information on how contaminant concentrations vary with depth.

Fish will be sampled primarily to estimate the potential health hazards to people eating them. The type of fish that will be sampled include whitefish, sucker, walleye, carp, bass, and sturgeon. These fish species were selected because they were identified by Native Americans as being part of their diet and/or because they are popular sport fish in the investigation area. Data generated will also be used when possible to estimate potential health risks to the fish itself.

Salmon (Chinook, steelhead, coho), Pacific Lamprey, and smelt are also part of the Native American diet but will not be sampled during this phase of the remedial investigation. Salmon do not spend much time in the Hanford Reach area during their lifetimes. Pacific Lamprey and smelt are not present in large numbers within the Hanford Reach.

The laboratory tests requested for each sample will depend on its location, collection purpose, and media type. Tests for most of the samples will include radionuclides and metals, which represent the most common groups and largest quantities of contaminants that resulted from Hanford Site operations. Tests for other contaminants, such as organic compounds, will be performed on a smaller number of samples.

Estimates of Potential Risk

Results from the new samples collected during this work will be combined with results from previous samples to estimate the potential health risks to humans, animals, and plants from exposure to Hanford Site releases to the Columbia River. These estimates of risk, which are also called risk assessments, will help inform decision makers on whether or not there is a need for additional investigation or cleanup activities to control or reduce the risk from exposure. Different methods will be used to estimate risk to humans and risk to animals and plants.

Ecological Risk Assessment. The ecological risk assessment will estimate potential risks to animals and plants. The CERCLA process that will be followed to estimate these risks includes eight steps. This work plan describes the approach for completing the first three steps of the eight-step process. Samples of plants and animals are not typically collected as part of these steps. Instead, sample results from media that plants and animals may be exposed to, such as sediment and surface water, are compared with "benchmarks" published by the scientific community. Comparison with these benchmarks provides an initial estimate of potential risk. Depending on the results of this comparison, additional studies may be needed as part of completing Steps 4 through 8 of the regulatory process for estimating risk to plants and animals. It is at this time that a plan would be developed to sample specific plants and animals that are present in the investigation area. If needed, the sampling plan and methods for estimating risk in Steps 4 through 8 would be developed and documented in a revision to this work plan or as a separate work plan.

Human Health Risk Assessment. Potential risk to humans will be estimated for a range of different exposure levels to the river media (sediment, surface water, island soils, and fish). Assumptions about the way in which the exposures occur (pathways), such as skin contact or from eating fish, are combined with assumptions about exposure duration or quantity for different media to establish an exposure "scenario." The human exposure scenarios proposed for this investigation are intended to represent a full range of uses from high to low intensities. Exposure scenarios have been created for the following people to represent a range of uses for this investigation:

- Native Americans who have ties to Columbia River and eat a large amount of fish from the river as a primary part of their daily diet

- Adults and older children who spend a lot of time fishing in the river and eat what they catch

- Adults and children who use the Columbia River for swimming, boating, and playing on beaches.

Information gathered during the investigation will be used to estimate the potential risk for each type of use represented by the exposure scenarios. The results will identify how much of the total estimated risk to humans would be caused by potential exposure to Hanford Site-related contaminants and how much would be caused by contaminants that may have come from places other than the Hanford Site. The contaminants and the exposure pathways that are risk "drivers," or those that have the greatest influence on the risk estimates, will be identified to assist in decision-making activities.

Project Schedule

Sample collection activities outlined in this work plan will begin in the fall of 2008 and continue through the summer of 2009. The results that are produced from the laboratory tests performed on the samples will be evaluated as they are returned and summarized in a report after all of the tests are complete. Sample results will then be used to perform the initial steps of the CERCLA process to estimate the potential risk to plants and animals and help decision makers determine if additional investigation is needed. This decision point is anticipated to occur in 2011.

Updates on the progress of work plan activities will be communicated to the regulators, Tribes, and stakeholders periodically during the performance of work. Unit manager meetings, Tribal consultations, Natural Resource Trustee Council meetings, Hanford Advisory Board meetings, and periodic workshops will provide opportunities for briefings on the project work and results.

Relation to Hanford Cleanup Activities Near the Columbia River

The results of this investigation are important to other Hanford Site cleanup activities in areas that border the Columbia River, also known as the "River Corridor." In the early 1990s, the Tri-Parties (the U.S. Environmental Protection Agency, the Washington State Department of Ecology, and the U.S. Department of Energy) decided that enough information was known about contaminated soil and groundwater at the Hanford Site to begin cleanup instead of performing additional studies to help refine the existing information. This decision led to an early start for cleanup of contaminated soil and groundwater in areas of the Hanford Site that border the river.

As the cleanup progresses, new information on the contamination is gathered and used to help influence future cleanup activities.

The Tri-Parties have recently developed a strategy to make final decisions about the actions that are needed to complete cleanup in the River Corridor. Part of the strategy is to split these final cleanup decisions into smaller pieces of work that are more manageable and aligned with Hanford Site operational functions. Final cleanup decisions will be developed for areas associated with the following:

- 100-B/C reactors
- 100-K reactors
- 100-N reactor
- 100-D and 100-H reactors
- 100-F reactor and Hanford townsite
- 300 Area fuel fabrication and development facilities.

Final decisions for each of these six areas will address the cleanup of contaminated soil and groundwater. The impacts of the Hanford Site releases to the Columbia River are an integral piece of these final decisions. If any cleanup actions are needed to address Hanford Site contamination in the river, they may be included with the final decisions for one or more of the six areas. It is also possible that a separate cleanup decision could be made that is specific to the Columbia River. The objective for all of these decisions would be to protect human health and the environment.

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ACRONYMS

ACOE	U.S. Army Corps of Engineers
ADD	average daily dose
AWQS	aquatic water quality standard
BERA	baseline ecological risk assessment
BHHRA	baseline human health risk assessment
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
COPC	contaminant of potential concern
COPEC	contaminant of potential ecological concern
CRCC	Columbia River Component
CRP	Community Relations Plan
CSF	cancer slope factor
CSM	conceptual site model
CTE	central tendency exposure
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
DCE	dichloroethene
DOE	U.S. Department of Energy
DQO	data quality objective
DWS	drinking water standard
Ecology	Washington State Department of Ecology
EPA	U. S. Environmental Protection Agency
EPC	exposure point concentration
FS	feasibility study
FY	fiscal year
HASP	health and safety plan
HEIS	Hanford Environmental Information System
ILCR	incremental lifetime cancer risk
IWCP	Integrated Work Control Program
JHA	job hazards analysis
kcfs	thousand cubic feet per second
LBGR	lower bound of gray region
LOAEL	lowest observed adverse effect level
MARSSIM	*Multi-Agency Radiation Surveys and Site Investigation Manual*
MCL	maximum contaminant level
MIS	multi-incremental sampling
MTCA	Model Toxics Control Act
NPL	National Priorities List
PCB	polychlorinated biphenyl
PCE	tetrachloroethylene
PHC	petroleum hydrocarbons
PNNL	Pacific Northwest National Laboratory
PQL	practical quantitation limit
QAPP	quality assurance project plan

Acronyms

QC	quality control
RAO	remedial action objective
RBC	risk-based concentration
RC	representative concentration
RCBRA	River Corridor Baseline Risk Assessment
RCRA	*Resource Conservation and Recovery Act of 1976*
RI	remedial investigation
RM	river mile
RME	reasonable maximum exposure
ROD	record of decision
SAP	sampling and analysis plan
SHOALS	Scanning Hydrographic Operational Airborne Lidar Survey
SSHASP	site-specific health and safety plan
SVOC	semivolatile organic compound
TAG	technical assistance grant
TCE	trichloroethene
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
UCL	upper confidence limit
VSP	Visual Sample Plan
VOC	volatile organic compound
WAC	*Washington Administrative Code*
WCH	Washington Closure Hanford

1.0 INTRODUCTION

The Columbia River stretches 2,000 km (1,243 mi) from the Canadian province of British Columbia through the U.S. State of Washington, forming much of the border between Washington and Oregon, before emptying into the Pacific Ocean. Measured by the volume of its flow, the Columbia River is the largest river flowing into the Pacific from North America and is the fourth-largest river in the United States. In south-central Washington State, the river flows through the U.S. Department of Energy (DOE) Hanford Site (Figure 1-1). An area known as the Hanford Reach is an 82-km (51-mi) stretch of the Columbia River that flows unimpeded between Priest Rapids Dam to the head of Lake Wallula upstream of McNary Dam. The Hanford Reach is the only free-flowing portion of the river above Bonneville Dam in the United States.

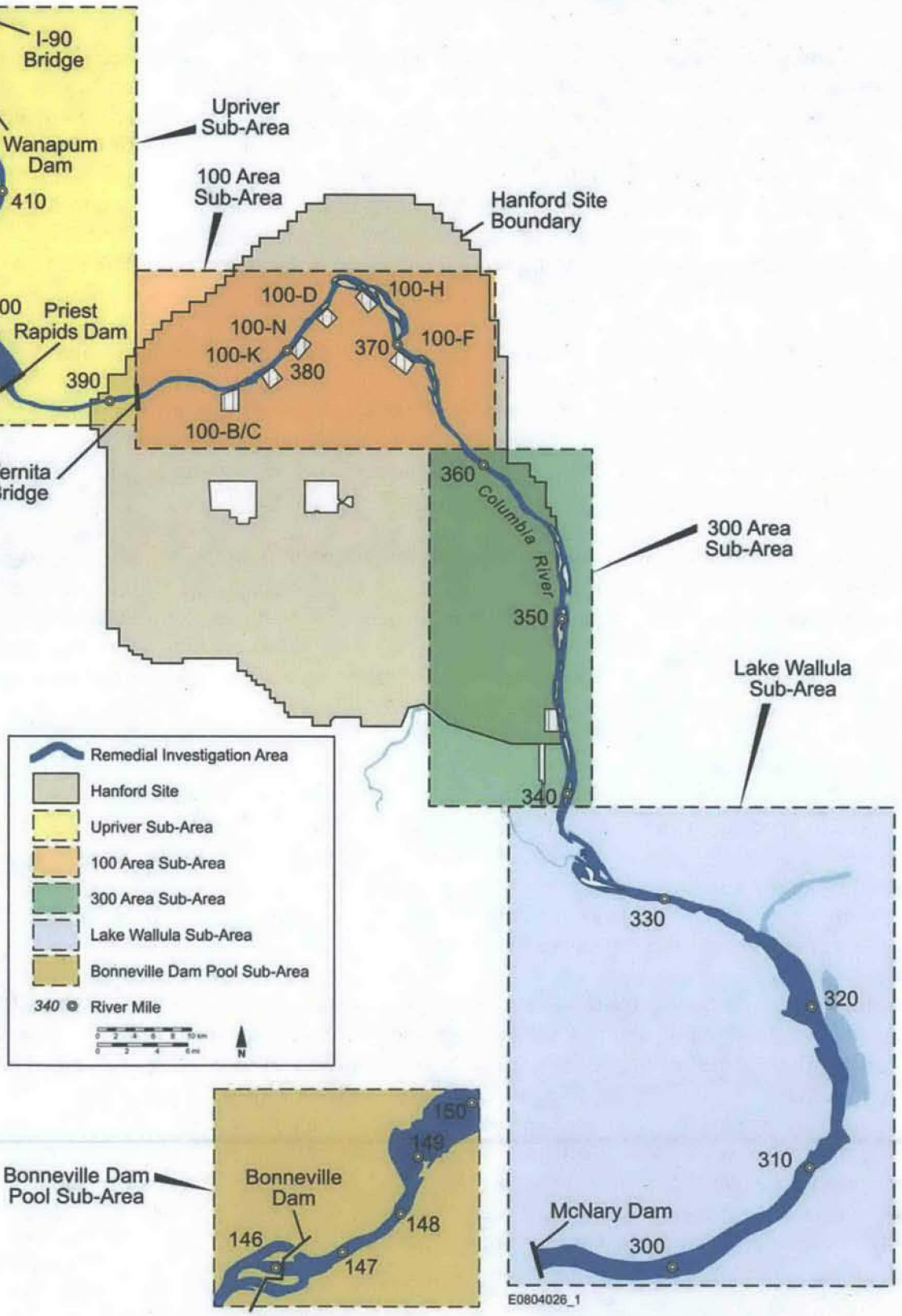
The Hanford Site is a 1,517-km^2 (586-mi^2) federal facility located within the semiarid shrub-steppe Pasco Basin of the Columbia Plateau in south-central Washington State. (Note: For the purposes of this report, the Hanford Site refers to the boundaries of the Hanford Reservation.) It is situated north and west of the cities of Richland, Kennewick, and Pasco. The Hanford Site became a federal facility in 1943 when the U.S. Government took possession of the land to produce weapons-grade plutonium during World War II.

During Hanford Site operations, liquid effluents from plutonium production reactors were discharged directly to the Columbia River, and unplanned overland flows from retention ponds and basins occasionally occurred. In addition, plumes of contaminated groundwater developed in portions of the Hanford Site as a result of the practice of discharging waste waters to the soil column and subsequent migration through the soil. Some of these contaminated groundwater plumes have reached the Columbia River, discharging in springs along the shoreline and upwelling through the river bottom.

Hanford Site production activities continued until the late 1980s, when the mission focus changed to cleaning up the radioactive and hazardous wastes that had been generated during the previous decades. In 1989, areas of the Hanford Site were placed on the National Priorities List (NPL) under the authority of the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA). Placement on the NPL initiated the CERCLA process that would result in the cleanup of contaminated areas.

A primary objective of the Hanford Site cleanup mission is protection of the Columbia River, through remediation of contaminated soil and groundwater that resulted from its production mission. These remedial actions were initiated in 1994 and continue today, with an emphasis on activities in the "River Corridor" because of its proximity to the river and presence of the former production reactors in the 100 Area and research and development facilities in the 300 Area. Current activities in the River Corridor also include performance of a baseline risk assessment of the upland, riparian, and near-shore areas (DOE/RL-2007-21, *River Corridor Baseline Risk Assessment Report, Source and Groundwater Component*). These areas are now referred to collectively as the Source and Groundwater Component.

Figure 1-1. Columbia River Remedial Investigation Area.



Within the Columbia River system, surface water, sediment, and biota samples related to potential Hanford Site hazardous substance releases have been collected since the start of Hanford operations. The impacts of Hanford Site hazardous substance releases to the Columbia River in areas upstream, within, and downstream of the Hanford Site boundary have been previously investigated as mandated by DOE requirements under the *Atomic Energy Act of 1954*. The current impacts are now being assessed under CERCLA via the remedial investigation (RI) activities described in this work plan.

1.1 PURPOSE AND SCOPE

The purpose of this work plan is to describe the approach for conducting a CERCLA compliant RI to:

- Characterize the nature and extent of Hanford Site-related contaminants that have come to be located within the Columbia River
- Assess the current risk to ecological and human health receptors that is posed by those Hanford Site-related contaminants
- Determine the need to perform remedial action.

To fulfill the purpose, this work plan has been prepared to direct the sample collection, analysis, data review activities, and methods to be used for a baseline human health risk assessment (BHHRA) and baseline ecological risk assessment (BERA). Although this work plan describes the initial sampling that will be conducted, additional phases of investigation may be considered and implemented based on the results of the RI.

The scope of this work plan focuses on the impacts of Hanford Site hazardous substance releases to the Columbia River. In order to evaluate the impacts from Hanford Site hazardous substance releases, it is also important to understand the contributions of non-Hanford influences to the Columbia River upstream, within, and downstream of the Hanford Site. To address this scope, the geographical investigation area for this work plan includes the Columbia River and islands from the Vernita Bridge (approximately 4 river miles [RM] upriver of the 100-B/C Reactor Area) to McNary Dam (the first downriver dam from the Hanford Site), plus a limited investigation of the area immediately upstream of Bonneville Dam. Limited sampling is planned in the vicinity of Bonneville Dam to address potential deposits that may have occurred prior to the construction of McNary Dam. Construction of Bonneville Dam started in 1935 and was completed in 1937, several years before Hanford Site operations started. This investigation area has been divided into five sub-areas based on proximity to the Hanford Site and the relation of production operations. These five sub-areas include the upriver, 100 Area, 300 Area, Lake Wallula (downriver), and Bonneville Dam Pool segments (Figure 1-1).

The lateral investigation area of the Columbia River extends shore to shore (ordinary high water mark to ordinary high water mark,[1] except for areas within the Hanford Reach that have been previously characterized and assessed by the River Corridor Baseline Risk Assessment (RCBRA) Source and Groundwater Component (nominally to a depth of 2 m [6 ft] into the river from the low water mark). In these areas of the Hanford Reach, the investigation area for this work plan begins where the RCBRA Source and Groundwater Component investigation left off. For abiotic media (e.g., soil, sediment, water) and most biota, sample collection for the RCBRA source and groundwater component stopped at the low water mark of the river, which is characterized by the presence of the "green line" of algae delineating the permanently inundated portion of the river channel. The lateral investigation areas are depicted in Figures 1-2 and 1-3. Additional information on the investigation area boundaries is presented in Section 4.0.

1.2 APPLICATION OF THE CERCLA RI/FS PROCESS

This RI work plan is prepared in accordance with the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988a). The RI/feasibility study (FS) process represents the methodology that the Superfund program has established for characterizing the nature and extent of hazardous substance releases, assessing the risks posed by exposure to these releases, and evaluating potential remedial options. It is meant to be viewed as a dynamic, flexible process that can be tailored to specific site circumstances. The objective of the RI/FS process is not removal of all uncertainty, but to gather sufficient information to make an informed risk management decision regarding potential remedial action.

The RI/FS process consists of multiple steps or phases, the first of which is "scoping." The scoping phase includes evaluating existing data, developing the conceptual site model (CSM), identifying data quality objectives (DQOs), and preparing project plans. The information presented in this work plan represents the culmination of the scoping phase of the RI/FS process for Hanford Site hazardous substance releases to the Columbia River.

An extensive data compilation effort was performed between 2004 and 2006, as documented in the *Columbia River Component Data Evaluation Summary Report* (WCH-91). The compiled data were then further evaluated with the purpose of identifying potential data gaps to be addressed in this RI work plan. Results of this evaluation and the associated data gaps were summarized in the *Columbia River Component Data Gap Analysis* (WCH-201). Previous investigations and a summary of the data compilation and evaluation efforts are presented in Section 2.0. The available body of information gathered and evaluated during the scoping effort provides the ability to develop the CSM, establish the initial DQOs, and support a rationale for conducting a focused sampling program as presented in Sections 3.0 and 4.0 of this work plan.

[1] From WAC 173-22-030, "the ordinary high water mark on all lakes, streams, and tidal water is that mark that will be found by examining the bed and banks and ascertaining where the presence and action of waters are so common and usual, and so long continued in all ordinary years, as to mark upon the soil a character distinct from that of the abutting upland..."

Figure 1-2. Remedial Investigation Area Within the Hanford Site.

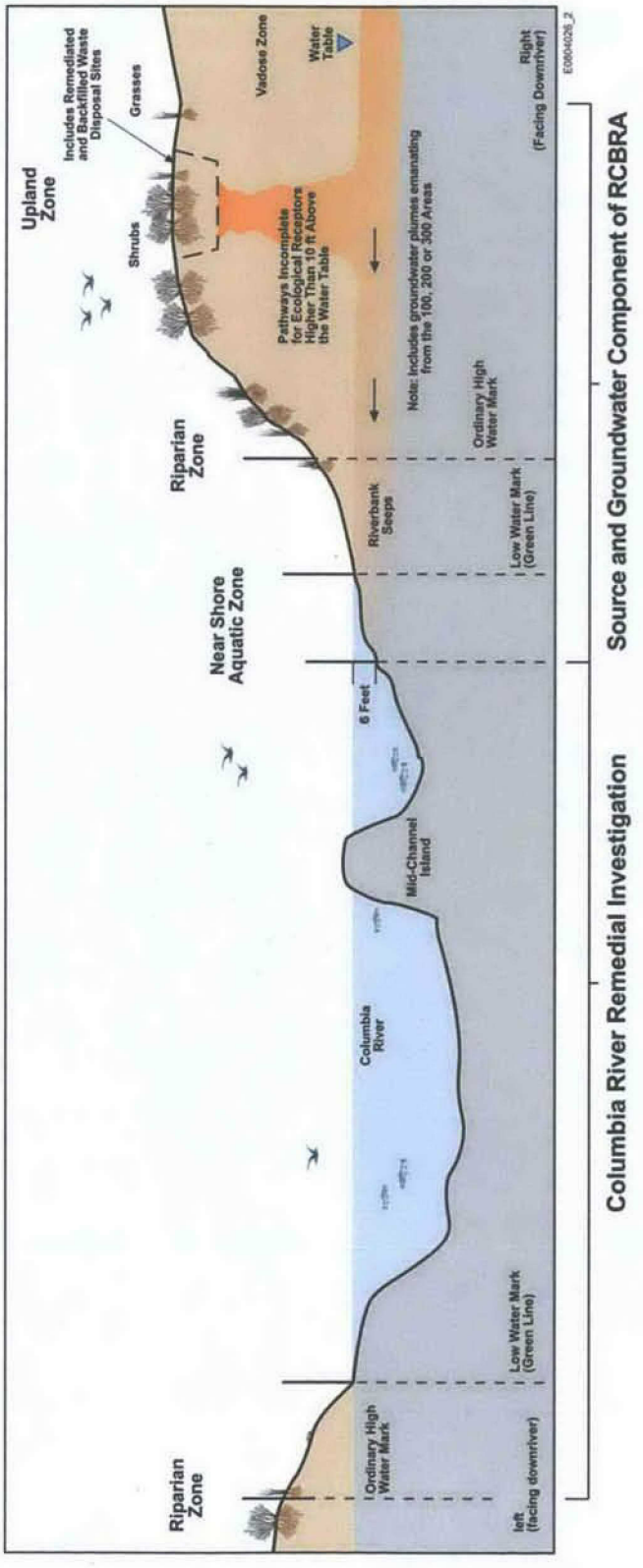
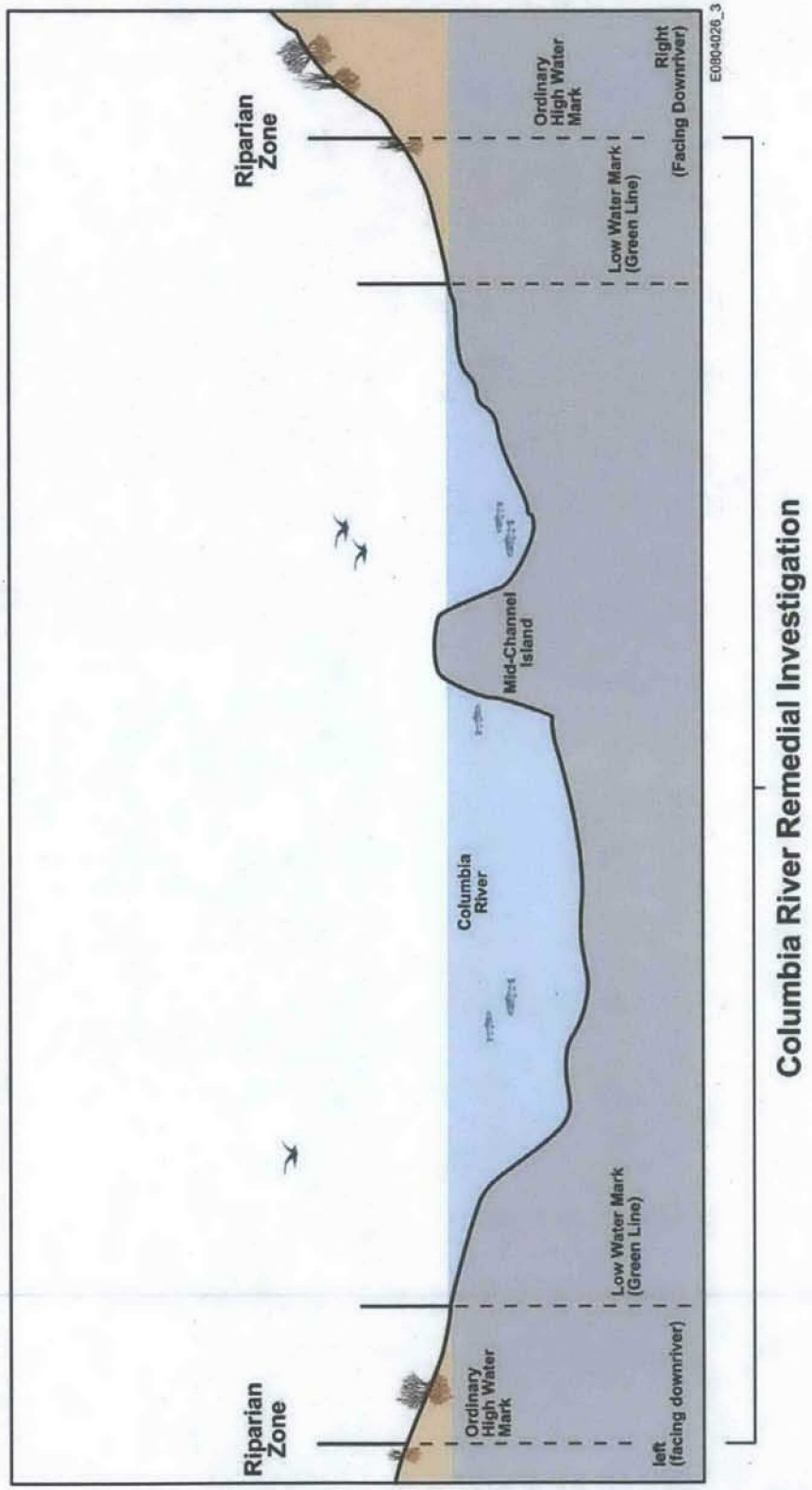


Figure 1-3. Remedial Investigation Area Downstream of the Hanford Site.



With approval of this work plan by the Tri-Parties (i.e., DOE, U.S. Environmental Protection Agency [EPA], and Washington State Department of Ecology [Ecology]), a transition from the scoping phase to the "site characterization" phase of the RI/FS process will be initiated for Hanford Site hazardous substance releases to the Columbia River. The site characterization phase will include a field investigation to collect additional information and sample data to build on and supplement the existing body of information and data evaluated in the scoping phase. The resulting combined data set will be used to conduct the BHHRA and BERA as part of the site characterization phase. These risk assessments will become the Columbia River Component (CRC) of the RCBRA and will be conducted in a manner that is consistent with the Source and Groundwater Component that is currently under way. The project plan for the field investigation and baseline risk assessment activities is presented in Section 4.0.

1.3 ROLE IN THE INTEGRATED CLEANUP STRATEGY FOR THE RIVER CORRIDOR

In 1991, the Tri-Parties agreed to a "bias-for-action" approach to the CERCLA process for the Hanford Site NPL sites. The agreement, known as the *Hanford Past-Practice Strategy* (DOE/RL-91-40), streamlined the RI/FS process to begin remediation of contaminated waste sites earlier than typically performed under the traditional CERCLA process in place at that time. The approach outlined in the *Hanford Past-Practice Strategy* (DOE/RL-91-40) is consistent with later EPA initiatives implemented to expedite cleanups, such as the *Superfund Accelerated Cleanup Model* (EPA 1998a) and the *RCRA Facility Stabilization Initiative* (DOE 2003).

The River Corridor consists of more than 544 km^2 (210 mi^2) adjacent to the Columbia River and includes the 100 Area and 300 Area NPL sites. To date, numerous RIs, FSs, proposed plans, and interim action records of decision (RODs) have been completed to support and authorize the source and groundwater cleanup activities that began in 1994. Remaining remedial actions at source operable units in the River Corridor are expected to take 5 to 7 years to complete. Consequently, the Tri-Parties developed a strategy to pursue a transition from interim remedial actions to final remedial actions for the River Corridor source and groundwater operable units. The final remedy RODs that are produced from this effort will establish the final remedial goals and objectives and any associated actions required to complete the CERCLA process for the River Corridor 100 Area and 300 Area NPL sites.

In accordance with the strategy developed by the Tri-Parties, six final remedy RODs are anticipated for the River Corridor. The decision to pursue six RODs was based on organizing the ROD development and review processes into manageable pieces that are generally aligned with an operational function or historical use (e.g., reactor areas). Final remedy RODs will be developed for the following areas:

- 100-B/C
- 100-K
- 100-N
- 100-D and 100-H

- 100-F and 100-IU-2/6
- 300 Area.

Boundaries for the six final remedy RODs were established by the Tri-Parties to provide complete coverage of the River Corridor geographical area and are depicted in Figure 1-4.

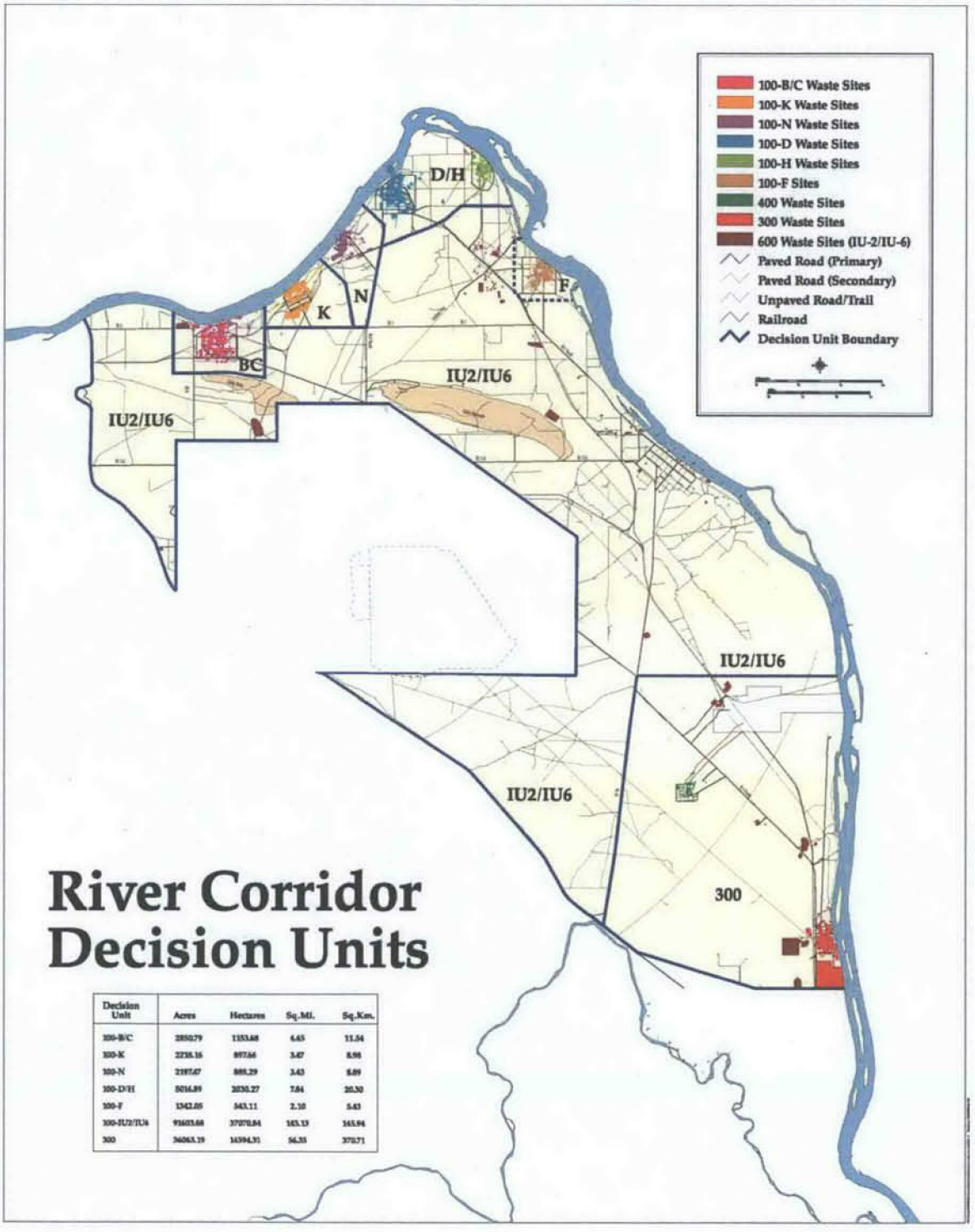
Each of the six final remedy RODs will be integrated to address both source and groundwater remedial actions for the decision area. In addition, the Tri-Parties have stated that the ability to address the impacts of Hanford Site hazardous substance releases to the Columbia River is another integral piece of the final ROD development process. The site characterization information that results from implementation of this work plan and the RI/FS process for the Columbia River is intended to provide the information needed to evaluate impacts to the river in the context of the proposed source and groundwater remedial actions.

1.4 COMMUNITY INVOLVEMENT

The *Community Relations Plan for the Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 2002) is the Hanford Site roadmap for public involvement under the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1989). The strategies outlined in the Community Relations Plan are designed to increase effectiveness and meaningful opportunities for interested parties to participate in key Hanford Site decisions. Compliance with CERCLA community involvement requirements as specified in 40 *Code of Federal Regulations* (CFR) 300.430 (c)(ii)(A) is presented in Section 5.2.

Throughout the history of the project, DOE has recognized the benefits of having deliberate and ongoing communication with the regulatory agencies, Tribes, and stakeholders, particularly in the development of study and sample design and selection of risk characterization methodologies. A number of workshops and meetings were held throughout the RI scoping process to facilitate participation of interested parties, including state and federal agencies, natural resource trustees, Tribal members, site contractors, and the public. These workshops served as important forums for soliciting input and feedback for project objectives, study design, and resource protection. Meeting notes from the various workshops held between 2004 and 2008, as well as other reference documents, are provided on the Washington Closure Hanford (WCH) End State and Final Closure project library web site in the section entitled "Remedial Investigation of Hanford Site Releases to the Columbia River": http://www.washingtonclosure.com/Projects/EndState/risk_library.html.

Figure 1-4. River Corridor Final Record of Decision Boundaries.[2]



Decision Unit	Acres	Hectares	Sq.Mi.	Sq.Km.
100-B/C	2850.79	1153.68	4.45	11.54
100-K	2238.16	897.66	3.47	8.98
100-N	2197.47	888.29	3.43	8.89
100-D/H	5016.89	2030.27	7.84	20.30
100-F	1342.05	543.11	2.10	5.43
100-IU2/IU6	91603.68	37070.84	143.13	143.94
300	34063.19	14394.31	56.35	370.71

[2] The 100-F and 100-IU-2/6 Areas will be addressed in a single Record of Decision document. A dashed boundary around the 100-F Area is shown because the Record of Decision will likely include a separate discussion of the associated reactor operations in the area.

2.0 SITE BACKGROUND AND SETTING

The physical setting, history, and background of the Hanford Site are summarized in this section. Discussion of this information, inclusive of chemical and radiological sources, and the extent of contamination are described to identify impacts from Hanford Site hazardous substance releases to the Columbia River. In addition, Columbia River dynamics and ecology are summarized, along with previous investigations and assessment activities. This summary provides a framework for an understanding of site conditions and development of the CSM for the RI (Section 3.0 of this work plan).

2.1 PHYSICAL SETTING

The Hanford Site is located in the Pasco Basin within the Yakima Fold Belt on the Columbia Plateau. The Hanford Site is considered one of the source areas for chemical and radiological contaminants that enter the Columbia River along a portion of the Hanford Reach. The Hanford Reach is an 82-km (51-mi) stretch of river that flows unimpeded from the base of Priest Rapids Dam downstream to the head of Lake Wallula above McNary Dam. It is the only free-flowing portion of the Columbia River above Bonneville Dam in the United States.

Primary surface water features associated with the Hanford Site are the Columbia and Yakima Rivers. The Yakima River flows along the southern boundary of the Hanford Site. Cold Creek and its tributary, Dry Creek, are ephemeral streams on the Hanford Site that are within the Yakima River drainage system. Cold Creek occasionally contains water after large precipitation events. The Yakima River drains into the Columbia River several miles south of the Hanford Site. The Snake River also drains into the Columbia River downstream of the Hanford Site near Pasco, Washington.

Topography, climate, and geology at the Hanford Site have been previously summarized and are not included in this RI work plan. Topographical information has been previously included in the *Columbia Gorge Mainstem Subbasin Plan* (NWPC 2004). Climatological data are monitored at the Hanford Meteorological Station, located between the 200 East and 200 West Areas, and at numerous locations throughout the Hanford Site. Meteorological data from the Hanford Meteorological Station span a period from 1945 to present and have been previously summarized in the *Hanford Site Environmental Report for Calendar Year 2006* (PNNL-16623). Geology at the Hanford Site has been summarized in previous reports, including *Geologic Setting of the 200 West Area* (Lindsey et al. 1991) and *Late Pleistocene- and Holocene-Age Columbia River Sediments and Bedforms: Hanford Reach Area* (BHI-01648).

2.2 HANFORD SITE HISTORY

The Hanford Site is located in southeastern Washington State and occupies an area about 1,450 km^2 (560 mi^2).

2.2.1 Cultural History

The Hanford Site's cultural resources are diverse, ranging from early prehistoric times to the atomic age. The Hanford Site contains a fragile and extensive record of human occupation stretching thousands of years into the past. Cultural history at the Hanford Site has been previously summarized in the *Hanford Cultural Resources Management Plan* (DOE/RL-98-10).

2.2.2 Operational History

In March 1943, construction at the Hanford Site began on three reactors (B, D, and F Reactors) and three chemical processing facilities (B, T, and U Plants). The Hanford Site was originally designed, built, and operated as part of the Manhattan Project to produce plutonium for nuclear weapons using production reactors and chemical reprocessing plants. After World War II, six additional reactors were built (H, DR, C, KW, KE, and N Reactors) along with two additional chemical separation plants. In the 1950s, energy research and development, isotope use, and other activities were added to the Hanford Site mission. Specific areas of the Hanford Site have been designated for the uses described above. Operational areas generally contain support facilities including maintenance buildings, powerhouses, raw water treatment plants, water storage tanks, electrical maintenance facilities, and subsurface sewage disposal systems.

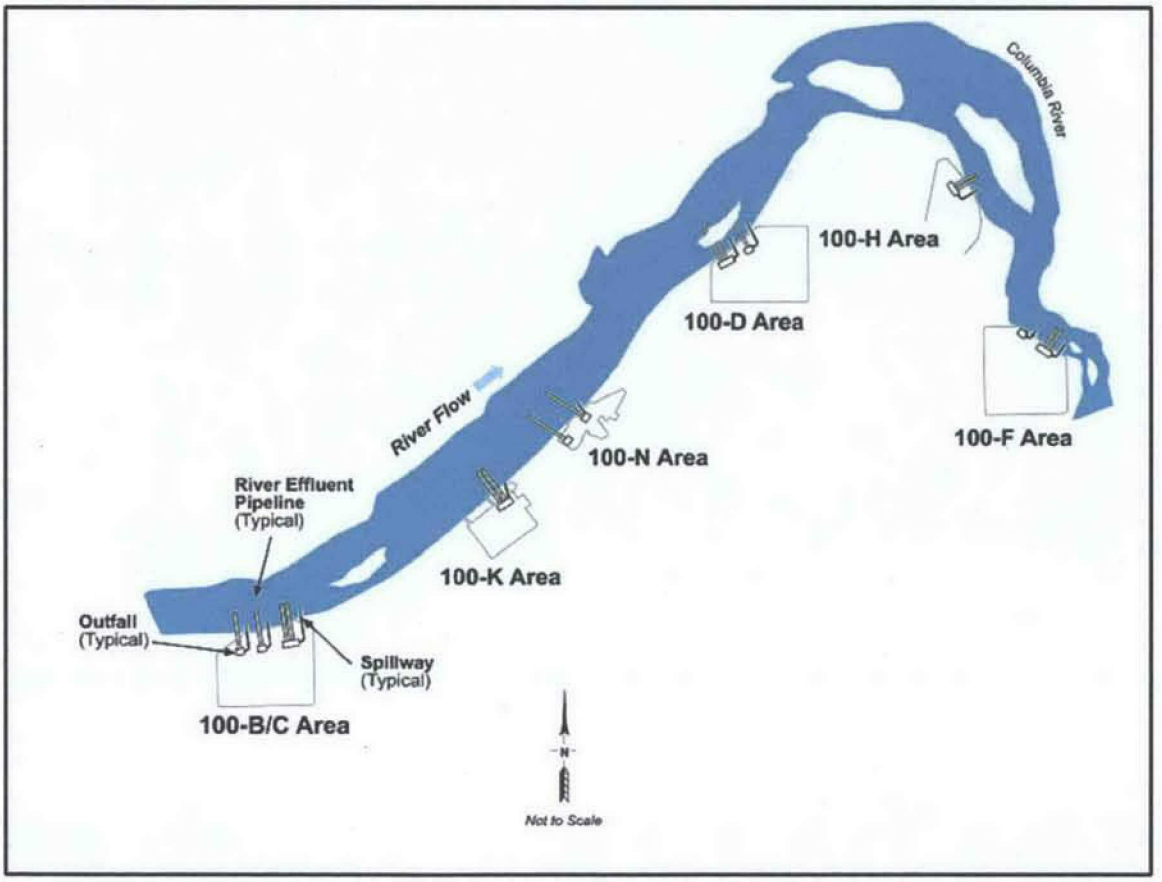
2.2.2.1 100 Areas. These areas are located upstream from the City of Richland along the Columbia River in the northern portion of the Hanford Site and occupy an area of approximately 68 km^2 (26 mi^2) (Figure 1-1). Between 1943 and 1962, nine water-cooled graphite-moderated plutonium production reactors were built along the shore of the Columbia River. Table 2-1 provides a summary of the time that the Hanford Site single-pass cooling water reactors were in production and their locations are shown in Figure 2-1. The mission of each reactor was to produce weapons-grade plutonium. The main component of each reactor was a large stack of graphite blocks (pile) with process tubes containing the fuel elements and cooling water. The confinement of large numbers of uranium fuel elements within the reactor piles created an intense radiation field and a nuclear chain reaction that converted some uranium atoms to plutonium atoms. Other atoms in the pile structure were converted into radioactive fission and activation products that were disposed of as waste.

The first eight reactors (105-B, 105-C, 105-D, 105-DR, 105-F, 105-H, 105-KE, and 105-KW) used water from the Columbia River for direct cooling of the reactor pile. The ninth reactor (105-N) recirculated purified water through the reactor core in a closed-loop cooling system. Effluent from the 105-N Reactor was discharged to trenches and cribs near the river.

Table 2-1. Hanford Site Single-Pass Cooling Water Reactor Time Line.

Reactor	Starts Production	Shut Down
105-B	September 1944	February 1968
105-D	December 1944	June 1967
105-F	February 1945	June 1963
105-H	October 1949	April 1965
105-C	November 1952	April 1969
105-DR	October 1949	1964
105-KW	January 1955	February 1970
105-KE	April 1955	January 1971

Figure 2-1. 100 Area Reactor Locations.



Columbia River water passed through 100 Area reactors, absorbing and removing heat generated by the nuclear process. Cooling water was withdrawn from the Columbia River though the river pump houses located directly on the river and sent to the reservoirs. The reservoirs each stored 25 million gallons of water for primary and secondary (backup) water uses (DOE/RL-97-1047). The water was pumped to a series of support buildings for treatment and filtration prior to use to remove particulate matter, dissolved gases (i.e., carbon dioxide and oxygen), and chemicals. Following injection of water into the reactor at a rate of about 113,562 L/min (30,000 gal/min), processed water was discharged to the retention basins where it cooled to allow for decay of short-lived radionuclides. From the retention basins, the water reentered the Columbia River via outfall structures and underground pipelines, emerging at the mid-channel of the Columbia River (DOE/RL-97-1047) (Figure 2-1).

Cooling water also contained radioactive materials (fission products) that escaped from the fuel elements or tube walls during the irradiation process (DOE/RL-97-02). The coolant water was occasionally contaminated while passing through reactors due to failed aluminum jackets. Failure of aluminum jackets allowed cooling water to come in direct contact with irradiated uranium. This resulted in a release of fission products and actinides to the effluent stream. Fission products included isotopes such as cesium, strontium, and iodine. This highly contaminated cooling water was sent to trenches rather than being returned to the Columbia River.

Other past waste disposal practices in the 100 Areas resulted in releases of radionuclides and chemicals to soil and groundwater. Unplanned and planned releases to the soil column in the 100 Areas also created hundreds of waste sites. Unplanned releases were mainly from leaks or overflow of reactor cooling water transfer systems. Planned releases were made at liquid waste sites, solid waste burial grounds, and "remaining sites" (a name used for administrative and remediation purposes).

Liquid waste sites in the 100 Area include retention basins, trenches, cribs, french drains, and effluent pipelines. Contaminated water from process tubes in which fuel cladding failures occurred was generally discharged to cribs distant from the reactors and percolated into the soil (DOE/RL-97-1047). Solid waste containing hazardous and radioactive wastes was managed within burial grounds. Burial grounds contain concrete, construction debris, and other wastes. The "remaining sites"are scattered across the 100 and 600 Areas and include, but are not limited to, septic systems, burn pits, french drains, pre-Hanford Site and Hanford-era waste dumps, small oil spills, nonreactor effluent pipelines, and animal experiment facilities. Additional details on 100 Area waste sites are found in the *Risk Assessment Work Plan for the 100 Area and 300 Area Component of the RCBRA* (DOE/RL-2004-37).

2.2.2.2 200 Areas (Central Plateau). After cooling in the 100 Areas, the irradiated fuel elements were taken to the 200 Areas for storage, additional cooling, and processing within the chemical separation plants. The 200 Areas (200 East and 200 West Areas) are located in the center of the Hanford Site and are located approximately 8 to 10 km (5 to 6 mi) from the Columbia River, respectively. The 200 Areas occupy approximately 16 km^2 (6 mi^2) and contained the facilities used to separate, isolate, store, and ship the plutonium. To separate the

plutonium from the base uranium and activated by-products formed in the irradiation process, the chemical separation plants first dissolved the fuel elements with acids and then chemically separated the plutonium isotopes from the liquefied materials. The plants produced large quantities of high-level radioactive waste that were stored first in single-shell underground tanks and later in double-shell underground tanks. The various separation processes are described in the *200 Areas Remedial Investigation/Feasibility Study Implementation Plan Environmental Restoration Program* (DOE/RL-98-28). Following separation and concentration, the plutonium (in the form of plutonium nitrate) was put into storage and then shipped to Los Alamos, New Mexico, during the Manhattan Project and later to Rocky Flats, Colorado. One metric ton of uranium metal produced approximately 250 g of plutonium (DOE/RL-97-1047).

The separation process in the 200 Areas generated large volumes of effluent. Most of the low-level liquid wastes were discharged to the soil column at liquid waste receiving sites (i.e., ponds, cribs, trenches, reverse wells, ditches, and cribs). Over 633 billion L (167 billion gal) of effluent was discharged to the soil column (PNL-5506). Other wastes such as uranium- and fission product-rich wastes were stored in the underground storage tanks. Over time some waste has leaked from the single-shell tanks. The maximum estimated volume of leaked waste from the single-shell tank system is approximately 3.8 million L (1 million gal) (CHG 2004). Unintentional and intentional releases to the ground from chemical separation operation have impacted the soil column and aquifer beneath the Hanford Site.

The discharge of effluent to the soil columns provided the primary driving force for liquid and contaminant migration through the vadose zone to groundwater. Key radionuclides with half-lives longer than 10 years that were discharged to the soil column included cesium-137, barium-137, iodine-129, strontium-90, yttrium-90, technetium-99, uranium, carbon-14, americium-241, plutonium-239/240, and tritium as tritiated water. Two-thirds of the radioactivity in liquids discharged to the ground is from tritium, which has a 12.3-year half-life. The least contaminated liquids were discharged to ponds and ditches, which comprised more than 90% by volume of all liquid waste discharged. Conversely, the low-volume streams contained 95% of all radionuclides discharged. The radioactive inventory in solid waste burial grounds represents a very small part of the total Hanford Site inventory.

Major chemicals in liquids discharged to the ground include nitrate, sodium, phosphate, sulfate, ammonia, carbon tetrachloride, fluoride, and sodium dichromate. Inorganic chemicals were used and discharged in much greater quantities than organics. The greatest amount of hazardous chemicals in liquids was discharged between 1945 and 1958 (WHC 1991, DOE/RL-98-28).

2.2.2.3 300 Area. This area borders the Columbia River on the southeastern edge of the Hanford Site and is located just north of the City of Richland. The 300 Area occupies approximately 1.35 km^2 (0.52 mi^2). In March 1943, construction of a fuel fabrication complex began at the Hanford Site in the 300 Area. As a manufacturer of uranium fuel, the 300 Area housed the first essential step in the plutonium production process. Nuclear fuel was fabricated from uranium shipped in from offsite support facilities. Metallic uranium was extruded into the proper shape and encapsulated in aluminum alloy cladding (during early years) or zirconium alloy cladding (during later years). In addition to housing the Hanford Site fuel fabrication

plants, the 300 Area was the center of many of the site research and development projects. Process improvement laboratories were constructed beginning with the Manhattan Project. These facilities included research laboratories, chemical process laboratories, test reactors, and numerous ancillary support structures. The addition of new research and laboratory facilities continued into the 1950s and 1960s to support defense and energy research. New support and laboratory facilities were added in the 1970s for further research on energy, waste management, biological sciences, and environmental sciences. The 300 Area continues to be an active industrial complex, housing many of the Hanford Site research and development facilities and analytical laboratories.

Operations in the 300 Area created both liquid and solid waste sites. Prior to 1973, a series of solid waste burial grounds were used for solid waste and debris (DOE/RL-2004-37). After 1973, the 300 Area burial grounds were no longer used for disposal, and waste was transported to other Hanford Site burial grounds. Between 1943 and 1994, unlined ponds and process trenches received millions of gallons of contaminated waste water from 300 Area operations. These ponds and trenches are suspected to be the primary source of uranium in the groundwater beneath the 300 Area.

2.2.3 Historical Contaminant Sources and Waste Streams

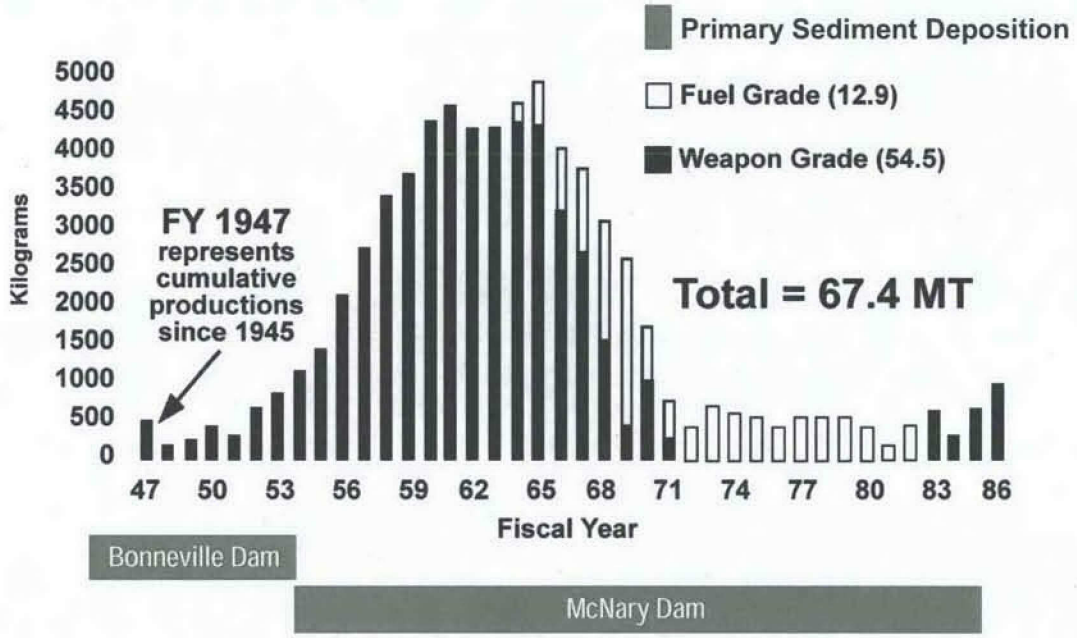
A comprehensive summary of radionuclides released from the eight single-pass reactors during operation from 1944 to 1971 is provided in DOE/RL-97-1047, *Hanford Site Historic District: History of the Plutonium Production Facilities: 1943-1990*. A majority of the radionuclides are short-lived and are no longer present. The following radionuclides are known to have been released to the Columbia River: cobalt-60, zinc-65, strontium-90, cesium-137, europium-152, europium-154, thorium-228, radium-226, plutonium-238, plutonium-239, plutonium-240, and americum-241 (BNWL-2305). In addition, nonradioactive chromium is known to have been released to the river through the river effluent pipelines. Figure 2-2 shows the total annual production of plutonium at the Hanford Site from 1947 until 1986. As shown in this figure, the highest production of plutonium at the Hanford Site occurred between 1954 and 1970, ranging between approximately 1,000 and 4,700 kg/yr. The highest production of plutonium at the Hanford Site occurred when construction of McNary Dam was completed (Section 2.3.1). Section 3.1.2.1 provides additional information on the river effluent discharge pipelines.

Groundwater contaminated by past operations continues to flow toward and discharge to the Columbia River. This upwelling groundwater contains chromium, nitrate, strontium-90, tritium and, in the 300 Area, uranium and volatile organic compounds (VOCs). Section 3.1.2.2 provides additional information on contaminated groundwater seepage to the river.

Historic spills and overland discharges are considered releases to the Columbia River. These included an overland discharge of liquid process effluent containing uranium from the 300 Area South Process pond in 1948 (EMO-1026) and a spill from a sodium dichromate storage tank at the 183-C Building in 1965 (DUN-3032). Section 3.1.2.3 provides additional information on limited overland flow.

Figure 2-2. Total Annual Production of Plutonium at the Hanford Site.

Adapted from DOE/RL-97-1047



2.3 COLUMBIA RIVER

The Columbia River originates in Canada on the west slope of British Columbia's Rocky Mountains and flows 1,954 km (1,214 mi) to the Pacific Ocean along the Washington/Oregon state boundary. Approximately 1,207 km (750 mi) of the river flows through the state of Washington.

The Hanford Reach is an 82 km (51-mi) stretch of river that flows unimpeded from the base of Priest Rapids Dam downstream to the head of Lake Wallula above McNary Dam. It is the only undammed portion of the Columbia River in the United States above Bonneville Dam.

The Columbia River enters the Hanford Site from the west and flows through the northern portion and along the eastern site boundary. The Yakima River flows south of the Hanford Site and drains to the Columbia River several miles south of the site boundary. The confluence of the Snake River, the largest tributary to the Columbia River, is located downstream. The smaller Walla Walla River drains to the Columbia River downstream of the Snake River confluence. The Yakima and Snake Rivers are the primary contributors of suspended sediment to the Columbia River (FH 1999).

2.3.1 River Dynamics

With respect to discharge, the Columbia River and its 30 major tributaries are the predominant river system in the Pacific Northwest and the fourth largest in the United States. The Pend Oreille and Spokane Rivers provide the largest annual tributary contributions to flow (over 850 m^3/sec [30,000 ft^3/sec]) on the Columbia River in the upper reach between Canada and Grand Coulee Dam. The tributaries between the Okanogan River and the Snake River contribute approximately 396 m^3/sec (14,000 ft^3/sec), and the Snake River itself contributes approximately 1,529 m^3/sec (54,000 ft^3/sec). Below the Snake River, downstream to Bonneville Dam, the mean annual tributary inflow totals approximately 396 m^3/sec (14,000 ft^3/sec) (CRWMP 2006).

The flow of water in the Columbia River is regulated by several dams within the United States that were constructed between 1938 and 1967. The construction of the dams greatly slowed the water travel times and resulted in lower sediment loads being discharged to the Pacific Ocean. Of the 11 major dams constructed along the main channel of the Columbia River, only 2 dams (Bonneville and Grand Coulee Dams) were in place when the first single-pass reactor (105-B Reactor) came on line in September 1944. Bonneville Dam was constructed downstream of the Hanford Site near Hood River, Oregon, in 1937. Grand Coulee Dam was completed in 1941, upstream of the Hanford Site, creating Lake Roosevelt. Table 2-2 provides a summary of the Columbia River dam construction dates in proximity to the Hanford Site and directly downstream, and Figure 2-3 shows the locations of these dams. Construction began on three additional dams downstream of the Hanford Site after operations began: McNary Dam (the nearest dam downstream of the Hanford Site) in the late 1940s, The Dalles Dam in the early 1950s, and John Day Dam in the late 1950s. Dams along the Columbia River were constructed for several purposes including flood control, water for irrigation, and electrical power generation. The net results have been a control of the river from its headwaters in Canada to the mouth and have resulted in "new" depositional areas behind each of these dams.

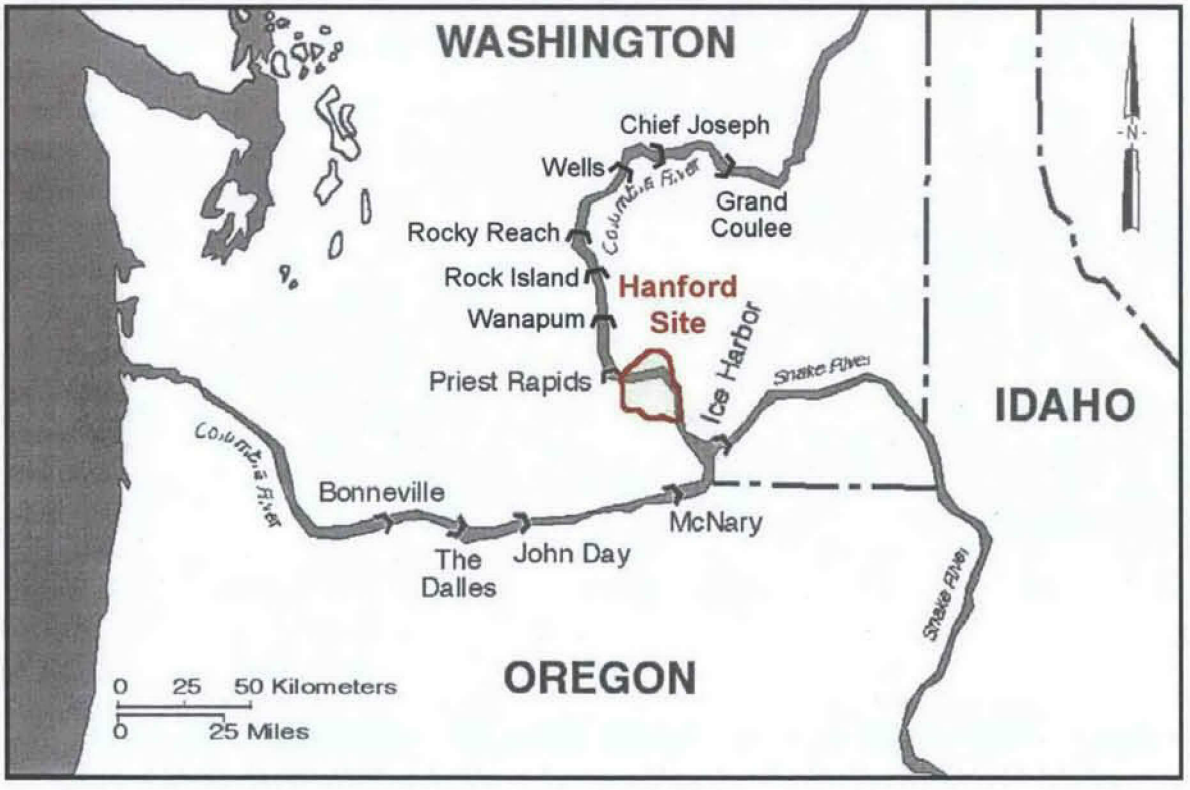
Flows through the Hanford Reach fluctuate significantly and are controlled primarily by power demand operations at Priest Rapids Dam (FH 1999), the nearest dam upstream of the Hanford Site. The flow rate of the Columbia River at Priest Rapids averages approximately 3,400 m^3/sec (120,000 ft^3/sec) (PNNL-14027). The tributaries along the Hanford Reach have average flow rates of approximately 1,529 m^3/sec (54,000 ft^3/sec) (Snake River), 99 m^3/sec (3,512 ft^3/sec) (Yakima River), and 16 m^3/sec (568 ft^3/sec) (Walla Walla River) (USGS 2006). As a result of the fluctuations in discharges at Priest Rapids Dam, the depth of the Columbia River varies significantly over time, and may change by up to 1 m (3 ft) within a few hours along the Hanford Reach (FH 1999).

Table 2-2. Dam Construction Along the Columbia River.

Name	Location Relative to the Hanford Site	Construction Dates[a]
Bonneville Dam	Downstream	1935 to 1937
Grand Coulee Dam	Upstream	1938 to 1941
McNary Dam	Directly downstream	1947 to 1954
The Dalles Dam	Downstream	1952 to 1957
John Day Dam	Downstream	1958 to 1971
Priest Rapids Dam	Directly upstream	1956 to 1961
Ice Harbor Dam	Last dam on the Snake River near confluence with Columbia River	1955 to 1961

[a] Dam construction dates from the U.S. Army Corps of Engineers (ACOE).

Figure 2-3. Dam Locations on the Columbia and Snake Rivers.



A number of studies have been conducted to measure flow and dispersion (e.g., mixing of surface water and sediments) within the Hanford Reach of the Columbia River. Additional information may be obtained from the following references: *The Turbulent Diffusion of River Contaminants* (HW-49195); *Progress in Studies of Radionuclides in Columbia River Sediment: A Summary of Hanford Achievements in this Program under General Electric, 1963-1964* (HW-83614); *Evaluation of the Effect of Water Management on Fall Chinook Spawning and*

Rearing Habitat, and on Stranding and Entrapment of Juvenile Fall Chinook (USFWS 2003); *River Data Package for Hanford Assessments* (PNNL-14824); and *Hydrodynamic Simulation of the Columbia River, Hanford Reach, 1940-2004* (PNNL-15226). These data have also been used to develop hydrodynamic models of this reach. The intent of these modeling efforts has been to provide a predictive tool that can be used to reconstruct historical river elevations or build scenarios of future river elevations for solving environmental problems such as groundwater-river interactions (e.g., mixing and mass transport) or fish habitat inventories (PNNL-15226). HW-49195 specifically focuses on the mixing that occurred within the river as cooling water was discharged via subsurface pipes.

The suspended load of the Columbia River is typically very low. The bedload consists mainly of fine and medium sand. The coarser sediments are typically deposited at the head of pools, while the finer sediments are deposited near or may be transported past the dams. Because of the flow rate along the Hanford Reach, the majority of this stretch of river is a nondepositional area. As applied to any river or section of river, the Wild and Scenic Rivers Act defines 'free flowing' as meaning 'existing or flowing in natural conditions without impoundment, diversion, straightening, rip-rapping, or other modification of the waterway.' Although the portion of the Columbia River in the RI area is frequently referred to as 'free flowing', river flow rates are affected by Priest Rapids dam discharges. As such, river deposits do occur but are far less than those occurring near the dams. The sediment thickness on the upstream side of McNary Dam was estimated at up to 9 m (30 ft), with an average annual depositional rate of 5 to 18 cm/yr (2 to 7 in./yr) in 1976 (BNWL-2305). Deposition of sediment also occurs on the shoreline portions of the islands along the Hanford Reach.

Groundwater beneath the Hanford Site discharges to the Columbia River. The presence of shoreline seeps and springs depends on the water level in the river. Groundwater levels are influenced by fluctuations in river stage, with locations near the river being most strongly affected (FH 1999). Changes in river-stage elevation can be correlated to changes in water table elevation 360 m (1,180 ft) from the river (PNL-8580). In many areas, water flows from the river into the aquifer at high river stages, causing local groundwater levels to rise. During low river stages, riverbank seeps can be observed discharging to the river.

Assessment of river stage is also important because it affects groundwater concentrations. Movement of river water into bank storage can dilute groundwater and contaminant concentrations in seeps along the river. However, as river water moves from bank storage during low river stage, the percentage of groundwater increases and concentrations are more representative of the aquifer. Specific conductivity is used to determine the presence of river water in bank storage. Hanford Site groundwater has a higher specific conductivity compared to Columbia River water (PNNL-16623). The flow of groundwater from the aquifer to the river is about 1.1 to 2.5 m^3/sec (39 to 99 ft^3/sec) (PNNL-14753). The influence of the river stage on bank storage (movement of river water into the riverbank) has been numerically modeled in some River Corridor areas including: 100-H and 300 (PNNL-13404). Refer to Section 3.1.2.2 for additional information on contaminated groundwater seepage to the river.

2.3.2 River Ecology

This section describes the aquatic ecosystem within the Columbia River in the vicinity of the Hanford Site. The following text was included in the September 2007 *Hanford Site National Environmental Policy Act (NEPA) Characterization* report (PNNL-6415) and has been modified and included below for the purposes of this work plan. References associated with the text below have not been included in this RI work plan, but can be found in PNNL-6415.

Aquatic resources on the Hanford Site are primarily associated with the Columbia River. The river crosses the Hanford Site entering at the northwest corner, traveling eastward, and then turning south, forming the eastern boundary of the Site. The Columbia River and associated riparian zones provide habitat for numerous wildlife and plant species. The area known as the Hanford Reach, the Columbia River from Priest Rapids Dam (RM 397) to McNary pool (RM 346), is the last nonimpounded, nontidal segment of the Columbia River in the United States.

The Columbia River supports a large and diverse population of plankton, benthic (bottom dwelling) invertebrates (e.g., insect larvae, clams, crayfish), fish, and other communities. Large rivers, like the Columbia River with its series of large reservoirs, contain significant populations of primary energy producers (e.g., algae and plants) that contribute to the biota's basic energy requirements. The following subsections discuss riverine (water column) and benthic habitats.

Plants and animals residing in the water column include planktonic species (phytoplankton and zooplankton), macrophytes, aquatic insects, and many species of fish. Phytoplankton and zooplankton populations at the Hanford Site are largely transient, flowing from one reservoir to another. With the relatively rapid flow of the Columbia River, there is generally insufficient time for characteristic endemic groups of phytoplankton and zooplankton to develop in the Hanford Reach, and cycles of population are more transient than observed within impoundments and reservoirs.

Macrophytes are sparse in the Columbia River because of strong currents, rocky bottom, and frequently fluctuating water levels. Rushes (*Juncus* spp.) and sedges (*Carex* spp.) occur along shorelines of the slack-water areas on the Hanford Site side of the river; these include White Bluffs Slough below the 100-H Area, the slough area downstream of the 100-F Area, and the Hanford Slough. Reed canary grass (*Phalaris arundinacea*) is a common non-native species found along shoreline areas. Macrophytes are also present along gently sloping shorelines that are subject to flooding during the spring freshet and daily fluctuating river levels (downstream of Coyote Rapids and the 100-D Area). Where they exist, macrophytes have considerable ecological value, providing food and shelter for juvenile fish and spawning areas for some species of warm-water game fish. Eurasian milfoil (*Myriophyllum spicatum*), an introduced macrophyte, has increased to nuisance levels since the late 1980s and may encourage increased sedimentation of fine particulate matter.

Forty-five species of fish have been listed in the Hanford Reach of the Columbia River, of which 16 are introduced. Of native species, Chinook salmon (*Oncorhynchus tshawytscha*), sockeye salmon (*Oncorhynchus nerka*), coho salmon (*Oncorhynchus kisutch*), and steelhead trout (*Oncorhynchus mykiss*) use the river as a migration route to and from upstream spawning areas and are of the greatest economic importance. Additionally, fall Chinook salmon and steelhead trout spawn in the Hanford Reach. Inundation of other mainstream Columbia River spawning grounds by dams has increased the relative importance of the Hanford Reach to fall Chinook salmon production in the Columbia and Snake Rivers. There are presently 10 areas identified in the Hanford Reach that support salmon spawning.

The steelhead fishery in the Hanford Reach consists almost exclusively of summer-run fish. The Washington State Department of Fish and Wildlife estimates steelhead sport catch for the 2002 season at 1,100 fish. The majority of these fish were marked hatchery fish.

American shad (*Alosa sapidissima*), an introduced anadromous species, may also spawn in the Hanford Reach. The upstream range of the shad has been increasing since 1956 when less than 10 adult shad passed McNary Dam. Since then, the number of shad ascending Priest Rapids Dam has risen to many thousands each year and young-of-the-year (fish born the year of collection) have been collected in the Hanford Reach. Shad are not dependent on the same conditions that are required by salmonids for spawning and apparently have found favorable conditions for reproduction.

Other fish of importance to sport anglers are the native mountain whitefish (*Prosopium williamsoni*) and white sturgeon (*Acipenser transmontanus*). Introduced species like smallmouth bass (*Micropterus dolomieui*), crappie (*Pomoxis nigromaculatus*), catfish (*Ictalurus punctatus*), walleye (*Stizostedion vitreum*), and yellow perch (*Perca flavescens*) are also present. Large populations of rough fish are also present, including introduced carp (*Cyprinus carpio*) and native species such as redside shiner (*Richardsonius balteatus*), suckers (*Catostomus macrocheilus*), and northern pikeminnow (*Ptychocheilus oregonensis*). Because northern pikeminnow feed on juvenile salmon, the Washington State Department of Fish and Wildlife has established a bounty program on adult pike minnow to bolster salmon runs.

Benthic (bottom) habitat and its associated biota are defined by the composition of the sediments that range from accumulations of fines (mud in the sloughs, backwater areas, and shoreline areas of reduced current flow) to a gradation of gravel and cobbles up to large (>0.5 m diameter) boulders. Classification schemes have been proposed for characterizing benthic habitat based on the distribution of cobble by size and the degree of embeddedness in the fines. Bottom-dwelling (benthic) organisms are found either attached to or closely associated with the substratum. A total of 151 different taxa of aquatic invertebrates have been identified in the Columia River. All major freshwater benthic taxa are represented in the Columbia River. Insect larvae such as caddisflies (*Trichoptera*), midge flies (*Chironomidae*), and black flies (*Simuliidae*) are dominant. Other benthic organisms include clams (*Corbicula* spp., *Anodontia* spp.), limpets (*Fisherola* spp.), snails (*Physa* spp.), sponges (*Spongilla* spp.), and crayfish (*Astacus trowbridgii*). River fluctuations from the operation of Priest Rapids Dam do not allow for the establishment of persistent benthic communities, particularly in shoreline areas. Clams and crayfish have

difficulty in establishing populations in stranded shoreline areas that are frequently left dewatered by river level fluctuations. Species with rapid life cycles are less likely to be impacted by river fluctuations.

2.4 PREVIOUS INVESTIGATIONS AND ASSESSMENT ACTIVITIES

Previous investigations and assessments include those conducted for the RCBRA and the Columbia River, both of which are summarized in the following subsections. The information provided in the previous investigations and assessments has been used to compile existing data, identify data gaps, establish a list of analytes, and support the risk assessments.

2.4.1 RCBRA Investigations

This subsection summarizes previous RCBRA investigations, including the Source and Groundwater Component investigations and the Inter-Areas assessment investigations. Data from all these studies are used to support both human health and ecological risk assessments. Table 2-3 summarizes the relationship between the risk assessment endpoints for the Source and Groundwater Component of the RCBRA and those supported by this RI work plan.

Table 2-3. Comparison Between Columbia River and Source and Groundwater Component Risk Assessment Endpoints. (2 Pages)

	Remedial Investigation of Hanford Releases to the Columbia River	River Corridor Baseline Risk Assessment Source and Groundwater Component
Human Health Risk Assessment Exposure Scenarios		
Scenario		
Recreational	Casual user	Casual user
	Avid angler	Avid angler
		Avid wild game hunter
Native American	Yakama Nation	Yakama Nation
		Confederated Tribes of the Umatilla Indian Reservation
Residential	Dredged sediment exposure	Rural resident
	Surface water consumption	Resident national monument worker
Industrial		Industrial worker

Table 2-3. Comparison Between Columbia River and Source and Groundwater Component Risk Assessment Endpoints. (2 Pages)

	Remedial Investigation of Hanford Releases to the Columbia River		River Corridor Baseline Risk Assessment Source and Groundwater Component
Ecological Assessment Endpoint Receptors			
Environment	**Steps 1-3**	**Steps 4-8 As Needed**	**Riparian and Near-Shore**
Aquatic	Fish	Fish	Fish
	Aquatic plants	Aquatic plants	Aquatic plants
	Algae and zooplankton	Algae and zooplankton	Algae and zooplankton
	Amphibians	Amphibians	Amphibians
	Benthic macroinvertebrates	Benthic invertebrates (insects, calms, snails, mussels)	Benthic macroinvertebrates (insects, clams, snails, mussels)
Terrestrial/ riparian	Soil invertebrates	Soil invertebrates	Soil invertebrates
	Terrestrial plants	Terrestrial plants	Terrestrial plants
	Mammals	Pocket mouse (herbivore), deer mouse (omnivore), grasshopper mouse (omnivore), badger, bats	Pocket mouse (herbivore), deer mouse (omnivore), grasshopper mouse (omnivore), badger, bats
	Birds	Kingbirds (insectivores), meadowlark (omnivore), mourning dove (herbivore), butterhead (carnivore), heron (carnivore)	Kingbirds (insectivores), Meadowlark (omnivore), mourning dove (herbivore), butterhead (carnivore), heron (carnivore)

2.4.1.1 Source and Groundwater Component Investigations. The groundwork for the Source and Groundwater Component (i.e., 100/300 and Inter-Area studies) of the RCBRA was initiated in the spring of 2003. Work conducted to support the risk assessment effort included defining the basis and assumptions of work scope (DOE/RL-2003-61), development of a work plan (DOE/RL-2004-37), public and stakeholder participation, identification of issues through a series of agency and stakeholder interviews, identification of DQOs (BHI-01757), development and implementation of a sampling and analysis plan (SAP) (DOE/RL-2005-42), and completion of the initial risk assessment evaluation for the Source and Groundwater Component of the RCBRA in June 2007.

The purpose of the Source and Groundwater Component of the RCBRA is two-fold:

- Evaluate human health and ecological risks resulting from conditions subsequent to the implementation of the remedial actions in the 100 Area and 300 Area of the Hanford Site
- Use results to support risk management decision making and to support development of final RODs.

The Source and Groundwater Component focused on the risk from current conditions (post-remediation) in operational areas, historical townsites, riparian areas adjacent to operational areas, and related groundwater plumes emerging in the near-shore river environment (DOE/RL-2005-37, DOE/RL-2004-37). Known emergent groundwater contaminant plume areas were evaluated as part of this component of the RCBRA investigation, and contaminant trends in groundwater were evaluated by location over time for each of the three key contaminants of potential concern (COPC) plume areas: chromium, strontium-90, and uranium.

2.4.1.2 Inter-Areas Assessment Investigations. After completion of the initial Source and Groundwater Component sampling effort, an additional study was identified to complete data gaps of various locations, media types, and potential contaminants. This additional study is referred to as the Inter-Areas assessment of the RCBRA. The primary purpose of the Inter-Areas assessment is to evaluate risks from current concentrations of chemicals and radionuclides in the riparian and near-shore aquatic zones between operational areas in the 100 Area and 300 Area. This includes evaluating areas from emerging 200 Area groundwater plumes (under current conditions), slough and backwater areas, and habitats found predominantly in areas between reactor and operational areas.

Data collected for the Inter-Areas assessment also filled data gaps for the RCBRA. The Inter-Areas DQOs and study design are documented in Appendix E of the *100 Area and 300 Area Component of the RCBRA Sampling and Analysis Plan* (DOE/RL-2005-42). Between October 2005 and December 2006, field sampling and surveys of soil, sediment, surface water, pore water, groundwater (well water), and biota were conducted. Results of the Inter-Areas assessment are being included in the next update of the RCBRA (DOE/RL-2007-21).

2.4.2 Columbia River Data Compilation and Data Gap Analysis

This subsection summarizes the assessment activities that were conducted in preparation for the Columbia River RI. These activities consisted of two parts: the compilation of all available and relevant Columbia River data into a single CRC database, and the use of that database to identify data gaps, which were then used as a basis for selecting sampling locations in this RI work plan. Both of these activities were described in the *Columbia River Component Data Gap Analysis* (WCH-201) and are summarized in Sections 2.4.2.1 and 2.4.2.2.

2.4.2.1 Data Compilation. Known and available data were reviewed and compiled into a single combined database as the first step in the Data Gap Analysis effort. In addition, river analytical data were obtained electronically from a variety of sources and combined into a single electronic

database that could be queried, crosschecked, and used to support mapping, data evaluation, and reporting needs.

The combined database for the *Columbia River Component Data Gap Analysis* (WCH-201) consists of data from the following sources:

- The original CRC database
- U.S. Army Corps of Engineers (ACOE)
- Data used in the Source and Groundwater Component of the RCBRA
- RCBRA Report for Inter-Areas data (WCH-274)
- Mid-Columbia River sediment data provided by EPA Region 10, Watershed Restoration Unit, on June 8, 2007
- 2004, 2005, and 2006 data from the Pacific Northwest National Laboratory (PNNL). Data from previous years were included in the original CRC database above.

The original CRC database was a compilation of data obtained from the detailed data collection effort conducted as part of the *Existing Source Information Summary Report Compilation/ Evaluation Effort: December 2004 to September 2005, Columbia River Component of the River Corridor Baseline Risk Assessment* (WCH-64) and *Columbia River Component Data Evaluation Summary Report* (WCH-91). As part of those efforts, data were obtained, reviewed, and selected by a team composed of researchers from universities, PNNL, WCH, and a Native American consulting firm through a process that involved extensive review and input by the Hanford Natural Resource Trustee Council. The Hanford Natural Resource Trustee Council consists of the following entities: Yakama Nation; Confederated Tribes of the Umatilla Indian Reservation (CTUIR); Nez Perce Tribe; State of Oregon Department of Energy; Washington State Department of Ecology; U.S. Department of Commerce (National Oceanic and Atmospheric Administration); DOE, Richland Operations Office; and U.S. Department of Interior (U.S. Fish and Wildlife Service). The extensive details of the data collection and evaluation method are provided in those documents, particularly WCH-64, and specific decisions about what data to include or exclude were made by those researchers.

Refer to Section 2.0 of the *Columbia River Component Data Gap Analysis* (WCH-201) for the quality control (QC), standardization, and usability evaluations conducted to confirm that the final combined data set was accurate, consistent, and scientifically sound.

For the Source and Groundwater Component of the RCBRA, a custom built software application known as the Guided Interactive Statistics Decision Tools serves as the user interface for data. The data presented using the Guided Interactive Statistics Decision Tools application were downloaded from the WCH Data Management web site (http://rcbra100-300.neptuneinc.org/rcbra100-300/home/index.xml).

During the time of data compilation for the CRC, data were being collected for the Inter-Areas assessment. Specific data from the Inter-Areas assessment were obtained from project staff at WCH between May and October 2007.

The 2004-2006 PNNL data from the Surface Environmental Surveillance Project were not previously included in the original CRC database due to the timing of the issuance of that document. However, as indicated above, these data have been included in the data review for this RI work plan.

The original CRC database was created in Microsoft® Access™ and was used as a framework for the development of the combined database created for the Data Gap Analysis (WCH-201). As part of the Data Gap Analysis, additional fields and tables were added to the original database to incorporate information from the other data sources listed previously. This information did not have a place in the original CRC database structure and was necessary to support other data-specific information, such as ecological and human health benchmarks.

The data used to create the combined CRC database for the Data Gap Analysis (WCH-201) are summarized in Table 2-2 of the Data Gap Analysis (WCH-201). This database is not inclusive of all available data from the entire 1,931 km (1,200 mi) of the Columbia River; rather, it was constructed using data sets focused on probable areas affected by Hanford Site-related contaminants. Data from beyond approximately 32 km (20 mi) upriver of the Hanford Site were excluded, as were large EPA data sets from the lower Columbia River (downriver of McNary Dam), because these data were highly influenced by other industrial and agricultural sources, and the focus of this analysis is on Hanford Site-related sources. Although other numerous contaminant sources exist both upriver and downriver of the Hanford Site, this study is focused on evaluating data needs relative to potential effects in proximity to known Hanford Site source areas. As with other industrialized rivers, there are a significant number of contaminant sources that drain into and thus affect the Columbia River. The majority of significant non-Hanford Site source areas are located downriver of the Hanford Site (e.g., Snake and Yakima Rivers). Data collected during the investigation and possible remediation of these downriver sites were not included in the Data Gap Analysis (WCH-201). Only those data that were collected in connection with past Hanford Site investigations were included.

The current database is included on the attached CD. The CRC database on this CD is simply a compilation of the existing data; it does not contain a user interface. Potential users will need to be familiar with Microsoft Access functions to successfully query this database.

2.4.2.2 Data Gap Analysis. The October 2007 *Columbia River Component Data Gap Analysis* (WCH-201), prepared subsequent to data compilation, was conducted to review the adequacy of the existing surface water and sediment data set from the Columbia River, with specific reference to the use of the data in future site characterization and baseline risk assessments. The goal was to determine if there are sufficient data to characterize the current effects of Hanford Site operations on the Columbia River. The specific technical objective of this effort was the

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identification of spatial, temporal, or analytical data gaps. The Data Gap Analysis identified site analytes and potential data gaps, which are described below. The Data Gap Analysis also identified the Study Area boundaries for this RI work plan, which are summarized in Section 4.1.1.1.

The initial list of compounds identified in the Data Gap Analysis (WCH-201) consisted of all detected compounds in samples from the Primary Study Area (i.e., the reach between the Vernita Bridge and McNary Dam). This initial list was subsequently narrowed down to the final list of site analytes during the Data Gap Analysis through a sequential series of data reviews that included the following:

1. Comparison of maximum detected concentration to lowest of either the human health or ecological risk-based values
2. Comparison to site-specific upriver background concentrations
3. Removal of known laboratory contaminants
4. Evaluation of low frequency of exceedance
5. Revision according to additional considerations: groundwater and biota data, site use, findings from the Source and Groundwater Component of the RCBRA, etc.

The purpose of the Data Gap Analysis was to identify potential data gaps in the temporal, spatial, and chemical composition of the existing data set and to determine if there were sufficient data to characterize the potential effects of Hanford Site operations on the Columbia River. Achieving this goal required the compilation of existing and relevant river data into a single database and identifying the specific portion of the river for which data gaps would be evaluated.

The preliminary data gaps identified in the Data Gap Analysis consisted of the following:

- Sloughs and backwaters on the left shore (facing downstream) of the river. Although both surface water and sediment sampling transects have been completed, most samples were collected on the right side of the river, which forms the Hanford Site boundary. Fewer data exist for the left side.
- Islands immediately downstream of source areas. Depositional areas exist around islands downstream of source areas, and some of these island depositional areas have not been fully characterized.
- Locations along the left shore downriver of source areas. River transport mechanisms can disperse sediment throughout the river, and sediment samples on the left shore are lacking downriver of some reactors and the White Bluffs and Hanford townsites.
- Several irrigation returns throughout the reach, particularly the Saddle Mountain Wasteway.

- Near-shore areas in the Richland area, including surface water for VOCs in the area upriver of the Richland pump house.

- Downriver in Lake Wallula. Several sampling and coring activities have focused on sediment behind McNary Dam, but fewer sediment samples exist near the headwaters of the lake or along the shorelines or channel in the middle reach of the lake.

- Sediment behind McNary Dam.

As noted, addressing these data gaps was the first objective of the sampling program described in this RI work plan.

3.0 INITIAL EVALUATION

The purpose of the CSM is to identify the Hanford Site sources of contamination and the environmental transport and exposure pathways between contaminant sources and applicable receptors by using historic information and existing data. This section organizes existing site information to identify contaminant sources (Section 3.1), release mechanisms and environmental transport media (Section 3.2), and potential exposure pathways between contaminants and applicable receptors (Section 3.3). As a communication tool, the preliminary CSM presented in this document affords the opportunity for continued refinement and will continue to be refined on the basis of new or improved technical or site-specific information and other relevant input.

3.1 CONTAMINANT SOURCES

Past and/or current Hanford Site-related contaminant sources are existing or potential sources of hazardous substances in the environment that may pose a threat of adverse effects to both human and ecological receptors. In addition, contaminant sources include upriver activities and other contributing influences (i.e. non-Hanford Site) within the RI investigation area (Figure 1-1). Non-Hanford Site sources (upriver and within the RI investigation area) and Hanford Site-related sources (i.e., past river effluent pipelines, contaminated groundwater seepage to the Columbia River, and limited overland flow) are described in the following subsections.

3.1.1 Non-Hanford Site Sources

This section summarizes potential current and historical contaminant sources upriver of the Hanford Site and other contributing influences within the RI investigation area (i.e., global, municipal, industrial, agricultural, and commercial sources). More detailed information about these non-Hanford Site contaminant sources is presented in WCH-91.

3.1.1.1 Upriver. While the presence of dams upriver from the Hanford Site currently limits the transport of contaminants from upstream sources, the magnitude and duration of historical and current discharges may provide a potential for long-range transport to the Hanford Site.

Contributions of contaminants to the Columbia River may come from direct sources to the river or indirect sources. Examples of direct and indirect sources include mining operations, smelting, pulp and paper production, runoff from cities and agricultural areas, municipal and industrial wastewater treatment plants, nuclear weapons production and atmospheric testing, and other activities that release materials that reach the river.

Mining operations at the Teck Cominco Mine in Trail, British Columbia, located 16 km (10 mi) north of the U.S./Canadian border, began in 1890, with smelter operations beginning in 1896 along the headwater of the Columbia River. These operations began prior to the construction of any dams along the Columbia River. The lead and zinc smelter on the banks of the Columbia River at the Trail facility dumped an estimated 10 million to 20 million tons of slag

into the river. The facility released dissolved iron, manganese, zinc, copper, lead, arsenic, cadmium, and mercury via liquid effluent and as solids in the form of slag, a smelting byproduct (WHC-SA-1989-FP). The EPA Region 10 contends that the Trail smelter is the largest source of metals pollution in Lake Roosevelt, a reservoir created when the river was blocked behind Grand Coulee Dam in 1937. In 2006, an EPA study of sediment samples concluded that the portion of the lake from Inchelium, Washington, upstream to the Canadian border already qualified for Superfund listing because of hazards to aquatic life from heavy metals (CH2MHill 2006). Metal contaminants flow down the river into Lake Roosevelt. Contaminants from this facility may exist downstream of Grand Coulee Dam within the Hanford Site RI investigation area.

Other smelting operations have taken place in Northport, Washington (EPA 2004a). The Celgar pulp mill in Castlegar, British Columbia, was a primary source of historical loading of dioxins and furans to the upper Columbia River (EPA 2004b). Alcoa's aluminum smelter facility in Wenatchee, Washington, is currently the only major U.S. industrial National Pollutant Discharge Elimination System permitted facility located upstream of the Hanford Site. It may contribute the following contaminants to the Columbia River: fluoride, aluminum, copper, benzo(a)pyrene, cyanide, oil, and grease (WCH-91). There are also nine municipal treatment plants that discharge effluent to the river upstream of the Hanford Site (WCH-91).

The Spokane River has elevated levels of polychlorinated biphenyls (PCBs) and metals. Some of the sources include the following:

- Mining waste and the associated metals that may have been transported downstream from the Coeur d'Alene Basin to the Spokane River.

- Midnite Mine, an open-pit uranium mine, operated along the Spokane River in the Selkirk Mountains of eastern Washington from the mid-1950s until 1981 and contributed contaminants upriver of the Hanford Site. Elevated levels of radioactivity (primary uranium) and heavy metals mobilized in acid mine drainage pose a potential threat to human health and the environment (EPA 2006a).

- Kaiser Trentwood, an aluminum plant, discharged PCBs to the Spokane River in excess of 2 kg/day in the early 1990s and as late as 2000 (Serdar et al. 2006).

- The Spokane Wastewater Treatment Plant discharged 0.25 kg/day of PCBs in 2001 (Serdar et al. 2006).

3.1.1.2 Global. Worldwide atmospheric nuclear testing contributed to radionuclide contaminants in surface waters and ultimately to sediments throughout the Pacific Northwest. Fallout from atmospheric testing by the United States, Russia, and China contributed significantly to radionuclide levels in the environment (WDOH 1994). The fallout materials consisted primarily of radionuclides such as cesium-137 (30.07 years) and strontium-90 (28.78 years), along with shorter lived radionuclides such as cerium-141 (32.50 days), zirconium-95/niobium-95 (63.98 days/35.15 days), and ruthenium-103/106 (39.28 days/

368.2 days) (WDOH 1994). Strontium and cesium are also associated with Hanford Site operations. The Soviet nuclear reactor accident at Chernobyl in 1986 also produced detectable levels of iodine-131 and cesium-137 in precipitation in the Pacific Northwest (WDOH 1994).

3.1.1.3 Remedial Investigation Area. The following primary non-Hanford Site source types have been identified in the Study Area (defined in Section 4.1.1.1) and are summarized below:

- Naturally occurring sources
- Municipal/urban sources
- Agricultural sources
- Commercial/recreational vessels.

Naturally Occurring Sources. Naturally occurring elements have been detected in sediment and surface water of the Columbia River. The following naturally occurring inorganic elements have been detected at background sediment locations: antimony, arsenic, barium, cadmium, manganese, nickel, potassium, and zinc. The naturally occurring radionuclides uranium-234, uranium-238, and potassium-40 have been detected at background sediment locations.

Aluminum, arsenic, barium, cadmium, manganese, and elemental uranium have been detected in surface water samples from background locations. In addition, the following radionuclides have been detected in background samples and are also naturally occurring in surface water: tritium, uranium-234, and uranium-238. While these elements and radionuclides are naturally occurring in the environment, their presence in sediment and surface water upstream of the Hanford Site is not necessarily representative of natural conditions, and may be related to upstream or non-Hanford Site sources (e.g., industrial, agricultural, or mining).

Municipal/Urban Sources. Municipal and urban activities contribute as point and nonpoint sources of contamination to the river. Other National Pollutant Discharge Elimination System permitted discharges to the Columbia River include stormwater, minor industrial process wastewater, contact and noncontact cooling waters, treated waters, and construction sites. Effluents from municipal sewage treatment plants also contribute to waste loading within the Columbia River system. A total of 41 municipal sewage treatment plants were identified in 2005 that discharge effluent to the Columbia River.

Urban contributions including nonpermitted residential and commercial stormwater runoff, residential use of fertilizers and pesticides, and septic sewage systems are some of the potential sources of contamination from communities along the banks of the Columbia River. Stormwater runoff can contain a number of contaminants such as pesticide and weed control products, contamination from leaking transformers, hydraulic and lubricating fluids, petroleum products, metals, polyaromatic hydrocarbons, and deicing salts. Runoff containing naturally occurring contaminants such as uranium also contributes to river contamination.

Agricultural Sources. By the 1920s, major irrigation projects along the Columbia River and tributaries operated with the benefit of federal programs. In 1948, the Columbia Basin Project

began transporting Columbia River water by canal to the more than 600 thousand acres of farms in central Washington (CCRH 2007).

Agricultural activities are a potential source of contamination. Water from the irrigation returns in the Hanford Reach has been sampled and contaminants include nitrogen, phosphate, copper, uranium, and suspended solids (Ecology 1981).

Sampling of irrigation return water from Franklin County and associated irrigation-related seeps entering the Columbia River, opposite the Hanford Site, have measured total uranium values of 8.6 pCi/L (PNNL-7500). Note: processed uranium contamination is isotopically different from that which has been detected in irrigation return water. Uranium is commonly present in phosphate-based fertilizers and is a natural constituent that weathers from some types of rocks in the region. In recent years, total uranium concentrations in the Hanford Reach have been elevated along the Franklin County shoreline. Previous studies have indicated these elevated concentrations are likely the result of groundwater seepage and water from irrigation returns that contain naturally occurring uranium.

Commercial/Recreational Vessels. Recreation and commercial activities on the Columbia River also contribute contamination to surface water and sediments via marinas, boats, or other recreational watercraft. Discharge of bilge and ballast water, engine oil, spills, and materials associated with boat and shipyard maintenance are potential sources of contamination. These sources may contain old paint scrapings (lead), anti-foulants (copper), solvents, oil and grease, fuels, PCBs, and cleaning agents. Pilings, docks, and bulkheads associated with marine structures treated with creosote, chromated copper arsenate, or copper zinc arsenate are other sources of contamination.

3.1.2 Hanford Site Sources

Hanford Site sources of contamination to the Columbia River include past river effluent pipeline discharges, current contaminated groundwater seepage to the river, limited overland flow from the operational areas, and limited airborne contamination (i.e., dust, debris, plant matter, etc.) during dust storms.

3.1.2.1 River Effluent Pipeline Discharges. Likely depositional areas directly downriver of the effluent pipelines have been identified as focus areas for the proposed RI field investigation (Section 4.0).

From 1943 to the present, the Columbia River has been used as a water supply by the Hanford Site. The following nine reactor sites are present in the 100 Area: 100-B, 100-C, 100-D, 100-DR, 100-F, 100-H, 100-KE, 100-KW, and 100-N. All of the reactors, except 100-N, used the single-pass river water for primary reactor core cooling purposes. The 100-N system provided river water to a secondary (or closed-loop) cooling. Most effluent pipelines stopped operating when the associated reactor was shut down or soon thereafter. One of the two 100-K lines (K-East) still services the 100-K Area.

During reactor operation, released cooling water from the reactor went to a short-term retention basin located between the reactor building and the Columbia River. Water retention permitted thermal cooling and the decay of short-lived radioisotopes prior to river discharge. As reactor production increased, the retention period decreased. The retention basins also served to hold up the flow of effluent with high radioactive isotope concentrations that resulted from fuel element failure. This higher concentration effluent was isolated and diverted either by gravity or pumping to trenches, which filtered the effluent through the soil before it reached the groundwater adjacent to the river edge. This process resulted in contaminated groundwater plumes migrating toward and upwelling in the Columbia River (Section 3.1.2.2).

Effluent pipeline observations and contaminant concentrations are available in the following piping characterization studies that are discussed in *100 Area River Effluent Pipelines Characterization Report* (BHI-01141):

- Beckstrom and Steffes (1986): In the early spring of 1984, the deactivated effluent water lines for the 100-C, 100-DR, and 100-F Reactors were radiologically and physically characterized. The predominant isotopes in the lines were found to be europium-152, europium-154, europium-155, cobalt-60, and cesium-137.

- WHC-SD-EN-TI-278 (1994): In April 1994, a comprehensive river geophysical survey located and mapped the 14 effluent pipelines using navigation and echo sounding, side-scanning sonar, sub-bottom profiling, seismic reflection profiling, and ground-penetrating radar.

- BHI-00538 (1996): In the summer of 1995, the interiors of the effluent pipelines at the 100-B (116-B-7 Outfall) and 100-D (116-D-5 Outfall) reactor sites were radiologically, chemically, and physically characterized. These two pipelines, based on reactor operations, years of operation, and discharge volume, were expected to represent a worst-case scenario with respect to radiological contamination and physical deterioration. Sediment and scale samples were collected from the 100-B and 100-D pipelines and analyzed for radiological constituents, gross alpha, gross beta, metals, and total organic carbon. The concentrations of chromium and mercury in the pipe scale and sediment found in the study, although high, suggest that they are not in a water-soluble form, so their toxicity to an occasional fish would be minimal. The insoluble form of the metals also presents no ecological risks.

3.1.2.2 Contaminated Groundwater Seepage to River. Past waste management and waste disposal practices at the Hanford Site have resulted in the presence of several contaminated groundwater plumes. Groundwater beneath the Hanford Site discharges to the Columbia River via springs and subaqueous (below the riverbed) groundwater upwellings. Groundwater provides a means for transporting Hanford Site-related contaminants to the Columbia River. General descriptions of the groundwater plumes emanating from the reactor and operation areas are provided in Section 4.2.

The flow of groundwater (seepage velocity) from beneath the majority of the Hanford Site (e.g., reactor areas) into the Columbia River is estimated to be 1 m^3/sec (35.32 ft^3/sec)

(FH 1999). Maximum seepage velocities were measured at the 300 Area up to 15 m/day (50 ft/day). The majority of the following text was included in the September 2007 *Hanford Site Environmental Report for Calendar Year 2006* (PNNL-16623) and has been slightly modified and included below for the purposes of this RI work plan. References associated with the text in this subsection have not been included in this RI work plan, but can be found in PNNL-16623.

In general, groundwater discharges are considered to be the current dominant pathway for Hanford Site-related contaminants to enter the Columbia River. Shoreline springs were documented along the Hanford Reach long before Hanford Site operations began during World War II. During the early 1980s, researchers identified 115 springs along a 66 km (41-mi) stretch of the Hanford Reach. They reported that the predominant areas of groundwater discharge at that time were in the vicinity of the 100-N Area, Hanford townsite, and 300 Area. Today, the 100-N Area no longer stands out due to declining water-table elevations, a consequence of the end of operations at the N Reactor, which have reduced discharge from the springs. In addition, effluent from the N Reactor was discharged to trenches and cribs near the river. Contaminants from the 100 Area trenches and cribs have impacted groundwater that discharges to the river.

The presence of shoreline springs also varies with river stage (river-level elevation). The water table near the Hanford Reach is strongly influenced by river stage fluctuations. As water levels fluctuate, groundwater levels and thus the presence of shoreline springs in the Hanford Reach vary. At the 300 Area, the river stage is also influenced by the elevation of the McNary Dam pool. River water moves into the Hanford Site aquifer as the river stage rises (bank storage) and then discharges from the aquifer in the form of shoreline springs as the river stage falls. Following an extended period of low river flow, groundwater discharge zones located above the water level of the river may cease to exist when the level of the aquifer comes into equilibrium with the level of the river. Thus, springs are most readily identified immediately following a decline in river stage. Bank storage of river water also affects the contaminant concentration of the springs. Spring water discharged immediately following a river stage decline generally consists of river water or a mixture of river water and groundwater. The percentage of groundwater in the spring water discharge increases over time following a drop in river stage. Measuring the specific conductance of the spring water discharge provides an indicator of the extent of bank storage because Hanford Site groundwater has a higher specific conductance than Columbia River water.

Groundwater contamination exists beneath the Hanford Site and along the Columbia River shoreline and near-shore river where groundwater mixes with the surface soils and Columbia River water (DOE/RL-2004-37). Figures 10.7.4 and 10.7.5 from PNNL-16623 show the distribution of major radionuclides and hazardous chemicals, respectively, in Hanford Site groundwater at concentrations above drinking water standards during 2006. In addition, the Hanford Environmental Information System (HEIS) database has been queried for groundwater contaminants occurring throughout the Hanford Site above detection limits. The list of contaminants and observed concentrations have been evaluated. According to this evaluation, the following contaminants could be associated with the groundwater emanating from the 100, 200, and 300 Areas:

- **100 Area Plumes:** Chromium, strontium-90, tritium, trichloroethene (TCE), nitrate
- **200 Area Plumes:** Carbon tetrachloride, chromium, technetium-99, tritium, uranium (elemental), iodine-129, nitrate, TCE
- **300 Area Plumes:** Nitrate, uranium (elemental), TCE, DCE, vinyl chloride, tritium.

The proposed field investigation will include analysis for the above contaminants. As part of this investigation, an assessment of plume upwelling locations will be conducted to identify sediment and surface water sampling locations.

3.1.2.3 Limited Overland Flow. While the most significant historic transport mechanism was direct discharge of the single-pass cooling water, historic overland flow was also associated with reactor operations. Historic information including aerial photographs clearly shows water seepage from the reactor cribs and trenches flowing across the land surface and discharging directly to the Columbia River. While this transport mechanism is no longer active, it is assumed that overland flow was a significant source of Hanford Site contaminants to the river during operations. Areas of suspected overland flow were evaluated in the 100 Area investigations. Hanford Site contaminants that reached the river during single-pass cooling water operations (1943 to 1972) via this transport mechanism have been washed downriver and presumably now reside in downriver sediments.

A significant overland flow that resulted in Hanford Site contamination flowing to the river occurred in October 1948, when the South Process Pond (300 Area) failed, releasing an estimated 14.5 million gallons of uranium-contaminated water down a natural channel into the river (EMO-1026). This one-time event resulted in an estimated 12 to 16 pounds of uranium (elemental) entering the river. Other such discharges include a spill from a sodium dichromate storage tank at the 183-C Building in 1965 (DUN-3032, *Chemicals Discharged to the Columbia River from DUN Facilities Fiscal Year 1967*). Additional overland discharges from leaks in the reactor effluent discharge systems (such as the 100-K Area retention basins and mile-long trench) are considered addressed by the information in the discussion of direct discharges through effluent pipelines.

3.2 RELEASE MECHANISMS AND ENVIRONMENTAL TRANSPORT MEDIA

The following potential contaminant migration pathways for the near-shore and river/aquatic zones were identified:

- **Infiltration, Percolation, and Leaching from Upland Soils**. The infiltration, percolation, and leaching contaminant migration mechanisms require a liquid medium to transport contaminants downward through the vadose zone, into groundwater, and to the river. The infiltration, percolation, and leaching contaminant migration pathways are currently

associated with water resulting from precipitation or other liquid discharges (e.g., septic systems).

- **Surface Runoff and Direct Discharge**. The surface runoff contaminant migration pathway is associated with the runoff of precipitation or other water sources, following contact with surface soil or waste sites. Surface runoff may discharge to nearby surface water and to near-shore sediments in the Columbia River. Because of the extremely porous nature of Hanford Site soils, this transport mechanism is expected to be virtually nonexistent.

- **Sediment Deposition.** Contaminants released to the Columbia River from the Hanford Site-related sources described in Section 3.1 may be deposited downstream of the Hanford Site. As shown in previous studies (HW-83614), the highest concentrations of contaminants reside in the fine-grained river sediments. Therefore, identifying and sampling areas of fine-grained sediments (generally <2 mm) are the focus of this RI. By understanding the river flow patterns, land elevations, topographical features, and process knowledge of the Hanford Reach environs, a preliminary assessment was made to describe where the bulk of sediment is known or suspected to be deposited in support of the RI field investigation. Bathymetric data collected within the RI investigation area include the following:

  - Sediment profiles collected by ACOE across Lake Wallula from 1953, 1978, 1986, 1996, and 2007.

  - Data collected by the ACOE in 1998 and 2003 using Scanning Hydrographic Operational Airborne Lidar Survey (SHOALS). These data were used to illustrate relative depths of the Hanford Reach down to three Secchi Disc lengths (approximately 15 m [50 ft] in most areas of the river). The two-dimensional resolution of the SHOALS data is 3 m by 3 m (10 ft by 10 ft), and the vertical accuracy is estimated to be 10 cm.

  - River knowledge obtained from several decades of sediment and surface water sampling obtained during the PNNL surveillance monitoring program.

  The cumulative results of prior investigations, past modeling efforts, and river knowledge will be used to identify areas of fine-grained sediment that will be targeted for sampling during the RI. A preliminary assessment of fine-grained sediment locations within the Hanford Reach and below Richland to McNary Dam was conducted in 2008. A proof-of-principal testing approach was conducted in late February and early March 2008 using a single beam sonar, with confirmatory sediment sampling completed using a petite ponar sampling tool (Appendix B). It is the intention of the RI investigation to conduct a sonar or underwater camera survey at all proposed river bottom sediment sampling locations to aid in locating fine-grained sediments.

  - **Shorelines**. Downstream shoreline portions of islands within the Columbia River provide a riparian habitat for a number of semi-aquatic species, and can be depositional areas for Hanford Site-related contaminants. These areas consist largely of riparian habitats of exposed shorelines and island areas that are flooded infrequently in the

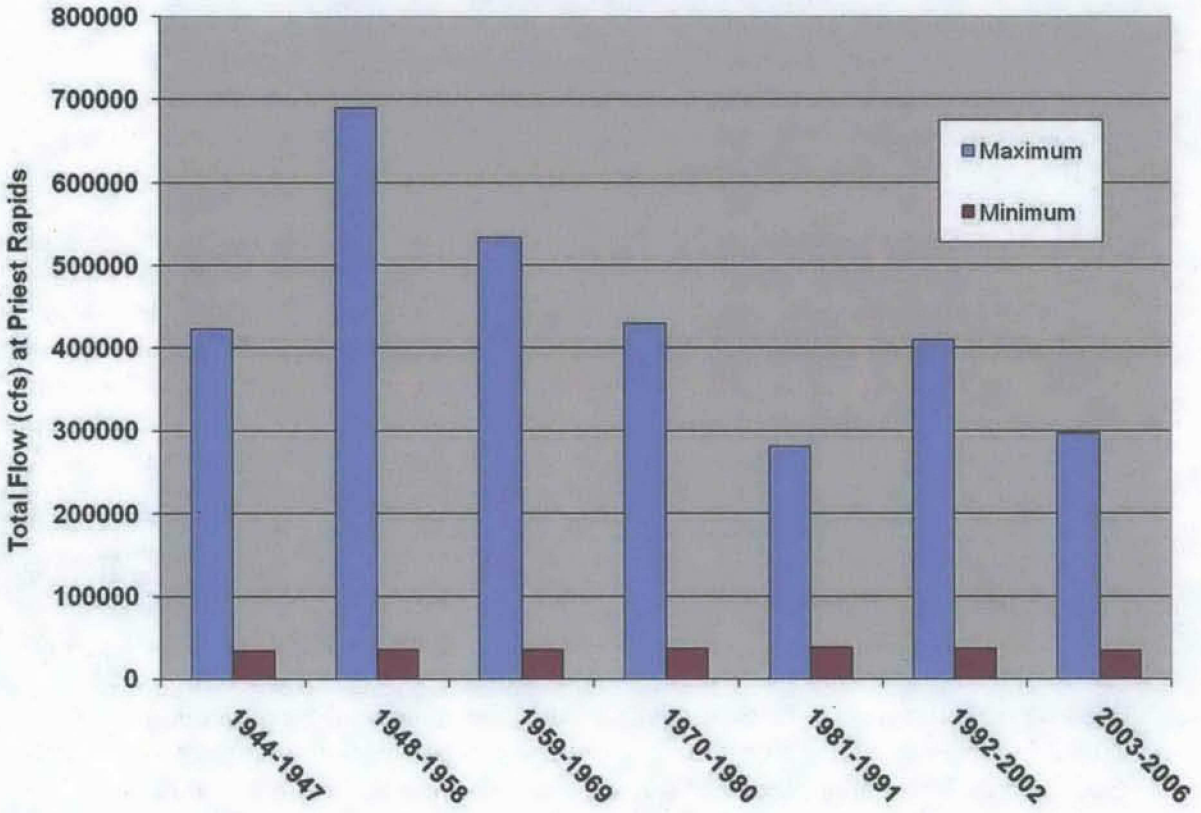
Hanford Reach and downriver as the result of releases from Priest Rapids Dam. Upper portions of the shorelines can be exposed for long periods of time, providing a feeding area for terrestrial or riparian habitat to resident species. In addition, far shorelines (left-shore areas on the opposite side of the river from the Hanford Site) are included in this designation, as well as depositional areas and shorelines in Lake Wallula. As recommended in the Data Gap Analysis (WCH-201), the primary focus for selection of proposed surface water and sediment sampling locations was on islands downstream of source areas, since these areas may be repositories of contaminants originating from the Hanford Site.

- **McNary Dam**. Construction of McNary Dam in 1947 created an impoundment on the river that is nearly 64 km (40 mi) long (Lake Wallula). The impoundment not only stores water for electric production, but also creates a settling basin for suspended sediments. The highest production of plutonium at the Hanford Site occurred when construction of McNary Dam was completed, and therefore sediments began to accumulate behind the dam just as plutonium production began to increase (see Figure 2-2). Several proposed surface water and sediment sampling locations within the McNary Dam area and Lake Wallula have been included in the field investigation to address Hanford Site-related contaminants that have been deposited in these depositional areas.

- **Redeposition of Sediments.** Measurable concentrations of Hanford Site-related contaminants (e.g., radioactive materials and industrial chemicals) have been deposited on the riverbed as sediment. The redeposition of sediments during times of normal flow and flooding may also pose a threat of adverse effects to ecological receptors in the Columbia River. Fluctuations in the river flow, as a result of the operation of upriver hydroelectric dams, annual spring high river flows, and occasional floods, have resulted in the resuspension, relocation, and subsequent redeposition of the sediment (Patton et al. 2005). However, sedimentation is limited along the Hanford Reach because of the relatively high river velocity. In general, sediment deposition areas in the Hanford Reach occur in backwater sloughs and along riverbank beaches (PNNL-16990).

  Maximum and minimum hourly and daily average discharge rates are summarized in Figure 3-1 from 1944 through 2006, consisting of 62 years of records from the U.S. Geological Survey Priest Rapids gauging station and Priest Rapids Dam. Ten-year periods, and smaller intervals near 1944 and 2006, were used to represent the results and depict trends. A single maximum daily average flow of 19,500 m^3/sec (690 thousand cubic feet per second [kcfs]) was recorded on June 12, 1948. Between the years 1981 and 1991, the maximum high was only 8,000 m^3/sec (281 kcfs) as shown in Figure 3-1. Discharge rates exceeded 11,300 m^3/sec (400 kcfs) in five of the seven periods shown in Figure 3-1, and the median maximum discharge rate for all seven periods was 12,000 m^3/sec (423 kcfs). Areas along the shoreline that are inundated at flows between 240 kcfs and 400 kcfs are shown in the figures in Section 2.0 of the SAP (Appendix A).

Figure 3-1. Maximum and Minimum Daily and Hourly Flows (cfs) Measured at the Priest Rapids Gauging Station and Priest Rapids Dam Between Years 1944 Through 2006.



Geographic information system shape files created using Modular Aquatic Simulation System 1 flow model results (PNNL-15226) in combination with the SHOALS data were developed to illustrate the extent of shoreline along the Hanford Reach that becomes inundated for flows ranging between 1,130 m^3/sec (40 kcfs) and 11,300 m^3/sec (400 kcfs) at 283 m^3/sec (10 kcfs) intervals. Regions along the Hanford Reach that are inundated when flows are between 6,800 m^3/sec (240 kcfs) and 11,300 m^3/sec (400 kcfs) were used to define the spatial boundaries above the persistent riparian communities. The primary causes of river flow fluctuations are described below.

- **Floods.** Resuspension of residual sediment occurs on a daily basis as well as during flood events. Sediments have been redeposited throughout the Columbia River. While flood events may move sediments to higher levels above normal high water along shorelines during periods of flooding, it is assumed that a majority of the suspended sediment loads during flooding will be deposited behind the dams. A significant flood occurred in 1948, which is prior to dam construction and when increased production began at the Hanford Site. According to the minimum and maximum flow rates presented in Figure 3-1, the maximum flow between 1948 and 1958 at Priest Rapids Dam was approximately 19,500 m^3/sec (690 kcfs).

- **Operation of Upriver Hydroelectric Dams.** The importance of flood control became a priority in the Columbia River Basin after the city of Vanport, Oregon, was destroyed by the 1948 flood. At that time, only two major federal dams (Bonneville and Grande Coulee) and one nonfederal dam (Rock Island) had been constructed (DOE/RL-2005-09). Changes in the elevation of the water table are influenced by river-stage fluctuations controlled by the release of water from Priest Rapids Dam, constructed in 1961. The flow of water past the Hanford Site is regulated by Priest Rapids Dam. Daily flows range from 1,152 to 7,787 m^3/sec (40,700 to 275,000 ft^3/sec), and average flows are approximately 3,400 m^3/sec (120,000 ft^3/sec) (DOE/RL-96-16). As a result of flow fluctuations at Priest Rapids Dam, river stage along the Hanford Reach may change by up to 3 m (10 ft) within a few hours and contaminated sediments can be redeposited along downriver shorelines.

- **Dust Generation through Wind and During Facility Operation**. The dust contaminant migration pathway is associated with the airborne release of dust emanating from surface soil during windy conditions or operation, maintenance, and construction activities at the facility. Any other airborne sources of contamination (such as stack releases) would be captured under the dust contamination migration pathway.

- **Biota Uptake**. The biota uptake contaminant migration pathway is associated with plant and animal uptake of contaminants from pore water, surface water, and sediment.

3.3 EXPOSURE PATHWAYS AND ECOLOGICAL AND HUMAN RECEPTORS

Exposure pathways are the linkage between the contaminant source and the receptor and help to illustrate how contaminants can reach potential receptors, as well as how and where these receptors might be exposed. Receptors are both humans and biota which, based on the exposure pathways and the life history of the receptor, are likely to be exposed to Hanford Site-related contaminants.

3.3.1 Exposure Pathways

An exposure pathway is the physical route of a radionuclide or chemical contaminants from the point of release to a receptor. To be complete, an exposure pathway must have all of the following components:

- A Hanford Site contaminant source

- Direct exposure or mechanism for contaminant release and transport and an environmental transport medium

- An exposure point

- A feasible route of intake and exposure
- A human or ecological receptor.

In the absence of any one of these components, an exposure pathway is considered incomplete, and by definition, there is no risk or hazard (EPA 1989a). With the exception of radionuclides, environmental contaminants must come into physical contact with the receptor for an exposure to occur. Exposure to external radiation can occur when a receptor comes within close proximity but does not physically contact a radiological contaminant. The following exposure pathways were identified:

- Dermal contact
- Incidental ingestion
- External radiation
- Biota/fish consumption
- Volatile and dust inhalation.

The ecological and human health exposure models are summarized in Figures 3-2 and 3-3, respectively.

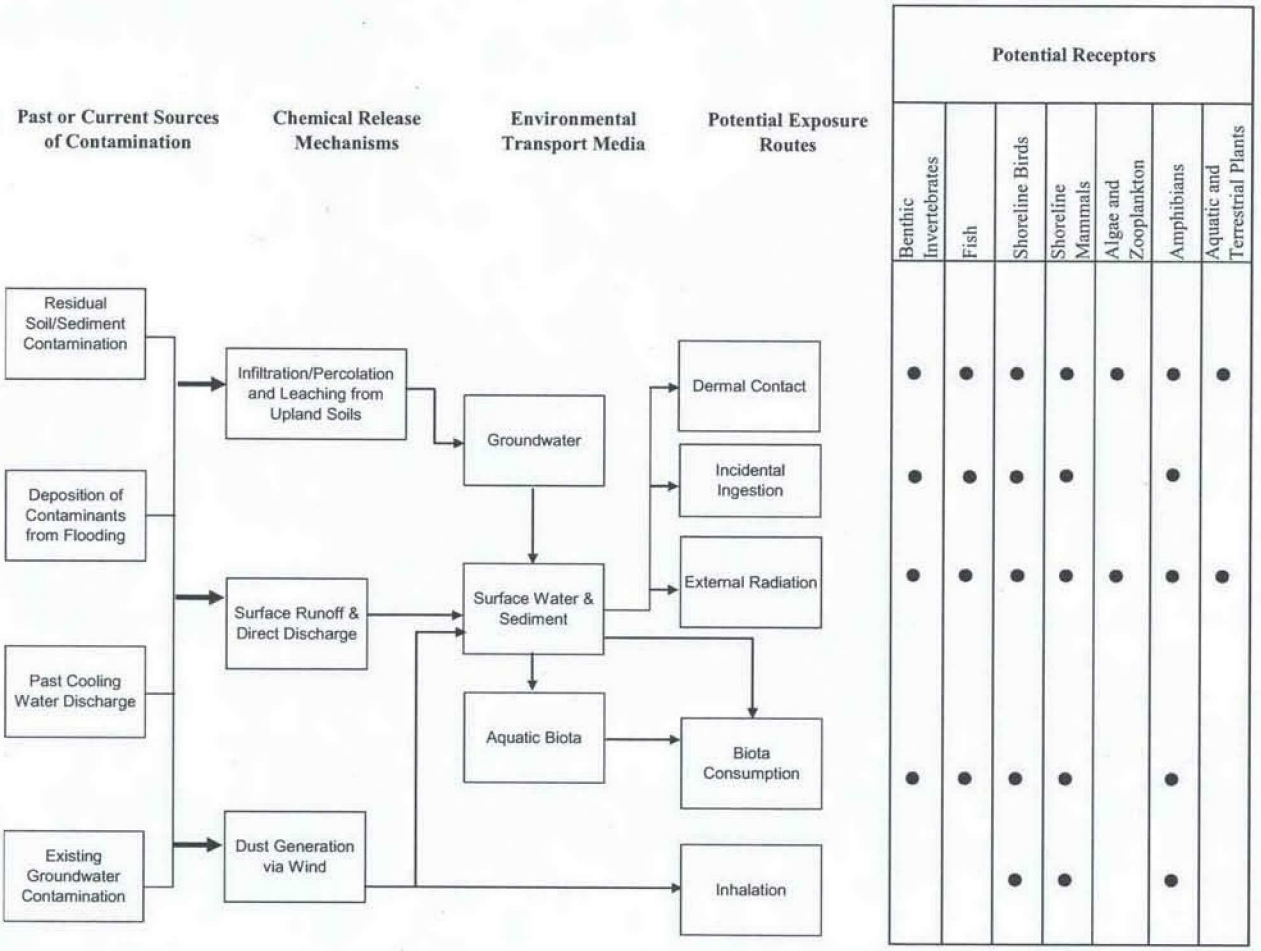
While Figures 3-2 and 3-3 show all potentially complete exposure pathways, some pathways are likely to result in minor or negligible levels of exposure. For birds and mammals, dermal exposure is typically insignificant compared to ingestion exposure, because the skin of these animals is protected by fur or feathers. Likewise, inhalation exposure of dust or volatilized compounds is also minor, especially when compared to ingestion. For these reasons, these pathways are typically not quantified (EPA 2003a).

3.3.2 Ecological Receptors

The biological resources of the Columbia River have been investigated by a number of authors, and are summarized in the September 2007 *Hanford Site National Environmental Policy Act (NEPA) Characterization* (PNNL-6415). Potential receptors in the Columbia River consist of a wide array of flora and fauna that are consistent with the ecology of a large, free-flowing river. Representative members of the general categories of potential receptors are described below (PNNL-6415).

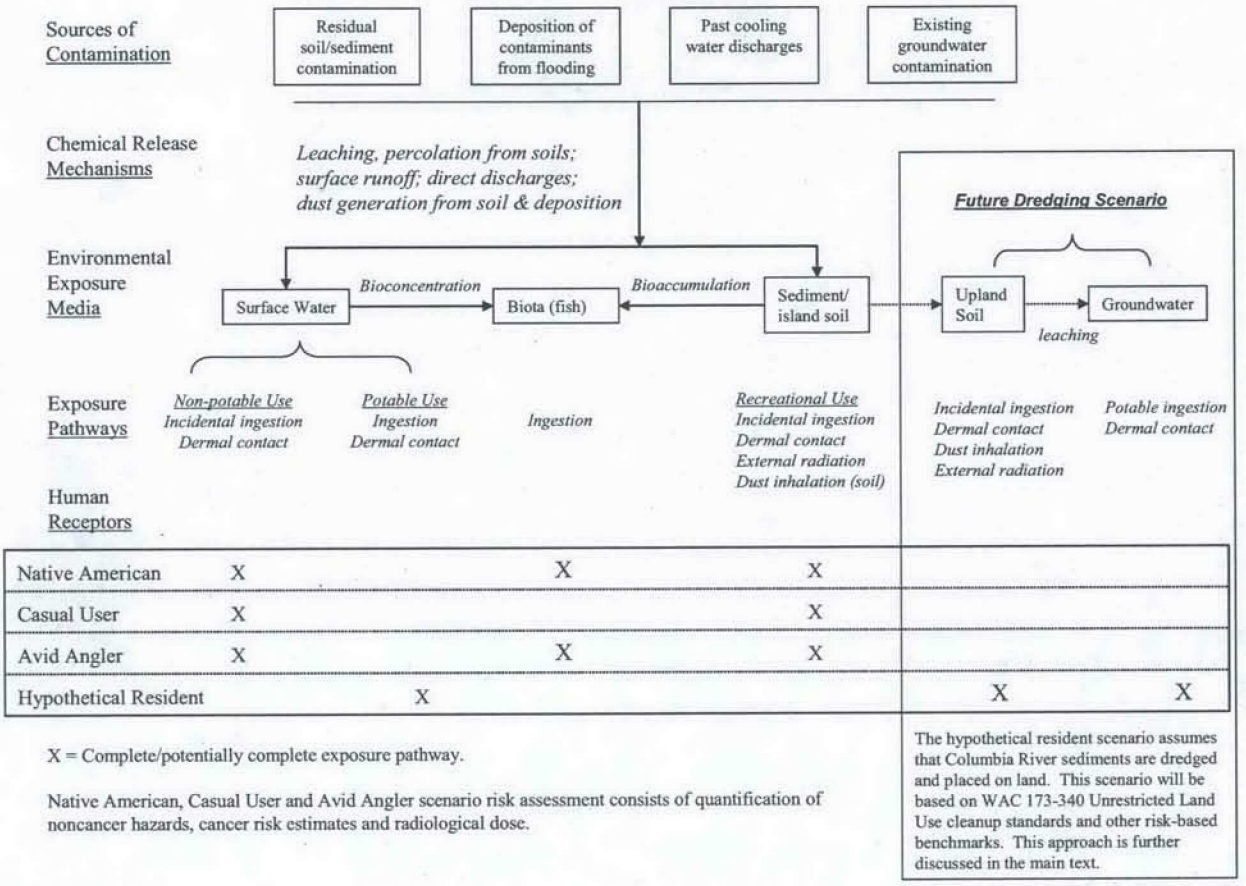
- **Fish**. Fish are the most economically important group, with more than 45 species having been documented in the Hanford Reach. Native mountain whitefish and white sturgeon, in addition to introduced bass, crappie, catfish, and walleye, and others, are important components of the strong recreational fishery on the river. These would be potential receptors primary to concentrations in surface water.

Figure 3-2. Conceptual Exposure Model – Ecological.



● = Complete or potentially complete exposure pathway for receptor.

Figure 3-3. Conceptual Exposure Model – Human Health.



- **Benthic Invertebrates.** Because of their diversity, benthic invertebrates would also be potentially exposed to pore water, surface water, and sediment. The dominant kinds of aquatic insects present – caddisflies, midgeflies, and black flies – exist generally on the surface of rocks, so would be exposed primarily to surface water and suspended particles flowing over and under rock surfaces. Likewise, the other major invertebrate species present, such as clams, limpets, snails, sponges, and crayfish, also exist on or among the cobble bottom, putting them in close proximity to sediment, which they may both contact and ingest. In quiescent areas, burrowing species more associated with the sediment may be expected, although communities in these areas would be negatively affected by the regularly changing water levels. However, crayfish, which are abundant in the fall, may have adapted to fluctuating water levels by staying in deeper water except when flows are relatively constant (TNC 2003). Because of their proximity to sediment, benthic invertebrates may be exposed to Hanford Site-related contaminants in both sediment and surface water.

- **Aquatic Macrophytes.** Aquatic macrophytes may be exposed to contaminants in surface water and sediment through both roots and leaves. However, these species are uncommon in

the Hanford Reach due to the strong current, rocky bottom, and fluctuating water levels (PNNL-6415). They exist in the backwater of some islands, but are much more common on the Hanford Site side of the river, where the many sloughs and inlets provide the quiescent conditions necessary for both sediment deposition and root establishment.

- **Amphibians.** Amphibians have been documented in the Study Area but, like aquatic plants, are generally associated with the backwaters and sloughs, where the presence of vegetation and protected waters provides favorable conditions for egg deposition and suitable habitat for both developing tadpoles and adults. The habitat of this type that would have the greatest exposure to Hanford Site-related contaminants is located on the Hanford Site side of the river, where several sloughs exist downstream of operating areas and the Hanford townsite. Like other littoral fauna, amphibians are subject to stress because of the frequently changing water levels in the river, which can expose eggs to drying and reduce habitat for tadpoles seeking both food and protection among littoral vegetation. Three species of amphibians, the Great Basin spadefoot toad, Woodhouse's toad, and the bullfrog, have been documented in the shoreline areas of the Hanford Reach (PNNL-15892, PNNL-16623).

- **Phytoplankton, Zooplankton, and Periphyton.** Phytoplankton and zooplankton populations at the Hanford Site are largely transient, flowing from one reservoir to another. With the relatively rapid flow of the Columbia River, there is generally insufficient time for characteristic endemic groups of phytoplankton and zooplankton to develop in the Hanford Reach, and cycles of population are more transient than observed within impoundments and reservoirs (PNNL-6415). Because of their transient nature, phytoplankton and zooplankton are likely to have relatively little exposure to site contaminants relative to more resident species. Phytoplankton (free-floating algae) are abundant in the Columbia River and provide food for herbivores such as immature insects. Diatoms are the dominant algae in the Columbia River phytoplankton and are composed primarily of species typical of those found in lakes and ponds and which originate in upstream reservoirs. A number of algae found as free-floating species in the Hanford Reach of the Columbia River are actually derived from the periphyton; they were detached and suspended by currents and frequent fluctuations of the water levels (PNNL-6415).

  The zooplankton populations in the Hanford Reach of the Columbia River are generally sparse. Studies indicate crustacean zooplankton were dominant in the open-water regions. Densities were lowest in winter and highest in the summer, with summer peaks dominated by *Bosmina*, ranging up to 160,650 organisms/m^3 (4,500 organisms/ft^3). Winter densities were generally less than 1,785 organisms/m^3 (50 organisms/ft^3).

  Communities of periphytic species or "benthic microflora" develop on suitable solid substrate wherever there is sufficient light for photosynthesis and adequate currents to prevent sediment from covering the colonies. Operation of Priest Rapids Dam results in frequent river level fluctuations, causing exposed shoreline areas that do not allow for the establishment of viable and persistent periphyton communities in shoreline areas where flows exceed 1,310 m^3/sec (46,300 ft^3/sec). Peaks of production were observed to occur in spring and late summer (PNNL-6415).

- **Soil Invertebrates.** Although no direct survey of invertebrates in Columbia River islands and shorelines has been conducted, species present can be expected to consist of many of those documented in upland portions of the site. Upland areas contain a wide variety of invertebrates, due to the diversity of vegetation and amount of undisturbed shrub-steppe habitat. Dominant species, which may also be present in the riparian zone and islands, include the darkling beetle, harvester ants, species of butterflies, and grasshoppers (PNNL-6415). Darkling beetles are considered to be representative of soil macroinvertebrates and are widespread across the Hanford Site (PNNL-6415, DOE/RL-2001-54). Soil macroinvertebrates would be expected to be exposed to Hanford Site-related contaminants that are present on upland portions of the islands as the result of historical flooding or high water events.

Of these receptor groups, fish and benthic invertebrates are likely to have the greatest exposure to Hanford Site-related contaminants in pore water, surface water, and sediment. These organisms spend their entire life cycle in surface water and/or sediment, and many remain in the same segment of the river for the bulk of their lives. In addition, abundant high-quality habitat for these organisms exists throughout the entire Study Area (defined in Section 4.1.1.1).

In addition, some terrestrial avian and mammalian species and terrestrial plants also have the potential to have a limited exposure to Hanford Site-related contaminants. These are described below.

- **Avian Species**. Islands and shorelines provide important nesting, feeding, and resting habitat for both resident and migrant birds. At least 163 different species of birds have been associated with the Columbia River or related riparian vegetation (TNC 1999). Island areas ranging from 0.05 to 0.08 mi^2 accommodate colonial nesting species that may range in population size up to 2,000 individuals (PNNL-6415). Mallards and Canada geese are the primary nesting species (PNL-8942). In general, the most common species that nest or feed on the islands and riparian areas around the river include, among others, Canada geese, great blue herons, white pelicans, ring-billed seagulls, mallards, cormorants, northern killdeer, spotted sandpiper, quail, kingbirds, and various other duck and shorebird species (Fickeisen et al. 1980, Rickard et al. 1982, PNL-8942). These species may be exposed by feeding along the shorelines or in or around the aquatic and riparian river environments.

- **Mammalian Species.** Mammals that have been observed in the riparian corridor of the Columbia River include a variety of small rodents in addition to larger species typical of riparian areas. Larger species that have been observed on islands or shorelines around the Columbia River include muskrats, beavers, minks, weasels, raccoons, river otters, rabbits, and badgers. In addition, a variety of smaller mammals, such as mice and shrews, also inhabit near-shore areas. Little information is available about populations or abundance, however, and these species may be more common on the less agricultural Hanford Site side of the river. Mammalian species would be exposed through feeding on plants or prey items and through incidental ingestion of sediment.

Mule deer are the most conspicuous of the mammals in the river corridor, since they use the islands for fawning and nursery areas in the spring. Islands afford some protection from predation but afford a limited supply of browse material, which may compromise the overall health of the herd (Rickard et al. 1982). During the summer, mule deer rely on riparian vegetation for foraging (Fickeisen et al. 1980, Rickard et al. 1982, PNL-8942).

- **Terrestrial Plants.** Islands and shorelines vary in types of soil and vegetation and range from narrow cobble benches to extensive dune habitats. The islands accommodate many of the same species that occur in mainland habitats. Operation of Priest Rapids Dam upstream of the Hanford Reach creates daily and seasonal fluctuations in river water levels, which may limit the development of plant communities and continued use by terrestrial animals and birds. Shoreline riparian vegetation that characterizes the islands and shorelines includes water smartweed, water speedwell, reed canarygrass, cattails, and bulrush, and various tree species such as willow, poplar, Russian olive, and mulberry. Species occurring on the island interior include sagebrush, buckwheat, lupine, mugwort, thickspike wheatgrass, giant wildrye, yarrow, and cheatgrass (Fickeisen et al. 1980, DOE/RL-96-16).

  Terrestrial plants, which occur primarily in the upland and riparian zones, would be exposed to Hanford Site-related contaminants that may be present in sediments or island soils deposited during flood events or high water discharges.

3.3.3 Human Receptors

The following human receptors within the study area have been identified.

- **Native American**. This receptor group includes local and regional Native Americans who have ties to the Hanford Reach of the Columbia River and surrounding lands. The Native American receptor can be exposed to contaminants via direct contact (dermal contact and incidental ingestion) with surface water and sediment, and ingestion of contaminants through wild food source consumption.

  Various Tribes have provided input into the work plan and risk assessment. To date, the CTUIR and Yakama Tribes have provided exposure scenarios to the Tri-Parties to use in the risk assessment. As part of the Columbia River investigation, the Yakama scenario is proposed to be evaluated. The CTUIR scenario was developed around a comprehensive "Lifeways" concept that encompasses a broad range of exposure pathways associated with subsistence land use of the Hanford Site. Human health risks from these pathways, which are associated with upland soils, riparian soils, groundwater, and river media, are cumulatively addressed in the Source and Groundwater Component of the RCBRA. Discussions with the Tri-Parties and CTUIR representatives resulted in a decision to have the CTUIR risk assessment be conducted entirely within the scope of the Source and Groundwater Component of the RCBRA. Sediment/surface water data generated as part of the proposed sampling plan will be included in an update to the RCBRA CTUIR risk assessment. Table 3-1 summarizes the Tribal scenarios for which risks are or will be estimated for the river corridor and/or Columbia River.

Table 3-1. Tribal Scenarios.

Tribal Scenario	Pathways Evaluated	Media Evaluated	Evaluation
CTUIR	Fish ingestion, direct contact with upland soil, ingestion of groundwater, inhalation of volatiles (sweat lodge), external radiation, direct contact with sediment	Upland soil, riparian soil, sediment, groundwater, surface water, fish tissue	Source and Groundwater Component of the RCBRA
Yakama	Fish ingestion, direct contact with surface water, island soil and sediment, external radiation	Shallow sediment, surface water, island soil, fish tissue	Columbia River and Source and Groundwater Component of the RCBRA

CTUIR = Confederated Tribes of the Umatilla Indian Reservation
RCBRA= River Corridor Baseline Risk Assessment

- **Avid Angler**. This receptor group includes both adults and children (older than age 6). Potential routes of exposure include dermal contact with contaminated sediment, island soil, and surface water while fishing and/or boating in the river, and ingestion of contaminants in fish tissue.

- **Casual User**. This receptor group includes adult or child (1 through 6 years old) individuals who use the Columbia River for recreational purposes (i.e., wading, swimming, boating, or participating in other activities in and along the river shoreline). Potential routes of exposure to contaminated sediment, island soil, and surface water include incidental ingestion and dermal contact during these recreational activities.

- **Future (Hypothetical) Resident**. The Columbia River is currently used as a source of potable water for the town of Richland. Treated water from the river is routinely monitored and meets federal drinking water standards. However, because there is the potential for surface water at any location along the Study Area to be used for potable water, an evaluation of residential drinking water use will also be conducted as part of the BHHRA. Additionally, the BHHRA will evaluate a hypothetical scenario in which a child and adult resident are routinely exposed to dredged sediments removed from behind McNary Dam that have been placed in upland residential areas. This is the only receptor identified for which exposure to dredge spoils may potentially occur.

Exposure scenarios for the BHHRA are further described in Section 4.6.

4.0 WORK PLAN RATIONALE

The sample design for the RI has been developed to be consistent with EPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA 1988a).

4.1 SAMPLE DESIGN APPROACH

The following describes the process by which the sample designs for the RI were developed to investigate and characterize Hanford Site hazardous substance releases to the Columbia River. As outlined in 40 CFR 300.430(b) (8), CERCLA requires SAPs that will provide a process for obtaining data of sufficient quantity and quality to satisfy project needs. Several data needs were defined as a result of the DQO process, including collection of supplemental data to better characterize the nature and extent of contamination as well as to support both a human health and ecological risk assessment.

The development of this sample design was a "bottom-up" process that was designed to answer three primary study questions as presented in the *DQO Summary Report for the Remedial Investigation of Hanford Site Releases to the Columbia River* (WCH-265):

1. Is the existing data set of sufficient quality and quantity to support the RI/FS process, including both human health and ecological risk assessments?

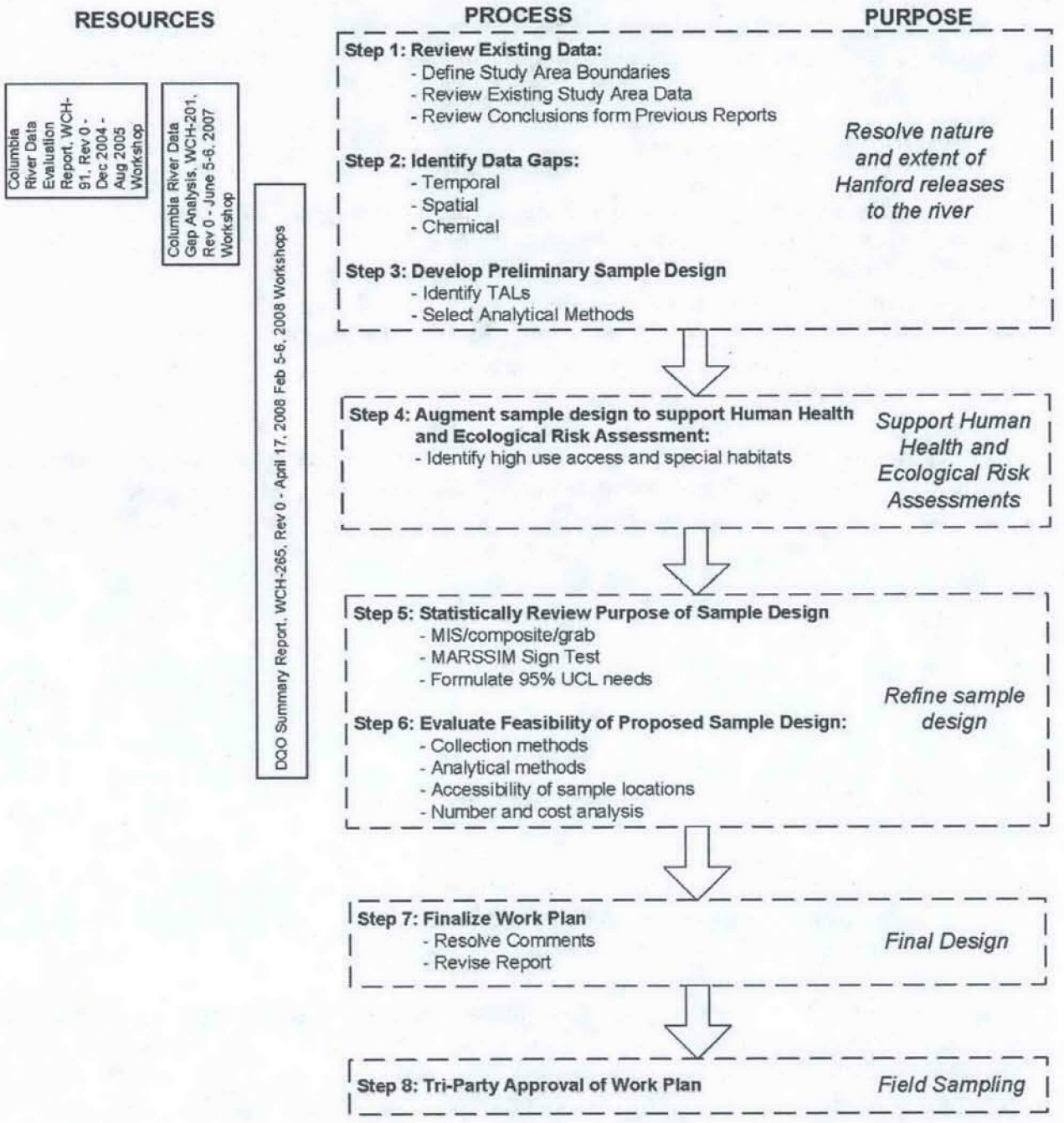
2. Are additional data required to complete the RI/FS and support the human health and ecological risk assessments?

3. Do Hanford Site-related contaminants in sediment, soil, surface water, pore water, and/or fish pose an unacceptable risk to human health or the environment and need to be evaluated in a further study?

To address these primary study questions, a systematic sample design approach was used that consisted of a series of sequential steps, as illustrated in Figure 4-1. The purpose and content of these steps is summarized below.

- Steps 1 through 3 were used to address the nature and extent of Hanford-related hazardous substance releases to the Columbia River as required under a CERCLA RI. Specifically, this included reviewing existing data (Step 1); identifying data gaps in the spatial, chemical, or temporal distribution of the data (Step 2); and then proposing sample types, locations, and numbers in a preliminary sample design specifically to address these data gaps (Step 3).

Figure 4-1. Remedial Investigation Sample Design Approach.



TAL = Target Analyte List
MIS = Multi-Incremental Sampling

- Step 4 was used to ensure sufficient data were collected to support the data needs of the human health and ecological risk assessments. In this step, samples were added to characterize specific exposure media, such as shoreline sediments, that will be used to evaluate exposure pathways in the human health and ecological risk assessments.

- Steps 5 and 6 were used to refine the proposed design based on the underlying statistical requirements. In these steps, the existing data were evaluated statistically to compare the proposed sample design to the needs-based approach of Steps 1 through 4 and to the feasibility of sample collection. The program design was then adjusted accordingly.

- Step 7 consisted of the review and comment resolution process required by CERCLA and Tri-Party Agreement. In this step, samples were added in specific response to comments from Tri-Party reviewers.

- Step 8 consists of reconnaissance surveys and approval of the RI work plan by the Tri-Parties prior to field sampling.

More detail on each of these steps is provided in the following sections (Sections 4.1.1 through 4.1.5).

4.1.1 Nature and Extent of Hanford Hazardous Substance Releases to the River – Steps 1 Through 3

The initial focus of any CERCLA RI is to identify the nature and extent of site-related contaminants. Because the Hanford Site has been the focus of several decades of study, there is a large amount of existing data available. To assess the usefulness and applicability of the existing data set, a wide range of existing data were compiled and evaluated in Step 1. The study area boundaries were also defined in this step. Based on a review and evaluation of these data for temporal, spatial, and chemical completeness, several data gaps were identified in Step 2. Step 3 resulted in development of a preliminary sample design to address the identified data gaps associated with the nature and extent of Hanford Site hazardous substance releases to the river.

4.1.1.1 Review Existing Data – Step 1. An extensive data compilation effort was performed between 2004 and 2006, as documented in the *Columbia River Component Data Evaluation Summary Report* (WCH-91) and the *Columbia River Component Data Gap Analysis* (WCH-201). The Data Evaluation Summary Report (WCH-91) documented the results of the initial study conducted by WCH to compile and review the currently available surface water and sediment data for the Columbia River near and downstream of the Hanford Site. The Data Gap Analysis (WCH-201) was conducted to review the adequacy of the existing surface water and sediment data set from the Columbia River, with specific reference to the use of the data in future site characterization and baseline risk assessments. The goal was to determine if there are sufficient data to characterize the current effects of Hanford Site operations on the Columbia River. In addition, the study boundaries were identified in terms of both spatial and temporal boundaries.

Define Study Boundaries. As reported in the Data Gap Analysis (WCH-201), the existing sediment data set from upstream of Priest Rapids Dam to Astoria, Oregon, was evaluated as part of the process for selecting the Study Area boundaries. McNary Dam was chosen as the lower boundary of the Study Area because numerous studies (including HW-83614; BNWL-2305; WDOH 1994, 2005; OHD 1994) have demonstrated that the highest Hanford-related inventory (radionuclides) is present behind this dam, which is the first dam downstream of the Hanford Site. Construction of McNary Dam was completed in 1954. The highest production of plutonium at the Hanford Site occurred between 1954 and 1970 (PNWD-2227; see Figure 2-2). Radionuclides released to the river flowed downstream and accumulated in the fine-grained sediment that settled in the depositional area behind McNary Dam. Data from studies have indicated that the concentrations of most radionuclides in the lower Columbia River sediment (i.e., below McNary Dam) were similar to background values measured upstream of the Hanford Site (WDOH 2005) or were similar to other Oregon surface water bodies not connected to the Hanford Site (OHD 1994).

The lateral boundaries of the Study Area extend from shore to shore (ordinary high water mark to ordinary high water mark) below the 300 Area. This boundary is depicted in Figure 1-3.

Within the Hanford Reach, the right bank is being characterized and assessed by the RCBRA Source and Groundwater Component (nominally to a depth of 2 m [6 ft] into the river for the low water mark). In these areas of the Hanford Reach, the investigation area for this work plan begins where the RCBRA Source and Groundwater Component investigation stopped. For abiotic media, and most biota, sample collection for the RCBRA Source and Groundwater Component stopped at a point related to the low water mark of the river, which is characterized by the presence of the "green line" of algae delineating the permanently inundated portion of the river channel. Samples were collected to a point beyond the green line where water is approximately 1.8 m (6 ft) deep. Biota samples for mussels were occasionally collected beyond this point. The lateral investigation area for this section of the Study Area is depicted in Figure 1-2.

For the purposes of this RI, the shoreline vegetation and soil characteristics that have been adopted to delineate ordinary water levels will be used to define the lateral boundaries of the Study Area (e.g., ordinary high water mark). The ordinary high water mark is defined in WAC 173-22-030 as "the ordinary high water mark on all lakes, streams, and tidal water is that mark that will be found by examining the bed and banks and ascertaining where the presence and action of waters are so common and usual, and so long continued in all ordinary years, as to mark upon the soil a character distinct from that of the abutting upland…"

Flow rates will also be considered for the lateral boundary determination. On the section of river below Priest Rapids Dam, the ordinary high water mark is generally considered to be defined at a flow of 220,000 cfs to 240,000 cfs. However, this is a dynamic system that rarely reaches a steady state. When a steady state is achieved, the upper boundary of riparian vegetation or "ordinary high water" is approximated at 220,000 cfs to 240,000 cfs. For purposes of this project, the ordinary high water mark coincides with the upper boundary of the riparian zone, while the low water mark coincides with the lower boundary of the riparian zone.

The boundaries of the riparian zone were estimated through the river flow model between 80 and 240 kcfs at Priest Rapids Dam. During field activities, these boundaries will be based on both shoreline characteristics and flow rates.

The lateral Study Area boundary was selected to coincide with the ordinary high water mark despite the flooding that has occurred post-1944 when the first single-pass reactor (105-B Reactor) came on line. At that time, Bonneville Dam, which was constructed in 1937 (see Table 2-2), was the only downstream dam. Currently, the nearest downstream dam to the Hanford Site is McNary Dam (see Figure 2-1), which was constructed between 1947 and 1954. These dams created "new" depositional areas. Several studies have been completed to sample and monitor radionuclide inventories behind each dam (HW-83614, BNWL-2305, and PNWD-2227). As discussed above, the highest production of plutonium at the Hanford Site occurred between 1954 and 1970, after the 1948 flood (see Section 3.2). Therefore, the majority of radionuclides entering the river during the years of peak releases would have been deposited in the sediment behind McNary Dam (Figure 2-2). Studies have shown that the highest concentration of radionuclides in sediments likely resides behind McNary Dam. The RI is designed to measure current concentrations of Hanford Site hazardous substance releases that may reside in the deep sediments behind McNary and Bonneville Dams. These are expected to have the highest residual concentrations of radionuclides because of production schedules and sediment accumulation.

For the purposes of this RI, sub-areas were developed to allow for more interpretive and focused conclusions in the RI/FS. The Study Area has been subdivided into the following five sub-areas that were selected based on spatial distribution of contaminant concentrations observed in surface water and sediment with respect to the various sources of contamination from the Hanford Site:

- Upriver Sub-Area: Upriver of Vernita Bridge and RM 420 to RM 388
- 100 Area Sub-Area: Vernita Bridge at RM 388 downstream to RM 365
- 300 Area Sub-Area: RM 365 downstream to RM 339
- Lake Wallula Sub-Area: RM 339 downstream to McNary Dam at RM 292
- Bonneville Dam Pool Sub-Area: RM 150 downstream to RM 144. Sampling in this sub-area is for characterization purposes only.

These five sub-areas are depicted in Figure 1-1 and described in more detail in Section 4.2.

Review Existing Study Area Data. As summarized in the Data Evaluation Summary Report (WCH-91) and the Data Gap Analysis (WCH-201), several thousand samples have been previously collected between the Vernita Bridge (RM 388) and McNary Dam (RM 292).

From 1976 to 2006, there were more than 23,000 sediment analyses completed from over 1,200 sampling locations within the Study Area. Of these results, approximately 11,000 were reported above the laboratory reporting limits, resulting in approximately 12,000 reported as nondetects. Results are summarized as follows:

- VOCs – more than 900 analyses
- Semivolatile organic compounds (SVOCs) – more than 940 analyses
- Metals – more than 6,100 analyses
- Pesticides/PCBs – approximately 3,380 analyses
- Radionuclides – more than 8,700 analyses.

From 1999 to 2006, there were more than 45,100 surface water analyses from over 4,200 sampling locations between Vernita Bridge and McNary Dam (i.e., Study Area). Of these results, approximately 23,700 were reported above the laboratory reporting limit, resulting in approximately 21,400 results reported as not detected. Results are summarized as follows:

- VOCs – more than 3,700 analyses
- SVOCs – 748 analyses
- Metals – more than 19,500 analyses
- Pesticides/PCBs – more than 1,700 analyses
- Radionuclides – more than 12,800 analyses.

Since the Data Gap Analysis was published in October 2007, additional data have been added to the database from the RCBRA and the Surface Environmental Surveillance Project (see Section 2.4.2.1). These data have been included in the CRC database and are summarized in Table 4-1. The majority of these samples were collected in the near-shore along the Hanford Reach. Additional samples are proposed to complete the RI and support the risk assessments (see Tables 2-2 through 2-6 in the SAP [Appendix A]). It is currently proposed that the new data collected during the RI will supplement the existing data set as summarized in the "Non-RCBRA Data Only" column (Table 4-1).

Table 4-1. Summary of Study Area Existing Data. (2 Pages)

River Sub-Area	Media[a]	Total Number of Existing Samples (RCBRA Data and Non-RCBRA Data)	Total Number of Existing Samples (Non-RCBRA Data Only)
Upriver	SD	201	201
Upriver	SW	1,030	1,030
100 Area	SD	302	19
100 Area	SW	1,423	157
300 Area	SD	338	51
300 Area	SW	2,988	1,628

Table 4-1. Summary of Study Area Existing Data. (2 Pages)

River Sub-Area	Media[a]	Total Number of Existing Samples (RCBRA Data and Non-RCBRA Data)	Total Number of Existing Samples (Non-RCBRA Data Only)
Lake Wallula	SD	293	293
Lake Wallula	SW	30	30
Totals		**6,605**	**3,409**

[a] SW data from 1999 to 2007, SD data from 1996 to 2007.

SD = sediment
SW = surface water

Review Conclusions from Previous Studies. Key historical documents were reviewed to further confirm the Study Area boundaries and understand the distribution of Hanford-related contaminants. More than 200 primary studies have been completed over the past 60 years relating to Hanford Site hazardous substance releases to the Columbia River and the effects on surface water and sediments. The following reports evaluated radionuclide inventories downstream of the Hanford Site:

- *Progress in Studies of Radionuclides in Columbia River Sediments: A Summary of Hanford Achievements in this Program under General Electric, 1963-1964* (HW-83614)
- *Environmental Radiological Surveillance Report on Oregon Surface Waters, 1961 – 1993,* Volume I (OHD 1994)
- *Special Report: Radioactivity in Columbia River Sediments and Their Health Effects* (WDOH 1994)
- *Summary of Radiological Monitoring of Columbia and Snake River Sediment, 1988 through 2004* (PNNL-16990)
- *Survey of Potential Hanford Site Contaminants in the Upper Sediment for the Reservoirs at McNary, John Day, The Dalles, and Bonneville Dams, 2003* (WDOH 2005).

Each of the studies arrived at a similar conclusion that, in general, concentrations of radionuclides in the Study Area are similar to background values measured upstream of the Hanford Site, further supporting McNary Dam as the downriver Study Area boundary.

4.1.1.2 Identify Data Gaps – Step 2. Once the existing data were compiled and reviewed, the actions summarized below were completed to assess the adequacy of the existing data set and identify potential data gaps in temporal, spatial, and chemical distribution.

Temporal Data Gaps. To assess the temporal data distribution, the existing data from the Study Area were evaluated to determine whether the temporal distribution of the existing data set was adequate based on the types of contaminants, relative concentration variability, and resident time for the surface water, sediment, and fish within the Study Area. The results of this analysis are presented below. The results of this analysis are presented in the Data Gap Analysis (WCH-201) and are summarized below.

To conduct the temporal analysis in the Data Gap Analysis report, the river was divided into the following three sections: I) upriver of Vernita Bridge, II) the Hanford Reach from the Vernita Bridge to McNary Dam, and III) from McNary Dam to the Pacific Ocean. For each section, the number of surface water and sediment analyses and samples collected per year was tabulated and graphed. This analysis showed that between 1999 and 2006 alone, anywhere from 196 to 758 sediment samples and from 750 to 3,549 surface water samples were analyzed each year for radionuclides and/or metals in River Section II, which corresponds to the Study Area for this RI. VOCs were analyzed every year in surface water. Other constituents were analyzed from one to five times during this time period and those with low sampling frequency like herbicides in surface water tended to have few detections (e.g., 0/102 samples for herbicides). In general, the analysis showed that the existing database is robust over time and no data gaps were identified based on temporal needs.

Surface Water – Based on an evaluation of the existing data set and an understanding of the river dynamics, it is clear that current and historical releases from the Hanford Site are quickly mixed and diluted in surface water to a concentration near or below most surface water quality benchmarks. This information is well-documented as part of the Hanford Site Surface Environmental Surveillance Project, which has been routinely monitoring surface water, sediment, and biota for more than 40 years. As a result, proposed surface water sampling locations (e.g., spatial) in the current investigation have been focused on areas of influx (e.g., near the release or source). A limited number of temporal data gaps were identified for surface water and include the following:

- **Other Contributing Influences** – The seasonal variability of surface water quality from other convergent flows into the Study Area are not well-documented. These other sources include upriver sources (e.g., Trail, British Columbia), irrigation returns, and confluence of the three major rivers (Yakima, Snake, and Walla Walla). In consequence, additional surface water samples will be collected in the fall of 2008 and the spring of 2009.

- **River Stage** - Because river stage controls groundwater upwelling to the river, pore-water, sediment, and surface water studies will be timed to coincide with low water conditions as discussed in Section 4.3.1.

Sediment – Based on an evaluation of the existing data set and the relatively long resident time associated with sediment within the Study Area, the following temporal data gap was identified:

- **Deep Sediment Dating** – Relative dating of the deep sediment cores behind Priest Rapids, McNary, and Bonneville Dams has been completed in the past but will be revisited during

the RI to obtain more information regarding disposal configuration of Hanford hazardous substance releases within the existing sediment sequence.

Fish – A number of fish studies have been previously completed. These studies have raised a number of questions regarding potential risk to humans through the consumption of fish. While the most significant data gaps associated with fish are spatial and chemical, the following temporal data gaps were identified:

- **Chemical** – Although numerous fish tissue data exist, there are many inconsistencies in the suites of analyses conducted for different species and tissue types. This sample plan proposes collecting data on a uniform and relatively comprehensive suite of analyses on multiple fish species.

- **Fish Migration** – Fish migration is an important element in the design of the fish sampling program. Collection of fish will consider the migratory nature of the targeted species.

- **Lipids**– Several organic contaminants concentrate in fish lipids (i.e., oil).

Spatial Data Gaps. To assess the spatial data gaps, the existing data were plotted on large-scale maps to assess the distribution of the data set. Because the goals and objectives of previous studies were generally focused on the near-shore environment and near source areas along the Hanford Reach, a vast majority of the existing data are clustered around these areas, resulting in some significant spatial data gaps outside these areas. The results of this analysis are presented in the Data Gap Analysis (WCH-201), and the identified spatial data needs consist of the following:

- Sloughs and backwaters on the left shore (looking downstream) of the river. Although both surface water and sediment sampling transects have been completed, most samples were collected on the right side of the river, which forms the Hanford Site boundary. Fewer data exist for the left side.

- Islands immediately downstream of source areas. Depositional areas exist around islands downstream of source areas, and some of these island depositional areas have not been fully characterized.

- Locations along the left shore downriver of source areas. River transport mechanisms can disperse sediment throughout the river, and sediment samples on the left shore are lacking downriver of some reactors and the White Bluffs and Hanford townsites.

- Areas of groundwater upwelling associated with source areas.

- Several irrigation returns throughout the reach.

- Near-shore areas in the Richland area.

- Downriver in Lake Wallula. Several sampling and coring activities have focused on sediment behind McNary Dam, but fewer sediment samples exist near the headwaters of the lake or along the shorelines or channel in the middle reach of the lake.

- Sediment behind McNary Dam.

Chemical Data Gaps. To assess potential chemical data gaps, the existing data were evaluated relative to the range of analytes tested. The results of this analysis are presented in the Data Gap Analysis (WCH-201). Data were compared to medium-specific human and ecological benchmarks. Tables 5-1 and 5-2 of the Data Gap Analysis show a comparison of the lowest relevant benchmark compared to the maximum value in the existing database. Based on these results, chemical data gaps identified analytes with low sample numbers or where new analytical methods have improved detections limits.

4.1.1.3 Develop Preliminary Sample Design – Step 3. To address the temporal, spatial, and chemical data gaps associated with the nature and extent of Hanford Site's hazardous substance releases to the river, approximately 730 surface water, sediment, and pore-water samples were added to the RI sampling program. These samples are identified in Tables 2-2 through 2-6 in the SAP (Appendix A).

One of the key project assumptions (see the DQO Summary Report [WCH-265]) for surface water samples is that current contamination will be greatest near the release and diminish with distance from the source area(s). This assumption has been confirmed from the existing data set. Concentrations of Hanford Site-related contaminants decrease with distance downriver. For example, VOCs are reported in the near-shore environment along the 300 Area and are diluted to nondetect levels within a very short distance downriver. As a result, proposed sampling locations have been biased toward areas directly downriver of the source areas.

A key assumption for sediment sampling is that contamination is mostly likely to be found in fine-grained depositional areas. As shown in Figures 2-2 through 2-20 provided in the SAP (Appendix A), the proposed sample locations are focused on depositional areas (fine-grained sediments and islands), locations directly downriver of the reactor discharge pipes, and/or suspected groundwater plume upwelling areas. Final sample locations will depend on the results of the reconnaissance surveys (see Step 8).

The sample design requirements for each sample are either focused, stratified/random, or multi-incremental sampling (MIS). The following is a description of each of the three samples types.

- **Focused Sampling** – Focused samples have been targeted at known or suspected locations of contamination or other known data gaps. These include, for example, groundwater plume upwelling areas, inlet trenches, irrigation returns, or known recreational use areas. These locations will be specifically targeted to identify "worst case" or frequent exposure points.

- **Stratified-Random** – This approach was developed to allow random sampling of the population of interest for sediment, surface water, and soil. For sediment samples, the target

population is fine-grained sediments located in depositional areas downstream of the reactor areas. To ensure that samples are representative of this population, fine-grained deposits must be located on a grid prior to sample collection. It is anticipated that the majority of target depositional areas will be identified and sampled during the RI. However, to enable statistical characterization of sediment data, samples will be collected in random locations within each grid cell. This random sampling accounts for the uncertainty of sediment deposition within the Study Area.

A stratified-random approach will also be used for upriver (e.g., background) surface water samples. The target population is upriver surface water. To ensure that samples are representative of this population, a single-cell sample grid will be established prior to sample collection. Samples will be collected at random locations within each grid cell. This random sampling enhances the representativeness of these samples for the population.

A stratified-random approach will also be used for shoreline sediments from recreational areas within Lake Wallula and island soils. For island soils, the target population is the river-transported sediments from the Hanford Site that have been deposited on islands during high river levels. To ensure that samples are representative of this population, a single-cell sample grid will be established prior to sample collection. Samples will be collected at random locations within each grid cell. This random sampling enhances the representativeness of these samples for the population.

- **MIS** – Multi-incremental sampling is based on particulate sampling theory (Gy 1992, Pitard 1993). To quantify specific exposure point concentrations for sediment at three individual recreational areas, MIS procedures will be used.[3] MIS consists of collecting and homogenizing 50 random sample increments over a prescribed decision area. In this case, the selected recreational areas are the decision areas. MIS works to reduce compositional and distributional heterogeneity. Compositional heterogeneity refers to contaminant variation between soil and sediment grains within the same area (intra-sample variation), while distributional heterogeneity refers to spatial variability between different areas of soil and sediment (inter-sample variation) (Alaska DEC 2007). Non-VOC samples are sieved to further reduce compositional heterogeneity. At each MIS location, random samples will be collected from a grid sized proportionally to the area to be sampled.

  Each investigation area will be evaluated by collecting five multi-incremental samples. The 95% upper confidence limit (UCL) of the mean concentration will be evaluated by collecting five multi-incremental samples from the three recreational sites. To further reduce error caused by soil heterogeneity, sub-sampling of each multi-incremental soil sample will be performed in the laboratory to obtain the final analytical soil sample.

Selection of Target Analytes. Target analytes are contaminants that were known or suspected to have been released from Hanford Site operations to the Columbia River or contaminants that have been detected above applicable regulatory criteria in the river environment. These two

[3] Use of MIS procedures was evaluated for other recreational areas but was not selected due to cultural resource considerations.

criteria were used to develop a consolidated list of analytes that include Hanford related and non-Hanford contaminants within the river environment. The purpose of identifying target analytes is to aid in the selection of appropriate analytical methods to be used during the RI. Specifically, if a compound is identified as a target analyte, then the analytical method that includes this target analyte will be specified in the RI, and all the compounds normally detected by that method will be analyzed and reported.

The process detailed in Table 1-4 of the DQO Summary Report (WCH-256) was used to identify the target analytes that were directly released or that could have been transported to the river. This process was a systematic approach of reviewing operational history, known contaminant sources, documented releases to the environment, and contaminant transport to the river. Media-specific target analytes were identified by comparing the existing data to the benchmarks described in Sections 4.5 and 4.6. Compounds that exceeded these benchmarks were tentatively identified as target analytes. The next step was to compare this tentative target analyte list to the "Exclusion List" and "Inclusion List" developed for the RCBRA process (see Section 4.5.3). Compounds on the inclusion list were added while compounds on the exclusion list were removed.

Master lists of target analytes are presented in Tables 4-2, 4-3, and 4-4 for sediment, surface water, and pore water, respectively. These master lists of contaminants include constituents identified during the Source and Groundwater Component of the RCBRA and compounds identified through the evaluation process described above and used in the Data Gap Analysis Report (WCH-201). To provide additional context to this list, each analyte has been preliminarily classified as to its suspected origin; naturally occurring and common in the natural environment, common in upriver or other background sources, and known to be Hanford-related.

These target analytes were used to identify appropriate analytical methods for each medium of concern (e.g., surface water, sediment, and pore water as shown in Tables 2-2 through 2-6 in the SAP [Appendix A]). A list of reported analytes for each proposed method is presented in Tables 3-1 through 3-3 of the SAP (Appendix A). The list of EPA analytical methods and the reporting lists associated with those methods for sediment/soil, surface water/pore water, and fish are presented in Tables 4-5, 4-6, and 4-7, respectively.

Once the field investigation has been completed and the data has been validated and compiled, the selection of COPCs will be initiated to identify compounds to be evaluated in the ecological and human health risk assessments. This process will be conducted as part of those risk assessments and is described in Sections 4.5 and 4.6 of the RI work plan, respectively.

4.1.2 Augment Sample Design to Support Ecological and Human Health Risk Assessments – Step 4

Once the number of samples for surface water, sediment, and pore water were identified, additional samples and analyses were added or superimposed on the program to address additional needs of the ecological and human health risk assessments.

Table 4-2. Target Analyte List – Sediment.

Metals	Class	Organics	Class	Radionuclides	Class
Aluminum	N	Anthracene	B, H	Carbon-14	H
Antimony	N	PCBs (aroclors and congeners)	B, H	Cesium-137	B, H
Arsenic	N	Benzo[a]anthracene	B, H	Cobalt-60	H
Barium	N	Benzo[a]pyrene	B, H	Europium-152	B
Cadmium	N	Benzo[b]fluoranthene	B, H	Europium-154	B
Chromium (total)	N	Benzo[ghi]perylene	B, H	Plutonium-239/240	H
Chromium – hexavalent	H	Benzo[k]fluoranthene	B, H	Strontium-90	H
Copper	B	Bis(2-ethylhexyl) phthalate	B, H	Technetium-99	H
Iron	N	Chrysene	B, H	Uranium-233/234	H
Lead	B, N	Dibenz[a,h]anthracene	B, H	Uranium-235	H
Lithium	N	Dieldrin	B	Uranium-238	H
Manganese	N	diethylphthalate	B		
Mercury	B	di-n-butylphthalate	B		
Nickel	N	Fluoranthene	B, H		
Selenium	N	Gamma-BHC	B		
Strontium	N	2-hexanone	B		
Uranium	B, H	Indeno[1,2,3-cd]pyrene	B, H		
Vanadium	N	Pentachlorophenol	B		
Zinc	N	Phenanthrene	B, H		
		Phenol	B, H		
		Pyrene	B, H		
		Xylenes (total)	B		
		Tetrachloroethene (PCE)	H		
		Trichloroethene	H		
		Total petroleum hydrocarbons	B		

B = background
H = Hanford-related
N = naturally occurring

Table 4-3. Target Analyte List – Surface Water.

Metals	Class	Organics	Class	Radionuclides	Class
Aluminum	N	1,2-Dichloroethene (DCE)	H	Carbon-14	H
Antimony	N	1,1,2-Trichloroethane (TCA)	H	Cesium-137	B, H
Arsenic	N	1,2-Dichloroethane (DCA)	H	Cobalt-60	H
Barium	N	Tetrachloroethene (PCE)	H	Europium-152	B
Beryllium	N	Trichloroethene (TCE)	H	Europium-154	B
Boron	N	Acenaphthene	B, H	Strontium-90	H
Cadmium	N	Anthracene	B, H	Tritium	H
Chromium (total)	N	PCBs (aroclors and congeners)	B	Technetium-99	H
Copper	B	Bis(2-ethylhexyl) phthalate	B, H	Uranium-233/234	H
Chromium–hexavalent	H	Benzo[a]anthracene	B, H	Uranium-235	H
Iron	N	Benzo[a]pyrene	B, H	Uranium-238	H
Lead	B, N	Benzo[b]fluoranthene	B, H		
Lithium	N	Benzo[ghi]perylene	B, H		
Manganese	N	Benzo[k]fluoranthene	B, H		
Mercury	B	Chrysene	B, H		
Nickel	N	Carbon tetrachloride	H		
Selenium	N	Chloroform	H		
Strontium	N	Fluoranthene	B, H		
Thallium	N	Dibenz[a,h]anthracene	B, H		
Uranium	B, H	Indeno[1,2,3-cd]pyrene	B, H		
Vanadium	N	Phenanthrene	B, H		
Zinc	N	Phenol	B, H		
		Pyrene	B, H		
		Naphthalene	B		
		Total petroleum hydrocarbons	B		

B = background
H = Hanford-related
N = naturally occurring

Table 4-4. Target Analyte List – Pore Water.

Inorganics	Class	Radionuclides	Class
Hexavalent chromium	H	Strontium-90	H
Metals and mercury	N/H	Uranium-233/234	H
Nitrate	H	Uranium-235	H
Organics		Uranium-238	H
VOCs	H	Tritium	H

H = Hanford-related
N = naturally occurring
VOCs = volatile organic compounds

Table 4-5. Sediment/Soil Analytical Methods and Analyte Reporting Lists. (2 Pages)

Volatile Organic Compounds	Semivolatile Organic Compounds		Pesticides	PCBs	TAL Metals	AVS/ SEM	Radionuclides				Other Methods
Method 8260B	Method 8270		Method 8081	Method 8082	Method 6010	EPA Method 200.8	Gamma Spec	Alpha Spec	Liquid Scintillation Counting	Alpha, Beta Proportional Counting	
1,1,1-Trichloroethane	1,2,4-Trichlorobenzene	Benzo(ghi) perylene	Aldrin	Aroclor-1016	Aluminum	Cadmium	Antimony-125	Uranium-233/234	C-14 low energy Beta	Strontium-90	Nitrate - EPA Method 300.1
1,1,2,2-Tetrachloroethane	1,2-Dichlorobenzene	Benzo(k) fluoranthene	Alpha-BHC	Aroclor-1221	Antimony	Copper	Beryllium-7	Uranium-235		Technetium-99	PHC - EPA Method 8115
1,1,2-Trichloroethane	1,3-Dichlorobenzene	Benzoic Acid	Delta-BHC	Aroclor-1232	Arsenic	Lead	Cesium-134	Uranium-238			TOC - EPA Method 9060
1,1-Dichloroethane	1,4-Dichlorobenzene	Bis(2-Chloroethoxy) methane	Dichlorodiphenyl-dichloroethane	Aroclor-1242	Barium	Nickel	Cesium-137	Thorium-232			Grain Size - ASTM D-422
1,1-Dichloroethene	2,4,5-Trichlorophenol	Bis(2-chloro-1-methylethyl) ether	Dichlorodiphenyl-dichloroethylene	Aroclor-1248	Beryllium	Silver	Cobalt-60	Americium-241			PCB Congeners - EPA Method 1668A
1,2-Dichloroethane	2,4,6-Trichlorophenol	Bis(2-chloroethyl) ether	Dichlorodiphenyl-trichloroethane	Aroclor-1254	Bismuth	Zinc	Europium-152	Plutonium-239/240, 238			Mercury Method 7470/7471
1,2-Dichloroethene (Total)	2,4-Dichlorophenol	Bis(2-ethylhexyl) phthalate	Dieldrin	Aroclor-1260	Boron		Europium-154				Hexavalent-chromium Method 7196A
1,2-Dichloropropane	2,4-Dimethylphenol	Butylbenzyl-phthalate	Endosulfan I		Cadmium		Europium-155				
2-Butanone	2,4-Dinitrophenol	Carbazole	Endosulfan II		Calcium		Potassium-40				
2-Hexanone	2,4-Dinitrotoluene	Chrysene	Endosulfan sulfate		Chromium		Radium-226				
4-Methyl-2-Pentanone	2,6-Dinitrotoluene	Di-n-butyl-phthalate	Endrin		Cobalt		Radium-228				
Acetone	2-Chloronaphthalene	Di-n-octylphthalate	Endrin aldehyde		Copper		Ruthenium-106				
Benzene	2-Chlorophenol	Dibenz[a,h]anthracene	Gamma-BHC (Lindane)		Iron						
Bromodichlo-romethane	2-Methylnaphthalene	Dibenzofuran	Heptachlor		Lead						
Bromoform	2-Methylphenol (cresol, o-)	Diethylphthalate	Heptachlor epoxide		Lithium						
Bromomethane	2-Nitroaniline	Dimethyl phthalate	Methoxychlor		Magnesium						
Carbon disulfide	2-Nitrophenol	Fluoranthene	Toxaphene		Manganese						
Carbon tetrachloride	3+4 Methylphenol (cresol, m+p)	Fluorene	alpha-Chlordane		Molybdenum						
Chlorobenzene	3,3'-Dichlorobenzidine	Hexachlorobenzene	beta-1,2,3,4,5,6-Hexachlorocyclohe		Nickel						

Table 4-5. Sediment/Soil Analytical Methods and Analyte Reporting Lists. (2 Pages)

Volatile Organic Compounds	Semivolatile Organic Compounds		Pesticides	PCBs	TAL Metals	AVS/ SEM	Radionuclides				Other Methods
Method 8260B	Method 8270		Method 8081	Method 8082	Method 6010	EPA Method 200.8	Gamma Spec	Alpha Spec	Liquid Scintillation Counting	Alpha, Beta Proportional Counting	
			xane								
Chloroethane	3-Nitroaniline	Hexachlorobutadiene	gamma-Chlordane		Phosphorus						
Chloroform	4,6-Dinitro-2-methylphenol	Hexachloro-cyclopentadiene			Potassium						
Chloromethane	4-Bromophenylphenyl ether	Hexachlo-roethane			Selenium						
Dibromochlorometha ne	4-Chloro-3-methylphenol	Indeno(1,2,3-cd)pyrene			Silicon						
Ethylbenzene	4-Chloroaniline	Isophorone			Silver						
Methylenechloride	4-Chlorophenylphenyl ether	N-Nitroso-di-n-dipropylamine			Sodium						
Styrene	4-Nitroaniline	N-Nitrosodiphenylamine			Strontium						
Tetrachloroethene	4-Nitrophenol	Naphthalene			Thallium						
Toluene	Acenaphthene	Nitrobenzene			Tin						
Trichloroethene	Acenaphthylene	Pentachlorophenol			Uranium						
Vinyl chloride	Anthracene	Phenanthrene			Vanadium						
Xylenes (total)	Benzo(a)anthracene	Phenol			Zinc						
cis-1,3-Dichloropropene	Benzo(a)pyrene	Pyrene									
trans-1,3-Dichloropropene	Benzo(b)fluoranthene										

NOTE: Analyses will be sample-specific as described in the SAP; not all sediment/soil samples will be analyzed by all methods in this table or for all compounds listed.
AVS/SEM = acid volatile sulfides/simultaneously extracted metals
PCB = polychlorinated biphenyl
PHC = petroleum hydrocarbon
TAL = target analyte list
TOC = total organic carbon .

Table 4-6. Surface Water/Pore-Water Analytical Methods Analyte Reporting Lists. (2 Pages)

Volatile Organic Compounds	Semivolatile Organic Compounds		Pesticides	PCBs	TAL Metals	Radionuclides				Other Methods
EPA Method 8260B	EPA Method 8270		EPA Method 8081	EPA Method 8082	Method 6010	Gamma Spec	Alpha Spec	Liquid Scintillation Counting	Alpha, Beta Proportional Counting	
1,1,1-Trichloroethane	1,2,4-Trichlorobenzene	Benzo(ghi)-perylene	Aldrin	Aroclor-1016	Aluminum	Antimony-125	Uranium-233/234	C-14	Strontium-90	Hardness - EPA Method 130.1
1,1,2,2-Tetrachloroethane	1,2-Dichlorobenzene	Benzo(k)-fluoranthene	Alpha-BHC	Aroclor-1221	Antimony	Beryllium-7	Uranium-235	Tritium	Technetium-99	DOC - EPA Method 415.1
1,1,2-Trichloroethane	1,3-Dichlorobenzene	Bis(2-Chloroethoxy) methane	Delta-BHC	Aroclor-1232	Arsenic	Cesium-134	Uranium-238			Alkalinity - EPA Method 310.1
1,1-Dichloroethane	1,4-Dichlorobenzene	Bis(2-chloro-1-methylethyl) ether	Dichlorodiphenyl-dichloroethane	Aroclor-1242	Barium	Cesium-137	Thorium-232			Nitrate - EPA Method 300.1
1,1-Dichloroethene	2,4,5-Trichlorophenol	Bis(2-chloroethyl) ether	Dichlorodiphenyl-dichloroethylene	Aroclor-1248	Beryllium	Cobalt-60	Americium-241			PHC - EPA Method 8115
1,2-Dichloroethane	2,4,6-Trichlorophenol	Bis(2-ethylhexyl) phthalate	Dichlorodiphenyl-trichloroethane	Aroclor-1254	Bismuth	Europium-152	Plutonium 239/240, 238			PCB Congeners - EPA Method 1668A
1,2-Dichloroethene (Total)	2,4-Dichlorophenol	Butylbenzyl-phthalate	Dieldrin	Aroclor-1260	Boron	Europium-154				Mercury Method 7470/7471
1,2-Dichloropropane	2,4-Dimethylphenol	Carbazole	Endosulfan I		Cadmium	Europium-155				Hexavalent-chromium Method 7196A
2-Butanone	2,4-Dinitrophenol	Chrysene	Endosulfan II		Calcium	Potassium-40				
2-Hexanone	2,4-Dinitrotoluene	Di-n-butylphthalate	Endosulfan sulfate		Chromium	Radium-226				
4-Methyl-2-Pentanone	2,6-Dinitrotoluene	Di-n-octylphthalate	Endrin		Cobalt	Radium-228				
Acetone	2-Chloronaphthalene	Dibenz[a,h]anthracene	Endrin aldehyde		Copper	Ruthenium-106				
Benzene	2-Chlorophenol	Dibenzofuran	Gamma-BHC (Lindane)		Iron					
Bromodichloro-methane	2-Methylnaphthalene	Diethylphthalate	Heptachlor		Lead					
Bromoform	2-Methylphenol (cresol, o-)	Dimethyl phthalate	Heptachlor epoxide		Lithium					
Bromomethane	2-Nitroaniline	Fluoranthene	Methoxychlor		Magnesium					
Carbon disulfide	2-Nitrophenol	Fluorene	Toxaphene		Manganese					
Carbon tetrachloride	3+4 Methylphenol (cresol, m+p)	Hexachloro-benzene	alpha-Chlordane		Molybdenum					
Chlorobenzene	3,3'-Dichloroben-zidine	Hexachloro-butadiene	beta-1,2,3,4,5,6-Hexachloro-		Nickel					

Table 4-6. Surface Water/Pore-Water Analytical Methods Analyte Reporting Lists. (2 Pages)

Volatile Organic Compounds	Semivolatile Organic Compounds		Pesticides	PCBs	TAL Metals	Radionuclides				Other Methods
EPA Method 8260B	EPA Method 8270		EPA Method 8081	EPA Method 8082	Method 6010	Gamma Spec	Alpha Spec	Liquid Scintillation Counting	Alpha, Beta Proportional Counting	
			cyclohexane							
Chloroethane	3-Nitroaniline	Hexachloro-cyclopentadiene	gamma-Chlordane		Phosphorus					
Chloroform	4,6-Dinitro-2-methylphenol	Hexachloro-ethane			Potassium					
Chloromethane	4-Bromophenyl-phenyl ether	Indeno(1,2,3-cd)pyrene			Selenium					
Dibromochloro-methane	4-Chloro-3-methylphenol	Isophorone			Silicon					
Ethylbenzene	4-Chloroaniline	N-Nitroso-di-n-dipropylamine			Silver					
Methylenechloride	4-Chlorophenyl-phenyl ether	N-Nitrosodi-phenylamine			Sodium					
Styrene	4-Nitroaniline	Naphthalene			Strontium					
Tetrachloroethene	4-Nitrophenol	Nitrobenzene			Thallium					
Toluene	Acenaphthene	Pentachlorophenol			Tin					
Trichloroethene	Acenaphthylene	Phenanthrene			Uranium					
Vinyl chloride	Anthracene	Phenol			Vanadium					
Xylenes (total)	Benzo(a)an-thracene	Pyrene			Zinc					
cis-1,3-Dichloropropene	Benzo(a)pyrene									
trans-1,3-Dichloropropene	Benzo(b)-fluoranthene									

NOTE: Analyses will be sample specific as described in the SAP; not all surface water/pore-water samples will be analyzed by all methods in this table or for all compounds listed.
DOC = dissolved organic carbon
PCB = polychlorinated biphenyl
PHC = petroleum hydrocarbon
TAL = target analyte list

Table 4-7. Fish Tissue Analytical Methods and Analyte Reporting Lists.

Pesticides	TAL Metals	Radionuclides		Other Methods
Method 8081	**Method 6010**	**Gamma Spec**	**Alpha Spec**	
Aldrin	Aluminum	Antimony-125	Uranium-233/234	**Percent Lipids** – Bligh-Dyer (1959)
Alpha-BHC	Antimony	Beryllium-7	Uranium-235	**PCB Congeners** – EPA Method 1668A
Delta-BHC	Arsenic [a]	Cesium-134	Uranium-238	Mercury Method 7471
Dichlorodiphenyl-dichloroethane	Barium	Cesium-137	Thorium-232	
Dichlorodiphenyl-dichloroethylene	Beryllium	Cobalt-60	Americium-241	
Dichlorodiphenyl-trichloroethane	Bismuth	Europium-152	Plutonium-239/240, 238	
Dieldrin	Boron	Europium-154	Alpha, beta proportional counting	
Endosulfan I	Cadmium	Europium-155	Strontium-90	
Endosulfan II	Calcium	Potassium-40	Technetium-99	
Endosulfan sulfate	Chromium	Radium-226	Tritium	
Endrin	Cobalt	Radium-228		
Endrin aldehyde	Copper	Ruthenium-106		
Gamma-BHC (Lindane)	Iron			
Heptachlor	Lead			
Heptachlor epoxide	Lithium			
Methoxychlor	Magnesium			
Toxaphene	Manganese			
alpha-Chlordane	Molybdenum			
beta-1,2,3,4,5,6-Hexachlorocyclohexane	Nickel			
gamma-Chlordane	Phosphorus			
	Potassium			
	Selenium			
	Silicon			
	Silver			
	Sodium			
	Strontium			
	Thallium			
	Tin			
	Uranium			
	Vanadium			
	Zinc			

[a] Speciated arsenic - organic and inorganic.
PCB = polychlorinated biphenyl
TAL = target analyte list

4.1.2.1 Additional Ecological Data Needs. The ecological conceptual exposure model (see Figure 3-2) identified potential exposure routes and ecological receptors. Based on these exposures, additional samples were added specifically to provide information about contaminant concentrations in media to which ecological receptors would be exposed. Approximately 320 pore-water, shallow sediment, surface water, fish tissue, and island soil samples were added to evaluate habitats occupied by potentially exposed ecological receptors in both the river and shoreline areas. These samples are identified in Tables 2-2 through 2-6 of the SAP (Appendix A). Samples added specifically for the ecological risk assessment included the following:

- Pore water to evaluate potential effects on fish and benthic invertebrates in areas of upwelling groundwater, which may contain hexavalent chromium
- Shallow sediments in depositional areas to evaluate potential effects on benthic invertebrates
- Surface water in channel and island or left-bank slough areas to evaluate effects on fish (particularly sturgeon and migrating salmon) and other aquatic organisms, as well as aquatic vegetation and amphibians
- Fish tissue data to assess potential effects of specific chemicals on nonmigratory fish and to use in future food chain modeling, if necessary
- Island soil and shoreline sediments to evaluate potential effects on plants and terrestrial receptors who live or feed on islands or left-bank shorelines.

These data will provide a robust data set for each habitat type evaluated in the BERA.

4.1.2.2 Additional Human Health Risk Assessment Data Needs. Based on the conceptual exposure model (Figure 3-3), potential exposure routes and receptors were identified. Subsequently, the human health risk assessment team reviewed the preliminary sample design and identified several data gaps relevant to specific human health data needs. Approximately 280 samples (identified in Tables 2-2 through 2-6 of the SAP [Appendix A]) were added specifically to support the data needs of the human health risk assessment. The additional samples were included in the sample design to address the following data needs:

- Fin-fish data
- Island soil and near-shore sediments
- High-use areas within Lake Wallula.

These data needs are described below.

Finfish. Finfish data are necessary to accurately quantify the potential exposure of river users to Hanford Site contaminants through the ingestion of fish. In addition, fish tissue data may also be used to evaluate potential ecological effects on the fish themselves. To meet these data needs, six species of fish will be sampled from each of the four sub-areas upriver of McNary Dam.

Sturgeon, walleye, carp, sucker, mountain whitefish, and smallmouth bass will be sampled. Five samples will be collected from each sub-area, and for all species except sturgeon, each sample will be a composite of five fish. Sturgeon samples will consist of a single fish. For each sample, the fillets, liver and kidney (combined), and carcass will be analyzed. Full details of the fish sampling program are described in Section 4.3.4.

Island Soils. Island soils have not been extensively characterized in previous studies. To evaluate island soils, sampling will be completed to characterize river-transported sediments from the Hanford Site that have been deposited on islands during high river levels and assess potential upriver contamination. These samples will be used for site characterization and to support the exposure scenarios in the human health risk assessment, and also to evaluate effects on terrestrial organisms in the ecological risk assessment.

High-Use Areas. Using local knowledge, a number of recreational sites were identified within the stretch between the 300 Area and McNary Dam. Recreational sites, habitats, and high-use Tribal areas were identified as spatial data gaps because of limited existing data in these areas. These high-use areas represent a high exposure frequency. To address these gaps, additional sampling has been proposed for these areas by MIS methods for near-shore sediments and stratified-random approach for surface water samples. Recreational areas are shown in Figures 2-14 through 2-18 of the SAP (Appendix A).

4.1.3 Sample Design Refinement – Steps 5 and 6

The final step in the sample design approach was a refinement step that took into consideration statistical design requirements, collection methods, analytical requirements, access to sample locations, and costs.

4.1.3.1 Review Proposed Sample Design Using Statistical Tools – Step 5. Once the data needs of the RI and the risk assessments were satisfied, a statistical approach for determining the number of samples needed for the RI was implemented. This approach involved defining an acceptable level of uncertainty and computing the required number of samples based on that uncertainty and on the variability of contaminants at the Site. This additional step of statistical evaluation of data needs was conducted to evaluate the robustness of the final data set from a strictly statistical standpoint. The data collected using this approach would be of sufficient quantity to support calculation of the statistic of interest and subsequent hypothesis testing if site conditions are similar to those shown in historical or field-screening data. To assess the appropriate number of required samples, a hypothesis test was conducted for each analyte of interest in each river sub-area by comparing the median concentration to the relevant human health benchmark value.

For this test, the null hypothesis for each test is that the river sub-area is contaminated (i.e., the true median or mean concentration is greater than or equal to the benchmark value). To provide a conservative estimate of the number of samples required, the assumption is made that all analytical data are asymmetric and ***not*** normally distributed. As a result, the one-sample, nonparametric *Multi-Agency Radiation Surveys and Site Investigation Manual* (MARSSIM)

(EPA 2000c) Sign test was used for hypothesis testing (PNNL-16939). Note that for asymmetric data, the MARSSIM sign test is a true test for the median and an approximate test for the mean (Gilbert et al. 2002). Once again the assumption of asymmetric data were used to conservatively estimate the sample size, and therefore the fact that the test is "approximate" for the mean does not adversely impact the sampling design with regard to statistical power. The absence of a normal or symmetric distribution simply means that more samples will be required to attain the desired level of statistical significance.

For illustrative purposes, historical surface water and sediment data for chromium within the 100 Area Sub-Area were input into Visual Sample Plan (VSP), a public-domain computer program designed to produce statistically defensible sampling plans that meet EPA DQOs. The required sample size for each medium was calculated assuming a type I error of 5%, a type II error of 10%, and a lower bound of gray region (LBGR; discussed below) equal to 70% of the benchmark value (decision error parameters are defined below). The results are summarized in Table 4-8, and demonstrate how the MARSSIM Sign test produces the most conservative sampling design.

Table 4-8. Visual Sample Plan Results for Chromium in the 100 Area.

	Surface Water	Sediment
Historic standard deviation	0.029124 mg/L	34.9 mg/kg
Human health benchmark	0.011 mg/L	30 mg/kg
Number of samples - normal distribution – one-sample T-test	669	131
Number of samples - nonparametric, symmetric distribution - Wilcoxon signed-rank test	776	151
Number of samples - nonparametric, asymmetric distribution - MARSSIM Sign test	1,264	249

It is important to note that the MARSSIM Sign test is the recommended approach in VSP for calculating the sample size for nonparametric, asymmetric data when comparing the true mean or median of data to an action level. The MARSSIM equations were included in VSP as they originate from "a multi-agency consensus document that was developed collaboratively by four federal agencies having authority and control over radioactive materials: the U.S. Departments of Defense and Energy, the U.S. Nuclear Regulatory Commission, and the EPA" (Gilbert et al. 2002).

The MARSSIM Sign test determines the required number of samples to conclude that the true median (approximate mean) analyte concentration in a sub-area is greater than or less than the benchmark value with ***prescribed*** levels of certainty.

For each analyte of interest in each river sub-area, a sensitivity analysis was conducted for the decision error parameters to better assess the statistical power of the systematic sampling approach. Specific decision error parameters are described in detail below:

- Alpha (α): Alpha is the type I error for the hypothesis tests and in this case is the probability of falsely rejecting the null hypothesis (concluding the mean to be lower than the benchmark value when it is in fact greater). For the Hanford Site analysis, alpha varied from 5% to 15%.

- Beta (β): Beta is the type II error for the hypothesis tests, and in this case is the probability of falsely accepting the null hypothesis (concluding the mean to be greater than the benchmark value when it is in fact lower). For the Hanford Site analysis, beta varied from 10% to 15%. In general, beta is higher than alpha as there are no public health implications for a "false positive." Costs for unnecessary assessment/cleanup are the primary consequences of a high type II error.

- Lower Bound of Gray Region (LBGR): The gray region is the range of true mean concentrations below the benchmark value within which it is considered acceptable to falsely conclude the site to be dirty. The gray region is also commonly known as the minimum detectable difference between the sample mean and benchmark concentration. For the Hanford analysis, the LBGR is set to 70% of the benchmark value. The prescribed type II error is achieved exactly at the LBGR region. Type II error decreases for true mean concentrations below the LBGR, and increases for true mean concentrations above the LBGR where the difference between the sample mean and benchmark is not statistically detectable. The sample size is very sensitive to the LBGR, and for most analytes, the number of required samples is impracticable with a higher LBGR.

Potential consequences of decision error are summarized in Table 4-9.

Table 4-9. Potential Consequence of Decision Error.

Type of Decision Error	Impact	Potential Consequences
False-negative (Type I Error α): Mistakenly reject the null hypothesis (i.e., erroneously conclude that site contamination ***does not*** require remedial action)	The site would not be remediated when it should be remediated.	Contamination continues to present a risk to human health and the environment Relative severity: High
False-positive (Type II Error β): Mistakenly fail to reject the null hypothesis (i.e., erroneously conclude that site contamination ***requires*** remedial action)	The site would be remediated unnecessarily.	Unnecessary costs for further characterization and remediation are incurred Relative severity: Low

The sensitivity analysis involved three decision error scenarios, summarized in Table 4-10. Results for surface water and sediment are shown in Tables 4-11 and 4-12, respectively. For some analytes, this test is not applicable due to the standard deviation being significantly higher than the benchmark value. For example, more than 250,000 surface water samples are needed for arsenic to attain type I and II errors of 15% in the 100 Area Sub-Area. For other analytes, the standard deviation is significantly less than the benchmark value, and the MARSSIM Sign test predicts that no additional samples are necessary. This occurs for cadmium in surface water and sediment in the 100 Area Sub-Area. There are also many analytes for which the MARSSIM Sign test calculates a sample size approximately equal to that proposed by the preliminary systematic design as defined and presented in Figure 4-1 (RI Sample Design Approach). For example, 206 sediment samples for chromium are needed in the 100 Area Sub-Area to achieve type I and II errors of 15%. This compares well with the systematic design recommendation of 249 samples.

For many of the target analytes, MARSSIM results were generally agreeable with the number of samples proposed in the RI work plan. Thus, the MARSSIM test results had only limited effect on the sample design. Taking into consideration the entire sample design process, including the DQOs, intended end use of the data, and tolerable decision error, the proposed plan has more than 1,100 new samples. These proposed samples will be the basis for the site characterization and will be augmented by the existing data set. It is anticipated that this combined data set will meet current project requirements.

Formulate 95% UCL Needs. The sampling plan was designed taking into consideration one of the major end uses of the data, namely the calculation of the 95% UCL of contaminant mean concentrations for the human health risk assessment. To perform 95% UCL calculations, samples must be collected at random from only the population(s) of interest. As a result, random samples will be taken from fine-grained sediments in depositional areas and from upriver surface water sampling locations. The stratified random approach ensures that inferences can be made about the data obtained in the RI. To further support the UCL calculations, the MARSSIM Sign test was used based on historical data to assess the statistical power of the sampling design. The number of samples recommended in the MARSSIM analysis was taken into consideration when finalizing the design, ensuring that enough samples will be taken to provide a robust data set for the UCL calculations.

Table 4-10. Hanford Site Visual Sample Plan Decision Error Scenarios.

Type I Error (α)	Type II Error (β)	Lower Bound of Gray Region (% of Benchmark Value)
5	10	70
10	15	70
15	15	70

Table 4-11. MARSSIM Sign Test Results for Surface Water. (5 Pages)

Sub-Area	Constituent Class	Constituent Name	CAS #	Units	Historic Number Analyzed	Historic Standard Deviation	Human Health Benchmark Value	Alpha = 5%, Beta = 10%, LBGR = 70%	Alpha = 10%, Beta = 15%, LBGR = 70%	Alpha = 15%, Beta = 15%, LBGR = 70%
								MARSSIM Suggested # of Samples	MARSSIM Suggested # of Samples	MARSSIM Suggested # of Samples
Reactor Area	Inorganic	Alkalinity	ALKALINITY	mg/L	13	1.41E+01				
Reactor Area	Inorganic	Bicarbonate	71-52-3	mg/L	1					
Reactor Area	Inorganic	Carbonate ion	3812-32-6	mg/L	2	4.31E+00				
Reactor Area	Inorganic	Chloride	16887-00-6	mg/L	297	4.53E+00				
Reactor Area	Inorganic	Dissolved oxygen	DO	mg/L	46	1.83E+00				
Reactor Area	Inorganic	Fluoride	16984-48-8	mg/L	297	1.76E-01	4.00E+00	11	8	6
Reactor Area	Inorganic	Nitrate	14797-55-8	mg/L	11	7.62E+00				
Reactor Area	Inorganic	Nitrogen in Nitrate	NO3-N	mg/L	300	1.73E+01				
Reactor Area	Inorganic	Nitrogen in Nitrite	NO2-N	mg/L	286	2.14E-02				
Reactor Area	Inorganic	Nitrogen in Nitrite and Nitrate	NO2+NO3-N	mg/L	40	3.69E+03				
Reactor Area	Inorganic	Oxidation Reduction Potential	EH	mV	96	7.72E+01				
Reactor Area	Inorganic	Phosphate	14265-44-2	mg/L	1					
Reactor Area	Inorganic	Sulfate	14808-79-8	mg/L	297	2.29E+01				
Reactor Area	Metal	Aluminum	7429-90-5	mg/L	131	2.47E+00	3.65E+00	88	56	45
Reactor Area	Metal	Antimony	7440-36-0	mg/L	503	3.35E-04	1.46E-03	17	11	9
Reactor Area	Metal	Arsenic	7440-38-2	mg/L	475	9.61E-04	1.80E-05	511,279	320,846	256,377
Reactor Area	Metal	Barium	7440-39-3	mg/L	139	3.36E-02	7.30E-01	11	8	6
Reactor Area	Metal	Beryllium	7440-41-7	mg/L	587	1.28E-04	4.00E-03	11	8	6
Reactor Area	Metal	Cadmium	7440-43-9	mg/L	562	5.10E-04	1.83E-03	21	14	11
Reactor Area	Metal	Calcium	7440-70-2	mg/L	117	1.20E+01				
Reactor Area	Metal	Chromium	7440-47-3	mg/L	592	2.91E-02	1.10E-02	1,264	794	634
Reactor Area	Metal	Cobalt	7440-48-4	mg/L	115	1.28E-03	7.30E-02	11	8	6
Reactor Area	Metal	Copper	7440-50-8	mg/L	588	2.90E-03	1.36E-01	11	8	6
Reactor Area	Metal	Hexavalent Chromium	18540-29-9	mg/L	9	2.29E-02	1.10E-02	791	497	398
Reactor Area	Metal	Iron	7439-89-6	mg/L	115	2.52E+00	3.00E-01	12,659	7,943	6,352
Reactor Area	Metal	Lead	7439-92-1	mg/L	475	3.79E-03	1.50E-02	18	12	10
Reactor Area	Metal	Magnesium	7439-95-4	mg/L	117	2.91E+00				
Reactor Area	Metal	Manganese	7439-96-5	mg/L	151	1.01E-01	5.00E-02	740	465	371
Reactor Area	Metal	Mercury	7439-97-6	mg/L	185	5.29E-06	6.26E-05	11	8	6
Reactor Area	Metal	Molybdenum	7439-98-7	mg/L	1		1.83E-02			
Reactor Area	Metal	Nickel	7440-02-0	mg/L	590	3.10E-03	7.30E-02	11	8	6
Reactor Area	Metal	Potassium	7440-09-7	mg/L	117	1.58E+00				
Reactor Area	Metal	Selenium	7782-49-2	mg/L	476	4.98E-04	1.83E-02	11	8	6
Reactor Area	Metal	Silicon	7440-21-3	mg/L	2	7.96E-02				
Reactor Area	Metal	Silver	7440-22-4	mg/L	575	5.36E-04	1.83E-02	11	8	6
Reactor Area	Metal	Sodium	7440-23-5	mg/L	117	3.91E+00				
Reactor Area	Metal	Strontium	7440-24-6	mg/L	115	6.78E-02				
Reactor Area	Metal	Thallium	7440-28-0	mg/L	430	2.29E-05	2.40E-04	11	8	6
Reactor Area	Metal	Thorium	7440-29-1	mg/L	3	5.21E-06				
Reactor Area	Metal	Uranium	7440-61-1	mg/L	38	3.99E-04				
Reactor Area	Metal	Uranium	7440-61-1	pCi/L	51	1.24E+00				
Reactor Area	Metal	Vanadium	7440-62-2	mg/L	115	7.96E-03	1.83E-02	41	26	21
Reactor Area	Metal	Zinc	7440-66-6	mg/L	590	3.25E-02	1.10E+00	11	8	6
Reactor Area	PHYSICAL	pH Measurement	PH	pH	125	4.04E-01				
Reactor Area	PHYSICAL	Specific Conductance	CONDUCT	uS/cm	125	9.41E+01				
Reactor Area	PHYSICAL	Temperature	TEMPERATURE	Deg. C	115	4.86E+00				
Reactor Area	RAD	Beryllium-7	13966-02-4	pCi/L	129	3.62E+00				
Reactor Area	RAD	Carbon-14	14762-75-5	pCi/L	6	2.42E+02	2.00E+03	11	8	6
Reactor Area	RAD	Cesium-137	10045-97-3	pCi/L	157	1.09E+00	2.00E+02	11	8	6
Reactor Area	RAD	Cobalt-60	10198-40-0	pCi/L	156	5.05E-01	1.00E+02	11	8	6
Reactor Area	RAD	Gross alpha	12587-46-1	pCi/L	252	3.65E+00				
Reactor Area	RAD	Gross beta	12587-47-2	pCi/L	232	4.35E+01				
Reactor Area	RAD	Plutonium-238	13981-16-3	pCi/L	5	2.02E-03	1.50E+01	11	8	6

Table 4-11. MARSSIM Sign Test Results for Surface Water. (5 Pages)

Sub-Area	Constituent Class	Constituent Name	CAS #	Units	Historic Number Analyzed	Historic Standard Deviation	Human Health Benchmark Value	Alpha = 5%, Beta = 10%, LBGR = 70% MARSSIM Suggested # of Samples	Alpha = 10%, Beta = 15%, LBGR = 70% MARSSIM Suggested # of Samples	Alpha = 15%, Beta = 15%, LBGR = 70% MARSSIM Suggested # of Samples
Reactor Area	RAD	Potassium-40	13966-00-2	pCi/L	138	2.51E+01				
Reactor Area	RAD	Radium-226	13982-63-3	pCi/L	10	1.20E-02	5.00E+00	11	8	6
Reactor Area	RAD	Radium-228	15262-20-1	pCi/L	10	3.12E-01	5.00E+00	11	8	6
Reactor Area	RAD	Strontium-90	10098-97-2	pCi/L	398	1.26E+01	8.00E+00	448	281	225
Reactor Area	RAD	Technetium-99	14133-76-7	pCi/L	76	2.19E+01	9.00E+02	11	8	6
Reactor Area	RAD	Tritium	10028-17-8	pCi/L	490	7.15E+03	2.00E+04	29	20	16
Reactor Area	RAD	Uranium-234	13966-29-5	pCi/L	249	8.07E-01	3.00E+01	11	8	6
Reactor Area	RAD	Uranium-235	15117-96-1	pCi/L	239	3.44E-02	3.00E+01	11	8	6
Reactor Area	RAD	Uranium-238	U-238	pCi/L	249	6.88E-01	3.00E+01	11	8	6
Reactor Area	VOC	1,1,2-Trichloroethane	79-00-5	mg/L	56	1.44E-04	2.00E-04	100	63	51
Reactor Area	VOC	1,2-Dichloroethane	107-06-2	mg/L	56	1.69E-04	1.23E-04	342	215	172
Reactor Area	VOC	Acetone	67-64-1	mg/L	56	9.98E-04	5.48E-01	11	8	6
Reactor Area	VOC	Benzene	71-43-2	mg/L	56	3.71E-05	3.54E-04	11	8	6
Reactor Area	VOC	Carbon tetrachloride	56-23-5	mg/L	55	5.42E-04	1.71E-04	1,799	1,130	904
Reactor Area	VOC	Chloroform	67-66-3	mg/L	56	7.79E-04	1.67E-04	3,904	2,450	1,959
Reactor Area	VOC	Methylenechloride	75-09-2	mg/L	56	1.22E-04				
Reactor Area	VOC	Toluene	108-88-3	mg/L	56	1.46E-04	2.28E-01	11	8	6
Reactor Area	VOC	Trichloroethene	79-01-6	mg/L	56	6.91E-04	2.80E-05	109,257	68,549	54,818
Reactor Area	VOC	Xylenes (total)	1330-20-7	mg/L	56	1.72E-04	2.03E-02	11	8	6
300 Area	Inorganic	Alkalinity	ALKALINITY	mg/L	8	1.92E+01				
300 Area	Inorganic	Chloride	16887-00-6	mg/L	257	4.53E+00				
300 Area	Inorganic	Dissolved oxygen	DO	mg/L	12	1.15E+00				
300 Area	Inorganic	Fluoride	16984-48-8	mg/L	257	7.36E-02	4.00E+00	11	8	6
300 Area	Inorganic	Nitrate	14797-55-8	mg/L	8	5.58E-01				
300 Area	Inorganic	Nitrogen in Nitrate	NO3-N	mg/L	265	3.18E+00				
300 Area	Inorganic	Nitrogen in Nitrite	NO2-N	mg/L	257	3.78E-02				
300 Area	Inorganic	Nitrogen in Nitrite and Nitrate	NO2+NO3-N	mg/L	38	8.43E+02				
300 Area	Inorganic	Oxidation Reduction Potential	EH	mV	69	5.62E+01				
300 Area	Inorganic	Sulfate	14808-79-8	mg/L	257	1.15E+01				
300 Area	Metal	Aluminum	7429-90-5	mg/L	14	3.65E-02	3.65E+00	11	8	6
300 Area	Metal	Antimony	7440-36-0	mg/L	437	4.15E-05	1.46E-03	11	8	6
300 Area	Metal	Arsenic	7440-38-2	mg/L	437	1.28E-03	1.80E-05	910,030	570,964	456,593
300 Area	Metal	Barium	7440-39-3	mg/L	14	1.64E-02	7.30E-01	11	8	6
300 Area	Metal	Beryllium	7440-41-7	mg/L	441	1.12E-04	4.00E-03	11	8	6
300 Area	Metal	Cadmium	7440-43-9	mg/L	433	1.40E-04	1.83E-03	11	8	6
300 Area	Metal	Calcium	7440-70-2	mg/L	4	2.70E+00				
300 Area	Metal	Chromium	7440-47-3	mg/L	441	2.60E-03	1.10E-02	17	11	9
300 Area	Metal	Cobalt	7440-48-4	mg/L	4	9.25E-04	7.30E-02	11	8	6
300 Area	Metal	Copper	7440-50-8	mg/L	441	2.80E-03	1.36E-01	11	8	6
300 Area	Metal	Iron	7439-89-6	mg/L	4	3.29E-03	3.00E-01	11	8	6
300 Area	Metal	Lead	7439-92-1	mg/L	437	2.70E-03	1.50E-02	14	9	8
300 Area	Metal	Magnesium	7439-95-4	mg/L	4	7.62E-01				
300 Area	Metal	Manganese	7439-96-5	mg/L	14	3.50E-03	5.00E-02	11	8	6
300 Area	Metal	Mercury	7439-97-6	mg/L	153	5.39E-06	6.26E-05	11	8	6
300 Area	Metal	Nickel	7440-02-0	mg/L	441	2.19E-03	7.30E-02	11	8	6
300 Area	Metal	Selenium	7782-49-2	mg/L	437	8.58E-04	1.83E-02	11	8	6
300 Area	Metal	Silver	7440-22-4	mg/L	441	1.05E-04	1.83E-02	11	8	6
300 Area	Metal	Sodium	7440-23-5	mg/L	4	1.48E+00				
300 Area	Metal	Strontium	7440-24-6	mg/L	4	1.18E-02				
300 Area	Metal	Thallium	7440-28-0	mg/L	397	2.88E-05	2.40E-04	11	8	6
300 Area	Metal	Uranium	7440-61-1	mg/L	10	1.63E-02				
300 Area	Metal	Uranium	7440-61-1	pCi/L	54	2.54E+01				
300 Area	Metal	Vanadium	7440-62-2	mg/L	4	1.23E-03	1.83E-02	11	8	6

Table 4-11. MARSSIM Sign Test Results for Surface Water. (5 Pages)

Sub-Area	Constituent Class	Constituent Name	CAS #	Units	Historic Number Analyzed	Historic Standard Deviation	Human Health Benchmark Value	Alpha = 5%, Beta = 10%, LBGR = 70%	Alpha = 10%, Beta = 15%, LBGR = 70%	Alpha = 15%, Beta = 15%, LBGR = 70%
								MARSSIM Suggested # of Samples	MARSSIM Suggested # of Samples	MARSSIM Suggested # of Samples
300 Area	Metal	Zinc	7440-66-6	mg/L	441	1.75E-02	1.10E+00	11	8	6
300 Area	PHYSICAL	pH Measurement	PH	pH	110	3.59E-01				
300 Area	PHYSICAL	Specific Conductance	CONDUCT	uS/cm	111	8.91E+01				
300 Area	PHYSICAL	Temperature	TEMPERATURE	Deg C	110	3.92E+00				
300 Area	PHYSICAL	Total suspended solids	TSS	mg/L	3	5.77E-01				
300 Area	RAD	Barium-140	14798-08-4	pCi/L	83	1.29E+00				
300 Area	RAD	Cesium-134	13967-70-9	pCi/L	171	3.14E-01	8.00E+01	11	8	6
300 Area	RAD	Cesium-137	10045-97-3	pCi/L	272	8.57E-01	2.00E+02	11	8	6
300 Area	RAD	Cobalt-60	10198-40-0	pCi/L	272	8.76E-01	1.00E+02	11	8	6
300 Area	RAD	Gross alpha	12587-46-1	pCi/L	69	4.63E+01				
300 Area	RAD	Gross beta	12587-47-2	pCi/L	256	1.25E+01				
300 Area	RAD	Iodine-127	7553-56-2	pCi/L	18	3.54E-02				
300 Area	RAD	Iodine-129	15046-84-1	pCi/L	30	1.10E-01	1.00E+00	11	8	6
300 Area	RAD	Iodine-129/Iodine-127 ratio	1129/127RT	ntomr	18	1.53E-04				
300 Area	RAD	Iodine-131	10043-66-0	pCi/L	75	2.45E-01				
300 Area	RAD	Iron-59	14596-12-4	pCi/L	115	1.07E+00				
300 Area	RAD	Plutonium-239/240	PU-239/240	pCi/L	1		1.50E+01			
300 Area	RAD	Potassium-40	13966-00-2	pCi/L	201	2.01E+01				
300 Area	RAD	Strontium-90	10098-97-2	pCi/L	293	2.09E-01	8.00E+00	11	8	6
300 Area	RAD	Technetium-99	14133-76-7	pCi/L	39	3.32E+01	9.00E+02	11	8	6
300 Area	RAD	Thorium-228	14274-82-9	pCi/L	6	4.01E-02	1.50E+01	11	8	6
300 Area	RAD	Thorium-230	14269-63-7	pCi/L	6	4.12E-02	1.50E+01	11	8	6
300 Area	RAD	Thorium-232	TH-232	pCi/L	6	3.83E-02	1.50E+01	11	8	6
300 Area	RAD	Tritium	10028-17-8	pCi/L	526	1.25E+04	2.00E+04	76	48	39
300 Area	RAD	Uranium-234	13966-29-5	pCi/L	359	1.24E+01	3.00E+01	38	23	20
300 Area	RAD	Uranium-235	15117-96-1	pCi/L	349	5.56E-01	3.00E+01	11	8	6
300 Area	RAD	Uranium-236	13982-70-2	pCi/L	6	3.04E-01				
300 Area	RAD	Uranium-238	U-238	pCi/L	359	1.14E+01	3.00E+01	33	21	17
300 Area	RAD	Zirconium-95	13967-71-0	pCi/L	65	4.81E-01				
300 Area	VOC	1,1,2-Trichloroethane	79-00-5	mg/L	30	2.14E-04	2.00E-04	212	134	107
300 Area	VOC	1,2-Dichloroethane	107-06-2	mg/L	30	3.23E-04	1.23E-04	1,239	777	622
300 Area	VOC	1,4-Dichlorobenzene	106-46-7	mg/L	30	4.62E-05	4.67E-04	11	8	6
300 Area	VOC	Acetone	67-64-1	mg/L	30	7.99E-04	5.48E-01	11	8	6
300 Area	VOC	Benzene	71-43-2	mg/L	30	3.43E-05	3.54E-04	11	8	6
300 Area	VOC	Carbon disulfide	75-15-0	mg/L	30	8.15E-05	1.00E-01	11	8	6
300 Area	VOC	Carbon tetrachloride	56-23-5	mg/L	30	4.61E-05	1.71E-04	20	12	10
300 Area	VOC	Chloroform	67-66-3	mg/L	30	1.40E-03	1.67E-04	12,388	7,899	6,317
300 Area	VOC	cis-1,2-Dichloroethylene	156-59-2	mg/L	30	9.51E-05	6.08E-03	11	8	6
300 Area	VOC	Methylenechloride	75-09-2	mg/L	30	1.53E-04				
300 Area	VOC	Tetrachloroethene	127-18-4	mg/L	30	1.35E-04	1.05E-04	305	192	154
300 Area	VOC	Toluene	108-88-3	mg/L	30	2.30E-04	2.28E-01	11	8	6
300 Area	VOC	Trichloroethene	79-01-6	mg/L	30	7.25E-04	2.80E-05	119,997	75,287	60,207
300 Area	VOC	Xylenes (total)	1330-20-7	mg/L	30	2.35E-04	2.03E-02	11	8	6
Lake Wallula	Inorganic	Alkalinity	ALKALINITY	mg/L	1					
Lake Wallula	Inorganic	Chloride	16887-00-6	mg/L	251	7.19E-01				
Lake Wallula	Inorganic	Fluoride	16984-48-8	mg/L	251	4.24E-02	4.00E+00	11	8	6
Lake Wallula	Inorganic	Nitrate	14797-55-8	mg/L	9	3.35E-01				
Lake Wallula	Inorganic	Nitrogen in Nitrate	NO3-N	mg/L	250	1.23E-01				
Lake Wallula	Inorganic	Nitrogen in Nitrite	NO2-N	mg/L	250	7.11E-03				
Lake Wallula	Inorganic	Nitrogen in Nitrite and Nitrate	NO2+NO3-N	mg/L	32	3.43E-01				
Lake Wallula	Inorganic	Oxidation Reduction Potential	EH	mV	41	4.34E+01				
Lake Wallula	Inorganic	Sulfate	14808-79-8	mg/L	251	1.83E+00				
Lake Wallula	Metal	Antimony	7440-36-0	mg/L	336	1.31E-04	1.46E-03	11	8	6

Table 4-11. MARSSIM Sign Test Results for Surface Water. (5 Pages)

Sub-Area	Constituent Class	Constituent Name	CAS #	Units	Historic Number Analyzed	Historic Standard Deviation	Human Health Benchmark Value	Alpha = 5%, Beta = 10%, LBGR = 70%	Alpha = 10%, Beta = 15%, LBGR = 70%	Alpha = 15%, Beta = 15%, LBGR = 70%
								MARSSIM Suggested # of Samples	MARSSIM Suggested # of Samples	MARSSIM Suggested # of Samples
Lake Wallula	Metal	Arsenic	7440-38-2	mg/L	336	1.47E-04	1.80E-05	12,000	7,529	6,021
Lake Wallula	Metal	Beryllium	7440-41-7	mg/L	336	8.23E-05	4.00E-03	11	8	6
Lake Wallula	Metal	Cadmium	7440-43-9	mg/L	336	5.53E-05	1.83E-03	11	8	6
Lake Wallula	Metal	Calcium	7440-70-2	mg/L	1					
Lake Wallula	Metal	Chromium	7440-47-3	mg/L	337	2.73E-03	1.10E-02	18	11	10
Lake Wallula	Metal	Copper	7440-50-8	mg/L	335	2.52E-04	1.36E-01	11	8	6
Lake Wallula	Metal	Hardness	HARDNESS	mg/L	1					
Lake Wallula	Metal	Lead	7439-92-1	mg/L	336	2.25E-04	1.50E-02	11	8	6
Lake Wallula	Metal	Magnesium	7439-95-4	mg/L	1					
Lake Wallula	Metal	Mercury	7439-97-6	mg/L	148	3.02E-07	6.26E-05	11	8	6
Lake Wallula	Metal	Nickel	7440-02-0	mg/L	336	1.10E-03	7.30E-02	11	8	6
Lake Wallula	Metal	Selenium	7782-49-2	mg/L	336	1.59E-04	1.83E-02	11	8	6
Lake Wallula	Metal	Silica	7631-86-9	mg/L	1					
Lake Wallula	Metal	Silver	7440-22-4	mg/L	335	1.41E-05	1.83E-02	11	8	6
Lake Wallula	Metal	Thallium	7440-28-0	mg/L	319	8.92E-06	2.40E-04	11	8	6
Lake Wallula	Metal	Uranium	7440-61-1	mg/L	6	1.54E-05				
Lake Wallula	Metal	Uranium	7440-61-1	pCi/L	13	1.57E-01				
Lake Wallula	Metal	Zinc	7440-66-6	mg/L	336	1.48E-03	1.10E+00	11	8	6
Lake Wallula	PHYSICAL	pH Measurement	PH	pH	89	4.22E-01				
Lake Wallula	PHYSICAL	Specific Conductance	CONDUCT	umhos/cm	1					
Lake Wallula	PHYSICAL	Specific Conductance	CONDUCT	uS/cm	94	1.56E+01				
Lake Wallula	PHYSICAL	Temperature	TEMPERATURE	Deg C	89	5.24E+00				
Lake Wallula	PHYSICAL	Total suspended solids	TSS	mg/L	3	1.00E+00				
Lake Wallula	RAD	Antimony-125	14234-35-6	pCi/L	193	1.05E-02	3.00E+02	11	8	6
Lake Wallula	RAD	Beryllium-7	13966-02-4	pCi/L	195	6.98E-01				
Lake Wallula	RAD	Carbon-14	14762-75-5	pCi/L	9	4.09E+00	2.00E+03	11	8	6
Lake Wallula	RAD	Cesium-134	13967-70-9	pCi/L	267	9.27E-02	8.00E+01	11	8	6
Lake Wallula	RAD	Cesium-137	10045-97-3	pCi/L	273	1.26E-01	2.00E+02	11	8	6
Lake Wallula	RAD	Cobalt-60	10198-40-0	pCi/L	273	3.16E-01	1.00E+02	11	8	6
Lake Wallula	RAD	Gross alpha	12587-46-1	pCi/L	177	3.21E-01				
Lake Wallula	RAD	Gross beta	12587-47-2	pCi/L	176	7.00E-01				
Lake Wallula	RAD	Iodine-127	7553-56-2	pCi/L	19	1.18E+01				
Lake Wallula	RAD	Iodine-129	15046-84-1	pCi/L	28	3.26E-05	1.00E+00	11	8	6
Lake Wallula	RAD	Iodine-129/Iodine-127 ratio	I129/127RT	atomr	19	2.45E-07				
Lake Wallula	RAD	Plutonium-238	13981-16-3	pCi/L	64	4.97E-04	1.50E+01	11	8	6
Lake Wallula	RAD	Plutonium-239/240	PU-239/240	pCi/L	64	3.81E-04	1.50E+01	11	8	6
Lake Wallula	RAD	Potassium-40	13966-00-2	pCi/L	232	8.26E+00				
Lake Wallula	RAD	Ruthenium-106	13967-48-1	pCi/L	195	3.45E-01				
Lake Wallula	RAD	Strontium-90	10098-97-2	pCi/L	387	3.32E-02	8.00E+00	11	8	6
Lake Wallula	RAD	Technetium-99	14133-76-7	pCi/L	104	1.51E-01	9.00E+02	11	8	6
Lake Wallula	RAD	Thorium-230	14269-63-7	pCi/L	1		1.50E+01			
Lake Wallula	RAD	Tritium	10028-17-8	pCi/L	469	5.26E+01	2.00E+04	11	8	6
Lake Wallula	RAD	Uranium-234	13966-29-5	pCi/L	380	7.82E-02	3.00E+01	11	8	6
Lake Wallula	RAD	Uranium-235	15117-96-1	pCi/L	378	8.24E-03	3.00E+01	11	8	6
Lake Wallula	RAD	Uranium-238	U-238	pCi/L	380	6.57E-02	3.00E+01	11	8	6
Lake Wallula	VOC	1,1,2-Trichloroethane	79-00-5	mg/L	63	1.33E-04	2.00E-04	87	54	44
Lake Wallula	VOC	1,2-Dichloroethane	107-06-2	mg/L	63	1.78E-04	1.23E-04	383	240	192
Lake Wallula	VOC	1,4-Dichlorobenzene	106-46-7	mg/L	63	3.49E-05	4.67E-04	11	8	6
Lake Wallula	VOC	Acetone	67-64-1	mg/L	63	7.28E-04	5.48E-01	11	8	6
Lake Wallula	VOC	Carbon disulfide	75-15-0	mg/L	63	2.96E-04	1.00E-01	11	8	6
Lake Wallula	VOC	Chloroform	67-66-3	mg/L	63	8.31E-04	1.67E-04	4,443	2,788	2,230
Lake Wallula	VOC	Methylenechloride	75-09-2	mg/L	63	1.59E-04				
Lake Wallula	VOC	Toluene	108-88-3	mg/L	63	2.40E-04	2.28E-01	11	8	6

Table 4-11. MARSSIM Sign Test Results for Surface Water. (5 Pages)

Sub-Area	Constituent Class	Constituent Name	CAS #	Units	Historic Number Analyzed	Historic Standard Deviation	Human Health Benchmark Value	Alpha = 5%, Beta = 10%, LBGR = 70%	Alpha = 10%, Beta = 15%, LBGR = 70%	Alpha = 15%, Beta = 15%, LBGR = 70%
								MARSSIM Suggested # of Samples	MARSSIM Suggested # of Samples	MARSSIM Suggested # of Samples
Lake Wallula	VOC	Trichloroethene	79-01-6	mg/L	63	4.20E-05	2.80E-05	408	257	206
Lake Wallula	VOC	Xylenes (total)	1330-20-7	mg/L	63	2.65E-04	2.03E-02	11	8	6

Notes:
RAD = Radionuclide
VOC = volatile organic compound
mg/L = milligrams per liter
pCi/L = picocuries per liter
mV = millivolts
uS/cm = microsiemens per centimeter
LBGR = lower bound of the gray region
MARSSIM = Multi-Agency Radiation Surveys and Site Investigation Manual

Table 4-12. MARSSIM Sign Test Results for Sediment. (6 Pages)

Sub-Area	Constituent Class	Constituent Name	CAS #	Units	Historic Number Analyzed	Historic Standard Deviation	Human Health Benchmark Value	Alpha = 5%, Beta = 10%, LBGR = 70% MARSSIM Suggested # of Samples	Alpha = 10%, Beta = 15%, LBGR = 70% MARSSIM Suggested # of Samples	Alpha = 15%, Beta = 15%, LBGR = 70% MARSSIM Suggested # of Samples
Reactor Area	Dioxin	2,3,7,8-Dioxin Total Equivalents	2378-DioxinTE	mg/kg	1		3.90E-06			
Reactor Area	Dioxin	Octachlorodibenzo-p-dioxin	3268-87-9	mg/kg	3	4.16E-06	3.90E-06	210	132	106
Reactor Area	Dioxin	Total Dioxin Equivalents	Total_TCDD_Equiv	mg/kg	3	3.95E-07				
Reactor Area	Dioxin	Total Dioxins	Total_Dioxin	mg/kg	3	3.32E-06	3.90E-06	137	86	69
Reactor Area	Furan	Dibenzofuran	132-64-9	mg/kg	3	4.21E-03	1.45E+01	11	8	6
Reactor Area	Furan	Total Furans	Total_Furan	mg/kg	6	3.08E-03	2.50E-01	11	8	6
Reactor Area	Herb	2,4-Dichlorophenoxyacetic acid	94-75-7	mg/kg	3	6.45E-03	6.90E+01	11	8	6
Reactor Area	Inorganic	Sulfide	18496-25-8	umole/g	9	4.46E+00				
Reactor Area	Metal	Aluminum	7429-90-5	%	1					
Reactor Area	Metal	Aluminum	7429-90-5	mg/kg	57	1.44E+04	7.73E+03	632	396	317
Reactor Area	Metal	Antimony	7440-36-0	mg/kg	103	2.01E+00	3.13E+00	81	51	41
Reactor Area	Metal	Arsenic	7440-38-2	mg/kg	101	2.61E+00	3.90E-01	8,019	5,032	4,024
Reactor Area	Metal	Barium	7440-39-3	mg/kg	70	2.97E+02	1.56E+03	14	9	8
Reactor Area	Metal	Beryllium	7440-41-7	mg/kg	117	7.12E-01	1.56E+01	11	8	6
Reactor Area	Metal	Boron	7440-42-8	mg/kg	1		1.60E+03			
Reactor Area	Metal	Cadmium	7440-43-9	mg/kg	123	1.26E+00	3.90E+00	26	16	14
Reactor Area	Metal	Cadmium	7440-43-9	umole/g	18	1.13E-02				
Reactor Area	Metal	Calcium	7440-70-2	%	1					
Reactor Area	Metal	Calcium	7440-70-2	mg/kg	54	1.24E+03				
Reactor Area	Metal	Cerium	7440-45-1	mg/kg	1					
Reactor Area	Metal	Chromium	7440-47-3	mg/kg	130	3.49E+01	3.00E+01	249	156	125
Reactor Area	Metal	Cobalt	7440-48-4	mg/kg	55	2.29E+00	9.03E+02	11	8	6
Reactor Area	Metal	Copper	7440-50-8	mg/kg	120	1.13E+01	2.91E+02	11	8	6
Reactor Area	Metal	Copper	7440-50-8	umole/g	18	7.02E-02				
Reactor Area	Metal	Iron	7439-89-6	%	1		5.48E+03			
Reactor Area	Metal	Iron	7439-89-6	mg/kg	54	4.27E+03	5.48E+03	116	72	58
Reactor Area	Metal	Lanthanum	7439-91-0	mg/kg	1					
Reactor Area	Metal	Lead	7439-92-1	mg/kg	114	1.52E+01	2.50E+02	11	8	6
Reactor Area	Metal	Lead	7439-92-1	umole/g	18	7.93E-02				
Reactor Area	Metal	Lithium	7439-93-2	mg/kg	1		1.56E+03			
Reactor Area	Metal	Magnesium	7439-95-4	%	1					
Reactor Area	Metal	Magnesium	7439-95-4	mg/kg	54	9.32E+02				
Reactor Area	Metal	Manganese	7439-96-5	mg/kg	70	5.49E+02	3.47E+02	456	287	230
Reactor Area	Metal	Mercury	7439-97-6	mg/kg	108	7.09E-02	2.30E+00	11	8	6
Reactor Area	Metal	Mercury	7439-97-6	umole/g	17	9.65E-06				
Reactor Area	Metal	Nickel	7440-02-0	mg/kg	123	7.45E+00	1.56E+02	11	8	6
Reactor Area	Metal	Nickel	7440-02-0	umole/g	18	2.41E-02				
Reactor Area	Metal	Niobium	7440-03-1	mg/kg	1					
Reactor Area	Metal	Percent Solids	%SOLIDS	%	15	1.60E+01				
Reactor Area	Metal	Phosphorus	7723-14-0	%	1		1.60E-01			
Reactor Area	Metal	Potassium	7440-09-7	%	1					
Reactor Area	Metal	Potassium	7440-09-7	mg/kg	54	2.56E+02				
Reactor Area	Metal	Scandium	7440-20-2	mg/kg	1					
Reactor Area	Metal	Selenium	7782-49-2	mg/kg	107	4.00E-01	3.91E+01	11	8	6
Reactor Area	Metal	Silver	7440-22-4	mg/kg	114	6.67E-01	3.91E+01	11	8	6
Reactor Area	Metal	Sodium	7440-23-5	%	1					
Reactor Area	Metal	Sodium	7440-23-5	mg/kg	54	7.04E+01				
Reactor Area	Metal	Strontium	7440-24-6	mg/kg	6	1.60E+02	4.69E+03	11	8	6
Reactor Area	Metal	Thallium	7440-28-0	mg/kg	97	3.82E-01	5.48E-01	94	59	47
Reactor Area	Metal	Thorium	7440-29-1	mg/kg	16	1.74E+00				
Reactor Area	Metal	Tin	7440-31-5	mg/kg	11	3.96E+00	4.69E+03	11	8	6
Reactor Area	Metal	Titanium	7440-32-6	%	1					
Reactor Area	Metal	Total organic carbon	TOC	%	23	5.91E-01				
Reactor Area	Metal	Uranium	7440-61-1	mg/kg	19	1.58E+00	1.56E+01	11	8	6
Reactor Area	Metal	Uranium	7440-61-1	pCi/g	39	7.02E-01				

Table 4-12. MARSSIM Sign Test Results for Sediment. (6 Pages)

Sub-Area	Constituent Class	Constituent Name	CAS #	Units	Historic Number Analyzed	Historic Standard Deviation	Human Health Benchmark Value	Alpha = 5%, Beta = 10%, LBGR = 70%	Alpha = 10%, Beta = 15%, LBGR = 70%	Alpha = 15%, Beta = 15%, LBGR = 70%
								MARSSIM Suggested # of Samples	MARSSIM Suggested # of Samples	MARSSIM Suggested # of Samples
Reactor Area	Metal	Vanadium	7440-62-2	mg/kg	55	1.80E+01	3.91E+01	45	28	23
Reactor Area	Metal	Yttrium	7440-65-5	mg/kg	1					
Reactor Area	Metal	Zinc	7440-66-6	mg/kg	113	1.23E+02	2.35E+03	11	8	6
Reactor Area	Metal	Zinc	7440-66-6	umole/g	18	2.43E+00				
Reactor Area	PCB	1,1'-Biphenyl,2,3',4,4',5-pentachloro-	31508-00-6	mg/kg	3	1.99E-04				
Reactor Area	PCB	2,2',4,4',5,5'-Hexachloro-Biphenyl	35065-27-1	mg/kg	3	2.37E-04				
Reactor Area	PCB	2,2',3,4,4',5,5'-heptachlorobiphenyl	35065-29-3	mg/kg	3	6.81E-05				
Reactor Area	PCB	2,2',3,4,4',5'-Hexachlorobiphenyl	35065-28-2	mg/kg	3	2.51E-04				
Reactor Area	PCB	2,2',4,5,5'-Pentachlorobiphenyl	37680-73-2	mg/kg	3	2.08E-04				
Reactor Area	PCB	2,2',5,5'-Tetrachlorobiphenyl	35693-99-3	mg/kg	3	6.99E-05				
Reactor Area	PCB	2,4,4'-Trichlorobiphenyl	7012-37-5	mg/kg	3	1.79E-04				
Reactor Area	PCB	Total PCBs	Total_PCB	mg/kg	4	1.25E-03	2.20E-01	11	8	6
Reactor Area	Pest/PCB	Anthracene	120-12-7	mg/kg	3	2.47E-04	2.19E+03	11	8	6
Reactor Area	Pest/PCB	Benzo(a)anthracene	56-55-3	mg/kg	3	7.17E-04	1.40E-01	11	8	6
Reactor Area	Pest/PCB	Benzo(a)pyrene	50-32-8	mg/kg	3	8.98E-04	1.48E-02	11	8	6
Reactor Area	Pest/PCB	Chrysene	218-01-9	mg/kg	3	1.06E-03	1.40E-01	11	8	6
Reactor Area	Pest/PCB	Delta-BHC	319-86-8	mg/kg	2	6.75E-05	4.00E-01	11	8	6
Reactor Area	Pest/PCB	Dichlorodiphenyldichloroethane	72-54-8	mg/kg	6	3.88E-04	2.44E+00	11	8	6
Reactor Area	Pest/PCB	Dichlorodiphenyldichloroethylene	72-55-9	mg/kg	7	6.35E-04	1.72E+00	11	8	6
Reactor Area	Pest/PCB	Dichlorodiphenyltrichloroethane	50-29-3	mg/kg	7	6.05E-04	1.72E+00	11	8	6
Reactor Area	Pest/PCB	Dieldrin	60-57-1	mg/kg	1		3.04E-02			
Reactor Area	Pest/PCB	Endosulfan II	33213-65-9	mg/kg	4	4.21E-04	3.70E+01	11	8	6
Reactor Area	Pest/PCB	Endosulfan sulfate	1031-07-8	mg/kg	3	7.79E-05	3.70E+01	11	8	6
Reactor Area	Pest/PCB	Endrin aldehyde	7421-93-4	mg/kg	3	3.37E-04	1.80E+00	11	8	6
Reactor Area	Pest/PCB	Fluoranthene	206-44-0	mg/kg	3	1.45E-03	2.29E+02	11	8	6
Reactor Area	Pest/PCB	Methoxychlor	72-43-5	mg/kg	4	2.71E-04	3.06E+01	11	8	6
Reactor Area	Pest/PCB	Pyrene	129-00-0	mg/kg	3	1.22E-03	2.31E+02	11	8	6
Reactor Area	Pest/PCB	Total BHC	Total_BHC	mg/kg	3	1.80E-04	9.02E-02	11	8	6
Reactor Area	Pest/PCB	Total High Mol Weight PAHs	Total_HMWPAH	mg/kg	3	3.70E-03				
Reactor Area	Pest/PCB	Total Low Mol Weight PAHs	Total_LMWPAH	mg/kg	3	1.36E-03				
Reactor Area	PHYSICAL	Percent moisture (wet sample)	%MOISTURE	%	6	2.11E+01				
Reactor Area	RAD	Americium-241	14596-10-2	pCi/g	48	3.50E-02	3.66E+00	11	8	6
Reactor Area	RAD	Antimony-125	14234-35-6	pCi/g	73	7.65E-03	6.17E-02	11	8	6
Reactor Area	RAD	Beryllium-7	13966-02-4	pCi/g	80	7.96E-02				
Reactor Area	RAD	Cesium-134	13967-70-9	pCi/g	116	1.60E-02	1.57E-02	194	122	98
Reactor Area	RAD	Cesium-137	10045-97-3	pCi/g	157	5.33E-01	4.38E-02	26,518	16,638	13,305
Reactor Area	RAD	Cobalt-60	10198-40-0	pCi/g	158	1.28E-01	9.00E-03	36,221	22,726	18,174
Reactor Area	RAD	Europium-152	14683-23-9	pCi/g	95	3.22E-01	2.11E-02	41,709	26,169	20,927
Reactor Area	RAD	Europium-154	15585-10-1	pCi/g	119	5.56E-02	1.91E-02	1,529	959	767
Reactor Area	RAD	Europium-155	14391-16-3	pCi/g	84	3.19E-02	9.00E-01	11	8	6
Reactor Area	RAD	Gross alpha	12587-46-1	pCi/g	37	7.24E+00				
Reactor Area	RAD	Gross beta	12587-47-2	pCi/g	51	5.40E+00				
Reactor Area	RAD	Lead-212	15092-94-1	pCi/g	1					
Reactor Area	RAD	Lead-214	15067-28-4	pCi/g	1					
Reactor Area	RAD	Manganese-54	13966-31-9	pCi/g	2	2.57E-02				
Reactor Area	RAD	Neptunium-237	13994-20-2	pCi/g	2	8.77E-02	1.40E-01	77	48	39
Reactor Area	RAD	Plutonium-238	13981-16-3	pCi/g	116	1.33E-02	2.92E+00	11	8	6
Reactor Area	RAD	Plutonium-239/240	PU-239/240	pCi/g	120	7.88E-03	2.87E+00	11	8	6
Reactor Area	RAD	Potassium-40	13966-00-2	pCi/g	157	1.86E+00	1.40E-01	31,656	19,862	15,884
Reactor Area	RAD	Radium-226	13982-63-3	pCi/g	41	2.53E-01	1.31E-02	66,999	42,036	33,616
Reactor Area	RAD	Radium-228	15262-20-1	pCi/g	4	2.09E-01	2.46E-02	12,995	8,153	6,520
Reactor Area	RAD	Strontium-90	10098-97-2	pCi/g	166	1.30E-01	5.51E+00	11	8	6
Reactor Area	RAD	Technetium-99	14133-76-7	pCi/g	3	2.17E-01	1.04E+02	11	8	6
Reactor Area	RAD	Thorium-228	14274-82-9	pCi/g	40	7.30E-01	1.44E-02	460,410	288,867	231,004
Reactor Area	RAD	Thorium-230	14269-63-7	pCi/g	5	2.06E-01	3.93E+00	11	8	6

Table 4-12. MARSSIM Sign Test Results for Sediment. (6 Pages)

Sub-Area	Constituent Class	Constituent Name	CAS #	Units	Historic Number Analyzed	Historic Standard Deviation	Human Health Benchmark Value	Alpha = 5%, Beta = 10%, LBGR = 70%	Alpha = 10%, Beta = 15%, LBGR = 70%	Alpha = 15%, Beta = 15%, LBGR = 70%
								MARSSIM Suggested # of Samples	MARSSIM Suggested # of Samples	MARSSIM Suggested # of Samples
Reactor Area	RAD	Thorium-232	TH-232	pCi/g	41	5.80E-01	3.44E+00	14	9	8
Reactor Area	RAD	Thorium-234	15065-10-8	pCi/g	2	8.84E-02				
Reactor Area	RAD	Tritium	10028-17-8	pCi/g	2	2.26E-02	5.10E+02	11	8	6
Reactor Area	RAD	Uranium-233/234	U-233/234	pCi/g	36	4.44E-01				
Reactor Area	RAD	Uranium-234	13966-29-5	pCi/g	98	4.25E-01	5.02E+00	11	8	6
Reactor Area	RAD	Uranium-235	15117-96-1	pCi/g	140	6.55E-02	2.06E-01	24	16	14
Reactor Area	RAD	Uranium-238	U-238	pCi/g	160	4.73E-01	9.79E-01	48	30	24
Reactor Area	RAD	Zirconium/Niobium-95	ZR/NB-95	pCi/g	17	2.00E-02				
Reactor Area	SVOC	2-Methylphenanthrene	2531-84-2	mg/kg	3	2.34E-02				
Reactor Area	Unknown	Acid Volatile Sulfide	AVS	umole/g	12	6.85E+00				
Reactor Area	Unknown	Gallium	7440-55-3	mg/kg	1					
Reactor Area	Unknown	Neodymium	7440-00-8	mg/kg	1					
Reactor Area	Unknown	Ytterbium	7440-64-4	mg/kg	1					
Reactor Area	VOC	Acenaphthene	83-32-9	mg/kg	3	6.66E-05	3.68E+02	11	8	6
Reactor Area	VOC	Benzo(b)fluoranthene	205-99-2	mg/kg	3	9.87E-04	1.40E-01	11	8	6
Reactor Area	VOC	Benzo(ghi)perylene	191-24-2	mg/kg	3	8.93E-04	2.30E+02	11	8	6
Reactor Area	VOC	Benzo(k)fluoranthene	207-08-9	mg/kg	3	1.18E-03	1.40E-01	11	8	6
Reactor Area	VOC	Dibenz[a,h]anthracene	53-70-3	mg/kg	3	1.71E-04	1.48E-02	11	8	6
Reactor Area	VOC	Indeno(1,2,3-cd)pyrene	193-39-5	mg/kg	3	9.38E-04	1.40E-01	11	8	6
Reactor Area	VOC	Naphthalene	91-20-3	mg/kg	3	1.58E-02	1.25E+01	11	8	6
Reactor Area	VOC	Phenanthrene	85-01-8	mg/kg	3	2.68E-03	3.70E+02	11	8	6
300 Area	Dioxin	2,3,7,8-Dioxin Total Equivalents	2378-DioxinTE	mg/kg	4	3.37E-09	3.90E-06	11	8	6
300 Area	Dioxin	Octachlorodibenzo-p-dioxin	3268-87-9	mg/kg	5	3.01E-05	3.90E-06	10,680	6,701	5,360
300 Area	Dioxin	Total Dioxin Equivalents	Total TCDD Equiv	mg/kg	5	3.88E-07				
300 Area	Dioxin	Total Dioxins	Total Dioxin	mg/kg	5	2.98E-05	3.90E-06	10,451	6,557	5,244
300 Area	Metal	Aluminum	7429-90-5	mg/kg	6	5.49E+02	7.73E+03	11	8	6
300 Area	Metal	Antimony	7440-36-0	mg/kg	34	1.69E+00	3.13E+00	59	38	30
300 Area	Metal	Arsenic	7440-38-2	mg/kg	35	2.17E+00	3.90E-01	5,585	3,504	2,802
300 Area	Metal	Barium	7440-39-3	mg/kg	6	1.51E+01	1.56E+03	11	8	6
300 Area	Metal	Beryllium	7440-41-7	mg/kg	39	5.21E-01	1.56E+01	11	8	6
300 Area	Metal	Cadmium	7440-43-9	mg/kg	41	4.10E-01	3.90E+00	11	8	6
300 Area	Metal	Calcium	7440-70-2	mg/kg	6	9.44E+02				
300 Area	Metal	Chromium	7440-47-3	mg/kg	45	2.75E+01	3.00E+01	158	99	80
300 Area	Metal	Cobalt	7440-48-4	mg/kg	6	2.17E+00	9.03E+02	11	8	6
300 Area	Metal	Copper	7440-50-8	mg/kg	44	4.12E+00	2.91E+02	11	8	6
300 Area	Metal	Iron	7439-89-6	mg/kg	6	6.01E+03	5.48E+03	222	140	112
300 Area	Metal	Lead	7439-92-1	mg/kg	35	1.05E+01	2.50E+02	11	8	6
300 Area	Metal	Magnesium	7439-95-4	mg/kg	6	5.28E+02				
300 Area	Metal	Manganese	7439-96-5	mg/kg	6	1.63E+02	3.47E+02	46	29	23
300 Area	Metal	Mercury	7439-97-6	mg/kg	35	9.78E-03	2.30E+00	11	8	6
300 Area	Metal	Nickel	7440-02-0	mg/kg	42	5.22E+00	1.56E+02	11	8	6
300 Area	Metal	Percent Solids	%SOLIDS	%	5	5.70E+00				
300 Area	Metal	Potassium	7440-09-7	mg/kg	6	1.53E+02				
300 Area	Metal	Selenium	7782-49-2	mg/kg	30	1.24E-01	3.91E+01	11	8	6
300 Area	Metal	Silver	7440-22-4	mg/kg	34	1.02E-01	3.91E+01	11	8	6
300 Area	Metal	Sodium	7440-23-5	mg/kg	6	1.12E+02				
300 Area	Metal	Strontium	7440-24-6	mg/kg	2	3.54E+00	4.69E+03	11	8	6
300 Area	Metal	Thallium	7440-28-0	mg/kg	30	6.83E-02	5.48E-01	11	8	6
300 Area	Metal	Tin	7440-31-5	mg/kg	5	2.84E+00	4.69E+03	11	8	6
300 Area	Metal	Total organic carbon	TOC	%	5	3.57E-01				
300 Area	Metal	Uranium	7440-61-1	pCi/g	7	2.31E+00	1.56E+01	12	8	6
300 Area	Metal	Vanadium	7440-62-2	mg/kg	6	1.58E+01	3.91E+01	36	23	18
300 Area	Metal	Zinc	7440-66-6	mg/kg	41	5.46E+01	2.35E+03	11	8	6
300 Area	Pest/PCB	Dichlorodiphenyldichloroethane	72-54-8	mg/kg	5	2.26E-04	2.44E+00	11	8	6
300 Area	Pest/PCB	Dichlorodiphenyldichloroethylene	72-55-9	mg/kg	5	8.37E-05	1.72E+00	11	8	6

Table 4-12. MARSSIM Sign Test Results for Sediment. (6 Pages)

Sub-Area	Constituent Class	Constituent Name	CAS #	Units	Historic Number Analyzed	Historic Standard Deviation	Human Health Benchmark Value	Alpha = 5%, Beta = 10%, LBGR = 70% MARSSIM Suggested # of Samples	Alpha = 10%, Beta = 15%, LBGR = 70% MARSSIM Suggested # of Samples	Alpha = 15%, Beta = 15%, LBGR = 70% MARSSIM Suggested # of Samples
300 Area	PHYSICAL	Percent moisture (wet sample)	%MOISTURE	%	3	7.23E+00				
300 Area	RAD	Actinium-228	14331-83-0	pCi/g	17	4.96E-01				
300 Area	RAD	Antimony-125	14234-35-6	pCi/g	54	7.95E-03	6.17E-02	11	8	6
300 Area	RAD	Barium-140	14798-08-4	pCi/g	4	5.50E-04				
300 Area	RAD	Beryllium-7	13966-02-4	pCi/g	80	9.78E-02				
300 Area	RAD	Cerium-141	13967-74-3	pCi/g	6	5.58E-03				
300 Area	RAD	Cerium-144	14762-78-8	pCi/g	20	5.38E-02	4.57E-01	11	8	6
300 Area	RAD	Cesium-134	13967-70-9	pCi/g	132	1.29E-02	1.57E-02	128	81	65
300 Area	RAD	Cesium-137	10045-97-3	pCi/g	149	1.46E-01	4.38E-02	1,997	1,253	1,002
300 Area	RAD	Cobalt-57	13981-50-5	pCi/g	51	7.03E-03				
300 Area	RAD	Cobalt-58	13981-38-9	pCi/g	4	1.15E-03				
300 Area	RAD	Cobalt-60	10198-40-0	pCi/g	147	1.50E-02	9.00E-03	504	317	254
300 Area	RAD	Europium-152	14683-23-9	pCi/g	92	4.82E-02	2.11E-02	944	593	474
300 Area	RAD	Europium-154	15585-10-1	pCi/g	55	1.40E-02	1.91E-02	102	65	52
300 Area	RAD	Europium-155	14391-16-3	pCi/g	53	1.88E-02	9.00E-01	11	8	6
300 Area	RAD	Gross beta	12587-47-2	pCi/g	18	3.91E+00				
300 Area	RAD	Iodine-131	10043-66-0	pCi/g	8	1.24E-02				
300 Area	RAD	Iron-59	14596-12-4	pCi/g	4	2.31E-03				
300 Area	RAD	Lanthanum-140	13981-28-7	pCi/g	7	6.30E-03				
300 Area	RAD	Lead-212	15092-94-1	pCi/g	3	3.05E-01				
300 Area	RAD	Lead-214	15067-28-4	pCi/g	3	1.89E-01				
300 Area	RAD	Manganese-54	13966-31-9	pCi/g	22	7.94E-03				
300 Area	RAD	Niobium-93	13967-76-5	pCi/g	17	7.28E-03				
300 Area	RAD	Plutonium-238	13981-16-3	pCi/g	18	1.23E-02	2.92E+00	11	8	6
300 Area	RAD	Plutonium-239/240	PU-239/240	pCi/g	18	8.25E-03	2.87E+00	11	8	6
300 Area	RAD	Potassium-40	13966-00-2	pCi/g	143	2.57E+00	1.40E-01	60,552	37,992	30,382
300 Area	RAD	Radium-226	13982-63-3	pCi/g	56	3.16E-01	1.31E-02	277,752	174,266	139,358
300 Area	RAD	Radium-228	15262-20-1	pCi/g	5	2.95E-01	2.46E-02	25,770	16,169	12,930
300 Area	RAD	Ruthenium-103	13968-53-1	pCi/g	11	4.29E-03				
300 Area	RAD	Ruthenium-106	13967-48-1	pCi/g	68	4.22E-02				
300 Area	RAD	Strontium-90	10098-97-2	pCi/g	56	4.86E-02	5.51E+00	11	8	6
300 Area	RAD	Technetium-99	14133-76-7	pCi/g	1		1.04E+02			
300 Area	RAD	Thorium-228	14274-82-9	pCi/g	56	9.75E-01	1.44E-02	822,932	516,317	412,894
300 Area	RAD	Thorium-230	14269-63-7	pCi/g	6	1.92E+00	3.93E+00	50	32	26
300 Area	RAD	Thorium-232	TH-232	pCi/g	6	1.84E-01	3.44E+00	11	8	6
300 Area	RAD	Uranium-234	13966-29-5	pCi/g	54	1.79E+00	5.02E+00	29	18	15
300 Area	RAD	Uranium-235	15117-96-1	pCi/g	79	7.33E-02	2.06E-01	29	18	15
300 Area	RAD	Uranium-236	13982-70-2	pCi/g	2	7.07E-03				
300 Area	RAD	Uranium-238	U-238	pCi/g	68	1.53E+00	9.79E-01	443	278	222
300 Area	RAD	Zinc-65	13982-39-3	pCi/g	33	2.09E-02	3.97E-02	36	35	29
300 Area	RAD	Zirconium-95	13967-71-0	pCi/g	21	3.78E-02				
Lake Wallula	Dioxin	1,2,3,4,6,7,8-Heptachlorodibenzodioxin	35822-46-9	ng/kg	21	5.71E-06	3.90E-06	390	245	196
Lake Wallula	Dioxin	2,3,7,8-Dioxin Total Equivalents	2378-DioxinTE	mg/kg	21	6.87E-08	3.90E-06	11	8	6
Lake Wallula	Dioxin	Octachlorodibenzo-p-dioxin	3268-87-9	mg/kg	21	2.87E-05	3.90E-06	9,713	6,095	4,874
Lake Wallula	Dioxin	Total Dioxin Equivalents	Total_TCDD_Equiv	mg/kg	21	3.59E-07				
Lake Wallula	Dioxin	Total Dioxins	Total_Dioxin	mg/kg	21	3.15E-05	3.90E-06	11,686	7,332	5,864
Lake Wallula	Furan	2,3,7,8-Tetrachlorodibenzofuran	51207-31-9	mg/kg	21	2.29E-07	3.90E-06	11	8	6
Lake Wallula	Furan	Dibenzofuran	132-64-9	mg/kg	3	5.06E-03	1.45E+01	11	8	6
Lake Wallula	Furan	Total Furans	Total_Furan	mg/kg	24	3.43E-03	2.50E-01	11	8	6
Lake Wallula	Inorganic	Phosphorous in phosphate	PO4-P	mg/kg	4	1.71E-02				
Lake Wallula	Inorganic	Sulfide	18496-25-8	mg/kg	4	9.18E-01				
Lake Wallula	Inorganic	Sulfide	18496-25-8	umole/g	15	1.64E+00				
Lake Wallula	Metal	Aluminum	7429-90-5	mg/kg	27	3.11E+03	7.73E+03	35	23	18
Lake Wallula	Metal	Antimony	7440-36-0	mg/kg	52	1.46E+00	3.13E+00	46	29	23
Lake Wallula	Metal	Arsenic	7440-38-2	mg/kg	91	3.42E+00	3.90E-01	13,761	8,634	6,905

Table 4-12. MARSSIM Sign Test Results for Sediment. (6 Pages)

Sub-Area	Constituent Class	Constituent Name	CAS #	Units	Historic Number Analyzed	Historic Standard Deviation	Human Health Benchmark Value	Alpha = 5%, Beta = 10%, LBGR = 70%	Alpha = 10%, Beta = 15%, LBGR = 70%	Alpha = 15%, Beta = 15%, LBGR = 70%
								MARSSIM Suggested # of Samples	MARSSIM Suggested # of Samples	MARSSIM Suggested # of Samples
Lake Wallula	Metal	Barium	7440-39-3	mg/kg	27	2.70E+01	1.56E+03	11	8	6
Lake Wallula	Metal	Beryllium	7440-41-7	mg/kg	62	6.89E-01	1.56E+01	11	8	6
Lake Wallula	Metal	Cadmium	7440-43-9	mg/kg	113	1.32E+00	3.90E+00	28	17	15
Lake Wallula	Metal	Cadmium	7440-43-9	umole/g	27	6.19E-03				
Lake Wallula	Metal	Calcium	7440-70-2	mg/kg	27	1.12E+03				
Lake Wallula	Metal	Chromium	7440-47-3	mg/kg	87	2.40E+01	3.00E+01	122	76	62
Lake Wallula	Metal	Cobalt	7440-48-4	mg/kg	27	3.52E+00	9.03E+02	11	8	6
Lake Wallula	Metal	Copper	7440-50-8	mg/kg	114	1.38E+01	2.91E+02	11	8	6
Lake Wallula	Metal	Copper	7440-50-8	umole/g	27	5.92E-02				
Lake Wallula	Metal	Iron	7439-89-6	mg/kg	27	6.79E+03	5.48E+03	282	178	142
Lake Wallula	Metal	Lead	7439-92-1	mg/kg	104	1.98E+01	2.50E+02	11	8	6
Lake Wallula	Metal	Lead	7439-92-1	umole/g	27	4.78E-02				
Lake Wallula	Metal	Magnesium	7439-95-4	mg/kg	27	1.17E+03				
Lake Wallula	Metal	Manganese	7439-96-5	mg/kg	27	1.37E+02	3.47E+02	35	22	18
Lake Wallula	Metal	Mercury	7439-97-6	mg/kg	71	6.31E-02	2.30E+00	11	8	6
Lake Wallula	Metal	Mercury	7439-97-6	umole/g	27	6.33E-05				
Lake Wallula	Metal	Nickel	7440-02-0	mg/kg	83	8.71E+00	1.56E+02	11	8	6
Lake Wallula	Metal	Nickel	7440-02-0	umole/g	27	3.91E-02				
Lake Wallula	Metal	Nitrogen in ammonia	NH3-N	mg/kg	4	3.95E+00				
Lake Wallula	Metal	Percent Solids	%SOLIDS	%	38	1.00E+01				
Lake Wallula	Metal	Potassium	7440-09-7	mg/kg	27	5.08E+02				
Lake Wallula	Metal	Selenium	7782-49-2	mg/kg	39	4.72E-01	3.91E+01	11	8	6
Lake Wallula	Metal	Silver	7440-22-4	mg/kg	72	3.78E-01	3.91E+01	11	8	6
Lake Wallula	Metal	Sodium	7440-23-5	mg/kg	27	9.26E+01				
Lake Wallula	Metal	Strontium	7440-24-6	mg/kg	5	1.64E+00	4.69E+03	11	8	6
Lake Wallula	Metal	Thallium	7440-28-0	mg/kg	39	5.62E-01	5.48E-01	196	123	99
Lake Wallula	Metal	Tin	7440-31-5	mg/kg	8	3.67E+00	4.69E+03	11	8	6
Lake Wallula	Metal	Total organic carbon	TOC	%	56	5.00E-01				
Lake Wallula	Metal	Uranium	7440-61-1	pCi/g	54	6.76E-01	1.56E+01	11	8	6
Lake Wallula	Metal	Vanadium	7440-62-2	mg/kg	27	1.82E+01	3.91E+01	46	29	23
Lake Wallula	Metal	Zinc	7440-66-6	mg/kg	114	1.22E+02	2.35E+03	11	8	6
Lake Wallula	Metal	Zinc	7440-66-6	umole/g	27	4.55E-01				
Lake Wallula	Organic	Oil and grease	OIL/GREASE	mg/kg	4	1.21E+01				
Lake Wallula	Organic	Total petroleum hydrocarbons	TPH	mg/kg	4	7.83E+00				
Lake Wallula	PCB	Aroclor-1254	11097-69-1	mg/kg	20	1.41E-04	2.22E-01	11	8	6
Lake Wallula	PCB	Aroclor-1260	11096-82-5	mg/kg	24	2.55E-03	2.22E-01	11	8	6
Lake Wallula	PCB	Total PCBs	Total PCB	mg/kg	5	4.47E-05	2.20E-01	11	8	6
Lake Wallula	Pest	o,p'-DDT	789-02-6	mg/kg	20	2.70E-04	1.70E+00	11	8	6
Lake Wallula	Pest/PCB	Anthracene	120-12-7	mg/kg	3	3.06E-03	2.19E+03	11	8	6
Lake Wallula	Pest/PCB	Benzo(a)anthracene	56-55-3	mg/kg	3	3.91E-03	1.40E-01	11	8	6
Lake Wallula	Pest/PCB	Benzo(a)pyrene	50-32-8	mg/kg	3	3.91E-03	1.48E-02	20	12	10
Lake Wallula	Pest/PCB	Chrysene	218-01-9	mg/kg	3	7.37E-03	1.40E-01	11	8	6
Lake Wallula	Pest/PCB	Dichlorodiphenyldichloroethane	72-54-8	mg/kg	24	3.63E-04	2.44E+00	11	8	6
Lake Wallula	Pest/PCB	Dichlorodiphenyldichloroethylene	72-55-9	mg/kg	24	5.62E-04	1.72E+00	11	8	6
Lake Wallula	Pest/PCB	Dichlorodiphenyltrichloroethane	50-29-3	mg/kg	29	8.37E-04	1.72E+00	11	8	6
Lake Wallula	Pest/PCB	Fluoranthene	206-44-0	mg/kg	3	2.06E-02	2.29E+02	11	8	6
Lake Wallula	Pest/PCB	Hexachlorobenzene	118-74-1	mg/kg	1		3.00E-01			
Lake Wallula	Pest/PCB	Pyrene	129-00-0	mg/kg	3	1.54E-02	2.31E+02	11	8	6
Lake Wallula	Pest/PCB	Total High Mol Weight PAHs	Total HMWPAH	mg/kg	3	3.06E-02				
Lake Wallula	Pest/PCB	Total Low Mol Weight PAHs	Total LMWPAH	mg/kg	3	2.57E-02				
Lake Wallula	PHYSICAL	Percent moisture (wet sample)	%MOISTURE	%	30	6.21E+00				
Lake Wallula	RAD	Americium-241	14596-10-2	pCi/g	3	2.12E-03	3.66E+00	11	8	6
Lake Wallula	RAD	Antimony-125	14234-35-6	pCi/g	64	1.51E-02	6.17E-02	18	11	10
Lake Wallula	RAD	Beryllium-7	13966-02-4	pCi/g	82	2.00E-01				
Lake Wallula	RAD	Cesium-134	13967-70-9	pCi/g	73	1.43E-02	1.57E-02	156	99	78

Table 4-12. MARSSIM Sign Test Results for Sediment. (6 Pages)

Sub-Area	Constituent Class	Constituent Name	CAS #	Units	Historic Number Analyzed	Historic Standard Deviation	Human Health Benchmark Value	Alpha = 5%, Beta = 10%, LBGR = 70%	Alpha = 10%, Beta = 15%, LBGR = 70%	Alpha = 15%, Beta = 15%, LBGR = 70%
								MARSSIM Suggested # of Samples	MARSSIM Suggested # of Samples	MARSSIM Suggested # of Samples
Lake Wallula	RAD	Cesium-137	10045-97-3	pCi/g	130	2.57E-01	4.38E-02	6,185	3,881	3,104
Lake Wallula	RAD	Cobalt-57	13981-50-5	pCi/g	1					
Lake Wallula	RAD	Cobalt-60	10198-40-0	pCi/g	121	7.83E-02	9.00E-03	13,576	8,518	6,812
Lake Wallula	RAD	Europium-152	14683-23-9	pCi/g	87	2.49E+03	2.11E-02	2,500,217,740,211	1,568,665,142,456	1,254,445,223,058
Lake Wallula	RAD	Europium-154	15585-10-1	pCi/g	77	5.07E-02	1.91E-02	1,272	798	639
Lake Wallula	RAD	Europium-155	14391-16-3	pCi/g	72	3.53E-02	9.00E-01	11	8	6
Lake Wallula	RAD	Gross beta	12587-47-2	pCi/g	7	1.03E+01				
Lake Wallula	RAD	Lead-212	15092-94-1	pCi/g	1					
Lake Wallula	RAD	Lead-214	15067-28-4	pCi/g	1					
Lake Wallula	RAD	Plutonium-238	13981-16-3	pCi/g	121	1.88E-03	2.92E+00	11	8	6
Lake Wallula	RAD	Plutonium-239/240	PU-239/240	pCi/g	124	4.78E-03	2.87E+00	11	8	6
Lake Wallula	RAD	Potassium-40	13966-00-2	pCi/g	130	1.73E+00	1.40E-01	27,484	17,244	13,791
Lake Wallula	RAD	Radium-226	13982-63-3	pCi/g	8	8.35E-02	1.31E-02	7,286	4,571	3,656
Lake Wallula	RAD	Ruthenium-106	13967-48-1	pCi/g	64	3.61E-02				
Lake Wallula	RAD	Strontium-90	10098-97-2	pCi/g	125	1.41E-02	5.51E+00	11	8	6
Lake Wallula	RAD	Thorium-232	TH-232	pCi/g	8	8.86E-02	3.44E+00	11	8	6
Lake Wallula	RAD	Uranium-234	13966-29-5	pCi/g	94	4.03E-01	5.02E+00	11	8	6
Lake Wallula	RAD	Uranium-235	15117-96-1	pCi/g	103	3.84E-02	2.06E-01	14	9	8
Lake Wallula	RAD	Uranium-238	U-238	pCi/g	122	4.51E-01	9.79E-01	45	28	23
Lake Wallula	RAD	Zinc-65	13982-39-3	pCi/g	29	2.13E-02	3.97E-02	58	36	29
Lake Wallula	RAD	Zirconium/Niobium-95	ZR/NB-95	pCi/g	29	6.91E-01				
Lake Wallula	Unknown	Acid Volatile Sulfide	AVS	umole/g	17	1.28E+00				
Lake Wallula	VOC	2-Methylnaphthalene	91-57-6	mg/kg	3	2.75E-03	3.20E+02	11	8	6
Lake Wallula	VOC	Acenaphthene	83-32-9	mg/kg	3	8.52E-03	3.68E+02	11	8	6
Lake Wallula	VOC	Benzo(ghi)perylene	191-24-2	mg/kg	3	5.29E-03	2.30E+02	11	8	6
Lake Wallula	VOC	Benzo(k)fluoranthene	207-08-9	mg/kg	3	9.67E-03	1.40E-01	11	8	6
Lake Wallula	VOC	Dibenz[a,h]anthracene	53-70-3	mg/kg	3	4.93E-03	1.48E-02	27	17	14
Lake Wallula	VOC	Fluorene	86-73-7	mg/kg	3	6.79E-03	2.64E+02	11	8	6
Lake Wallula	VOC	Indeno(1,2,3-cd)pyrene	193-39-5	mg/kg	3	5.63E-03	1.40E-01	11	8	6
Lake Wallula	VOC	Phenanthrene	85-01-8	mg/kg	3	2.93E-02	3.70E+02	11	8	6

Notes:
RAD = Radionuclide
VOC = volatile organic compound
mg/kg = milligrams per kilogram
pCi/g = picocuries per gram
umole/g = micromoles per gram
LBGR = lower bound of the gray region
MARSSIM = Multi-Agency Radiation Surveys and Site Investigation Manual

4.1.3.2 Evaluate Feasibility of Proposed Sample Design – Step 6. Once the design had been modified to accommodate statistical considerations, final modifications were completed to facilitate the sample collection and analysis. The following items were evaluated and considered in the final design and are described below:

- Sample representativeness
- Analytical volume requirements
- Reliability of sampling equipment
- Accessibility of sample locations
- Analytical methods
- Number and costs
- Adjacent study areas (e.g., RCBRA).

Obtain Representative Sample for Analysis. Sample activities must not disturb the sampled matrix to the extent that it will physically or substantially change the properties of interest. For example, sediment samples collected for simultaneously extracted metals/acid volatile sulfides analysis should not be overly exposed to oxygen, which would change the chemical properties of the sample.

Obtain Sufficient Sample Volume to Meet Analytical Volume Requirements. Collection equipment has been matched to meet the volume requirements of the proposed analytical methods. For example, the petite ponar sampling tool has been tested in a variety of settings along the Study Area to ensure that an adequate sample volume can be retrieved to the surface.

Consider Reliability of Sampling Equipment. Sampling equipment and methods must be sufficiently robust to withstand sampling conditions. For example, deep sediment core samples will be collected using 10-cm (4-in.)-diameter casing to withstand the anticipated unsupported distance (> 27 m [90 ft]) from surface to the bottom of Lake Wallula.

Accessibility of Proposed Sample Locations. The physical constraints associated with sample collection and retrieval was considered in the final design. The following are examples of this evaluation.

- Sediment/soil sampling requires low-flow conditions.
- While most surface water sampling can occur during high-flow conditions, this will tend to dilute contaminant concentrations and will create bank storage conditions within upwelling areas.
- Island soil sampling requires low-flow conditions.

Analytical Methods. As discussed above, once all analytes were identified for each medium, appropriate analytical methods were selected to meet project objectives. Tables 4-5, 4-6, and 4-7 present proposed analytical methods.

Number and Cost of Analysis. Costs of collection and analysis were taken into consideration in the final design. As shown in Section 7.0 of the DQO Summary Report (WCH-265), approaching the sample design simply on the basis of statistical test results can result in a cost-prohibitive number of samples. To maximize available resources, the following rationale is provided. As shown in Tables 4-11 and 4-12, the following compounds were identified by the MARSSIM sign test for an extraordinary number of additional samples.

- Antimony, arsenic, chromium, iron, and magnesium. These elements are naturally occurring and are known to be prevalent in upriver sources (e.g., non-Hanford origin), and therefore it was determined that only a limited number of additional samples are required.

- Volatile organic compounds in surface water adjacent to the 300 Area. Because of very low benchmarks and relatively few detections of VOCs in surface water, the MARRSSIM Sign test required a very large number of samples to resolve this issue. A focused approach is being used. Pore water and sediments will be analyzed for VOCs to evaluate the potential sources of VOCs to surface water.

Sample Density of Adjacent Study Areas (e.g., 100/300 and Inter-Areas). As stated above, this investigation was focused on areas that have not been evaluated in prior studies and those areas that should have the highest likelihood of retaining Hanford contaminants. Prior studies have focused on source areas resulting in a high sample density within the near-shore RCBRA areas. While this information will be used in conjunction with the proposed sample design to develop a comprehensive understanding of the nature and extent of Hanford-related contaminants within the Study Area, it will not be used directly within the quantitative human health and ecological risk assessments. However, these data were used to support the selection of target analytes.

4.1.4 Draft Final Sample Design – Step 7

Based on this process and input received from the Tri-Parties, the Remedial Investigation Work Plan for Hanford Releases to the Columbia River was developed and submitted for review. Once approved, this work plan forms the basis for the subsequent field work.

4.1.5 Reconnaissance Surveys and Tri-Party Approval of Work Plan – Step 8

Once the Tri-Parties have agreed on the outcome of the comment disposition process, the work plan will be approved.

Prior to completing the sample design, three types of reconnaissance surveys are planned for the RI:

- Groundwater plume upwelling survey (Section 4.3.1)
- Fine-grained sediment survey (Section 4.3.2)
- Habitat survey (Section 4.5.3.1.1).

The results of the reconnaissance surveys will be used to finalize sampling locations, which will be approved by the Tri-Parties. As each reconnaissance survey is completed, maps summarizing the results, including recommendations to complete the proposed sampling design, will be developed. These figures and associated text will present the proposed locations for additional sampling and will be submitted for Tri-Party review, comment, and approval.

4.2 SITE CHARACTERIZATION APPROACH BY SUB-AREA

This section summarizes the RI site characterization approach for each of the five sub-areas described in Section 4.1.1.1: Upriver, 100 Area, 300 Area, Lake Wallula, and Bonneville Dam Pool. For each sub-area, as appropriate, the following information was assessed as part of the site characterization approach.

Current Groundwater Plume Upwelling. A groundwater plume upwelling is the area where the groundwater is discharging through the riverbed into the river. To assess the concentration, nature, and extent of groundwater contaminants near the Columbia River on the Hanford Site, monitoring wells and aquifer tubes have been sampled. The *Aquifer Sampling Tube Results for Fiscal Year 2007* report (SGW-35028) summarizes the analytical results of aquifer tubes from the groundwater plume upwelling areas for fiscal year (FY) 2007 and compares results to historical trends and contaminant distribution in the aquifer. Aquifer tube coverage exists along the Hanford Shoreline from just upstream of the 100-B/C Area downstream to the former Hanford town site and the 300 Area. Sites are more closely spaced along some segments where spatial resolution of contaminant plumes is needed (SGW-35028). For the chromium data, dissolved chromium is represented, which studies show is dominantly hexavalent in Hanford Site groundwater (SGW-35028). Aquifer tube and monitoring well data are also summarized in annual calendar year reports for the Pump-and-Treat Systems in the 100-HR-3, 100-KR-4, and 100-NR-2 groundwater operable units and in the annual Hanford Site Groundwater Monitoring reports. This information is summarized below for the groundwater plume upwelling associated with the 100 Area and 300 Area Sub-Areas. All available aquifer sampling tube results (including results for sampling preceding 2007) are retained in the HEIS database and may be retrieved by aquifer tube number

Site-Specific Conceptual Site Model. The site-specific CSMs are based on the overall CSM presented in Section 3.0 of this RI work plan and focus on a smaller scale to identify contaminant sources, migration pathways, and receptors specific to each sub-area. The evaluation of each sub-area resulted in similar CSMs (see Figures 1-2 and 1-3).

Review of Existing Data. The existing data that were reviewed for the work plan approach include the combined CRC database that consists of data from the following sources: the original CRC database; ACOE; data used in the Source and Groundwater Component of the RCBRA; HEIS; RCBRA Report Inter-Areas data; mid-Columbia River sediment data; and 2004, 2005, and 2006 data from PNNL presented in the Surface Environmental Surveillance Program reports. A detailed description of these data is included in the DQO Summary Report (WCH-265). For the Upriver, 100 Area, 300 Area, and Lake Wallula Sub-Areas, detected analytes in

surface water and sediment are summarized, including exceedances of applicable ecological and human health benchmarks. (Note: The radionuclide results were not corrected for decay.)

Additional Data Needs. Based on the results of the DQO process and a review of the operational history (Section 2.2.2), existing data set, and a detailed understanding of migration pathways and exposure points, additional data needs for each sub-area were identified. The groundwater plume upwelling, sediment, surface water, fish, island soil, and sediment core data needs are summarized by sample type (e.g., shallow surface water, deep sediment) for each of the five sub-areas in Section 4.5. Table 4-13 provides a description of each sample type by medium. Additional information on the field sampling program is provided in Section 2.0 of the SAP (Appendix A).

Table 4-13. Summary of Sample Types. (2 Pages)

Medium	Sample Type	Description	Use of Data
Groundwater plume upwelling (pore-water, sediment/surface water)	Pore water	Pore-water samples will be collected in situ 0 - 0.3 m (0 - 12 in.) below mudline.	• Characterize nature and extent of groundwater upwelling locations
	Surface water/sediment	Deep surface water and deep sediment samples collected in areas directly adjacent to known or suspected groundwater plume upwellings based on pore-water sampling results.	• Site characterization • Support ecological and human risk assessments
Sediment	Shallow sediment samples (i.e., submerged)	Sediments collected from the upper 10 cm (4 in.) of the sediment (e.g., generally submerged).	• Site characterization • Support human health risk assessment • Support ecological risk assessment
	Shoreline sediment samples	Sediment samples collected from the upper 10 cm (4 in.) of the lower riparian zone, typically the area devoid of terrestrial vegetation.	• Site characterization • Support human health risk assessment • Support ecological risk assessment
	Deep sediment samples	Sediment samples collected from the upper 10 cm (4 in.) of the sediment, in greater than 1.8 m (6 ft) of water.	• Site characterization • Support ecological risk assessment
Surface water	Surface water samples	Surface water samples collected at two-thirds the depth of the water column.	• Site characterization • Support human health risk assessment • Support ecological risk assessment
	Deep surface water samples	Surface water samples collected from directly above the	• Site characterization • Support ecological risk

Table 4-13. Summary of Sample Types. (2 Pages)

Medium	Sample Type	Description	Use of Data
		riverbed.	assessment
Fish	Fish tissue	• Fillets (muscle and skin) • Liver and kidney combined • Carcass (e.g., bones and head)	• Support human health risk assessment and limited ecological assessment (see Sections 4.5 and 4.6).
Island soils	Island soils (e.g., generally above the high water line)	Island soils will be collected from the upper 15 cm (6 in.) of the riparian and upland zones of the islands. These samples are reworked sediments that are currently the result of subaerial deposition.	• Site characterization • Support human health risk assessment • Support ecological risk assessment
Sediment cores	Shallow sediment cores	Cores completed using a vibracore drilling tool in sediment sequences that are generally thinner than 3 m (10 ft) thick.	• Site characterization • Support human health risk assessment • Support ecological risk assessment
	Deep sediment cores	Cores completed at water depths of up to 27 m (90 ft) with anticipated thick sediments sequences (greater than 3 m [10 ft] thick).	• Site characterization • Support ecological and human health risk assessment (upper 10 cm [4 in.] only)[a]

[a] Bonneville data to be used for characterization only (e.g., not for ecological or human health risk).

4.2.1 Upriver Sub-Area

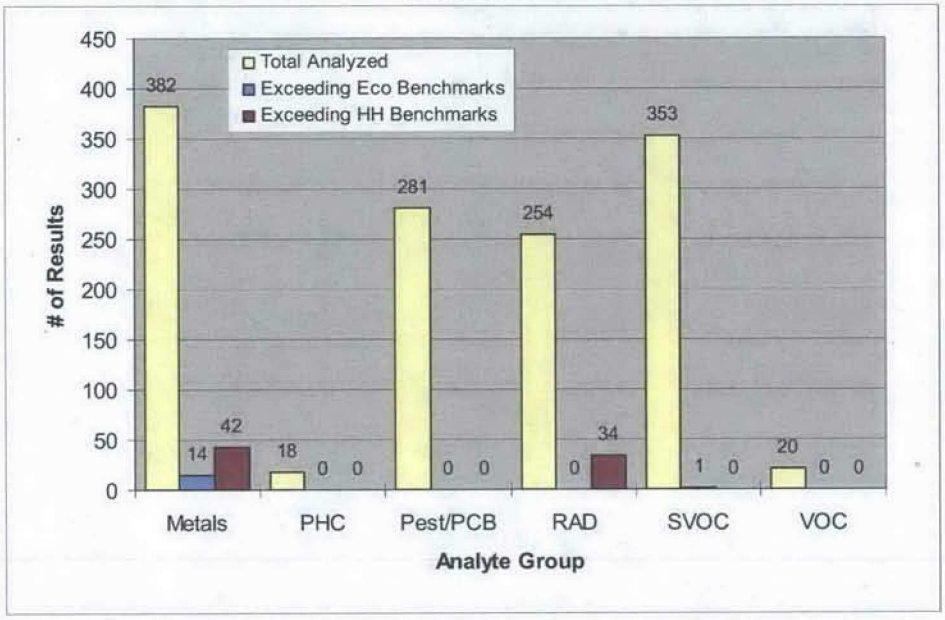
The Upriver Sub-Area includes the stretch of river between Vernita Bridge (RM 388) and above Priest Rapids Dam (RM 401). This section is situated approximately 6 to 27 km (4 to 17 mi) upstream of the most upriver reactor area (100-B/C) at the Hanford Site. Priest Rapids Dam is located 4.8 km (3 mi) upstream of the Hanford Site boundary. This upriver section is being evaluated to characterize other contributing influences (i.e., non-Hanford) to the Study Area.

The northern Hanford Site boundary is concurrent with the Vernita Bridge. Based on operational history, there is no information to suggest that Hanford Site hazardous substance releases occurred upriver of the bridge. Therefore, samples collected within the Priest Rapids Dam pool and directly below the dam (within two miles) are believed to be indicative of upriver (or background) conditions.

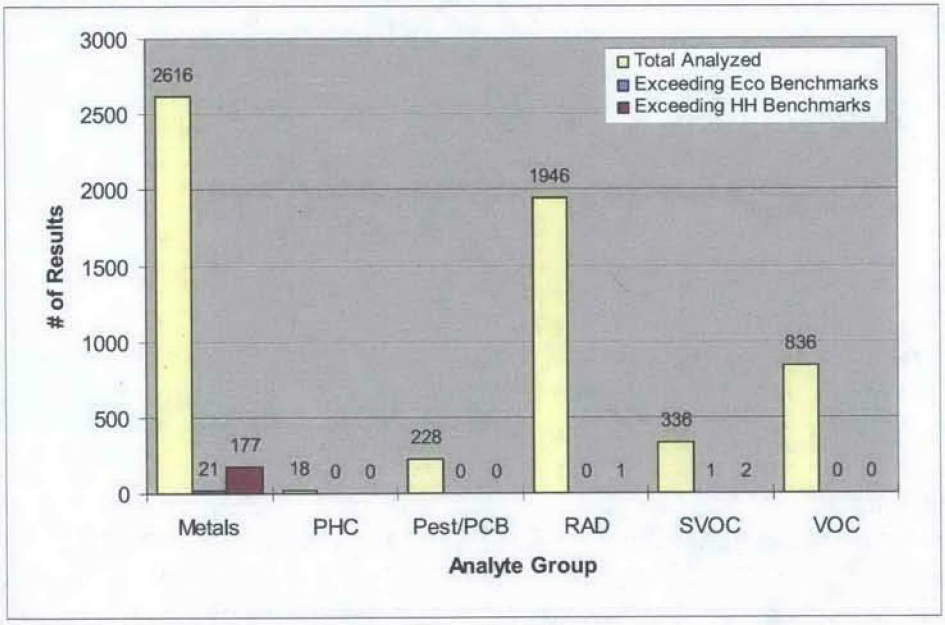
4.2.1.1 Review of Existing Data (Upriver Sub-Area). Figure 4-2 presents a graphical representation of existing analytical results compared to applicable benchmarks within this sub-area. For a more detailed discussion of existing data, refer to the Data Gap Analysis (WCH-201).

Figure 4-2. Summary of Analytical Results Compared to Benchmarks – Upriver Sub-Area.

Sediment



Surface Water



Notes:
Radionuclide results not corrected for decay
Eco = ecological
HH = human health
Pest/PCB = pesticides/polychlorinated biphenyls
PHC = petroleum hydrocarbons
RAD = radionuclides
SVOC = semivolatile organic compounds
VOC = volatile organic compounds

4.2.1.2 Additional Data Needs (Upriver Sub-Area). Based on the results of the DQO process, the following additional data needs were identified for the Upriver Sub-Area to provide additional information on conditions upriver of the Hanford Site.

- **Shallow Sediments** – Shallow sediment samples are needed to evaluate the sediment conditions upriver of the Hanford Site.
- **Shoreline Sediments** – Shoreline sediment samples are needed to evaluate conditions upriver of the Hanford Site and to provide background data for the impacts to ecological and human receptors.
- **Surface Water** – Surface water samples are needed to characterize upriver surface water conditions behind and below Priest Rapids Dam.
- **Fish** – Fish samples are needed to evaluate conditions upriver of the Hanford Site. Samples will be collected from Priest Rapids and Wanapum Dam pools.
- **Island Soils** – Soil samples are needed to characterize upriver island soils and to provide additional background data for the ecological and human health risk assessments.
- **Deep Sediment Core** – A sediment profile is needed to characterize deep sediments upriver of the Hanford Site.

4.2.2 100 Area Sub-Area

The 100 Area Sub-Area includes the reach between Vernita Bridge (RM 388) downstream to upriver of the Hanford townsite (RM 365), including the reactor areas (each of the reactor areas within the 100 Area of the Hanford Site: 100-B/C, 100-K, 100-N, 100-D, 100-H, and 100-F). Samples collected within this sub-area are intended to characterize sediments at the intake structures, outfall structures (e.g., spillways and pipelines), the left shore of the river, depositional areas near the islands, the reactor areas, and other contributing influences (e.g., wasteways/irrigation returns) that are not attributable to Hanford Site hazardous substance releases, but are geographically located within this stretch of river.

4.2.2.1 Current Groundwater Plume Upwelling (100 Area Sub-Area). Contaminated groundwater plumes are emanating from the reactor areas within the 100 Area Sub-Area and are discharging to the Columbia River via shoreline and potentially offshore seeps and springs. Localized groundwater contamination within this sub-area has resulted from historic operations conducted at each of the reactor areas (see Section 3.1.2.2). The maximum concentrations detected in aquifer tubes in this sub-area are summarized in SGW-35028.

The following constituents were among those detected in the aquifer tube samples during FY 2007 (Note: not all reactor areas were sampled for all constituents):

- Hexavalent chromium (all reactor areas)
- Nitrate (100-B/C, 100-K, 100-D, 100-H, 100-F, and 100-N reactor areas)
- Strontium-90 (100-B/C, 100-K, 100-N, 100-D, 100-H, and 100-F reactor areas)
- Tritium (100-B/C, 100-K, 100-N, 100-D, and 100-H reactor areas)
- Technetium-99 (100-K and 100-H reactor areas)
- Carbon-14 (100-K reactor area)
- Tetrachloroethylene (PHC) (100-N reactor area)
- TCE (100-F reactor area)
- Sulfate (100-N reactor area).

4.2.2.2 Site-Specific Conceptual Site Model (100 Area Sub-Area). The following is a summary of the CSM, including contaminants, migration pathways, exposure routes, and receptors, for the 100 Area Sub-Area.

- **Contaminant Sources** – Contaminant sources include the cooling water and emergency discharges from the reactor effluent systems (100-B/C, 100-K, 100-N, 100-D, 100-H, and 100-F Reactors) and the associated reactor operations.

- **Source-Specific Analytes** – Contaminants associated with the 100 Area Sub-Area sources are as follows:

  - Reactor cooling water effluent: Metals, radionuclides, hexavalent chromium

  - Reactor operations: Arsenic, carbon-14, chromium, nitrate, strontium-90, technetium-99, tritium

  - Other waste disposal activities (e.g., 183-H): uranium, fluoride.

- **Migration Pathways** – The primary migration pathways for contaminants include direct discharge from the river effluent pipelines and outfall structures to the Columbia River, sediment transport from near-shore areas to downstream areas, surface runoff following contact with surface soil or the reactor sites, continued contaminated groundwater plume upwelling as seeps and springs discharging into the river, and dust from wind-blown soil.

- **Exposure Routes** – Exposure routes include incidental ingestion and dermal contact with surface water, sediment and island soil, dust inhalation, ingestion of fish, and external radiation from contaminated sediment.

- **Receptors** – Potential receptors include humans, fish, benthic organisms, and terrestrial birds and mammals.

4.2.2.3 Review of Existing Data (100 Area Sub-Area). Figure 4-3 presents a graphical representation of existing analytical results compared to applicable benchmarks within this sub-area. For a more detailed discussion of existing data, refer to the Data Gap Analysis (WCH-201).

4.2.2.3.1 Additional Data Needs (100 Area Sub-Area). Based on the outcome of the DQO process, the following additional data needs were identified for this sub-area.

- **Groundwater Plume Upwelling** – Surface water, pore water, and sediment samples are needed to further characterize the impacts of the 100 Area groundwater plumes discharging to the river. Pore-water samples will first be collected to characterize these upwellings. The data are also needed to support human health and ecological risk assessments.

- **Shallow Sediments** – Shallow sediment samples are needed to characterize the left and/or right shore(s) of the river directly downriver of the reactor areas. In addition, samples are needed from the depositional areas of Coyote Island and associated bar; D Island; Islands 2, 3, 8, 9, and 10; and in the vicinity of Locke Island. These data are needed to support both human health and ecological risk assessments. Shallow sediment samples are also needed to characterize sediments for human health exposure at a site on the left side of the river, across from the White Bluffs townsite.

- **Shoreline Sediments** – Sediment samples are needed to further characterize the left shoreline downriver of the reactor areas and to support both human health and ecological risk assessments. In addition, samples from the shoreline areas of D Island; Locke Island; and Islands 2, 3, 5, 8, 9, and 10 are needed particularly to evaluate ecological risk.

- **Deep Sediments** – Deep sediment samples are needed to characterize the 100BC Hole upriver from the 100-B/C reactor area.

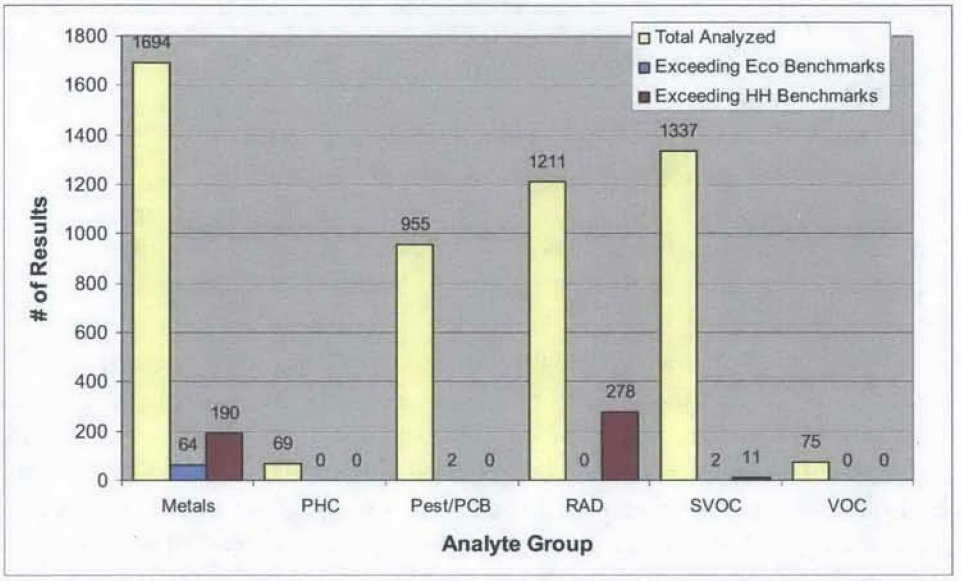
- **Surface Water** – Surface water samples are needed downriver of the reactor areas, on the left and/or right shore(s). In addition, samples are needed from the slough near Island 3, across the river from the White Bluffs townsite, and in the vicinity of Locke Island and Islands 8 and 9. The data are also needed to support human health and ecological risk assessments.

- **Fish** – Fish samples are needed within this sub-area to support the human health risk assessment. Specifically, samples will be targeted from the 100BC Hole, 100K Hole, 100N Hole, 100D Hole, WB Hole 1, and WB Hole 2.

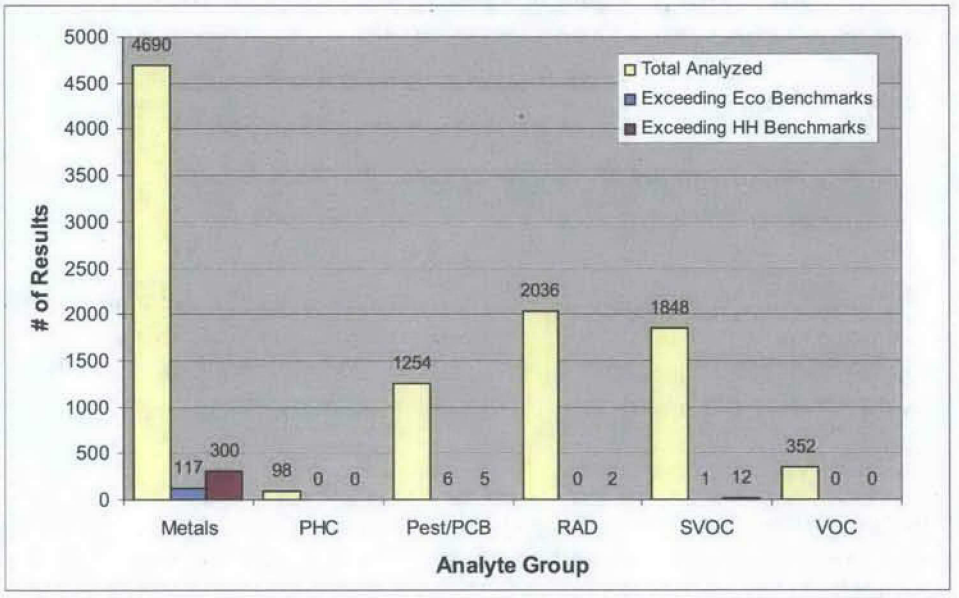
- **Island Soil** – Surface soil samples from Island 3 and Locke Island are needed to support human health and ecological risk assessments.

Figure 4-3. Summary of Analytical Results Compared to Benchmarks – 100 Area Sub-Area.

Sediment



Surface Water



Notes:
Radionuclide results not corrected for decay
Eco = ecological
HH = human health
Pest/PCB = pesticides/polychlorinated biphenyls
PHC = petroleum hydrocarbons
RAD = radionuclides
SVOC = semivolatile organic compounds
VOC = volatile organic compounds

- **Shallow Sediment Cores** – Sediment profile samples are needed to characterize the sediment in the inlet structures associated with the reactors where sediments have accumulated. Only the top 10 cm (4 in.) of the sediment core is needed for human health and ecological risk assessments. The entire core is needed for site characterization.

- **Other Contributing Influences** – In order to assess impacts to the river from sources other than the Hanford Site, shallow sediment and surface water samples are needed from the Saddle Mountain Wasteway.

4.2.3 300 Area Sub-Area

For purposes of this RI work plan, the focus of this discussion is the presence of groundwater plumes originating from the 200 and 300 Areas that are migrating to the Columbia River.

The 200 Areas (200 East and 200 West Areas) are located in the center of the Hanford Site and are located approximately 8 to 9 km (5 to 6 mi) west of the Columbia River, respectively. The 200 Area was used mainly for chemical separation of special nuclear materials from spent nuclear fuel and contained all the facilities used to separate, isolate, store, and ship the plutonium. The plants produced large quantities of high-level radioactive waste that were stored first in single-shell underground tanks and later in double-shell underground tanks.

The 300 Area Sub-Area, located between RM 365 and RM 339, includes the Hanford townsite area and the 300 Area. In addition, this sub-area includes sampling areas intended to characterize other contributing influences (e.g., wasteways/irrigation returns) that are not attributable to Hanford Site hazardous substance releases, but are geographically located within this stretch of river.

Construction of a fuel fabrication complex began at the Hanford Site in the 300 Area in March 1943. As a manufacturer of uranium fuel, the 300 Area housed the first essential step in the plutonium production process. Nuclear fuel was fabricated from uranium shipped in from off-site support facilities. Metallic uranium was extruded into the proper shape and encapsulated in aluminum alloy cladding (during early years) or zirconium alloy cladding (during later years). The 300 Area was also the center of many of the site research and development projects and included research laboratories, chemical process laboratories, test reactors, and numerous ancillary support structures.

4.2.3.1 Current Groundwater Plume Upwelling (300 Area Sub-Area). Contaminated groundwater plumes are emanating from the 200 and 300 Areas and are discharging to the Columbia River via shoreline seeps and springs near the Hanford townsite and within the 300 Area. Although the sources are not well differentiated (e.g., technetium-99), localized groundwater contamination within this sub-area has resulted from historic operations conducted within the 200 and 300 Areas (see Sections 3.1.2.2 and 4.2.3). The maximum concentrations detected in this sub-area are summarized in SGW-35028.

The following constituents were among those detected in the aquifer tube samples during FY 2007 (Note: not all aquifer tubes were sampled for all constituents):

- Nitrate (Hanford townsite and 300 Area)
- Tritium (Hanford townsite and 300 Area)
- Technetium-99 (Hanford townsite)
- Hexavalent chromium (300 Area)
- Uranium (300 Area)
- VOCs including TCE, PCE, and cis-1,2-DCE (300 Area).

4.2.3.2 Site-Specific Conceptual Site Model (300 Area Sub-Area). The following is a summary of the CSM, including contaminants, migration pathways, exposure routes, and receptors.

- **Contaminant Sources** – Contaminants associated with this sub-area are from 200 and 300 Area operations.

- **Source-Specific Analytes** – Contaminants associated with operations within the 200 and 300 Areas are hexavalent chromium, nitrate, tritium, uranium, and TCE.

- **Migration Pathways** – The primary migration pathways for contaminants from the 300 Area Sub-Area include sediment transport from near-shore areas to downstream areas, surface runoff following contact with surface soil in the 300 Area, continued contaminated groundwater plume upwelling as seeps and springs discharge into the river within the 300 Area and Hanford townsite, and dust from wind-blown soil.

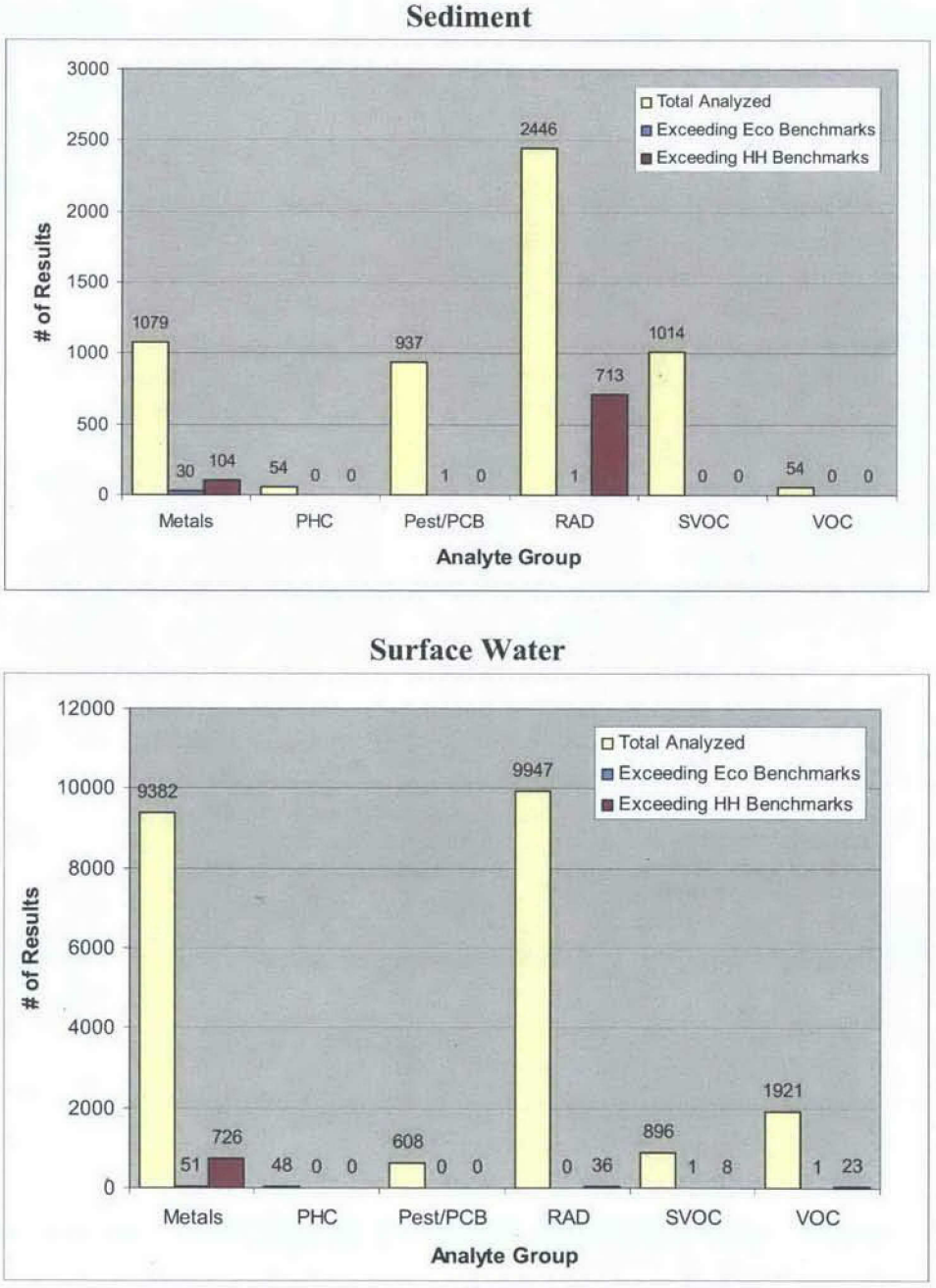
- **Exposure Routes** – Exposure routes include incidental ingestion and dermal contact, dust inhalation, food chain exposures (i.e., fish), and external radiation from contaminated surface water and sediment/island soil.

- **Receptors** – Potential receptors include humans, fish, benthic organisms, and terrestrial birds and mammals.

4.2.3.3 Review of Existing Data (300 Area Sub-Area). Figure 4-4 presents a graphical representation of existing analytical results compared to applicable benchmarks within the sub-area. For a more detailed discussion of existing data, refer to the Data Gap Analysis (WCH-201).

4.2.3.4 Additional Data Needs (300 Area Sub-Area). Based on the outcome of the DQO process, the following additional data needs were identified for the 300 Area Sub-Area.

Figure 4-4. Summary of Analytical Results Compared to Benchmarks – 300 Area Sub-Area.



Notes:
Radionuclide results not corrected for decay
Eco = ecological
HH = human health
Pest/PCB = pesticides/polychlorinated biphenyls
PHC = petroleum hydrocarbons
RAD = radionuclides
SVOC = semivolatile organic compounds
VOC = volatile organic compounds

- **Groundwater Plume Upwelling** – Surface water and sediment samples are needed to further characterize the impacts of the 200 Area groundwater plume and to differentiate contaminant sources discharging to the river downriver of the Hanford townsite and groundwater plume discharge to the river in the 300 Area. Pore-water samples will first be collected to characterize these upwellings. These data are also needed to support human health and ecological risk assessments.

- **Shallow Sediments** – Shallow sediment samples are needed from the depositional areas upriver, adjacent to, and downriver of the Hanford townsite, along both the left and right shores of the townsite including the sediments of Islands 11, 13, 14, and 15; Savage Island; Homestead Island; and Wooded Island. In addition, shallow sediment samples are needed from the depositional areas along the left shore across the river from and downriver of the 300 Area. These samples are needed for site characterization and human health and ecological risk characterization.

- **Shoreline Sediments**– Shoreline sediment samples are needed to further characterize the sediments and evaluate human health and ecological risk of the islands near the 300 Area, along the shoreline upriver, adjacent to, and downriver of the Hanford townsite, particularly along the shorelines of Leslie Grove City Park; Islands 11, 12, 14, and 15; Homestead Island; Wooded Island; the island adjacent to the 300 Area; the island across from the Richland Pump House; and Nelson Island.

- **Surface Water** – Surface water samples are needed to characterize surface water along the left side of the river near Savage Island and in the sloughs near Island 11 and Wooded Island, downriver of the Hanford townsite. In addition, surface water samples are needed offshore from Leslie Grove City Park/Boat Launch. The data are also needed to support human health and ecological risk assessments.

- **Fish** – Fish samples are needed within this sub-area to support the human health risk assessment. Specifically, samples will be targeted from HTS Hole 1, HTS Hole 2, Ringold, Taylor Flats, 300A Hole 1, and 300A Hole 2.

- **Island Soil** – Surface soil samples from Johnson Island, Homestead Island, and Wooded Island are needed to evaluate potential human health and ecological risks. In addition, soil samples are needed from the Ringold Recreational Area to supplement previous sampling events and support the human health risk assessment.

- **Shallow Sediment Cores** – Sediment profile samples are needed to characterize sediment from both sides of the river below the 300 Area: above Johnson Island, adjacent (right side) to Johnson Island, downriver of Johnson Island (left side), downriver of the Potholes Canal/Pasco Wasteway, and halfway between the Port of Benton and Richland Pump House. Only the top 10 cm (4 in.) of the sediment core is needed for ecological assessments. The entire core is needed for site characterization.

- **Other Contributing Influences** – In order to assess impacts to the river from sources other than the Hanford Site, shallow and shoreline sediment and surface water samples are needed within this sub-area to evaluate inputs from the WB-5 Wasteway, the Ringold Irrigation Return, the PE 16.4 Wasteway, the Potholes Canal Wasteway, and the Esquatzel Coulee Wasteway.

4.2.4 Lake Wallula Sub-Area

The Lake Wallula Sub-Area includes recreational areas and wildlife management areas downstream of the Hanford Site. This river section also includes the major river confluences (e.g., Yakima, Snake, and Walla Walla). Samples from these areas will be used to characterize other contributing influences. The Lake Wallula Sub-Area stretches between RM 339 and RM 292.

Construction of McNary Dam started in 1947 and was completed in 1954. The eight single-pass cooling water reactors were in operation from 1944 to 1972. During this time Hanford Site contamination was released to the river primarily through the cooling water discharge systems. Based on production records, the majority of these releases occurred from the mid-1950s to the late 1960s (DOE/RL-97-1047). Consistent with the findings of previous investigators (BNWL-2305) the maximum concentrations of radionuclides were identified in the deep sediments of the McNary pool.

4.2.4.1 Site-Specific Conceptual Site Model (Lake Wallula Sub-Area). The following is a summary of the CSM, including contaminants, migration pathways, exposure routes, and receptors, for the Lake Wallula sub-area.

- **Contaminant Sources** – Contaminants associated with this area are from the upriver Hanford Site and non-Hanford Site sources.

- **Source-Specific Analytes** – Contaminants associated with Lake Wallula are based on the historical results as presented in Section 4.2.4.2.

- **Migration Pathways** – The primary migration pathway for contaminants in Lake Wallula includes sediment transport and redeposition from upriver areas to downstream areas within Lake Wallula.

- **Exposure Routes** – Exposure routes include ingestion and dermal contact, dust inhalation, food chain exposures (i.e., fish), and external radiation from contaminated surface water and sediment.

- **Receptors** – Potential receptors include humans, fish, benthic organisms, and terrestrial birds and mammals.

4.2.4.2 Review of Existing Data (Lake Wallula Sub-Area). Figure 4-5 presents a graphical representation of existing analytical results compared to applicable benchmarks within this sub-area. For a more detailed discussion of existing data, refer to the Data Gap Analysis (WCH-201).

4.2.4.3 Additional Data Needs (Lake Wallula Sub-Area). Based on the outcome of the DQO process, the following additional data needs were identified for the Lake Wallula area and the recreational areas within Lake Wallula.

- **Shallow Sediments** – Shallow sediment samples are needed to characterize sediments above the confluence of the Yakima River, within the Wallula paper mill channel, along the right shore near the Toothaker Wildlife Management Unit and Columbia Park, and within Wallula Bay. These data are also needed to support both human health and ecological risk assessments.

- **Shoreline Sediments** – Shoreline sediment samples are needed to further characterize the shoreline sediments near the Peninsula Wildlife and Toothaker Wildlife Management Units, the shoreline of Badger Island, and the Lake Wallula shoreline below the confluence of the Walla Walla River to McNary Dam. These data are also needed to support both human health and ecological risk assessments.

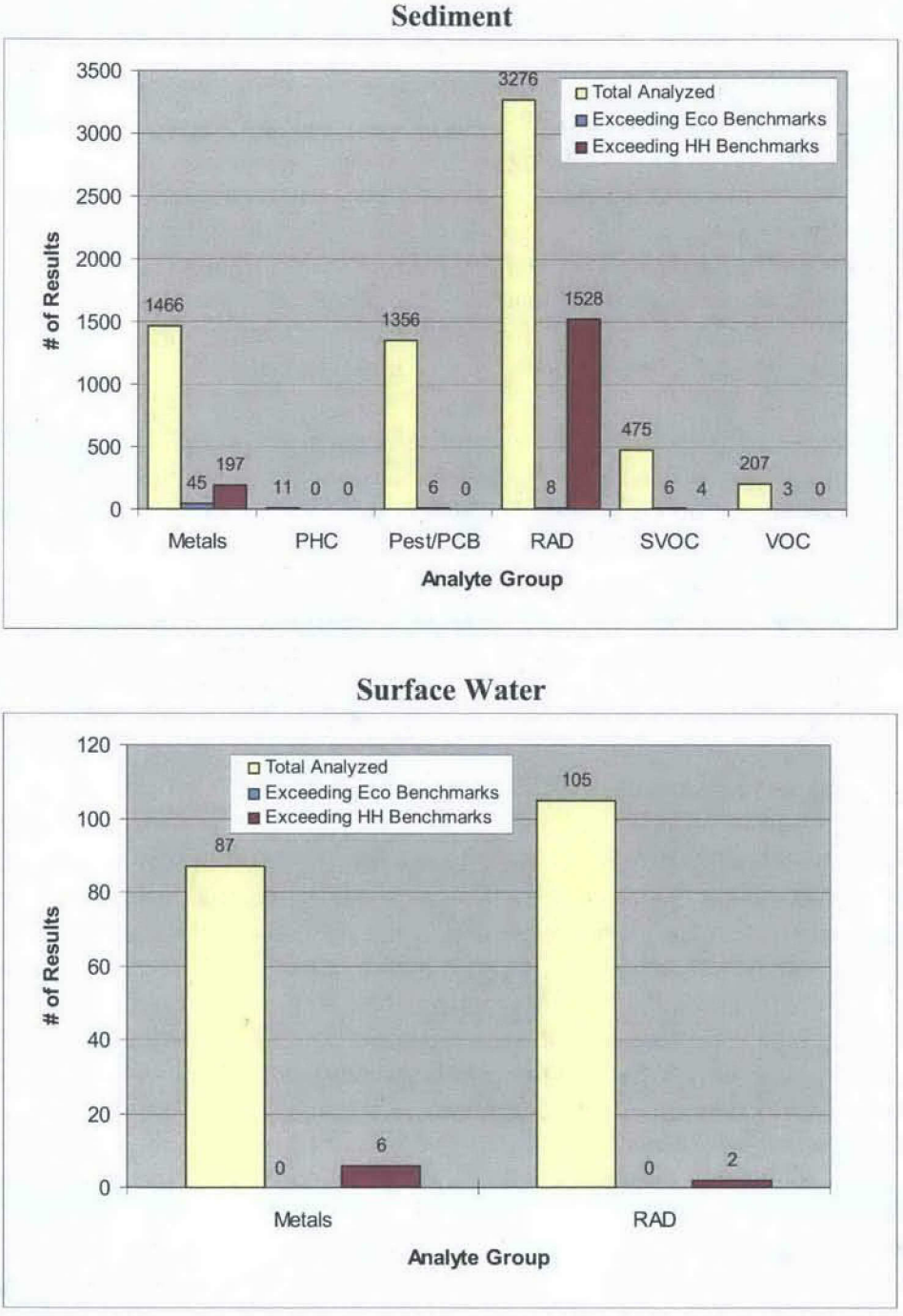
  In addition, shoreline sediment samples are needed to characterize the following recreational areas for human health and ecological exposures:

  - Howard Amon Park
  - Columbia Point Marina/Park
  - Bateman Island boat launch
  - Clover Island
  - Two Rivers Park
  - Cascade Marina
  - Sacajawea State Park
  - Port Kelley Boat Ramp
  - Hat Rock State Park
  - McNary Dam boat ramps.

- **Deep Sediments** – Deep sediment samples are needed to characterize sediments throughout the deep water areas above and below the confluence of the Yakima and Columbia Rivers and within Lake Wallula to support the ecological risk assessment.

- **Surface Water** – Surface water samples are needed to characterize the surface water near the recreational areas for human health and ecological exposure. Samples are needed near the recreational areas listed under "Shoreline Sediments" above.

Figure 4-5. Summary of Analytical Results Compared to Benchmarks – Lake Wallula Sub-Area.



Notes:
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Eco = ecological
HH = human health
Pest/PCB = pesticides/polychlorinated biphenyls
PHC = petroleum hydrocarbons
RAD = radionuclides
SVOC = semivolatile organic compounds
VOC = volatile organic compounds

- **Deep Surface Water** – Deep surface water samples are also needed to characterize the surface water of Lake Wallula, downriver of the Walla Walla River confluence, and behind McNary Dam to support the ecological risk assessment.

- **Fish** – Fish samples are needed within this sub-area to support the human health risk assessment. Specifically, samples will be targeted from the Yakima River Delta, Burbank Slough, Finley Slough, and Wallula Gap.

- **Shallow Sediment Cores** – Shallow sediment profile samples are needed to characterize sediments within the Yakima River Delta and along the right shore near Foundation Island, downriver of the Snake River confluence. These samples are also needed to support the ecological risk assessment. Only the top 10 cm (4 in.) of the sediment core is needed for ecological assessments. The entire core is needed for site characterization.

- **Deep Sediment Cores** – Deep sediment profile samples are needed to characterize the following areas within the Lake Wallula area and to support the ecological risk assessment: (1) deep sediments within Lake Wallula, downriver of the Walla Walla River confluence, and (2) deep sediments behind McNary Dam.

- **Other Contributing Influences** – In order to assess impacts to the river from sources other than the Hanford Site, shallow sediment and surface water samples are needed within this area to evaluate inputs to the river from the Yakima River, the Snake River, and the Walla Walla River.

4.2.5 Bonneville Dam Pool Sub-Area

The Bonneville Dam Pool Sub-Area is situated between RM 150 and RM 144. Construction of the Bonneville Dam started in 1935 and was completed in 1937, several years before Hanford Site operations started. McNary Dam construction started 3 years after start of operation at the Hanford Site and finished 11 years after the start of operations.

There are existing data from core sediments in the pool behind Bonneville Dam (BNWL-2305), and the Tri-Parties determined that additional data are needed to define the nature and extent of contamination. Two deep sediment cores are needed within Bonneville Dam pool to characterize the sediments within the pool and to complement the existing core sample on the right side of the river. These two core locations are situated near the center and on the left side of the river. The purpose of the additional cores is to provide additional information regarding potential historic radionuclide releases to the river. The last single-pass reactor was closed 40 years ago. It is anticipated that later sediment deposition covered residual Hanford-related contaminants (see BNWL-2305). Therefore, a quantitative risk evaluation of this sub-area will not be included in either the BERA or BHHRA. See Section 4.3.6.2 for more detailed information about the deep sediment core sampling program.

4.3 SITE CHARACTERIZATION SUMMARY BY MEDIUM

This section summarizes the RI work plan approach by sample medium including groundwater plume upwelling, sediment, surface water, fish, island soils, and sediment cores.

4.3.1 Groundwater Plume Upwelling

Pore-water, sediment, and surface water samples are proposed along the river at locations where contaminated groundwater plumes are discharging to the river. Samples will be collected from each of the reactor sites (100-B/C, 100-K, 100-N, 100-D, 100-H, and 100-F), the Hanford townsite, and the 300 Area to characterize the plume discharges.

Prior to collecting groundwater plume upwelling samples in these areas, a groundwater plume upwelling survey will be conducted. The purpose of the groundwater plume upwelling survey is to delineate areas of contaminated groundwater plume upwelling into the Columbia River for subsequent sampling. Once areas of groundwater plume upwelling have been identified, focused pore-water, sediment, and surface water sampling locations will be identified and provided to the Tri-Parties for review and approval at the unit managers meetings. Upon receiving approval, samples will be collected for laboratory analysis and the results will be used to characterize the nature and extent of Hanford Site releases to the river and to evaluate potential risk to humans and river biota. This survey will be completed in three phases:

- Phase I (Technology Demonstration) is a test of the applicability of the proposed Trident probe technology to Hanford Reach conditions.

- Phase II (Groundwater Plume Upwelling Delineation) will be divided into two sub-phases (a and b). Phase II(a) will focus on delineating eight areas of suspected groundwater plume upwelling. This activity will include in situ pore-water measurements of specific conductance and temperature. Phase II(b) will include a screening analysis of key Hanford Site indicator contaminants (e.g., Cr+6, strontium-90, uranium, and tritium).

- Phase III (Groundwater Plume Upwelling Characterization) will be characterization of upwelling conditions through pore-water, sediment, and surface water sampling at locations selected from review of the Phase II results.

The following provides a detailed discussion of these phases.

Phase I: Technology Demonstration – The first phase of this investigation was conducted in September 2008 to test the Trident probe technology within the Hanford Reach river environment. Locations at 100-B/C, 100-N, 100-D, and the 300 Area were investigated during the test. The Trident probe is a flexible, multi-sensor, water-sampling probe for screening and mapping groundwater plumes at the surface water interface. Its capabilities include the following:

- In situ conductivity: Contrast between groundwater and surface water

- In situ temperature: Detects groundwater by thermal contrast with surface water

- Trident probe pore-water and surface water sampler: Allows for simultaneous collection and monitoring of pore-water and surface water samples for contaminant screening and characterization.

During this technology demonstration, the probe was successfully deployed within a range of river conditions and bottom formations including; fine-grained sediments (e.g., silt), course-grained sediments (e.g., gravel and cobbles), and at a variety of water depths and velocities. Pore water was drawn along with in situ temperature and conductivity measurements of both surface water and groundwater. It was determined that differences in temperature and conductivity were good indicators of upwelling groundwater. The Trident probe was successful in identifying groundwater upwelling in a variety of substrate types, river velocities, and river depths. Additional tools that increased efficiencies of groundwater delineations included sonar and underwater video camera surveys. During this demonstration, a number of surface water measurements obtained one foot above the groundwater upwellings indicated little to no influence of groundwater in the surface water.

Phase II: Groundwater Plume Upwelling Delineation – As discussed in Section 2.3.1, river stage may be a key factor to determine nature and extent of groundwater discharges to the river. In general, favorable conditions will be present at sustained flows of 80 to 120 kcfs at Priest Rapids Dam. However, repeated field measurements of in situ conductance may be used to verify the range of suitable river stages for Phase II and Phase III activities. Once these favorable flow conditions (i.e., consistent groundwater discharges to the river) are met, pore-water screening activities for indicator contaminants will be completed at each of eight upwelling study areas (100-B/C Area, 100-K Area, 100-N Area, 100-D Area, 100-H Area, 100-F Area, Hanford townsite, and 300 Area).

- **Phase II(a) Conductivity Mapping** – Mapping of five transects is planned for each of the eight upwelling study areas (Figures 2-4 through 2-11 and Figure 2-14 of the SAP [Appendix A]). Transects were selected based on the 2007 aquifer tube sampling results provided in SGW-35028. These selections were reviewed and modified based on comments and suggestions from the Fluor Hanford Groundwater Project technical teams. Five additional transects have been located between reactor areas and south of the 300 Area to provide information outside of known plume areas (Figures 2-4 through 2-11 and Figure 2-14 of the SAP).

  Transects will start at the near shore (e.g., reactors areas) and continue across the entire river channel to the far shore. Depending on subsurface conditions and plume upwelling conditions encountered, it is anticipated that probe measurements will be taken at five locations per transect. Phase I findings have suggested that transects alone may not adequately characterize groundwater upwelling patterns influenced by preferential flow paths (e.g., river channeling, dredging). Consequently, 5 to 10 additional probe measurements will

be taken in the vicinity of each transect to enhance delineation of groundwater upwellings. Locations of interest that have been initially identified include the following:

- 100-N Area south of the apatite barrier but within the Sr-90 plume (Figure 2-6)
- 100-D Area adjacent to the effluent pipelines between the shore and D Island (Figure 2-7)
- 100-H Area between the shore and Island #4 (Figure 2-8)
- South of the 300 Area between transects T-300-1 and T-300-2 (Figure 2-14).

Selection of additional measurement points will consider factors such as elevated readings from other adjacent areas, bathymetry, presence of sediment accumulation areas, indications from sonar or underwater camera observations, observed changes in geologic formations, and the locations of structures (pipelines, outfalls, and intakes) that may present opportunities for preferential flow.

- **Indicator Contaminants Screening (Phase IIb)** – Approximately 20 to 30 samples of pore water will be collected at each of the eight upwelling study areas. Criteria to be used for selection of sampling locations include areas of high conductivity (>160 µS/cm), spatial distribution of data, and consideration of factors such as known or suspected areas of contamination (e.g., close to aquifer tube locations) and anticipated pore-water extraction rates. Final indicator contaminant screening locations and quantities are subject to approval by the Tri-Parties.

  The Trident probe will be deployed approximately 15 to 30 cm (6 to 12 in.) below the riverbed. Exceptions may occur in areas where hard-pan (e.g., Ringold Formation) is encountered. Pore water will be extracted using a peristaltic pump. The pump rate will depend on aquifer recharge conditions determined by continuous in situ monitoring of selected field parameters to assure minimal short-circuiting with surface water. Field measurements consisting of temperature and conductivity will be collected to verify that surface water has not been drawn down into the sampling port by pumping conditions (i.e., short-circuit). Images taken with an underwater camera will be used to document conditions found at the time of sampling. At each sampling location pore water will be collected for the following indicator compounds:

  – 100-B/C, 100-K, 100-D, 100-H, 100-F: Cr+6
  – 100-N: Strontium-90
  – Hanford townsite: Tritium
  – 300 Area: VOC, uranium

Once pore-water results for indicator compounds, temperature, and conductivity are available, maps summarizing the results of the screening will be developed for each of the eight groundwater plume upwelling areas. These figures will also present the proposed locations for additional pore-water, sediment, and surface water sampling that are needed for plume characterization (Phase III below).

Phase III: Groundwater Plume Upwelling Characterization – Based on the results of the pore-water screening (Phase II[b]), pore-water sampling locations will be selected for groundwater plume upwelling characterization. One of the objectives of this phase is to select locations with the highest concentration of indicator contaminants. At a minimum, at least one location on each transect line in an area will be included. Images taken with an underwater camera will be used to document conditions found at the time of sampling. Pore-water, surface water, and sediment will be collected concurrently at each sample location to evaluate the potential impact upwelling groundwater plumes are having on these media. Sediment samples will be collected as described in Section 2.5 of the SAP (Appendix A). Pore-water, sediment, and surface water samples will be analyzed for the following analytical parameters:

- **Pore-Water Analyses** – As shown in Tables 2-2 through 2-6 of the SAP, all pore-water samples collected for groundwater plume upwelling characterization will be analyzed for metals (including uranium), Cr+6, and tritium. Pore-water samples collected in the 300 Area will also be analyzed for VOCs. Samples in the 100-B/C, 100-K, 100-N, 100-D, 100-H, and 100-F Areas will be analyzed for strontium-90. These results will be used to characterize groundwater plume upwellings into the river and to characterize potential biota exposure to bottom dwelling invertebrates.

- **Sediment and Surface Water Analyses** – Details regarding the sediment and surface water sampling and analysis are provided in Tables 2-2 through 2-6 of the SAP (Appendix A).

Final sample locations and quantities for plume upwelling characterization are subject to approval by the Tri-Parties.

4.3.2 Sediment Sampling

The sediment sampling program below summarizes the different types of sediment samples that will be collected, including shallow sediment, shoreline sediment, and deep sediment. These sample types are defined and described in Table 4-13.

Prior to sediment sampling, a fine-grained sediment survey will be conducted to better define areas of fine-grained material and subsequently finalize sampling locations. Studies have shown that fine-grained sediments (e.g., <2 mm) contain a higher proportion of contaminants than coarser grained material (HW-83614). However, the distribution or occurrence of these fine-grained materials within the river is not well documented. Based on the existing data set and local knowledge, suspected areas of fine-grained sediment deposition are shown in Figures 2-3 through 2-14 of the SAP (Appendix A). As shown in Figures 2-15 through 2-19 of the SAP, there is little to no detailed information about fine-grained sediment deposition below RM 339.

The cumulative results of prior investigations, past modeling efforts, and river knowledge will be used to identify areas of fine-grained sediment that will be targeted for sampling during the RI. A preliminary assessment of fine-grained sediment locations within the Hanford Reach and below Richland to McNary Dam was conducted in 2008. A proof-of-principle testing approach was conducted in late February and early March 2008 using a single beam sonar, with

confirmatory sediment sampling completed using a petite ponar sampling tool (Appendix B). As part of the RI, a sonar survey will be conducted at all proposed river bottom sediment sampling locations to aid in locating fine-grained sediments.

Once this fine-grained sediment reconnaissance survey is completed, the location and distribution of sediment sampling locations will be provided to the Tri-Parties for review and approval. A discussion of the proposed survey methods is provided in Section 2.0 of the SAP (Appendix A).

4.3.2.1 Shallow Sediment. Shallow river sediment samples (below normal low water; i.e., the lower boundary of the riparian zone estimated through modeling at 80 kcfs at Priest Rapids Dam) will be collected from the river channel and near-shore areas to characterize areas not previously investigated. Key shallow sediment sampling locations include the following:

- Other contributing influences – Wasteways/irrigation returns and other rivers including the Yakima, Snake, and Walla Walla Rivers
- Downriver islands – Locke Island; Coyote Island; D Island; Islands 2, 3, 8, 9, 10, 11, 13, 14, and 15; Homestead Island; Savage Island; and Wooded Island
- Other sediment depositional areas between the reactor areas and McNary Dam.

Results from these samples will be used for site characterization and to support the human health and ecological (aquatic) risk evaluation.

4.3.2.2 Shoreline Sediment and Island Soil. Shoreline sediment samples (inundated zone) will be collected from the downriver islands and non-Hanford Site (i.e., left) shoreline to characterize areas not previously investigated. These sediment samples will generally be collected in the lower riparian zone, which is routinely inundated by river water. Additionally, surficial soil samples will be collected from 17 islands within the river channel. Key shoreline and island sampling areas include the following:

- Other contributing influences – Wasteways/irrigation returns and other rivers including the Yakima, Snake, and Walla Walla Rivers
- Downriver islands – Islands 2, 3, 5, 8, 9, 10, 11, 12, 14, and 15; Homestead Island; Wooded Island; 300 Area Islands; Nelson Island; D Island; Locke Island; and Badger Island
- Recreational areas
- Shoreline areas – Opposite the reactor areas, the 300 Area, Hanford townsite, Leslie Grove City Park, habitat areas, and Lake Wallula.

Results from the shoreline sediment samples will be used for site characterization and to support the human health and ecological (terrestrial) risk evaluation.

4.3.2.3 Deep Sediment. Deep river sediment samples will be collected from the river channel to characterize areas not previously investigated and to support the ecological risk assessment. Samples will be collected in greater than 1.8 m (f ft) of water. Key deep sediment sampling areas include the following:

- 100BC Hole upriver from the 100-B/C Area
- Lake Wallula
- Above and below the confluence of the Yakima and Columbia Rivers.

4.3.3 Surface Water Sampling

Surface water samples will be collected from several areas within the Study Area for site characterization. Samples will be collected from the 100 Areas, the 300 Area, recreational locations, Lake Wallula, McNary Dam, and from upriver of the Hanford Site and other contributing influences (i.e., other rivers joining the Columbia River, irrigation returns/wasteways).

4.3.3.1 Deep Surface Water. Deep surface water samples will be collected directly above the riverbed within Lake Wallula, downriver of the Walla Walla River confluence, and behind McNary Dam to augment existing data and to support the ecological risk assessment.

4.3.4 Fish Sampling

DOE proposes to conduct fish sampling within the Hanford Reach of the Columbia River and downstream to McNary Dam, due to historical releases of contaminants from the Hanford Site into the river and data from previous investigations that indicate potentially high levels of contaminants in resident fish. The objective of the proposed fish sampling project is to obtain tissue samples for analysis of contaminants that have been identified as originating from the Hanford Site. The primary use of the fish sampling data is to determine the potential health risk to nearby residents who consume these fish as a part of their diet. However, fish tissue data will also be used to support the evaluation of fish in the ecological risk assessment.

In addition to the main objective of obtaining samples in support of conducting the human health risk assessment, the following goals have also been identified for the project:

- Characterize concentrations of analytes (see Table 2-9 of the SAP) in each target fish species
- Characterize the distribution of Hanford Site-related contaminants in different parts of fish
- Confirm detections of target analytes in fish samples collected and analyzed during previous investigations

- Establish background concentrations of contaminants in fish collected from areas of the river not impacted by activities associated with the Hanford Site
- Estimate which areas of the river contain fish with the highest concentrations of Hanford Site-related contaminants
- Evaluate and summarize the variability of concentrations of Hanford Site-related contaminants within each fish species and between different species
- Provide an update to the RCBRA human health risk assessment
- Provide data for current and future evaluations of ecological risk.

4.3.4.1 Target Fish Species. The Columbia River provides abundant opportunity for recreational fishing, and is an important fishery resource to local Native American tribes. Primary recreational species include salmon, bass, and sturgeon (PNNL 2002). Salmon comprise the majority of the fish eaten by Native American tribes, although other preferentially fished species include sturgeon, bass, smelt, lamprey, suckers, and whitefish (Ridolfi 2007, EPA 2002a, DOE/RL-96-16).

Although migratory fish species, such as salmon, comprise a substantial portion of the recreational and Native American fish harvest, the conclusions of several studies, including the *Columbia River Basin Fish Contaminant Survey 1996-1998* (EPA 2002a), indicate that resident species of fish have the highest levels of contaminants from the Hanford Site. For example, data from this study confirm that higher concentrations of organic chemicals have been detected in nonmigratory, resident fish such as sturgeon, suckers, walleye, and whitefish than in the migratory, transient fish such as salmon and steelhead. Salmon, which spend most of their lives in the ocean and therefore have little opportunity to be exposed to Hanford Site-related contaminants, will not be sampled as part of this program. Because of their longer residency time in the river, non-migratory fish have more opportunity for exposure and for accumulation of site-related contaminants. Therefore, based on this information, the fact that resident fish are available year-round for harvest, and since many of the resident species are also species routinely harvested and eaten, the fish sampling effort will focus on resident species (rather than migratory species) to develop both representative and conservative human health and ecological risk estimates.

Specimens of white sturgeon (*Acipenser transmonatnus*), common carp (*Cyprinus carpio*), mountain whitefish (*Prosopium williamsoni*), walleye (*Stizostedion vitreum),* smallmouth bass (*Micropterus dolomieui*), and either largescale sucker (*Catostomus macocheilus*) or bridgelip sucker (*Catostomus columbianus*)[4] will be selected for collection because these species are year-round resident fish with a high rate of harvest and consumption among the local population.

[4] Species collected will be dependent upon availability/ease of collection.

A summary of the proposed fish sampling program is presented in Table 4-14. The proposed sampling period is the late summer and early fall. During this period of the year angler harvest of the target species is highest, the lipid content in the fish tissue is at its greatest level (the majority of organic contaminants are stored in the lipids of the animal), and the water levels in the river are anticipated to be low to allow for easier boat handling and more effective gear deployment and retrieval. Only legal-sized fish of each species will be collected; efforts will be made to ensure that fish that comprise a sample are similar in size.

4.3.4.2 Sampling Locations. Fish sample collection is proposed from the sub-areas within the Hanford Reach portion of the Columbia River and upriver background areas as well as the area of the Lake Wallula pool. The four sub-areas from which these samples will be collected consist of the following:

- Upriver Sub-Area: Upriver of Priest Rapids Dam (all fish except sturgeon, which will be collected upriver of the Wanapum Dam)
- 100 Area Sub-Area: RM 388 downstream to RM 365
- 300 Area Sub-Area: RM 365 downstream to RM 339
- Lake Wallula Sub-Area: RM 339 downstream to McNary Dam at RM 292.

The Upriver Sub-Area was selected as an upstream reference area to establish background and baseline levels of contaminants listed in Table 2-9 of the SAP (Appendix A) from upriver sources that are not associated with the Hanford Site. The other sub-areas were selected based on an understanding of the distribution of concentrations of contaminants in surface water and sediments relative to the Hanford Site reactor areas.

The collection of specimens may take place at any location within each sub-area. To the extent possible, different samples will be collected from different parts of each sub-area. However, since the primary objective of the project is to obtain data to perform a human health risk assessment, sampling efforts will focus on popular recreational fishing spots that receive high use. These recreational fishing spots are harvest areas that will provide the most representative samples from which to calculate risk. These areas have been identified through discussions with local fishermen and are presented in Figures 2-2 through 2-20 of the SAP (Appendix A). Table 2-8 of the SAP provides a summary of these fishing areas. Attempts will be made to collect fish samples from different fishing areas.

Specific fishing areas were not identified for suckers. Collection efforts within each sub-area will focus on areas of the river with fast-moving water, which is a preferred habitat for these fish.

Table 4-14. Proposed Fish Sampling Program Summary. (2 Pages)

Target Fish Species	Study Sub-Areas	Preferred Habitat[a]	Proposed Sampling Period[b]	Sampling Design	Tissues for Separate Analyses	Analyses per Tissue Type
Sturgeon	Entire reach and Lake Wallula (four sub-areas)	Shallow inshore slough areas evening, mid-river channel day; spawn in high velocity, rocky areas	Summer	Five samples per sub-area; one fish per sample	• Fillets (muscle) with fatty tissue but without skin • Kidney and liver combined • Carcass • Eggs, if available • Sediment or mussels in stomach, if present in large quantities	• Radionuclides • Metals, including total mercury and speciated arsenic • PCB congeners • Pesticides • Percent lipids • Stomach contents, if present, analyzed for radionuclides only
Carp	Entire reach and Lake Wallula (four sub-areas)	Shallow, vegetated areas, sloughs; spawn in shallow turbid areas of the river	Fall	Five samples per sub-area; five fish per sample	• Fillets (muscle) with skin • Kidney and liver combined • Carcass	• Radionuclides • Metals, including total mercury and speciated arsenic • Percent lipids • PCB congeners • Pesticides
Suckers (Bridgelip or largescale, depending on availability)	Entire reach and Lake Wallula (four sub-areas)	Shoreline areas with aquatic vegetation; spawns in riffle areas over cobble	Fall	Five samples per sub-area; five fish per sample	• Fillets (muscle) with skin • Kidney and liver combined • Carcass	• Radionuclides • Metals, including total mercury and speciated arsenic • Percent lipids • PCB congeners • Pesticides

Table 4-14. Proposed Fish Sampling Program Summary. (2 Pages)

Target Fish Species	Study Sub-Areas	Preferred Habitat[a]	Proposed Sampling Period[b]	Sampling Design	Tissues for Separate Analyses	Analyses per Tissue Type
Walleye	Entire reach and Lake Wallula (four sub-areas)	Semi-turbid, low-velocity portions of the river	Fall	Five samples per sub-area; five fish per sample	• Fillets (muscle) with skin • Kidney and liver combined • Carcass	• Radionuclides • Metals, including total mercury and speciated arsenic • Percent lipids • PCB congeners • Pesticides
Whitefish	Entire reach and Lake Wallula (four sub-areas)	Low velocity areas of river - sand, gravel, or mud bottom	Fall	Five samples per sub-area; five fish per sample	• Fillets (muscle) with skin • Kidney and liver combined • Carcass	• Radionuclides • Metals, including total mercury and speciated arsenic • Percent lipids • PCB congeners • Pesticides
Smallmouth bass	Entire reach and Lake Wallula (four sub-areas)	Sloughs and backwaters, and low-velocity portions of river	Fall	Five samples per sub-area; five fish per sample	• Fillets (muscle) with skin • Kidney and liver combined • Carcass	• Radionuclides • Metals, including total mercury and speciated arsenic • percent lipids • PCB congeners • pesticides

[a] Source: *Columbia Basin Fish Contaminant Survey*, U.S. Environmental Protection Agency, Region 10, January 2002.

[b] Season open year round in study area with exception of the old Hanford townsite powerline towers to Vernita Bridge, which is only open from February 1 to October 22.

In the event that sample collection at the popular fishing spots is unsuccessful, sampling efforts will shift to other areas within the study area, with special attention given to preferred habitats for each species of fish. The preferred habitat for each of the target species is summarized in Table 4-14.

The latitude and longitude of each sample point will be saved using a global positioning system to accurately define the locations from which specimens were obtained.

4.3.4.3 Sample Number. Five fish samples of each species are proposed for collection from each specified sub-area. Each fish sample (except for sturgeon) will consist of a composite sample composed of at least five individual fish. Additional fish may be included in the composite if necessary to meet the required mass for chemical analysis. The number of fish to be collected is based on professional judgment, and considers both the end use of the data as well as the sensitivity of local fisheries. This number is also consistent with EPA fish sampling guidance (EPA 2000a) and the PNNL Surface Environmental Surveillance program, which typically collects five fish per area of interest (PNNL-15892, PNNL-16623).

Because of their large size and lower population numbers, sturgeon samples will not be composites; each sample will be collected entirely from a single fish.

4.3.4.4 Tissue Collection. The following fish tissues will be collected and analyzed separately on all fish samples:

- Fillets (muscle and skin)
- Liver and kidney combined
- Sturgeon eggs, if available
- Remaining carcass (bones and head).

For all fish except sturgeon, tissue samples will consist of composites of tissue from five separate fish. As noted previously, sturgeon samples will not be composited; all tissue types will be obtained from a single fish.

Muscle tissue analysis will be conducted on fillets with skin attached. Two fillets will be collected from each of the specimens (one from each side of the fish, from the approximate middle of the body) and submitted for analyses. This fillet area corresponds to the portion of the fish most commonly removed by fisherman and consumed by the public. Except for sturgeon, these fillets will include the skin and the dark tissue adjacent to the skin; this dark tissue consists of fat in which organic contaminants such as PCBs and pesticides may potentially be concentrated. Dark meat will be included in the fillet sample and homogenized with the rest of the muscle tissue during laboratory processing. The skin will not be included in sturgeon samples, since the skin is typically not consumed; however, sturgeon skin will be included and analyzed with the rest of the fish carcass.

Organs such as the stomach and liver are also sometimes consumed by fishermen living in the vicinity of the sub-areas. To address the potential risk associated with consumption of these

portions of the fish, the liver and kidneys, which tend to accumulate contaminants to the highest levels, will be removed from each specimen and combined for chemical analyses. The liver and kidneys will be combined and packaged separately for shipment to the laboratory. The combined liver and kidney samples will be analyzed separately from fillet and carcass samples.

Other organ tissue that remains after the kidney and liver are removed will not be analyzed, but will be weighed prior to disposal.

The skeletal system and remaining carcass of the fish are generally not intentionally eaten. However, "pin" or rib bones in the thoracic region of the fish are sometimes inadvertently cut off and included with the fillet, and bones may be used to make soups or stews. Radionuclides such as strontium-90 are concentrated in the skeletal system of the fish. For this reason, the remaining carcass will also be analyzed. The carcass will include the head, bones, skin (of sturgeon), and fins.

After the fillets, liver, and kidneys (and sturgeon eggs, if present) have been removed from the specimens, the remaining carcasses of the fish samples will be individually wrapped after processing and shipped to the laboratory for chemical and radiological analysis. The results from these analyses will provide data on concentrations of chemical and radiological constituents in the skeletal structures of the fish and potential exposure to residents who either purposely or inadvertently consume these portions of their catch. The sturgeon has a cartilaginous skeleton rather than a bony one, but the carcass will be analyzed in the same manner.

As part of the sample collection process, the weight of each of the tissue types will be measured. These sample weights can be combined with sample results to obtain the total concentration of contaminants for the whole fish. The results will be tabulated and compared to evaluate differences between the different species and various sub-areas. The data will also identify which parts of the fish's body contain the greatest concentrations of contaminants.

For sturgeon only, an additional component may be collected and analyzed. Anecdotal evidence indicates that some sturgeon will accumulate large quantities of sediment or mussels during feeding, to an extent that the bellies of such individuals may be distended with such material. If such an individual is caught in the course of sturgeon collection, the stomach contents will be collected and submitted for analysis as an additional sample. This sampling will be conducted opportunistically, as such fish are encountered; no additional sampling will be conducted to obtain these specimens. Sturgeon stomach contents, if collected, will be analyzed for radionuclides only. The concern with these stomach contents is that, because of their apparent accumulation in the gut, they may present a continuing source of radiation exposure to the fish. Stomach content data will be used qualitatively as appropriate in the risk assessment.

Finally, the otoliths from each sturgeon will be removed and saved in order to be used later to determine sturgeon age.

4.3.4.5 Sample Analyses. The target analytes identified for surface water and sediment were generally used to guide the analytical suites chosen for fish tissue samples. All fish tissue will be analyzed for the following constituents:

- Total analyte list metals
- Speciated arsenic (inorganic/organic)
- Radionuclides
- PCB congeners
- Percent lipids.

Sample methods are described in Table 2-9 of the SAP (Appendix A).

4.3.4.6 Additional Field Data. In order to support the ecological risk assessment, physical factors of each fish caught will be measured and recorded to the extent practical. Such factors include the following:

- Length
- Weight
- Sex
- Presence/absence of sturgeon eggs
- Color of fatty tissue in sturgeon.

4.3.5 Island Soil Sampling

Island soils will be sampled as part of the RI to characterize river-transported sediments from the Hanford Site that have been deposited on islands during high river levels and assess potential upriver contamination. Key sampling areas include the Ringold Recreational Area and the following downriver islands: Island 3, Locke Island, Homestead Island, Wooded Island, and Johnson Island. These islands were identified as key sampling locations because of their downriver location from source areas, depositional areas, and/or recreational use. Soil samples will be collected in areas above the ordinary high water mark, where riparian vegetation becomes dominant. This area of the island shoreline has been approximately correlated with river conditions that exist when flows from the upriver dam are stable at 80-kcfs. Since flow conditions over the period of time preceding a 80-kcfs flow rate will affect river elevation throughout the Study Area, delineation of the target habitat in the field will be performed in order to verify that samples are collected in the appropriate areas of the island. These samples will be used for site characterization and to support the human health and ecological (terrestrial) risk assessments.

4.3.6 Sediment Core Sampling

The sediment core sampling program described below summarizes the different types of sediment cores that will be collected, including shallow and deep cores.

4.3.6.1 Shallow Sediment Cores. Shallow sediment core (vibracores less than 3 m [10 ft] thick sediment sequences) samples will be collected from depositional areas that may contain sediments dating back to operational time frames. Key shallow sediment core sampling locations include 100-B/C, 100-K, 100-N, and 100-D Reactor inlet structures; below the 300 Area; the head of Lake Wallula pool; the Yakima River delta; and Snake River deposits. It is anticipated that the shallow sediment cores will extend to refusal. Cores will be divided into subsamples approximately 0.3 m (1 ft) each. The purpose of the shallow sediment cores will be to "look back" in the sediment record to when the reactors were active. In addition, results from the top sample (10 cm below the riverbed) will be used for the human health and ecological risk assessments.

4.3.6.2 Deep Sediment Cores. Deep sediment cores will be completed using a drill rig located on a barge. These cores are planned to investigate depositional areas located within Lake Wallula and from within the Bonneville Dam pool as well as an upstream location in the backwaters of Priest Rapids Dam. It is anticipated that these cores will be completed at water depth of up to 27 m (90 ft). Cores will be completed to refusal and divided into subsamples approximately 0.2 m (8 in.) each. Core locations have been selected in areas of anticipated thick sediment sequences that may contain sediments dating back to operational time frames.

Because of the inherent limitations associated with deep sediment core retrieval, it is anticipated that some of the sample volume may be lost as it is brought to the surface. This loss of sample core (e.g., volume) may have an impact on the number of analyses completed on each sample. If sufficient volume is not obtained, then the hierarchy of analysis will be implemented, which is described in Section 2.4.4 of the SAP (Appendix A).

All of the deep sediment cores will be dated using cesium-137, the most commonly and conveniently measured isotope. The worldwide deposition/fallout of man-made radioactive isotopes, namely cesium-137, formed in the atmosphere during atmospheric atomic bomb testing in the 1950s and early 1960s, providing a convenient and commonly used marker in the sedimentary record (Cox et al. 2005). The prevalent and consistent pattern of cesium-137 deposition in undisturbed sediments shows a build up starting in 1954 leading to a sub-peak in 1958, followed by a major peak in 1963 and followed by a relatively precipitous drop-off after the 1963 peak reflecting a test ban treaty that went into effect in 1963 (Charles and Hites 1987, Miller and Heit 1986, Ritchie and McHenry 1990). There are numerous examples of this common cesium-137 concentration pattern in sediment cores from all over the world. Sediment dating using cesium-137 concentrations is used widely as a means of determining soil erosion rates, sediment accumulation rates, and for determining timelines for man-made contamination events.

Dating will be conducted through relating measured cesium-137 activities to depth of the sediment sample analyzed. Because world-wide peak concentrations of cesium-137 are anticipated to reflect fallout from 1963, it is assumed that sediments in deep core samples that have the highest activities are attributed to the year 1963. By knowing the depth of sediments with peak activities, the age of sediment samples collected at a certain depth can be estimated from the sample's depth relative to the depth of the sample representing year 1963.

Priest Rapids Dam. A deep core will be completed upriver of Priest Rapids Dam. This core will be advanced to refusal through the unconsolidated sediments. It is anticipated that this core will be completed at the water depth of up to 10 m (30 ft). Cores will be completed to refusal and divided into subsamples approximately 0.2 m (8 in.) each.

Lake Wallula. Deep cores will be completed within the lower reaches of Lake Wallula (from Port Kelley, Hat Rock, and just upriver of McNary Dam). These cores will be advanced through the unconsolidated sediments to refusal. It is anticipated that the cores at Port Kelley and Hat Rock will be 1.5 to 3 m (5 to 10 ft) thick, while the core near McNary Dam may be up to 9 m (30 ft) thick. These cores will be divided into separate subsamples approximately 0.2 m (8 in.) each. Results from the deep sediment cores will be used to characterize sediments deposited from reactor operations to the present. Results from the 0- to 10-cm subsample will also be used during the ecological risk evaluation.

Bonneville Dam Pool. Deep cores will be completed upriver of the Bonneville Dam. These cores will be advanced to refusal through the unconsolidated sediments. It is anticipated that these will be 1.5 to 3 m (5 to 10 ft) thick. These cores will be divided into separate subsamples approximately 0.2 m (8 in.) each. Results from these deep sediment cores will be used to characterize sediments deposited from reactor operations to the present.

4.4 DATA MANAGEMENT AND EVALUATION

The data generated from the proposed sampling plan will be combined with existing data in the CRC database for use in evaluating the nature and extent of contamination as well as in evaluating potential human health and ecological risks. Sample analysis, data acquisition and review, data validation, and quality/usability assessments are described in detail in Section 3.0 of the SAP (Appendix A). This section briefly summarizes the statistical methods that may be employed to evaluate contaminant distributions within the Study Area. Results from this evaluation will be used to update the CSM, estimate human health and ecological risks, and identify any remaining data gaps. If the data evaluation indicates additional data gaps in characterization of the nature and extent of contamination (such as the presence of hot particles), the Tri-Parties will direct future sampling activities.

As previously described, a review of existing environmental data led to the segregation of the study area into four separate sub-areas, based on an analysis of spatial trends in contaminant concentrations relative to potential source areas. Subsequent to receipt of data from the additional samples to be collected under the Columbia River RI, the sub-area boundaries will be reevaluated to determine if the existing division by river mile is appropriate or whether the boundaries warrant modification.

Graphical and statistical testing methods for evaluating the data collected in this investigation are discussed in the following subsections.

4.4.1 Graphical Data Displays

As part of data interpretation, graphical representation of analytical results will be generated for use in evaluation of contaminant trends. Exploratory data analysis plots allow for visual inspection and summary of the data (Chambers et al. 1983). Each plot described below provides a different visual presentation of the distributions of contaminants. The choice of plotting procedure(s) depends on the hypothesis being tested and may include and/or depend on the following:

- The type of difference that is to be displayed, such as an overall shift in concentration (shift of central location)
- When the centers are nearly equal, a difference between the upper tails of the two distributions (elevated concentrations in a small fraction of one distribution).

The plotting method chosen will accommodate characteristics of the data sets (e.g., the rate of detection or censoring) or the amount of overlap or multiplicity of results reported at a few values. When there are both detects and nondetects in a data set, the convention used for plotting the nondetects is given. It is typical to use different plotting characters for detects and nondetects and to include nondetects at their reported detection limits or estimated quantitation limit. However, additional evaluation of censored results will be conducted and, if warranted, alternative statistical methods will be employed when including nondetect results in graphical analysis. Additional details are provided below on the types of plots that may be used.

4.4.1.1 Histograms. Histograms split the full range of results into equal-width data classes (intervals). Each interval is represented by a vertical bar, and the height of each bar may depict the number of samples that fall into that data class. The horizontal axis indicates the observed results in the appropriate units. Units are provided with each histogram, and the total number of observations included ("n") is presented in text below the histogram. When separate histograms are presented for different data sets (e.g., site data and background data), the same scale often is used for the axes of both plots to aid comparison.

4.4.1.2 Estimated (Probability) Density Functions. In density functions, the horizontal axis indicates the analyte results in the appropriate units. The curve, or density estimate, is merely a smoothed histogram. As an estimate of a density function, the area under the curve is approximately equal to one. The area under the curve between two possible observed values gives an estimate of the relative frequency for which observations of those magnitudes occur as compared to the other observations within the data set. These density estimates are nonparametric (i.e., they have no shape restriction).

4.4.1.3 Box Plots. Box plots summarize information about the shape and spread of the distribution of data. Box plots consist of a box, a (median) line across the box, whiskers (lines extended beyond the box and terminated with a perpendicular line segment), and points outside the whiskers. The y-axis displays the data in the appropriate units. The area enclosed by the box shows the concentration range containing the middle half of the data. That is, the lower box

edge is at the first or lower quartile of the data (Q1, also called the 25th percentile; 25% of the data fall below Q1), and the upper box edge is at the third or upper quartile of the data (Q3, the 75th percentile; 25% of the measurements fall above Q3). The height of the box (the interquartile range, Q3-Q1) is a measure of the spread of the results. The horizontal line across the box represents the median (50th percentile or second quartile) of the data, a measure of the center of the concentration distribution. If the median line divides the box into two approximately equal parts, this indicates that the shape of the distribution of results is symmetric; if not, it indicates that the distribution is skewed or nonsymmetric. Frequently, the results are plotted as points overlaying the box plot. When a data set contains results for both detects (detected chemical concentrations) and nondetects (nondetected chemicals reported as less than a sample-specific detection limit), it is standard to use different plotting symbols for the detects and nondetects.

The format for large data sets, or data sets with much redundancy, result in an amount of overlap or multiplicity of results reported at a few values. One also may plot the detected concentrations with an "x" and the detection limits of nondetects with an "o." Within each group (site or background), the points that represent individual observations are spread out laterally to reduce overlap. The random horizontal "jitter" has no significance; it is used strictly to improve the readability of the plot.

4.4.1.4 Outlier Box Plots. The purpose of this type of format is to display or draw attention to extreme values (Iglewicz and Hoaglin 1993). The intent is not to exclude such values from the data set; outliers represent important results that should be explained or at least evaluated. The upper and lower "fences" enclose a range that extends beyond the box. The length of each fence is a multiple of the interquartile range, K*(Q3-Q1), K=1.5 is a standard choice. The fences are not plotted, per se, in the figure, but are implied by the whiskers. The whiskers (dashed line) extend beyond the box and terminate at "adjacent values." The upper adjacent value is the largest observed value within the upper fence. The lower adjacent value is the smallest observed value within the lower fence. The range enclosed by the fences is the equivalent of a nonparametric confidence interval around the median. Points beyond the whiskers, "outside points" (all points beyond the whiskers are outside the fences), represent data that may be evaluated for their potential to be outliers (extreme or unusual values).

4.4.1.5 Quantile Plots. Quantile plots provide a comparison of different data sets by plotting the results of each group in increasing order and evenly spread out. The y-axis displays the concentration scale, and the x-axis displays the quantiles (or percentiles) of the data. Each position along the x-axis displays the fraction or percent of the data that falls below the corresponding concentration value. If the x-axis and the y-axis were reversed, the resulting plot would be called a cumulative probability distribution function.

4.4.1.6 Normal Quantile-Quantile (Q-Q) Plots (Normal Probability Plot). The normal Q-Q plot is a particular type of quantile plot. The data set results are plotted in increasing order and are spread out in a manner that allows comparison of their distribution to that of a theoretical distribution, the standard normal distribution. The quantiles of the data set (y-axis) are plotted against the quantiles for a standard normal (x-axis). The quantiles of a standard normal

(i.e., normal with mean=0 and standard deviation=1) are those for the theoretical distribution and can be found in tables of the cumulative normal distribution. For example, the 50th quantile is 0, the 90th quantile is approximately 1.282, and the 95th quantile is about 1.645. In the normal Q-Q plots, 0 corresponds to the 50th percentile (median), 1 corresponds to (approximately) the 84th quantile, 2 corresponds to (approximately) the 98th quantile, and 3 would correspond to (approximately) the 99.9th quantile. If the data set closely follows that of a normal distribution, the points in the plot will lie close to the diagonal straight line (Q-Q line) overlaying the plot. The subsets of the data set that differ the most from those expected from a normal distribution are seen as points straying from the Q-Q line. Often, the difference is seen in the extreme values of the data set (the largest or smallest data values at one or both ends of the plot), even for data sets that produce histograms that look rather "normal." Often, these plots are used to determine whether a data set looks more "normal" (all points fall closer to the Q-Q line) after a data transformation. Two different data sets (site and background) can be compared to each other and to a normal distribution by plotting a separate line for each data set in the same display. The viewer can see where, if anywhere, the two Q-Q plots follow the same line, overlap, or intersect indicating that they have equal concentrations at that (those) associated quantile(s).

4.4.1.7 Bivariate Plots. Scatter plots are an example of a bivariate display used to look for a mutual relationship or correlation between two variables of interest in the same sample. Data relating to one variable (y-axis) are plotted against data from a second variable (x-axis). Each point represents the values of the two variables from the same sample. Two variables have a positive correlation if they have a tendency to increase together and a negative correlation if an increase in one tends to produce a decrease in the other. The strength of the correlation between the two variables may be interpreted by the scatter of points around a sloped least squares fit line. The scatter of points typically follows the general pattern and is described as an ellipse. The shape of the ellipse reflects the strength of the correlation (i.e., the magnitude of r, the correlation coefficient). The shape of the ellipse ranges from circular when there is no correlation (r=0) to a thin ellipse that collapses into straight line (a degenerate ellipse) when the variables are perfectly correlated (r=1, or r=-1). The slope of the line or ellipse of points (positive or negative slope) indicates whether there is a positive or negative correlation. Both parametric and nonparametric methods are available to assess data for correlations; and a statistical model may be developed using tools like simple linear regression using a pre-determined alpha value; e.g., 5%).

A series of scatter plots for pairs of analytes from a set of samples often are used to explore potential (or expected) relationships among the analytes. Scatter plots of related isotopes provide a visual display of isotopic ratios to evaluate secular equilibrium or (for uranium isotopes) to evaluate evidence of depleted or enriched uranium.

4.4.1.8 Spatial Plots. Spatial plots present data across a given area using a variety of techniques. One simple plot used to provide information on spatial trends for two-dimensional data is a circle plot. Circle plots provide simple graphical representations of the magnitude of results at each sample location. Each concentration of a particular analyte is represented as a circle with an area proportional to the value. The circles are centered at the locations from which the samples were collected, typically the lateral surface locations throughout an area. Spatial

trends along the Columbia River will be illustrated using a bivariate plot of the lines of evidence (y-axis) versus the river mile location (x-axis).

4.4.2 Testing for Statistical Differences Between Groups

4.4.2.1 Distribution Shift Tests. Instead of simply comparing to a single threshold value representing background (e.g., the 90th percentile of background), distribution shift tests compare the potentially affected site data to the entire distribution of background or reference site concentrations. A distribution shift test is used to determine whether site data are systematically greater than background or reference site data. Several types of distribution shift tests are available. These tests are presented below; where there are multiple options, the preferred statistical method in each group is indicated. The result of performing each statistical test on two data sets (one that represents background and one that represents the site) is a test statistic and an associated significance level (also known as a p-value). The significance level is the probability that the test statistic would be as large as or larger than the one produced if the two data sets were from the same distribution (both were from the background distribution). When the significance level is small, this indicates that it is not likely that the two data sets came from the same distribution. It is standard to consider a "small" significance level to be less than 5% (0.05); i.e., such a large test statistic would occur by chance less than 1 out of 20 times when the sampled populations are the same.

4.4.2.1.1 Overall Distribution Shift. To detect an overall distribution shift between potentially affected areas of the river adjacent to the Hanford Site and background (upstream) data, the following statistical tests may be employed. The tests are to be performed as one-sided tests with the null hypothesis of site concentrations are not greater than background (or reference area concentrations), and the alternative hypothesis that the site is greater than background (or reference area concentrations).

- **Student's t-test.** A parametric, two-sample test that determines whether the mean concentration of site data is statistically greater than the mean concentration of background or reference site data (Gilbert 1987). It is the most powerful test when data from both sets are distributed normally. Data analysts should be aware that the t-test performs well for some deviations from normality but, in the absence of normality, increased power may be obtained through nonparametric methods (Miller 1986, p. 40-44). Note that Miller (1986) contains a helpful discussion of the robustness limitations of the t-test. Normality can be assessed visually using a normal probability plot (also known as a probit plot or normal quantile-quantile plot; see discussion above). Formal tests for normality may be performed first, such as the Shapiro-Wilk W test (Gilbert 1987, p. 158). Results from multi-increment soil sampling are appropriate for the t-test, because they are expected to conform to a normal statistical distribution.

- **Welch's t-test.** Welch's t-test (Welch 1947) is an adaptation of the Student's t-test, described above, for use in circumstances where the variances of the site and background data are unequal. The t-value is calculated for Welch's t-test using independent sample sizes and variances for each population, rather than by using a pooled variance estimate.

- **Wilcoxon rank sum test (or Mann-Whitney U-test).** This test is the nonparametric equivalent to the t-test (Gilbert 1987, 55619; Gilbert and Simpson 1992). The Wilcoxon test pools site and background or reference site data into one aggregate set and determines whether the average rank of the site data is greater than that of the background data. The Wilcoxon test is recommended when nondetects are relatively infrequent (less than 10%) and all have the same detection limit. The nondetects are treated as tied at a value less than the smallest detected concentration. The Wilcoxon rank sum test will have about the same or more power than the t-test for most distributions (Gilbert and Simpson 1992).

- **Bartlett's test.** This test is used to determine homogeneity of variance between samples from two populations (Snedecor and Cochran 1989). The null hypothesis of the test is that the variances of all of the populations are equal. Bartlett's test performs poorly when population distributions are not normal or near-normal, and will not be applied in such cases.

- **Gehan test.** When, as is frequently the case for environmental data, some of the data are "censored" or reported as below a detection limit, and especially when not all the detection limits are identical, the Gehan modification to the Wilcoxon test is useful (Gehan 1965). The Gehan test uses a modified ranking of sample results to accommodate nondetected values together with detected values, and then applies the Wilcoxon rank sum test. The Gehan test is recommended when nondetects are relatively frequent (greater than 10% and less than 50%). It handles data sets with nondetects reported at multiple detection limits in a statistically robust manner (Gehan 1965, Millard and Deverel 1988). An appendix to this document provides further explanation, including an example comparing the Wilcoxon and Gehan ranking procedures. The Gehan test is not recommended if either of the two data sets has more than 50% nondetects. It is identical to the Wilcoxon rank sum test when applied to results containing no nondetects. The Gehan test is the preferred test because of its applicability to a majority of environmental data sets.

4.4.2.1.2 Partial Shift. To detect distribution shifts between the upper range of the potentially affected site data and the background or reference site data, the following statistical tests may be used.

- **Quantile test.** The quantile test determines whether more of the observations in the top 20% (chosen percentile) of the combined data set come from the site data set than would be expected by chance, given the relative sizes of the site and background data sets. If the relative proportion of the two populations being tested is different in the top 20% of the data from the remainder of the data, the distributions may be partially shifted due to a subset of site data. This test is capable of detecting a statistical difference when only a small number of potentially affected site concentrations are elevated (Gilbert and Simpson 1992). The quantile test is the most useful distribution shift test for potentially affected sites at which samples from a release represent a small fraction of the overall data collected. The quantile test is applied at a pre-specified quantile or threshold, and we have selected the 80th percentile for this project. The test cannot be performed if more than 80% (or, in general, more than the chosen percentile) of the combined data are nondetected values. It can be used when the frequency of nondetects is approximately the same as the quantile

being tested. For example, in a case with 75% nondetects in the combined background or reference site and potentially affected site data set, application of a quantile test comparing 80th percentiles is appropriate. The threshold percentage can be adjusted to accommodate the detection rate of an analyte, or to look for differences further into the distribution tails. The quantile test is more powerful than the Wilcoxon (or Gehan) test for detecting differences when only a small percentage of the potentially affected site concentrations are elevated.

- **Slippage test.** This test is based on the maximum observed concentration in the background or reference site data set and the number ("n") of potentially affected site concentrations that exceed the maximum concentration in the background or reference data set (Gilbert and Simpson 1990, pp. 5-8). The result (p-value) of the slippage test is the probability that "n" site samples (or more) exceed the maximum background or reference site concentration by chance alone. The test accounts for the number of samples in each data set (number of samples from the site and number of samples from background or the reference site) and determines the probability of "n" (or more) exceedances if the two data sets came from identical distributions. This test is similar to the hot-measurement test in that it evaluates the largest site measurements. It is more useful than the hot measurement comparison because it is based on a statistical hypothesis test, not simply on a statistic calculated from the background distribution.

4.4.2.1.3 Other Tests. For analytes that are rarely detected (e.g., some trace metals in soil samples), an increased detection rate at the site may provide evidence of an affect. The following test is recommended.

- The Chi-square goodness-of-fit test can be used to check for differences in proportions from data sets that fall into given categories. Categorizing proportions from data sets on the basis of two attributes and testing for a difference is also referred to as a test for independence of attributes. For example, this test can be used to test whether the attribute of detection (proportion of detected results out of the total analyses performed) is the same in the site data set and the background or reference data set (attribute of membership in the category of "site" or "background" or "reference" data sets). If these proportions are not statistically significantly different, the detection rate attribute is "independent" of the categorization into "background vs. site" sets (Box et al. 1978, pp. 149-150). This test on detection rates is inappropriate when the two data sets were not analyzed with similar methods or do not have similar detection limits.

4.4.2.1.4 Simultaneous Tests. To infer a significant result in a single distribution shift test, a 95% confidence level is used. Given that multiple comparisons (comparisons for multiple analytes from the same sample) will be performed with the distribution shift test, there are statistical interpretation issues (e.g., 1 of 20 hypotheses would be expected to reject the null hypothesis based on selecting a 5% alpha value). No adjustment to the alpha level is proposed; instead, the chance for false-positives and false-negatives as a result of simultaneous testing and issues associated with data variability and sample size will be considered as part of the uncertainty analysis.

In addition to test results described in this section, the data will be plotted spatially and evaluated relative to the conceptual site model, the descriptive summary, and interpretation of the site that includes input from the entire technical team. The conceptual model is based on information from the four general categories of site description, operational history, field survey information (including data taken by field instruments, engineering surveys and ecological surveys which look at morphological features affecting transport and rate of migration or environmental redistribution), and analytical data (concentrations and quality assurance/quality control information). Spatial plots of the data are used to verify or better define the site conceptual model.

Two specific aspects of the conceptual model that warrant a statistical assessment are the collocation or correlation of contaminant concentrations. Another important step in revising the CSM is evaluating geochemical or geologic data patterns. For example, concentrations should be evaluated as a function of distance from a source areas and it would be appropriate to look at spatial plots (e.g., circle plots). One purpose is to look for patterns to identify a trend or sub-area that might be considered an elevated sample result as opposed to a random or sporadic distribution of the relatively larger concentrations.

4.4.2.1.5 Testing for Relationships Between Variables (Gradient or Trend Analysis). An association or correlation between two variables is indicated if the points on the scatter plot follow (approximately) a positively or negatively sloped straight line. A horizontal line indicates no relationship between the variables. Linear regression is used as one statistical model to relate pairs of variables to data that conform to a normal statistical distribution. One variable is the independent variable and is plotted on the x-axis – which for this project will primarily be the contaminant concentrations in abiotic media (i.e., surface water or sediment). The dependent variable is plotted on the y-axis, and concentrations in fish tissue will be evaluated as dependent variables. The regression analysis yields a model with a slope and intercept. The fit of the data to the model is calculated as the coefficient of determination (also known as r^2 or the explained variance of the model). A coefficient of determination of 1 occurs when a perfect fit occurs (the errors are all zero). A coefficient of determination of 0 means that the model predicts the fish tissue concentrations no better than the overall response mean (the regression would have a slope of zero in this case). As with all other statistical tests, statistical significance will be associated with p-values that are less than 0.05. When both detects and nondetects are in a data set, they will be denoted graphically with different characters and nondetect values will be displayed at their detection limits or estimated quantitation limit and will be analyzed using appropriate EPA guidance and WAC 173-340-740(7)(f).

For data that do not conform to a normal statistical distribution, nonparametric analyses are available to determine the correlation of degree of association between variables. Nonparametric methods are also useful for evaluating nonlinear relationships between variables. Spearman rank correlation is one method that assigns ranks to each variable and calculates the correlation of the ranks (Zar 1974). This analysis yields a correlation coefficient, which is a number between -1 and +1 and a p-value or significance level for the correlation. P-values less than 0.05 are considered to be statistically significant. A correlation coefficient of -1 indicates that there is a perfect negative association between the ranks of these variables and a correlation coefficient of

+1 indicates that there is a perfect positive association between the ranks of these variables. A correlation coefficient of 0 indicates no relationship between the ranks of these variables.

4.4.3 Evaluation of Background Contaminants

The Columbia River runs through multiple urban, agricultural, and/or industrialized areas and has a long history of impacts from both point and nonpoint sources of pollution. Consequently, there exists a baseline level of contamination within the river in the absence of impacts attributed to the Hanford Site.

Because of the presence of these other sources of contaminants to the Columbia River, it is important to understand the relative contribution of other non-Hanford Site sources and the resulting baseline or "background" concentrations of constituents present in the river but unrelated to the site. Thus, concentrations of contaminants detected in areas upstream of the Hanford Site, as well as in other contributing areas (such as irrigation returns and wasteways), will be compared to concentrations of similar contaminants detected within the study area to determine which chemicals and radioisotopes are present in surface water and sediment along the Hanford Reach at concentrations consistent with those observed in these "background" areas. Compounds present at concentrations consistent with background will be identified as "background" contaminants.

For surface water, sediment, fish tissue, and island soil, a comparative statistical evaluation will be conducted for all detected constituents in accordance with EPA guidance to identify a subset of contaminants that are consistent with background conditions, in order to differentiate constituents attributed to the Hanford Site from constituents attributed to non-Hanford Site sources. This approach is consistent with the statistical evaluations performed in the RCBRA (DOE/RL-2007-21, Draft B or most current version, as available).

Samples collected upstream of the Vernita Bridge at RM 388 as well as other areas (such as irrigation returns or tributaries) will be considered representative of background conditions for the purpose of this risk assessment. Sediment, island soil, fish tissue, and surface water at these upstream locations are presumed to not have been affected by releases from the Hanford Site.

4.4.3.1 Decision Logic for Statistical Comparisons. While Sections 4.4.1 and 4.4.2 of this RI work plan describe in general terms how data will be evaluated and presented, the following approach is specific to the background evaluation. The number of samples and the frequency of detection will initially be considered in the background comparison evaluation. In cases where less than 10 samples are available for any constituent within any data set, no statistical comparisons will be performed due to an insufficient data set. The detection frequency for each constituent with 10 or more samples will be calculated independently in the background data set (Upriver Sub-Area) and within the downstream sections of the river. The frequency of detection for the background data set will be evaluated for each analyte to determine if it is appropriate to make statistical inferences. Box and whisker plots will be generated to provide visual comparisons of the data, and analytes present at a low frequency of detection within the Study Area will be further evaluated qualitatively to determine whether the concentrations are

noticeably consistent with (or greater than) upstream areas or whether supplemental information is required to make such a determination.

Figure 4-6 summarizes the approach to be used in evaluating background. If censored values (nondetects) are present in the data set, the data set will be checked to determine if the proportion of nondetects in both groups is greater than 50%. If this is not the case, box and whisker plots will be used as described above to evaluate the data. If greater than or equal to 50% of the data in both groups are detects, the nonparametric Gehan test, described in Section 4.4.2.1.1, will be used to test for differences between the groups. The Gehan test is a generalization of the Wilcoxon Rank-Sum test that incorporates censored values, including values with multiple censoring points, when ranking the data and calculating the test statistic (the "G" statistic).

The Gehan test reduces to the standard Wilcoxon Rank-Sum test when no censored values are present in the data sets being compared. The Gehan test is not reliable when there are fewer than 10 samples in the data sets being compared, and thus results derived under these circumstances will be flagged. The EPA software program Pro-UCL 4.00.02 (EPA 2007ad) will be used to conduct the Gehan tests. For this test, the null hypothesis will be that there is no significant difference between the Study Area data set and the background data set. A two-sided Gehan test will be conducted for all comparisons, and the null hypothesis will be rejected if the calculated p-value is less than 0.05.

If censored values are not present in either the background or river Study Area, and both data sets have sufficient sample sizes and detection frequencies, then the Shapiro-Wilk test will be performed on both data sets to determine if the distribution of the data sets conform to a normal distribution. The Shapiro-Wilk test calculates a W-statistic – the closer the W-statistic is to one, the more closely the data set approximates a normal distribution.

If both the background and Study Area data set approach a normal distribution, Bartlett's test will be performed to determine equivalence of the variances between the data sets. Bartlett's test is the most appropriate means for testing for homogeneity of variance in cases where the data sets are normally or near-normally distributed. If the variances of the Study Area data set and the background data set were equal, a standard Student's t-test will be performed to test for differences between the means; otherwise, a Welch's t-test will be performed, which corrects for unequal variances. For both the Student's and Welch's t-test, the null hypothesis will be that there was no significant difference between the Study Area data set and the background data set. A two-sided test will be conducted for all comparisons, and the null hypothesis will be rejected if the calculated p value is less than 0.05. If either the background data set or the Study Area data set is not normally distributed for a given constituent, then the nonparametric Wilcoxon Rank-Sum test will be used to compare the data sets.

Figure 4-6. Decision Logic for Background Comparisons.

This figure is under development.

All constituents identified as present at concentrations greater than those of background samples will be flagged as "Hanford-Related" constituents. Constituents determined to be present at levels less than or consistent with background levels will be flagged as "Background-Related" constituents.

4.5 BASELINE ECOLOGICAL RISK ASSESSMENT

This section presents the proposed methodology of the initial steps of a BERA that will be conducted on the surface water and sediment of the Columbia River adjacent to and downriver of the Hanford Site. Remedial activities at the Hanford Site are being conducted within the regulatory framework of CERCLA. The Columbia River itself, which contains residuals both from historical activities at the Hanford Site as well as current upstream non-Hanford Site sources, is not formally part of the Hanford Site, but is being investigated under the same CERCLA process. Accordingly, this BERA will be completed as part of the RI which is being undertaken to evaluate Hanford Site hazardous substance releases to the Columbia River. This risk assessment will be conducted in accordance with the following guidance:

- *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final* (EPA 1997a)
- *Guidelines for Ecological Risk Assessment* (EPA 1998b)
- *ECO Update: The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments* (EPA 2001a).

The ultimate goal of the BERA is to evaluate whether river areas, media, or constituents pose a significant risk (i.e., risk estimates exceeding regulatory risk limits) that may require additional response actions or study, or do not pose a risk and so do not warrant further action. In accordance with EPA guidance (EPA 1997a), the BERA will follow an eight-step process (Figure 4-7) that begins with a preliminary screening of compounds and progresses incrementally to more detailed studies. Because the components of each step depend on the findings of the preceding step, the exact scope of the entire BERA cannot be determined in detail at this time; however, the methodology of the first two steps for the CRC are known and are described in the following sections. Additional steps in the BERA process will depend on the findings of this initial assessment, and will be described in a subsequent work plan. The BERA steps described in the following sections are as follows:

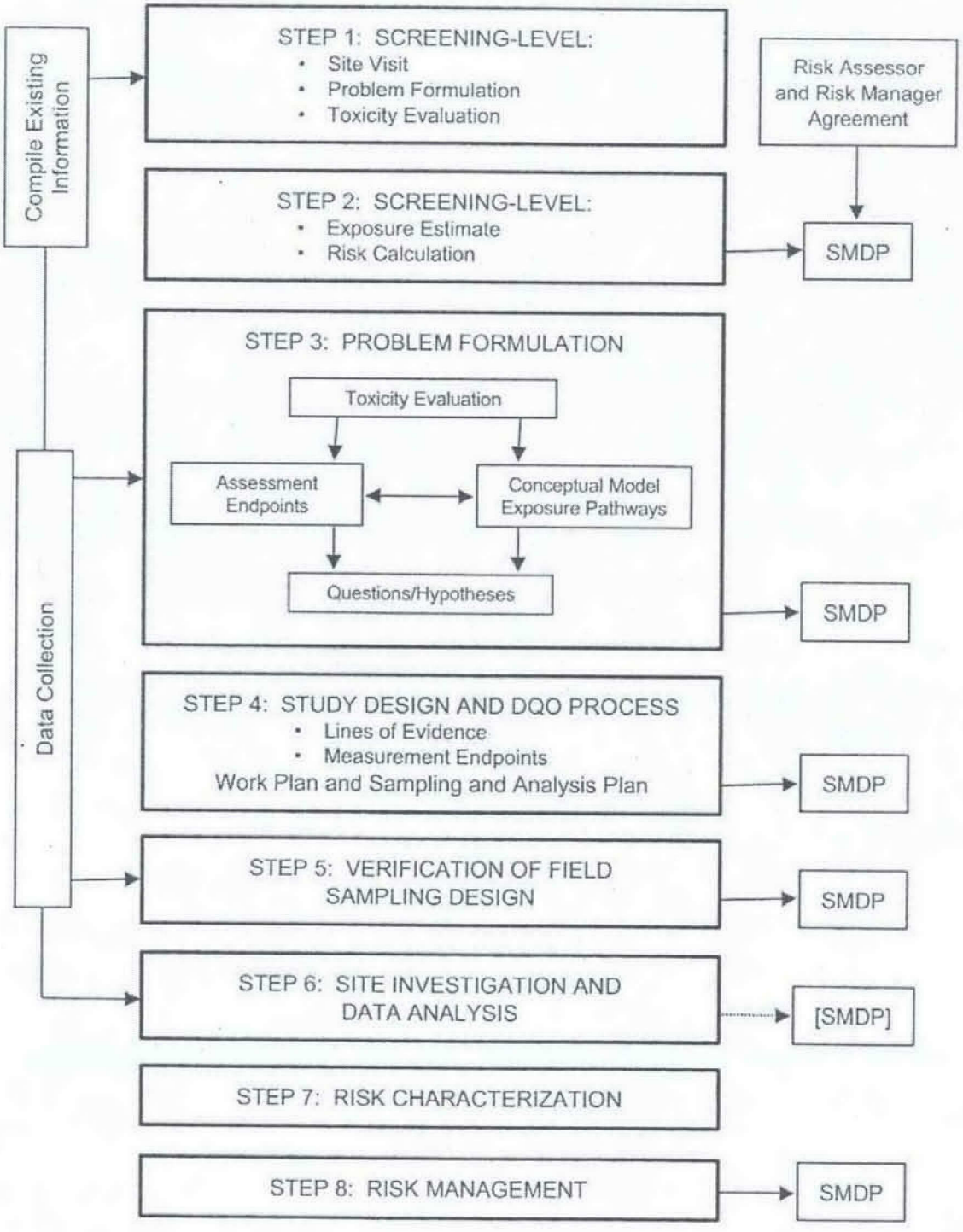
Step 1:

Screening-Level Problem Formulation
Screening-Level Toxicity Evaluation

Step 2:

Screening-Level Exposure Estimate
Screening-Level Risk Calculation

Figure 4-7. Eight-Step Ecological Risk Assessment Process for Superfund.



Source: EPA 1997a
SMDP = Scientific/Management Decision Point

As recommended by EPA (2001a), Step 3 will consist of a refinement of the results obtained from Steps 1 and 2. The general methodology of Step 3 is described in this document. The composition of subsequent steps in the risk assessment will depend on the results of the Step 3 analysis and will be developed after Step 3 has been completed.

4.5.1 Area of Study

The area of study for the BERA is characterized in two dimensions: longitudinal (the reach of the river) and lateral (shore to shore).

The longitudinal area of study for this BERA is the Columbia River from the Vernita Bridge to McNary Dam. This is the area of greatest potential impact of Hanford Site contaminants and contains the highest detected concentrations. It is also thus the focus area for additional surface water and sediment sampling.

The lateral area of evaluation in the BERA is the Columbia River, from shore to shore, including the islands and the left bank (facing downriver) shoreline. The right side of the river in the Hanford Reach has been characterized (by sampling) and assessed as part of the Source and Groundwater Component of RCBRA, which evaluated riparian and near-shore areas in the operational and inter-area portion of the Hanford Site. That effort used both abiotic and biotic samples to evaluate risk in the sloughs, riparian, and near-shore portions of the river, from the Vernita Bridge to the lower site boundary at the 300 Area. That area is considered to be adequately characterized and will not be subject to further characterization as part of this RI.

For the BERA, data will not be averaged or otherwise aggregated over each sub-area; rather, data will be evaluated on a point-specific basis. Data will be divided into sub-areas only for the purpose of background comparisons. The use of sub-areas for background evaluations will help ensure that any elevated concentrations of constituents in the 100 and 300 Areas remain distinct in the statistical comparison to background, rather than being combined with potentially lower concentrations in Lake Wallula.

4.5.2 Data Description and Use

The data used for the BERA will consist of a comprehensive CRC database that includes Inter-Areas and other data obtained as part of the Source and Groundwater Component of the RCBRA and other studies. In general, use of these data reflect the coordination of this study with the Source and Groundwater Component of the RCBRA, and so follows in general a similar approach. Details of data use are provided as follows.

- In accordance with the approach for the Source and Groundwater Component of the RCBRA, only data from 1990 and later are used in the risk assessment. This relatively recent data more accurately reflect current conditions and exposures at the site and present a more reliable basis for decision making than historical data. However, all data are used in the evaluation of the nature and extent of contamination.

- For sediment exposures, only shallow sediment, 10 cm (4 in.) or less in depth, is included in the screening. This is the zone of exposure of most aquatic organisms, which typically live in the top 10 cm (4 in.) of material.

Other details of data use are described in relevant sections.

4.5.3 BERA Methodology

The following sections present the proposed methodology for completing the BERA of the CRC of the RCBRA.

As noted above, the right side of the river has already been evaluated by the Source and Groundwater Component of RCBRA and will not be reevaluated as part of the RI. The following sections apply to the portion of the river that has not yet been evaluated, namely the river (including shorelines and islands) to the left of the RCBRA "Near-Shore Areas" in the Hanford Reach, and the whole river (including shorelines) downstream of the Hanford Reach.

4.5.3.1 Step 1: Screening-Level Problem Formulation. Problem formulation is the first and most important step in ecological risk assessment. The purpose of the problem formulation is to determine the focus and scope of the BERA by systematically identifying the stressor characteristics, the ecosystems potentially at risk, and the ecological effects to be evaluated. Selection of these elements will be based on the management goals identified in the project planning phase preceding the assessment. In accordance with EPA guidance (EPA 1997a), the problem formulation will consist of the following:

- Habitat description
- Selection of COPCs
- Exposure pathways and potential receptors
- Ecological CSM
- Assessment endpoints and measures of effect.

These possible conclusions are of necessity tentative at this point, since the full investigation has not been completed, but are presented here for general discussion and review.

4.5.3.1.1 Habitat Assessment. This section will present an overall description of the Columbia River in the area of study, which is from Vernita Bridge to McNary Dam. A great deal of study and investigation has been conducted on this stretch of the river, and existing sources will be consulted to develop a description of the physical and biological characteristics of both the Hanford Reach adjacent to the Site and Lake Wallula, which extends from Richland down to McNary Dam. Particular attention will be paid to the presence of distinct habitat types within the Hanford Reach, since these will affect the choice of receptor groups for use as assessment endpoints.

In support of the Habitat Assessment, a habitat survey will be conducted prior to the selection of sample locations. This survey will be completed to support the ecological risk assessment and

will consist of a focused inspection of island and left-bank ecology in the Hanford Reach, and of shoreline sampling areas downriver of the Hanford Reach. The goal of this effort is three-fold:

- To identify the general types of terrestrial and shoreline habitats present on islands and the left shore
- To confirm the appropriateness of the receptors included as assessment endpoints in the ecological risk assessment
- To ensure that sample locations will be representative of habitats used by selected receptor species.

As part of the survey, the presence or potential presence of proposed receptor species will be evaluated by both direct observation (conducted opportunistically) and inferred by habitat review. Receptors of particular interest consist of aquatic plant and amphibians, for which island terrain is of uncertain suitability.

In the Hanford Reach, the survey will be conducted by observing the shorelines and terrestrial portions of islands either by boat or by a physical review on land. The location of sediment samples included specifically for the evaluation of ecological receptors will be observed to ensure that samples are representative of the habitats used by proposed receptors. The conditions at each sample area will be documented as part of the survey. Downstream of the Hanford Reach, the visual review will focus on areas currently slated for shoreline sampling. Information from this survey will help to enhance the understanding of island and shoreline ecology, an understanding which is fundamental to assessing potential risks in the BERA.

The results of the habitat survey will be used to finalize sampling locations, which will be approved by the Tri-Parties.

4.5.3.1.2 Selection of Contaminants of Potential Concern. Contaminants of Potential Concern are selected from among the compounds analyzed for in the RI and constitute those compounds for which risk will be quantitatively evaluated. Selection of the appropriate COPCs is critical to preparing an assessment that is representative of risks resulting from Hanford Site operations and useful for making remedial action decisions. COPC selection should occur through a process that is deliberate, systematic, and based on established selection criteria. The risk assessment must be able to differentiate between background materials, non Site-related materials, and contaminants directly related to site activities. A consequence of not establishing an appropriately focused list of Hanford Site-related contaminants for this assessment is that the calculated risks from non-Hanford Site constituents are high enough to mask the impacts from site contaminants. This section describes the approach developed to identify and focus the COPCs identified for the risk assessment evaluation.

The selection of contaminants of potential ecological concern (COPECs) follows generally the approach discussed by the Tri-Parties during meetings held in January through April 2008, for

the RCBRA Source and Groundwater Component risk assessment.[5] However, because the exposure media for the Columbia River consist largely of sediments and surface water rather than soils, the approach has been modified to reflect the characteristics of the data set for those media. Because the river is subject to contributions from upriver sources, the identification of constituents that originate from upriver is an important component of this analysis, since these are considered to be representative of background conditions. The statistical method to distinguish site contaminants from background is described in this section. Unlike the RCBRA Source and Groundwater Component risk assessment, no comparisons between external dosimeter data collected in upland/riparian areas and reference sites for the RCBRA are made since this information is not relevant for the surface water and sediment of the Columbia River.

The approach for COPC refinement outlines a process for focusing contaminants based on comparing mean concentrations to background or reference sites using conclusions and data summaries from field investigations. The process is consistent with guidance pertaining to selection of COPCs for risk assessment (EPA 1989a, RAGS Part A Chapter 5, "Data Evaluation"). The COPC refinement process includes a number of complementary steps and criteria, which begins with a pre-selected list of contaminants that will be excluded (Table 4-15), and a list that will be included (Table 4-16). These compounds will be excluded or included, respectively, prior to any formal screening of the data. The inclusion and exclusion lists recognize and take advantage of the knowledge gained through decades of Hanford Site characterization and cleanup work that has preceded this assessment.

Table 4-15. Analytes Excluded as Contaminants of Potential Concern per the RCBRA Source and Groundwater Component. (2 Pages)

Analyte	Criterion	Analyte	Criterion
Soil Analytes (apply to biota, except physical meas.)			
Actimium-228	Half-life < 3 yr	% Retained on no.16 screen	Physical meas.
Cerium-144	Half-life < 3 yr	% Retained on no.200 screen	Physical meas.
Cesium-134	Half-life < 3 yr	% Retained on no.30 screen	Physical meas.
Cobalt-58	Half-life < 3 yr	% Retained on no.325 screen	Physical meas.
Iron-59	Half-life < 3 yr	% Retained on no.50 screen	Physical meas.
Lead-212	Half-life < 3 yr	% Retained on no.8 screen	Physical meas.
Lead-214	Half-life < 3 yr	Nitrogen, Kjeldahl total	Physical meas.
Manganese-54	Half-life < 3 yr	Percent moisture	Physical meas.
Ruthenium-103	Half-life < 3 yr	pH measurement	Physical meas.
Ruthenium-106	Half-life < 3 yr	Total organic carbon	Physical meas.
Sodium-22	Half-life < 3 yr	Potassium-40	Background rad.

[5] The RCBRA source and groundwater report (DOE/RL-2007-21) has not been reviewed and approved by the Tri-Parties. If the COPEC refinement process documented in the report is revised during the course of review and approval, it is expected that the COPEC refinement process for this remedial investigation will be revised in a similar way.

Table 4-15. Analytes Excluded as Contaminants of Potential Concern per the RCBRA Source and Groundwater Component. (2 Pages)

Analyte	Criterion	Analyte	Criterion
Thorium-234	Half-life < 3 yr	Radium-224	Background rad.
Tin-113	Half-life < 3 yr	Radium-226	Background rad.
Calcium	Essential nutrient	Radium-228	Background rad.
Magnesium	Essential nutrient	Thorium-228	Background rad.
Potassium	Essential nutrient	Thorium-230	Background rad.
Sodium	Essential nutrient	Thorium-232	Background rad.
% Retained on no.100 screen	Physical meas.	Silicon	Other
Groundwater Analytes (apply to biota, except water quality)			
Actimium-228	Half-life < 3 yr	Hardness	Water quality
Antimony-125	Half-life < 3 yr	Ignitability	Water quality
Beryllium-7	Half-life < 3 yr	Oxidation reduction potential	Water quality
Cesium-134	Half-life < 3 yr	Sodium dithionite	Water quality
Cobalt-58	Half-life < 3 yr	Specific conductance	Water quality
Iron-59	Half-life < 3 yr	Temperature	Water quality
Lead-212	Half-life < 3 yr	Total inorganic carbon	Water quality
Lead-214	Half-life < 3 yr	Total organic carbon	Water quality
Ruthenium-106	Half-life < 3 yr	Total organic halides	Water quality
Sodium-22	Half-life < 3 yr	Turbidity	Water quality
Calcium	Essential nutrient	pH measurement	Water quality
Magnesium	Essential nutrient	Potassium-40	Background rad.
Potassium	Essential nutrient	Radium-226	Background rad.
Sodium	Essential nutrient	Radium-228	Background rad.
Alkalinity	Water quality	Thorium-228	Background rad.
Coliform bacteria	Water quality	Thorium-230	Background rad.
Conductivity	Water quality	Thorium-232	Background rad.
Dissolved oxygen	Water quality	Silicon	Other

COPC = contaminant of potential concern

Table 4-16. Analytes Included as Contaminants of Potential Concern per the RCBRA Source and Groundwater Component.

Analyte	100 Area	300 Area	Analyte	100 Area	300 Area
Waste Site Analytes					
Hexavalent chromium	Yes	No	Total chromium	Yes	No
Cobalt-60	Yes	Yes	Mercury	Yes	No
Cesium-137	Yes	Yes	Plutonium-239/240	Yes	Yes
Lead	Yes	Yes	Uranium-238	Yes	Yes
Europium-152	Yes	No	Uranium-233/234[a]	Yes	Yes
Europium-154	Yes	No	Uranium-235[a]	Yes	Yes
Strontium-90	Yes	Yes	Total uranium[a]	Yes	Yes
Key Groundwater Plume Analytes					
Chromium	Yes	No	Carbon-14	Yes	No
Hexavalent chromium	Yes	No	Strontium-90	Yes	Yes
Uranium[b]	Yes	Yes	Technetium-99	Yes	Yes
Nitrate	Yes	No	Tritium	Yes	Yes
Petroleum hydrocarbons[c]	Yes (100-N only)	No	cis-1,2-dichloroethene	No	Yes
Sulfate	Yes	No	Tetrachloroethene	No	Yes
Tributyl phosphate	No	Yes	Trichloroethene	Yes	Yes

[a] Uranium-233/234, uranium-235, and total uranium are included based on the identifying uranium-238.
[b] Isotopic and total uranium are included.
[c] Petroleum hydrocarbon constituents are included.

The use of automatic inclusion and exclusion lists has a number of advantages and disadvantages. The use of inclusion lists ensures that key site contaminants, which may be missed in sampling events, are included and evaluated in the risk assessment; however, this conservative approach may overestimate risk and obscure the case where key contaminants truly are absent. Exclusion lists save time and money by eliminating from the assessment compounds acknowledged to present negligible risk; however, they may underestimate risks if such compounds are present in elevated concentrations. Because these compounds are not present at elevated concentrations at the Hanford Site, and because many site contaminants are well-known, the use of inclusion and exclusion lists is an appropriate component in the selection of COPCs. Additional selection steps included evaluation of detection status, statistical comparisons of Hanford Site data to background and reference site data, evaluation of potential toxicity (through the availability of ecological benchmarks), and a chemical-specific "narrative analysis" that evaluates the results of the various statistical comparisons of site data to background or reference data. The narrative analysis integrates a variety of information to support a conclusion on COPC identification when the results of statistical comparisons are ambiguous. The quantitative methods provide valuable information for the included analytes and also provide a sound technical basis for eliminating less relevant analytes from the quantitative risk assessment.

Figure 4-8 provides an overview of the COPEC refinement process.

Pre-Screening Exclusion List. As noted previously, some compounds will be excluded as COPECs prior to the formal COPEC screening process. These analytes have been excluded from consideration as COPECs by agreement among the Tri-Parties and based on relevant Hanford Site data. Separate exclusion lists have been developed for waste sites and groundwater contaminant plumes. The analytes excluded as COPECs per the RCBRA Source and Groundwater Component (DOE/RL-2007-21, Draft B) are summarized in Table 4-15. These constituents will not be evaluated in this BERA.

Pre-Screening Inclusion List. Similar to excluded compounds, some analytes were automatically included as COPECs based on evaluation of the commonly reported analytes in waste site cleanup reports or based on the most prevalent contaminants in the groundwater plumes. The analytes included as COPECs per the RCBRA Source and Groundwater Component (DOE/RL-2007-21, Draft B) are summarized in Table 4-16. The inclusion list reflects those contaminants that the Tri-Parties must see addressed in this risk assessment in order to prepare meaningful and effective regulatory documents. This list includes analytes known or expected to be associated with former operations and activities at the Hanford Site. Constituents listed on the "Inclusion List" in the RCBRA Source and Groundwater Component risk assessment will be automatically included as COPECs in this BERA.

Evaluation of Nondetected Analytes. Analytical results for soil, sediment, water, and biota collected for the RCBRA investigation are evaluated against the quality criteria specified in the Quality Assurance Project Plan (QAPP) (Section 3.0 of the SAP [Appendix A]). As a measure of data quality, analytical results identified as nondetects in the RCBRA data set are compared to the laboratory required detection limits prescribed in the QAPP. Nondetect results reported at values higher than the prescribed detection limit are identified for additional consideration and are labeled an "uncertain COPEC." The results associated with the "uncertain COPECs" where the nondetect result exceeded the target practical quantitation limit (PQL)[6] are acknowledged as uncertainties in the BERA.

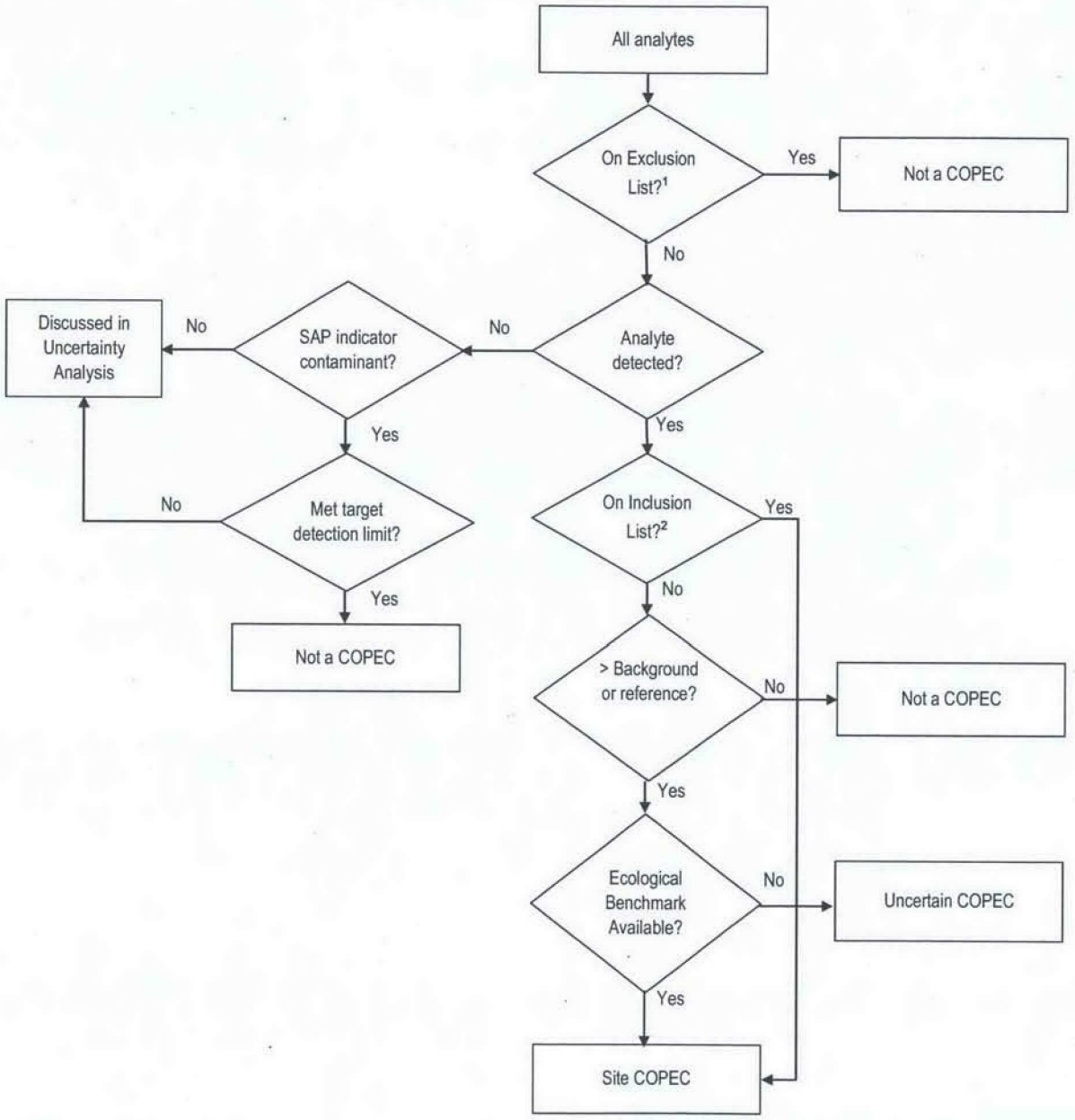
Analytes that are nondetected, but either have no target PQL in the RCBRA SAP or meet the target PQL, are not included as COPECs.

Detected Analytes. Detected analytes are the dominant focus of COPEC refinement. Statistical analyses and the narrative analysis are used to determine the COPEC list. Statistical methods for distinguishing background from site concentrations are described below.

Evaluation of Background Concentrations. Section 4.4.3 discussed identification of "background"-related constituents detected in river media. Constituents present at concentrations consistent with background are not included as COPECs.

[6] A value approximately five to tenfold higher than the analytical method detection limit corresponding to a reasonably high degree of confidence in the reported result.

Figure 4-8. Contaminant of Potential Ecological Concern Refinement Process Flow Diagram.



[1] Consisting of four groups of analytes:
1) Half-life <3 years
2) Essential nutrient
3) Physical property of sample medium
4) Consensus of Tri-Party managers

[2] These analytes are retained as COPECs

Toxicity Evaluation and Narrative Analysis. COPCs remaining after the background evaluation will be subject to two final screens: the toxicity evaluation and, if necessary, the narrative analysis.

The toxicity evaluation consists of a determination of whether or not a screening benchmark exists for the compound in question. Compounds for which no ecological benchmark exists will be identified as "uncertain COPCs" and discussed in the uncertainty section.

Remaining compounds may be subject to a narrative analysis. As described previously, the narrative analysis involves a consideration of factors such as process knowledge, results in other media, and results for similar analytes to support a conclusion on COPC identification when the results of statistical comparisons are ambiguous or show marginal differences only. This is an optional step that will not be implemented in many cases.

Final COPEC List. Compounds that were not excluded by one or more of the screening steps described above will be designated as COPECs. These will be subject to further evaluation in the BERA, according to the methods described in subsequent sections.

4.5.3.1.3 Exposure Pathways and Potential Receptors. Exposure pathways are the linkage between the contaminant source and the receptor and help to illustrate how contaminants can reach potential receptors, as well as how and where these receptors might be exposed. Ecological receptors are those organisms that, based on the exposure pathways and the life history of the receptor, are likely to be exposed to site contaminants.

Based on the habitat description, exposure pathways for each habitat type in the Columbia River will be identified. Based on the exposure pathways, receptor groups for each habitat will then be identified. These will not be specific species, but rather general categories of organisms that could be present in each habitat and which would share exposure characteristics. Groups of organisms that current information suggests may have a potential for exposure were described in Section 3.3.2 and consist of fish, algae and zooplankton, aquatic and terrestrial invertebrates, aquatic and terrestrial plants, amphibians, birds, and mammals.

Terrestrial habitat consists of shorelines that are periodically flooded and exposed. Because of the frequent inundation, this area would not support typical terrestrial receptors such as terrestrial arthropods or worms, but does present an easily accessible exposure route to benthic invertebrates that are stranded by the falling water level. These organisms would then be available to shorebirds. The receptor groups associated with each habitat type would form the basis of the assessment endpoints and group-specific measures of effect developed in subsequent sections of the report.

4.5.3.1.4 Ecological Conceptual Site Model. As described by Suter (1993), the major purpose of the CSM is to develop a series of working hypotheses about how stressors might affect ecological resources in the natural environment. The CSM combines information about stressors, exposure pathways, and potential receptors into an integrated model of the site, and through visual depiction serves to simplify and illustrate risk hypotheses.

For this study, the conceptual model will be constructed to depict not only the pathways from contaminant source to receptors, but also to show the relationship of near-shore areas to the channel portions of the river. This model is expected to be similar to that presented in Section 3.0, but may be modified based on RI sampling results. Near-shore areas on the right side of the river in the Hanford Reach include sloughs and seeps, which may be current or historical discharge points for Site contaminants. These areas were evaluated by the Source and Groundwater Component of the RCBRA. Sediments from near-shore areas are transported during high water periods to downstream areas, where they are deposited and exposed during low-water periods. Likewise, surface water from near-shore areas enters the normal river current system to mix downstream with water farther out in the channel. Through these mechanisms, most Hanford Site-related constituents are transported from near-shore areas to the main channel of the river, forming a complete exposure pathway to aquatic receptors, or in the case of sediments, to terrestrial receptors who may contact sediment exposed on low-water shorelines downstream of source areas. These mechanisms will be illustrated visually in the ecological CSM for the site.

4.5.3.1.5 Assessment Endpoints and Measures of Effect. Assessment endpoints, which are the entity (receptor group) and the attributes of the entity to be protected, will be based on the receptor groups identified in Section 3.3.2, modified if appropriate by the findings of the RI. Measures of effect, which are the methods used to evaluate the potential for effect for each of the assessment endpoints, will be conservative, generic, media- and receptor-specific ecological benchmarks. The assessment endpoints and measures of effect for each of the habitat areas previously identified are anticipated as summarized in Table 4-17.

Table 4-17. Preliminary Assessment Endpoints and Anticipated Measures of Effect. (2 Pages)

Habitat Type	Assessment Endpoint	Measure of Effect
Aquatic habitat	Survival, growth, and reproduction of fish	Aquatic life water quality criteria and benchmarks Tissue residue effects concentrations
	Survival, growth, and reproduction of aquatic plants	Plant-based soil benchmarks
	Survival, growth, and reproduction of algae (phytoplankton and periphyton) and zooplankton	Aquatic life water quality criteria
	Survival, growth, and reproduction of amphibians	Amphibian-specific benchmarks and toxicity values, where available; aquatic life water quality criteria.
	Survival, growth, and reproduction of benthic organisms	Sediment benchmarks

Table 4-17. Preliminary Assessment Endpoints and Anticipated Measures of Effect. (2 Pages)

Habitat Type	Assessment Endpoint	Measure of Effect
Terrestrial habitat	Survival, growth, and reproduction of soil invertebrates	Invertebrate-based benchmarks
	Survival, growth, and reproduction of terrestrial plants	Plant-based soil benchmarks
	Survival, growth, and reproduction of mammals	Wildlife-based soil benchmarks
	Survival, growth, and reproduction of birds	Wildlife-based soil benchmarks

These endpoints, which reflect general categories of receptors, are appropriate for the initial screenings of Steps 1 and 2. However, for Step 3, potential effects on additional endpoints will be considered, as described in more detail in Section 3.0.

4.5.3.2 Step 1: Screening-Level Toxicity Evaluation. According to EPA guidance (EPA 1997a), the effects evaluation is the establishment of contaminant exposure levels that represent conservative thresholds for adverse ecological effects. These are screening ecotoxicity values, or ecological benchmarks. In this section, the sources and values of ecological benchmarks for the BERA will be identified.

Most of the benchmark literature sources and values in the BERA will be the same as those used in the Source and Groundwater Component of the RCBRA. However, additional benchmarks were added, and include amphibian-specific surface water benchmarks, residue-effects levels for fish tissue evaluation, and updated sediment benchmarks developed for Ecology. In addition, bioaccumulation-based wildlife values will also be used, as available.

Table 4-18 shows the ecological benchmarks that will be used for compounds detected in surface water (both aquatic life and amphibians) and sediment to date. For completeness, these benchmark tables include all compounds detected in the Groundwater and Source Area Component of the RCBRA and so may include compounds neither analyzed nor evaluated in the present study. Because of its size, Table 4-18 is included in a separate section located at the end of this RI work plan.

Benchmarks were drawn from the sources described below. Benchmarks for any additional compounds detected in the RI sampling will be drawn from the same sources, or, if unavailable in these sources, from other EPA or literature sources as necessary. Amphibian benchmarks, which were not used in the Groundwater and Source Area Component of the RCBRA, were drawn entirely from the literature. These are available only for metals and some organic compounds.

NOTE: See the "Remedial Investigation Work Plan Tables" section located at the end of this work plan for the following table:

Table 4-18. Selected Ecological Surface Water and Sediment Benchmarks.

4.5.3.2.1 Surface Water Benchmark Sources. The screening benchmarks for freshwater aquatic biota were obtained from the following sources:

- *RESRAD Biota for Windows*, Version 1.21 (http://web.ead.anl.gov/resrad/home2/) (ANL 2006)
- WAC 173-201A, "Water Quality Standards for Surface Waters of the State of Washington"
- *National Recommended Water Quality Criteria* (http://www.epa.gov/waterscience/criteria/wqctable/index.html) (EPA 2006b)
- *Ecorisk Database* (Release 2.2) (LANL 2005)
- *Guidance for Ecological Risk Assessment Level II Screening Level Value*s (ODEQ 2001)
- *Toxicological Benchmarks for Screening of Potential Contaminants of Concern for Effects on Aquatic Biota on Oak Ridge Reservation: 1996 Revision* (Suter, G. W. and C. L. Tsao 1996).

4.5.3.2.2 Sediment Benchmark Sources. Sediment benchmarks were drawn from the following sources:

- *RESRAD Biota for Windows*, Version 1.21 (http://web.ead.anl.gov/resrad/home2/) (ANL 2006)
- *Creation and Analysis of Freshwater Sediment Quality Values in Washington* (Ecology1997)
- "Calculation and Evaluation of Sediment Effect Concentrations for the Amphipod *Hyalella azteca* and the Midge *Chironomus riparius"* (Ingersoll et al. 1996)
- *Ecorisk Database* (Release 2.2) (LANL 2005)
- *Guidance for Ecological Risk Assessment Level II Screening Level Value*s (ODEQ 2001)
- *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1997 Revision* (ORNL 1997)
- *Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario* (Persaud et al. 1993).

In addition, many benchmarks were drawn from the following more recent source:

- Ecology, 2003, *Development of Freshwater Sediment Quality Values for Use in Washington State, Phase II Report: Development and Recommendations of SQVs for Freshwater Sediments in Washington State.*

Where available, values from this updated source were used in place of older values from Ecology (1997).

4.5.3.2.3 Soils Benchmark Sources. Soils values will be used to evaluate exposed shoreline sediments. These values will also be used to evaluate dredge spoils, as part of the scenario described in Section 4.6.7.4. Sources of soils benchmarks are consistent with those used in the RCBRA, and are as follows:

- *RESRAD Biota for Windows*, Version 1.21 (http://web.ead.anl.gov/resrad/home2/) (ANL 2006)
- WAC 173-340, Table 749-3, *Ecological Indicator Soil Concentrations for Protection of Terrestrial Plants and Animals* (http://www.ecy.wa.gov/programs/tcp/policies/terrestrial/table_749-3.htm)
- *Ecological Soil Screening Levels,* Office of Solid Waste and Emergency Response (http://www.epa.gov/ecotox/ecossl/) (EPA, various dates)
- *Thermal Treatment Unit Ecological Risk Screen* (Hill Air Force Base 2005).

4.5.3.2.4 Amphibian Benchmark Sources. Amphibian benchmarks for surface water were drawn from the following sources:

- "Integrating Amphibians into Ecological Risk Assessment Strategies" (Westerman et al. 2003)
- "Ecotoxicology of Metals" (Linder and Grillitsch 2000)
- Hazardous Substance Database (EPA 2007b)
- "Comparative Toxicology and Risk Assessment of Amphibians" (Birge et al. 2000).

Sources for Tissue Residue Effects Levels. Tissue residue effects levels are concentrations in specific fish tissues, such as muscle or liver, that have been found to correlate to specific effects, such as reproduction. Effects levels for this study will be drawn primarily from the following databases:

- Environmental-Residue Effects Database, U.S. Army Corps of Engineers, Dredging Operation Technical Support Program
- *Linkage of Effects to Tissue Residues: Development of a Comprehensive Database for Aquatic Organisms Exposed to Inorganic and Organic Chemicals* (http://www.epa.gov/med/Prods_Pubs/tox_residue.htm) (Jarvinen and Ankley 1999).

Because the extensive data in these sources have not been aggregated into benchmarks, the database will be searched as necessary to obtain the lowest representative value to use as a screening value in the risk assessment. This will be during completion of the risk assessment, when specific compounds for which values are required is known.

For each medium listed above, other EPA or literature sources may also be consulted for compounds that do not have benchmarks from the sources identified.

4.5.3.3 Step 2: Screening-Level Exposure Estimate. In accordance with EPA guidance (EPA 1997a), the highest measured contaminant concentration in each media will be used to estimate exposure. This step will ensure that no potential ecological threats are missed.

4.5.3.4 Step 2: Screening-Level Risk Calculation. The risk calculation is the final component of the screening process of Steps 1 and 2. Risk calculation integrates the exposure and effects information collected as described in the analysis phase of the risk assessment to produce an estimate of the potential for effects on the designated assessment endpoints.

In this section, exposure and effects data for each compound are presented and compared to obtain an assessment of potential risks for each of the populations identified in the endpoints.

Media concentrations relative to a benchmark will be represented by the use of a hazard quotient (HQ). Single chemical HQs are a simple and effective means of integrating exposure and toxicity data. Specifically, the HQ quantifies the exposure experienced by a receptor to the exposures associated with toxicological effects documented in the literature. The HQ is expressed as the following:

$$HQ = \frac{\text{Exposure concentration or dose}}{\text{Chemical-specific benchmark}}$$

For this analysis, maximum detected concentrations are compared to benchmarks. Compounds with maximum concentrations that exceed benchmarks, as indicated by an HQ greater than 1.0, are identified as draft COPECs and retained for further evaluation in the Step 3 evaluation. Radionuclides will be evaluated as a group using a sum-of-fractions approach. Compounds with reporting limits that are greater than benchmarks are not evaluated quantitatively as COPECs, but will be discussed in the Uncertainty Section of the final report.

4.5.3.5 Step 3: Refinement of Assessment Endpoints and COPECs. Step 3 will constitute a more detailed evaluation of both assessment endpoints and potential effects. It involves consideration of a wider array of site and toxicity data, with the goal of focusing the results of the Step 2 analysis as much as possible with readily available information. At the end of Step 3, a draft report will be issued with recommendations about whether site-specific biota sampling or testing is necessary to resolve the risk questions at the site. The analysis provided by Step 3 is necessary to design successful biota studies, which target specific compounds, media, and receptors. Details of the components of Step 3 are provided below.

As described previously, the screening of Steps 1 and 2 will produce a list of draft COPECs, which are compounds with concentrations that exceed the receptor-specific benchmarks in at least one sample. Because of the conservatism of these generic benchmarks, however, an exceedance of benchmarks does not suggest that adverse effects are present or even likely, but does indicate that these compounds should be subject to additional evaluation to determine if effects are likely at this Site. In addition, the benchmarks for birds and mammals are typically based on exposure parameters (such as earthworm consumption) very different from those present in CRC habitats. For this reason, the additional evaluations of Step 3 will be conducted to further assess the potential for risk.

The goal of this analysis is to increase the accuracy and scientific validity of the risk conclusions by incorporating as much of the available and relevant site-specific and literature data as possible to estimate the actual exposure and effects in the CRC. No new analyses or testing will be conducted for this step. The results of this analysis will be a focused list of final COPECs and assessment endpoints for which the potential for risk is sufficient to warrant further consideration by more detailed ecological studies, such as biota collection or testing.

As noted previously, the study of risk in the Columbia River is unique in that extensive studies on the near-shore and riparian portion of the river have already been conducted in the Hanford Reach as part of the RCBRA risk assessment. The RCBRA effort assessed potential effects to the following receptor groups, which are generally the same as those evaluated by screening benchmarks in Steps 1 and 2:

- Plants
- Soil invertebrates (potential endpoint)
- Benthic macroinvertebrates (both sediment and water exposures)
- Amphibians
- Fish
- Birds (insectivores, herbivores, omnivores, and carnivores)
- Mammals (herbivores, omnivores, carnivores).

The near-shore aquatic zone included the portion of the river along the Hanford Site shoreline, including source areas and sloughs, and the aquatic habitats in these areas are in many ways similar to the habitats in the channel and left-bank portions of the river that comprise the rest of the study area of the CRC evaluation. Likewise, the riparian portions of the Hanford Site shoreline include exposed sediment depositional areas that constitute a soil exposure route to mammals and birds, and so in those respects are similar to the downstream islands evaluated as part of this study. Because of the similarity in habitat, exposure pathways, and receptor groups, the results of the RCBRA are appropriate as the basis of addition analysis in Step 3. Specifically, ecological studies conducted on the receptors in near-shore and Hanford Site riparian areas are an appropriate source of relevant information about potential effects in the remainder of the Columbia River in the Hanford Reach.

The array of evaluative approaches used in Step 3 will vary by assessment endpoint, and will draw from a variety of techniques that vary by assessment endpoint. For fish and benthic macroinvertebrates, COPECs identified in Steps 1 and 2 will be further evaluated by a closer examination of characteristics of the benchmark exceedances. This further examination may include the following.

1. **Location of Benchmark Exceedances:** As a first analysis, the location of benchmark exceedances will be evaluated, by mapping if appropriate. The location of exceedances can help identify potential sources. The relationship of a compound exceedance to potential Hanford Site and non-Hanford Site sources will be considered in the identification risk drivers.

2. **Magnitude of Exceedance:** The magnitude of benchmark exceedances will also be considered. Because of the conservatism of screening benchmarks, which are often based on large uncertainty factors, exceedances are not necessarily indicative of potential risk. As noted earlier, ecological benchmarks are typically based on concentrations with a low, or no, probability of effects. Associated with these values are usually lowest-observed-adverse-effect-levels (LOAEL) that reflect concentrations at which effects are likely. The actual concentration at which effects begin to occur in organisms typically lies somewhere between the two, so comparing concentrations to these two values helps to bracket the potential for risk. Concentrations that exceed no-effect benchmarks, but are still well below the probable-effects levels or LOAELs, are often not likely to present a significant potential for risk. This evaluation is highly compound-specific and will be based on a compound-specific evaluation of the benchmarks and supporting toxicity data.

3. **Duration of Exposure:** In some scenarios, such as mammals and birds exposed to shoreline soils, the assumption is made that receptor species feed 100% of the time in the area of interest. In actuality, these species would feed there primarily during periods of low water, which occurs a minority of the time. Duration of exposure may thus be significantly less than assumed in the screening of Steps 1 and 2, and this assumption will be reconsidered in the revised evaluation of risk.

4. **Number of Exceedances:** Compounds that exceed benchmarks in relatively few locations, particularly if exceedances are small and widely scattered, may not be indicative of point sources or widespread risk. These factors will be considered in the identification of risk drivers.

In addition, all assessment endpoints will be evaluated by a review of the RCBRA risk assessment studies. These studies are not compound-specific, but evaluate the effects of site constituents in combination, as they exist in the sources areas adjacent to the river. For this component of the Step 3 evaluation, the many ecological tests conducted as part of the RCBRA will be reviewed to estimate potential effects on similar compounds and similar concentrations detected in the rest of the river. Compounds with concentrations in CRC surface water and sediment similar to those in the portions of the river evaluated in the RCBRA will be assumed to have effects similar to effects identified in the RCBRA ecological studies. Likewise, for wildlife

receptors on the islands, compounds with shoreline soil concentrations similar to those from riparian areas evaluated in the RCBRA studies will be assumed to have bioaccumulation effects similar to effects identified in the RCBRA bioaccumulation and food chain models.

The specific studies conducted during the RCBRA that may be relevant to the Columbia River BERA, and which may be consulted during the Step 3 analysis consists of the following, by assessment endpoint (DOE/RL-2007-21):

- Plants:
  - Toxicity tests
- Soil invertebrates:
  - Nematode bioassays
  - Benchmarks
- Benthic invertebrates:
  - Toxicity testing with *Hyalella* and *Ceriodaphnia*
  - Rock basket studies for community composition
  - Tissue concentrations
  - In situ clam survival
  - Clam histopathology
  - Snail diversity and abundance
- Fish:
  - COPEC concentrations in fish tissue
  - Fish histopathology
- Birds and mammals:
  - Exposure modeling of middle and upper trophic-level avian and mammalian receptors
  - Measured tissue concentrations
  - Field studies: Avian reproductive success, small mammal balanced gender ratios, juvenile recruitment, relative abundance, gross morphology
- Amphibians:
  - Frog Embryo Teratogenesis Assay Xenopus bioassays
  - Tissue concentrations.

Several of the RCBRA studies assessed contaminant mixtures (e.g., bioassays, histopathology), while other studies evaluated individual COPCs (e.g., gradient analysis, reference/waste site comparison).

These studies provide a comprehensive assessment of COPECs and receptors. As noted, these studies will be particularly relevant for instances where the concentrations of COPECs in the media present in the area evaluated by the RCBRA studies are similar to the concentration in media elsewhere in the river. In the Hanford Reach, results may be directly transferable, since many characteristics of the river are similar shore-to-shore in this reach. These studies will also be used as appropriate in the evaluation of downstream areas of Lake Wallula, unless characteristics of individual investigation areas suggest a more specific approach.

The results generated at the end of the Step 3 analysis will be included in the RI report. The results of this analysis will be a list of final COPECs or assessment endpoints for which further evaluation may be necessary. The need for and type of potential further evaluation will depend on the specific COPEC or assessment endpoint, and will be considered within the wider context of Superfund remediation, risk assessment, and risk management options.

4.5.3.6 Future Studies. At the end of Step 3, a draft report will be issued that documents the findings, conclusions, and recommendations of Steps 1 through 3 of the BERA. At this stage, referred to as a Scientific Management Decision Point, the project will pause to allow the Tri-Parties, Tribes, Trustees, and stakeholders time to review the results of the draft report and discuss the path forward. This stage is implemented to ensure that the next step of the BERA, which typically involves expensive biota field and laboratory studies, is undertaken with full advantage of the formal review and consultation process.

After the detailed evaluations of Step 3, any COPECs or media associated with potential risk will be considered for further ecological studies in accordance with the general steps and procedures of EPA guidance (EPA 1997a). The design of these studies, if implemented, will depend on the specific receptors and media associated with the risk, as revealed by the Step 3 analysis. Recommended studies may include toxicity tests, bioaccumulation studies, additional biota tissue sampling, and similar activities.

Specific receptors will be chosen as surrogates for the categories of receptors used in the Step 1 and 2 analysis. In the event that additional studies are required, additional assessment endpoints may include the following:

- Survival, growth, and reproduction of amphibians
- Survival, growth, and reproduction of middle trophic-level birds: mourning dove (herbivore), meadowlark (omnivore), and kingbird (insectivore)
- Survival and growth of upper trophic level birds: red-tailed hawk, bufflehead, and heron (carnivores)

- Survival, growth, and reproduction of insectivorous mammals (bats)
- Survival, growth, and reproduction of middle trophic-level riparian mammals: pocket mouse (herbivores), deer mouse, and grasshopper mouse (omnivore)
- Survival, growth, and reproduction of upper-trophic-level mammals: badger (carnivore).

Any additional BERA studies will be described in a separate work plan that outlines the purpose and specific methodologies of each biological test or collection. This work plan will be subject to Tri-Party review and Tribal and stakeholder input, in accordance with the communication objectives for the RCBRA.

4.6 BASELINE HUMAN HEALTH RISK ASSESSMENT

This section provides a description of the methodology for the BHHRA for the RI of Hanford Site hazardous substance releases to the Columbia River. Remedial activities at the Hanford Site are being conducted within the regulatory framework of CERCLA and to date have consisted of extensive studies in the upland and riparian areas of the Hanford Site and the near-shore areas of the Columbia River. The Columbia River, which contains residuals from both historical activities at the Hanford Site as well as upstream and other non-Hanford Site sources, is not formally part of the Hanford Site, but is being assessed using the same CERCLA process.

This work is part of a larger effort by DOE to conduct a comprehensive evaluation of Hanford Site hazardous substance releases to the Columbia River. Upland, riparian, and near-shore areas proximate to the former reactor areas are currently being evaluated by a separate risk assessment for the Source and Groundwater Component of the RCBRA (DOE/RL-2007-21).

This BHHRA focuses on the section of the Columbia River adjacent to and immediately downstream of the Hanford Site (Study Area). Specifically, the boundaries of the Study Area to be evaluated within the BHHRA extend from the Vernita Bridge (RM 388) to McNary Dam (RM 292), and will also include islands located within these boundaries. Note that the Study Area does not include portions of the shoreline along the Hanford Site that were addressed as part of the Source and Groundwater Component of the RCBRA (DOE/RL-2007-21).

The objective of the BHHRA is to conduct a conservative human health risk analysis to evaluate whether river areas/media/constituents pose a significant human health risk and thus may require additional response actions or study, or to determine if no further action is warranted.

The BHHRA will focus on estimating health risks for the receptor groups most likely to have potential exposures to river media (sediment, surface water, island soil, and/or fin fish) and will evaluate risks over a range of exposure levels in accordance with EPA risk assessment guidance. The exposure scenarios proposed for evaluation represent those groups who will likely have the fullest range of exposures to these various media, ranging from the more casual/intermittent user

of these resources to those anticipated to have the highest intensity/frequency of potential exposures to river media. The BHHRA will quantify health risks for the following receptors:

- Subsistence Native American, as represented by the Yakama Tribe (highest overall river exposures/fish consumption rates)
- Casual recreational user (waterskier/swimmer/beachgoer)
- Avid angler (boat fisher/wader with high fish consumption rates).

As previously discussed in Section 3.3.3, a risk assessment will not be conducted for the CTUIR scenario, as this scenario is presently being evaluated under the Source and Groundwater Component of the RCBRA.

For all receptors except the Native American receptor groups, both central tendency exposures (CTEs) and reasonable maximum exposures (RMEs) will be evaluated. The CTE reflects average exposures to a population, whereas the RME reflects upper-bound exposures. Although response actions are typically based on risks associated with RME scenarios, the evaluation of a range of exposures provides a quantitative means of measuring the uncertainty surrounding exposure estimates (EPA 1989b). For the Native American scenario, evaluation of only the RME scenario will be included.

Additionally, the BHHRA will evaluate potential future use of dredged sediment as fill soils in a residential setting, as well as potable use of Columbia River surface water. These two evaluations will be conducted through a comparative approach where environmental concentrations of contaminants are compared to medium-specific, risk-based benchmarks, as further discussed in Section 4.6.8.

4.6.1 Guidance for the Baseline Human Health Risk Assessment

The methodology presented herein is consistent with EPA guidance for performance of human health risk assessments at CERCLA or *Resource Conservation and Recovery Act of 1976* (RCRA) sites, and also reflects recent discussions with representatives from EPA Region 10, Ecology, DOE, and other interested parties. Although, as discussed, the Study Area within the Columbia River is not a designated CERCLA site; the CERCLA approach will be followed for completion of the BHHRA. This approach is consistent with that taken in the Source and Groundwater Component of the RCBRA (DOE/RL-2007-21), as well as the process outlined in the *Columbia River Component of the River Corridor Baseline Risk Assessment: Basis and Assumptions on Project Scope* (DOE/RL-2004-49).

In addition to the quantitative CERCLA-compliant BHHRA, this approach includes a separate risk assessment methodology consistent with the State of Washington *Model Toxics Control Act* (MTCA) (WAC 173-340) regulations. This approach, which consists of comparisons of chemical concentrations to MTCA/Washington medium-specific benchmarks, is discussed further in Section 4.6.8.

The quantitative BHHRA will be characterized in accordance with EPA Superfund risk assessment guidance and results will be presented in a format consistent with that specified by *Risk Assessment Guidance for Superfund (RAGS) Part D* (EPA 2001b). Full citations for specific risk assessment guidance documents referred to within this work plan are provided in Section 8.0.

4.6.2 Overview of the BHHRA

Consistent with EPA guidance, the BHHRA consists of five main components:

- Hazard identification – includes data usability assessment, describes nature and extent of contamination, and identifies which chemicals of potential concern will be carried through the quantitative analysis (i.e., COPCs).

- Exposure assessment – estimates chemical concentrations in environmental media, identifies who may be exposed (receptor), the applicable exposure media and pathways, and quantifies the rate/dose of exposure.

- Dose-response assessment – uses chemical-specific animal and human toxicity data to identify what health effects might be caused by exposure to selected COPCs.

- Risk characterization – provides estimates of potential health effects and radiation doses for each exposure scenario and clarifies which chemicals and exposure pathways are associated with these potential risks.

- Uncertainty analysis – presents key areas of uncertainty associated with the various components of the risk assessment, including data gaps in toxicological or exposure assessment information and the conservative assumptions or scientific judgments used to bridge these data gaps.

The first steps in the BHHRA are to understand what environmental data will be used and what receptor groups will be evaluated, and to select appropriate exposure parameters for calculation of exposure dose, including receptor and chemical-specific information (e.g., exposure point concentrations [EPCs]). These components are included in the hazard identification and exposure assessment components of the BHHRA. The results of these two steps are then integrated with the dose-response information for each evaluated chemical/radionuclide to calculate noncancer and cancer risks, as well as effective doses for radionuclides. In this document, both noncancer and cancer effects are collectively referred to, simply, as "risks." The results for these three human health effects endpoints will be compared to EPA risk management criteria/endpoints to provide an indication of compounds and locations that exceed these criteria to assess the need for additional response actions/consideration in a future FS.

4.6.3 Site Description

A description of releases to the Columbia River is provided in Section 2.0 and is not repeated here. A detailed description of Hanford Site history and impacts to the Columbia River may also be found in the *Columbia River Component Data Gap Analysis* (WCH-201).

The Study Area extends from Vernita Bridge to McNary Dam (RM 388 to RM 292), encompassing 96 linear miles of river, and includes river islands and shoreline on the banks of the river opposite the Hanford Site. Additionally, points upstream of Vernita Bridge and other contributing non-Hanford Site sources to the river were considered as background locations. These background areas were evaluated with respect to conditions within the Study Area as a means of identifying baseline levels of contamination resulting from non-Hanford Site sources of impact. As previously discussed, the study area has preliminarily been subdivided into four separate risk assessment sub-areas:

- Upriver: Upriver of Vernita Bridge and RM 388 to RM 420
- 100 Area: Vernita Bridge at RM 388 downstream to RM 365
- 300 Area: RM 365 downstream to RM 339
- Lake Wallula: RM 339 downstream to McNary Dam, at RM 292.

These areas were selected based on spatial distribution of contaminant concentrations observed in surface water and sediment, with respect to the various sources of contamination from the Hanford Site. The surface water and sediment data were reviewed by generating plots of concentration by river mile for metals, organics, and radionuclides. Certain metals (e.g., chromium, lead, and thallium) and radionuclides (e.g., uranium-234, uranium-238, and tritium) showed pronounced variability by river mile. Based on these spatial plots and locations relative to the former 100 and 300 Areas, the river was divided into the four sub-areas (Upriver, 100 Area, 300 Area, and Lake Wallula Sub-Areas) listed above.

The evaluation of these smaller parcels within the river, rather than the entire river stretch, will allow for more interpretive and focused conclusions from the BHHRA. Unlike certain upland exposures being evaluated within the aforementioned Source and Groundwater Component of the RCBRA (DOE/RL-2007-21), the recreational uses and activities proposed for evaluation in this Columbia River BHHRA are focused on "broad area" rather than smaller parcel/point exposures. The only potential exceptions to this breakdown into the separate sub-areas may be for separate evaluation of islands and recreational areas, or smaller areas of the river with significantly elevated concentrations of contaminants (i.e., "hot spots"). Final subdivision of the river areas, however, will be dependent upon the results of data collection proposed within the SAP.

For the two uppermost sub-areas of the Study Area, the lateral boundaries of the study area were set to complement the study boundaries of the Source and Groundwater Component of the RCBRA (DOE/RL-2007-21). These studies evaluated the near-shore portion of the river to a water depth of approximately 1.8 m (6 ft) from the low-water mark ("green line") on the right shore (facing downriver). The Study Area boundaries are further described in Section 4.1.1.1.

4.6.4 Hazard Identification

The objective of the hazard identification is to present the relevant sampling data, discuss the use of such data in the BHHRA, and select the COPCs for each medium. The COPCs are the chemicals and radioisotopes that are carried through the quantitative risk assessment.

4.6.4.1 Available Data Sets

A significant amount of historical environmental data exists for the Columbia River, dating back to the 1940s and reflecting a number of individual state and federal monitoring programs and studies. These data have been extensively examined and a subset, considered as usable for characterization purposes, is included in an electronic database referred to as the "CRC database" (WCH-64, WCH-91). All data included in the CRC database are assumed to be usable for risk assessment (WCH-64), although more recent data (e.g., 1990 and later) may be used preferentially over historical data in order to characterize recent environmental conditions. Due to the sediment suspension, mixing, and redeposition processes in addition to chemical degradation and/or dilution processes that have continuously occurred in the river since the initial releases from the Hanford Site, these more recent data are likely to better represent current conditions throughout the Hanford Reach. Sediment, fish tissue, and surface water data collected as part of this RI sampling plan will augment the existing data set.

Additional collection of surface water, island soil, sediment, and fish tissue samples is anticipated to begin in the fall of 2008. These data will be incorporated into the CRC data set and used in the BHHRA.

4.6.4.2 Data Management. For the BHHRA, all data incorporated into the CRC database, exclusive of the river data used in the Source and Groundwater Component of the RCBRA (DOE/RL-2007-21), will be considered useable, with a few exceptions. The general treatment of the data is summarized below.

Data Qualifiers: Sample results include various levels of data validation. With the exception of samples qualified as rejected ("R"-flagged) or samples with detected concentrations less than five times the detected laboratory or field blank concentration ("B"-flagged), all qualified data will considered to be usable for purposes of risk assessment.

Duplicate Samples/Analyses: Where duplicate samples are collected, either the maximum detected concentration (if detected in either or both samples) or minimum PQL (if nondetect in both samples) between the primary and duplicate sample results will be used as the representative concentration (RC) for that sample. Likewise, where a constituent is analyzed via more than one analytical method, the maximum detected result or minimum PQL among the various results will be used as the RC for that constituent.

Censored Data (chemical constituents): Censored data (i.e., results reported as not detected at the PQL) will be evaluated as part of the BHHRA. Use of censored results in generating summary statistics is often problematic, as the constituent may be present at levels just below the

PQL or may not be present at all. Several approaches for evaluating and using censored data will be used as described below.

Sample-specific reporting limits potentially may be elevated relative to typical PQL s among other sample results. All censored results will be evaluated with respect to maximum detected concentrations within a data set as well as the data quality objectives set forth in the QAPP (Section 3.0 of the SAP [Appendix A]). Depending on the magnitude of elevation and the number of censored results within a sample set, elevated PQL s may be excluded from the BHHRA data set. As a rule of thumb, PQL s exceeding twice the maximum detected concentration within a data set will not be used in the risk assessment. This approach is consistent with EPA risk assessment guidance (EPA 1989b), which instructs the risk assessor to exclude elevated reporting limits from the quantitative risk assessment "if they cause the calculated exposure point concentration to exceed the maximum detected concentration for a particular sample set" (p. 5-10). Where a detection limit exceeds more than twice the maximum detected value, use of the PQL for the censored value would result in inclusion of a value greater than the maximum detected concentration, thereby artificially inflating the EPC above the maximum positive result. If the condition arises where a relatively high number of elevated detection limits occurs in a data set, the data set will be flagged as a potential data gap and discussed in the uncertainty analysis.

If censored data meet project-specific PQL s and are determined to be suitable for inclusion in the BHHRA, then the censored data will be evaluated with respect to the size of the data set, the number of censored results, and data distribution. Statistical approaches other than substitution will be employed as a means of calculating summary statistics and EPCs. Such approaches may include Kaplan-Meier method, Maximum Likelihood Estimation, or regression-on-order statistics.

Radioisotopes. Radioisotope results will be reported as numerical values. Due to the estimation procedure used to determine results for some radionuclides, the results of certain samples may be reported as negative numbers. Negative values will be used without modification in generating summary statistics.

4.6.4.3 Selection of Contaminants of Potential Concern. A list of COPCs will be generated for the BHHRA that is different from those generated for the BERA. The approach for COPC refinement outlines a process for focusing contaminants based on comparing Hanford Site concentrations to background or reference areas using conclusions and data summaries from field investigations. The process is consistent with guidance pertaining to selection of COPCs for risk assessment (EPA 1989b, RAGS Part A Chapter 5, "Data Evaluation") and the approach established for the RCBRA source and groundwater component.[7] The COPC refinement process includes a number of complementary steps and criteria, which begin with a pre-selected list of contaminants that will be excluded and a list that will be included. These constituents were

[7] The COPC refinement approach documented in this work plan RCBRA source and groundwater report (DOE/RL-2007-21) has not been reviewed and approved by the Tri-Parties. If the COPEC refinement process documented in the report is revised during the course of review and approval, it is expected that the COPEC refinement process for this remedial investigation will be revised in a similar way.

previously identified in Tables 4-15 and 4-16, respectively. The inclusion and exclusion lists recognize and take advantage of the knowledge gained through decades of Hanford Site characterization and cleanup work that has preceded this assessment.

Figure 4-9 provides an overview of the COPC refinement process for the BHHRA. In addition to the inclusion/exclusion list, additional selection steps include evaluation of detection status, comparison to screening criteria, and statistical comparisons of site data to background or reference data. The quantitative methods used as part of the statistical analysis will provide valuable information for the included analytes and also provide a sound technical basis for eliminating less relevant analytes from the quantitative risk assessment.

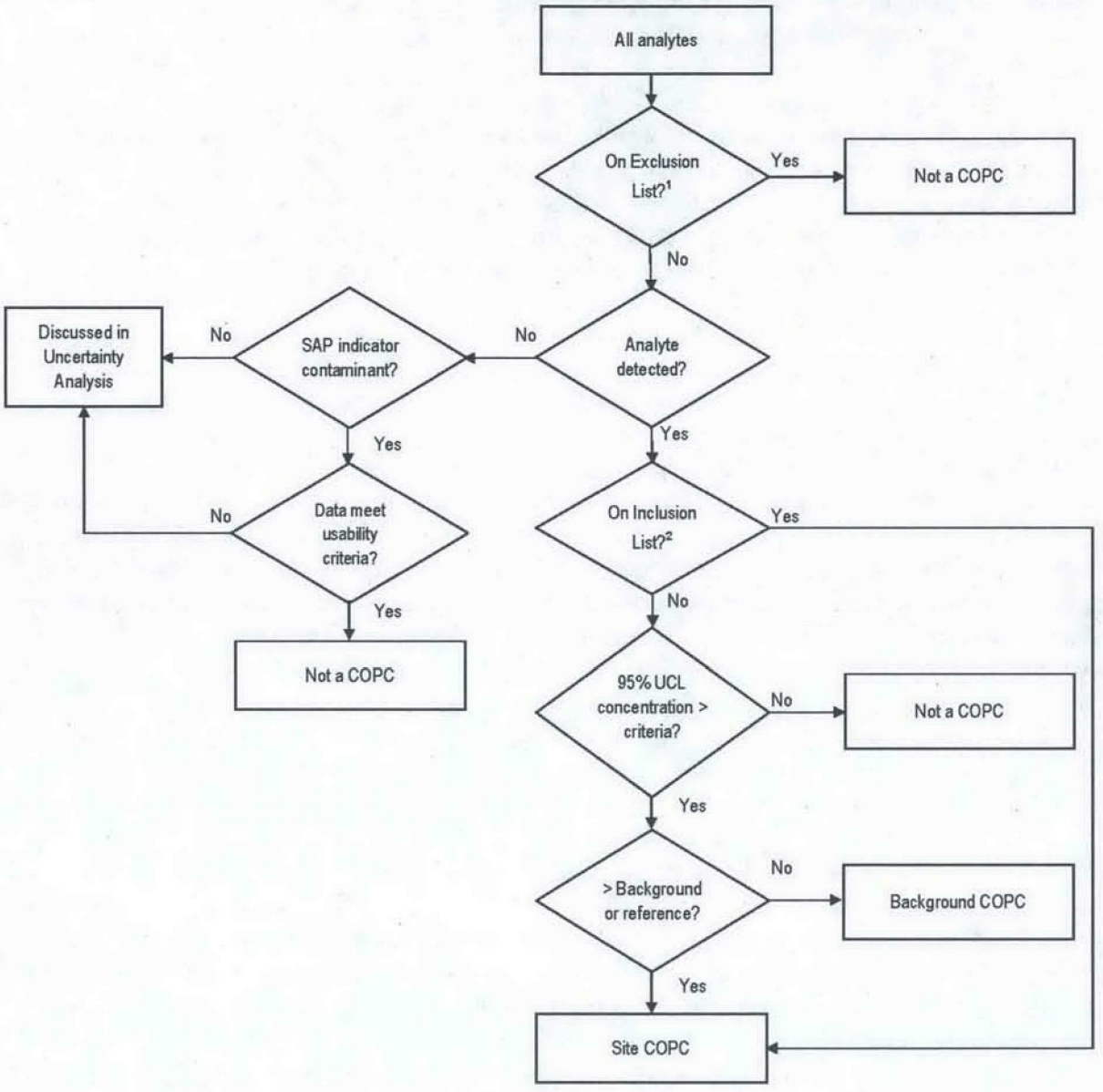
4.6.4.3.1 Nondetected Analytes. Analytical results for island soil, sediment, water, and biota collected for the Columbia River investigation will be evaluated against the data quality criteria specified in the QAPP (Section 3.0 of the SAP [Appendix A]). As a measure of data quality, analytical results for chemical constituents identified as nondetects in the Columbia River data set will be compared to the laboratory-required detection limits prescribed in the QAPP. Nondetect results reported at values higher than the prescribed detection limit will be identified for additional consideration. The results associated with these analytes where the nondetect result exceeded the target PQL[8] will be acknowledged as uncertainties in the BHHRA. (As previously discussed, all radioisotope data will be presented as numeric [i.e., noncensored] values.) Nondetect constituents with detection limits lower than the target PQL will be ruled out as COPCs and will not be considered further in the risk assessment.

4.6.4.3.2 Detected Analytes. Detected analytes are the dominant focus of COPC refinement. Comparison to screening criteria, background concentrations, statistical comparisons, and the narrative analysis are used to determine the COPC list.

4.6.4.3.3 Screening Criteria. In lieu of a toxicity criteria screen described in the RCBRA, the 95% UCL of the mean concentration of each detected analyte will be compared to human health risk-based screening criteria to focus the COPC list. This concentration screening approach is consistent with EPA risk assessment guidance (EPA 1989b). Constituents with 95% UCL concentrations exceeding the screening criteria or standards are identified as draft COPCs. Concentration of these analytes will then be compared to background/reference concentrations, and classified as either "Background COPCs" or "Site COPCs" and be retained for further analysis in the BHHRA. These statistical comparisons are discussed further in Section 4.4.3. Constituents with 95% UCL concentrations less than screening criteria are assumed to pose relatively negligible risk and are not proposed to be evaluated further in the BHHRA.

[8] A value approximately five to tenfold higher than the analytical method detection limit corresponding to a reasonably high degree of confidence in the reported result.

Figure 4-9. COPC Refinement Process Flow Diagram.



[1] Consisting of four groups of analytes:
1) Half-life <3 years
2) Essential nutrient
3) Physical property of sample medium
4) Consensus of Tri-Party managers

[2] By consensus of Tri-Party managers these analytes are retained as COPCs

The human health benchmarks that will be used to select draft COPCs for surface water, island soil, sediment, and fish data include both risk-based concentrations, which reflect potential health effects, as well as other regulatory standards and criteria, as available. For each compound, risk-based or regulatory criteria from a variety of sources, including both EPA and Ecology, will be reviewed, and then the lowest value from among the sources will be chosen as the final human health screening value. A summary of regulatory benchmarks that were considered are provided in Tables 4-19 through 4-21, which are included in a separate section located at the end of this work plan. Because the identification of site analytes and the selection processes for COPCs have not been finalized, these tables and the Analytical Performance Requirement tables presented in Section 3.0 of the SAP (Tables 3-1 through 3-3) have a very wide range of analytes presented on them. Tables 4-5, 4-6, and 4-7 list the analytical methods proposed for the RI, along with the analyte reporting list associated with each method.

The selection of the appropriate criteria relies on the EPA Region 10 Memorandum dated April 17, 2007 (EPA 2007c), which provided recommendations for human health screening at EPA Region 10 CERCLA and RCRA sites. As per this memorandum, risk-based values for noncarcinogenic effects will be adjusted downward by a factor of 10 to reflect an HQ of 0.1; cancer-based values are based on 1×10^{-6} cancer risk and will remain unadjusted. A summary of the benchmarks to be considered in this evaluation is presented below by medium.

Surface Water: Surface water in the stretch of the Columbia River comprising the Study Area is used for both recreational purposes (i.e., boating, fishing, swimming) and as a drinking water source for various municipalities (e.g., Richland). For surface water, the following criteria will be considered:

- *Region 6 Human Health-Medium Specific Screening Levels* for residential water (EPA 2007d). If Region 6 values are not available for a constituent, then Region 9 preliminary remediation goals for "tap water" (EPA 2004c) will be used when available.

- *National Recommended Water Quality Criteria, 2006* (EPA 2006b). Values for "consumption of water and organisms" will be used.

- *National Primary Drinking Water Standards* (EPA 2003b). Values for maximum contaminant levels (MCLs) will be used if available; if not available, then Health Advisories will be used (EPA 2006c).

- Ecology Cleanup Levels and Risk Calculation (CLARC) Searchable Database, Method B Surface Water Standards and Method B Groundwater Standards (Ecology 2007). The lower of noncancer- and cancer-based values will be applied.

- Radiological drinking water MCLs (EPA 2000b, 2003c) will be used for radioisotopes.

NOTE: See the "Remedial Investigation Work Plan Tables" section located at the end of this work plan for the following tables:

Table 4-19. Selected Human Health Benchmarks for Island Soil and Sediments in the Columbia River Baseline Human Health Risk Assessment.

Table 4-20. Selected Human Health Benchmarks for Surface Water for the Columbia River Baseline Human Health Risk Assessment.

Table 4-21. Selected Human Health Benchmarks for Fish Baseline Human Health Risk Assessment.

Sediment and Island Soil: Directly applicable human health criteria for freshwater sediment have not been identified.[9] Therefore, available soil benchmarks will be used for human health sediment screening criteria, as well as for island soil. Generally, the use of soil benchmarks for the evaluation of sediment concentrations is very conservative because the frequency of access to and contact with sediments is typically much lower than those for soils in a residential setting, and the exposure pathways considered in soil benchmarks (e.g., produce ingestion for radionuclides) may not be relevant for sediment/island soil exposure scenarios. Nevertheless, these benchmarks will be used as conservative screening criteria for selection of sediment and island soil COPCs. The soil benchmarks will be drawn from the following sources:

- *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (EPA 2002b)
- *Soil Screening Guidance: Technical Background Document* (EPA 1996)
- *EPA Region 6 Human Health Medium-Specific Screening Levels* for residential soil (EPA 2007d). In cases where a Region 6 value is not available, Region 9 preliminary remediation goals for "residential soil" values will be used if available (EPA 2004c)
- Ecology CLARC Searchable Database, Method B Unrestricted Land Use Values for Soil (Ecology 2007). The lower of noncancer and cancer based values will be applied
- Ecology Method B Soil Concentrations for Groundwater Protection, derived in accordance with the exposure assumptions and formulae provided in WAC 173-340-747
- Benchmarks for radiological compounds will consist of the cleanup values cited in EPA's Technical Background Document, *Soil Screening Guidance for Radionuclides,* Table D-1 generic (no accounting for decay) Soil Screening Levels for Radionuclides (the minimum value between direct ingestion of soil and external radiation exposure will be used) (EPA 2000b).

As noted, the lowest value among the screening criteria provided above (for each medium) will then used as the "final" human health screening level for comparison to surface water, island soil and sediment concentrations in the Study Area. These comparisons will be made by comparing the 95% UCL of each Hanford Site concentration in sediment, island soil, or surface water data collected from the Study Area and comparing that concentration to the lowest of the applicable benchmarks described above. Constituents with 95% UCL concentrations exceeding the human health-based benchmark will be retained as "draft" COPCs and be carried through the next step consisting of comparison of site concentrations to background/reference concentrations.

[9] The freshwater sediment benchmarks identified to date are either focused exclusively on protection of ecological biota or are stated to be protective of both human health and ecological receptors and, thus, are not directly relevant.

For cases in which a benchmark is not available for a particular constituent, the benchmark for another constituent that is structurally similar to the chemical of interest will be used, as appropriate. If a reasonable surrogate is not available, then the constituent will be excluded as a COPC but will be discussed in the uncertainty analysis.

Fish Tissue: Applicable finfish data in the CRC database will be evaluated for suitability for inclusion in the BHHRA. Biota data will be limited to that obtained from various finfish fillet, organ, and/or whole body samples. The following criteria will be sequentially used to identify the COPCs in finfish tissue data retained for this analysis.

1. If a constituent is detected in fish tissue and was also detected in either surface water and/or sediment, then the constituent will be screened using criterion #2. If the detected constituent is not detected in either surface water and/or sediment, then it will be further evaluated for inclusion or elimination as a COPC for this medium, taking into account factors such as frequency of detection, toxicity, background concentrations, and Hanford Site process knowledge. All constituents detected in fish tissue that are eliminated as COPCs will be discussed in the uncertainty analysis of the BHHRA.

2. 95% UCL finfish tissue concentrations for chemicals retained during step 1 will be compared to risk-based concentrations (RBCs) for fish developed by EPA Region 3 (EPA 2007e). These risk-based concentrations will be adjusted to account for the high consumption rates for some of these receptors (e.g., subsistence Native American scenarios) by substituting the default fish ingestion rate with the highest fish ingestion rate among the receptors proposed for evaluation. Fish RBCs are currently not available for radionuclides; therefore, using the same assumptions underlying RBCs for chemical constituents and the equations for calculating radiological exposures as provided in EPA (1989b), RBCs will be derived for radionuclides.

   Chemicals with 95% UCL concentrations above these adjusted risked-based concentrations will be retained as a draft COPC for finfish tissue, and will be carried through to the next step consisting of comparisons to background concentrations.

Evaluation of Background Concentrations. As previously discussed in Section 4.4.3, "background"-related chemicals and radioisotopes will be identified, although they will be retained as COPCs throughout the human health risk assessment process. Note that this information (determination of "background" contaminants) will be used to understand the background contribution to cumulative health risks and guide future remedial actions, if warranted. Therefore, "background-related" constituents will be identified and carried through the quantitative BHHRA as "background COPCs" in order to estimate cumulative health risks. This approach differs from that used in the RCBRA, in which "background/reference" contaminants were eliminated as (site-related) COPCs, although background risks were separately evaluated in the risk assessment. A discussion of how Site-related risks (associated with "Site COPCs") will be differentiated from those associated with "background" COPCs in the Columbia River BHHRA is provided in Section 4.6.7.

4.6.5 Exposure Assessment

The objective of the exposure assessment is to estimate the type and magnitude of potential exposure to site-related COPCs present at or migrating from the Site. Exposure is quantified for the populations potentially exposed to contaminated media via specific exposure pathways, based on current and future potential land and water uses. Both complete and potentially complete exposure pathways will be evaluated as part of the human health risk assessment.

The exposure assessment will be conducted in a manner consistent with EPA risk assessment guidance (e.g., EPA 1989b, 1997a, 2001b, 2004d). For each identified receptor at each exposure point, complete or potentially complete exposure pathways will be identified based on site activities and uses and the presence of COPCs in environmental media. Age groups that represent the longest or most intense exposure periods will be selected to be adequately protective of all stages of the receptor's life.

4.6.5.1 Preliminary Conceptual Site Model. Section 3.0 provides a detailed description of the CSM. The CSM identifies the sources of contamination and the environmental transport and exposure pathways between contaminant sources and applicable receptors by using historical information and existing data. Figure 3-3 provides a CSM summary of contaminant sources, transport/migration pathways, potential human receptors and potentially complete exposure pathways. The current CSM reflects historical information and analytical data collected to date, as well as discussions with federal and state regulators and other interested parties. As additional environmental data are generated, the CSM will be reevaluated and, if necessary, adjusted.

The Columbia River is widely used for recreational purposes such as boating, wading, swimming, fishing, and water-skiing, and numerous beaches, boat ramps, and wildlife viewing areas are located throughout the Study Area. The Hanford Reach National Monument consists of an 82-km (51-mi) stretch of the Columbia River and federally owned riparian lands. Below the southern site boundary recreational use is wide-spread throughout Lake Wallula, the next 80 km (50 mi) of the McNary Dam impoundment.

Numerous islands are located within the Study Area. Most of these islands are owned by federal or state agencies and are designated as conservation/recreation areas. Many of the islands (or portions of the islands) are entirely submerged during periods of high water and consequently subject to depositional/erosional forces.

In addition to recreational use, surface water of the Columbia River is used for river navigation/transportation, hydropower, and as a domestic, agricultural, and industrial water supply. The town of Richland relies on filtered/treated river water as its source of public drinking water; the Richland Pumphouse, a primary treatment system, is located near RM 340. The river also provides essential habitat for a variety of resident and migratory fish and wildlife.

Based on regional land use and beneficial water use, the following exposure scenarios will be evaluated in the BHHRA. These scenarios reflect the receptors most likely to have the longest and/or most intense and/or most comprehensive exposures to any of the four river media: sediment, surface water, island soil and fish. Accordingly, evaluation of these four different receptor groups is assumed to be protective of other lesser exposed receptors. The approach for selection of these receptors also considered previously issued scoping documents (e.g., DOE/RL-2004-49) and the Source and Groundwater Component of the RCBRA (DOE/RL-2007-21) as well as numerous meetings, workshops, and discussions with the Tri-Parties and various stakeholders. As discussed, the BHHRA for the Columbia River evaluates only riverine exposures and does not address potential exposure scenarios associated with upland areas of the Hanford Site. The BHHRA does, however, include evaluation of potential residential exposure to sediments assumed to be dredged from the Columbia River channel and placed on upland areas with no restrictions on use assumed. In addition to the evaluation of the four receptors described below, the BHHRA will also include an assessment of potable water use of Columbia River surface water. Each of these scenarios is described briefly below.

Native American. The Native American scenario includes local and regional tribes who have ties to the Hanford Reach of the Columbia River and surrounding lands. For this BHHRA, subsistence fishing-related exposures to only Yakama Nation receptors will be evaluated. The CTUIR scenario, in its entirety, is currently being evaluated in the Source and Groundwater Component of the RCBRA and therefore is not included as part of the Columbia River BHHRA. Environmental data collected during the RI will be provided for an update to the CTUIR scenario in the future.

Potential routes of exposure to COPCs in contaminated sediment, island soil, and/or surface water include incidental ingestion, dermal contact, and dust inhalation during a variety of activities including boating, fishing, swimming, or other cultural activities.[10] The Native American receptors could also potentially be exposed to COPCs through consumption of fish from the river. In fact, the majority of their daily diet is assumed to consist of finfish caught in the Columbia River. This subsistence Native American scenario is consistent with scoping statements provided in Section 3.2.8 in the Columbia River Component of the RCBRA: Basis and Assumptions on Project Scope (DOE/RL-2004-49), as well as the "Yakama Nation Exposure Scenario for Hanford Site Risk Assessment, Richland, Washington" (Ridolfi 2007).

Avid Angler. The Avid Angler scenario includes both adults and older children (older than age 6). The Avid Angler could potentially be exposed to contaminants through consumption of fish from the river. Other potential routes of exposure to contaminated sediment, island soil, and/or surface water include incidental ingestion, dermal contact, and dust inhalation while fishing, wading, and/or boating in the river. This receptor was also included in the Source and Groundwater Component of the RCBRA (DOE/RL-2007-21).

[10] Potential exposure to near shore surface water COPCs associated with tribal use of sweat lodges is being assessed as part of the RCBRA Source and Groundwater Component and thus is not evaluated in this complementary BHHRA.

Casual User. The Casual User is an adult or child individual who uses the Columbia River for seasonal recreational purposes. This scenario includes adults and children, who may swim, water ski, boat, wade, camp, or participate in other similar activities along the river. Potential routes of exposure to contaminated sediment, island soil, and/or surface water include incidental ingestion, dermal contact, and dust inhalation during these recreational activities. This receptor was also included in the Source and Groundwater Component of the RCBRA (DOE/RL-2007-21).

Future Resident (Upland Exposures). The BHHRA will evaluate a scenario in which a child and adult are routinely exposed to dredged sediments, removed from within existing navigational channels where the ACOE has authority to dredge (e.g., 14 ft [+2] mean low water), and placed in upland residentially zoned areas. This is the only receptor identified for which exposure to dredge spoils may occur. Potential routes of exposure for this scenario include dermal contact with and incidental ingestion of sediment (as soil), as well as the inhalation of dust. Additionally, because constituents in the dredged sediment may leach into groundwater, there is the potential for future residents to ingest or dermally contact constituents that have migrated to groundwater. It should be noted that past dredging projects in the Columbia River conducted by the ACOE required extensive permitting and evaluations of "beneficial use" of dredged sediments to ensure that the ultimate disposition of dredge spoils would not pose health risks to future potential receptors/users of such materials.

As mentioned, the Columbia River is currently used as a source of potable water for the town of Richland. Treated water from the river is routinely monitored and meets federal drinking water standards. Because there is the potential for surface water at any location along the Study Area to be used for potable water, an evaluation of residential drinking water use will also be conducted as part of the BHHRA.

Both the drinking water and dredged sediment exposure pathways (i.e., "Future Resident" receptor scenario) will be evaluated through a simplified process in the BHHRA. Rather than generate cumulative risk estimates for this hypothetical future residential scenario, sediment (soil) and surface water data will be directly compared to medium-specific benchmarks protective of residential exposures. This evaluation is discussed further in Section 4.6.7.

Table 4-22 summarizes the receptors and exposure pathways to be evaluated in the BHHRA.

Table 4-22. Summary of Proposed Exposure Scenarios. (2 Pages)

Scenario Time Frame	Exposure Medium	Exposure Point	Receptor Population	Receptor	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Current/ future	Sediment, island soil, surface water	Columbia River	Casual User	Child and Adult	Ingestion, dermal contact, external radiation	Quantified	A recreational user is assumed to swim, waterski and/or play at a beach along the Columbia River. These activities will result in dermal contact with and incidental ingestion of surface water and sediment/island soil, and external radiation to radionuclides in the sediment/island soils.
Current/ future	Fish tissue, sediment, island soil, surface water	Columbia River	Avid Angler	Older child/ Adult	Ingestion, dermal contact, external radiation	Quantified	Anglers are assumed to eat their catch. Anglers would also be exposed to surface water and shoreline sediments/island soil during fishing-related recreational activities (e.g., boating, fly-fishing).
Current/ future	Fish tissue, sediment, island soil, surface water	Columbia River	Subsistence Native American (as represented by Yakama tribes)	Child/Adult	Ingestion, dermal contact, external radiation	Quantified	Native Americans living in the Columbia River basin could be exposed to contaminants in sediment, island soil and surface water while fishing or swimming in the river. Native Americans who live in the area are also known to regularly consume fish as part of their diet. Thus, relevant exposure pathways include dermal contact and incidental ingestion of surface water and sediment/island soil, external radiation to sediment/soil, and ingestion of fish.
Future	Surface water	Drinking water taken from Columbia River	Residents	NA	Ingestion, dermal contact	Comparative	Surface water is treated and used as potable water by the Tri-Cities. It is assumed this treatment meets all applicable regulations. However, surface water exposure point concentrations will be compared to federal drinking water standards and risk-based benchmarks protective of tap water.

Table 4-22. Summary of Proposed Exposure Scenarios. (2 Pages)

Scenario Time Frame	Exposure Medium	Exposure Point	Receptor Population	Receptor	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Future	Dredged sediment	Dredge sediments from Columbia River	Residents	NA	Ingestion, dermal contact, external radiation	Comparative	It is assumed that dredge spoils may used as upland fill. Therefore, it was conservatively assumed that in the future, local residents may be exposed to dredged sediments (as upland soil). A comparative evaluation will be conducted comparing sediment exposure point concentrations from behind McNary Dam to risk-based benchmarks for soil (residential use).

NA= Not applicable because analysis will consist of a comparative, semiquantitative comparison to medium-specific, risk-based benchmarks.

As indicated in Table 4-22 as well as the text provided above, it is not proposed to include an "Avid Hunter" scenario (i.e., waterfowl hunter and consumer) within this river-focused BHHRA. The rationale for this is as follows:

- Waterfowl are typically migratory birds that feed on biota in both upland areas as well as within the river itself; thus, only a fraction of their time is likely to be spent within the three Study Area sub-areas to be evaluated.

- Hanford Site-related COPCs present in surface water and sediment are generally not known biomagnifiers; therefore, the higher exposure potential to human receptors is most likely through ingestion of fish tissue.

- On an average daily basis, waterfowl are anticipated to compose a small fraction of diet relative to fish and other food categories such as fruits, vegetables, terrestrial game, domestic cattle, and poultry, etc.

A comprehensive "Avid Hunter" scenario is included in the Source and Groundwater Component of the RCBRA (DOE/RL-2007-21). This receptor is assumed to consume upland game (deer, gamebirds) and may also include waterfowl. Because of the relatively small risk presented by waterfowl hunting, as compared to other pathways of exposure, it is not proposed to evaluate a waterfowl hunter exposure scenario.

4.6.5.2 Quantitation of Exposure. The quantitative exposure assessment describes a conservative estimate of exposure to a representative individual within the subpopulation (receptor group) based on the defined exposure profiles. The exposure dose therefore represents the amount of a COPC to which an individual receptor may come into contact. It is a function of receptor-specific exposure assumptions and chemical-specific exposure parameters. The material that reaches the receptor's absorption barrier (such as the skin, lung, or gastrointestinal tract) is referred to as the applied dose (for ingestion and inhalation exposures), while the absorbed (or internal) dose is defined as the amount of material that actually crosses the receptor's exchange boundary.

Exposure doses for chemical constituents are calculated as the daily amount of constituent taken into the body per unit body weight per unit time (mg/kg-day). Average daily doses (ADDs) or lifetime average daily dose for carcinogenic COPCs will be based on conservative exposure assumptions and factors developed in accordance with EPA risk assessment guidelines and other relevant guidance. The general intake equation for radiation dose is analogous to that for chemical exposures, except that averaging time and body weight are omitted.

Exposure doses will be calculated using receptor-specific exposure variables and chemical-specific exposure parameters (e.g., the appropriate EPC, anatomical/physiological parameters, absorption adjustment factors, skin permeability coefficients) to calculate the chemical-specific doses or exposures for each receptor and pathway. All intake/dose equations and parameters will be documented in the BHHRA.

4.6.5.2.1 Exposure Parameters. Exposure parameters describe physiological or behavioral aspects of each target receptor and will represent a mix of central tendency and upper-bound exposure assumptions and recommendations from EPA risk assessment guidance, as well as professional judgment. For the purposes of this BHHRA, both CTE and RME scenarios for each receptor group, with the exception of the Native American scenario, will be evaluated. As previously described, for the Yakama Nation scenario only RME parameters are used as they are most reflective of the traditional and/or subsistence lifestyle of the tribal members.

Several different resources were consulted for the non-Native American receptors (i.e., casual user, avid angler). The priority established for these resources is as follows: The exposure parameters provided in the Source and Groundwater Component of the RCBRA (DOE/RL-2007-21) were used when the receptor and route of exposure were similar. River usage parameters (e.g., time spent fishing or swimming) were taken from the *2001 Columbia River Recreation Survey – Implications for the Hanford Site Integrated Assessment* (PNNL-13840). Standard exposure parameters that are specific to the scenarios evaluated in this baseline risk assessment were taken from EPA guidance documents (e.g., EPA 1997a, 2004d).

The Yakama Nation exposure parameters are taken primarily from the "Yakama Nation Exposure Scenario for Hanford Site Risk Assessment, Richland, Washington" (Ridolfi 2007). Values from the Columbia River Comprehensive Impact Assessment Screening Risk Assessment (DOE/RL-96-16 and Harris and Harper 2004) were used for parameters not specifically included in the Yakama Nation report. For example, Ridolfi (2007) does not differentiate exposure parameters for surface water versus groundwater. However, the report does indicate that the vast majority of "respondents" (i.e., tribal members who participated in the interview process) relied on groundwater wells as their primary source of drinking water (see Section 3.2.4.1, "Water Consumption," Ridolfi 2007). As this risk assessment will only address fishing-related exposures to the Columbia River, many of the parameters for groundwater exposure are not appropriate for estimating surface water exposure.

For recreational receptors (casual user and avid angler), activity factors specific to the Columbia River recreational areas will be used to estimate exposures. For the casual user, exposure parameters specific to swimming, wading and waterskiing will be considered. For the avid angler scenario, the majority of anglers participate in boat fishing (PNNL-13840); therefore, exposure factors will reflect this activity.

The specific exposure parameters for all receptors proposed for quantitative evaluation in this risk assessment are presented in Tables 4-23 through 4-28. These tables contain the values, the basis of the value, and the citation for that value. For the future residential (dredged sediments) scenario, risks will be evaluated through a comparison of chemical concentrations to medium-specific benchmarks rather than through estimation of intake and risk, as further described in Section 4.6.7. The medium-specific benchmarks are risk-based values, however, and therefore, the underlying exposure assumptions used in derivation of these benchmarks are also summarized in Tables 4-23 through 4-28.

Table 4-23. Proposed Values Used for Daily Intake Calculations, Surface Water - Reasonable Maximum Exposure. (4 Pages)

Exposure Route	Receptor Population	Parameter Code	Parameter Definition	Value	Units	Reference	
Incidental ingestion of and dermal contact with surface water	Casual User Child	BW	Body weight	16.6	kg	EPA 1997	1
		SA	Skin surface area	6,600	cm^2	EPA 2004	2
		IR_{sw}	Ingestion rate - surface water	0.05	L/hour	EPA 1989	3
		EV	Event frequency	1	events/day	EPA 1989	4
		EF	Exposure frequency	58	days/year	PNNL 2002	5
		ED	Exposure duration	6	years	EPA 1989	6
		t_e	Event duration	4	hours/event	PNNL 2002	7
		AT_c	Averaging time-cancer	70	years	EPA 1989	8
		AT_{nc}	Averaging time-noncancer	6	years	EPA 1989	9
Incidental ingestion of and dermal contact with surface water	Casual User Adult	BW	Body weight	70	kg	EPA 1989	1
		SA	Skin surface area	18,000	cm^2	EPA 2004	2
		IR_{sw}	Ingestion rate - surface water	0.05	L/hour	EPA 1989	3
		EV	Event frequency	1	events/day	EPA 1989	4
		EF	Exposure frequency	58	days/year	PNNL 2002	5
		ED	Exposure duration	30	years	EPA 1989	6
		t_e	Event duration	4	hours/event	PNNL 2002	7
		AT_c	Averaging time-cancer	70	years	EPA 1989	8
		AT_{nc}	Averaging time-noncancer	30	years	EPA 1989	9
Incidental ingestion of and dermal contact with surface water	Avid Angler Youth	BW	Body weight	37	kg	EPA 1997	1
		SA	Skin surface area	4,015	cm^2	EPA 1997	2
		IR_{sw}	Ingestion rate - surface water	0.025	L/hour	Professional judgment	3
		EV	Event frequency	1	events/day	EPA 1989	4
		EF	Exposure frequency	58	days/year	PNNL 2002	5
		ED	Exposure duration	7	years	Professional judgment	6
		t_e	Event duration	6.1	hours/event	PNNL 2002	7
		AT_c	Averaging time-cancer	70	years	EPA 1989	8
		AT_{nc}	Averaging time-noncancer	7	years	EPA 1989	9

Table 4-23. Proposed Values Used for Daily Intake Calculations, Surface Water - Reasonable Maximum Exposure. (4 Pages)

Exposure Route	Receptor Population	Parameter Code	Parameter Definition	Value	Units	Reference	
Incidental ingestion of and dermal contact with surface water	Avid Angler Adult	BW	Body weight	70	kg	EPA 1989	1
		SA	Skin surface area	5,700	cm^2	EPA 2004	2
		IR_{sw}	Ingestion rate - surface water	0.025	L/hour	Professional judgment	3
		EV	Event frequency	1	events/day	EPA 1989	4
		EF	Exposure frequency	58	days/year	PNNL 2002	5
		ED	Exposure duration	30	years	EPA 1989	6
		t_e	Event duration	6.1	hours/event	PNNL 2002	7
		AT_c	Averaging time-cancer	70	years	EPA 1989	8
		AT_{nc}	Averaging time-noncancer	30	years	EPA 1989	9
Incidental ingestion of and dermal contact with surface water	Subsistence Native American: Yakama Child	BW	Body weight	16	kg	EPA 1991; Ridolfi 2007	1
		SA	Skin surface area	6,600	cm^2	EPA 2004	2
		IR_{sw}	Ingestion rate - surface water	0.05	L/hour	EPA 1989	3
		EV	Event frequency	1	events/day	EPA 1989	4
		EF	Exposure frequency	150	days/year	PNNL 1998	5
		ED	Exposure duration	6	years	EPA 1989	6
		t_e	Event duration	2.6	hours/event	PNNL 1998	7
		AT_c	Averaging time-cancer	70	years	EPA 1989	8
		AT_{nc}	Averaging time-noncancer	6	years	EPA 1989	9
Incidental ingestion of and dermal contact with surface water	Subsistence Native American: Yakama Adult	BW	Body weight	70	kg	EPA 1989; Ridolfi 2007	1
		SA	Skin surface area	18,000	cm^2	EPA 2004	2
		IR_{sw}	Ingestion rate - surface water	0.05	L/hour	EPA 1989	3
		EV	Event frequency	1	events/day	EPA 1989	4
		EF	Exposure frequency	150	days/year	PNNL 1998	5
		ED	Exposure duration	70	years	EPA 1989; Ridolfi 2007	6
		t_e	Event duration	2.6	hours/event	PNNL 1998	7
		AT_c	Averaging time-cancer	70	years	EPA 1989	8
		AT_{nc}	Averaging time-noncancer	70	years	Ridolfi 2007	9

Table 4-23. Proposed Values Used for Daily Intake Calculations, Surface Water - Reasonable Maximum Exposure. (4 Pages)

Exposure Route	Receptor Population	Parameter Code	Parameter Definition	Value	Units	Reference

Notes:

1. The body weight for the child recreator scenario is based on the mean body weight of male and female children, ages 1 to 6 years (EPA 1997, Tables 7-6 and 7-7).
   For the Avid Angler youth, the body weight is the mean weight of males/females ages 7 < 14 years (EPA 1997).
   The body weights for the subsistence Native American (Yakama) scenario were obtained from Table 7 of Ridolfi (2007).
   For all adult receptors, the default mean body weight of 70 kg is used (EPA 1989).
2. The skin surface area (SA_{sw}) value for child receptors reflects the 50th percentile value for males and females, according to age range, for exposed skin on the entire body (EPA 2004, Exhibit C-1).
   The skin surface area for the Casual User and Yakama scenarios (child and adult) assumes whole body immersion; thus, it is a total body value.
   The skin surface area (SA_{sw}) value for Avid Angler receptor reflects the 50th percentile value for males and females, for exposed skin on the forearms, hands, face, lower leg, and feet (EPA 2004, Exhibit C-1).
   Youth values are for ages 7 < 14 years, based on SA values from EPA (1997).
3. The ingestion rate for surface water (IR_{sw}) for the Recreational user and the Yakama Nation receptors is the default value for swimming, as recommended by EPA (1989), Exhibit 6-12.
   The ingestion rate for surface water (IR_{sw}) for the Avid Angler is one-half the default value recommended by EPA (1989), Exhibit 6-12. As these receptors are not swimming, they are assumed to incidentally ingest a minimal amount of river water while fishing.
4. Event frequency (EV) describes how many "events" occur for each day of exposure. For all receptors, it was assumed that one event (swimming, boating, waterskiing) would occur on each day of exposure as recommended by EPA (1989).
5. The exposure frequency (EF) describes how often the exposure occurs over a given period of time.
6. The exposure duration (ED) describes the length of time over which the receptor comes into contact with contaminants.
   ED values for the casual user scenarios reflect a 30-year residential tenure, which is the recommended RME value for residents (EPA 1989).
   The child casual user ED represents a child 0-6 years; the youth Avid Angler ED represents an older child ages 7-14 years.
7. The event duration (t_e) describes how long each exposure event will occur.
   Event duration information specific to the Yakama Tribe was unavailable. As such, values used in CRCIA 1996 ("Native American river-focused hunter and fisher scenario") were applied for the Yakama Nation.
   For the Recreational User, the event duration is based on the survey data from PNL March 2002 (Table 4.6) and represents the total amount of time spent when the primary activity is waterskiing.
   For the Avid Angler scenario, the event duration is based on the survey data from PNL March 2002 (Table 4.6) and represents the total amount of time spent when the primary activity is fishing from a boat.
8. The averaging time (AT) for cancer effects (AT_c) for all receptors is set equal to a lifetime (i.e., 70 years), as recommended by EPA (1989).
9. The averaging time for noncancer effects (AT_{nc}) for all receptors is set equal to the exposure duration, as recommended by EPA (1989).

Table 4-23. Proposed Values Used for Daily Intake Calculations, Surface Water - Reasonable Maximum Exposure. (4 Pages)

Exposure Route	Receptor Population	Parameter Code	Parameter Definition	Value	Units	Reference

References:

EPA, 1989, *Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Part A, Interim Final,* OSWER Directive 9285.701A, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1991c, *Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors,* OSWER Directive 9285.6-03, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1997, *Exposure Factors Handbook, Volume I: General Factors,* EPA/600/P-95/002Fa, Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1997b, *Exposure Factors Handbook, Volume II: Activity Factors,* EPA/600/P-95/002Fc, Table 15-176, Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 2002b, *Child-Specific Exposure Factors Handbook,* EPA/600/P-00//002B, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 2004, EPA/540/R/99/005. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final, OSWER Directive 9285.7-02EP, EPA, Washington D.C. (EPA 2004).

Harris, S. G. and B. L. Harper, 2004, Exposure Scenario for CTUIR Traditional Subsistence Lifeways, Confederated Tribes of the Umatilla Indian Reservation, dated September 15, 2004. Updated April 9, 2007 (Harris and Harper 2004).

PNNL, 1998, *Screening Assessment and Requirements for a Comprehensive Assessment*, Columbia River Comprehensive Impact Assessment, Part 1: CRCIA – Screening Assessment, DOE/RL-96-16, Rev. 1, Final, UC-630, Pacific Northwest National Laboratory, Richland, Washington.

PNNL, 2002, *2001 Columbia River Recreation Survey - Implications for the Hanford Site Integrated Assessment*, PNL-13840, Pacific Northwest National Laboratory, Richland, Washington.

Ridolfi Inc., 2007, *Yakama Nation Exposure Scenario for Hanford Site Risk Assessment*, September 2007, Richmond, Virginia.

Table 4-24. Proposed Values used for Daily Intake Calculations, Sediment - Reasonable Maximum Exposure. (4 Pages)

Exposure Route	Receptor Population	Parameter Code	Parameter Definition	Value	Units	Reference	
Incidental ingestion and dermal contact	Casual User Child	IR_{sed}	Ingestion rate of sediment	200	mg/day	EPA 1989	1
		AF_{sed}	Sediment adherence factor	0.2	mg/cm^2	EPA 2004	2
		SA_{sed}	Skin surface area - child	2,800	cm^2	EPA 2004	3
		EF	Exposure frequency	58	days/yr	PNNL 2002	4
		ED	Exposure duration	6	years	EPA 1989	5
		ET_{out}	Exposure time outdoors	6.1	hours/day	PNNL 2002	6
		BW	Body weight	16.6	kg	EPA 1997	7
		AT_c	Averaging time - cancer	70	years	EPA 1989	8
		AT_{nc}	Averaging time - noncancer	6	years	EPA 1989	9
Incidental ingestion and dermal contact	Casual User Adult	IR_{sed}	Ingestion rate of sediment	100	mg/day	EPA 1989	1
		AF_{sed}	Sediment adherence factor	0.1	mg/cm^2	EPA 2004	2
		SA_{sed}	Skin surface area	5,700	cm^2	EPA 2004	3
		EF	Exposure frequency	58	days/yr	PNNL 2002	4
		ED	Exposure duration	30	years	EPA 1989	5
		ET_{out}	Exposure time outdoors	6.1	hours/day	PNNL 2002	6
		BW	Body weight	70	kg	EPA 1989	7
		AT_c	Averaging time - cancer	70	years	EPA 1989	8
		AT_{nc}	Averaging time - noncancer	30	years	EPA 1989	9
Incidental ingestion and dermal contact	Avid Angler Youth	IR_{sed}	Ingestion rate of sediment	100	mg/day	EPA 1989	1
		AF_{sed}	Sediment adherence factor	0.2	mg/cm^2	EPA 2004	2
		SA_{sed}	Skin surface area - youth	4,015	cm^2	EPA 1997	3
		EF	Exposure frequency	58	days/yr	PNNL 2002	4
		ED	Exposure duration	7	years	Professional judgment	5
		ET_{out}	Exposure time outdoors	6.7	hours/day	PNNL 2002	6
		BW	Body weight	37	kg	EPA 1997	7
		AT_c	Averaging time - cancer	70	years	EPA 1989	8
		AT_{nc}	Averaging time - noncancer	7	years	Professional judgment	9

Table 4-24. Proposed Values used for Daily Intake Calculations, Sediment - Reasonable Maximum Exposure. (4 Pages)

Exposure Route	Receptor Population	Parameter Code	Parameter Definition	Value	Units	Reference	
Incidental ingestion and dermal contact	Avid Angler Adult	IR_{sed}	Ingestion rate of sediment	100	mg/day	EPA 1989	1
		AF_{sed}	Sediment adherence factor	0.1	mg/cm^2	EPA 2004	2
		SA_{sed}	Skin surface area	5,700	cm^2	EPA 2004	3
		EF	Exposure frequency	58	days/yr	PNNL 2002	4
		ED	Exposure duration	30	years	EPA 1989	5
		ET_{out}	Exposure time outdoors	6.7	hours/day	PNNL 2002	6
		BW	Body weight	70	kg	EPA 1989	7
		AT_c	Averaging time - cancer	70	years	EPA 1989	8
		AT_{nc}	Averaging time - noncancer	30	years	EPA 1989	9
Incidental ingestion and dermal contact	Subsistence Native American: Yakama Child	IR_{sed}	Ingestion rate of sediment	400	mg/day	Ridolfi 2007	1
		AF_{sed}	Sediment adherence factor	0.2	mg/cm^2	EPA 2004	2
		SA_{sed}	Skin surface area - child	2,800	cm^2	EPA 2004	3
		EF	Exposure frequency	150	days/yr	PNNL 1998	4
		ED	Exposure duration	6	years	Ridolfi 2007	5
		ET_{out}	Exposure time outdoors	7	hours/day	Ridolfi 2007	6
		BW	Body weight	16	kg	EPA 1991; Ridolfi 2007	7
		AT_c	Averaging time - cancer	70	years	EPA 1989	8
		AT_{nc}	Averaging time - noncancer	6	years	Ridolfi 2007	9
Incidental ingestion and dermal contact	Subsistence Native American: Yakama Adult	IR_{sed}	Ingestion rate of sediment	200	mg/day	Ridolfi 2007	1
		AF_{sed}	Sediment adherence factor	0.3	mg/cm^2	EPA 2004	2
		SA_{sed}	Skin surface area	5,700	cm^2	EPA 2004	3
		EF	Exposure frequency	150	days/yr	PNNL 1998	4
		ED	Exposure duration	70	years	Ridolfi 2007	5
		ET_{out}	Exposure time outdoors	7	hours/day	Ridolfi 2007	6
		BW	Body weight	70	kg	EPA 1989; Ridolfi 2007	7
		AT_c	Averaging time - cancer	70	years	EPA 1989	8
		AT_{nc}	Averaging time - noncancer	70	years	Ridolfi 2007	9

Table 4-24. Proposed Values used for Daily Intake Calculations, Sediment - Reasonable Maximum Exposure. (4 Pages)

Exposure Route	Receptor Population	Parameter Code	Parameter Definition	Value	Units	Reference

Notes:

1. The daily sediment ingestion rates (IR_{sed}) for the Yakama tribe were those recommended by Ridolfi (2007) for child and adult members.
   The sediment ingestion rate for the Casual User child receptor (0 to 6 years) reflects that recommended by EPA for children less than 6 years (EPA 1989). Value represents a "conservative estimate of the mean" for children.
   Sediment ingestion rates for the Casual User adult and Avid Angler youth/adult scenarios is the EPA-default soil ingestion rate for ages >6 years.
2. The sediment adherence factor (AF_{sed}) for the Casual User child, Yakama child and Avid Angler youth reflects the geometric mean AF for "children playing in wet soil" (EPA 2004, Exhibit C-3). This value was selected for the RME because the river sediments are predominantly sandy soils which do not absorb water like soils with a high organic content. (Based on 37 samples, the mean total sand content was 66%.)
   The AF for "gardeners" was used for the adult Casual User and Avid Angler. For the Yakama adult receptor, the AF for "reed gatherers" was used.
3. The sediment skin surface area (SA_{sed}) value for all child receptors reflects the 50th percentile value for males and females ages 0 < 7 years for exposed skin on the face, hands, forearms, lower legs, and feet (EPA 2004,Table C-1).
   The sediment skin surface area (SA_{sed}) value for all adults reflects the 50th percentile value for males and females (for specific age groups) for exposed skin on the face, hands, forearms, lower legs, and feet (EPA 1997, Table 6-4).
4. The exposure frequency (EF) describes how often the exposure occurs over a given period of time.
   For members of the Yakama tribe (both children and adults) it was assumed that EF is that used in the CRCIA (1996), due to lack of more recent information on this specific pathway.
   EF value for the Casual User scenario is based on the survey results published by PNL (March 2002; Table 4.4) and represents the maximum number of visits per year among various Washington counties and other areas.
5. The exposure duration (ED) describes the length of time over which the receptor comes into contact with contaminants.
   ED values for the Casual User scenarios reflect a 30-year residential tenure, which is the recommended RME value for residents (EPA 1989).
   The child Casual User ED represents a child 0-6 years; the youth Avid Angler ED represents an older child ages 7-14 years.
   The ED value for the child Yakama (1 to 6 years) and Yakama adult scenarios is that recommended by Ridolfi (2007).
6. ET out is the duration spent outdoors in contact with sediment. It is used is the calculation of external radiation dose.
   For the Yakama tribe, it is assumed they spend 7 hours per day outdoors. This is the value cited in Ridolfi (2007) for the maximum time spent outdoors.
   For the Recreational User and Avid Angler scenarios, ET reflects the total hours per trip (waterskiing and fishing from boat, respectively) as cited in PNL (2002).
7. The body weight for child members of the Yakama tribe (16 kg) and all adult receptors (70 kg) is that presented in EPA (1991) and Ridolfi (2007).
   The body weights for the Casual User child scenario and Avid Angler youth scenario are based on mean body weights of male and female children for the various age ranges (1-6 years for the Casual User and 7-14 years for the Avid Angler youth (EPA 1997, Table 7-3).
8. The averaging time (AT) for cancer effects (AT_c) for all receptors is set equal to a lifetime (i.e., 70 years), as recommended in EPA (1989).
9. The averaging time for non-cancer effects (AT_{nc}) for all receptors is set equal to the exposure duration, as recommended in EPA (1989).

Table 4-24. Proposed Values used for Daily Intake Calculations, Sediment - Reasonable Maximum Exposure. (4 Pages)

Exposure Route	Receptor Population	Parameter Code	Parameter Definition	Value	Units	Reference

References:

EPA, 1989, *Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Part A, Interim Final,* OSWER Directive 9285.701A, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1991c, *Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors,* OSWER Directive 9285.6-03, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1997, *Exposure Factors Handbook, Volume I: General Factors,* EPA/600/P-95/002Fa, Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1997b, *Exposure Factors Handbook, Volume II: Activity Factors,* EPA/600/P-95/002Fc, Table 15-176, Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C.

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EPA, 2004, EPA/540/R/99/005. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final, OSWER Directive 9285.7-02EP, EPA, Washington D.C. (EPA 2004).

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PNNL, 1998, *Screening Assessment and Requirements for a Comprehensive Assessment*, Columbia River Comprehensive Impact Assessment, Part 1: CRCIA – Screening Assessment, DOE/RL-96-16, Rev. 1, Final, UC-630, Pacific Northwest National Laboratory, Richland, Washington.

PNNL, 2002, *2001 Columbia River Recreation Survey - Implications for the Hanford Site Integrated Assessment*, PNL-13840, Pacific Northwest National Laboratory, Richland, Washington.

Ridolfi Inc., 2007, *Yakama Nation Exposure Scenario for Hanford Site Risk Assessment*, September 2007, Richmond, Virginia.

Table 4-25. Proposed Values used for Daily Intake Calculations, Fish Tissue - Reasonable Maximum Exposure. (2 Pages)

Exposure Route	Receptor Population	Parameter Code	Parameter Definition	Value	Units	Reference	
Fish ingestion	Avid Angler Youth	IR_f	Ingestion rate of fish	122,100	mg/day	EPA 1997	1
		EF	Exposure frequency	365	days/year	EPA 1989	2
		ED	Exposure duration	7	years	EPA 1989	3
		BW	Body weight	37	kg	EPA 1997	4
		AT_c	Averaging time - cancer	70	years	EPA 1989	5
		AT_{nc}	Averaging time - noncancer	7	years	EPA 1989	6
Fish ingestion	Avid Angler Adult	IR_f	Ingestion rate of fish	231,000	mg/day	EPA 1997	1
		EF	Exposure frequency	365	days/year	EPA 1989	2
		ED	Exposure duration	30	years	EPA 1989	3
		BW	Body weight	70	kg	EPA 1989	4
		AT_c	Averaging time - cancer	70	years	EPA 1989	5
		AT_{nc}	Averaging time - noncancer	30	years	EPA 1989	6
Fish ingestion	Subsistence Native American: Yakama Child	IR_f	Ingestion rate of fish	363,000	mg/day	Ridolfi 2007; EPA 2002	1
		EF	Exposure frequency	365	days/year	Ridolfi 2007	2
		ED	Exposure duration	6	years	Ridolfi 2007	3
		BW	Body weight	16	kg	EPA 1991; Ridolfi 2007	4
		AT_c	Averaging time - cancer	70	years	EPA 1989	5
		AT_{nc}	Averaging time - noncancer	6	years	EPA 1989	6
Fish ingestion	Subsistence Native American: Yakama Adult	IR_f	Ingestion rate of fish	519,000	mg/day	Ridolfi 2007; EPA 2002	1
		EF	Exposure frequency	365	days/year	Ridolfi 2007	2
		ED	Exposure duration	70	years	Ridolfi 2007	3
		BW	Body weight	70	kg	EPA 1989; Ridolfi 2007	4
		AT_c	Averaging time - cancer	70	years	EPA 1989	5
		AT_{nc}	Averaging time - noncancer	70	years	EPA 1989	6

Table 4-25. Proposed Values used for Daily Intake Calculations, Fish Tissue - Reasonable Maximum Exposure. (2 Pages)

Exposure Route	Receptor Population	Parameter Code	Parameter Definition	Value	Units	Reference

Notes:

1. The daily fish ingestion rates for members of the Yakama tribe (both children and adults) are those recommended in Ridolfi (2007). These values reflect upper-bound values for the U.S. population for each age range (EPA 2002).
   For the Avid Angler scenarios, the daily fish ingestion rates reflect the 95th percentile value for consumer-only intake of fish in the western United States (EPA 1997, Table 13-27).
   Fish ingestion rates for the Avid Angler scenario incorporate an 11% preparation loss during cooking, as recommended by EPA (1997, Table 13-5) and are calculated by multiplying the estimated rate (mg/kg-day) by the appropriate body weight for the receptor.
2. The exposure frequency (EF) describes how often the exposure occurs over a given period of time. For all receptors, it was assumed that ingestion of fish would occur each day of the year.
3. The exposure duration (ED) describes the length of time over which the receptor comes into contact with contaminants.
   ED values for the Avid Angler scenario reflects a 30-year residential tenure, which is the recommended RME value for residents (EPA 1989).
   The youth Avid Angler ED represents an older child ages 7-14 years.
   The ED value for the child Yakama (1 to 6 years) and Yakama adult scenarios is that recommended by Ridolfi (2007).
4. The body weight for child members of the Yakama tribe (16 kg) and all adult receptors (70 kg) is that presented in EPA (1991) and Ridolfi (2007).
   The body weights for the Casual User child scenario and Avid Angler youth scenario are based on mean body weights of male and female children for the various age ranges (1-6 years for the Casual User and 7-14 years for the Avid Angler youth; [EPA 1997, Table 7-3]).
5. The averaging time (AT) for cancer effects (AT_c) for all receptors is set equal to a lifetime (i.e., 70 years), as recommended in EPA (1989).
6. The averaging time for noncancer effects (AT_{nc}) for all receptors is set equal to the exposure duration, as recommended in EPA (1989).

References:

EPA, 1989, *Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Part A, Interim Final,* OSWER Directive 9285.701A, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1991c, *Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors,* OSWER Directive 9285.6-03, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1997, *Exposure Factors Handbook, Volume I: General Factors,* EPA/600/P-95/002Fa, Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1997b, *Exposure Factors Handbook, Volume II: Activity Factors,* EPA/600/P-95/002Fc, Table 15-176, Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C.

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Ridolfi Inc., 2007, *Yakama Nation Exposure Scenario for the Hanford Site Risk Assessment*, September 2007, Richmond, Virginia.

Table 4-26. Proposed Values used for Daily Intake Calculations, Surface Water - Central Tendency Exposure. (3 Pages)

Exposure Route	Receptor Population	Parameter Code	Parameter Definition	Value	Units	Reference	
Incidental ingestion and dermal contact	Casual User Child	BW	Body weight	16.6	kg	EPA 1997	1
		SA	Skin surface area	6,600	cm^2	EPA 2004	2
		IR_{sw}	Ingestion rate - surface water	0.05	L/hour	EPA 1989	3
		EV	Event frequency	1	events/day	EPA 1989	4
		EF	Exposure frequency	47	days/year	PNNL 2002	5
		ED	Exposure duration	6	years	EPA 1989	6
		t_e	Event duration	3	hours/event	PNNL 2002	7
		AT_c	Averaging time-cancer	70	years	EPA 1989	8
		AT_{nc}	Averaging time-noncancer	6	years	EPA 1989	9
Incidental ingestion and dermal contact	Casual User Adult	BW	Body weight	70	kg	EPA 1989	1
		SA	Skin surface area	18,000	cm^2	EPA 2004	2
		IR_{sw}	Ingestion rate - surface water	0.05	L/hour	EPA 1989	3
		EV	Event frequency	1	events/day	EPA 1989	4
		EF	Exposure frequency	47	days/year	PNNL 2002	5
		ED	Exposure duration	9	years	EPA 1989	6
		t_e	Event duration	4	hours/event	PNNL 2002	7
		AT_c	Averaging time-cancer	70	years	EPA 1989	8
		AT_{nc}	Averaging time-noncancer	9	years	EPA 1989	9
Incidental ingestion and dermal contact	Avid Angler Youth	BW	Body weight	37	kg	EPA 1997	1
		SA	Skin surface area	4,015	cm^2	EPA 2004	2
		IR_{sw}	Ingestion rate - surface water	0.025	L/hour	Professional judgment	3
		EV	Event frequency	1	events/day	EPA 1989	4
		EF	Exposure frequency	47	days/year	PNNL 2002	5
		ED	Exposure duration	7	years	Professional judgment	6
		t_e	Event duration	3	hours/event	PNNL 2002	7
		AT_c	Averaging time-cancer	70	years	EPA 1989	8
		AT_{nc}	Averaging time-noncancer	7	years	EPA 1989	9

Table 4-26. Proposed Values used for Daily Intake Calculations, Surface Water - Central Tendency Exposure. (3 Pages)

Exposure Route	Receptor Population	Parameter Code	Parameter Definition	Value	Units	Reference	
Dermal contact	Avid Angler Adult	BW	Body weight	70	kg	EPA 1989	1
		SA	Skin surface area	5,700	cm^2	EPA 2004	2
		IR_{sw}	Ingestion rate - surface water	0.025	L/hour	Professional judgment	3
		EV	Event frequency	1	events/day	EPA 1989	4
		EF	Exposure frequency	47	days/year	PNNL 2002	5
		ED	Exposure duration	9	years	EPA 1989	6
		t_e	Event duration	3	hours/event	PNNL 2002	7
		AT_c	Averaging time-cancer	70	years	EPA 1989	8
		AT_{nc}	Averaging time-noncancer	9	years	EPA 1989	9

Notes:

1. The body weight for the child recreator scenario is based on the mean body weight of male and female children, ages 1 to 6 years (EPA 1997, Tables 7-6 and 7-7).
   For the Avid Angler youth, the body weight is the mean weight of males/females ages 7 < 14 years (EPA 1997).
   For all adult receptors, the default mean body weight of 70 kg is used (EPA 1989).
2. The skin surface area (SA_{sw}) value for child receptors reflects the 50th percentile value for males and females, according to age range, for exposed skin on the entire body (EPA 2004, Exhibit C-1).
   The skin surface area for the Casual User scenarios (child and adult) assumes whole body immersion; thus it is a total body value.
   The skin surface area (SA_{sw}) value for Avid Angler receptor reflects the 50th percentile value for males and females, for exposed skin on the forearms, hands, face, lower legs, and feet (EPA 2004, Exhibit C-1).
   Youth angler values are for ages 7 < 14years and are based on SA values from EPA 1997 (EPA 2004, Exhibit C-1).
3. The ingestion rate for surface water (IR_{sw}) for Recreational User receptors is the default value recommended by EPA (1989), Exhibit 6-12.
   The ingestion rate for surface water (IR_{sw}) for Avid Angler receptors is the one-half the default value recommended by EPA (1989), Exhibit 6-12 as this receptor is not swimming.
4. Event frequency (EV) describes how many swimming "events" occur for each day of exposure. For all receptors, it was assumed that one swimming event would occur on each day of exposure as recommended by EPA (1989).
5. The exposure frequency (EF) describes how often the exposure occurs over a given period of time. Values are based on survey data reported in PNL March 2002, Table 4.6.
6. The exposure duration (ED) describes the length of time over which the receptor comes into contact with contaminants.
7. The event duration (t_e) describes how long each exposure event will occur. Values are based on survey data reported in PNL March 2002, Table 4.6.
8. The averaging time (AT) for cancer effects (AT_c) for all receptors is set equal to a lifetime (i.e., 70 years), as recommended by EPA (1991c).
9. The averaging time for noncancer effects (AT_{nc}) for all receptors is set equal to the exposure duration, as recommended by EPA (1989).

Table 4-26. Proposed Values used for Daily Intake Calculations, Surface Water - Central Tendency Exposure. (3 Pages)

Exposure Route	Receptor Population	Parameter Code	Parameter Definition	Value	Units	Reference

References:

EPA, 1989, *Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Part A, Interim Final,* OSWER Directive 9285.701A, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1991c, *Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors,* OSWER Directive 9285.6-03, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1997, *Exposure Factors Handbook, Volume I: General Factors,* EPA/600/P-95/002Fa, Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1997b, *Exposure Factors Handbook, Volume II: Activity Factors,* EPA/600/P-95/002Fc, Table 15-176, Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 2002b, *Child-Specific Exposure Factors Handbook,* EPA/600/P-00/002B, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 2004, EPA/540/R/99/005. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final, OSWER Directive 9285.7-02EP, EPA, Washington D.C. (EPA 2004).

PNNL, 1998, *Screening Assessment and Requirements for a Comprehensive Assessment*, Columbia River Comprehensive Impact Assessment, Part 1: CRCIA – Screening Assessment, DOE/RL-96-16, Rev. 1, Final, UC-630, Pacific Northwest National Laboratory, Richland, Washington.

PNNL, 2002, *2001 Columbia River Recreation Survey - Implications for the Hanford Site Integrated Assessment*, PNL-13840, Pacific Northwest National Laboratory, Richland, Washington.

Table 4-27. Proposed Values used for Daily Intake Calculations, Sediment - Central Tendency Exposure. (3 Pages)

Exposure Route	Receptor Population	Parameter Code	Parameter Definition	Value	Units	Reference	
Incidental ingestion and dermal contact	Casual User Child	IR_{sed}	Ingestion rate of sediment	100	mg/day	EPA 1997	1
		AF_{sed}	Sediment adherence factor	0.2	mg/cm^2	EPA 2004	2
		SA_{sed}	Skin surface area - child	2,800	cm^2	EPA 2004	3
		EF	Exposure frequency	47	days/yr	PNNL 2002	4
		ED	Exposure duration	6	years	EPA 1989	5
		ET_{out}	Exposure time outdoors	6.1	hours/day	PNNL 2002	6
		BW	Body weight	16.6	kg	EPA 1997	7
		AT_c	Averaging time - cancer	70	years	EPA 1989	8
		AT_{nc}	Averaging time - noncancer	6	years	EPA 1989	9
Incidental ingestion and dermal contact	Casual User Adult	IR_{sed}	Ingestion rate of sediment	50	mg/day	EPA 1997	1
		AF_{sed}	Sediment adherence factor	0.1	mg/cm^2	EPA 2004	2
		SA_{sed}	Skin surface area	5,700	cm^2	EPA 2004	3
		EF	Exposure frequency	47	days/yr	PNNL 2002	4
		ED	Exposure duration	9	years	EPA 1989	5
		ET_{out}	Exposure time outdoors	6.1	hours/day	PNNL 2002	6
		BW	Body weight	70	kg	EPA 1989	7
		AT_c	Averaging time - cancer	70	years	EPA 1989	8
		AT_{nc}	Averaging time - noncancer	9	years	EPA 1989	9
Incidental ingestion and dermal contact	Avid Angler Youth	IR_{sed}	Ingestion rate of sediment	100	mg/day	EPA 1997	1
		AF_{sed}	Sediment adherence factor	0.2	mg/cm^2	EPA 2004	2
		SA_{sed}	Skin surface area - youth	4,015	cm^2	EPA 2004	3
		EF	Exposure frequency	47	days/yr	PNNL 2002	4
		ED	Exposure duration	7	years	Professional judgment	5
		ET_{out}	Exposure time outdoors	6.7	hours/day	PNNL 2002	6
		BW	Body weight	37	kg	EPA 1997	7
		AT_c	Averaging time - cancer	70	years	EPA 1989	8
		AT_{nc}	Averaging time - noncancer	6	years	EPA 1989	9

Table 4-27. Proposed Values used for Daily Intake Calculations, Sediment - Central Tendency Exposure. (3 Pages)

Exposure Route	Receptor Population	Parameter Code	Parameter Definition	Value	Units	Reference	
Incidental ingestion and dermal contact	Avid Angler Adult	IR_{sed}	Ingestion rate of sediment	50	mg/day	EPA 1997	1
		AF_{sed}	Sediment adherence factor	0.1	mg/cm^2	EPA 2004	2
		SA_{sed}	Skin surface area	5,700	cm^2	EPA 2004	3
		EF	Exposure frequency	47	days/yr	PNNL 2002	4
		ED	Exposure duration	9	years	EPA 1989	5
		ET_{out}	Exposure time outdoors	6.7	hours/day	PNNL 2002	6
		BW	Body weight	70	kg	EPA 1989	7
		AT_c	Averaging time - cancer	70	years	EPA 1989	8
		AT_{nc}	Averaging time - noncancer	9	years	EPA 1989	9

Notes:

1. The sediment ingestion rate for the casual user child receptor is the average soil ingestion rate for children less than 6 years (EPA 1997).
   Sediment ingestion rates for the casual user adult and avid angler youth/ adult scenarios is the EPA default soil ingestion rate for adults (EPA 1997).
2. The sediment adherence factor (AF_{sed}) for the casual user child and avid angler youth reflects the geometric mean AF for "children playing in wet soil" (EPA 2004, Exhibit C-3).
   The AF for "gardeners" was used for the adult casual user and avid angler.
3. The sediment skin surface area (SA_{sed}) value for all receptors assumes exposed skin on the face, hands, forearms, lower legs, and feet (EPA 1997, Table 6-4). Values are calculated according to age of receptor.
4. The exposure frequency (EF) describes how often the exposure occurs over a given period of time.
   EF values for the Recreational User and Avid Angler scenarios is based on the average number of visits per year as reported in PNL 2002, Table 4.4.
5. ED values for the casual user scenarios reflect a 9 year residential tenure, which is the recommended CTE value for residents (EPA 1989).
   The child casual user ED represents a child 0-6 years; the youth avid angler ED represents an older child ages 7-14 years.
6. ETout is the duration spent outdoors in contact with sediment. It is used is the calculation of external radiation dose.
   For the Recreational User and Avid Angler scenarios, ET reflects the total hours per trip (waterskiing and fishing from boat, respectively) as cited in PNL 2002 (Table 4.6).
7. The body weight for all adult receptors (70 kg) is that presented in EPA 1989.
   The body weights for the Casual User child scenario and avid angler youth scenario are based on mean body weights of male and female children for the various age ranges (1-6 years for the casual user and 7-14 years for the avid angler youth; EPA 1997, Table 7-3).
8. The averaging time (AT) for cancer effects (ATc) for all receptors is set equal to a lifetime (i.e., 70 years), as recommended by EPA 1989.
9. The averaging time for non-cancer effects (ATnc) for all receptors is set equal to the exposure duration, as recommended by EPA 1989.

Table 4-27. Proposed Values used for Daily Intake Calculations, Sediment - Central Tendency Exposure. (3 Pages)

Exposure Route	Receptor Population	Parameter Code	Parameter Definition	Value	Units	Reference

References:

EPA, 1989, *Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Part A, Interim Final,* OSWER Directive 9285.701A, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1991c, *Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors,* OSWER Directive 9285.6-03, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1997, *Exposure Factors Handbook, Volume I: General Factors,* EPA/600/P-95/002Fa, Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1997b, *Exposure Factors Handbook, Volume II: Activity Factors,* EPA/600/P-95/002Fc, Table 15-176, Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 2002, *Child-Specific Exposure Factors Handbook,* EPA/600/P-00//002B, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 2002b, *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*, OSWER 9355.4-24, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 2004, EPA/540/R/99/005. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final, OSWER Directive 9285.7-02EP, EPA, Washington D.C. (EPA 2004).

PNNL, 1998, *Screening Assessment and Requirements for a Comprehensive Assessment*, Columbia River Comprehensive Impact Assessment, Part 1: CRCIA – Screening Assessment, DOE/RL-96-16, Rev. 1, Final, UC-630, Pacific Northwest National Laboratory, Richland, Washington.

PNNL, 2002, *2001 Columbia River Recreation Survey - Implications for the Hanford Site Integrated Assessment*, PNL-13840, Pacific Northwest National Laboratory, Richland, Washington.

Table 4-28. Proposed Values used for Daily Intake Calculations, Fish - Central Tendency Exposure. (2 Pages)

Exposure Route	Receptor Population	Parameter Code	Parameter Definition	Value	Units	Reference	
Fish ingestion	Avid Angler Youth	IR_f	Ingestion rate of fish	18,130	mg/day	EPA 1997	1
		EF	Exposure frequency	365	days/year	EPA 1989	2
		ED	Exposure duration	7	years	Professional judgment	3
		BW	Body weight	37	kg	EPA 1997	4
		AT_c	Averaging time - cancer	70	years	EPA 1989	5
		AT_{nc}	Averaging time - noncancer	7	years	EPA 1989	6
Fish ingestion	Avid Angler Adult	IR_f	Ingestion rate of fish	34,300	mg/day	EPA 1997	1
		EF	Exposure frequency	365	days/year	EPA 1989	2
		ED	Exposure duration	9	years	EPA 1989	3
		BW	Body weight	70	kg	EPA 1989	4
		AT_c	Averaging time - cancer	70	years	EPA 1989	5
		AT_{nc}	Averaging time - noncancer	9	years	EPA 1989	6

Notes:

1. For the Avid Angler scenarios, the daily fish ingestion rates reflect the 50th percentile value for consumer only intake of fish in the western United States (EPA 1997, Table 13-27).
   Fish ingestion rates for the Avid Angler scenario incorporate an 11% preparation loss during cooking, as recommended by EPA (1997, Table 13-5).
   Additionally, the fish ingestion rate was adjusted for body weight for each age range.
2. The exposure frequency (EF) describes how often the exposure occurs over a given period of time. For all receptors, it was assumed that ingestion of fish would occur each day of the year.
3. ED values for the casual user scenarios reflect a 9-year residential tenure, which is the recommended CTE value for residents (EPA 1989).
   The child Casual User ED represents a child 0-6 years; the youth Avid Angler ED represents an older child ages 7-14 years.
4. The body weight for the youth Avid Angler is based on the mean body weight of male and female children, ages 1 to 6 years (EPA 1997, Table 7-3).
   For all adult receptors, a mean body weight of 70 kg is used (EPA 1989).
5. The averaging time (AT) for cancer effects (AT_c) for all receptors is set equal to a lifetime (i.e., 70 years), as recommended by EPA (1989).
6. The averaging time for noncancer effects (AT_{nc}) for all receptors is set equal to the exposure duration, as recommended by EPA (1989).

Table 4-28. Proposed Values used for Daily Intake Calculations, Fish - Central Tendency Exposure. (2 Pages)

Exposure Route	Receptor Population	Parameter Code	Parameter Definition	Value	Units	Reference

References:

EPA, 1989, *Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Part A, Interim Final,* OSWER Directive 9285.701A, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1991c, *Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors,* OSWER Directive 9285.6-03, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1997, *Exposure Factors Handbook, Volume I: General Factors,* EPA/600/P-95/002Fa, Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1997b, *Exposure Factors Handbook, Volume II: Activity Factors,* EPA/600/P-95/002Fc, Table 15-176, Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C.

4.6.5.2.2 Methods for Estimating Exposure Point Concentrations. EPCs are concentrations of COPCs in an environmental medium assumed to be representative of a human receptor's exposure potential. EPCs will be calculated for the Study Area using the relevant data within the CRC database, as previously discussed. This data set includes surface water, sediment, and biota (fish tissue) data currently in the CRC database and will be updated following completion of the proposed fall 2008 sampling event to include additional data points for those media as well as data proposed for collection from soils on the islands.

The EPCs will be calculated after reviewing the data for the Study Area for spatial trends as well as exposure potential. For example, physically different areas of the river such as sloughs, open channels, recreational areas, and islands may be associated with different types or intensities of exposure. As part of this analysis, data will be evaluated to determine whether discrete areas exist where the concentrations are anomalous (e.g., an area where the data are all nondetects or an area of particularly elevated concentrations). If such areas exist, the data will be reviewed relative to the exposure analysis to determine if an EPC for a particular exposure scenario should be based on a subset of the data. Any spatial variability identified will be evaluated as it correlates to exposure pathways. If such a situation exists, then receptor exposures may be weighted according to location.

EPCs will be derived for both CT and RME scenarios, as appropriate.

For recreational areas where MIS sampling is conducted, the MIS result will be used as the EPC for both CTE/RME scenarios for these areas. Because five MIS samples will be collected in these areas, the 95% UCL of the mean concentration among the five samples will be used as the EPC for the relevant exposure unit.

For other areas of the river where MIS sampling is not conducted, separate CT and RME EPCs will be calculated based on the analytical results from discrete samples collected from each area.

CT EPCs will be based on mean concentrations for each medium. The RME EPCs used in this BHHRA will be reflective of conservative upper-bound concentrations, but not extreme values. RME EPCs will be calculated from the appropriate subset of data based on the exposure pathway. For surface water, fish, and sediment, the 95% UCL of the arithmetic mean will be calculated for the data from each relevant exposure point unless the data analysis indicates another approach is more appropriate (e.g., weighting by area).

As recently discussed with EPA Region 10 representatives, it is assumed that sediment EPCs for the Casual User (e.g., child beachgoer), Avid Angler, and subsistence Native American receptors will be based on shallow sediment and/or island soil data, while the post-dredging scenario (Future Resident) may consider sediment data reflecting variable sediment depths. Information received to date regarding areas likely to be dredged (e.g., portions of Lake Wallula behind McNary Dam) indicates that sediments located at depths up to 4.9 m (16 ft) below the high water mark may need to be considered.

In general, the process described in the following sections follows EPA guidance as provided in the *ProUCL Version 4.0 User's Guide* (EPA 2007f). Several issues need to be considered for determining the most appropriate methods for estimating EPCs for CTE and RME scenarios:

- What was the intended use of the sample results (what were the DQOs)?
- How many sample results are available for the exposure unit?
- Are the data censored (are there nondetect sample results)?
- What estimation methods are mathematically stable for the data being evaluated and therefore provide reasonable estimates of the mean and upper bound on the mean?

The *Washington Administrative Code* (WAC) also provides methods for calculating EPCs. The WAC methods can be found in the compliance monitoring sections of the code (e.g., WAC 173-340-740(7)); these methods use the lognormal distribution assumptions and other statistical methodologies no longer advocated in EPA guidance. However, the WAC does permit use of "other statistical methods approved by the department." The EPA ProUCL approach is provided as an alternative statistical method.

This process is consistent with the approach used in the RCBRA in estimating EPCs and/or representative concentrations (DOE/RL-2007-21 or most current version, as available). The decision logic for choosing an appropriate statistical method is largely based on the number of detected samples and the statistical distribution of the available samples for the spatial scale of interest (e.g., site versus operational area). The process is largely based on EPA guidance as presented in ProUCL (EPA 2007f).

In *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (EPA 2002c), EPA recommends using the average concentration to represent "a reasonable estimate of the concentration likely to be contacted over time" (EPA 1989a) and "because of the uncertainty associated with estimating the true average concentration at a site" recommends that the 95% UCL on the mean be used for assessing a reasonable maximum exposure. There are many parametric and nonparametric methodologies available for calculating UCLs.

The 95% UCL calculations for the appropriate data sets for each medium of concern will be generated using the EPA Technical Support Center for Monitoring and Site Characterization's ProUCL program, version 4.0 (EPA 2007a). This program computes an appropriate UCL of the unknown population mean using a distinct probability distribution (e.g., normal, lognormal, gamma) and/or an appropriate nonparametric method (EPA 2007a). Since this program calculates multiple parametric/nonparametric UCL values, the program-recommended UCL will be used as EPC. This approach is consistent with that described in the EPA Office of Emergency and Remedial Response document *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (EPA 2002c). EPCs for each medium will be summarized in tabular format, and derivation of EPCs and/or EPC software output will be clearly documented in the BHHRA report.

In some instances where sample population variability is high, numerous censored results are present, and/or sample size is small, the 95% UCL may greatly exceed the maximum detected concentration in a data set. If this condition occurs, the magnitude of exceedance will be addressed in the uncertainty analysis; however, the 95% UCL concentration will be used as the EPC.

For small sample sizes, calculation of the 95% UCL is problematic because of the low number of samples and corresponding statistical variability. In the event of samples sizes less than 10, the Tri-Parties will consult and decide the appropriate action.

Treatment of environmental data and calculation of EPCs for each medium and river reach will be clearly explained in the BHHRA text.

4.6.6 Dose Response Assessment

The dose response assessment describes the relationship between the level of exposure and the likelihood and/or severity of an adverse effect. In other words, the dose response assessment quantifies the toxicity of each COPC using information obtained from published literature describing epidemiologic or toxicological studies. The products of the dose response assessment are the toxicity values used to predict the likelihood of adverse health effects in identified receptors at site-specific exposure levels.

In general, sources of toxicity information will be consistent with those used in the RCBRA (DOE/RL-2007-21). For each of the COPCs, toxicity values for the relevant exposure periods (i.e., subchronic, chronic and/or lifetime) will be selected according to the following hierarchy, and in accordance with OSWER Directive 9285.7-53 (EPA 2003c).

Tier 1: EPA *Integrated Risk Information System (IRIS) On-Line Database* (EPA 2008)

Tier 2: EPA Provisional Peer Reviewed Toxicity Values, as provided by the EPA Superfund Technical Support Center

Tier 3: Other sources, including the *Health Effects Assessment Summary Tables FY-1997 Update* (EPA 1997b), California Environmental Protection Agency, Agency for Toxic Substance Disease Registry, and other EPA regional and state hazardous waste site programs.

Radionuclide cancer slope factors will generally be obtained from *Health Effects Assessment Summary Tables (HEAST): Radionuclides* (EPA 2001c) and Federal Guidance Report No. 13 (EPA 1999). Dose conversion factors will be obtained from RESRAD Version 6.4; these values are based on International Commission on Radiological Protection 72.

All toxicity values will be tabulated and presented as part of the dose-response assessment in the BHHRA report. Sources of toxicological information will be documented in the relevant toxicity tables. If no toxicity information is available on these chemicals and/or appropriate surrogates

cannot be identified, impacts of these constituents in the risk assessment will be qualitatively addressed as part of the uncertainty analysis.

4.6.7 Risk Characterization

Characterization of risk to human health is the estimation of the incidence and severity of the adverse effects likely to occur in a human population due to chemical exposures, expressed as risk estimates. Risk estimates are based on the comparison of the results of the exposure assessment and the dose-response assessment and are indicative of the likelihood that adverse effects will occur. The purpose of a risk characterization is to present numerical estimates of risk (of both cancer and noncancer effects) in a context that can be used to make decisions about the current and potential future use of the site.

Calculation of cumulative risk estimates for each receptor and the relevant exposure pathways will be summarized in the EPA standard tabular format and compared to EPA risk limits. In this section, risks under both CT and RME scenarios will be evaluated (only RME will be conducted for the Native American scenario), primary risk drivers (both COPCs and specific areas/locations) will be identified, and site-related risks (associated with site COPCs) will be discussed relative to risks attributable to background sources. Evaluation of both the CT and RME for a particular receptor permits a greater understanding of the potential range of exposures and risks that may occur for a variable population, such as those being considered herein.

4.6.7.1 Noncancer Risk. Not all chemicals are carcinogenic, but exposure to them may affect developmental, reproductive, neurobehavioral, and other physiological functions. These effects are assumed to have a threshold (or "safe") dose, below which no effects are expected. The potential for noncarcinogenic health effects is characterized by the HQ, which is the ratio of the estimated average daily dose and a toxicity value considered to be the level above which adverse health effects would not be observed (i.e., reference dose, RfD):

$$HQ = ADD / RfD$$

To account for exposures that a receptor may receive from multiple chemicals and exposure routes, the cumulative noncancer risk estimate, known as the hazard index (HI), is calculated as the sum of the chemical-specific HQs. As shown in the following two equations, the cumulative

HI for a receptor is calculated by summing the route-specific HI. Route-specific HIs are calculated as the sum of all chemical-specific HQs:

$$\text{Total } HI_{\text{route-specific}} = \sum HQ_{\text{chemical-specific}}$$

$$\text{Cumulative } HI_{\text{receptor}} = \sum HI_{\text{route-specific}}$$

Route-specific HIs may also be broken down further by summing the cumulative risks for each target organ or adverse effect. The cumulative HI for each receptor is then compared with the EPA noncancer risk threshold of 1. If the HI is less than or equal to 1, then it is assumed that chemical concentrations of COPCs do not pose a risk of harm to human health.

If the cumulative HI exceeds 1 for a receptor/scenario, then the HI will be segregated by target organ or health effect. HIs for COPCs with a common target organ will be summed, and the cumulative HI for each target organ will be compared to the HI threshold of 1. If the HI is less than or equal to 1, then it is assumed that chemical concentrations of COPCs do not pose a risk of harm to human health. If the HI exceeds 1, then it will be concluded that concentrations of COPCs may present a significant risk of harm to human health; results will then be evaluated to inform risk management decisions regarding the future need for remedial actions.

For this assessment, in addition to calculating cumulative risk (i.e., summed risks for both background and site-related COPCs for each receptor scenario), noncancer hazards attributable to *background* contaminants (identified in the hazard identification) are segregated from noncancer hazards attributed to *site-related* COPCs. Differentiating background risks from site-related risks is consistent with EPA guidance (OSWER 9285.6-07P [EPA 2002e]) and may help focus remedial efforts, if warranted.

Specifically, the risk summary tables will include quantification of risks for two separate components: a set of chemicals will be labeled as/include only those COPCs that are considered to be Hanford Site related ("Site COPCs"), while another set will include only those COPCs that are attributed to background conditions ("Background COPCs"). Total (summed) noncancer and cancer risks will be presented for Hanford Site-related COPCs, background COPCs, and cumulative (sum of both Hanford Site-related and background COPCs). Table 4-29 provides a graphical (hypothetical) example of this proposed format. This approach is consistent with that recommended in the EPA Risk Assessment Guidance, Part D (EPA 2001b).

4.6.7.2 Cancer Risk. The potential for carcinogenic health effects is characterized as the incremental lifetime cancer risk (ILCR). The ILCR represents the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogenic COPC, and is calculated for carcinogenic chemicals as well as radioisotopes. For a given chemical, the ILCR is the product of the quantified exposure and the measure of carcinogenic potency (i.e., cancer slope factor [CSF] or unit risk [UR]):

$$ILCR = ADD \times CSF$$

The ILCR, which represents the probability of developing cancer above and beyond the "background incidence" of cancer in the general population, is presented in scientific notation. For example, ILCR of a specific chemical might be expressed as 1×10^{-6} or one in one million, which means that the probability of an individual developing cancer due to lifetime exposure to that potentially carcinogenic COPC is one in one million.

Table 4-29. Example of Noncancer Hazard Summary Table for Exposure Scenario.

Chemical of Potential Concern	Hazard Quotient			Hazard Index
	Incidental Ingestion of Sediment	Dermal Contact with Sediment	Fish Tissue Ingestion	
Site COPCs				
Chemical A	0.1	0.2	0.3	0.6
Chemical B	0.1	0.2	0.3	0.6
Chemical C	0.1	0.2	0.3	0.6
Chemical D	0.1	0.2	0.3	0.6
Background COPCs				
Chemical E	0.1	0.2	0.3	0.6
Chemical F	0.1	0.2	0.3	0.6
Chemical G	0.1	0.2	0.3	0.6
Cumulative HI-site + background	0.7	1.4	2.1	4.2
Cumulative HI - site	0.4	0.8	1.2	2.4
Cumulative HI - background	0.3	0.6	0.9	1.8

COPC = contaminant of potential concern
HI = hazard index

To account for exposures that a receptor may receive from multiple chemicals and radioisotopes, the ILCRs for all COPCs are summed to calculate a route-specific ILCR. The cumulative ILCR is then calculated by summing all of the route-specific ILCRs for each type of exposure, as demonstrated by the following equations:

$$\text{Total ILCR}_{\text{route-specific}} = \sum \text{ILCR}_{\text{COPC-specific}}$$
$$\text{Cumulative ILCR} = \sum \text{ILCR}_{\text{route-specific}}$$

The cumulative ILCR is compared to EPA's cumulative receptor cancer risk limits, which range from one-in-one million (1×10^{-6}) to one in ten thousand (1×10^{-4}). An ILCR of 1×10^{-6} for individual COPCs and a cumulative risk limit of 1×10^{-5}, which is the midpoint of EPA's target risk range, has been promulgated by the State of Washington (WAC 173-340-705[4]). Cumulative cancer risks within or exceeding the upper end of the target ILCR range may require a risk management decision to determine if further remedial action is warranted. Similar to the process described above for noncarcinogenic chemicals, cumulative cancer risks will be segregated with respect to background and site COPCs in order to determine the relative contribution of risk resulting from non-Hanford Site sources of contamination.

4.6.7.3 Radioisotope Dose. Cancer risks will be calculated for radioisotope COPCs as discussed in the previous section. In addition, radiation doses will be calculated for each receptor/exposure scenario. Radiation doses for each exposure route and radionuclide COPC will be summed to calculate the total annual dose to an individual. This radiation dose will then be compared to a threshold dose limit of 15 mrem/yr, which is the maximum dose limit specified by EPA (1997b) and by DOE Order 5400.5.

4.6.7.4 Additional Benchmark Comparisons for Human Health and Ecological Scenarios. As part of the CERCLA-based risk assessment, potable ingestion of surface water and upland residential exposures to (dredged) sediments will be evaluated through a comparison of sediment and surface water EPCs to medium-specific risk-based benchmarks and/or applicable or relevant and appropriate requirements.

It is assumed that (untreated and unfiltered) surface water will be used as a potable water source. The EPCs for surface water along each sub-area (100 Area, 300 Area, and Lake Wallula) will be compared to the following surface water benchmarks:

- Region 6 Human Health Medium Specific Screening Levels for residential water (or Region 9 tap water values, if Region 6 levels are not available)
- Federal Drinking Water Standards (i.e., MCLs) and Health Advisories
- Ecology Method B Surface Water Standards (WAC 173-340-730) and Method B Groundwater Standards (WAC 173-340-720).

There is potential that sediment could be dredged in two of the study sub-areas. Potentially dredged sediment is defined as sediment taken up to 4.9 m (16 ft) below the low water mark in the navigation channel. EPCs will be compared to EPA Soil Screening Levels (Section 4.6.3.2.3), Region 6/9 residential soil RBCs, and/or to Ecology unrestricted land use soil cleanup standards for direct contact and protection of groundwater (WAC 173-340-740 and WAC 173-340-747). These screening levels are shown in Tables 4-19 and 4-20.

Protection of terrestrial ecological receptors will also be evaluated. EPCs for potentially dredged sediment will be compared to Ecology Ecological Indicator Soil Concentrations for Protection of Terrestrial Plants and Animals (WAC 173-340-900, Table 749-3). Those EPCs will also be compared to EPA and other benchmarks as identified in Table 4-8.

An EPC exceedance of a benchmark will be further assessed to determine if there is significant risk.

4.6.8 Uncertainty Analysis

As part of this BHHRA, information will also be presented on the uncertainty associated with the various components of the risk assessment, including data gaps in toxicological or exposure assessment information and the conservative assumptions or scientific judgments used to bridge

these data gaps. A discussion of the uncertainty and conservatism associated with this BHHRA will be provided to facilitate an understanding of the strengths and limitations of the BHHRA conducted for the site. Although this BHHRA uncertainties analysis will be primarily qualitative, attempts will be made to indicate the direction and, where possible, magnitude of bias that the uncertainties introduce into the risk characterization through a summary table.

4.6.9 Conclusions

The results of the BHHRA will be coupled with information about uncertainties to:

1. Identify potential risks posed by Hanford Site-related COPCs

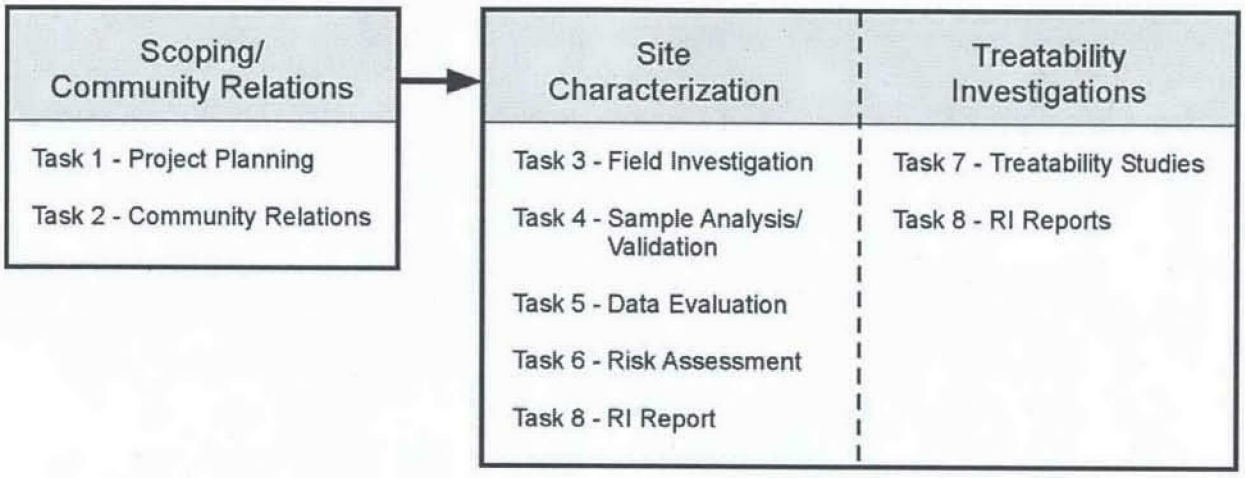
2. If unacceptable risk is identified, provide recommendations for future response actions (i.e., targeted remediation or supplemental characterization) to be conducted at the Hanford Site.

Specifically, an identification of chemical, radiological, and/or area/location "drivers" of risk will be performed and results will be integrated into the RI/FS process to assist in focusing remedial activities. Risk-based cleanup goals and applicable or relevant and appropriate requirements may be considered within the FS in evaluating the feasibility and effectiveness of potential response actions.

5.0 REMEDIAL INVESTIGATION TASKS

This section summarizes the RI tasks completed during the planning stages of the project or planned during the remainder of the RI, including the field investigation and risk assessments. Figure 5-1 illustrates the RI tasks. This section has been organized in accordance with the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988a).

Figure 5-1. Remedial Investigation Tasks.



Adapted from EPA/540/G-89/004 (EPA 1988a).

5.1 TASK 1 – PROJECT PLANNING

The following activities have been completed during the project planning phase of the RI and are described in detail below:

- Project meetings
- Compilation of existing data
- Identification of preliminary remedial action objectives
- Identification of additional data needs
- Development of sample design
- Development of an RI work plan that documents development process.

5.1.1 Project Meetings

Several Tri-Party and stakeholder meetings have been conducted and subsequent agreements have been reached to identify project goals and develop the scope of the RI. These include the following meetings and/or presentations:

- Ten workshops held regarding Hanford Site hazardous substance releases to the Columbia River for the RCBRA Project, December 2004 through September 2005
- Decision to proceed with Data Gap Analysis agreed to by the Tri-Parties, February 2007
- Data Gap Analysis workshop with regulatory agencies and Natural Resource Trustee Council members to discuss the results of the Data Gap Analysis held on June 5 and 6, 2007
- Approval from the DOE, Richland Operations Office to proceed with DQO/SAP and work plan to address data gap sampling received on October 15, 2007
- DQO workshop to discuss scoping of the RI held on February 5 and 6, 2008
- Tri-Party meeting to agree on scope and schedule of the RI held on March 8, 2008
- DQO workshop to present updated scope and schedule of the RI held on April 17, 2008
- Tri-Party meeting held August 11 through 14, 2008, to resolve issues relating to scope and schedule of the RI.

5.1.2 Compilation of Existing Data

The consolidation of many independent studies conducted on the Columbia River began in 2004 with a series of workshops and subsequent documents. The following data compilation reports have been developed:

- *Existing Source Information Summary Report Compilation/ Evaluation Effort: December 2004 to September 2005* (WCH-64) issued in January 2006
- *Columbia River Component Data Evaluation Summary Report* (WCH-91) issued in July 2006
- *Columbia River Component Data Gap Analysis* (WCH-201) issued in October 2007
- *DQO Summary Report for the Remedial Investigation of Hanford Site Releases to the Columbia River*, Rev. 0 (WCH-265) issued in June 2008.

The purpose of these reports was to identify potential data gaps in the spatial, temporal, and chemical composition of the existing data set and to determine if there are sufficient data to

characterize the effects of Hanford Site operations on the Columbia River. These identified data gaps (Section 4.1.1.2) coupled with data needed for the BHHRA and BERA (Section 4.1.2) were used to develop the sample design presented in Section 2.0 of the SAP (Appendix A).

5.1.3 Identification of Preliminary Remedial Action Objectives

Remedial action objectives (RAOs) will be identified in the FS that will be completed subsequent to the RI. However, RAOs are often modeled after either human health and/or ecological benchmarks, and therefore preliminary RAOs will be equivalent to the benchmarks at this early stage in the RI/FS process. Ecological and human health benchmarks are identified in Tables 4-18, 4-19, 4-20, and 4-21. Sources for ecological benchmarks are referenced in Section 4.5.3 of this RI work plan, and sources for human health benchmarks are referenced in Section 4.6.4.

5.1.4 Identification of Additional Data Needs

Based on the results of the DQO process and a review of the operational history, existing data set, and a detailed understanding of migration pathways and exposure points in the CSM, additional data needs for each sub-area were identified. The data needs, summarized by sample type for each of the five sub-areas are provided in Section 4.2 of this RI work plan.

5.1.5 Development of Sample Design

The DQO Summary Report (WCH-265) identified the data needed to characterize the nature and extent of Hanford Site hazardous substance releases to the Columbia River. The goal of the proposed investigation is to collect sufficient data to characterize current conditions within the Study Area (Vernita Bridge to McNary Dam) and to support human health and ecological risk assessments. The sample design approach is based on the data quality requirements presented in the DQO Summary Report (WCH-265) and the data needs identified in Section 4.2 of this RI work plan. Section 2.3 of the SAP (Appendix A) provides a detailed description of the proposed sample design.

5.1.6 Development of RI Work Plan

The purpose of this work plan is to document the scoping process and establish the approach for conducting a CERCLA-compliant RI to:

- Characterize the nature and extent of Hanford Site-related contaminants that have come to be located within the Columbia River
- Assess the current risk to ecological and human receptors posed by Hanford Site-related contaminants
- Determine the need to perform remedial action.

The scope of this work plan focuses on the impacts of Hanford Site hazardous substance releases to the Columbia River and its users. In order to evaluate the impacts from Hanford Site hazardous substance releases, it will also be important to understand the contributions of non-Hanford Site influences to the Columbia River upstream, within, and downstream of the Hanford Site. The risk assessment activities performed as part of this work plan will become a component of the RCBRA.

5.2 TASK 2 – COMMUNITY RELATIONS

As outlined in the Tri-Party Agreement, the Parties will comply with CERCLA requirements of 40 CFR 300.430(c)(ii)(A) to "ensure the public appropriate opportunities in a wide variety of site-related discussions, including site analysis and characterization and selection of remedy." The following activities have been completed to meet CERCLA requirements.

- **Conducting Interviews:** DOE has conducted interviews with local officials, community residents, public interest groups, and the Tribes to solicit their concerns and information needs, and to learn how and when citizens would like to be involved in the CERCLA process. In addition to the meetings and workshops identified in Section 5.1.1, DOE conducted local interviews with the following:

  - Hanford Advisory Board
  - Nez Perce Tribe
  - Confederated Tribes of the Umatilla Indian Reservation
  - Yakama Nation
  - Wanapum
  - Hanford Natural Resource Trustees.

  The parties recognize that several Northwest Indian tribes have treaty-reserved rights to resources outside their reservation boundaries. In some instances, these resources are either located on the Hanford Site or could be affected by activities on the Hanford Site. Treaty-reserved rights give these tribes a governmental interest in waste management and environmental restoration activities at the Hanford Site. These are further described in the Tri-Party Agreement.

- **Preparing a Formal Community Relations Plan:** DOE has developed and implemented the Community Relations Plan (CRP) in a manner consistent with CERCLA that responds to the need for an interactive relationship with all interested community elements, both on and off the Hanford Site, regarding activities and elements of work undertaken by DOE under the Tri-Party Agreement.

  DOE agreed to develop and implement the CRP in a manner consistent with CERCLA Sec. 117; the "National Oil and Hazardous Substances Contingency Plan"; EPA guidelines set forth in EPA;s Community Relations Handbook, and any modifications thereto; and the

public participation requirements of RCRA and Chapter 70.105 of the *Revised Code of Washington*.

The current CRP, *Hanford Site Tri-Party Agreement Public Involvement Community Relations Plan*, is available on DOE's Hanford Site web site at the following link: http://www.hanford.gov/hanford/files/tpa/pdf/crp.paf.

- **Establishing Local Information Repository:** Four public repositories have been established for the Hanford Site:

  - University of Washington
    Suzzallo Library
    University of Washington Box 352900
    Seattle, Washington 98195-2900
    (206) 543-4664

  - DOE Public Reading Room
    Washington State University, Tri-Cities
    Consolidated Information Center, Room 101-L
    2770 University Drive
    Richland, Washington 99352
    (509) 372-7443

  - Portland State University
    Government Information
    Branford Price Millar Library
    1875 SW Park Avenue
    Portland, Oregon 97207-1151
    (503) 725-4709

  - Gonzaga University
    Foley Center
    E. 502 Boone
    Spokane, Washington 99258-0001
    (509) 323-3834, extension 3844

  In addition, there are a number of web sites that provide a variety of information that can be accessed from the DOE Hanford Site web site: http://www.hanford.gov/

- **Technical Assistance Grants:** The EPA has funding available for technical assistance grants (TAGs) found in Section 117(e) of CERCLA. The EPA will be responsible for administering any federal TAG that is applied for in conjunction with the Hanford Site. The TAG is a mechanism by which the EPA provides reimbursement to the public for a level of effort spent on CERCLA document review. In this way, the public can be directly involved

in the review process of various CERCLA documents in more depth than otherwise might be possible. Information on TAGs can be obtained by contacting the following:

Technical Assistance Grant Coordinator
U.S. Environmental Protection Agency
1200 Sixth Avenue, ECO-081
Seattle, Washington 98101

- **Community Relations Program:** The Tri-Parties have an extensive community relations program as outlined in the CRP.

- **Conduct Technical Discussions:** As listed previously in Section 5.1.1, the Tri-Parties have conducted a number of workshops to provide a forum for technical discussions regarding the scoping and implementation of the RI.

5.3 TASK 3 – FIELD INVESTIGATION

5.3.1 Procure Subcontractor

WCH has pre-qualified subcontractors for planning and implementation of the proposed scope outlined in the SAP (Appendix A). Interested and qualified firms have submitted a questionnaire that has been used by WCH to assess subcontractors' qualifications and experience in order to establish a list of firms that were invited to submit a proposal for the work. For WCH to obtain quality services in the variety and breadth of services covered by the planned subcontract, it is expected that the proposed subcontract will be awarded to a single lead firm under the oversight of WCH, and that the lead firm will be supported by one or more subcontractors that will be directed and managed by the lead firm. It is anticipated that a contract will be awarded by mid-September 2008.

5.3.2 Mobilization

Mobilization of all necessary personnel and equipment will be scheduled in advance for each discrete field activity to ensure that all necessary resources are available to complete the activities in a timely manner while meeting all quality control and quality assurance requirements. The overall project schedule is provided in Section 7.0 of this work plan.

5.3.3 Field Investigation Subtasks

Based on the current proposed scope of the SAP (Appendix A), the following work sequence has been developed.

Step 1: Reconnaissance Survey – Three reconnaissance surveys will be conducted prior to completing the sample design. These include the following:

- Groundwater plume upwelling survey (Section 4.3.1)
- Fine-grained sediment survey (Section 4.3.2)
- Habitat survey (Section 4.5.3.1.1).

A more detailed description of these surveys is presented in Section 2.2 of the SAP. Once these surveys are completed and the information is reviewed and evaluated, final sample numbers and locations will be produced in "D-Size" drawings and updated tables. These will be provided to the Tri-Parties for review prior to sample collection.

Step 2: Collect Fish Samples – Based on fish migratory patterns and seasonal development (lipid oil content), fish sampling will be scheduled for the fall and early winter. However, sturgeon sampling will be conducted in the spring/summer of 2009. It is anticipated that sturgeon will be more active as water temperatures increase.

Step 3: Collect Sediment and Surface Water Samples – To take advantage of favorable weather conditions and seasonally low river water levels, the majority of the sediment and surface water samples will be collected in the fall. A second round of sediment and surface water samples will be collected in the spring from the irrigation returns to monitor seasonal variability in these returns.

5.3.4 Health and Safety

Refer to Section 6.0 ("Health and Safety") for additional information.

5.3.5 Waste Management

Waste generated by sampling activities will be managed in accordance with a waste management plan that will be prepared before field work is initiated. Unused samples and associated laboratory waste for analysis will be dispositioned in accordance with the laboratory contract and agreements. In accordance with 40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," "Procedures for Planning and Implementing Off-Site Response Actions," Risk Assessment Project Manager approval is required before unused samples or wastes are returned from offsite laboratories.

5.4 TASK 4 – SAMPLE ANALYSIS/VALIDATION

As samples are collected they will be submitted to the laboratory for analysis as described in Tables 2-2 through 2-6 in the SAP (Appendix A). Sample analysis and validation is described in Section 3.0 of the SAP.

5.5 TASK 5 – DATA EVALUATION

Data interpretation and statistical analysis will be completed following sample analysis and validation. This process will involve using graphical data displays and statistical tests to determine data distributions and using distribution shift tests to compare group means and medians, as described in Section 4.4. Comparisons between site and background concentrations of COPCs will be conducted using the decision logic described in Section 4.4.3 and in Figure 4-6.

5.6 TASK 6 – RISK ASSESSMENT

Baseline human health and ecological risk assessment work plans were developed as part of Task 6, and provide a summary of the scope and proposed methods to be used for the baseline risk assessments. The BERA and BHHRA work plans are included in Sections 4.5 and 4.6 of this work plan, respectively.

The proposed methodology of a BERA will be conducted on the surface water and sediment of the Columbia River adjacent to and downriver of the Hanford Site. The goal of the BERA is to evaluate whether river areas, media, or constituents pose a significant risk that may require additional response actions or study, or do not pose a risk and so do not warrant further action. In accordance with EPA guidance (EPA 1997a), the BERA will follow an eight-step process that begins with a preliminary screening of compounds and progresses incrementally to more detailed studies. Because the components of each step depend on the findings of the preceding step, the exact scope of the entire BERA cannot be determined in detail at this time.

The objective of the BHHRA is to conduct a conservative human health risk analysis to evaluate whether river areas/media/constituents pose a significant human health risk and thus may require additional response actions or study, or to determine if no further action is warranted.

5.7 TASK 7 – TREATABILITY STUDIES

Treatability studies are not planned during this proposed scope of work. If it is determined that a remedy is required, the need for a treatability study(s) will be revisited.

5.8 TASK 8 – RI REPORTS

An example of a typical RI report format has been developed in accordance with the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988a) and is presented in Figure 5-2. An RI report will be prepared following a similar format, the outline of which will be approved by the Tri-Parties.

Figure 5-2. Proposed RI Report Format.

Executive Summary

1. Introduction
   - 1.1. Purpose of Report
   - 1.2. Site Background
     - 1.2.1. Site Description
     - 1.2.2. Site History
     - 1.2.3. Previous Investigation
   - 1.3. Report Organization

2. Study Area Investigation/Site Characterization
   - 2.1. Surface Features (topographic mapping, etc.) (natural and manmade features)
   - 2.2. Contaminant Source Investigations
   - 2.3. Meteorological Investigations
   - 2.4. Surface-Water and Sediment Investigations
   - 2.5. Geological Investigations
   - 2.6. Soil and Vadose Zone Investigations
   - 2.7. Ground-Water Investigations
   - 2.8. Human Population Surveys
   - 2.9. Ecological Investigations

3. Physical Characteristics of the Study Area
   - 3.1. Surface Features
   - 3.2. Meteorology
   - 3.3. Surface-Water Hydrology
   - 3.4. Geology
   - 3.5. Soils
   - 3.6. Hydrogeology
   - 3.7. Demography and Land Use
   - 3.8. Ecology

4. Nature and Extent of Contamination
   - 4.1. Sources (lagoons, sludges, tanks, etc.)
   - 4.2. Soils and Vadose Zone
   - 4.3. Ground Water
   - 4.4. Surface Water and Sediments
   - 4.5. Air

5. Contaminant Fate and Transport
   - 5.1. Migration Routes (i.e., air, ground water, etc.)
   - 5.2. Contaminant Migration
   - 5.3. Contaminant Fate

6. Baseline Risk Assessment
   - 6.1. Human Health
     - 6.1.1. Exposure Assessment
     - 6.1.2. Toxicity Assessment
     - 6.1.3. Risk Characterization
   - 6.2. Ecological

7. Summary and Conclusions
   - 7.1. Summary
     - 7.1.1. Nature and Extent of Contamination
     - 7.1.2. Fate and Transport
     - 7.1.3. Risk Assessments
   - 7.2. Conclusions
     - 7.2.1. Data Limitations and Recommendations for Future Work
     - 7.2.2. Recommended Remedial Actions Objectives

6.0 HEALTH AND SAFETY

The health and safety plan (HASP) identifies known or suspected hazards in the Study Area. For work performed in support of the RI, all field operations will be performed in accordance with health and safety requirements and other applicable contractor safety procedures. The sampling procedures and associated activities will implement as low as reasonably achievable practices to minimize the radiation exposure to the sampling team, consistent with the requirements defined in 10 CFR 835, "Occupational Radiation Protection," as amended.

During the execution of the River Corridor Closure Contract, hazards are identified and hazard controls are developed and applied via two fundamental mechanisms: job hazards analysis (JHA) and a HASP. The JHA process is used during all work that is performed through the application of a work package. The JHA process is described in PAS-2, *Integrated Work Control Program*, PAS-2-1.1, "Integrated Work Control." The work package process is controlled by the Integrated Work Control Program (IWCP) and is independent of where the facility, location, or work activity is in the project life cycle. The IWCP is used to plan and implement field work for WCH-managed facilities. The IWCP utilizes multi-disciplinary teamwork and worker involvement to support the identification and analysis of work site hazards, development of the work package, performance of work, and observational approach for newly identified hazards. Also covered are administrative work package closeout activities. Work packages are developed and approved for release using a graded approach based on risk and complexity of the work hazards and worker competence.

For all other activities outside of the IWCP process, a HASP is used to identify hazards and hazards controls. The development and maintenance of the HASP is described in SH-1, *Safety and Health*, SH-1-6.1, "Project/Facility Safety Planning and Documentation." For work that falls within the scope of 29 CFR 1910.120, "Hazardous Waste Operations and Emergency Response," a site-specific health and safety plan (SSHASP) is developed. The SSHASP and JHA include job-specific hazards analysis, hazards inventory, and the actions prescribed to minimize environmental and Safety, Health and Quality hazards. The development of the SSHASP and JHA is based on 10 CFR 851, "Worker Safety and Health," Environmental, Safety, Health and Quality Assessment procedures and programs, lessons learned, and past work experience. Based on the conclusions of the detail design, certain classes of work require the development of emergency response implementation instructions. These documents are revised as new hazards are recognized.

7.0 REMEDIAL INVESTIGATION SCHEDULE

Figure 7-1 shows the anticipated project schedule for the initial activities in this RI work plan (i.e., the field sampling, sample analysis, data evaluation) that will lead to a scientific management decision point. It is at this scientific management decision point that the Tri-Parties will identify the scope and begin the associated planning process for any further investigation activities that may be needed to continue the remedial investigation process. Updates to the project schedule will be made as necessary to complete the work presently scope in RI. New schedules that reflect any further investigation activities beyond the scientific management decision point will be included in the work plan documents that are prepared to identify and authorize that work

Updates to the schedule and general status of the work plan activities will be communicated to the regulators, stakeholders, and Tribes periodically during the performance of work. Unit managers meetings, Hanford Natural Resource Trustee Council meetings, Hanford Advisory Board meetings, consultation with Tribal nations, and periodic workshops will be utilized to communicate work progress and schedule updates.

Remedial Investigation Schedule

Figure 7-1. Project Schedule.

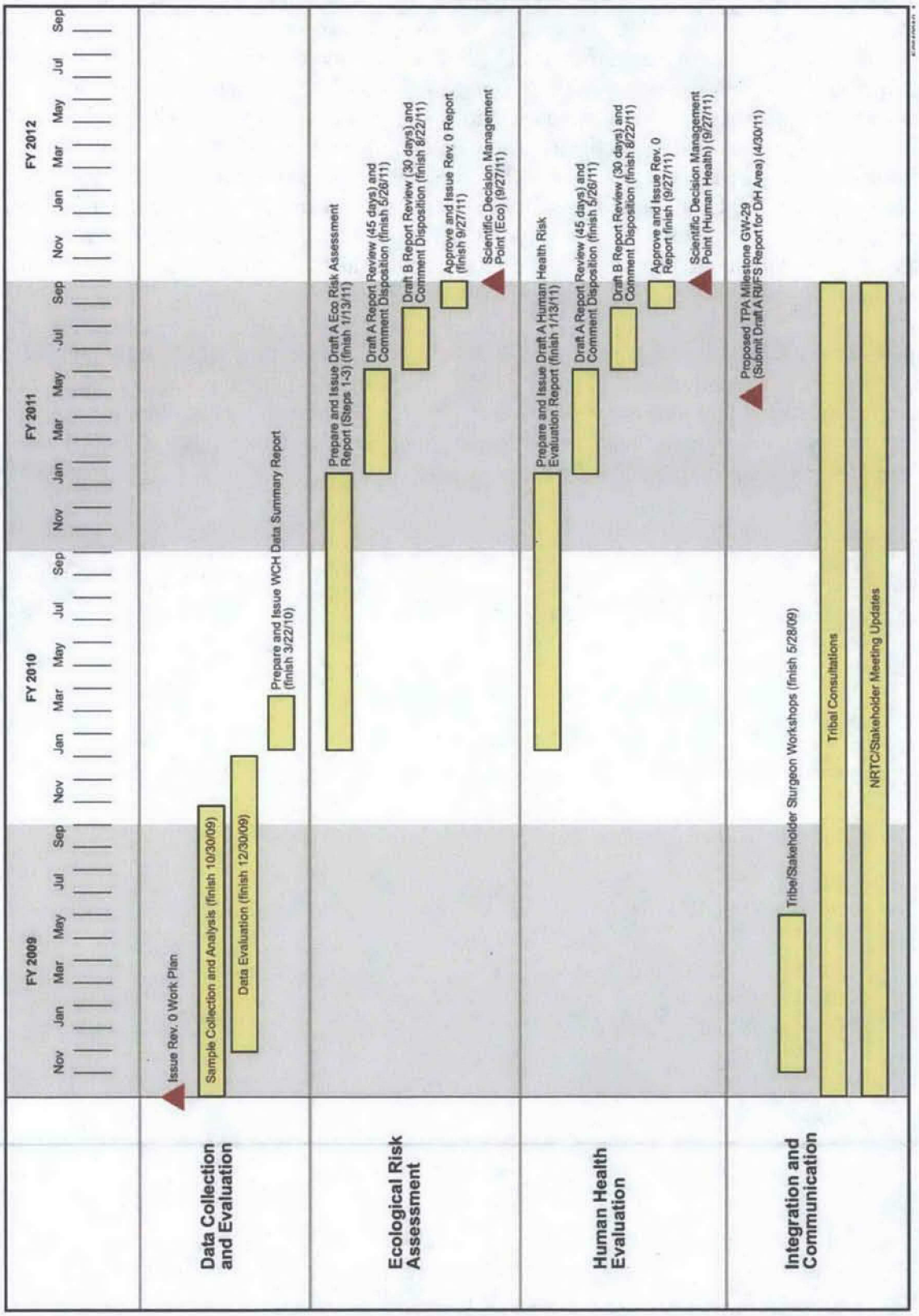


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Table 4-18. Selected Ecological Surface Water and Sediment Benchmarks. (4 Pages)

Analyte	CAS #/Analyte Code	Selected Surface Water Aquatic Life Benchmark	Surface Water Units	Surface Water Aquatic Life Benchmark Source	Selected Surface Water Amphibian Benchmark, mg/L	Surface Water Amphibian Benchmark Source	Selected Sediment Benchmark	Sediment Units	Sediment Benchmark Source	Soils Benchmark*	Soil Units	Soil Benchmark Source	Soil Receptor
VOLATILE ORGANICS													
1, 1, 1-Trichloroethane	71-55-6	0.011	mg/L	Suter and Tsao 1996			0.03	mg/kg	ORNL 1997				
1, 1, 2-Trichloroethane	79-00-5	1.2	mg/L	Suter and Tsao 1996			1.2	mg/kg	ORNL 1997				
1, 1-Dichloroethane	75-34-3	0.047	mg/L	Suter and Tsao 1996			0.27	mg/kg	ORNL 1997				
1, 2-Dichloroethane	107-06-2	0.91	mg/L	Suter and Tsao 1996	0.06	Westerman, et al. 2003	0.25	mg/kg	ORNL 1997				
1, 2-Dichloropropane	78-87-5	5.7	mg/L	ODEQ, 2001						700	mg/kg	Ecology 2001	soil biota
1, 4-Dichlorobenzene	106-46-7	0.015	mg/L	Suter and Tsao 1996			0.34	mg/kg	ORNL 1997	20	mg/kg	Ecology 2001	soil biota
1, 2, 3-Trichlorobenzene	87-61-6	0.11	mg/L	Suter and Tsao 1996			9.6	mg/kg	ORNL 1997	20	mg/kg	Ecology 2001	soil biota
2-Butoxyethanol	111-76-2		mg/L										
2-Hexanone	591-78-6	0.099	mg/L	ODEQ, 2001			0.022	mg/kg	ORNL 1997				
2-Methylphthalene	91-57-6	0.0021	mg/L	ODEQ, 2001			0.02	mg/kg	ODEQ 2001	3	mg/kg	Hill AFB 2005	soil biota
4-Methyl-2-Pentanone	108-10-1	0.17	mg/L	Suter and Tsao 1996			0.033	mg/kg	ORNL 1997				
Acetone	67-64-1	1.5	mg/L	Suter and Tsao 1996	106	Westerman, et al. 2003	0.0087	mg/kg	ORNL 1997				
Benzene	71-43-2	0.13	mg/L	Suter and Tsao 1996	0.196	Westerman, et al. 2003	0.16	mg/kg	ORNL 1997	20	mg/kg	Ecology 2001	soil biota
Carbon disulfide	75-15-0	0.00092	mg/L	ODEQ, 2001			0.00085	mg/kg	ORNL 1997				
Carbon tetrachloride	56-23-5	0.0098	mg/L	Suter and Tsao 1996	0.064	Westerman, et al. 2003	0.047	mg/kg	ORNL 1997				
Chlorobenzene	108-90-7	0.064	mg/L	Suter and Tsao 1996	0.068	Westerman, et al. 2003	0.41	mg/kg	ORNL 1997	40	mg/kg	Ecology 2001	soil biota
Chloroform	67-66-3	0.028	mg/L	Suter and Tsao 1996	0.302	Westerman, et al. 2003	0.022	mg/kg	ORNL 1997				
cis-1, 2-Dichloroethylene	156-59-2	0.047	mg/L	Suter and Tsao 1996			0.4	mg/kg	ORNL 1997				
Dichloroethylene	25323-30-2	0.025	mg/L	ODEQ, 2001			0.4	mg/kg	ORNL 1997				
Ethylbenzene	100-41-4	0.0073	mg/L	Suter and Tsao 1996			0.089	mg/kg	ORNL 1997				
Methylene chloride	75-09-2	2.2	mg/L	Suter and Tsao 1996	4.16	Westerman, et al. 2003	0.37	mg/kg	ORNL 1997	1600	mg/kg	LANL 2005	plant
Naphthalene	91-20-3				0.017	Westerman, et al. 2003	0.529	mg/kg	Michelsen 2003	2	mg/kg	Hill AFB 2005	soil biota
Styrene	100-42-5									300	mg/kg	Ecology 2001	plant
Tetrachloroethene	127-18-4	0.84	mg/L	ODEQ, 2001 1998			0.057	mg/kg	ODEQ 2001	10	mg/kg	LANL 2005	plant
Toluene	108-88-3	0.0098	mg/L	Suter and Tsao 1996	0.068	Westerman, et al. 2003	0.05	mg/kg	ORNL 1997	200	mg/kg	Ecology 2001	plant
trans-1,2-Dichloroethylene	156-60-5	0.047	mg/L	Suter and Tsao 1996			0.4	mg/kg	ORNL 1997				
Trichloroethene	79-01-6	0.047	mg/L	Suter and Tsao 1996	0.46	Westerman, et al. 2003	0.22	mg/kg	ORNL 1997				
Vinyl acetate	108-05-4	0.016	mg/L	Suter and Tsao 1996			0.00084	mg/kg	ORNL 1997				
Vinyl Chloride**	75-01-4	1.3	mg/L	ODEQ, 1998			0.03	mg/kg	ODEQ, 1998				
Xylenes (total)	1330-20-7	0.013	mg/L	Suter and Tsao 1996	1.07	Westerman, et al. 2003	0.16	mg/kg	ORNL 1997	40	mg/kg	Ecology 2001	soil invertebrate
SEMIVOLATILE ORGANICS													
1, 2, 4-Trichlorobenzene	120-82-1	0.11	mg/L	Suter and Tsao 1996			9.6	mg/kg	ORNL 1997	20	mg/kg	Ecology 2001	soil biota
1, 2, 3, 4-Tetrachlorobenzene	634-66-2							mg/kg		10	mg/kg	Ecology 2001	soil biota
1, 2-Dichlorobenzene	95-50-1	0.014	mg/L	ODEQ, 2001	1.73	Westerman, et al. 2003	0.33	mg/kg	ORNL 1997	20	mg/kg	Ecology 2001	soil biota
1, 3-Dichlorobenzene	541-73-1	0.071	mg/L	ODEQ, 2001			1.7	mg/kg	ORNL 1997	20	mg/kg	Ecology 2001	soil biota
2, 3, 4, 5-Tetrachlorophenol	4901-51-3									20	mg/kg	Ecology 2001	soil biota
2, 4, 5-Trichlorophenol	95-95-4						0.003	mg/kg	ODEQ 2001	4	mg/kg	Ecology 2001	plant
2, 4, 6-Trichlorophenol	88-06-2	0.97	mg/L	ODEQ, 2001	0.012	Westerman, et al. 2003	0.006	mg/kg	ODEQ 2001	10	mg/kg	Ecology 2001	soil biota
2, 4-Dinitrotoluene	121-14-2	0.23	mg/L	ODEQ, 2001						4	mg/kg	Ecology 2001	plant
2, 6-Dinitrotoluene	606-20-2	0.23	mg/L	ODEQ, 2001						4	mg/kg	Ecology 2001	plant
2-Chlorophthalene	91-58-7	0.032	mg/L	ODEQ, 2001						4	mg/kg	Ecology 2001	plant
2, 4-Dichlorophenol	120-83-2	3.65	mg/L	ODEQ, 2001						20	mg/kg	Ecology 2001	plant
2, 4-Dimethylphenol	105-67-9	0.042	mg/L	ODEQ, 2001			0.018	mg/kg	ODEQ 2001	4	mg/kg	Ecology 2001	plant
2, 4-Dinitrophenol	51-28-5									20	mg/kg	Ecology 2001	plant
2-Chlorophenol	95-57-8	2	mg/L	ODEQ, 2001						7	mg/kg	Ecology 2001	plant
2-Methylphenol (cresol, o-)	95-48-7	0.013	mg/L	ODEQ, 2001			0.008	mg/kg	ODEQ 2001	20	mg/kg	Ecology 2001	plant
2-Nitrophenol	88-75-5	0.15	mg/L	ODEQ, 2001						7	mg/kg	Ecology 2001	soil biota
4-Nitrophenol	100-02-7	0.15	mg/L	ODEQ, 2001						7	mg/kg	Ecology 2001	soil biota
Acephthene	83-32-9	0.52	mg/L	ODEQ, 2001			1.06	mg/kg	Michelsen 2003	20	mg/kg	Ecology 2001	plant
Acephthylene	208-96-8						0.47	mg/kg	Michelsen 2003	2.3	mg/kg	Hill AFB 2005	soil biota
Anthracene	120-12-7	0.013	mg/L	ODEQ, 2001			1.23	mg/kg	Michelsen 2003	1.2	mg/kg	Hill AFB 2005	plant
Benzo(a)anthracene	56-55-3	0.000027	mg/L	ODEQ, 2001			4.26	mg/kg	Michelsen 2003	18	mg/kg	LANL 2005	plant
Benzo(a)pyrene	50-32-8	0.000014	mg/L	ODEQ, 2001	0.01	Westerman, et al. 2003	3.3	mg/kg	Michelsen 2003	12	mg/kg	Ecology 2001	wildlife
Benzo(b)fluoranthene	205-99-2						1.8	mg/kg	ODEQ 2001	18	mg/kg	LANL 2005	plant
Benzo(ghi)perylene	191-24-2						4.02	mg/kg	Michelsen 2003	1.2	mg/kg	Hill AFB 2005	plant
Benzo(k)fluoranthene	207-08-9						0.027	mg/kg	ODEQ 2001	1.2	mg/kg	Hill AFB 2005	plant
Benzoic acid	65-85-0	0.042	mg/L	ODEQ, 2001	4.33	HSD	2.91	mg/kg	Michelsen 2003				
Benzyl alcohol	100-51-6	0.0086	mg/L	Suter and Tsao 1996			0.0011	mg/kg	ORNL 1997				
Biphenyl	92-52-4	0.014	mg/L	ODEQ, 2001			1.1	mg/kg	ORNL 1997	60	mg/kg	Ecology 2001	plant
Bis(2-ethylhexyl)phthalate	117-81-7	0.003	mg/L	ODEQ, 2001			2.52	mg/kg	Michelsen 2003	100	mg/kg	Ecology 2001	plant
Butylbenzylphthalate	85-68-7	0.019	mg/L	ODEQ, 2001			0.26	mg/kg	Michelsen 2003	10	mg/kg	Hill AFB 2005	plant
Chrysene	218-01-9						5.94	mg/kg	Michelsen 2003	1.2	mg/kg	Hill AFB 2005	plant

Table 4-18. Selected Ecological Surface Water and Sediment Benchmarks. (4 Pages)

Analyte	CAS #/Analyte Code	Selected Surface Water Aquatic Life Benchmark	Surface Water Units	Surface Water Aquatic Life Benchmark Source	Selected Surface Water Amphibian Benchmark, mg/L	Surface Water Amphibian Benchmark Source	Selected Sediment Benchmark	Sediment Units	Sediment Benchmark Source	Soils Benchmark*	Soil Units	Soil Benchmark Source	Soil Receptor
Dibenz[a,h]anthracene	53-70-3						0.8	mg/kg	Michelsen 2003	1.2	mg/kg	Hill AFB 2005	plant
Dibenzofuran	132-64-9	0.037	mg/L	ODEQ, 2001			0.399	mg/kg	Michelsen 2003	6.1	mg/kg	LANL 2005	plant
Diethylphthalate	84-66-2	0.21	mg/L	ODEQ, 2001			0.6	mg/kg	ORNL 1997	100	mg/kg	Ecology 2001	plant
Dimethyl phthalate	131-11-3	0.003	mg/L	ODEQ, 2001			0.311	mg/kg	Michelsen 2003	200	mg/kg	Ecology 2001	soil biota
Di-n-butylphthalate	84-74-2	0.035	mg/L	ODEQ, 2001			0.103	mg/kg	Michelsen 2003	200	mg/kg	Ecology 2001	plant
Di-n-octylphthalate	117-84-0						0.011	mg/kg	Michelsen 2003	100	mg/kg	Ecology 2001	plant
Fluoranthene	206-44-0	0.00616	mg/L	ODEQ, 2001			11.1	mg/kg	Michelsen 2003	4.7	mg/kg	Hill AFB 2005	soil biota
Fluorene	86-73-7	0.0039	mg/L	ODEQ, 2001			1.07	mg/kg	Michelsen 2003	30	mg/kg	Ecology 2001	soil biota
Heptadecane	629-78-7												
Hexachlorobutadiene	87-68-3	0.0093	mg/L	ODEQ, 2001			0.001	mg/kg	ODEQ 2001	10	mg/kg	Ecology 2001	plant
Hexachlorocyclopentadiene	77-47-4	0.0052	mg/L	ODEQ, 2001						10	mg/kg	Ecology 2001	plant
Hexachloroethane	67-72-1	0.54	mg/L	ODEQ, 2001			1	mg/kg	ORNL 1997	10	mg/kg	Ecology 2001	plant
Indeno(1, 2, 3-cd)pyrene	193-39-5						4.12	mg/kg	Michelsen 2003				
Nitrobenzene	98-95-3	0.54	mg/L	ODEQ, 2001	0.026	Westerman, et al. 2003	0.021	mg/kg	ODEQ 2001	40	mg/kg	Ecology 2001	soil biota
N-Nitroso-di-n-dipropylamine	621-64-7	0.117	mg/L	ODEQ, 2001			0.028	mg/kg	ODEQ 2001	20	mg/kg	Ecology 2001	soil biota
N-Nitrosodiphenylamine	86-30-6	0.021	mg/L	ODEQ, 2001						20	mg/kg	Ecology 2001	soil biota
Pentachlorobenzene	608-93-5	0.00047	mg/L	Suter and Tsao 1996						10	mg/kg	Ecology 2001	soil biota
Pentachlorophenol	87-86-5	0.015	mg/L	ODEQ, 2001	0.001	Westerman, et al. 2003	0.017	mg/kg	ODEQ 2001	2.1	mg/kg	Ecology 2001	bird
Phenthrene	85-01-8	0.0063	mg/L	ODEQ, 2001			6.1	mg/kg	Michelsen 2003	2.1	mg/kg	Hill AFB 2005	soil biota
Phenol	108-95-2	0.11	mg/L	ODEQ, 2001	0.028	Westerman, et al. 2003	0.048	mg/kg	Ecology 1997	30	mg/kg	Ecology 2001	soil biota
Pyrene	129-00-0						8.79	mg/kg	Michelsen 2003	1.3	mg/kg	Hill AFB 2005	soil invertebrate
METALS													
Aluminum	7429-90-5	0.087	mg/L	USEPA 2006	0.01	Westerman, et al. 2003	14000	mg/kg	Ingersoll 1996	50	mg/kg	Ecology 2001	plant
Antimony	7440-36-0	0.03	mg/L	Suter and Tsao 1996	0.03	Westerman, et al. 2003	0.6	mg/kg	Michelsen 2003	0.27	mg/kg	EPA SSL	mammal
Arsenic	7440-38-2	0.15	mg/L	USEPA 2006	0.01	Westerman, et al. 2003	31.4	mg/kg	Michelsen 2003	10	mg/kg	Ecology 2001	plant
Barium	7440-39-3	0.004	mg/L	Suter and Tsao 1996	0.766	Westerman, et al. 2003	48	mg/kg	ODEQ 2001	102	mg/kg	Ecology 2001	wildlife
Beryllium	7440-41-7	0.00066	mg/L	Suter and Tsao 1996	0.011	Westerman, et al. 2003	0.46	mg/kg	Michelsen 2003	10	mg/kg	Ecology 2001	plant
Boron	7440-42-8	0.0016	mg/L	ODEQ, 2001	0.242	Westerman, et al. 2003				0.5	mg/kg	Ecology 2001	plant
Cadmium	7440-43-9	0.00025	mg/L	USEPA 2006	0.002	Westerman, et al. 2003	2.39	mg/kg	Michelsen 2003	0.36	mg/kg	EPA SSL	mammal
Calcium	7440-70-2	116	mg/L	Suter and Tsao 1996									
Chromium	7440-47-3	0.074	mg/L	USEPA 2006	0.006	Westerman, et al. 2003	95	mg/kg	Michelsen 2003	26	mg/kg	EPA SSL	bird
Cobalt	7440-48-4	0.023	mg/L	Suter and Tsao 1996	0.017	Westerman, et al. 2003	50	mg/kg	Persaud et. al. 1993	13	mg/kg	EPA SSL	plant
Copper	7440-50-8	0.009	mg/L	USEPA 2006	0.003	Westerman, et al. 2003	619	mg/kg	Michelsen 2003	28	mg/kg	EPA SSL	bird
Hexavalent Chromium	18540-29-9	0.01	mg/L	Ecology 2006	0.133	Linder and Grillitsch 2000				81	mg/kg	EPA SSL	mammal
Iron	7439-89-6	1	mg/L	USEPA 2006	0.3	Westerman, et al. 2003	200000	mg/kg	Ingersoll, 1996				
Lead	7439-92-1	0.0025	mg/L	Ecology 2006	0.008	Westerman, et al. 2003	335	mg/kg	Michelsen 2003	11	mg/kg	EPA SSL	bird
Lithium	7439-93-2	0.014	mg/L	ODEQ, 2001	0.078	Westerman, et al. 2003				35	mg/kg	Ecology 2001	plant
Magnesium	7439-95-4	82	mg/L	Suter and Tsao 1996	13.9	Westerman, et al. 2003							
Manganese	7439-96-5	0.12	mg/L	Suter and Tsao 1996	0.0142	Birge, et al. 2000	1800	mg/kg	Ecology 1997	220	mg/kg	EPA SSL	plant
Mercury	7439-97-6	0.000012	mg/L	Ecology 2006	0.001	Westerman, et al. 2003	0.8	mg/kg	Michelsen 2003	0.1	mg/kg	Ecology 2001	soil biota
Molybdenum	7439-98-7	0.37	mg/L	ODEQ, 2001	6.8	Westerman, et al. 2003				2	mg/kg	Ecology 2001	plant
Nickel	7440-02-0	0.052	mg/L	USEPA 2006	0.003	Westerman, et al. 2003	53.1	mg/kg	Michelsen 2003	30	mg/kg	Ecology 2001	plant
Potassium	7440-09-7	53	mg/L	Suter and Tsao 1996									
Selenium	7782-49-2	0.005	mg/L	Ecology 2006	0.01	Westerman, et al. 2003	1	mg/kg	ODEQ 2001	0.3	mg/kg	Ecology 2001	wildlife
Silver	7440-22-4	0.00036	mg/L	Suter and Tsao 1996	0.001	Westerman, et al. 2003	0.545	mg/kg	Michelsen 2003	2	mg/kg	Ecology 2001	plant
Sodium	7440-23-5	680	mg/L	Suter and Tsao 1996									
Strontium	7440-24-6	1.5	mg/L	Suter and Tsao 1996	0.107	Westerman, et al. 2003							
Thallium	7440-28-0	0.012	mg/L	Suter and Tsao 1996	0.014	Westerman, et al. 2003				1	mg/kg	Ecology 2001	plant
Tin	7440-31-5	0.073	mg/L	Suter and Tsao 1996	0.005	Westerman, et al. 2003				50	mg/kg	Ecology 2001	plant
Uranium	7440-61-1	0.0026	mg/L	Suter and Tsao 1996						5	mg/kg	Ecology 2001	plant
Vadium	7440-62-2	0.02	mg/L	Suter and Tsao 1996	0.025	Westerman, et al. 2003	57	mg/kg	ODEQ 2001	2	mg/kg	Ecology 2001	plant
Zinc	7440-66-6	0.105	mg/L	Ecology 2006	0.003	Westerman, et al. 2003	683	mg/kg	Michelsen 2003	86	mg/kg	Ecology 2001	plant
Cyanide	57-12-5	0.0052	mg/L	LANL 2005				mg/kg					
RADIONUCLIDES													
Americium-241	14596-10-2	438	pCi/L	ANL 2006			5150	pCi/g	ANL 2006	3890	pCi/g	ANL 2006	soil invertebrate
Antimony-125	14234-35-6	400000	pCi/L	ANL 2006			7000	pCi/g	ANL 2006	3520	pCi/g	ANL 2006	soil invertebrate
Barium-140	14798-08-4	94.6	pCi/L	ANL 2006			230	pCi/g	ANL 2006	7.32	pCi/g	ANL 2006	soil invertebrate
Carbon-14	14762-75-5	609	pCi/L	ANL 2006			59000	pCi/g	ANL 2006	4760	pCi/g	ANL 2006	soil invertebrate
Cerium-141	13967-74-3	7890	pCi/L	ANL 2006			15900	pCi/g	ANL 2006	7900	pCi/g	ANL 2006	soil invertebrate
Cerium-144	14762-78-8	8830	pCi/L	ANL 2006			2900	pCi/g	ANL 2006	1440	pCi/g	ANL 2006	soil invertebrate
Cesium-137	10045-97-3	42.6	pCi/L	ANL 2006			3120	pCi/g	ANL 2006	20.8	pCi/g	ANL 2006	soil invertebrate
Cobalt-58	13981-38-9	66.3	pCi/L	ANL 2006			3800	pCi/g	ANL 2006	1800	pCi/g	ANL 2006	soil invertebrate
Cobalt-60	10198-40-0	3760	pCi/L	ANL 2006			1460	pCi/g	ANL 2006	692	pCi/g	ANL 2006	soil invertebrate

Table 4-18. Selected Ecological Surface Water and Sediment Benchmarks. (4 Pages)

Analyte	CAS #/Analyte Code	Selected Surface Water Aquatic Life Benchmark	Surface Water Units	Surface Water Aquatic Life Benchmark Source	Selected Surface Water Amphibian Benchmark, mg/L	Surface Water Amphibian Benchmark Source	Selected Sediment Benchmark	Sediment Units	Sediment Benchmark Source	Soils Benchmark[a]	Soil Units	Soil Benchmark Source	Soil Receptor
Curium-244	13981-15-2	66.3	pCi/L	ANL 2006			5190	pCi/g	ANL 2006	4060	pCi/g	ANL 2006	soil invertebrate
Europium-152	14683-23-9	25500	pCi/L	ANL 2006			3040	pCi/g	ANL 2006	1520	pCi/g	ANL 2006	soil invertebrate
Europium-154	15585-10-1	20000	pCi/L	ANL 2006			3000	pCi/g	ANL 2006	1290	pCi/g	ANL 2006	soil invertebrate
Europium-155	14391-16-3	264000	pCi/L	ANL 2006			31600	pCi/g	ANL 2006	15800	pCi/g	ANL 2006	soil invertebrate
Iodine-129	15046-84-1	40000	pCi/L	ANL 2006			28600	pCi/g	ANL 2006	5670	pCi/g	ANL 2006	soil invertebrate
Iodine-131	10043-66-0	13700	pCi/L	ANL 2006			5490	pCi/g	ANL 2006	862	pCi/g	ANL 2006	soil invertebrate
Neptunium-237	13994-20-2	68.5	pCi/L	ANL 2006			7630	pCi/g	ANL 2006	3860	pCi/g	ANL 2006	soil invertebrate
Plutonium-238	13981-16-3	176	pCi/L	ANL 2006			5730	pCi/g	ANL 2006	5270	pCi/g	ANL 2006	soil invertebrate
Plutonium-239/240	PU-239/240	187	pCi/L	ANL 2006			5860	pCi/g	ANL 2006	6110	pCi/g	ANL 2006	soil invertebrate
Potassium-40	13966-00-2	250	pCi/L	ANL 2006			4430	pCi/g	ANL 2006	119	pCi/g	ANL 2006	soil invertebrate
Radium-226	13982-63-3	4	pCi/L	ANL 2006			100	pCi/g	ANL 2006	50.6	pCi/g	ANL 2006	soil invertebrate
Radium-228	15262-20-1	3	pCi/L	ANL 2006			90	pCi/g	ANL 2006	43.9	pCi/g	ANL 2006	soil invertebrate
Strontium-90	10098-97-2	300	pCi/L	ANL 2006			600	pCi/g	ANL 2006	22.5	pCi/g	ANL 2006	soil invertebrate
Technetium-99	14133-76-7	700000	pCi/L	ANL 2006			42200	pCi/g	ANL 2006	4490	pCi/g	ANL 2006	soil invertebrate
Thorium-228	14274-82-9	374	pCi/L	ANL 2006			805	pCi/g	ANL 2006	530	pCi/g	ANL 2006	soil invertebrate
Thorium-229	15594-54-4	374	pCi/L	ANL 2006			1050	pCi/g	ANL 2006	789	pCi/g	ANL 2006	soil invertebrate
Thorium-230	14269-63-7	2570	pCi/L	ANL 2006			10400	pCi/g	ANL 2006	9980	pCi/g	ANL 2006	soil invertebrate
Thorium-232	TH-232	300	pCi/L	ANL 2006			1000	pCi/g	ANL 2006	1510	pCi/g	ANL 2006	soil invertebrate
Tritium	10028-17-8	300000000	pCi/L	ANL 2006			374000	pCi/g	ANL 2006	174000	pCi/g	ANL 2006	soil invertebrate
Uranium-233	13968-55-3	200	pCi/L	ANL 2006			5,280 pCi/g	pCi/g	ANL 2006	4830	pCi/g	ANL 2006	soil invertebrate
Uranium-233/234	U-233/234	5270	pCi/L	ANL 2006							pCi/g		
Uranium-234	13966-29-5	200	pCi/L	ANL 2006			5000	pCi/g	ANL 2006	5130	pCi/g	ANL 2006	soil invertebrate
Uranium-235	15117-96-1	200	pCi/L	ANL 2006			4000	pCi/g	ANL 2006	2770	pCi/g	ANL 2006	soil invertebrate
Uranium-238	U-238	200	pCi/L	ANL 2006			2000	pCi/g	ANL 2006	1580	pCi/g	ANL 2006	soil invertebrate
Zinc-65	13982-39-3	13.2	pCi/L	ANL 2006			1,430 pCi/g	pCi/g	ANL 2006	413	pCi/g	ANL 2006	soil invertebrate
Zirconium/Niobium-95	ZR/NB-95						2,330 pCi/g	pCi/g	ANL 2006		pCi/g		
Zirconium-95	13967-71-0	7330	pCi/L	ANL 2006				pCi/g		1170			
PESTICIDES/POLYCHLORITED BIPHENYLS													
Aldrin	309-00-2	0.0000019	mg/L	Ecology 2006			0.04	mg/kg	ODEQ 2001	0.1	mg/kg	Ecology 2001	wildlife
Alpha-BHC	319-84-6	0.0022	mg/L	ODEQ, 2001			0.006	mg/kg	Persaud et. al. 1993	6	mg/kg	Ecology 2001	wildlife
alpha-Chlordane	5103-71-9	0.0000043	mg/L	Ecology 2006			0.01	mg/kg	ODEQ 2001	1	mg/kg	Ecology 2001	soil biota
beta-1, 2, 3, 4, 5, 6-Hexachlorocyclohexane	319-85-7									10	mg/kg	Ecology 2001	plant
Bromine	7726-95-6									10	mg/kg	Ecology 2001	plant
Chlordane	57-74-9	0.0000043	mg/L	ODEQ, 2001			0.0045	mg/kg	ODEQ 2001	1	mg/kg	Ecology 2001	soil biota
Delta-BHC	319-86-8	0.0022	mg/L	Suter and Tsao 1996			0.12	mg/kg	ORNL 1997	6	mg/kg	Ecology 2001	wildlife
Dichlorodiphenyldichloroethane	72-54-8	0.000001	mg/L	Ecology 2006									
Dichlorodiphenyldichloroethylene	72-55-9	0.000001	mg/L	Ecology 2006									
Dichlorodiphenyltrichloroethane	50-29-3	0.000001	mg/L	Ecology 2006						3.7	mg/kg	LANL 2005	plant
Dieldrin	60-57-1	0.0000019	mg/L	Ecology 2006			0.003	mg/kg	ODEQ 2001	0.0049	mg/kg	EPA SSL	mammal
Endosulfan I	959-98-8	0.000056	mg/L	LANL 2005				mg/kg					
Endosulfan II	33213-65-9	0.000056	mg/L	LANL 2005			0.006	mg/kg	LANL 2005				
Endosulfan sulfate	1031-07-8	0.000056	mg/L	LANL 2005			0.006	mg/kg	LANL 2005				
Endrin	72-20-8	0.0000023	mg/L	Ecology 2006	0.051	Westerman, et al. 2003	0.003	mg/kg	ODEQ 2001	0.2	mg/kg	Ecology 2001	wildlife
Endrin aldehyde	7421-93-4						0.003	mg/kg	ODEQ 2001	0.0034	mg/kg	LANL 2005	plant
Endrin ketone	53494-70-5	0.0000023	mg/L	Ecology 2006						0.0034	mg/kg	LANL 2005	plant
Gamma-BHC (Lindane)	58-89-9	0.00008	mg/L	Ecology 2006			0.0009	mg/kg	ODEQ 2001	0.1	mg/kg	LANL 2005	plant
gamma-Chlordane	5103-74-2	0.0000043	mg/L	Ecology 2006			0.0045 mg/kg	mg/kg	ODEQ 2001	2.2	mg/kg	LANL 2005	plant
Heptachlor	76-44-8	0.0000038	mg/L	Ecology 2006	0.004	Westerman, et al. 2003	0.01	mg/kg	ODEQ 2001	0.4	mg/kg	LANL 2005	plant
Heptachlor epoxide	1024-57-3	0.0000038	mg/L	USEPA 2006			O.0006	mg/kg	ODEQ 2001				
Hexachlorobenzene	118-74-1						0.1	mg/kg	ODEQ 2001	17	mg/kg	Ecology 2001	wildlife
Methoxychlor	72-43-5	0.00003	mg/L	USEPA 2006			0.019	mg/kg	ORNL 1997				
Parathion	56-38-2	0.000013	mg/L	Ecology 2006	0.011	Westerman, et al. 2003							
Total BHC	Total_BHC						0.1	mg/kg	ODEQ 2001	6	mg/kg	Ecology 2001	wildlife
Total Heptachlors	Total_Heptachlor	0.0000038	mg/L	Ecology 2006			0.01	mg/kg	ODEQ 2001	0.4	mg/kg	Ecology 2001	wildlife
o,p'-DDD	53-19-0	0.000001	mg/L	Ecology 2006			0.004 mg/kg	mg/kg	ODEQ 2001				
o,p'-DDE	3424-82-6	0.000001	mg/L	Ecology 2006			0.0015 mg/kg	mg/kg	ODEQ 2001				
o,p'-DDT	789-02-6	0.000001	mg/L	Ecology 2006			0.004 mg/kg	mg/kg	ODEQ 2001				
Total DDT	TOTALDDT	0.000001	mg/L	Ecology 2006			0.019	mg/kg	Michelsen 2003	0.021	mg/kg	EPA SSL	mammal
Aroclor-1016	12674-11-2				0.0014	Westerman, et al. 2003				40	mg/kg	Ecology 2001	plant
Aroclor-1221	11104-28-2	0.00028	mg/L	ODEQ, 2001						40	mg/kg	Ecology 2001	plant
Aroclor-1232	11141-16-5	0.00058	mg/L	ODEQ, 2001						40	mg/kg	Ecology 2001	plant
Aroclor-1242	53469-21-9	0.000053	mg/L	ODEQ, 2001	0.00042	Westerman, et al. 2003				40	mg/kg	Ecology 2001	plant
Aroclor-1248	12672-29-6	0.000081	mg/L	ODEQ, 2001			0.021	mg/kg	Ecology 1997	40	mg/kg	Ecology 2001	plant

Table 4-18. Selected Ecological Surface Water and Sediment Benchmarks. (4 Pages)

Analyte	CAS #/Analyte Code	Selected Surface Water Aquatic Life Benchmark	Surface Water Units	Surface Water Aquatic Life Benchmark Source	Selected Surface Water Amphibian Benchmark, mg/L	Surface Water Amphibian Benchmark Source	Selected Sediment Benchmark	Sediment Units	Sediment Benchmark Source	Soils Benchmark*	Soil Units	Soil Benchmark Source	Soil Receptor
Aroclor-1254	11097-69-1	0.000033	mg/L	ODEQ, 2001	0.00014	Westerman, et al. 2003	0.23	mg/kg	Michelsen 2003	40	mg/kg	Ecology 2001	plant
Aroclor-1260	11096-82-5	0.094	mg/L	ODEQ, 2001			0.138	mg/kg	Michelsen 2003	40	mg/kg	Ecology 2001	plant
Aroclor-1262	37324-23-5									40	mg/kg	Ecology 2001	plant
Aroclor-1268	11100-14-4									40	mg/kg	Ecology 2001	plant
Total PCBs	Total_PCB	0.000014	mg/L	Ecology 2006			0.062	mg/kg	Michelsen 2003	0.65	mg/kg	Ecology 2001	wildlife
HERBICIDES													
2-secButyl-4,6-dinitrophenol(DNBP)	88-85-7												
DIOXINS/FURANS													
Total Dioxins	Total_Dioxin									0.000002	mg/kg	Ecology 2001	wildlife
Total Furans	Total_Furan									600	mg/kg	Ecology 2001	plant
OTHER ALYTES													
Chloride	16887-00-6	230	mg/L	Ecology 2006									
Sulfide	18496-25-8						720	mg/kg	Michelsen 2003				
Total organic carbon	TOC						9.82	%	Michelsen 2003				

Notes:

*Value shown is the lowest benchmark from among all soil receptors . Receptor-specific values will be used in the BERA.

**Benchmarks for vinyl chloride based on effects to mammals.

CAS # = chemical abstract service number

mg/L = milligrams per liter

mg/kg = milligrams per kilogram

blank means no value available

Surface Water Aquatic Life Benchmark Sources

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Surface Water Amphibian Benchmark Sources

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Sediment Benchmark Sources

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Soils Benchmark Sources

Ecology, 2001. Ecological Indicator Soil Concentrations for Protection of Terrestrial Plants and Animals, WAC 173-340, Table 749-3. Most values as cited in RCBRA and reflect use of surrogates, as follows: benzene based on 1, 4 dichlorobenzene value; xylene based on chlorobenzene value; dichlorobenzenes based on 1, 4 dichlorobenzene value; dinitrotoluenes, 2-chlorophthalene, and methylphenols based on 2, 4, 5-trichlorophenol; 2, 4-dichlorophenol based on 3, 4-dichlorophenol; 2-chlorophenol based on 3-chlorophenol; 2-nitrophenol based on 4-nitrophenol; bis-2(ethylhexyl) phthalate, di-n-octylphthalate based on diethylphthalate; hexachlorobutadiene, hexachloroethane, hexachlorocyclohexane based on hexachlorocyclopentadiene; n-nitroso-di-n-propylamine based on n-nitrosdiphenylamine, pentachlorobenzene based on 1, 2, 3, 4-tetrachlorobenzene.

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Table 4-19. Selected Human Health Benchmarks for Island Soil and Sediments in the Columbia River Baseline Human Health Risk Assessment. (5 Pages)

Analyte	CAS #/Analyte Code	Region 9 PRG (mg/kg)[1]	Region 6 Screening Level (mg/kg)[1]	Basis for Region 6/9 Screening Level[1]	Adjusted Region 6/9 Values (mg/kg)[2]	SSL (mg/kg)[3]	SSL-rad (pCi/g)[4]	MCTA-Residential, Direct Contact (mg/kg)[5]	MCTA Leaching-Based Values (mg/kg)[6]	Notes	Selected Benchmark[7]	Units	Basis for Selected Benchmark
VOLATILE ORGANICS													
1, 1, 1-Trichloroethane	71-55-6		1.39E+03	sat	1.39E+03	1.20E+03	NA	7.20E+04	5.70E+01		5.70E+01	mg/kg	MCTA-Leaching
1, 1, 2, 2-Tetrachloroethane	79-34-5		3.80E-01	C	3.80E-01	6.00E-01	NA	5.00E+00	1.36E-03		1.36E-03	mg/kg	MCTA-Leaching
1, 1, 2-Trichloroethane	79-00-5		8.44E-01	C	8.44E-01	1.00E+00	NA	1.80E+01	4.28E-03		4.28E-03	mg/kg	MCTA-Leaching
1, 1-Dichloroethane	75-34-3		8.46E+02	N	8.46E+01	1.20E+03	NA	8.00E+03	8.73E+00		8.73E+00	mg/kg	MCTA-Leaching
1, 2, 3-Trichlorobenzene	87-61-6		1.43E+02	N	1.43E+01	6.10E+02	NA	8.00E+02	1.48E+00	Value for 1, 2, 4-trichlorobenzene	1.48E+00	mg/kg	MCTA-Leaching
1, 2, 3, 4-Tetrachlorobenzene	634-66-2		1.80E+01	N	1.80E+00	NA	NA	2.40E+01	1.33E-01	Value for 1, 2, 4, 5-tetrachlorobenzene	1.33E-01	mg/kg	MCTA-Leaching
1, 2, 4-Trichlorobenzene	120-82-1		1.43E+02	N	1.43E+01	6.10E+02	NA	8.00E+02	1.48E+00		1.48E+00	mg/kg	MCTA-Leaching
1, 2-Dichlorobenzene	95-50-1		2.79E+02	N	2.79E+01	6.00E+02	NA	7.20E+03	8.43E+00		8.43E+00	mg/kg	MCTA-Leaching
1, 3-Dichlorobenzene	541-73-1		6.85E+01	N	6.85E+00	NA	NA	NA	NA		6.85E+00	mg/kg	Region 6/9
1, 2-Dichloroethane	107-06-2		3.47E-01	C	3.47E-01	4.00E-01	NA	1.10E+01	2.32E-03		2.32E-03	mg/kg	MCTA-Leaching
1, 2-Dichloropropane	78-87-5		3.51E-01	C	3.51E-01	9.00E+00	NA	1.50E+01	3.29E-03		3.29E-03	mg/kg	MCTA-Leaching
1, 4-Dichlorobenzene	106-46-7		3.20E+00	C	3.20E+00	2.00E+01	NA	4.20E+01	2.97E-02		2.97E-02	mg/kg	MCTA-Leaching
2-Butanone	78-93-3		3.20E+04	N	3.20E+03	NA	NA	4.80E+04	1.96E+01		1.96E+01	mg/kg	MCTA-Leaching
2-Butoxyethanol	111-76-2		3.06E+04	N	3.06E+03	NA	NA	4.00E+04	1.61E+01		1.61E+01	mg/kg	MCTA-Leaching
2-Hexanone	591-78-6		NA	NA	NA	NA	NA	NA	NA		NA	mg/kg	NA
4-Methyl-2-Pentanone	108-10-1		5.80E+03	N	5.80E+02	NA	NA	6.40E+03	2.71E+00		2.71E+00	mg/kg	MCTA-Leaching
Acetone	67-64-1		1.42E+04	N	1.42E+03	7.80E+03	NA	8.00E+03	3.23E+00		3.23E+00	mg/kg	MCTA-Leaching
Benzene	71-43-2		6.56E-01	C	6.56E-01	8.00E-01	NA	1.80E+01	4.51E-03		4.51E-03	mg/kg	MCTA-Leaching
Carbon disulfide	75-15-0		7.20E+02	sat	7.20E+02	7.20E+02	NA	8.00E+03	4.03E+00		4.03E+00	mg/kg	MCTA-Leaching
Carbon tetrachloride	56-23-5		2.40E-01	C	2.40E-01	3.00E-01	NA	7.70E+00	3.04E-03		3.04E-03	mg/kg	MCTA-Leaching
Chlorobenzene	108-90-7		2.73E+02	N	2.73E+01	3.80E+02	NA	1.60E+03	1.39E+00		1.39E+00	mg/kg	MCTA-Leaching
Chloroform	67-66-3		2.45E-01	C	2.45E-01	7.80E+02	NA	1.60E+02	3.83E-02		3.83E-02	mg/kg	MCTA-Leaching
cis-1, 2-Dichloroethylene	156-59-2		4.30E+01	N	4.30E+00	7.80E+02	NA	8.00E+02	4.14E-01		4.14E-01	mg/kg	MCTA-Leaching
Dichloroethylene	25323-30-2		4.30E+01	N	4.30E+00	7.80E+02	NA	8.00E+02	4.14E-01	Value for 1, 1-DCE	4.14E-01	mg/kg	MCTA-Leaching
Diethyl Ether	60-29-7		1.80E+03	sat	1.80E+03	NA	NA	1.60E+04	6.68E+00		6.68E+00	mg/kg	MCTA-Leaching
Ethylbenzene	100-41-4		2.34E+02	sat	2.34E+02	4.00E+02	NA	8.00E+03	1.19E+01		1.19E+01	mg/kg	MCTA-Leaching
Methyl isobutyl ketone	108-10-1		5.80E+03	N	5.80E+02	NA	NA	6.40E+03	2.71E+00		2.71E+00	mg/kg	MCTA-Leaching
Methylenechloride	75-09-2		8.90E+00	C	8.90E+00	1.30E+01	NA	1.30E+02	2.57E-02		2.57E-02	mg/kg	MCTA-Leaching
Naphthalene	91-20-3		1.25E+02	N	1.25E+01	1.70E+02	NA	1.60E+03	4.46E+00		4.46E+00	mg/kg	MCTA-Leaching
Styrene	100-42-5		1.70E+03	sat	1.70E+03	1.50E+03	NA	3.30E+01	3.36E-02		3.36E-02	mg/kg	MCTA-Leaching
Tetrachloroethene	127-18-4		5.54E-01	C	5.54E-01	1.00E+00	NA	1.90E+00	8.54E-04		8.54E-04	mg/kg	MCTA-Leaching
Toluene	108-88-3		5.21E+02	sat	5.21E+02	6.50E+02	NA	6.40E+03	4.65E+00		4.65E+00	mg/kg	MCTA-Leaching
trans-1, 2-Dichloroethylene	156-60-5		1.22E+02	N	1.22E+01	1.60E+03	NA	1.60E+03	8.67E-01		8.67E-01	mg/kg	MCTA-Leaching
Trichloroethene	79-01-6		4.26E-02	C	4.26E-02	7.00E-02	NA	2.50E+00	7.23E-04		7.23E-04	mg/kg	MCTA-Leaching
Vinyl acetate	108-05-4		9.88E+02	N	9.88E+01	9.80E+02	NA	8.00E+04	3.33E+01		3.33E+01	mg/kg	MCTA-Leaching
Vinyl chloride	75-01-4		4.30E-02	C	4.30E-02	4.00E-01	NA	6.70E-01	1.82E-04		1.82E-04	mg/kg	MCTA-Leaching
Xylenes (total)	1330-20-7		2.14E+02	sat	2.14E+02	1.60E+05	NA	1.60E+04	2.13E+01		2.13E+01	mg/kg	MCTA-Leaching
SEMIVOLATILE ORGANICS													
2, 3, 4, 5-Tetrachlorophenol	4901-51-3		1.80E+03	N	1.80E+02	NA	NA	2.40E+03	4.61E+00	Value for 2, 3, 4, 6-tetrachlorophenol	4.61E+00	mg/kg	MCTA-Leaching
2, 4, 5-Trichlorophenol	95-95-4		6.11E+03	N	6.11E+02	6.10E+03	NA	8.00E+03	2.22E+01		2.22E+01	mg/kg	MCTA-Leaching
2, 4, 6-Trichlorophenol	88-06-2		4.42E+01	C	4.42E+01	4.40E+01	NA	9.10E+01	1.11E-01		1.11E-01	mg/kg	MCTA-Leaching
2, 4-Dichlorophenol	120-83-2		1.83E+02	N	1.83E+01	1.80E+02	NA	2.40E+02	4.40E-01		4.40E-01	mg/kg	MCTA-Leaching
2, 4-Dimethylphenol	105-67-9		1.22E+03	N	1.22E+02	1.20E+03	NA	1.60E+03	2.94E+00		2.94E+00	mg/kg	MCTA-Leaching
2, 4-Dinitrophenol	51-28-5		1.22E+02	N	1.22E+01	1.20E+02	NA	1.60E+02	3.61E-01		3.61E-01	mg/kg	MCTA-Leaching
2, 4-Dinitrotoluene	121-14-2		1.22E+02	N	1.22E+01	7.00E-01	NA	1.60E+02	3.61E-01		3.61E-01	mg/kg	MCTA-Leaching
2, 6-Dinitrotoluene	606-20-2		6.11E+01	N	6.11E+00	7.00E-01	NA	8.00E+01	1.83E-01		1.83E-01	mg/kg	MCTA-Leaching
2-Chloronaphthalene	91-58-7		3.86E+03	N	3.86E+02	NA	NA	6.40E+03	4.07E+01		4.07E+01	mg/kg	MCTA-Leaching
2-Chlorophenol	95-57-8		6.35E+01	N	6.35E+00	3.10E+02	NA	4.00E+02	5.15E-01		5.15E-01	mg/kg	MCTA-Leaching
2-Methylnaphthalene	91-57-6		NA	NA	NA	NA	NA	3.20E+02	2.03E+00		2.03E+00	mg/kg	MCTA-Leaching
2-Methylphenol (cresol, o-)	95-48-7	3.06E+03	NA	NA	3.06E+02	3.10E+03	NA	4.00E+03	5.14E+00		5.14E+00	mg/kg	MCTA-Leaching

Table 4-19. Selected Human Health Benchmarks for Island Soil and Sediments in the Columbia River Baseline Human Health Risk Assessment. (5 Pages)

Analyte	CAS #/Analyte Code	Region 9 PRG (mg/kg)[1]	Region 6 Screening Level (mg/kg)[1]	Basis for Region 6/9 Screening Level[1]	Adjusted Region 6/9 Values (mg/kg)[2]	SSL (mg/kg)[3]	SSL-rad (pCi/g)[4]	MCTA-Residential, Direct Contact (mg/kg)[5]	MCTA Leaching-Based Values (mg/kg)[6]	Notes	Selected Benchmark[7]	Units	Basis for Selected Benchmark
2-Nitrophenol	88-75-5		4.90E+02	N	4.90E+01	NA	NA	NA	NA	Value for 4-nitrophenol	4.90E+01	mg/kg	Region 6/9
4-Nitrophenol	100-02-7		4.89E+02	N	4.89E+01	NA	NA	NA	NA		4.89E+01	mg/kg	Region 6/9
Acenaphthene	83-32-9		3.68E+03	N	3.68E+02	3.40E+03	NA	4.80E+03	9.79E+01		9.79E+01	mg/kg	MCTA-Leaching
Acenaphthylene	208-96-8		3.70E+03	N	3.70E+02	3.40E+03	NA	4.80E+03	9.79E+01	Value for acenaphthene	9.79E+01	mg/kg	MCTA-Leaching
Anthracene	120-12-7		2.19E+04	N	2.19E+03	1.70E+04	NA	2.40E+04	2.27E+03		2.19E+03	mg/kg	Region 6/9
Benzo(a)anthracene	56-55-3		1.48E-01	C	1.48E-01	6.00E-01	NA	1.40E-01	8.59E-01		1.40E-01	mg/kg	MCTA-Direct Contact
Benzo(a)pyrene	50-32-8		1.48E-02	C	1.48E-02	6.00E-02	NA	1.40E-01	2.33E-01		1.48E-02	mg/kg	Region 6/9
Benzo(b)fluoranthene	205-99-2		1.48E-01	C	1.48E-01	6.00E-01	NA	1.40E-01	1.93E+00		1.40E-01	mg/kg	MCTA-Direct Contact
Benzo(ghi)perylene	191-24-2		2.30E+03	N	2.30E+02	1.70E+03	NA	2.40E+03	6.55E+02	Value for pyrene	2.30E+02	mg/kg	Region 6/9
Benzo(k)fluoranthene	207-08-9		1.48E+00	C	1.48E+00	6.00E+00	NA	1.40E-01	1.89E+00		1.40E-01	mg/kg	MCTA-Direct Contact
Benzoic Acid	65-85-0		1.00E+05	max	1.00E+05	3.10E+05	NA	3.20E+05	2.75E+02		2.75E+02	mg/kg	MCTA-Leaching
Benzyl alcohol	100-51-6		1.83E+04	N	1.83E+03	NA	NA	2.40E+04	1.04E+01		1.04E+01	mg/kg	MCTA-Leaching
Biphenyl	92-52-4		3.00E+03	N	3.00E+02	NA	NA	4.00E+03	5.16E+01		5.16E+01	mg/kg	MCTA-Leaching
Bis(2-ethylhexyl) phthalate	117-81-7		3.47E+01	C	3.47E+01	3.50E+01	NA	7.10E+01	2.09E+01		2.09E+01	mg/kg	MCTA-Leaching
Butylbenzylphthalate	85-68-7		2.40E+02	sat	2.40E+02	1.20E+04	NA	1.60E+04	8.93E+02		2.40E+02	mg/kg	Region 6/9
Carbazole	86-74-8		2.40E+01	C	2.40E+01	2.40E+01	NA	5.00E+01	1.01E+00		1.01E+00	mg/kg	MCTA-Leaching
Chrysene	218-01-9		1.48E+01	C	1.48E+01	6.20E+01	NA	1.40E-01	5.67E+00		1.40E-01	mg/kg	MCTA-Direct Contact
Dibenz[a,h]anthracene	53-70-3		1.48E-02	C	1.48E-02	6.00E-02	NA	1.40E-01	4.29E+00		1.48E-02	mg/kg	Region 6/9
Dibenzofuran	132-64-9		1.45E+02	N	1.45E+01	NA	NA	1.60E+02	NA		1.45E+01	mg/kg	Region 6/9
Diethylphthalate	84-66-2		4.89E+04	N	4.89E+03	4.90E+04	NA	6.40E+04	7.33E+01		7.33E+01	mg/kg	MCTA-Leaching
Dimethyl phthalate	131-11-3		1.00E+05	max	1.00E+05	NA	NA	8.00E+04	9.02E+01		9.02E+01	mg/kg	MCTA-Leaching
Di-n-butylphthalate	84-74-2		6.11E+03	N	6.11E+02	6.10E+03	NA	8.00E+03	5.65E+01		5.65E+01	mg/kg	MCTA-Leaching
Di-n-octylphthalate	117-84-0	2.4.E+03	NA	N	2.44E+02	1.20E+03	NA	1.60E+03	1.28E+00		1.28E+00	mg/kg	MCTA-Leaching
Fluoranthene	206-44-0		2.29E+03	N	2.29E+02	2.30E+03	NA	3.20E+03	6.31E+02		2.29E+02	mg/kg	Region 6/9
Fluorene	86-73-7		2.64E+03	N	2.64E+02	2.30E+03	NA	3.20E+03	1.01E+02		1.01E+02	mg/kg	MCTA-Leaching
Hexachlorobutadiene	87-68-3		6.24E+00	C	6.24E+00	6.00E+00	NA	1.30E+01	1.38E-02		1.38E-02	mg/kg	MCTA-Leaching
Hexachlorocyclopentadiene	77-47-4		3.66E+02	N	3.66E+01	2.90E+01	NA	4.80E+02	1.88E+00		1.88E+00	mg/kg	MCTA-Leaching
Hexachloroethane	67-72-1		3.47E+01	C	3.47E+01	3.50E+01	NA	7.10E+01	2.72E-02		2.72E-02	mg/kg	MCTA-Leaching
Indeno(1, 2, 3-cd)pyrene	193-39-5		1.48E-01	C	1.48E-01	6.00E-01	NA	1.40E-01	6.42E+00		1.40E-01	mg/kg	MCTA-Direct Contact
Isophorone	78-59-1		5.10E+02	C	5.10E+02	5.10E+02	NA	1.10E+03	2.38E-01		2.38E-01	mg/kg	MCTA-Leaching
Nitrobenzene	98-95-3		1.97E+01	N	1.97E+00	3.10E+01	NA	4.00E+01	3.13E-02		3.13E-02	mg/kg	MCTA-Leaching
N-Nitroso-di-n-dipropylamine	621-64-7		6.95E-02	C	6.95E-02	7.00E-02	NA	1.40E-01	NA		6.95E-02	mg/kg	Region 6/9
N-Nitrosodiphenylamine	86-30-6		9.93E+01	C	9.93E+01	9.90E+01	NA	2.00E+02	NA		9.90E+01	mg/kg	SSL
Pentachlorobenzene	608-93-5		4.89E+01	N	4.89E+00	NA	NA	6.40E+01	8.41E+00		4.89E+00	mg/kg	Region 6/9
Pentachlorophenol	87-86-5		2.98E+00	C	2.98E+00	3.00E+00	NA	8.30E+00	5.23E-02		5.23E-02	mg/kg	MCTA-Leaching
Phenanthrene	85-01-8		3.70E+03	N	3.70E+02	3.40E+03	NA	4.80E+03	9.79E+01	Value for acenaphthene	9.79E+01	mg/kg	MCTA-Leaching
Phenol	108-95-2		1.83E+04	N	1.83E+03	1.80E+04	NA	4.80E+04	4.49E+01		4.49E+01	mg/kg	MCTA-Leaching
Pyrene	129-00-0		2.31E+03	N	2.31E+02	1.70E+03	NA	2.40E+03	6.55E+02		2.31E+02	mg/kg	Region 6/9
TPH	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA	mg/kg	NA
METALS													
Aluminum	7429-90-5		7.73E+04	N	7.73E+03	NA	NA	NA	NA		7.73E+03	mg/kg	Region 6/9
Antimony	7440-36-0		3.13E+01	N	3.13E+00	3.10E+01	NA	3.20E+01	NA		3.13E+00	mg/kg	Region 6/9
Arsenic	7440-38-2		3.90E-01	C	3.90E-01	4.00E-01	NA	6.70E-01	NA		3.90E-01	mg/kg	Region 6/9
Barium	7440-39-3		1.56E+04	N	1.56E+03	5.50E+03	NA	1.60E+04	NA		1.56E+03	mg/kg	Region 6/9
Beryllium	7440-41-7		1.56E+02	N	1.56E+01	1.60E+02	NA	1.60E+02	NA		1.56E+01	mg/kg	Region 6/9
Boron	7440-42-8		1.60E+04	N	1.60E+03	NA	NA	1.60E+04	NA		1.60E+03	mg/kg	Region 6/9
Cadmium	7440-43-9		3.90E+01	N	3.90E+00	7.00E+01	NA	4.00E+01	NA		3.90E+00	mg/kg	Region 6/9
Calcium	7440-70-2	NA	NA	NA	NA	NA	NA	NA	NA		NA	mg/kg	NA
Chromium	7440-47-3		3.00E+01	C	3.00E+01	2.30E+02	NA	2.40E+02	NA	Value for Cr6+	3.00E+01	mg/kg	Region 6/9
Cobalt	7440-48-4		9.03E+02	C	9.03E+02	NA	NA	NA	NA		9.03E+02	mg/kg	Region 6/9
Copper	7440-50-8		2.91E+03	N	2.91E+02	NA	NA	3.00E+03	NA		2.91E+02	mg/kg	Region 6/9
Cyanide (total)	57-12-5		1.22E+03	N	1.22E+02	1.60E+03	NA	1.60E+03	NA		1.22E+02	mg/kg	Region 6/9
Hexavalent Chromium	18540-29-9		3.00E+01	C	3.00E+01	2.30E+02	NA	2.40E+02	NA		3.00E+01	mg/kg	Region 6/9
Iron	7439-89-6		5.48E+04	N	5.48E+03	NA	NA	NA	NA		5.48E+03	mg/kg	Region 6/9

Table 4-19. Selected Human Health Benchmarks for Island Soil and Sediments in the Columbia River Baseline Human Health Risk Assessment. (5 Pages)

Analyte	CAS #/Analyte Code	Region 9 PRG (mg/kg)[1]	Region 6 Screening Level (mg/kg)[1]	Basis for Region 6/9 Screening Level[1]	Adjusted Region 6/9 Values (mg/kg)[2]	SSL (mg/kg)[3]	SSL-rad (pCi/g)[4]	MCTA-Residential, Direct Contact (mg/kg)[5]	MCTA Leaching-Based Values (mg/kg)[6]	Notes	Selected Benchmark[7]	Units	Basis for Selected Benchmark
Lead	7439-92-1		4.00E+02		4.00E+02	NA	NA	2.50E+02	NA		2.50E+02	mg/kg	MCTA-Direct Contact
Lithium	7439-93-2	1.6.E+03	NA	N	1.56E+02	NA	NA	NA	NA		1.56E+02	mg/kg	Region 6/9
Magnesium	7439-95-4	NA	NA	NA	NA	NA	NA	NA	NA		NA	mg/kg	NA
Manganese	7439-96-5		3.47E+03	N	3.47E+02	NA	NA	1.10E+04	NA		3.47E+02	mg/kg	Region 6/9
Mercury	7439-97-6		2.30E+01	N	2.30E+00	1.00E+01	NA	2.40E+01	5.02E+00		2.30E+00	mg/kg	Region 6/9
Molybdenum	7439-98-7		3.91E+02	N	3.91E+01	NA	NA	4.00E+02	NA		3.91E+01	mg/kg	Region 6/9
Nickel	7440-02-0		1.56E+03	N	1.56E+02	1.60E+03	NA	1.60E+03	NA		1.56E+02	mg/kg	Region 6/9
Phosphorus	7723-14-0		1.60E+00	N	1.60E-01	NA	NA	1.60E+00	NA		1.60E-01	mg/kg	Region 6/9
Potassium	7440-09-7	NA	NA	NA	NA	NA	NA	NA	NA		NA	mg/kg	NA
Selenium	7782-49-2		3.91E+02	N	3.91E+01	3.90E+02	NA	4.00E+02	NA		3.91E+01	mg/kg	Region 6/9
Silver	7440-22-4		3.91E+02	N	3.91E+01	3.90E+02	NA	4.00E+02	NA		3.91E+01	mg/kg	Region 6/9
Sodium	7440-23-5	NA	NA	NA	NA	NA	NA	NA	NA		NA	mg/kg	NA
Strontium (elemental)	7440-24-6		4.69E+04	N	4.69E+03	NA	NA	4.80E+04	NA		4.69E+03	mg/kg	Region 6/9
Thallium	7440-28-0		5.48E+00	N	5.48E-01	6.00E+00	NA	5.60E+00	NA		5.48E-01	mg/kg	Region 6/9
Tin	7440-31-5		4.69E+04	N	4.69E+03	NA	NA	4.80E+04	NA		4.69E+03	mg/kg	Region 6/9
Uranium (inorganic)	7440-61-1	4.7.E+01	NA	N	4.68E+00	NA	NA	2.40E+02	NA	Value for soluble salts	4.68E+00	mg/kg	Region 9; adjusted to account for EPA Office of Water revised RfD of 0.0006 mg/kg/d.
Vanadium	7440-62-2		3.91E+02	N	3.91E+01	5.50E+02	NA	5.60E+02	NA		3.91E+01	mg/kg	Region 6/9
Zinc	7440-66-6		2.35E+04	N	2.35E+03	2.30E+04	NA	2.40E+04	NA		2.35E+03	mg/kg	Region 6/9
RADIONUCLIDES													
Americium-241	14596-10-2	NA	NA	NA	NA	NA	3.7.E+00	NA	NA		3.66E+00	pCi/g	SSL-rad
Antimony-125	14234-35-6	NA	NA	NA	NA	NA	6.2.E-02	NA	NA		6.17E-02	pCi/g	SSL-rad
Barium-140	14798-08-4	NA	NA	NA	NA	NA	NA	NA	NA		NA	pCi/g	NA
Carbon-14	14762-75-5	NA	NA	NA	NA	NA	2.8.E+02	NA	NA		2.84E+02	pCi/g	SSL-rad
Cerium-141	13967-74-3	NA	NA	NA	NA	NA	NA	NA	NA		NA	pCi/g	NA
Cerium-144	14762-78-8	NA	NA	NA	NA	NA	4.6.E-01	NA	NA		4.57E-01	pCi/g	SSL-rad
Cesium-134	13967-70-9	NA	NA	NA	NA	NA	1.6.E-02	NA	NA		1.57E-02	pCi/g	SSL-rad
Cesium-137	10045-97-3	NA	NA	NA	NA	NA	4.4.E-02	NA	NA		4.38E-02	pCi/g	SSL-rad
Cobalt-58	13981-38-9	NA	NA	NA	NA	NA	NA	NA	NA		NA	pCi/g	NA
Cobalt-58	13981-38-9	NA	NA	NA	NA	NA		NA	NA		0.00E+00		SSL-rad
Cobalt-60	10198-40-0	NA	NA	NA	NA	NA	9.0.E-03	NA	NA		9.00E-03	pCi/g	SSL-rad
Curium-244	13981-15-2	NA	NA	NA	NA	NA	4.4.E+00	NA	NA		4.39E+00	pCi/g	SSL-rad
Europium-152	14683-23-9	NA	NA	NA	NA	NA	2.1.E-02	NA	NA		2.11E-02	pCi/g	SSL-rad
Europium-154	15585-10-1	NA	NA	NA	NA	NA	1.9.E-02	NA	NA		1.91E-02	pCi/g	SSL-rad
Europium-155	14391-16-3	NA	NA	NA	NA	NA	9.0.E-01	NA	NA		9.00E-01	pCi/g	SSL-rad
Iodine-129	15046-84-1	NA	NA	NA	NA	NA	2.9.E+00	NA	NA		2.93E+00	pCi/g	SSL-rad
Iodine-131	10043-66-0	NA	NA	NA	NA	NA	NA	NA	NA		NA	pCi/g	NA
Neptunium-237	13994-20-2	NA	NA	NA	NA	NA	1.4.E-01	NA	NA		1.40E-01	pCi/g	SSL-rad
Nickel-63	13981-37-8	NA	NA	NA	NA	NA	3.0.E+01	NA	NA		2.96E+01	pCi/g	SSL-rad
Niobium-94	14681-63-1	NA	NA	NA	NA	NA	1.5.E-02	NA	NA		1.53E-02	pCi/g	SSL-rad
Plutonium-238	13981-16-3	NA	NA	NA	NA	NA	2.9.E+00	NA	NA		2.92E+00	pCi/g	SSL-rad
Plutonium-239/240	PU-239/240	NA	NA	NA	NA	NA	2.9.E+00	NA	NA		2.87E+00	pCi/g	SSL-rad
Plutonium-241	14119-32-5	NA	NA	NA	NA	NA	2.4.E+02	NA	NA		2.41E+02	pCi/g	SSL-rad
Potassium-40	13966-00-2	NA	NA	NA	NA	NA	1.4.E-01	NA	NA		1.40E-01	pCi/g	SSL-rad
Radium-226	13982-63-3	NA	NA	NA	NA	NA	1.3.E-02	NA	NA		1.31E-02	pCi/g	SSL-rad
Radium-228	15262-20-1	NA	NA	NA	NA	NA	2.5.E-02	NA	NA		2.46E-02	pCi/g	SSL-rad
Strontium-90	10098-97-2	NA	NA	NA	NA	NA	5.5.E+00	NA	NA		5.51E+00	pCi/g	SSL-rad
Technetium-99	14133-76-7	NA	NA	NA	NA	NA	1.0.E+02	NA	NA		1.04E+02	pCi/g	SSL-rad
Manganese-54	13966-31-9	NA	NA	NA	NA	NA	2.9.E-02	NA	NA		2.87E-02		SSL-rad
Thorium-228	14274-82-9	NA	NA	NA	NA	NA	1.4.E-02	NA	NA		1.44E-02	pCi/g	SSL-rad
Thorium-229	15594-54-4	NA	NA	NA	NA	NA	9.5.E-02	NA	NA		9.54E-02	pCi/g	SSL-rad
Thorium-230	14269-63-7	NA	NA	NA	NA	NA	3.9.E+00	NA	NA		3.93E+00	pCi/g	SSL-rad
Cobalt-57	13981-50-5	NA	NA	NA	NA	NA	3.1.E-01	NA	NA		3.14E-01	pCi/g	SSL-rad

Table 4-19. Selected Human Health Benchmarks for Island Soil and Sediments in the Columbia River Baseline Human Health Risk Assessment. (5 Pages)

Analyte	CAS #/Analyte Code	Region 9 PRG (mg/kg)[1]	Region 6 Screening Level (mg/kg)[1]	Basis for Region 6/9 Screening Level[1]	Adjusted Region 6/9 Values (mg/kg)[2]	SSL (mg/kg)[3]	SSL-rad (pCi/g)[4]	MCTA-Residential, Direct Contact (mg/kg)[5]	MCTA Leaching-Based Values (mg/kg)[6]	Notes	Selected Benchmark[7]	Units	Basis for Selected Benchmark
Thorium-232	TH-232	NA	NA	NA	NA	NA	3.4.E+00	NA	NA		3.44E+00	pCi/g	SSL-rad
Tritium	10028-17-8	NA	NA	NA	NA	NA	5.1.E+02	NA	NA		5.10E+02	pCi/g	SSL-rad
Uranium-233	13968-55-3	NA	NA	NA	NA	NA	5.0.E+00	NA	NA		4.96E+00	pCi/g	SSL-rad
Uranium-234	13966-29-5	NA	NA	NA	NA	NA	5.0.E+00	NA	NA		5.02E+00	pCi/g	SSL-rad
Uranium-235	15117-96-1	NA	NA	NA	NA	NA	2.1.E-01	NA	NA		2.06E-01	pCi/g	SSL-rad
Uranium-238	U-238	NA	NA	NA	NA	NA	9.8.E-01	NA	NA		9.79E-01	pCi/g	SSL-rad
Uranium-233/234	U-233/234	NA	NA	NA	NA	NA	5.0.E+00	NA	NA		4.96E+00		SSL-rad
Uranium-236	13982-70-2	NA	NA	NA	NA	NA	5.3.E+00	NA	NA		5.33E+00		SSL-rad
Zinc-65	13982-39-3	NA	NA	NA	NA	NA	4.0.E-02	NA	NA		3.97E-02	pCi/g	SSL-rad
Zirconium/Niobium-95	ZR/NB-95	NA	NA	NA	NA	NA	NA	NA	NA		NA	pCi/g	NA
PESTICIDES/POLYCHLORINATED BIPHENYLS													
77 3, 3', 4, 4'-tetrachlorobiphenyls			3.90E-02	C	3.90E-02	NA	NA	1.10E-01	NA		3.90E-02	mg/kg	Region 6/9
81 3, 4, 4', 5-tetrachlorobiphenyl			1.30E-02	C	1.30E-02	NA	NA	3.67E-02	NA		1.30E-02	mg/kg	Region 6/9
105 2, 3, 3', 4, 4'- pentachlorobiphenyls			1.30E-01	C	1.30E-01	NA	NA	3.67E-01	NA		1.30E-01	mg/kg	Region 6/9
114 2, 3, 4, 4', 5- pentachlorobiphenyls			1.30E-01	C	1.30E-01	NA	NA	3.67E-01	NA		1.30E-01	mg/kg	Region 6/9
118 2, 3', 4, 4', 5- pentachlorobiphenyls			1.30E-01	C	1.30E-01	NA	NA	3.67E-01	NA		1.30E-01	mg/kg	Region 6/9
123 2', 3, 4, 4', 5- pentachlorobiphenyls			1.30E-01	C	1.30E-01	NA	NA	3.67E-01	NA		1.30E-01	mg/kg	Region 6/9
126 3, 3', 4, 4', 5-pentachlorobiphenyls			3.90E-05	C	3.90E-05	NA	NA	1.10E-04	NA		3.90E-05	mg/kg	Region 6/9
156 2, 3, 3', 4, 4', 5- hexachlorobiphenyls			1.30E-01	C	1.30E-01	NA	NA	3.67E-01	NA		1.30E-01	mg/kg	Region 6/9
157 2, 3, 3', 4, 4', 5'- hexachlorobiphenyls			1.30E-01	C	1.30E-01	NA	NA	3.67E-01	NA		1.30E-01	mg/kg	Region 6/9
167 2, 3', 4, 4', 5, 5'- hexachlorobiphenyls			1.30E-01	C	1.30E-01	NA	NA	3.67E-01	NA		1.30E-01	mg/kg	Region 6/9
169 3, 3', 4, 4', 5, 5'-hexachlorobiphenyls			1.30E-04	C	1.30E-04	NA	NA	3.67E-04	NA		1.30E-04	mg/kg	Region 6/9
189 2, 3, 3', 4, 4', 5, 5'-heptachlorobiphenyls			1.30E-01	C	1.30E-01	NA	NA	3.67E-01	NA		1.30E-01	mg/kg	Region 6/9
Aldrin	309-00-2		2.86E-02	C	2.86E-02	4.00E-02	NA	5.90E-02	2.54E-03		2.54E-03	mg/kg	MCTA-Leaching
Alpha-BHC	319-84-6		9.02E-02	C	9.02E-02	1.00E-01	NA	1.60E-01	5.49E-04		5.49E-04	mg/kg	MCTA-Leaching
alpha-Chlordane	5103-71-9		1.60E+00	C	1.60E+00	2.00E+00	NA	2.90E+00	2.58E-01	Value for chlordane	2.58E-01	mg/kg	MCTA-Leaching
Aroclor-1016	12674-11-2		3.93E+00	N	3.93E-01	NA	NA	5.60E+00	2.36E+00		3.93E-01	mg/kg	Region 6/9
Aroclor-1221	11104-28-2		2.22E-01	C	2.22E-01	NA	NA	5.00E-01	4.85E-01	Region 6/9: Value for total PCBs; MCTA: value for Aroclor 1254	2.22E-01	mg/kg	Region 6/9
Aroclor-1232	11141-16-5		2.22E-01	C	2.22E-01	NA	NA	5.00E-01	4.85E-01		2.22E-01	mg/kg	Region 6/9
Aroclor-1242	53469-21-9		2.22E-01	C	2.22E-01	NA	NA	5.00E-01	4.85E-01		2.22E-01	mg/kg	Region 6/9
Aroclor-1248	12672-29-6		2.22E-01	C	2.22E-01	NA	NA	5.00E-01	4.85E-01		2.22E-01	mg/kg	Region 6/9
Aroclor-1254	11097-69-1		2.22E-01	C	2.22E-01	NA	NA	5.00E-01	4.85E-01		2.22E-01	mg/kg	Region 6/9
Aroclor-1260	11096-82-5		2.22E-01	C	2.22E-01	NA	NA	5.00E-01	4.85E-01		2.22E-01	mg/kg	Region 6/9
Aroclor-1262	37324-23-5		2.20E-01	C	2.20E-01	NA	NA	5.00E-01	4.85E-01		2.20E-01	mg/kg	Region 6/9
Aroclor-1268	11100-14-4		2.20E-01	C	2.20E-01	NA	NA	5.00E-01	4.85E-01		2.20E-01	mg/kg	Region 6/9
beta-1, 2, 3, 4, 5, 6-Hexachlorocyclohexane	319-85-7		3.16E-01	C	3.16E-01	4.00E-01	NA	5.60E-01	3.51E-03		3.51E-03	mg/kg	MCTA-Leaching
Bromine	7726-95-6	NA	NA	NA	NA	NA	NA	NA	NA		NA	mg/kg	NA
Chlordane	57-74-9		1.62E+00	C	1.62E+00	2.00E+00	NA	2.90E+00	2.58E-01		2.58E-01	mg/kg	MCTA-Leaching
Delta-BHC	319-86-8		4.40E-01	C	4.40E-01	4.00E-01	NA	7.70E-01	2.08E-03	Value for gamma BHC	2.08E-03	mg/kg	MCTA-Leaching
Dichlorodiphenyldichloroethane	72-54-8		2.44E+00	C	2.44E+00	3.00E+00	NA	4.20E+00	1.10E+00		1.10E+00	mg/kg	MCTA-Leaching
Dichlorodiphenyldichloroethylene	72-55-9		1.72E+00	C	1.72E+00	2.00E+00	NA	2.90E+00	7.94E-01		7.94E-01	mg/kg	MCTA-Leaching
Dichlorodiphenyltrichloroethane	50-29-3		1.72E+00	C	1.72E+00	2.00E+00	NA	2.90E+00	1.15E+00		1.15E+00	mg/kg	MCTA-Leaching
Dieldrin	60-57-1		3.04E-02	C	3.04E-02	4.00E-02	NA	6.30E-02	2.83E-03		2.83E-03	mg/kg	MCTA-Leaching
Endosulfan I	959-98-8		3.70E+02	N	3.70E+01	4.70E+02	NA	4.80E+02	4.30E+00	Value for endosulfan	4.30E+00	mg/kg	MCTA-Leaching
Endosulfan II	33213-65-9		3.70E+02	N	3.70E+01	4.70E+02	NA	4.80E+02	4.30E+00	Value for endosulfan	4.30E+00	mg/kg	MCTA-Leaching
Endosulfan sulfate	1031-07-8		3.70E+02	N	3.70E+01	4.70E+02	NA	4.80E+02	4.30E+00	Value for endosulfan	4.30E+00	mg/kg	MCTA-Leaching
Endrin	72-20-8		1.83E+01	N	1.83E+00	2.30E+01	NA	2.40E+01	1.06E+00		1.06E+00	mg/kg	MCTA-Leaching
Endrin aldehyde	7421-93-4		1.80E+01	N	1.80E+00	2.30E+01	NA	2.40E+01	1.06E+00	Value for endrin	1.06E+00	mg/kg	MCTA-Leaching
Endrin ketone	53494-70-5		1.80E+01	N	1.80E+00	2.30E+01	NA	2.40E+01	1.06E+00	Value for endrin	1.06E+00	mg/kg	MCTA-Leaching
Gamma-BHC (Lindane)	58-89-9		4.37E-01	C	4.37E-01	4.00E-01	NA	7.70E-01	2.08E-03		2.08E-03	mg/kg	MCTA-Leaching
gamma-Chlordane	5103-74-2		1.60E+00	C	1.60E+00	2.00E+00	NA	2.90E+00	2.58E-01	Value for chlordane	2.58E-01	mg/kg	MCTA-Leaching
Heptachlor	76-44-8		1.08E-01	C	1.08E-01	1.00E-01	NA	2.20E-01	3.70E-03		3.70E-03	mg/kg	MCTA-Leaching
Heptachlor epoxide	1024-57-3		5.30E-02	C	5.30E-02	7.00E-02	NA	1.10E-01	5.24E-04		5.24E-04	mg/kg	MCTA-Leaching

Table 4-19. Selected Human Health Benchmarks for Island Soil and Sediments in the Columbia River Baseline Human Health Risk Assessment. (5 Pages)

Analyte	CAS #/Analyte Code	Region 9 PRG (mg/kg)[1]	Region 6 Screening Level (mg/kg)[1]	Basis for Region 6/9 Screening Level[1]	Adjusted Region 6/9 Values (mg/kg)[2]	SSL (mg/kg)[3]	SSL-rad (pCi/g)[4]	MCTA-Residential, Direct Contact (mg/kg)[5]	MCTA Leaching-Based Values (mg/kg)[6]	Notes	Selected Benchmark[7]	Units	Basis for Selected Benchmark
Heptadecane	629-78-7		1.10E+02	sat	1.10E+02	NA	NA	4.80E+03	NA	Value for n-hexane	1.10E+02	mg/kg	Region 6/9
Hexachlorobenzene	118-74-1		3.04E-01	C	3.04E-01	3.00E-01	NA	6.30E-01	8.82E-02		8.82E-02	mg/kg	MCTA-Leaching
Methoxychlor	72-43-5		3.06E+02	N	3.06E+01	3.90E+02	NA	4.00E+02	1.28E+02		3.06E+01	mg/kg	Region 6/9
Parathion	56-38-2		3.67E+02	N	3.67E+01	NA	NA	4.80E+02	3.80E+00		3.80E+00	mg/kg	MCTA-Leaching
Total PCBs	Total_PCB		2.20E-01	C	2.20E-01	NA	NA	5.00E-01	4.85E-01	MCTA values based on Aroclor 1254	2.20E-01	mg/kg	Region 6/9
HERBICIDES													
2-secButyl-4, 6-dinitrophenol(DNBP)	88-85-7		6.11E+01	N	6.11E+00	NA	NA	8.00E+01	NA		6.11E+00	mg/kg	Region 6/9
DIOXINS/FURANS													
1, 2, 3, 4, 6, 7, 8-Heptachlorodibenzodioxin	35822-46-9		3.90E-06	C	3.90E-06	NA	NA	NA	NA		3.90E-06	mg/kg	Region 6/9
Total Dioxins	Total_Dioxin		3.90E-06	C	3.90E-06	NA	NA	1.10E-05	NA	Value for TCDD	3.90E-06	mg/kg	Region 6/9
Total Furans	Total_Furan		2.50E+00	N	2.50E-01	NA	NA	NA	NA		2.50E-01	mg/kg	Region 6/9
OTHER ANALYTES													
Chloride	16887-00-6	NA	NA	NA	NA	NA	NA	NA	NA		NA		NA
Sulfide	18496-25-8	NA	NA	NA	NA	NA	NA	NA	NA		NA		NA
Total organic carbon	TOC	NA	NA	NA	NA	NA	NA	NA	NA		NA		NA

Notes:

[1] Region 6 Residential Soil Screening Level used as primary source of EPA regional screening values. If no Region 6 value available, then Region 9 Preliminary Remedial Goal (PRG) for residential soil used, if available.
For PCB congeners, the Region 6 risk-based concentrations are calculated by adjusting the Region 6 values for 2, 3, 7, 8-TCDD by the 2005 World Health Organization Toxic Equivalency Factors (TEFs).
Region 9 Preliminary Remediation Goals (PRGs), Residential Soil. October 2004. http://www.epa.gov/region09/waste/sfund/prg/files/prgtable2004.xls
EPA Region 6 Human Health Medium-Specific Screening Levels, December 2007. Dallas, Texas 75202.

[2] Region 6/9 screening value divided by 10 for noncancer-based benchmarks, based on EPA Region 10 memorandum dated April 17, 2007.

[3] SSLs: USEPA Soil Screening Levels, Exhibit A-1 Generic SSLs for Residential Scenario. From "Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites," EPA Office of Emergency and Remedial Response, December 2002.

[4] SSL-rad: USEPA Soil Screening Guidance for Radionuclides, Technical Background Document. Table A-1 Generic (no accounting for decay) SSLs for Radionuclides (minimum between direct ingestion of soil and external radiation exposure). EPA Office of Radiation and Indoor Air, Office of Solid Waste and Emergency Response, October 2000.

[5] Model Toxics Control Act (MCTA), Method B unrestricted land use-direct contact (lowest between carcinogenic and noncarcinogenic values). Values obtained from Washington State Department of Ecology (WADOE) Cleanup Levels and Risk Calculation (CLARC).

[6] MCTA Method B Soil Concentrations for Groundwater Protection. Values derived in accordance with WAC 173-340-747 (eq. 747-1) using Method B groundwater values and default soil and chemical/physical parameters. Where default chemical parameters were not values obtained from Oak Ridge National Laboratory (ORNL) table of Chemical Specific Parameters (June 12, 2008). If no MCTA Method B groundwater value available, then no leaching standard calculated.

[7] Lowest benchmark used as screening level.

C = carcinogenic effects
CAS # = chemical abstract service number
max = ceiling limit
N = noncarcinogenic effects
NA = benchmark not available
mg/kg = milligrams per kilogram
pCi/g = picocuries per gram
sat = soil saturation

Table 4-20. Selected Human Health Benchmarks for Surface Water for the Columbia River Baseline Human Health Risk Assessment. (4 Pages)

Analyte	CAS #/Analyte Code	Region 9 PRG (Tapwater) [1] (ug/L)	Region 6 Screening Level (Residential) [1] (ug/L)	Basis for Region 6/9 Screening Level [1]	Adjusted Region 6/9 Values [2] (ug/L)	MTCA Surface Water Method B Standards [3] (ug/L)	MTCA Groundwater Method B Standards [4] (ug/L)	MCLs [5] (ug/L)	MCL-rad [6] (pCi/L)	NRWQC [7] (ug/L)	Notes	Selected Benchmark [8]	Basis for Selected Benchmark
VOLATILE ORGANICS													
1, 1, 1-Trichloroethane	71-55-6		7.30E+04	N	7.30E+03	4.20E+05	7.20E+03	2.00E+02	NA	NA		2.00E+02	MCL
1, 1, 2, 2-Tetrachloroethane	79-34-5		5.50E-02	C	5.50E-02	6.50E+00	2.20E-01	NA	NA	1.70E-01		5.50E-02	Region 6
1, 1, 2-Trichloroethane	79-00-5		2.00E-01	C	2.00E-01	2.50E+01	7.70E-01	5.00E+00	NA	5.90E-01		2.00E-01	Region 6
1, 1-Dichloroethane	75-34-3		1.22E+03	N	1.22E+02	NA	1.60E+03	NA	NA	NA		1.22E+02	Region 6
1, 2, 3-Trichlorobenzene	87-61-6		8.20E+00	N	8.20E-01	2.30E+02	8.00E+01	7.00E+01	NA	3.50E+01	Value for 1,2,4-	8.20E-01	Region 6
1, 2-Dichloroethane	107-06-2		1.23E-01	C	1.23E-01	5.90E+01	4.80E-01	5.00E+00	NA	3.80E-01		1.23E-01	Region 6
1, 2-Dichloropropane	78-87-5		1.65E-01	C	1.65E-01	2.30E+01	6.40E-01	5.00E+00	NA	5.00E-01		1.65E-01	Region 6
1, 4-Dichlorobenzene	106-46-7		4.67E-01	C	4.67E-01	4.90E+00	1.80E+00	7.50E+01	NA	6.30E+01		4.67E-01	Region 6
2-Butanone	78-93-3		7.10E+03	N	7.10E+02	NA	4.80E+03	NA	NA	NA		7.10E+02	Region 6
2-Butoxyethanol	111-76-2		1.83E+04	N	1.83E+03	NA	4.00E+03	NA	NA	NA		1.83E+03	Region 6
1, 2, 3, 4, 6, 7, 8-Heptachlorodibenzodioxin	35822-46-9						#N/A		NA			#N/A	
2-Hexanone	591-78-6		2.00E+03	N	2.00E+02	NA	6.40E+02	NA	NA		Value for methyl isobutyl	2.00E+02	Region 6
4-Methyl-2-Pentanone	108-10-1		2.00E+03	N	2.00E+02	NA	6.40E+02	NA	NA			2.00E+02	Region 6
Acetone	67-64-1		5.48E+03	N	5.48E+02	NA	8.00E+02	NA	NA	NA		5.48E+02	Region 6
Benzene	71-43-2		3.54E-01	C	3.54E-01	2.30E+01	8.00E-01	5.00E+00	NA	2.20E+00		3.54E-01	Region 6
2, 3, 7, 8-Dioxin Total Equivalents	2378-DioxinTE						#N/A		NA			#N/A	
2, 3, 7, 8-Tetachlorodibenzofuran	51207-31-9						#N/A		NA			#N/A	
Carbon disulfide	75-15-0		1.00E+03	N	1.00E+02	NA	8.00E+02	NA	NA	NA		1.00E+02	Region 6
Carbon tetrachloride	56-23-5		1.71E-01	C	1.71E-01	2.70E+00	3.40E-01	5.00E+00	NA	2.30E-01		1.71E-01	Region 6
Chlorobenzene	108-90-7		9.13E+01	N	9.13E+00	5.00E+03	1.60E+02	1.00E+02	NA	1.30E+02		9.13E+00	Region 6
Chloroform	67-66-3		1.67E-01	C	1.67E-01	2.80E+02	7.20E+00	NA	NA	5.70E+00		1.67E-01	Region 6
cis-1,2-Dichloroethylene	156-59-2		6.08E+01	N	6.08E+00	NA	8.00E+01	7.00E+01	NA	NA		6.08E+00	Region 6
Dichloroethylene	25323-30-2		3.40E-02	N	3.40E-03	1.90E+00	7.20E+02	NA	NA	NA	Value for 1,2-dce, mixed	3.40E-03	Region 6
Diethyl Ether	60-29-7		1.20E+03	N	1.20E+02	NA	1.60E+03	NA	NA	NA	Value for ethyl ether	1.20E+02	Region 6
Ethylbenzene	100-41-4		1.34E+03	N	1.34E+02	6.90E+03	8.00E+02	7.00E+02	NA	5.30E+02		1.34E+02	Region 6
Methyl isobutyl ketone	108-10-1		1.99E+03	N	1.99E+02	NA	6.40E+02	NA	NA	NA		1.99E+02	Region 6
Methylene chloride	75-09-2		4.28E+00	C	4.28E+00	9.60E+02	5.80E+00	NA	NA	4.60E+00		4.28E+00	Region 6
Naphthalene	91-20-3		6.20E+00	N	6.20E-01	4.90E+03	1.60E+02	NA	NA	NA		6.20E-01	Region 6
Styrene	100-42-5		1.60E+03	N	1.60E+02	NA	1.50E+00	1.00E+02	NA	NA		1.50E+00	MTCA GW B
Tetrachloroethene	127-18-4		1.05E-01	C	1.05E-01	3.90E-01	8.10E-02	5.00E+00	NA	6.90E-01		8.10E-02	MTCA GW B
Toluene	108-88-3		2.28E+03	N	2.28E+02	1.90E+04	6.40E+02	1.00E+03	NA	1.30E+03		2.28E+02	Region 6
trans-1, 2-Dichloroethylene	156-60-5		1.07E+02	N	1.07E+01	3.30E+04	1.60E+02	1.00E+02	NA	1.40E+02		1.07E+01	Region 6
Tributyl phosphate	126-78-3	7.30E+00	NA	C	7.30E+00	NA	NA	NA	NA	NA		7.30E+00	Region 9 PRG
Trichloroethene	79-01-6		2.80E-02	C	2.80E-02	1.50E+00	1.10E-01	5.00E+00	NA	2.50E+00		2.80E-02	Region 6
Vinyl acetate	108-05-4		4.12E+02	N	4.12E+01	NA	8.00E+03	NA	NA	NA		4.12E+01	Region 6
Vinyl chloride	75-01-4		1.50E-02	C	1.50E-02	3.70E+00	2.90E-02	2.00E+00	NA	2.50E-02		1.50E-02	Region 6
Xylenes (total)	1330-20-7		2.03E+02	N	2.03E+01	NA	1.60E+03	1.00E+04	NA	NA		2.03E+01	Region 6
SEMIVOLATILE ORGANICS													
1, 2, 3, 4-Tetrachlorobenzene	634-66-2		1.10E+01	N	1.10E+00	NA	4.80E+00	NA	NA	9.70E-01	Value for 1,2,4,5-	9.70E-01	NRWQC
1, 2, 4-Trichlorobenzene	120-82-1		8.16E+00	N	8.16E-01	2.30E+02	8.00E+01	7.00E+01	NA	3.50E+01		8.16E-01	Region 6
1, 2-Dichlorobenzene	95-50-1		4.93E+01	N	4.93E+00	4.20E+03	7.20E+02	6.00E+02	NA	4.20E+02		4.93E+00	Region 6
1, 3-Dichlorobenzene	541-73-1		1.45E+01	N	1.45E+00	NA	7.20E+02	NA	NA	3.20E+02	Value for 1,2-	1.45E+00	Region 6
2, 3, 4, 5-Tetrachlorophenol	4901-51-3		1.10E+03	N	1.10E+02	NA	4.80E+02	NA	NA	NA	Value for 2,3,4,6-	1.10E+02	Region 6
2, 4, 5-Trichlorophenol	95-95-4		3.65E+03	N	3.65E+02	NA	8.00E+02	NA	NA	NA		3.65E+02	Region 6
2, 4, 6-Trichlorophenol	88-06-2		6.11E+00	C	6.11E+00	3.90E+00	4.00E+00	NA	NA	1.40E+00		1.40E+00	NRWQC
2, 4-Dichlorophenol	120-83-2		1.10E+02	N	1.10E+01	1.90E+02	2.40E+01	NA	NA	7.70E+01		1.10E+01	Region 6
2, 4-Dimethylphenol	105-67-9		7.30E+02	N	7.30E+01	5.50E+02	1.60E+02	NA	NA	3.80E+02		7.30E+01	Region 6
2, 4-Dinitrophenol	51-28-5		7.30E+01	N	7.30E+00	3.50E+03	3.20E+01	NA	NA	6.90E+01		7.30E+00	Region 6
2, 4-Dinitrotoluene	121-14-2		7.30E+01	N	7.30E+00	1.40E+03	3.20E+01	NA	NA	1.10E-01		1.10E-01	NRWQC
2, 4-Dichlorophenoxyacetic acid	94-75-7						1.60E+02		NA			1.60E+02	
2, 6-Dinitrotoluene	606-20-2		3.65E+01	N	3.65E+00	NA	1.60E+01	NA	NA	NA		3.65E+00	Region 6
2-Chloronaphthalene	91-58-7		4.87E+02	N	4.87E+01	1.00E+03	6.40E+02	NA	NA	1.00E+03		4.87E+01	Region 6
2-Chlorophenol	95-57-8		3.04E+01	N	3.04E+00	9.70E+01	4.00E+01	NA	NA	8.10E+01		3.04E+00	Region 6
2-Methylnaphthalene	91-57-6		6.20E+00	N	6.20E-01	4.90E+03	3.20E+01	NA	NA	NA		6.20E-01	Region 6
2-Methylphenol (cresol, o-)	95-48-7	1.82E+03	NA	NC	1.82E+02	NA	4.00E+02	NA	NA	NA		1.82E+02	Region 9 PRG
2-Nitrophenol	88-75-5		2.92E+02	N	2.92E+01	NA	NA	NA	NA	NA	Value for 4-nitrophenol	2.92E+01	Region 6
4-Nitrophenol	100-02-7		2.92E+02	N	2.92E+01	NA	NA	NA	NA	NA		2.92E+01	Region 6
Acenaphthene	83-32-9		3.65E+02	N	3.65E+01	6.40E+02	9.60E+02	NA	NA	6.70E+02		3.65E+01	Region 6
Acenaphthylene	208-96-8		3.70E+02	N	3.70E+01	6.40E+02	9.60E+02	NA	NA	NA	value for acenaphthene	3.70E+01	Region 6
Anthracene	120-12-7		1.83E+03	N	1.83E+02	2.60E+04	4.80E+03	NA	NA	8.30E+03		1.83E+02	Region 6
Benzo(a)anthracene	56-55-3		2.95E-02	C	2.95E-02	3.00E-02	1.20E-01	NA	NA	3.80E-03	Toxic equivalency factor	3.80E-03	NRWQC
Benzo(a)pyrene	50-32-8		2.95E-03	C	2.95E-03	3.00E-02	1.20E-02	2.00E-01	NA	3.80E-03	Toxic equivalency factor	2.95E-03	Region 6
Benzo(b)fluoranthene	205-99-2		2.95E-02	C	2.95E-02	3.00E-02	1.20E-01	NA	NA	3.80E-03	Toxic equivalency factor	3.80E-03	NRWQC
Benzo(ghi)perylene	191-24-2		1.80E+02	N	1.80E+01	2.60E+03	4.80E+02	NA	NA	NA	Value for pyrene applied	1.80E+01	Region 6
Benzo(k)fluoranthene	207-08-9		2.95E-01	C	2.95E-01	3.00E-02	1.20E-01	NA	NA	3.80E-03	Toxic equivalency factor	3.80E-03	NRWQC
Benzoic Acid	65-85-0		1.50E+05	N	1.50E+04	NA	6.40E+04	NA	NA	NA		1.50E+04	Region 6
Benzyl alcohol	100-51-6		1.10E+04	N	1.10E+03	NA	2.40E+03	NA	NA	NA		1.10E+03	Region 6
Biphenyl	92-52-4		3.00E+02	N	3.00E+01	NA	4.00E+02	NA	NA	NA		3.00E+01	Region 6

Table 4-20. Selected Human Health Benchmarks for Surface Water for the Columbia River Baseline Human Health Risk Assessment. (4 Pages)

Analyte	CAS #/Analyte Code	Region 9 PRG (Tapwater) [1] (ug/L)	Region 6 Screening Level (Residential) [1] (ug/L)	Basis for Region 6/9 Screening Level [1]	Adjusted Region 6/9 Values [2] (ug/L)	MTCA Surface Water Method B Standards [3] (ug/L)	MTCA Groundwater Method B Standards [4] (ug/L)	MCLs [5] (ug/L)	MCL-rad [6] (pCi/L)	NRWQC [7] (ug/L)	Notes	Selected Benchmark [8]	Basis for Selected Benchmark
Bis(2-ethylhexyl) phthalate	117-81-7		4.80E+00	C	4.80E+00	3.60E+00	6.30E+00	NA	NA	1.20E+00		1.20E+00	NRWQC
Butylbenzylphthalate	85-68-7		7.30E+03	N	7.30E+02	1.30E+03	3.20E+03	NA	NA	1.50E+03		7.30E+02	Region 6
Manganese-54	13966-31-9						#N/A		NA			#N/A	
Carbazole	86-74-8		3.40E+00	C	3.40E+00	NA	4.40E+00	NA	NA	NA		3.40E+00	Region 6
Chrysene	218-01-9		2.95E+00	C	2.95E+00	3.00E-02	1.20E+00	NA	NA	3.80E-03	Toxic equivalency factor	3.80E-03	NRWQC
Dibenz[a,h]anthracene	53-70-3		2.95E-03	C	2.95E-03	3.00E-02	1.20E-01	NA	NA	3.80E-03	Toxic equivalency factor	2.95E-03	Region 6
Dibenzofuran	132-64-9		1.22E+01	N	1.22E+00	NA	3.20E+01	NA	NA	NA		1.22E+00	Region 6
Diethylphthalate	84-66-2		2.92E+04	N	2.92E+03	2.80E+04	1.30E+04	NA	NA	1.70E+04		2.92E+03	Region 6
Dimethyl phthalate	131-11-3		3.65E+05	N	3.65E+04	7.20E+04	1.60E+04	NA	NA	2.70E+05		1.60E+04	MTC GW B
Di-n-butylphthalate	84-74-2		3.65E+03	N	3.65E+02	2.90E+03	1.60E+03	NA	NA	2.00E+03		3.65E+02	Region 6
Di-n-octylphthalate	117-84-0	1.50E+03	NA	N	1.50E+02	NA	3.20E+02	NA	NA	NA		1.50E+02	Region 9 PRG
Endosulfan sulfate	1031-07-8						#N/A		NA			#N/A	
Ethylene glycol	107-21-1		7.30E+04	N	7.30E+03	NA	1.60E+04	NA	NA	NA		7.30E+03	Region 6
Fluoranthene	206-44-0		1.46E+03	N	1.46E+02	9.00E+01	6.40E+02	NA	NA	1.30E+02		9.00E+01	MTCA SW B
Fluorene	86-73-7		2.43E+02	N	2.43E+01	3.50E+03	6.40E+02	NA	NA	1.10E+03		2.43E+01	Region 6
Hexachlorobutadiene	87-68-3		8.62E-01	C	8.62E-01	3.00E+01	5.60E-01	NA	NA	4.40E-01		4.40E-01	NRWQC
Hexachlorocyclopentadiene	77-47-4		2.19E+02	N	2.19E+01	3.60E+03	4.80E+01	5.00E+01	NA	4.00E+01		2.19E+01	Region 6
Hexachloroethane	67-72-1		4.80E+00	C	4.80E+00	5.30E+00	3.10E+00	NA	NA	1.40E+00		1.40E+00	NRWQC
Indeno(1, 2, 3-cd)pyrene	193-39-5		2.95E-02	C	2.95E-02	3.00E-02	1.20E-01	NA	NA	3.80E-03	Toxic equivalency factor	3.80E-03	NRWQC
Isophorone	78-59-1		7.10E+01	C	7.10E+01	1.60E+03	4.60E+01	NA	NA	3.50E+01		3.50E+01	NRWQC
Nitrobenzene	98-95-3		3.40E+00	N	3.40E-01	4.50E+02	4.00E+00	NA	NA	1.70E+01		3.40E-01	Region 6
N-Nitroso-di-n-dipropylamine	621-64-7		9.60E-03	C	9.60E-03	8.20E-01	NA	NA	NA	5.00E-03		5.00E-03	NRWQC
N-Nitrosodiphenylamine	86-30-6		1.37E+01	C	1.37E+01	9.70E+00	NA	NA	NA	3.30E+00		3.30E+00	NRWQC
Pentachlorobenzene	608-93-5		2.92E+01	N	2.92E+00	NA	1.30E+01	NA	NA	1.40E+00		1.40E+00	NRWQC
Pentachlorophenol	87-86-5		5.60E-01	C	5.60E-01	4.90E+00	7.30E-01	1.00E+00	NA	2.70E-01		2.70E-01	NRWQC
Phenanthrene	85-01-8		3.70E+02	N	3.70E+01	6.40E+02	9.60E+02	NA	NA	NA		3.70E+01	Region 6
Phenol	108-95-2		1.10E+04	N	1.10E+03	1.10E+06	4.80E+03	NA	NA	2.10E+04		1.10E+03	Region 6
Pyrene	129-00-0		1.83E+02	N	1.83E+01	2.60E+03	4.80E+02	NA	NA	8.30E+02		1.83E+01	Region 6
TPH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA	
METALS													
Aluminum	7429-90-5		3.65E+04	N	3.65E+03	NA	NA	NA	NA	NA		3.65E+03	Region 6
Antimony	7440-36-0		1.46E+01	N	1.46E+00	1.00E+03	6.40E+00	6.00E+00	NA	5.60E+00		1.46E+00	Region 6
Arsenic	7440-38-2		4.48E-02	C	4.48E-02	9.80E-02	5.80E-02	1.00E+01	NA	1.80E-02		1.80E-02	NRWQC
Barium	7440-39-3		7.30E+03	N	7.30E+02	NA	3.20E+03	2.00E+03	NA	1.00E+03		7.30E+02	Region 6
Beryllium	7440-41-7		7.30E+01	N	7.30E+00	2.70E+02	3.20E+01	4.00E+00	NA	NA		4.00E+00	MCL
Boron	7440-42-8		7.30E+03	N	7.30E+02	NA	3.20E+03	NA	NA	NA		7.30E+02	Region 6
Cadmium	7440-43-9		1.83E+01	N	1.83E+00	2.00E+01	8.00E+00	5.00E+00	NA	NA		1.83E+00	Region 6
Calcium	7440-70-2	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA	
Chromium	7440-47-3		1.10E+02	N	1.10E+01	NA	2.40E+04	1.00E+02	NA	NA	Value for hexavalent	1.10E+01	Region 6
Cobalt	7440-48-4		7.30E+02	N	7.30E+01	NA	NA	NA	NA	NA		7.30E+01	Region 6
Copper	7440-50-8		1.36E+03	N	1.36E+02	2.70E+03	5.90E+02	1.30E+03	NA	1.30E+03		1.36E+02	Region 6
Ruthenium-106	13967-48-1						#N/A		NA			#N/A	
Cyanide (total)	57-12-5		7.30E+02	N	7.30E+01	5.20E+04	NA	2.00E+02	NA	1.40E+02		7.30E+01	Region 6
Hexavalent Chromium	18540-29-9		1.10E+02	N	1.10E+01	4.90E+02	4.80E+01	NA	NA	NA		1.10E+01	Region 6
Iron	7439-89-6		2.56E+04	N	2.56E+03	NA	NA	NA	NA	3.00E+02		3.00E+02	NRWQC
Lead	7439-92-1		1.50E+01	N	1.50E+01	NA	1.50E+01	1.50E+01	NA	NA	MCTA Method A	1.50E+01	MCL / MCTA GW
Lithium	7439-93-2	7.30E+02	NA	N	7.30E+01	NA	NA	NA	NA	NA		7.30E+01	Region 9 PRG
Magnesium	7439-95-4	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA	
Manganese	7439-96-5		1.70E+03	N	1.70E+02	NA	2.20E+03	NA	NA	5.00E+01		5.00E+01	NRWQC
Mercury	7439-97-6		6.26E-01	N	6.26E-02	NA	4.80E+00	2.00E+00	NA	NA		6.26E-02	Region 6
Molybdenum	7439-98-7		1.83E+02	N	1.83E+01	NA	8.00E+01	NA	NA	NA		1.83E+01	Region 6
Nickel	7440-02-0		7.30E+02	N	7.30E+01	1.10E+03	3.20E+02	NA	NA	6.10E+02		7.30E+01	Region 6
Phosphorus	7723-14-0		7.30E-01	N	7.30E-02	NA	1.60E-01	NA	NA	NA		7.30E-02	Region 6
Potassium	2023695	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA	
Selenium	7782-49-2		1.83E+02	N	1.83E+01	2.70E+03	8.00E+01	5.00E+01	NA	1.70E+02		1.83E+01	Region 6
Silver	7440-22-4		1.83E+02	N	1.83E+01	2.60E+04	8.00E+01	NA	NA	NA		1.83E+01	Region 6
Sodium	7440-23-5	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA	
Strontium (elemental)	7440-24-6		2.19E+04	N	2.19E+03	NA	9.60E+03	NA	NA	NA		2.19E+03	Region 6
Thallium	7440-28-0		2.56E+00	N	2.56E-01	1.60E+00	1.10E+00	2.00E+00	NA	2.40E-01		2.40E-01	NRWQC
Tin	7440-31-5		2.19E+04	N	2.19E+03	NA	9.60E+03	NA	NA	NA		2.19E+03	Region 6
Uranium (inorganic)	7440-61-1	2.19E+01	NA	N	2.19E+00	NA	NA	3.00E+01	NA	NA		2.19E+00	Region 9 (adjusted to account for revised
Vanadium	7440-62-2		1.83E+02	N	1.83E+01	NA	1.10E+02	NA	NA	NA		1.83E+01	Region 6
Zinc	7440-66-6		1.10E+04	N	1.10E+03	1.70E+04	4.80E+03	NA	NA	7.40E+03		1.10E+03	Region 6
RADIONUCLIDES													
Americium-241	14596-10-2	NA	NA	NA	NA	NA	NA	NA	1.50E+01	NA		1.50E+01	MCL-rad
Antimony-125	14234-35-6	NA	NA	NA	NA	NA	NA	NA	3.00E+02	NA		3.00E+02	MCL-rad
Burium-140	14798-08-4	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA	
Carbon-14	14762-75-5	NA	NA	NA	NA	NA	NA	NA	2.00E+03	NA		2.00E+03	MCL-rad
Cerium-141	13967-74-3	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA	

Table 4-20. Selected Human Health Benchmarks for Surface Water for the Columbia River Baseline Human Health Risk Assessment. (4 Pages)

Analyte	CAS #/Analyte Code	Region 9 PRG (Tapwater) [1] (ug/L)	Region 6 Screening Level (Residential) [1] (ug/L)	Basis for Region 6/9 Screening Level [1]	Adjusted Region 6/9 Values [2] (ug/L)	MTCA Surface Water Method B Standards [3] (ug/L)	MTCA Groundwater Method B Standards [4] (ug/L)	MCLs [5] (ug/L)	MCL-rad [6] (pCi/L)	NRWQC [7] (ug/L)	Notes	Selected Benchmark [8]	Basis for Selected Benchmark
Cerium-144	14762-78-8	NA	NA	NA	NA	NA	NA	NA	3.00E+01	NA		3.00E+01	MCL-rad
Cesium-134	13967-70-9	NA	NA	NA	NA	NA	NA	NA	8.00E+01	NA		8.00E+01	MCL-rad
Cesium-137	10045-97-3	NA	NA	NA	NA	NA	NA	NA	2.00E+02	NA		2.00E+02	MCL-rad
Cobalt-57	13981-50-5	NA	NA	NA	NA	NA	NA	NA	1.00E+03	NA		1.00E+03	MCL-rad
Cobalt-58	13981-38-9	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA	
Cobalt-58	13981-38-9	NA	NA	NA	NA			NA	NA			NA	
Cobalt-60	10198-40-0	NA	NA	NA	NA	NA	NA	NA	1.00E+02	NA		1.00E+02	MCL-rad
Curium-244	13981-15-2	NA	NA	NA	NA	NA	NA	NA	1.50E+01	NA		1.50E+01	MCL-rad
Europium-152	14683-23-9	NA	NA	NA	NA	NA	NA	NA	2.00E+02	NA		2.00E+02	MCL-rad
Europium-154	15585-10-1	NA	NA	NA	NA	NA	NA	NA	6.00E+01	NA		6.00E+01	MCL-rad
Carbon disulfide	75-15-0											0.00E+00	
Europium-155	14391-16-3	NA	NA	NA	NA	NA	NA	NA	6.00E+02	NA		6.00E+02	MCL-rad
Iodine-129	15046-84-1	NA	NA	NA	NA	NA	NA	NA	1.00E+00	NA		1.00E+00	MCL-rad
Uranium-233/234	U-233/234											0.00E+00	
Iodine-131	10043-66-0	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA	
Neptunium-237	13994-20-2	NA	NA	NA	NA	NA	NA	NA	1.50E+01	NA		1.50E+01	MCL-rad
Nickel-63	13981-37-8	NA	NA	NA	NA	NA	NA	NA	5.00E+01	NA		5.00E+01	MCL-rad
Niobium-94	14681-63-1	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA	
Plutonium-238	13981-16-3	NA	NA	NA	NA	NA	NA	NA	1.50E+01	NA		1.50E+01	MCL-rad
Plutonium-239/240	PU-239/240	NA	NA	NA	NA	NA	NA	NA	1.50E+01	NA		1.50E+01	MCL-rad
Plutonium-241	14119-32-5	NA	NA	NA	NA	NA	NA	NA	2.70E+01	NA		2.70E+01	MCL-rad
Potassium-40	13966-00-2	NA	NA	NA	NA	NA	NA	NA	1.90E+00	NA		1.90E+00	MCL-rad
Radium-226	13982-63-3	NA	NA	NA	NA	NA	NA	NA	5.00E+00	NA		5.00E+00	MCL-rad
Radium-228	15262-20-1	NA	NA	NA	NA	NA	NA	NA	5.00E+00	NA		5.00E+00	MCL-rad
Strontium-90	10098-97-2	NA	NA	NA	NA	NA	NA	NA	8.00E+00	NA		8.00E+00	MCL-rad
Technetium-99	14133-76-7	NA	NA	NA	NA	NA	NA	NA	9.00E+02	NA		9.00E+02	MCL-rad
Thorium-228	14274-82-9	NA	NA	NA	NA	NA	NA	NA	1.50E+01	NA		1.50E+01	MCL-rad
Thorium-229	15594-54-4	NA	NA	NA	NA	NA	NA	NA	1.50E+01	NA		1.50E+01	MCL-rad
Thorium-230	14269-63-7	NA	NA	NA	NA	NA	NA	NA	1.50E+01	NA		1.50E+01	MCL-rad
Thorium-232	TH-232	NA	NA	NA	NA	NA	NA	NA	1.50E+01	NA		1.50E+01	MCL-rad
Tritium	10028-17-8	NA	NA	NA	NA	NA	NA	NA	2.00E+04	NA		2.00E+04	MCL-rad
Uranium-233	13968-55-3	NA	NA	NA	NA	NA	NA	NA	NA [9]	NA		NA	
Uranium-234	13966-29-5	NA	NA	NA	NA	NA	NA	NA	NA [9]	NA		NA	
Uranium-235	15117-96-1	NA	NA	NA	NA	NA	NA	NA	NA [9]	NA		NA	
Uranium-238	U-238	NA	NA	NA	NA	NA	NA	NA	3.00E+01	NA		3.00E+01	MCL-rad
Zinc-65	13982-39-3	NA	NA	NA	NA	NA	NA	NA	3.00E+02	NA		3.00E+02	MCL-rad
Zirconium/Niobium-95	ZR/NB-95	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA	
PESTICIDES/POLYCHLORINATED BIPHENYLS													
77 3, 3', 4, 4'-tetrachlorobiphenyls	32598-13-3		4.50E-03	C	4.50E-03	NA	NA	NA	NA	NA		4.50E-03	Region 6
81 3, 4, 4', 5-tetrachlorobiphenyl			1.50E-03	C	1.50E-03	NA	NA	NA	NA	NA		1.50E-03	Region 6
105 2, 3, 3', 4, 4'- pentachlorobiphenyls			1.50E-02	C	1.50E-02	NA	NA	NA	NA	NA		1.50E-02	Region 6
114 2, 3, 4, 4', 5- pentachlorobiphenyls			1.50E-02	C	1.50E-02	NA	NA	NA	NA	NA		1.50E-02	Region 6
118 2, 3', 4, 4', 5- pentachlorobiphenyls			1.50E-02	C	1.50E-02	NA	NA	NA	NA	NA		1.50E-02	Region 6
123 2', 3, 4, 4', 5- pentachlorobiphenyls			1.50E-02	C	1.50E-02	NA	NA	NA	NA	NA		1.50E-02	Region 6
126 3, 3', 4, 4', 5-pentachlorobiphenyls			4.50E-06	C	4.50E-06	NA	NA	NA	NA	NA		4.50E-06	Region 6
156 2, 3, 3', 4, 4', 5- hexachlorobiphenyls			1.50E-02	C	1.50E-02	NA	NA	NA	NA	NA		1.50E-02	Region 6
157 2, 3, 3', 4, 4', 5'- hexachlorobiphenyls			1.50E-02	C	1.50E-02	NA	NA	NA	NA	NA		1.50E-02	Region 6
167 2, 3', 4, 4', 5, 5'- hexachlorobiphenyls			1.50E-02	C	1.50E-02	NA	NA	NA	NA	NA		1.50E-02	Region 6
169 3, 3', 4, 4', 5, 5'-hexachlorobiphenyls			1.50E-05	C	1.50E-05	NA	NA	NA	NA	NA		1.50E-05	Region 6
189 2, 3, 3', 4, 4', 5, 5'-heptachlorobiphenyls			1.50E-02	C	1.50E-02	NA	NA	NA	NA	NA		1.50E-02	Region 6
Aldrin	309-00-2		3.95E-03	C	3.95E-03	8.20E-05	2.60E-03	NA	NA	NA		8.20E-05	MTCA SW B
Alpha-BHC	319-84-6		1.07E-02	C	1.07E-02	7.90E-03	1.40E-02	NA	NA	NA		7.90E-03	MTCA SW B
alpha-Chlordane	5103-71-9		1.90E-01	C	1.90E-01	1.30E-03	2.50E-01	2.00E+00	NA	8.00E-04	Value for chlordane	8.00E-04	NRWQC
Aroclor-1016	12674-11-2		9.60E-01	C	9.60E-01	5.80E-03	1.10E+00	5.00E-01	NA	6.40E-05		6.40E-05	NRWQC
Aroclor-1221	11104-28-2		3.36E-02	C	3.36E-02	1.10E-04	3.20E-01	5.00E-01	NA	6.40E-05	Value for A1254	6.40E-05	NRWQC
Aroclor-1232	11141-16-5		3.36E-02	C	3.36E-02	1.10E-04	3.20E-01	5.00E-01	NA	6.40E-05	Value for A1254	6.40E-05	NRWQC
Aroclor-1242	53469-21-9		3.36E-02	C	3.36E-02	1.10E-04	3.20E-01	5.00E-01	NA	6.40E-05	Value for A1254	6.40E-05	NRWQC
Aroclor-1242/1016	PCB1242/1016		3.40E-02	C	3.40E-02	1.10E-04	3.20E-01	5.00E-01	NA	6.40E-05	Value for A1254	6.40E-05	NRWQC
Aroclor-1248	12672-29-6		3.36E-02	C	3.36E-02	1.10E-04	3.20E-01	5.00E-01	NA	6.40E-05	Value for A1254	6.40E-05	NRWQC
Aroclor-1254	11097-69-1		3.36E-02	C	3.36E-02	1.70E-03	3.20E-01	5.00E-01	NA	6.40E-05		6.40E-05	NRWQC
Aroclor-1260	11096-82-5		3.36E-02	C	3.36E-02	NA	3.20E-01	5.00E-01	NA	6.40E-05	Value for A1254	6.40E-05	NRWQC
Aroclor-1262	37324-23-5		3.40E-02	C	3.40E-02	1.10E-04	3.20E-01	5.00E-01	NA	6.40E-05	Value for A1254	6.40E-05	NRWQC
Aroclor-1268	11100-14-4		3.40E-02	C	3.40E-02	1.10E-04	3.20E-01	5.00E-01	NA	6.40E-05	Value for A1254	6.40E-05	NRWQC
beta-1, 2, 3, 4, 5, 6-Hexachlorocyclohexane	319-85-7		3.74E-02	C	3.74E-02	2.80E-02	4.90E-02	NA	NA	9.10E-03		9.10E-03	NRWQC
Bromine	7726-95-6	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA	
Chlordane	57-74-9		1.92E-01	C	1.92E-01	1.30E-03	2.50E-01	2.00E+00	NA	8.00E-04		8.00E-04	NRWQC
Delta-BHC	319-86-8		5.20E-02	C	5.20E-02	NA	NA	NA	NA	NA		5.20E-02	Region 6
Dichlorodiphenyldichloroethane (DDD)	72-54-8		2.80E-01	C	2.80E-01	5.00E-04	3.60E-01	NA	NA	3.10E-04		3.10E-04	NRWQC
Dichlorodiphenyldichloroethylene (DDE)	72-55-9		1.98E-01	C	1.98E-01	3.60E-04	2.60E-01	NA	NA	2.20E-04		2.20E-04	NRWQC

Table 4-20. Selected Human Health Benchmarks for Surface Water for the Columbia River Baseline Human Health Risk Assessment. (4 Pages)

Analyte	CAS #/Analyte Code	Region 9 PRG (Tapwater) [1] (ug/L)	Region 6 Screening Level (Residential) [1] (ug/L)	Basis for Region 6/9 Screening Level [1]	Adjusted Region 6/9 Values [2] (ug/L)	MTCA Surface Water Method B Standards [3] (ug/L)	MTCA Groundwater Method B Standards [4] (ug/L)	MCLs [5] (ug/L)	MCL-rad [6] (pCi/L)	NRWQC [7] (ug/L)	Notes	Selected Benchmark [8]	Basis for Selected Benchmark
Dichlorodiphenyltrichloroethane (DDT)	50-29-3		1.98E-01	C	1.98E-01	3.60E-04	2.60E-01	NA	NA	2.20E-04		2.20E-04	NRWQC
Dieldrin	60-57-1		4.20E-03	C	4.20E-03	8.70E-05	5.50E-03	NA	NA	5.20E-05		5.20E-05	NRWQC
Endosulfan I	959-98-8		2.20E+02	N	2.20E+01	5.80E+01	9.60E+01	NA	NA	6.20E+01	Value for endosulfan	2.20E+01	Region 6
Endosulfan II	33213-65-9		2.20E+02	N	2.20E+01	5.80E+01	9.60E+01	NA	NA	6.20E+01	Value for endosulfan	2.20E+01	Region 6
Endosulfan sulfate	1031-07-8		2.20E+02	N	2.20E+01	5.80E+01	9.60E+01	NA	NA	6.20E+01	Value for endosulfan	2.20E+01	Region 6
Endrin	72-20-8		1.10E+01	N	1.10E+00	2.00E-01	4.80E+00	2.00E+00	NA	5.90E-02		5.90E-02	NRWQC
Endrin aldehyde	7421-93-4		1.10E+01	N	1.10E+00	2.00E-01	4.80E+00	NA	NA	2.90E-01	Value for endrin	2.00E-01	MTCA SW B
Endrin ketone	53494-70-5		1.10E+01	N	1.10E+00	2.00E-01	4.80E+00	NA	NA	NA	Value for endrin	2.00E-01	MTCA SW B
Gamma-BHC (Lindane)	58-89-9		5.17E-02	C	5.17E-02	3.80E-02	6.70E-02	2.00E-01	NA	9.80E-01		3.80E-02	MTCA SW B
gamma-Chlordane	5103-74-2		1.90E-01	C	1.90E-01	1.30E-03	2.50E-01	2.00E+00	NA	8.00E-04	Value for chlordane	8.00E-04	NRWQC
Heptachlor	76-44-8		1.49E-02	C	1.49E-02	1.30E-04	1.90E-02	4.00E-01	NA	7.90E-05		7.90E-05	NRWQC
Heptachlor epoxide	1024-57-3		7.40E-03	C	7.40E-03	6.40E-05	4.80E-03	2.00E-01	NA	3.90E-05		3.90E-05	NRWQC
Heptachlor epoxide	1024-57-3						4.80E-03		NA			4.80E-03	
Heptadecane	629-78-7		NA	N	NA	NA	NA	NA	NA	NA		NA	Region 6
Hexachlorobenzene	118-74-1		4.20E-02	C	4.20E-02	4.70E-04	5.50E-02	1.00E+00	NA	2.80E-04		2.80E-04	NRWQC
Methoxychlor	72-43-5		1.83E+02	N	1.83E+01	8.40E+00	8.00E+01	4.00E+01	NA	NA		8.40E+00	MTCA SW B
o,p'-DDD	53-19-0		2.80E-01	C	2.80E-01	5.00E-04	#N/A	NA	NA	3.10E-04		#N/A	NRWQC
o,p'-DDE	3424-82-6		2.00E-01	C	2.00E-01	3.60E-04	#N/A	NA	NA	2.20E-04		#N/A	NRWQC
o,p'-DDT	789-02-6		2.00E-01	C	2.00E-01	3.60E-04	#N/A	NA	NA	2.20E-04		#N/A	NRWQC
Parathion	56-38-2		2.19E+02	N	2.19E+01	NA	9.60E+01	NA	NA	NA		2.19E+01	Region 6
Total BHC	Total_BHC		1.10E-02	C	1.10E-02	7.90E-03	1.40E-02	NA	NA	2.60E-03	Value for alpha-BHC	2.60E-03	NRWQC
Total DDT	TOTALDDT		2.00E-01	C	2.00E-01	3.60E-04	NA	NA	NA	2.20E-04		2.20E-04	NRWQC
Total Heptachlors	Total_Heptachlor		1.50E-02	C	1.50E-02	1.30E-04	NA	4.00E-01	NA	7.90E-05		7.90E-05	NRWQC
Octachlorodibenzo-p-dioxin	3268-87-9				0.00E+00		#N/A		NA			#N/A	NRWQC
Total PCBs	Total_PCB		3.40E-02	C	3.40E-02	1.10E-04	4.40E-02	5.00E-01	NA	6.40E-05		6.40E-05	NRWQC
Uranium-236	13982-70-2						#N/A		NA			#N/A	
HERBICIDES													
2-secButyl-4,6-dinitrophenol(DNBP)	88-85-7		3.65E+01	N	3.65E+00	NA	NA	NA	NA	NA		3.65E+00	Region 6
DIOXINS/FURANS													
1, 2, 3, 4, 6, 7, 8-Heptachlorodibenzodioxin	35822-46-9		4.50E-07	C	4.50E-07	NA	NA	3.00E-05	NA	5.00E-09	Value for 2,3,7,8-TCDD	5.00E-09	NRWQC
Total Dioxins	Total_Dioxin		4.50E-07	C	4.50E-07	NA	NA	3.00E-05	NA	5.00E-09	Value for 2,3,7,8-TCDD	5.00E-09	NRWQC
Total Furans	Total_Furan		6.10E+00	N	6.10E-01	NA	8.00E+00	NA	NA	NA		6.10E-01	Region 6
OTHER ANALYTES													
Chloride	16887-00-6	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA	
Hardness	Hardness	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA	
Fluoride	Fluoride	NA	NA	NA	NA	NA	NA	4.00E+03	NA	NA		4.00E+03	MCL
Sulfide	18496-25-8	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA	
Total organic carbon	TOC	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA	

Notes:

[1] Region 6 Residential Tap Water value used as primary source of EPA regional screening values. If no Region 6 value available, then Region 9 Preliminary Remedial Goal (PRG) for tapwater used, if available.
For PCB congeners, the Region 6 risk-based concentrations are calculated by adjusting the Region 6 values for 2, 3, 7, 8-TCDD by the 2005 World Health Organization Toxic Equivalency Factors (TEFs).
Region 9 Preliminary Remediation Goals (PRGs). October 2004. http://www.epa.gov/region09/waste/sfund/prg/files/prgtable2004.xls
EPA Region 6 Human Health Medium-Specific Screening Levels, December 2007. Dallas, Texas 75202.

[2] Region 6/9 screening value divided by 10 for noncancer-based benchmarks, based on EPA Region 10 memorandum dated April 17, 2007.

[3] Model Toxics Control Act (MCTA), Method B Surface Water Standards (lowest between carcinogenic and noncarcinogenic values). Values obtained from Washington State Department of Ecology (WADOE) Cleanup Levels and Risk Calculation (CLARC).

[4] MCTA Method B Ground Water Standards (lowest between carcinogenic and noncarcinogenic values). Values obtained from Washington State Department of Ecology (WADOE) Cleanup Levels and Risk Calculation (CLARC).

[5] Federal Maximum Contaminant Levels (MCLs), National Primary Drinking Water Regulations, EPA, June 2003. EPA 816-F-03-016.

[6] SSL-rad: USEPA Soil Screening Guidance for Radionuclides, Technical Background Document. Table 2.3-Radionuclide Drinking Water MCLs. Current MCL applied if available, otherwise Risk Based Limit applied.
EPA Office of Radiation and Indoor Air, Office of Solid Waste and Emergency Response, October 2000.

[7] National Recommended Water Quality Criteria (NRWQC), Human Health for Consumption of Water + Organism values. USEPA Office of Water/Office of Science and Technology, 2006.

[8] Lowest benchmark used as surface water screening level.

[9] MCL of 30 pCi/L for total uranium.

C = carcinogenic effects
CAS # = chemical abstract service number
N = noncarcinogenic effects
NA = benchmark not available
pCi/L = picocuries per liter
ug/L = micrograms per liter

Table 4-21a. Human Health Benchmarks for Fish Tissue-Chemical Constituents. (9 Pages)

Analyte	CAS #/Analyte Code	Region 3 Fish RBC[a] (mg/kg)		Adjusted Fish Benchmark, HI=0.1 (noncarcinogenic adjustment) (mg/kg)	Selected Fish Benchmark - Native American[c] (mg/kg)
ACETOCHLOR	34256821	2.7E+01	N	2.7E+00	1.0E-01
ACETONE	67641	1.2E+03	N	1.2E+02	4.5E+00
ACETOPHENONE	98862	1.4E+02	N	1.4E+01	5.0E-01
ACROLEIN	107028	6.8E-01	N	6.8E-02	2.5E-03
ACRYLAMIDE	79061	7.0E-04	C	7.0E-04	2.6E-05
ACRYLONITRILE	107131	5.8E-03	C	5.8E-03	2.2E-04
ALACHLOR	15972608	3.9E-02	C	3.9E-02	1.5E-03
ALAR	1596845	2.0E+02	N	2.0E+01	7.6E-01
ALDICARB	116063	1.4E+00	N	1.4E-01	5.0E-03
ALDICARB SULFONE	1646884	1.4E+00	N	1.4E-01	5.0E-03
ALDRIN	309002	1.9E-04	C	1.9E-04	6.9E-06
ALUMINUM	7429905	1.4E+03	N	1.4E+02	5.0E+00
AMINODINITROTOLUENES		2.7E+00	N	2.7E-01	1.0E-02
ANILINE	62533	5.5E-01	C	5.5E-01	2.1E-02
ANTIMONY	7440360	5.4E-01	N	5.4E-02	2.0E-03
ANTIMONY TRIOXIDE	1309644	5.4E-01	N	5.4E-02	2.0E-03
ARSENIC	7440382	2.1E-03	C	2.1E-03	7.8E-05
ASSURE	76578148	1.2E+01	N	1.2E+00	4.5E-02
ATRAZINE	1912249	1.4E-02	C	1.4E-02	5.3E-04
BARIUM	7440393	2.7E+02	N	2.7E+01	1.0E+00
BAYGON	114261	5.4E+00	N	5.4E-01	2.0E-02
BAYTHROID	68359375	3.4E+01	N	3.4E+00	1.3E-01
BENTAZON	25057890	4.1E+01	N	4.1E+00	1.5E-01
BENZALDEHYDE	100527	1.4E+02	N	1.4E+01	5.0E-01
BENZENE	71432	5.7E-02	C	5.7E-02	2.1E-03
BENZENETHIOL	108985	1.4E-02	N	1.4E-03	5.0E-05
BENZIDINE	92875	1.4E-05	C	1.4E-05	5.1E-07
BENZOIC ACID	65850	5.4E+03	N	5.4E+02	2.0E+01
BENZYL ALCOHOL	100516	6.8E+02	N	6.8E+01	2.5E+00
BENZYL CHLORIDE	100447	1.9E-02	C	1.9E-02	6.9E-04
BERYLLIUM	7440417	2.7E+00	N	2.7E-01	1.0E-02
BIPHENYL	92524	6.8E+01	N	6.8E+00	2.5E-01
BIS(2-CHLOROETHYL) ETHER	111444	2.9E-03	C	2.9E-03	1.1E-04
BIS(2-CHLOROISOPROPYL) ETHER	108601	4.5E-02	C	4.5E-02	1.7E-03
BIS(CHLOROMETHYL) ETHER	542881	1.4E-05	C	1.4E-05	5.3E-07
BIS(2-ETHYLHEXYL) PHTHALATE	117817	2.3E-01	C	2.3E-01	8.4E-03
BORON	7440428	2.7E+02	N	2.7E+01	1.0E+00
BROMODICHLOROMETHANE	75274	5.1E-02	C	5.1E-02	1.9E-03
BROMOFORM	75252	4.0E-01	C	4.0E-01	1.5E-02
BROMOMETHANE	74839	1.9E+00	N	1.9E-01	7.1E-03
BROMOPHOS	2104963	6.8E+00	N	6.8E-01	2.5E-02

Table 4-21a. Human Health Benchmarks for Fish Tissue-Chemical Constituents. (9 Pages)

Analyte	CAS #/Analyte Code	Region 3 Fish RBC[a] (mg/kg)		Adjusted Fish Benchmark, HI=0.1 (noncarcinogenic adjustment) (mg/kg)	Selected Fish Benchmark - Native American[c] (mg/kg)
1-BUTANOL	71363	1.4E+02	N	1.4E+01	5.0E-01
BUTYLBENZYLPHTHALATE	85687	2.7E+02	N	2.7E+01	1.0E+00
CADMIUM-FOOD	7440439	1.4E+00	N	1.4E-01	5.0E-03
CAPROLACTAM	105602	6.8E+02	N	6.8E+01	2.5E+00
CARBARYL	63252	1.4E+02	N	1.4E+01	5.0E-01
CARBON DISULFIDE	75150	1.4E+02	N	1.4E+01	5.0E-01
CARBON TETRACHLORIDE	56235	2.4E-02	C	2.4E-02	9.1E-04
CARBOSULFAN	55285148	1.4E+01	N	1.4E+00	5.0E-02
CHLORAL HYDRATE	302170	1.4E+02	N	1.4E+01	5.0E-01
CHLORANIL	118752	7.9E-03	C	7.9E-03	2.9E-04
CHLORDANE	57749	9.0E-03	C	9.0E-03	3.4E-04
CHLORINE DIOXIDE	10049044	4.1E+01	N	4.1E+00	1.5E-01
CHLOROACETIC ACID	79118	2.7E+00	N	2.7E-01	1.0E-02
4-CHLOROANILINE	106478	5.4E+00	N	5.4E-01	2.0E-02
CHLOROBENZENE	108907	2.7E+01	N	2.7E+00	1.0E-01
2-CHLORO-1, 3-BUTADIENE	126998	2.7E+01	N	2.7E+00	1.0E-01
CHLOROETHANE	75003	1.1E+00	C	1.1E+00	4.1E-02
CHLOROFORM	67663	1.4E+01	N	1.4E+00	5.0E-02
4-CHLORO-2-METHYLANILINE	95692	5.4E-03	C	5.4E-03	2.0E-04
BETA-CHLORONAPHTHALENE	91587	1.1E+02	N	1.1E+01	4.0E-01
2-CHLOROPHENOL	95578	6.8E+00	N	6.8E-01	2.5E-02
O-CHLOROTOLUENE	95498	2.7E+01	N	2.7E+00	1.0E-01
P-CHLOROTOLUENE	106434	9.5E+01	N	9.5E+00	3.5E-01
CHLORPYRIFOS	2921882	4.1E+00	N	4.1E-01	1.5E-02
CHLORPYRIFOS-METHYL	5598130	1.4E+01	N	1.4E+00	5.0E-02
CHROMIUM III	16065831	2.0E+03	N	2.0E+02	7.6E+00
CHROMIUM VI	18540299	4.1E+00	N	4.1E-01	1.5E-02
COPPER	7440508	5.4E+01	N	5.4E+00	2.0E-01
CUMENE	98828	1.4E+02	N	1.4E+01	5.0E-01
CYANIDE (FREE)	57125	2.7E+01	N	2.7E+00	1.0E-01
CALCIUM CYANIDE	592018	5.4E+01	N	5.4E+00	2.0E-01
COPPER CYANIDE	544923	6.8E+00	N	6.8E-01	2.5E-02
CYANOGEN	460195	5.4E+01	N	5.4E+00	2.0E-01
HYDROGEN CYANIDE	74908	2.7E+01	N	2.7E+00	1.0E-01
POTASSIUM CYANIDE	151508	6.8E+01	N	6.8E+00	2.5E-01
POTASSIUM SILVER CYANIDE	506616	2.7E+02	N	2.7E+01	1.0E+00
SILVER CYANIDE	506649	1.4E+02	N	1.4E+01	5.0E-01
SODIUM CYANIDE	143339	5.4E+01	N	5.4E+00	2.0E-01
THIOCYANATES		2.7E-01	N	2.7E-02	1.0E-03
ZINC CYANIDE	557211	6.8E+01	N	6.8E+00	2.5E-01
CYCLOHEXANONE	108941	6.8E+03	N	6.8E+02	2.5E+01

Table 4-21a. Human Health Benchmarks for Fish Tissue-Chemical Constituents. (9 Pages)

Analyte	CAS #/Analyte Code	Region 3 Fish RBC[a] (mg/kg)		Adjusted Fish Benchmark, HI=0.1 (noncarcinogenic adjustment) (mg/kg)	Selected Fish Benchmark - Native American[c] (mg/kg)
CYHALOTHRIN/KARATE	68085858	6.8E+00	N	6.8E-01	2.5E-02
CYPERMETHRIN	52315078	1.4E+01	N	1.4E+00	5.0E-02
DACTHAL	1861321	1.4E+01	N	1.4E+00	5.0E-02
DALAPON	75990	4.1E+01	N	4.1E+00	1.5E-01
DDD	72548	1.3E-02	C	1.3E-02	4.9E-04
DDE	72559	9.3E-03	C	9.3E-03	3.5E-04
DDT	50293	9.3E-03	C	9.3E-03	3.5E-04
DIAZINON	333415	1.2E+00	N	1.2E-01	4.5E-03
DIBENZOFURAN	132649	1.4E+00	N	1.4E-01	5.0E-03
1, 4-DIBROMOBENZENE	106376	1.4E+01	N	1.4E+00	5.0E-02
DIBROMOCHLOROMETHANE	124481	3.8E-02	C	3.8E-02	1.4E-03
1, 2-DIBROMO-3-CHLOROPROPANE	96128	3.9E-03	C	3.9E-03	1.5E-04
1, 2-DIBROMOETHANE	106934	1.6E-03	C	1.6E-03	5.9E-05
DIBUTYLPHTHALATE	84742	1.4E+02	N	1.4E+01	5.0E-01
DICAMBA	1918009	4.1E+01	N	4.1E+00	1.5E-01
1, 2-DICHLOROBENZENE	95501	1.2E+02	N	1.2E+01	4.5E-01
1, 3-DICHLOROBENZENE	541731	4.1E+00	N	4.1E-01	1.5E-02
1, 4-DICHLOROBENZENE	106467	1.3E-01	C	1.3E-01	4.9E-03
3, 3'-DICHLOROBENZIDINE	91941	7.0E-03	C	7.0E-03	2.6E-04
DICHLORODIFLUOROMETHANE	75718	2.7E+02	N	2.7E+01	1.0E+00
1, 1-DICHLOROETHANE	75343	2.7E+02	N	2.7E+01	1.0E+00
1, 2-DICHLOROETHANE	107062	3.5E-02	C	3.5E-02	1.3E-03
1, 1-DICHLOROETHENE	75354	6.8E+01	N	6.8E+00	2.5E-01
CIS-1, 2-DICHLOROETHENE	156592	1.4E+01	N	1.4E+00	5.0E-02
TRANS-1, 2-DICHLOROETHENE	156605	2.7E+01	N	2.7E+00	1.0E-01
TOTAL 1, 2-DICHLOROETHENE	540590	1.2E+01	N	1.2E+00	4.5E-02
2, 4-DICHLOROPHENOL	120832	4.1E+00	N	4.1E-01	1.5E-02
2, 4-D	94757	1.4E+01	N	1.4E+00	5.0E-02
4-(2, 4-DICHLOROPHENOXY)BUTYRIC ACID	94826	1.1E+01	N	1.1E+00	4.0E-02
1, 2-DICHLOROPROPANE	78875	4.6E-02	C	4.6E-02	1.7E-03
1, 3-DICHLOROPROPANE	142289	2.7E+01	N	2.7E+00	1.0E-01
2, 3-DICHLOROPROPANOL	616239	4.1E+00	N	4.1E-01	1.5E-02
1, 3-DICHLOROPROPENE	542756	3.2E-02	C	3.2E-02	1.2E-03
DICHLORVOS	62737	1.1E-02	C	1.1E-02	4.1E-04
DIELDRIN	60571	2.0E-04	C	2.0E-04	7.4E-06
DIETHYLPHTHALATE	84662	1.1E+03	N	1.1E+02	4.0E+00
DI(2-ETHYLHEXYL) ADIPATE	103231	2.6E+00	C	2.6E+00	9.8E-02
DIETHYLSTILBESTROL	56531	6.7E-07	C	6.7E-07	2.5E-08
DIFENZOQUAT (AVENGE)	43222486	1.1E+02	N	1.1E+01	4.0E-01
DIISOPROPYL	1445756	1.1E+02	N	1.1E+01	4.0E-01

Table 4-21a. Human Health Benchmarks for Fish Tissue-Chemical Constituents. (9 Pages)

Analyte	CAS #/Analyte Code	Region 3 Fish RBC[a] (mg/kg)		Adjusted Fish Benchmark, HI=0.1 (noncarcinogenic adjustment) (mg/kg)	Selected Fish Benchmark - Native American[c] (mg/kg)
METHYLPHOSPHONATE (DIMP)					
3, 3'-DIMETHOXYBENZIDINE	119904	2.3E-01	C	2.3E-01	8.4E-03
N, N-DIMETHYLANILINE	121697	2.7E+00	N	2.7E-01	1.0E-02
2, 4-DIMETHYLPHENOL	105679	2.7E+01	N	2.7E+00	1.0E-01
2, 6-DIMETHYLPHENOL	576261	8.1E-01	N	8.1E-02	3.0E-03
3, 4-DIMETHYLPHENOL	95658	1.4E+00	N	1.4E-01	5.0E-03
1, 2-DINITROBENZENE	528290	1.4E-01	N	1.4E-02	5.0E-04
1, 3-DINITROBENZENE	99650	1.4E-01	N	1.4E-02	5.0E-04
1, 4-DINITROBENZENE	100254	1.4E-01	N	1.4E-02	5.0E-04
4, 6-DINITRO-O-CYCLOHEXYL PHENOL	131895	2.7E+00	N	2.7E-01	1.0E-02
2, 4-DINITROPHENOL	51285	2.7E+00	N	2.7E-01	1.0E-02
DINITROTOLUENE MIX		4.6E-03	C	4.6E-03	1.7E-04
2, 4-DINITROTOLUENE	121142	2.7E+00	N	2.7E-01	1.0E-02
2, 6-DINITROTOLUENE	606202	1.4E+00	N	1.4E-01	5.0E-03
DINOSEB	88857	1.4E+00	N	1.4E-01	5.0E-03
1, 4-DIOXANE	123911	2.9E-01	C	2.9E-01	1.1E-02
DIPHENYLAMINE	122394	3.4E+01	N	3.4E+00	1.3E-01
1, 2-DIPHENYLHYDRAZINE	122667	3.9E-03	C	3.9E-03	1.5E-04
DIQUAT	85007	3.0E+00	N	3.0E-01	1.1E-02
DISULFOTON	298044	5.4E-02	N	5.4E-03	2.0E-04
1, 4-DITHIANE	505293	1.4E+01	N	1.4E+00	5.0E-02
DIURON	330541	2.7E+00	N	2.7E-01	1.0E-02
ENDOSULFAN	115297	8.1E+00	N	8.1E-01	3.0E-02
ENDRIN	72208	4.1E-01	N	4.1E-02	1.5E-03
EPICHLOROHYDRIN	106898	3.2E-01	C	3.2E-01	1.2E-02
ETHION	563122	6.8E-01	N	6.8E-02	2.5E-03
ETHYL ACETATE	141786	1.2E+03	N	1.2E+02	4.5E+00
ETHYLBENZENE	100414	1.4E+02	N	1.4E+01	5.0E-01
ETHYLENE GLYCOL	107211	2.7E+03	N	2.7E+02	1.0E+01
ETHYLENE GLYCOL, MONOBUTYL ETHER	111762	6.8E+02	N	6.8E+01	2.5E+00
ETHYLENE OXIDE	75218	3.2E-03	C	3.2E-03	1.2E-04
ETHYL ETHER	60297	2.7E+02	N	2.7E+01	1.0E+00
FENAMIPHOS	22224926	3.4E-01	N	3.4E-02	1.3E-03
FLUOMETURON	2164172	1.8E+01	N	1.8E+00	6.6E-02
FLUORINE	7782414	8.1E+01	N	8.1E+00	3.0E-01
FOMESAFEN	72178020	1.7E-02	C	1.7E-02	6.2E-04
FONOFOS	944229	2.7E+00	N	2.7E-01	1.0E-02
FORMALDEHYDE	50000	2.7E+02	N	2.7E+01	1.0E+00
FURAN	110009	1.4E+00	N	1.4E-01	5.0E-03

Table 4-21a. Human Health Benchmarks for Fish Tissue-Chemical Constituents. (9 Pages)

Analyte	CAS #/Analyte Code	Region 3 Fish RBC[a] (mg/kg)		Adjusted Fish Benchmark, HI=0.1 (noncarcinogenic adjustment) (mg/kg)	Selected Fish Benchmark - Native American[c] (mg/kg)
FURFURAL	98011	4.1E+00	N	4.1E-01	1.5E-02
GLYPHOSATE	1071836	1.4E+02	N	1.4E+01	5.0E-01
HEPTACHLOR	76448	7.0E-04	C	7.0E-04	2.6E-05
HEPTACHLOR EPOXIDE	1024573	3.5E-04	C	3.5E-04	1.3E-05
HEXABROMOBENZENE	87821	2.7E+00	N	2.7E-01	1.0E-02
HEXACHLOROBENZENE	118741	2.0E-03	C	2.0E-03	7.4E-05
HEXACHLOROBUTADIENE	87683	4.0E-02	C	4.0E-02	1.5E-03
ALPHA-HCH	319846	5.0E-04	C	5.0E-04	1.9E-05
BETA-HCH	319857	1.8E-03	C	1.8E-03	6.5E-05
GAMMA-HCH (LINDANE)	58899	2.4E-03	C	2.4E-03	9.1E-05
TECHNICAL HCH	608731	1.8E-03	C	1.8E-03	6.5E-05
HEXACHLOROCYCLOPENTADIENE	77474	8.1E+00	N	8.1E-01	3.0E-02
HEXACHLORODIBENZODIOXIN MIX	19408743	5.1E-07	C	5.1E-07	1.9E-08
HEXACHLOROETHANE	67721	2.3E-01	C	2.3E-01	8.4E-03
HEXACHLOROPHENE	70304	4.1E-01	N	4.1E-02	1.5E-03
HMX	2691410	6.8E+01	N	6.8E+00	2.5E-01
HYDRAZINE	302012	1.1E-03	C	1.1E-03	3.9E-05
HYDROGEN SULFIDE	7783064	4.1E+00	N	4.1E-01	1.5E-02
IRON	7439896	9.5E+02	N	9.5E+01	3.5E+00
ISOBUTANOL	78831	4.1E+02	N	4.1E+01	1.5E+00
ISOPHORONE	78591	3.3E+00	C	3.3E+00	1.2E-01
TETRAETHYLLEAD	78002	1.4E-04	N	1.4E-05	5.0E-07
KEPONE	143500	6.8E-01	N	6.8E-02	2.5E-03
LITHIUM	7439932	2.7E+01	N	2.7E+00	1.0E-01
MALATHION	121755	2.7E+01	N	2.7E+00	1.0E-01
MALEIC ANHYDRIDE	108316	1.4E+02	N	1.4E+01	5.0E-01
MANGANESE-FOOD	7439965	1.9E+02	N	1.9E+01	7.1E-01
MEPHOSFOLAN	950107	1.2E-01	N	1.2E-02	4.5E-04
MEPIQUAT CHLORIDE	24307264	4.1E+01	N	4.1E+00	1.5E-01
MERCURIC CHLORIDE	7487947	4.1E-01	N	4.1E-02	1.5E-03
METHYLMERCURY	22967926	1.4E-01	N	1.4E-02	5.0E-04
METHANOL	67561	6.8E+02	N	6.8E+01	2.5E+00
METHIDATHION	950378	1.4E+00	N	1.4E-01	5.0E-03
METHOXYCHLOR	72435	6.8E+00	N	6.8E-01	2.5E-02
METHYL ACETATE	79209	1.4E+03	N	1.4E+02	5.0E+00
METHYL ACRYLATE	96333	4.1E+01	N	4.1E+00	1.5E-01
2-METHYLANILINE	95534	1.3E-02	C	1.3E-02	4.9E-04
4-(2-METHYL-4-CHLOROPHENOXY) BUTYRIC ACID	94815	1.4E+01	N	1.4E+00	5.0E-02
2-METHYL-4-CHLOROPHEN-OXYACETIC ACID (MCPA)	94746	6.8E-01	N	6.8E-02	2.5E-03

Table 4-21a. Human Health Benchmarks for Fish Tissue-Chemical Constituents. (9 Pages)

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2-(2-METHYL-4-CHLORO-PHENOXY)PROPIONIC ACID (MCPP)	93652	1.4E+00	N	1.4E-01	5.0E-03
METHYLENE BROMIDE	74953	1.4E+01	N	1.4E+00	5.0E-02
METHYLENE CHLORIDE	75092	4.2E-01	C	4.2E-01	1.6E-02
4, 4'-METHYLENE BIS(2-CHLORO-ANILINE)	101144	3.2E-02	C	3.2E-02	1.2E-03
4,4'-METHYLENE BIS(N, N'DIMETHYL) ANILINE	101611	6.9E-02	C	6.9E-02	2.6E-03
METHYL ETHYL KETONE (2-BUTANONE)	78933	8.1E+02	N	8.1E+01	3.0E+00
METHYL METHACRYLATE	80626	1.9E+03	N	1.9E+02	7.1E+00
METHYL PARATHION	298000	3.4E-01	N	3.4E-02	1.3E-03
2-METHYLPHENOL	95487	6.8E+01	N	6.8E+00	2.5E-01
3-METHYLPHENOL	108394	6.8E+01	N	6.8E+00	2.5E-01
4-METHYLPHENOL	106445	6.8E+00	N	6.8E-01	2.5E-02
METHYLSTYRENE MIX	25013154	8.1E+00	N	8.1E-01	3.0E-02
ALPHA-METHYLSTYRENE	98839	9.5E+01	N	9.5E+00	3.5E-01
METHYL TERT-BUTYL ETHER	1634044	7.9E-01	C	7.9E-01	2.9E-02
METOLACHLOR (DUAL)	51218452	2.0E+02	N	2.0E+01	7.6E-01
MIREX	2385855	2.7E-01	N	2.7E-02	1.0E-03
MOLYBDENUM	7439987	6.8E+00	N	6.8E-01	2.5E-02
MONOCHLORAMINE	10599903	1.4E+02	N	1.4E+01	5.0E-01
NALED	300765	2.7E+00	N	2.7E-01	1.0E-02
NICKEL	7440020	2.7E+01	N	2.7E+00	1.0E-01
NITRATE	14797558	2.2E+03	N	2.2E+02	8.1E+00
NITRITE	14797650	1.4E+02	N	1.4E+01	5.0E-01
NITROBENZENE	98953	6.8E-01	N	6.8E-02	2.5E-03
NITROGLYCERIN	55630	1.4E-01	N	1.4E-02	5.0E-04
N-NITROSO-DI-N-BUTYLAMINE	924163	5.8E-04	C	5.8E-04	2.2E-05
N-NITROSODIETHANOLAMINE	1116547	1.1E-03	C	1.1E-03	4.2E-05
N-NITROSODIETHYLAMINE	55185	2.1E-05	C	2.1E-05	7.8E-07
N-NITROSODIMETHYLAMINE	62759	6.2E-05	C	6.2E-05	2.3E-06
N-NITROSODIPHENYLAMINE	86306	6.4E-01	C	6.4E-01	2.4E-02
N-NITROSODIPROPYLAMINE	621647	4.5E-04	C	4.5E-04	1.7E-05
N-NITROSO-N-METHYLETHYLAMINE	10595956	1.4E-04	C	1.4E-04	5.3E-06
N-NITROSOPYRROLIDINE	930552	1.5E-03	C	1.5E-03	5.6E-05
O-NITROTOLUENE	88722	1.4E+01	N	1.4E+00	5.0E-02
P-NITROTOLUENE	99990	2.0E-01	C	2.0E-01	7.4E-03
NUSTAR	85509199	9.5E-01	N	9.5E-02	3.5E-03
ORYZALIN	19044883	6.8E+01	N	6.8E+00	2.5E-01
OXADIAZON	19666309	6.8E+00	N	6.8E-01	2.5E-02
OXAMYL	23135220	3.4E+01	N	3.4E+00	1.3E-01

Table 4-21a. Human Health Benchmarks for Fish Tissue-Chemical Constituents. (9 Pages)

Analyte	CAS #/Analyte Code	Region 3 Fish RBC[a] (mg/kg)		Adjusted Fish Benchmark, HI=0.1 (noncarcinogenic adjustment) (mg/kg)	Selected Fish Benchmark - Native American[c] (mg/kg)
OXYFLUORFEN	42874033	4.1E+00	N	4.1E-01	1.5E-02
PARAQUAT DICHLORIDE	1910425	6.1E+00	N	6.1E-01	2.3E-02
PARATHION	56382	8.1E+00	N	8.1E-01	3.0E-02
PENTACHLOROBENZENE	608935	1.1E+00	N	1.1E-01	4.0E-03
PENTACHLOROETHANE	76017	3.5E-02	C	3.5E-02	1.3E-03
PENTACHLORONITROBENZENE	82688	1.2E-02	C	1.2E-02	4.5E-04
PENTACHLOROPHENOL	87865	2.6E-02	C	2.6E-02	9.8E-04
PERCHLORATE		9.5E-01	N	9.5E-02	3.5E-03
PERMETHRIN	52645531	6.8E+01	N	6.8E+00	2.5E-01
PHENOL	108952	4.1E+02	N	4.1E+01	1.5E+00
M-PHENYLENEDIAMINE	108452	8.1E+00	N	8.1E-01	3.0E-02
O-PHENYLENEDIAMINE	95545	6.7E-02	C	6.7E-02	2.5E-03
P-PHENYLENEDIAMINE	106503	2.6E+02	N	2.6E+01	9.6E-01
PHOSPHINE	7803512	4.1E-01	N	4.1E-02	1.5E-03
PHOSPHORUS (WHITE)	7723140	2.7E-02	N	2.7E-03	1.0E-04
PHTHALIC ANHYDRIDE	85449	2.7E+03	N	2.7E+02	1.0E+01
POLYBROMINATED BIPHENYLS		3.5E-04	C	3.5E-04	1.3E-05
POLYCHLORINATED BIPHENYLS	1336363	1.6E-03	C	1.6E-03	5.9E-05
AROCLOR-1016	12674112	4.5E-02	C	4.5E-02	1.7E-03
AROCLOR-1221	11104282	1.6E-03	C	1.6E-03	5.9E-05
AROCLOR-1232	11141165	1.6E-03	C	1.6E-03	5.9E-05
AROCLOR-1242	53469219	1.6E-03	C	1.6E-03	5.9E-05
AROCLOR-1248	12672296	1.6E-03	C	1.6E-03	5.9E-05
AROCLOR-1254	11097691	1.6E-03	C	1.6E-03	5.9E-05
AROCLOR-1260	11096825	1.6E-03	C	1.6E-03	5.9E-05
ACENAPHTHENE	83329	8.1E+01	N	8.1E+00	3.0E-01
ANTHRACENE	120127	4.1E+02	N	4.1E+01	1.5E+00
BENZ[A]ANTHRACENE	56553	4.3E-03	C	4.3E-03	1.6E-04
BENZO[B]FLUORANTHENE	205992	4.3E-03	C	4.3E-03	1.6E-04
BENZO[K]FLUORANTHENE	207089	4.3E-02	C	4.3E-02	1.6E-03
BENZO[A]PYRENE	50328	4.3E-04	C	4.3E-04	1.6E-05
CARBAZOLE	86748	1.6E-01	C	1.6E-01	5.9E-03
CHRYSENE	218019	4.3E-01	C	4.3E-01	1.6E-02
DIBENZ[A,H]ANTHRACENE	53703	4.3E-04	C	4.3E-04	1.6E-05
FLUORANTHENE	206440	5.4E+01	N	5.4E+00	2.0E-01
FLUORENE	86737	5.4E+01	N	5.4E+00	2.0E-01
INDENO[1,2,3-C,D]PYRENE	193395	4.3E-03	C	4.3E-03	1.6E-04
2-METHYLNAPHTHALENE	91576	5.4E+00	N	5.4E-01	2.0E-02
NAPHTHALENE	91203	2.7E+01	N	2.7E+00	1.0E-01
PYRENE	129000	4.1E+01	N	4.1E+00	1.5E-01
PROMETON	1610180	2.0E+01	N	2.0E+00	7.6E-02

Table 4-21a. Human Health Benchmarks for Fish Tissue-Chemical Constituents. (9 Pages)

Analyte	CAS #/Analyte Code	Region 3 Fish RBC[a] (mg/kg)		Adjusted Fish Benchmark, HI=0.1 (noncarcinogenic adjustment) (mg/kg)	Selected Fish Benchmark - Native American[c] (mg/kg)
PROMETRYN	7287196	5.4E+00	N	5.4E-01	2.0E-02
PROPACHLOR	1918167	1.8E+01	N	1.8E+00	6.6E-02
PROPARGITE	2312358	2.7E+01	N	2.7E+00	1.0E-01
PROPYLENE GLYCOL, MONOETHYL ETHER	52125538	9.5E+02	N	9.5E+01	3.5E+00
PROPYLENE GLYCOL, MONOMETHYL ETHER	107982	9.5E+02	N	9.5E+01	3.5E+00
PURSUIT	81335775	3.4E+02	N	3.4E+01	1.3E+00
PYRIDINE	110861	1.4E+00	N	1.4E-01	5.0E-03
QUINOLINE	91225	1.1E-03	C	1.1E-03	3.9E-05
RDX	121824	2.9E-02	C	2.9E-02	1.1E-03
RESMETHRIN	10453868	4.1E+01	N	4.1E+00	1.5E-01
ROTENONE	83794	5.4E+00	N	5.4E-01	2.0E-02
SELENIUM	7782492	6.8E+00	N	6.8E-01	2.5E-02
SILVER	7440224	6.8E+00	N	6.8E-01	2.5E-02
SIMAZINE	122349	2.6E-02	C	2.6E-02	9.8E-04
SODIUM DIETHYLDITHIOCARBAMATE	148185	1.2E-02	C	1.2E-02	4.4E-04
STRONTIUM, STABLE	7440246	8.1E+02	N	8.1E+01	3.0E+00
STRYCHNINE	57249	4.1E-01	N	4.1E-02	1.5E-03
STYRENE	100425	2.7E+02	N	2.7E+01	1.0E+00
2,3,7,8-TETRACHLORODIBEN-ZODIOXIN	1746016	2.1E-08	C	2.1E-08	7.8E-10
1,2,4,5-TETRACHLOROBENZENE	95943	4.1E-01	N	4.1E-02	1.5E-03
1,1,1,2-TETRACHLOROETHANE	630206	1.2E-01	C	1.2E-01	4.5E-03
1,1,2,2-TETRACHLOROETHANE	79345	1.6E-02	C	1.6E-02	5.9E-04
TETRACHLOROETHENE	127184	5.8E-03	C	5.8E-03	2.2E-04
2,3,4,6-TETRACHLOROPHENOL	58902	4.1E+01	N	4.1E+00	1.5E-01
P,A,A,A-TETRACHLOROTOLUENE	5216251	1.6E-04	C	1.6E-04	5.9E-06
TETRAHYDROFURAN	109999	4.2E-01	C	4.2E-01	1.5E-02
TETRYL	479458	5.4E+00	N	5.4E-01	2.0E-02
THALLIUM	7440280	9.5E-02	N	9.5E-03	3.5E-04
THALLIUM ACETATE	563688	1.2E-01	N	1.2E-02	4.5E-04
THALLIUM CARBONATE	6533739	1.1E-01	N	1.1E-02	4.0E-04
THALLIUM CHLORIDE	7791120	1.1E-01	N	1.1E-02	4.0E-04
THALLIUM NITRATE	10102451	1.2E-01	N	1.2E-02	4.5E-04
THALLIUM SULFATE (2:1)	7446186	1.1E-01	N	1.1E-02	4.0E-04
THIOBENCARB	28249776	1.4E+01	N	1.4E+00	5.0E-02
TIN	7440315	8.1E+02	N	8.1E+01	3.0E+00
TOLUENE	108883	1.1E+02	N	1.1E+01	4.0E-01
TOLUENE-2, 4-DIAMINE	95807	9.9E-04	C	9.9E-04	3.7E-05
TOLUENE-2, 5-DIAMINE	95705	8.1E+02	N	8.1E+01	3.0E+00

Table 4-21a. Human Health Benchmarks for Fish Tissue-Chemical Constituents. (9 Pages)

Analyte	CAS #/Analyte Code	Region 3 Fish RBC[a] (mg/kg)		Adjusted Fish Benchmark, HI=0.1 (noncarcinogenic adjustment) (mg/kg)	Selected Fish Benchmark - Native American[c] (mg/kg)
TOLUENE-2, 6-DIAMINE	823405	4.1E+01	N	4.1E+00	1.5E-01
P-TOLUIDINE	106490	1.7E-02	C	1.7E-02	6.2E-04
TOXAPHENE	8001352	2.9E-03	C	2.9E-03	1.1E-04
1, 2, 4-TRIBROMOBENZENE	615543	6.8E+00	N	6.8E-01	2.5E-02
TRIBUTYLTIN OXIDE	56359	4.1E-01	N	4.1E-02	1.5E-03
2, 4, 6-TRICHLOROANILINE	634935	9.3E-02	C	9.3E-02	3.5E-03
1, 2, 4-TRICHLOROBENZENE	120821	1.4E+01	N	1.4E+00	5.0E-02
1, 1, 1-TRICHLOROETHANE	71556	2.7E+03	N	2.7E+02	1.0E+01
1, 1, 2-TRICHLOROETHANE	79005	5.5E-02	C	5.5E-02	2.1E-03
TRICHLOROETHENE	79016	7.9E-03	C	7.9E-03	2.9E-04
TRICHLOROFLUOROMETHANE	75694	4.1E+02	N	4.1E+01	1.5E+00
2, 4, 5-TRICHLOROPHENOL	95954	1.4E+02	N	1.4E+01	5.0E-01
2, 4, 6-TRICHLOROPHENOL	88062	2.9E-01	C	2.9E-01	1.1E-02
2, 4, 5-T	93765	1.4E+01	N	1.4E+00	5.0E-02
2-(2, 4, 5-TRICHLOROPHENOXY) PROPIONIC ACID	93721	1.1E+01	N	1.1E+00	4.0E-02
1,1,2-TRICHLOROPROPANE	598776	6.8E+00	N	6.8E-01	2.5E-02
1,2,3-TRICHLOROPROPANE	96184	1.6E-03	C	1.6E-03	5.9E-05
1,1,2-TRICHLORO-1, 2, 2-TRIFLUORO-ETHANE	76131	4.1E+04	N	4.1E+03	1.5E+02
1, 3, 5-TRINITROBENZENE	99354	4.1E+01	N	4.1E+00	1.5E-01
2, 4, 6-TRINITROTOLUENE	118967	1.1E-01	C	1.1E-01	3.9E-03
URANIUM (SOLUBLE SALTS)	7440611	4.1E+00	N	4.1E-01	1.5E-02
VANADIUM	7440622	1.4E+00	N	1.4E-01	5.0E-03
VINCLOZOLIN	50471448	3.4E+01	N	3.4E+00	1.3E-01
VINYL ACETATE	108054	1.4E+03	N	1.4E+02	5.0E+00
VINYL CHLORIDE: adult	75014	4.4E-03	C	4.4E-03	1.6E-04
WARFARIN	81812	4.1E-01	N	4.1E-02	1.5E-03
XYLENES	1330207	2.7E+02	N	2.7E+01	1.0E+00
ZINC	7440666	4.1E+02	N	4.1E+01	1.5E+00
ZINEB	12122677	6.8E+01	N	6.8E+00	2.5E-01

Notes:

[a] EPA Region 3 Risk-Based Concentration (RBC), October 2007.

[b] Noncancer-based RBCs were divided by 10 to reflect a Hazard Quotient of 0.1.

[c] Region 3 RBC benchmark divided by a factor of 11.5 to account for CTUIR fishing rate of 620 g/d vs. default of 54 g/d and a factor of 2.3 to account for CTUIR exposure duration of 70 years, vs. default of 30 years. (CTUIR parameters obtained from Harris and Harper 2004). Uranium benchmark further adjusted downward by 5 to account for revised Office of Water oral reference dose of 0.0006 mg/kg-d.

CTUIR = Confederated Tribes of the Umatilla Indian Reservation
C = carcinogenic effects
N = noncarcinogenic effects
HI = hazard index
RBC = risk-based concentration
g/d = grams per day
mg/kg = milligrams per kilogram

Table 4-21b. Human Health Benchmarks for Fish Tissue-Radionuclides.

Radionuclides	CAS No./Analyte Code	CSF	Fish RBC (pCi/g)
Americium-241	14596-10-2	1.34E-10	4.71E-04
Antimony-125	14234-35-6	7.21E-12	8.76E-03
Barium-140	14798-08-4	2.17E-11	2.91E-03
Carbon-14	14762-75-5	2.00E-12	3.16E-02
Cerium-141	13967-74-3	6.77E-12	9.32E-03
Cerium-144	14762-78-8	5.18E-11	1.22E-03
Cesium-134	13967-70-9	5.14E-11	1.23E-03
Cesium-137	10045-97-3	3.74E-11	1.69E-03
Cobalt-57	13981-50-5	1.49E-12	4.24E-02
Cobalt-58	13981-38-9	4.18E-12	1.51E-02
Cobalt-60	10198-40-0	2.23E-11	2.83E-03
Curium-244	13981-15-2	1.08E-10	5.85E-04
Europium-152	14683-23-9	8.70E-12	7.26E-03
Europium-154	15585-10-1	1.49E-11	4.24E-03
Europium-155	14391-16-3	2.77E-12	2.28E-02
Iodine-129	15046-84-1	3.22E-10	1.96E-04
Iodine-131	10043-66-0	1.34E-10	4.71E-04
Neptunium-237	13994-20-2	9.10E-11	6.94E-04
Nickel-63	13981-37-8	9.51E-13	6.64E-02
Niobium-94	14681-63-1	1.11E-11	5.69E-03
Plutonium-238	13981-16-3	1.69E-10	3.74E-04
Plutonium-239/240	PU-239/240	1.74E-10	3.63E-04
Plutonium-241	14119-32-5	2.28E-12	2.77E-02
Potassium-40	13966-00-2	3.43E-11	1.84E-03
Radium-226	13982-63-3	5.15E-10	1.23E-04
Radium-228	15262-20-1	1.43E-09	4.41E-05
Strontium-90	10098-97-2	9.53E-11	6.62E-04
Technetium-99	14133-76-7	4.00E-12	1.58E-02
Thorium-228	14274-82-9	4.22E-10	1.50E-04
Thorium-229	15594-54-4	2.90E-10	2.18E-04
Thorium-230	14269-63-7	1.19E-10	5.30E-04
Thorium-232	TH-232	1.33E-10	4.75E-04
Tritium	10028-17-8	1.44E-13	4.38E-01
Uranium-233	13968-55-3	9.69E-11	6.51E-04
Uranium-234	13966-29-5	9.55E-11	6.61E-04
Uranium-235	15117-96-1	9.76E-11	6.47E-04
Uranium-238	U-238	1.21E-10	5.22E-04
Zinc-65	13982-39-3	1.54E-11	4.10E-03
Zirconium/Niobium-95	ZR/NB-95	6.59E-12	9.58E-03

Exposure assumptions based on CTUIR scenario (Harris and Harper, 2004)
CSF values from EPA (2001c)
Fish ingestion RBC_{rad} = TR/(CSF*IR*EF*ED)
RBCrad = risk-based concentration, radionuclides (pCi/g) -calculated
TR = target risk (unitless; 1E-06)
CSF = cancer slope factor (risk/pCi)
IR = fish ingestion rate (620 g/day)
EF = exposure frequency (365 days/year)
ED = exposure duration (70 years)

APPENDIX A

SAMPLING AND ANALYSIS PLAN

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ACRONYMS

ACOE	U.S. Army Corps of Engineers
ASTM	American Society for Testing Materials
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CPR	cardiopulmonary resuscitation
DOE	U.S. Department of Energy
DOE-RL	U.S. Department of Energy, Richland Operations Office
DOT	U.S. Department of Transportation
DQA	data quality assessment
DQO	data quality objective
Ecology	Washington State Department of Ecology
ECP	Environmental Control Plan
ENRE	Environmental Restoration (database)
EPA	U.S. Environmental Protection Agency
EPL	Environmental Project Lead
FSP	field sampling plan
HASQARD	*Hanford Analytical Services Quality Assurance Requirements Documents*
MIS	multi-incremental sampling
PCB	polychlorinated biphenyl
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
RCBRA	River Corridor Baseline Risk Assessment
RCCC	River Corridor Closure Contract
RCRA	*Resource Conservation and Recovery Act of 1976*
RI	remedial investigation
RL	reporting limit
RM	river mile
RPD	relative percent difference
SAF	sample authorization form
SAI	sampling and analysis instruction
SAP	sampling and analysis plan
SOP	standard operating procedure
SS&SF	Sample Storage and Shipping Facility
SSWMI	site-specific waste management instruction
STR	subcontract technical representative
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
WAC	*Washington Administrative Code*
WCH	Washington Closure Hanford
WI	work instruction

1.0 INTRODUCTION

This sampling and analysis plan (SAP) presents the details of the proposed sampling identified in the *Remedial Investigation Work Plan for Hanford Site Releases to the Columbia River* (this document, hereafter called the RI work plan). This SAP is based on the results of the data quality objectives (DQO) process, which is summarized in the *DQO Summary Report for the Remedial Investigation of Hanford Site Releases to the Columbia River* (DQO Summary Report) (WCH-265) that identified the additional data needed to characterize Hanford Site hazardous substance releases to the Columbia River and support human health and ecological baseline risk assessments.

The geographical investigation area (Study Area) for this SAP includes the Columbia River and islands from above Priest Rapids Dam to McNary Dam (the first downriver dam from the Hanford Site), plus a limited investigation of the area immediately upstream of Bonneville Dam. This investigation area has been divided into five sub-areas based on proximity to the Hanford Site and the relation of production operations to facilitate the baseline human health risk assessment. These five sub-areas include the Upriver Sub-Area, 100 Area Sub-Area, 300 Area Sub-Area, Lake Wallula Sub-Area, and Bonneville Dam Pool Sub-Area (Figure 1-1).

The lateral investigation area of the Columbia River extends shore to shore (ordinary high water mark to ordinary high water mark[1]), except for areas within the Hanford Reach that have been previously characterized and assessed by the River Corridor Baseline Risk Assessment (RCBRA) Source and Groundwater Component (nominally to a depth of 2 m [6 ft] into the river from the low water mark). In these areas of the Hanford Reach, the investigation area for this SAP begins where the RCBRA Source and Groundwater Component investigation stopped. For abiotic media, and most biota, sample collection for the RCBRA Source and Groundwater Component stopped at 1.8 m (6 ft) below the low water mark of the river, which is characterized by the presence of the "green line" of algae delineating the permanently inundated portion of the river channel. Biota samples for mussels and fish were occasionally collected below the green line. The lateral investigation areas are depicted in Figures 1-2 and 1-3. As shown in these figures, contaminated groundwater enters the river along the right[2] bank through seeps and springs. Additional information on the investigation area boundaries is presented in Section 4.1 of the RI work plan.

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[1] From WAC 173-22-030, "the ordinary high water mark on all lakes, streams, and tidal water is that mark that will be found by examining the bed and banks and ascertaining where the presence and action of waters are so common and usual, and so long continued in all ordinary years, as to mark upon the soil a character distinct from that of the abutting upland…"

[2] For ease of reference within this report, the terms "left" and "right" are used when referring to the river banks. These terms reflect the view when facing downriver.

Figure 1-1. Columbia River Remedial Investigation Area.

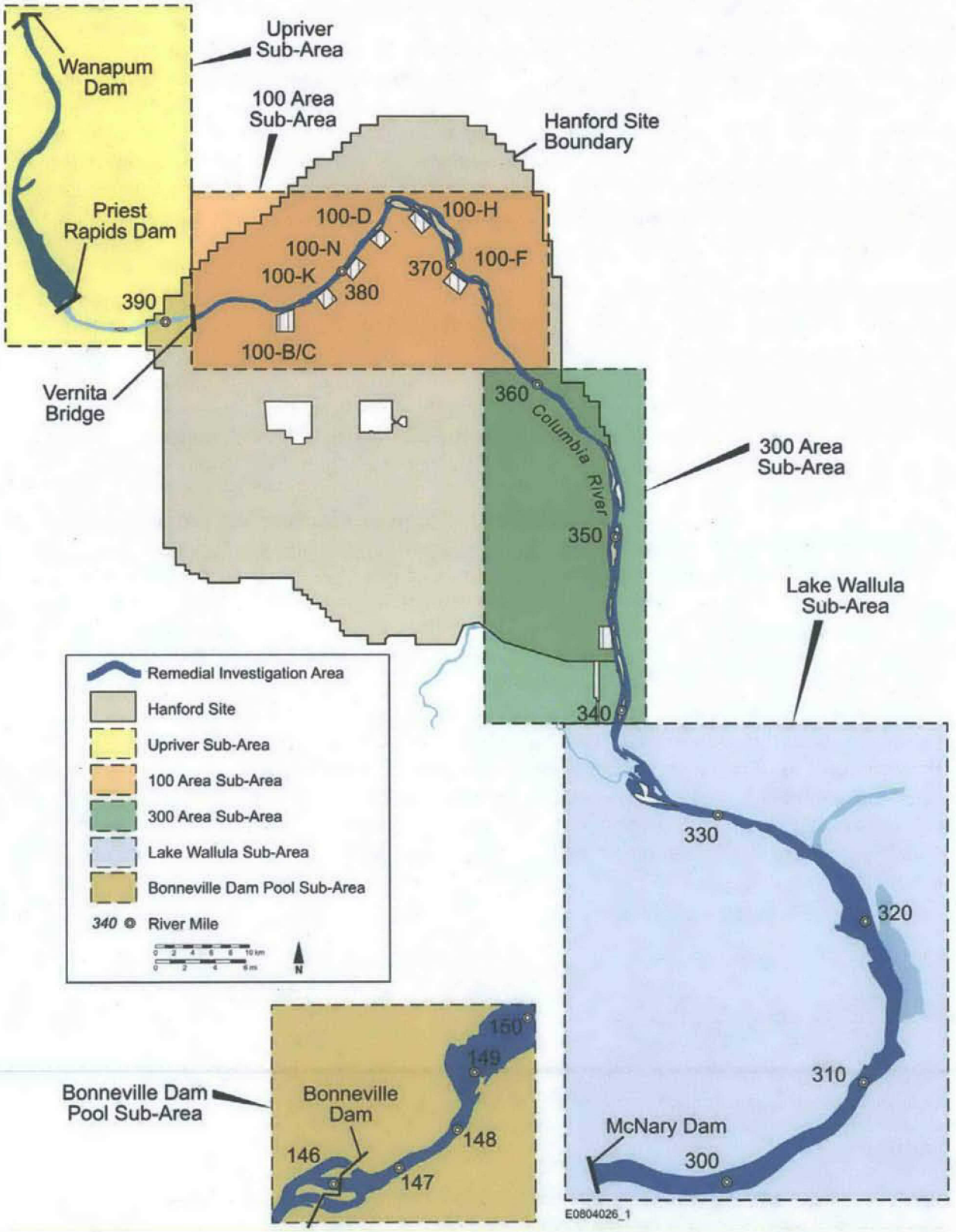


Figure 1-2. Remedial Investigation Area Within the Hanford Site.

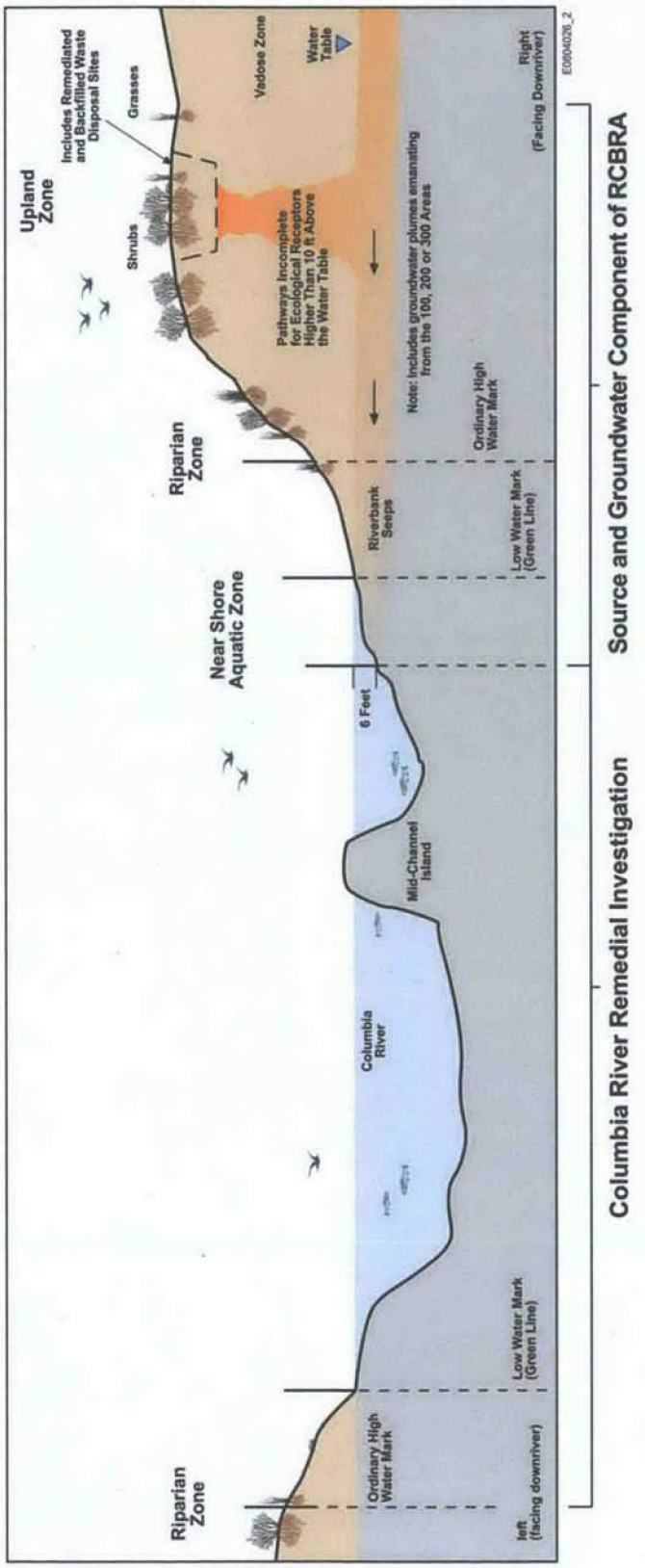
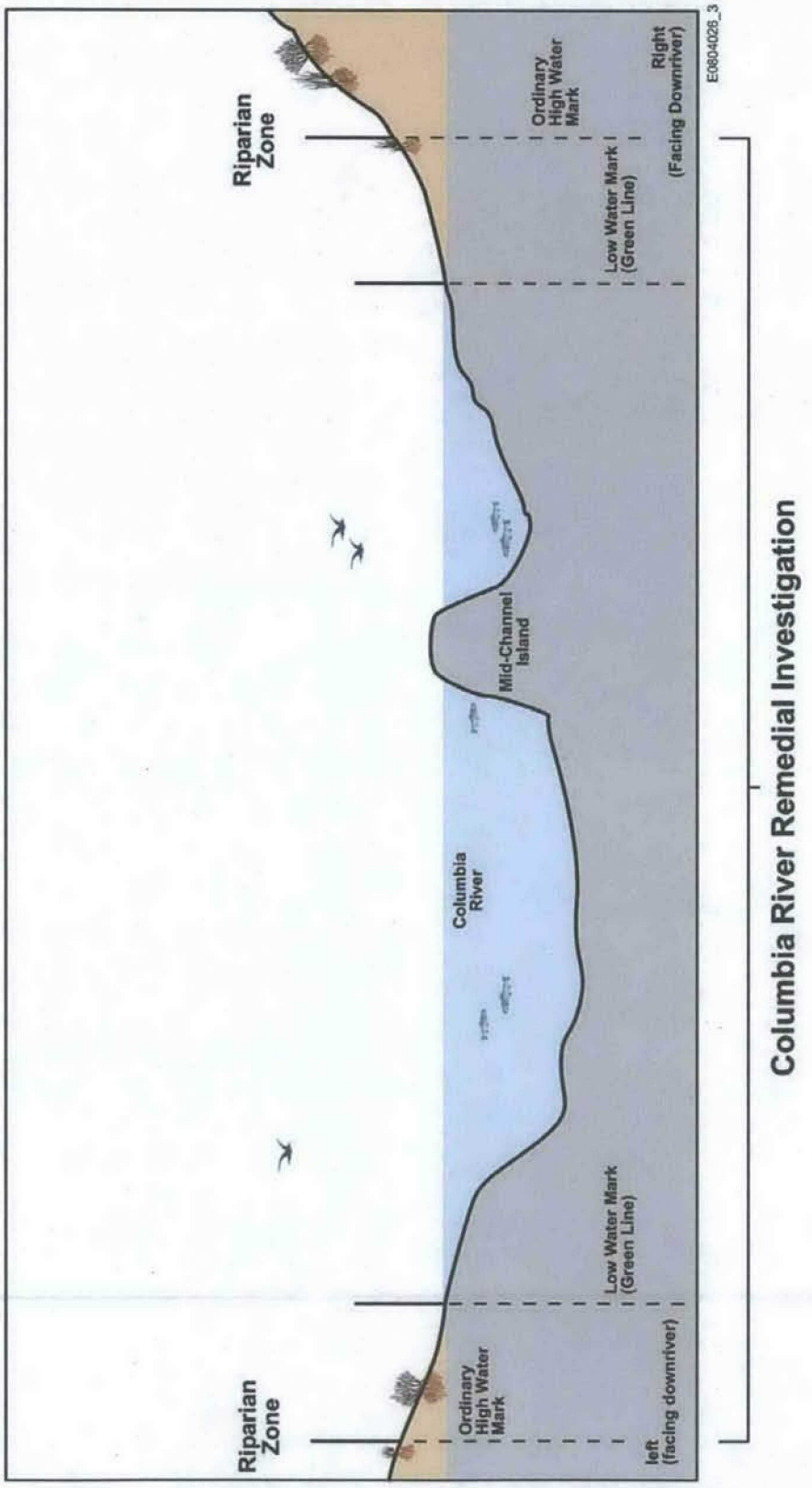


Figure 1-3. Remedial Investigation Area Downstream of the Hanford Site.



2.0 FIELD SAMPLING PLAN

The field sampling plan (FSP) describes the sampling objectives (Section 2.1), reconnaissance surveys (Section 2.2), recommended sampling design (Section 2.3), sampling procedures (Section 2.4), sampling and onsite environmental measurement procedures (Section 2.5), sample management (Section 2.6), and management of investigation-derived waste (Section 2.7). Figure 2-1 provides an overview of the Study Area. Figures 2-2 through 2-20 show the proposed sampling locations for sediment, surface water, fish, and soil for the remedial investigation (RI). Figures 2-2 through 2-20 are included in a separate section located at the end of this SAP.

2.1 SAMPLING OBJECTIVES

The DQO Summary Report (WCH-265) identified the data needed to characterize the nature and extent of Hanford Site hazardous substance releases to the Columbia River. The goal of this proposed investigation is to collect sufficient data to characterize current conditions within the Study Area (defined in Section 1.0 of this SAP) and to support human health and ecological risk assessments consistent with applicable regulatory guidance. The sampling rationale and approach are detailed in Section 4.0 of the RI work plan.

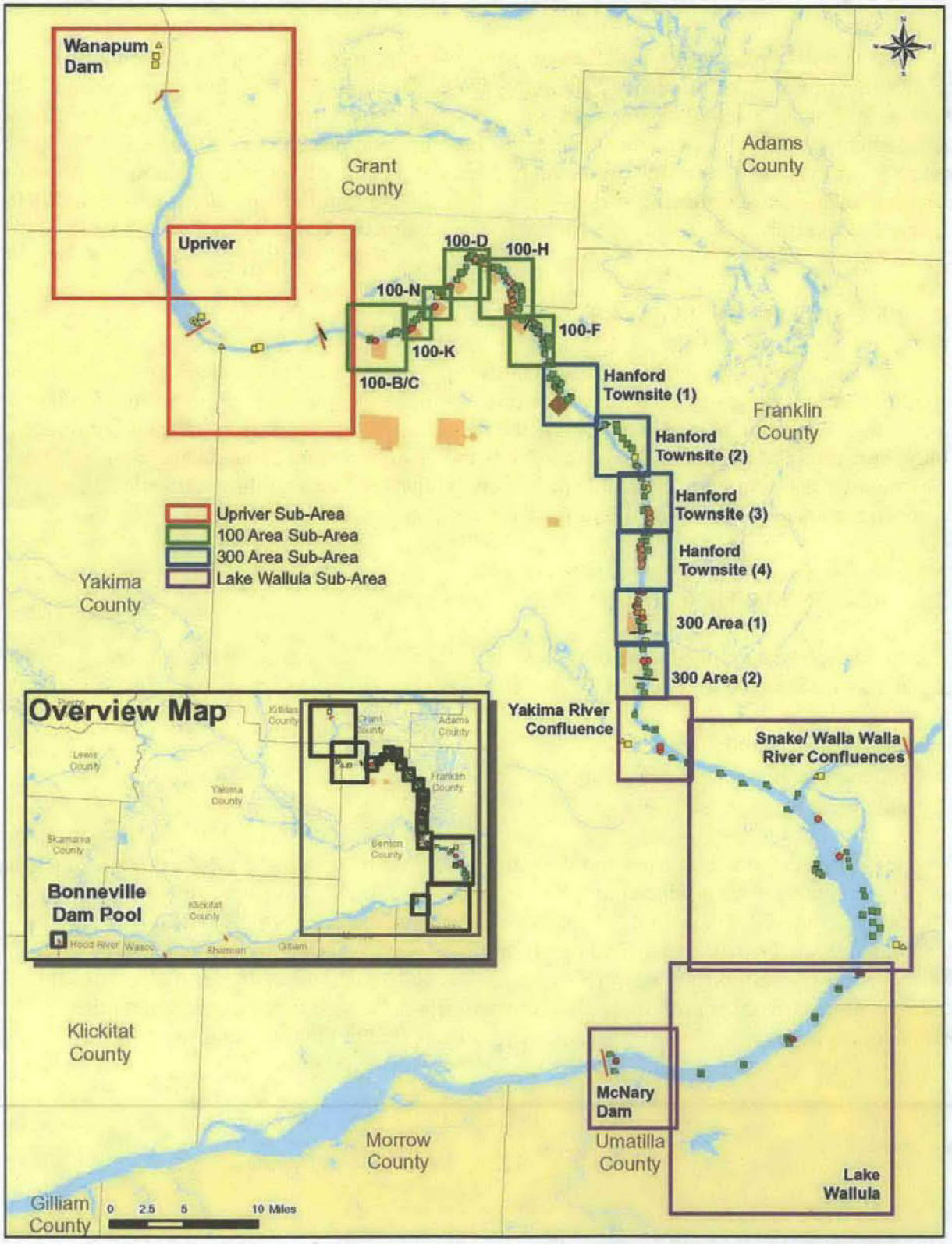
2.2 RECONNAISSANCE SURVEYS

Prior to finalizing sampling design presented in Section 2.3, the following three types of reconnaissance surveys are planned for the RI:

- Fine-grained sediment survey
- Groundwater plume upwelling survey
- Habitat survey.

Once these surveys are completed and the information has been reviewed and evaluated, the final sample locations will be produced in "D-Size" drawings. These will be provided to the U.S. Department of Energy (DOE), U.S. Environmental Protection Agency (EPA), and Washington State Department of Ecology (Ecology) (hereinafter referred to as the Tri-Parties) for review prior to sample collection. The current sediment and groundwater plume upwelling locations discussed are approximate. Final locations will be based on the outcome of the reconnaissance surveys. Each of these surveys is described in the following sections.

Figure 2-1. Study Area Overview Map.



NOTE: See the "Sampling and Analysis Plan Figures and Tables" section located at the end of this SAP for the following figures:

Figure 2-2. Proposed Sampling Locations – Wanapum Dam
Figure 2-3. Proposed Sampling Locations – Upriver Sub-Area.
Figure 2-4. Proposed Sampling Locations – 100 Area Sub-Area (100-B/C).
Figure 2-5. Proposed Sampling Locations – 100 Area Sub-Area (100-K).
Figure 2-6. Proposed Sampling Locations – 100 Area Sub-Area (100-N).
Figure 2-7. Proposed Sampling Locations – 100 Area Sub-Area (100-D).
Figure 2-8. Proposed Sampling Locations – 100 Area Sub-Area (100-H).
Figure 2-9. Proposed Sampling Locations – 100 Area Sub-Area (100-F).
Figure 2-10. Proposed Sampling Locations – 300 Area Sub-Area (Hanford Townsite (1)).
Figure 2-11. Proposed Sampling Locations – 300 Area Sub-Area (Hanford Townsite (2)).
Figure 2-12. Proposed Sampling Locations – 300 Area Sub-Area (Hanford Townsite (3)).
Figure 2-13. Proposed Sampling Locations – 300 Area Sub-Area (Hanford Townsite (4)).
Figure 2-14. Proposed Sampling Locations –300 Area Sub-Area (1).
Figure 2-15. Proposed Sampling Locations –300 Area Sub-Area (2).
Figure 2-16. Proposed Sampling Locations – Lake Wallula Sub-Area (Yakima River Confluence).
Figure 2-17. Proposed Sampling Locations – Lake Wallula Sub-Area (Snake/Walla Walla River Confluences).
Figure 2-18. Proposed Sampling Locations – Lake Wallula Sub-Area (Lake Wallula).
Figure 2-19. Proposed Sampling Locations – Lake Wallula Sub-Area (McNary Dam).
Figure 2-20. Proposed Sampling Locations – Bonneville Dam Pool Sub-Area.

2.2.1 Fine-Grained Sediment Survey

Prior to sampling, a reconnaissance survey will be conducted using a single-beam sonar (i.e., depth sounder) to identify fine-grained sediments within the area of interest. Once the extent of fine-grained sediments has been identified, they will be sampled following the approach described in Section 4.0 of the RI work plan.

2.2.2 Groundwater Plume Upwelling Survey

The purpose of the groundwater plume upwelling survey is to delineate areas of contaminated groundwater plume upwelling into the Columbia River for subsequent sampling. Once areas of groundwater plume upwelling have been identified, focused pore-water, sediment, and surface water sampling locations will be identified and provided to the Tri-Parties for review and approval at the unit managers meetings. Upon receiving approval, samples will be collected for laboratory analysis and the results will be used to characterize the nature and extent of Hanford Site releases to the river and to evaluate potential risk to humans and river biota. This survey will be completed in three phases:

- Phase I (Technology Demonstration) is a test of the applicability of the proposed Trident probe technology to Hanford Reach conditions.
- Phase II (Groundwater Plume Upwelling Delineation) will be divided into two sub-phases (a and b). Phase II(a) will focus on delineating eight areas of suspected groundwater plume upwelling. This activity will include in situ pore-water measurements of specific conductance and temperature. Phase II(b) will include a screening analysis of key Hanford Site indicator contaminants (e.g., Cr+6, strontium-90, uranium, and tritium).
- Phase III (Groundwater Plume Upwelling Characterization) will be characterization of upwelling conditions through pore-water, sediment, and surface water sampling at locations selected from review of the Phase II results.

The following provides a detailed discussion of these phases.

2.2.2.1 Phase I: Technology Demonstration. The first phase of this investigation was conducted in September 2008 to test the Trident probe technology within the Hanford Reach river environment. Locations at 100-B/C, 100-N, 100-D, and the 300 Area were investigated during the test. The Trident probe is a flexible, multi-sensor, water-sampling probe for screening and mapping groundwater plumes at the surface water interface. Its capabilities include the following:

- In situ conductivity: Contrast between groundwater and surface water
- In situ temperature: Detects groundwater by thermal contrast with surface water

- Trident probe pore-water and surface water sampler: Allows for simultaneous collection and monitoring of pore-water and surface water samples for contaminant screening and characterization.

During this technology demonstration, the probe was successfully deployed within a range of river conditions and bottom formations, including fine-grained sediments (e.g., silt), coarse-grained sediments (e.g., gravel and cobbles), and at a variety of water depths and velocities. Pore water was drawn along with in situ temperature and conductivity measurements of both surface water and groundwater. It was determined that differences in temperature and conductivity were good indicators of upwelling groundwater. The Trident probe was successful in identifying groundwater upwelling in a variety of substrate types, river velocities, and river depths. Additional tools that increased efficacy of groundwater delineations included sonar and underwater video camera surveys. During this demonstration, a number of surface water measurements obtained 0.3 m (1 ft) above the groundwater upwellings indicated little to no influence of groundwater in the surface water.

2.2.2.2 Phase II: Groundwater Plume Upwelling Delineation. As discussed in Section 2.3.1 of the work plan, river stage may be a key factor to determine nature and extent of groundwater discharges to the river. In general, favorable conditions will be present at sustained flows of 80 to 120 kcfs at Priest Rapids Dam. However, repeated field measurements of in situ conductance may be used to verify the range of suitable river stages for Phase II and Phase III activities. Once these favorable flow conditions (i.e., consistent groundwater discharges to the river) are met, pore-water screening activities for indicator contaminants will be completed at each of eight upwelling study areas (100-B/C Area, 100-K Area, 100-N Area, 100-D Area, 100-H Area, 100-F Area, Hanford townsite, and 300 Area).

- Phase II(a) Conductivity Mapping – Mapping of five transects is planned for each of the eight upwelling study areas (Figures 2-4 through 2-11 and Figure 2-14 of the SAP). Transects were selected based upon the 2007 aquifer tube sampling results provided in SGW-35028. These selections were reviewed and modified based on comments and suggestions from the Fluor Hanford Groundwater Project technical teams. Five additional transects have been located between reactor areas and south of the 300 Area to provide information outside of known plume areas (Figures 2-4 through 2-11 and Figure 2-14 of the SAP).

  Transects will start at the near shore (e.g., reactors areas) and continue across the entire river channel to the far shore. Depending on subsurface conditions and plume upwelling conditions encountered, it is anticipated that probe measurements will be taken at five locations per transect. Phase I findings have suggested that transects alone may not adequately characterize groundwater upwelling patterns influenced by preferential flow paths (e.g., river channeling, dredging). Consequently, 5 to 10 additional probe measurements will be taken near each transect to enhance delineation of groundwater upwellings. Locations of interest that have been initially identified include the following:

  – 100-N Area south of the apatite barrier but within the strontium-90 plume (Figure 2-6)

- 100-D Area adjacent to the effluent pipelines between the shore and D Island (Figure 2-7)
- 100-H Area between the shore and island #4 (Figure 2-8)
- South of the 300 Area between transects T-300-1 and T-300-2 (Figure 2-14).

Selection of these additional measurement points will consider factors such as elevated readings from other adjacent areas, bathymetry, presence of sediment accumulation areas, indications from sonar or underwater camera observations, or observed changes in geologic formations.

- Indicator Contaminants Screening (Phase IIb) – Approximately 20 to 30 samples of pore water will be collected at each of the eight upwelling study areas. Criteria to be used for selection of sampling locations include areas of high conductivity (>160 µS/cm), spatial distribution of data, and consideration of factors such as known or suspected areas of contamination (e.g., close to aquifer tube locations) and anticipated pore-water extraction rates. Final indicator contaminant screening locations and quantities are subject to approval by the Tri-Parties.

  The Trident probe will be deployed approximately 15 to 30 cm (6 to 12 in.) below the riverbed. Exceptions may occur in areas where hard-pan (e.g., Ringold Formation) is encountered. Pore water will be extracted using a peristaltic pump. The pump rate will depend on aquifer recharge conditions determined by continuous in situ monitoring of selected field parameters to assure minimal short-circuiting with surface water. Field measurements consisting of temperature and conductivity will be collected to verify that surface water has not been drawn down into the sampling port by pumping conditions (i.e., short-circuit). Images taken with an underwater camera will be used to document conditions found at the time of sampling. At each sampling location pore water will be collected for the indicator compounds listed below.

Groundwater Upwelling Areas	Indicator Compound	Analytical Method	Estimated Volume Requirements (mL)
100-B/C	Cr+6	Method 7196	500
100-K	Cr+6	Method 7196	500
100-N	Sr-90	α, β proportional counting	1000
100-D	Cr+6	Method 7196	500
100-H	Cr+6	Method 7196	500
100-F	Cr+6	Method 7196	500
Hanford townsite	Tritium	Liquid scintillation counting	125
300 Area	Volatile organic compounds, uranium	Method 8260 and 6010TR	540

Once pore-water results for indicator compounds, temperature, and conductivity are available, maps summarizing the results of the screening will be developed for each of the eight groundwater plume upwelling areas. These figures will also present the proposed locations for additional pore-water, sediment, and surface water sampling that are needed for plume characterization (Phase III below).

2.2.2.3 Phase III: Groundwater Plume Upwelling Characterization. Based on the results of the pore-water screening (Phase II[b]), pore-water sampling locations will be selected for groundwater plume upwelling characterization. One of the objectives of this phase is to select locations with the highest concentration of indicator contaminants. At a minimum, at least one location on each transect line in an area will be included. Images taken with an underwater camera will be used to document conditions found at the time of sampling. Pore-water, surface water, and sediment will be collected concurrently at each sample location to evaluate the potential impact upwelling groundwater plumes are having on these media. Sediment samples will be collected as described in Section 2.5 of the SAP. Pore-water, sediment, and surface water samples will be analyzed for the following analytical parameters:

- Pore-Water Analyses – As shown in Tables 2-2 through 2-6 of the SAP, all pore-water samples collected for groundwater plume upwelling characterization will be analyzed for metals (including uranium), Cr+6, and tritium. Pore-water samples collected in the 300 Area will also be analyzed for volatile organic compounds. Samples in the 100-B/C, 100-K, 100-N, 100-D, 100-H, and 100-F Areas will be analyzed for strontium-90. These results will be used to characterize groundwater plume upwellings into the river and to characterize potential biota exposure to bottom dwelling invertebrates.

- Sediment and Surface Water Analyses – Details regarding the sediment and surface water sampling and analysis are provided in Tables 2-2 through 2-6 of the SAP.

Final sample locations and quantities for plume upwelling characterization are subject to approval by the Tri-Parties.

2.2.3 Habitat Survey

Habitat survey will involve visual review of the site to assess the physical conditions at potential sampling locations and to verify the presence of key receptor species in support of the ecological risk assessment. As part of the survey, the presence or potential presence of proposed receptor species will be evaluated by both direct observation and literature review. Receptors of particular interest consist of aquatic plant and amphibians for which island terrain is of uncertain suitability.

In the Hanford Reach, the survey will be conducted by observing the shorelines and terrestrial portions of islands either by boat or by a physical review on land. The location of sediment samples included specifically for the evaluation of ecological receptors will be observed to ensure that samples are representative of the habitats used by proposed receptors. Downstream of the Hanford Reach, the visual review will focus on areas currently slated for shoreline sampling. Information from this survey will help to enhance the understanding of island and shoreline ecology, an understanding which is fundamental to assessing potential risks in the baseline ecological risk assessment.

2.3 RECOMMENDED SAMPLING DESIGN

The sample design for the RI investigation has been developed to be consistent with EPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988). The details of the development of sampling approach are described in Section 4.0 of the RI work plan, which includes a description and summary of data needs by sub-area. The sampling program was designed to meet the data needs identified for each sub-area. The various types of samples to be collected are defined in Table 2-1.

Table 2-1. Summary of Sample Types. (2 Pages)

Medium	Sample Type	Description	Use of Data
Groundwater plume upwelling (pore water, sediment/surface water)	Pore water	Pore water samples will be collected in situ 0 to 0.3 m (0 to 12 in.) below mudline.	• Characterize nature and extent of groundwater upwelling locations
	Surface water/sediment	Deep surface water and deep sediment samples collected in areas directly adjacent to known or suspected groundwater plume upwellings based on pore-water sampling results.	• Site characterization • Support ecological and human risk assessments
Sediment	Shallow sediment samples (i.e., submerged)	Sediments collected from the upper 10 cm (4 in.) of the sediment (e.g., generally submerged).	• Site characterization • Support human health risk assessment • Support ecological risk assessment
	Shoreline sediment samples	Sediment samples collected from the upper 10 cm (4 in.) of the lower riparian zone, typically the area devoid of terrestrial vegetation.	• Site characterization • Support human health risk assessment • Support ecological risk assessment
	Deep sediment samples	Sediment samples collected from the upper 10 cm (4 in.) of the sediment, in greater than 1.8 m (6 ft) of water.	• Site characterization • Support ecological risk assessment
Surface water	Surface water samples	Surface water samples collected at two-thirds the depth of the water column.	• Site characterization • Support human health risk assessment • Support ecological risk assessment
	Deep surface water samples	Surface water samples collected from directly above the riverbed.	• Site characterization • Support ecological risk assessment

Table 2-1. Summary of Sample Types. (2 Pages)

Medium	Sample Type	Description	Use of Data
Fish	Fish tissue	• Fillets (muscle and skin) • Liver and kidney combined • Sturgeon eggs, if available • Remaining carcass (bones and head)	• Support human health risk assessment and limited ecological assessment
Island soils	Island soils (e.g., generally above the high water line)	Island soils will be collected from the upper 15 cm (6 in.) of the riparian and upland zone. These samples are reworked sediments that are currently subaerial deposition.	• Site characterization • Support human health risk assessment • Support ecological risk assessment
Sediment cores	Shallow sediment cores	Cores completed using a vibracore drilling tool in sediment sequences that are generally thinner than 3 m (10 ft) thick.	• Site characterization • Support human health risk assessment • Support ecological risk assessment
	Deep sediment cores	Cores completed at water depths of up to 27 m (90 ft) with anticipated thick sediments sequences (greater than 3 m [10 ft] thick).	• Site characterization • Support ecological risk assessment (top 10 cm [4 in.] only)[a]

[a] Bonneville data to be used for characterization only (e.g., not for ecological or human health risk).

The final proposed sampling design is presented by sub-area in Tables 2-2 through 2-6. Because of their size, these tables are included in a separate section located at the end of this SAP. These tables summarize the results of the sample design process by sub-area and for each sample or sample group, describe the proposed media to be collected, the sample collection method, the number of samples to be collected, the analyses by method, the intended end use of the data, and the rationale for including the sample(s) in the design. The following is a short description of the information presented in Tables 2-2 though 2-6, working from the left hand side of the table to the right.

Figure Number – The associated figure from the SAP is presented in this column. These figures present all proposed sampling locations along the river.

Designation – This column indicates whether the sample location was selected to evaluate a reactor area, recreational area, other contributing influence, or other area of interest.

Sample Type – This column describes the medium and sample media type for each proposed sample. These are described in Table 2-1.

NOTE: See the "Sampling and Analysis Plan Figures and Tables" section located at the end of this SAP for the following tables:

Table 2-2. Proposed Sampling and Analytical Plan for the Upriver Sub-Area.
Table 2-3. Proposed Sampling and Analytical Plan for the 100 Area Sub-Area.
Table 2-4. Proposed Sampling and Analytical Plan for the 300 Area Sub-Area.
Table 2-5. Proposed Sampling and Analytical Plan for Lake Wallula Sub-Area.
Table 2-6. Proposed Sampling and Analytical Plan for Bonneville Dam Pool Sub-Area.

Collection Method – This column lists the methods or tools that will be used to collect the sample. Additional information regarding sample collection is provided in Section 2.5 of this SAP.

Sampling Location – This column contains a brief description of the sampling location.

Temporary Sample Identification – Each sample has been assigned a temporary sample identification to facilitate discussion and identification in tables and figures. These identifications will be amended to match Hanford Site protocol once the SAP has been finalized.

Sample Design – This column summaries the sample design requirements for each sample. These consist of focused, stratified/random, or multi-incremental sampling. These were identified to support the end use of the data (refer to Section 4.1.1.3 of the RI work plan).

Sample Depth – This column presents the proposed depth below the surface for each sample.

Number of Samples by Media – This column presents the number of samples proposed for each sample type.

Analyses – These columns depict how many samples, by sample type, will be analyzed for the given analytical class.

End Use – This column presents a summary by medium of the intended end use of the data to be collected. Data may be used for site characterization, in support of the human health risk assessment and/or in support of the ecological risk assessment.

Rationale – This column presents, by medium, a brief rationale for the location and number of samples.

Figure 2-1 provides an overview of the Study Area. Figures 2-2 through 2-20 show the proposed sampling locations for sediment, surface water, fish, and soil for the RI. In addition to the proposed sampling locations, Figures 2-2 through 2-20 provide a summary of the bathymetric data collected within the Study Area. Figures 2-2 through 2-20 are included in a separate section located at the end of this SAP. As shown in these figures, the river bathymetry is divided into deep water, shallow water, and riparian areas. These areas are defined based on river level along the Hanford Reach as modeled using Modular Aquatic Simulation System 1 (PNNL-15226). This modeling was only completed above river mile (RM) 339 (Nelson Island). This is a one-dimensional, unsteady river flow model that is based on U.S. Army Corps of Engineers (ACOE) bathymetric data at transects spaced approximately 0.4 km (0.25 mi) apart along the Hanford Reach. The input flows were measured at Priest Rapids Dam, Ice Harbor Dam, Yakima River, and Walla Walla River locations, and were then compared to the surface water elevations at McNary Dam. The model calculates time-specified discharge and water surface elevation at ACOE bathymetric transects. The bathymetric details in Figures 2-2 through 2-20 include the following:

- **Deep Water** – Based on this modeling and the Scanning Hydrographic Operational Airborne Lidar Survey, areas that are greater than 6 m (20 ft) below a surface water elevation at approximately 80 kcfs at Priest Rapids Dam are shown in dark blue on the figures (approximated through modeling).

- **Shallow Water** – Shallow water or nonriparian areas are shown in a medium shade of blue on the figures. These areas were modeled as less than 6 m (20 ft) deep below a surface water elevation at 80 kcfs at Priest Rapids Dam.

- **Riparian Areas** – Riparian areas are shown as light green zones on the figures. These boundaries of these areas were estimated through modeling at flows between 80 and 240 kcfs at Priest Rapids Dam.

- **Inundated Areas** – Areas that might have been inundated when flows from Priest Rapids Dam were discharging at 400 kcfs were estimated through modeling and are shown as light pink zones on the figures.

- **Fine-Grained Sediments** – Areas of fine-grained sediments (i.e., <2 mm) were initially identified based on prior investigations including the river flow modeling and direct observation over many years of sampling by Pacific Northwest National Laboratory and Environmental Assessment Services field staff. Areas of fine-grained sediments are shown in orange on the figures.

The five sub-areas (Figure 2-1) will be used to segregate the data set to facilitate the baseline human health risk assessment. The human health risk will be calculated for each sub-area, with the exception of the Bonneville Dam pool (see below).

- **Upriver Sub-Area** (RM 420 to RM 388) – This includes the stretch of river between Vernita Bridge upstream to behind Wanapum Dam to characterize other contributing influences (i.e., non-Hanford Site). The proposed sampling and analytical plan for the Upriver Sub-Area is summarized in Table 2-2. Figures 2-2 and 2-3 depict the proposed sampling locations for the Upriver Sub-Area.

- **100 Area Sub-Area** (RM 388 to RM 365) – This includes the reach between Vernita Bridge downstream to upriver of the Hanford townsite, including the reactor areas (each of the reactor areas within the 100 Area of the Hanford Site: 100-B/C, 100-K, 100-N, 100-D, 100-H, and 100-F). The sampling design for this area includes samples intended to characterize the left shore of the river, depositional areas near the islands, the reactor areas, and other contributing influences (e.g., wasteways/irrigation returns) that are not attributable to Hanford Site hazardous substance releases, but are geographically located within this stretch of river. The proposed sampling and analytical plan for the 100 Area Sub-Area is summarized in Table 2-3. Figures 2-4 through 2-9 depict the proposed sampling locations for the 100 Area Sub-Area.

- **300 Area Sub-Area** (RM 365 to RM 339) – This includes the Hanford townsite area and the 300 Area, as well as samples intended to characterize other contributing influences (e.g., wasteways/irrigation returns) that are not attributable to Hanford Site hazardous substance releases, but are geographically located within this stretch of river. The proposed sampling and analytical plan for the 300 Area Sub-Area is summarized in Table 2-4. Figures 2-10 through 2-15 depict the proposed sampling locations for the 300 Area Sub-Area.

- **Lake Wallula Sub-Area** (RM 339 to RM 292) – This includes recreational areas and wildlife management areas downstream of the Hanford Site. This river section also includes the major river confluences (e.g., Yakima, Snake, and Walla Walla). Samples from these major river confluences will be used to characterize other contributing influences. The proposed sampling and analytical plan for the Lake Wallula Sub-Area is summarized in Table 2-5. Figures 2-16 through 2-19 depict the proposed sampling locations for the Lake Wallula Sub-Area.

- **Bonneville Dam Pool Sub-Area** (RM 150 to RM 144) – This includes a limited area directly adjacent to two existing sediment cores collected in 1976. These data will be used for site characterization. Risk calculations will not be conducted for the Bonneville Dam pool at this time. The purpose of the core samples at Bonneville Dam pool is to complete the site characterization regarding historic discharges from the Hanford Site. It is anticipated that Hanford Site contaminants, if present, will be below several feet of "clean sediment" and where there is no direct contact. Therefore, they are not a current risk to humans or biota. The proposed sampling and analysis plan for the Bonneville Dam Pool Sub-Area is summarized in Table 2-6. Figure 2-20 depicts the proposed sampling locations for the Bonneville Dam Pool Sub-Area.

2.4 SAMPLING PROCEDURES

The following provides a summary of the procedure and methods that will be used to collect representative surface water, sediment, and fish samples from the Study Area. The various types of samples to be collected are described by medium in Table 2-1. Analytical parameters specific to each sample, or group of samples, are listed in Tables 2-2 through 2-6. A summary list of the analytical methods that may be used for each medium is presented in Table 2-7.

2.4.1 Pore-Water Sampling

As discussed in Section 2.2.2, in groundwater plume upwelling areas additional pore-water samples will be collected once the plume upwelling reconnaissance survey has been completed and the final design has been approved by the Tri-Parties. The pore-water samples will be collected using a Trident probe, as described in Section 2.2.2. Analytical parameters specific to each pore-water sample are listed in Tables 2-2 through 2-6 and Table 2-7.

Table 2-7. Summary of Analytical Methods by Medium.

Analytical Parameter	EPA Method	Surface Water	Sediment	Pore Water	Soil	Fish
VOCs	8260B	X	X	X	--	--
SVOCs	8270C	X	X	--	X	--
Metals	6010/6020/7471	X	X	X	X	X[a]
Hexavalent chromium (Cr^{+6})	7196A	X	X	X	X	--
Pesticides	8081	X	X	--	X	X
PCBs	8082	X	X	--	X	--
PCB congeners	1668A	X[b]	X[b]	--	--	X
TOC	9060	--	X	--	X	--
Grain size	ASTM D-422	--	X	--	X	--
PHC	8115	X	X	--	X	--
AVS/SEM	200.8	--	X	--	--	--
Nitrate	300.0	X	--	X	--	--
Radionuclides	GEA/AEA/LCS	X	X	X	X	X
Hardness	130.1	X	--	--	--	--
DOC	415.1	X	--	--	--	--
Alkalinity	310.1	X	--	--	--	--
% Lipids	Bligh-Dyer (1959)	--	--	--	--	X
Field parameters[c]	Field instruments	X	--	X	--	--

Note: Analyses will be sample-specific as shown in Tables 2-2 through 2-6; not all samples will be analyzed by all methods in this table.

[a] Fish samples will be analyzed for inorganic and organic arsenic and total mercury.
[b] Every 10th surface water and sediment sample analyzed for PCB Aroclors by 8082 will also be analyzed for PCB congeners.
[c] Field parameters for surface water samples are measured in the field and consist of temperature, specific conductivity, dissolved oxygen, and pH. Field parameters for pore water consist of temperature and conductivity.

AEA = alpha energy analysis
AVS/SEM = acid volatile sulfides/simultaneously extracted metals
DOC = dissolved organic carbon
GEA = gamma energy analysis
LCS = liquid scintillation counting
PCB = polychlorinated biphenyl
PHC = petroleum hydrocarbon
SVOC = semivolatile organic compounds by EPA Method 8270C
TOC = total organic carbon
VOC = volatile organic compound

2.4.2 Surface Water Sampling

The purpose of surface water sampling is to estimate the concentrations of contaminants in surface water for site characterization. Surface water sampling has been divided up into three subcategories:

- Groundwater plume upwelling areas
- Surface water
- Deep surface water.

Unfiltered surface water samples will be collected to evaluate the nature and extent of Hanford Site hazardous substance releases to the Columbia River. These results will be used to support both human health and ecological risk assessments. Human health exposure pathways will include a drinking water pathway and, under the casual recreational user scenario, incidental ingestion and dermal exposure. For the ecological assessment, surface water results will be used to evaluate exposure to aquatic and terrestrial biota. A summary of the analytical methods for surface water is presented in Table 2-7. Analytical parameters specific to each surface water sample are listed in Tables 2-2 through 2-6.

Groundwater Plume Upwelling Areas – Once areas of groundwater plume upwelling have been identified (see Section 2.2.2) and the proposed sampling location approved by the Tri-Parties, surface water samples will be collected adjacent to the pore-water sampling locations to evaluate the potential impact upwelling groundwater plumes are having on these media. These samples will be collected directly above the riverbed (e.g., less than 0.3 m [1 ft] above sediment) using tubing and a pump. Analytical parameters specific to each surface water (groundwater upwelling) sample are listed in Tables 2-2 through 2-6.

Surface Water Samples – The majority of surface water samples will be collected at two-thirds the depth of the water. The water depth will be measured using a tape measure or single-beam depth meter. The sampling equipment will be lowered to the required depth and the required volume will be collected. The samples may be collected directly into sample containers by holding the sample containers at the correct depth and simply opening. During collection the following field parameters will be measured: temperature, pH, conductivity, and dissolved oxygen. Analytical parameters specific to each surface water sample are listed in Tables 2-2 through 2-6. Both filtered and unfiltered samples will be collected for metals analysis.

Surface water samples collected to characterize contributing influences from wasteways will be collected from the river directly at or below the confluence.

Deep Surface Water Samples – To assess potential exposures of aquatic biota, a limited number of "deep" surface water samples will be collected from deep river trenches and near the bottom of Lake Wallula. These samples will be collected directly above the riverbed (e.g., less than 0.3 m [1 ft] above sediment) as described above. During collection the following field parameters will be measured: temperature, pH, conductivity, and dissolved oxygen. Analytical parameters specific to each deep surface water sample are listed in Tables 2-2 through 2-6. Both filtered and unfiltered samples will be collected for metals analysis.

2.4.3 Sediment Sampling

The purpose of sediment sampling is to estimate the concentrations of contaminants in sediment for site characterization. The following describes the six subcategories of sediment samples depicted in Figure 2-21:

- Shallow sediments
- Deep sediments
- Shoreline sediments
- Island soils
- Shallow cores
- Deep cores.

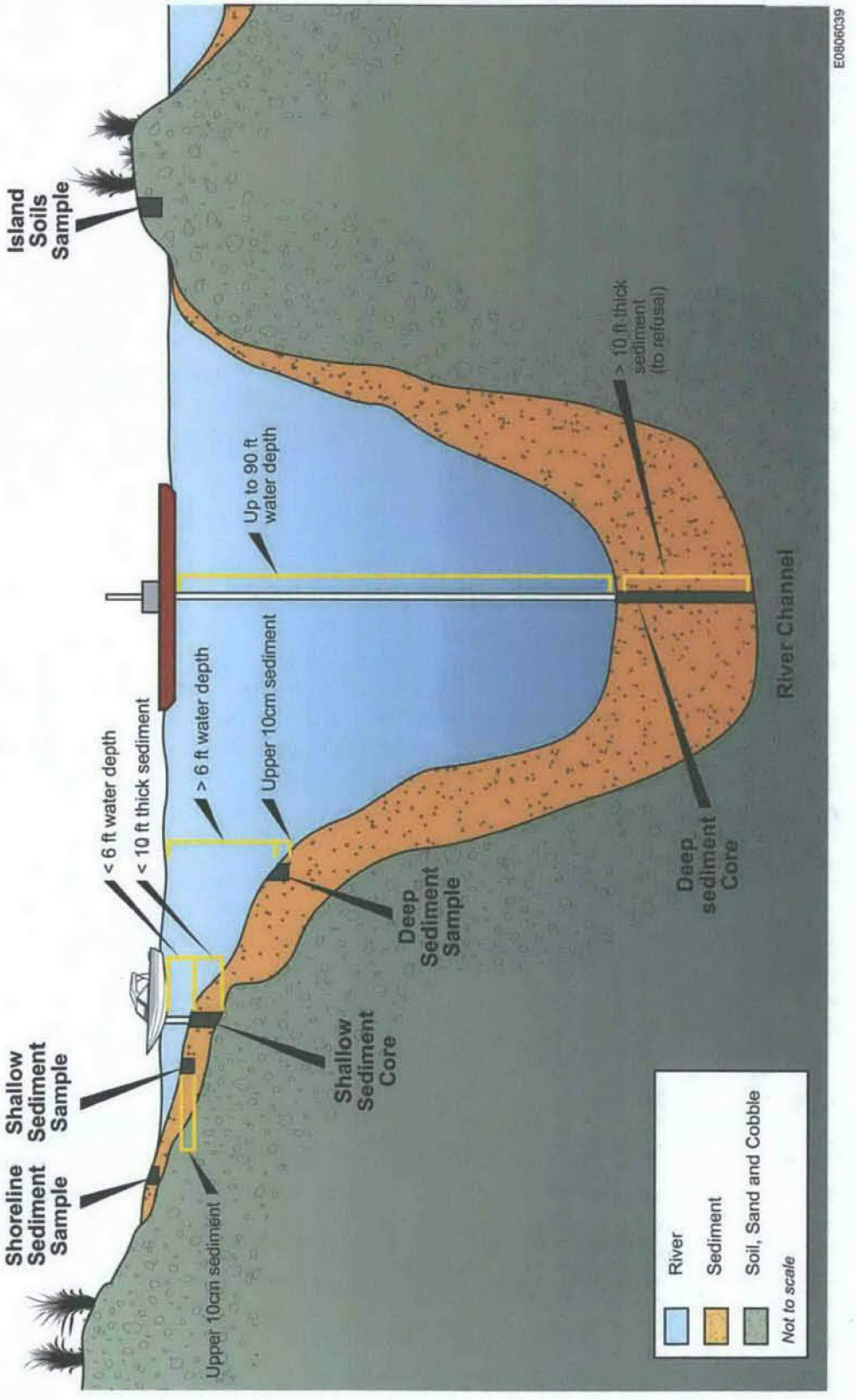
Contaminant concentrations in sediment are data that are commonly collected to support environmental risk (Menzie 1997) and human health risk assessments. As described in previous studies, relative to other substrate classes, fine-grained sediment has the highest surface area. This high surface area allows for more contaminants to adsorb on to the fine particles relative to sands, which have a smaller surface area for a given mass (Reneau et al. 2004). It should be noted that fine sediments (e.g., ≤ 2 mm) represent a relatively small proportion of the riverine habitat. In addition, there is some uncertainty associated with the use of risk-based soil standards (such as the Model Toxics Control Act soil cleanup levels) for screening sediments.

These standards are protective of unrestrictive (e.g., residential) exposures to soil, whereas the types of activities associated with sediment exposure are anticipated to be of lesser frequency and intensity than those associated with soil. Therefore, the soil screening standards are a conservative means of screening sediment data and may overestimate potential risk.

A summary of the analytical methods for sediment is presented in Table 2-7. Analytical parameters specific to each sediment sample are listed in Tables 2-2 through 2-6.

Shallow Sediments – Shallow sediments describe samples that are collected from the top of the riverbed and will be collected from the upper 10 cm (4 in.) of the sediment below the mean low waterline (e.g., generally submerged). This upper region of the sediment is the most biologically active zone and where humans are most likely to come in contact with sediments and therefore will be the focus of this investigation. Prior to sampling, a reconnaissance survey will be conducted using a single-beam sonar (i.e., depth sounder) to identify fine-grained sediments within the area of interest. Grab samples will be collected to confirm the presence of fine-grained sediment. The samples will be single grab samples collected using a petite ponar sampling tool. For those samples designated as "random/stratified" in Tables 2-2 through 2-6, once the extent of fine-grained sediments has been identified, an unaligned sampling grid will be established using the systematic sampling approach.

Figure 2-21. Categories of Sediment Samples.



Sediment samples collected to characterize other contributing influences from wasteways will be collected from the river directly at or below the confluence.

Groundwater Plume Upwelling Sediments – As discussed in Section 2.2.2, in groundwater plume upwelling areas sediment samples will be collected once the plume upwelling reconnaissance survey has been completed. These samples will be collected concurrently with pore-water and surface water sampling using a ponar sampling tool.

Deep Sediments – Deep sediment samples are those that are collected in greater than 1.8 m (6 ft) of water. Prior to sampling, a reconnaissance survey will be conducted using a single-beam sonar to identify fine-grained sediments within the area of interest, and grab samples will be collected to confirm the presence of fine-grained sediment. The samples will be single grab samples collected using a petite ponar sampling tool. Based on a preliminary study conducted by Environmental Assessment Services in March 2008, the petite ponar generally penetrates to a depth of 10 cm (4 in.) (see Appendix B of the RI work plan). Deep sediment results will be used primarily in the assessment of ecological exposure.

However, several deep sediment samples will also be collected from navigational channels where dredging is planned or has occurred in the past. These samples will be used to assess potential exposure to humans. Analytical results will be compared to both state and federal residential soil screening criteria.

Shoreline Sediments – Shoreline sediments will be collected from the lower riparian zone, typically the area devoid of terrestrial vegetation. As previously discussed, an unaligned sampling grid will be established using the systematic sampling approach previously described. These samples will be collected with a stainless steel spoon in accordance with ENV-1, *Environmental Monitoring & Management,* ENV-1-2.16, "Soil and Sediment Sampling." Shoreline sediments collected from the downriver recreational sites in Lake Wallula will be collected by multi-incremental sampling (MIS) to quantify specific exposure point concentrations for shoreline sediments. These samples will be used to assess potential exposure to ecological and human receptors. MIS consists of collecting and homogenizing 50 random sample increments over a prescribed decision area. In this case, individual recreational areas are the decision areas. Non-VOC samples are sieved to further reduce compositional heterogeneity. At each MIS location, random samples will be collected from a grid sized proportionally to the area to be sampled. These sampling plans will be developed based on the fine-grained sediment survey and habitat reconnaissance.

Each investigation area will be evaluated by collecting five multi-incremental samples (e.g., 5-by-50). The 95% upper confidence limit of the mean concentration will be evaluated by collecting five multi-incremental samples from all of the recreational sites. To further reduce error caused by soil heterogeneity, sub-sampling of each multi-incremental soil sample will be performed in the laboratory to obtain the final analytical soil sample.

Island Soils – Island soils will be collected from the riparian zone and above. These soils are distinctly different in origin and composition from the upland soils sampled in the 100/300 Area investigation. Island soils are reworked sediments that currently reside above the ordinary low

water line. These samples will be collected in a similar manner to the shoreline sediment samples (see above). For purposes of the human health and ecological risk assessments these samples will be treated as soils in these assessments. However, analytical results will be compared to upriver sediments to distinguish Hanford Site hazardous substance releases from upriver contributions.

Shallow Sediment Cores – The purpose of shallow sediment core is to evaluate the occurrence and concentrations of Hanford Site-related contaminants (e.g., radionuclides) in sediment depositional areas (e.g., sediment traps). Shallow sediment cores will be completed using a vibracore drilling tool that will result in continuous 0.6-cm (2-in.)-diameter cores. This tool can typically penetrate fine-grained sediments up to 3 m (10 ft) thick with a 80% to 90% recovery success. These cores will be advanced through the unconsolidated sediments to refusal. Shallow sediment cores will be divided into separate sub-samples (approximately 0.3 m [1 ft] each). Each linear foot of sample will result in approximately 600 g of sample. Analytical parameters specific to each core sample are listed in Tables 2-2 through 2-6. If additional mass is need for the shallow interval (0 to 0.3 m), a second shallow core will be completed to obtain sufficient mass. Analytical results from the sediment cores will be used to characterize sediments deposited from reactor operations to the present.

Shallow cores are planned to investigate depositional areas located within the source areas (e.g., water inlet structures), at the head of Lake Wallula (e.g., directly upriver of the 300 Area), from the Yakima River delta, and directly downriver of the Snake River confluence. It is anticipated that these cores will be completed at a water depth of up to 9 m (30 ft). Core locations have been selected in areas of anticipated relatively thick sediment sequences that may contain sediments dating back to operational time frames. Because the biologically active zone is limited to the upper 10 cm, the results from the 0- to 0.3- m sub-sample will also be used during the ecological and human health risk evaluation. Ten centimeters deep into the matrix substrate generally corresponds to a depth below the surface of the riverbed between 20 cm and 50 cm depending on the size of the dominant unconsolidated substrate.

Deep Sediment Cores – Deep sediment cores will be completed using a drill rig located on a barge or a vibracore drilling tool. These cores are planned to investigate depositional areas located within Lake Wallula and from within the Bonneville Dam pool as well as an upstream location in the backwaters of Priest Rapid Dam. It is anticipated that these cores will be completed at a water depth of up to 27 m (90 ft). Deep sediment cores will be completed using a drilling rig or vibracore tool that will result in continuous 10-cm (4-in.)-diameter cores. This tool can typically penetrate fine-grained sediments to refusal with a 80% to 90% recovery success. Deep sediment cores will be divided into separate sub-samples (approximately 0.2 m [8 in.] each). Each linear foot of sample will result in approximately 2,400 g of sample. Analytical parameters specific to each deep core sample are listed in Tables 2-2 through 2-6. Analytical results from the sediment cores will be used to characterize sediments deposited from reactor operations to the present. Because the biologically active zone is limited to the upper 10 cm, the results from the 0- to 0.2-m sub-sample will also be used during the ecological risk evaluation.

2.4.4 Fish Sampling

2.4.4.1 Sample Locations. The collection of specimens may take place at any location within each sub-area. However, because the primary objective of the project is to obtain data to perform a human health risk assessment, sampling efforts will focus on popular recreational fishing spots that receive high use from the local population. These recreational fishing spots are harvest areas that will provide the most representative samples from which to calculate risk. These areas have been identified through discussions with local fishermen and are presented in Figures 2-2 through 2-17 of this SAP. Table 2-8 provides a summary of these recreational fishing areas. Specific recreational fishing areas were not identified for suckers. Collection efforts within each study area will focus on areas of the river with fast-moving water, which is a preferred habitat for these fish. In the event that sample collection at the popular fishing spots is unsuccessful, sampling efforts will shift to other areas within the study area, with special attention given to preferred habitats for each species of fish. The preferred habitat for each of the target species is summarized in Table 4-16 of the RI work plan. The latitude and longitude of each sample point will be saved using a global positioning system to accurately define the locations from which specimens were obtained.

Table 2-8. Recreational Fishing Areas.

Study Area	Fishing Spot	Figure Number
Upriver Sub-Area	Wanapum Pool	2-2
	Priest Rapids Dam Pool	2-2, 2-3
100 Area Sub-Area	100BC Hole	2-4
	100K Hole	2-4, 2-5
	100N Hole	2-6
	100D Hole	2-7
	WB Hole	2-7, 2-8
	WB Hole 2	2-8
300 Area Sub-Area	HTS Hole 1	2-10
	HTS Hole 2	2-11
	Ringold	2-11, 2-12
	Taylor Flats	2-13
	300A Hole 1	2-14
	300A Hole 2	2-14
Lake Wallula Sub-Area	YR Delta	2-16
	Finley Slough	2-17
	Burbank Slough	2-17
	Wallula Gap	2-17

The most effective methods will be used to capture specimens of each species submitted for tissue analysis. Methods that will be used to collect the fish samples include but may not be limited to the following:

- Electrofishing
- Hook and line
- Long-lines.

Electrofishing involves the transmission of an electrical current through the water, creating a high voltage potential. If a fish is in the vicinity of this potential, it becomes temporarily stunned through uncontrolled muscular contractions that cause it to be immobilized so that it can be captured with a net. A minimum of two sampling crew members are needed to net the fish stunned from the electrical current delivered by the generator or backpack unit. Electrofishing may be conducted from the shore using a backpack unit or from a boat equipped with a generator. The advantage using this method is that, in most cases, nontarget species of fish which are unintentionally captured can be released without harm back to the river. The efficiency of electrofishing is dependent on water depth and the conductivity of the water. The technique is most effective in shallow waters of high conductivity. The target species for which this collection method is expected to be most successful are whitefish, carp, and suckers.

Hook and line is a method most often used by recreational fishermen to catch fish and has been adopted by biologists as a means to assess fish populations. This method is expected to be implemented in deeper areas of the river where electrofishing is less effective or in areas that might have been missed using other techniques. Baited hooks or lures will be deployed in areas selected for fish sampling. Baited hooks may be allowed to rest on bottom to allow the target species of fish more opportunity to detect the bait. Hook-and-line methods are expected to be an especially effective means for collecting walleye, whitefish, and sturgeon.

Setlines with baited hooks may be used to capture white sturgeon. This method provides the greatest catch-rate of white sturgeon, while minimizing captures of non-target species. A long line configuration will be used. Hooks (with barbs) will be attached at specified intervals. Rocker anchors with float lines will be attached at both ends of the line and clipped weights will be attached at several points along the ground line to ensure that it will rest near the bottom. Hook lines will have a swivel snap and a ganging line tied between the swivel and the hook. Setline hooks will be baited with commercially available pickled squid. This is the same bait that has been used in recent years by the Washington Department of Fish and Wildlife to capture white sturgeon in other areas of the Columbia River. Setlines will be deployed from a boat and set either parallel to the shore in fast flowing water areas or perpendicular to the shore in calm water. Prior to each set, water depth will be determined by echo sounder, and this information will be used to select a float line of appropriate length. Crews will attach an anchor and float line to one end of the mainline.

Only the target species will be retained for tissue analyses. Nontarget species that are incidentally captured will be immediately released back at sample location from which they were taken.

In order to support ecological risk assessment, physical factors of each fish caught will be measured and recorded to the extent practical. Such factors include the following:

- Length
- Weight
- Sex
- Presence/absence of eggs
- Color of fatty tissue in sturgeon
- Presence, location, and type of lesions or other abnormalities.

Figure 2-22 is an example of a form that will be used to document fish collection.

2.4.4.2 Target Species. Specimens of white sturgeon (*Acipenser transmonatnus*), common carp (*Cyprinus carpio*), mountain whitefish (*Prosopium williamsoni*), walleye (*Stizostedion vitreum),* smallmouth bass (*Micropterus dolomieui*), and either largescale sucker (*Catostomus macocheilus*) or bridgelip sucker (*Catostomus columbianus*)[3] will be selected for collection because these species are year-round resident fish with a high rate of harvest and consumption among the local population. Table 2-9 lists the target fish and includes the target size of the fish and number of samples to be collected.

2.4.4.3 Sample Number. Five fish samples of each species are proposed for collection from each specified sub-area. Each fish sample (except for sturgeon) will consist of a composite sample composed of at least five individual fish (see Table 2-9). Additional fish may be included in the composite if necessary to meet the required mass for chemical analysis. If more fish than necessary are collected, then the large specimens will be used for the sample. The number of fish to be collected is based on professional judgment, and considers both the end use of the data as well as the sensitivity of local fisheries; this number is also consistent with EPA fish sampling guidance (EPA 2000d) and the Environmental Surveillance program, which typically collects five fish per area of interest (PNNL-15892, PNNL-16623).

Individual fish for a composite sample will be of similar size, and the smallest individual in a composite will be no less than 75% of the total length/size of the largest individual in the same composite. EPA guidance (EPA 2000d) suggests that the relative difference between the average length of individuals within any composite sample and the average length of all individuals in all composite samples should not exceed 10%.

Because of their large size and lower population numbers, sturgeon samples will not be composites; each sample will be collected entirely from a single fish.

[3] Species collected will be dependent upon availability/ease of collection.

Figure 2-22. Example of Fish Tissue Collection Form.

Fish Tissue Collection Form					
Species:		*Sample No:*		*Specimen No:*	
Lab Information:					
Analysis Type:	Fillets Organs Carcass	**Requested Analyses:**	PCBs, Pesticides, Radionuclides, Metals, Mercury, %Lipids	**Sample Date:**	___/___/200__
Site Information					
Site ID:		**Sub-Area:** _____		**Lat:**_____	**Long:**_____
Sample ID	_____		**Sample type:** Standard or Duplicate	**Collection Method:** Electrofishing Hook and Line Seine Net Longline	**Sample Time:**
Collector Information					
Collector Name:			**Affiliation:**		
Address:					
Sample Information					
Fish species:			**Species Code:**		
Length (cm)	**Weight (g)**	**Sex (M or F)**	**General Condition:**		
Organs/Carcass/Eggs					
	Weight (g)	**General Condition/Notes:**			
Total muscle					
Fillet sample					
Kidney & liver					
Discarded gut					
Carcass					
Eggs					
Stomach contents (Sturgeon only)					
Flag	*Comments*				
Chain of Custody					
USEPA project Manager (name, address, phone#):					
Relinquished by (signature):		**Date:**		**Time:**	
Received by (sign and agency):		**Date:**		**Time:**	

Table 2-9. Summary of Target Fish Sample Sizes/Numbers.

	Carp	Sturgeon	Suckers[a]	Whitefish	Walleye	Bass
Target size	>18 in.	48 – 60 in.	>12 in.	>10 in.	> 18 in.	≤14 in.
Number of composite samples per sub-area	5	--	5	5	5	5
Anticipated number of individuals per composite	5	Composite not collected	5	5	5	5
Number of noncomposite per sub-area	--	5	--	--	--	--
Anticipated number of individuals for entire study	100	20	100	100	100	100
Total number of samples for entire study	20	20	20	20	20	20

[a] Either largescale sucker or bridgelip sucker may be collected.

2.4.4.4 Tissue Collection. The following fish tissues will be collected and analyzed separately on all fish samples:

- Fillets (muscle and skin)
- Liver and kidney combined
- Eggs, if available
- Carcass (skin, bones, and head).

For all fish except sturgeon, tissue samples will consist of composites of tissue from five separate fish. As noted previously, sturgeon samples will not be composited; all tissue types will be obtained from a single fish.

Muscle tissue analysis will be conducted on fillets with skin attached. Two fillets will be collected from each of the specimens (one from each side of the fish, from the approximate middle of the body) and submitted for analyses. This fillet area corresponds to the portion of the fish most commonly removed by fishermen and consumed by the public. Except for sturgeon, these fillets will include the skin and the dark tissue adjacent to the skin; this dark tissue consists of fat in which organic contaminants such as polychlorinated biphenyls (PCBs) and pesticides may potentially be concentrated. Dark meat will be included in the fillet sample and homogenized with the rest of the muscle tissue during laboratory processing. The skin will not be included in sturgeon samples, since the skin is typically not consumed; however, sturgeon skin will be included and analyzed with the rest of the fish carcass.

The liver and kidneys will be combined and packaged separately for shipment to the laboratory. The combined liver and kidney samples will be analyzed separately from fillet and carcass samples. Other organ tissue that remains after the kidney and liver are removed will not be analyzed, but will be weighed prior to disposal. The remaining carcass will also be analyzed. The carcass will include the head, bones, skin, and fins.

Eggs, if present, will be removed, weighted, and submitted for separate analysis. The number of fish with eggs included in the sample will be recorded, as will the field identifier of the specific fish from which the eggs were removed.

After the fillets, liver, and kidneys (and eggs, if present) have been removed from the specimens, the remaining carcasses of the fish samples will individually wrapped after processing and shipped to the laboratory for chemical and radiological analysis. The sturgeon has a cartilaginous skeleton rather than a bony one, but the carcass will be analyzed in the same manner.

As part of the sample collection process, the weight of each of the tissue types will be measured. These sample weights can be combined with sample results to obtain the total concentration of contaminants for the whole fish.

For sturgeon only, stomach contents, if present in large quantities, may be collected and analyzed. Anecdotal evidence indicates that some sturgeon will accumulate large quantities of sediment or mussels during feeding, to an extent that the bellies of such individuals may be distended with such material. If such an individual is caught in the course of sturgeon collection, the stomach contents will be collected and submitted for analysis as an additional sample. This sampling will be conducted opportunistically, as such fish are encountered; no additional sampling will be conducted to obtain these specimens. Sturgeon stomach contents, if collected, will be analyzed for radionuclides only.

Finally, the otoliths from each sturgeon will be removed and saved in order to be used later to determine sturgeon age.

2.4.4.5 Regulatory Considerations. All fish collection activities will be in accordance with state, federal, and/or tribal laws. Prior to the commencement of sampling activities, all of the associated permits and/or licenses will be obtained from the respective regulatory agencies to collect fish samples using the previously described methods to harvest and possess the target species.

The project goal is to harvest five fish samples of each target species in all four of the sub-areas. In the event that the fishing is unsuccessful for a particular size or species of fish using the collection techniques described previously, sampling efforts will be redirected to other locations within the sub-area. Other fish collection techniques such as trap nets may be deployed to reach project collection goals.

2.4.4.6 Sample Processing. Specimens selected for tissue analysis will be euthanized following American Veterinary Medical Association (AVMA1986) approved techniques,

bagged (individually), labeled, and kept on ice until taken to the sample processing and shipment location. A specimen number will be assigned to each individual fish collected for tissue analysis. The specimen number will be used to uniquely identify each individual. Other information such as collection method, global positing system coordinates of the sample collection location, species, and date of collection will be recorded in the field notebook.

Fish samples will be processed and prepared for shipment to the analytical laboratory following *Comprehensive Environmental Response Compensation and Liability Act of 1980* (CERCLA)/*Resource Conservation and Recovery Act of 1976* (RCRA) and Washington Closure Hanford (WCH) guidelines. Initial sample processing activities will include determination of the individual's weight, length, sex, and specimen's general condition. Fillets will be cut and separated from the fish. The organs will also be removed and separated from the remaining carcass. Separate analyses will be performed on the fillets, organs, and carcass of the fish. The concentrations of the three will be summed to obtain whole fish concentrations for each target analyte.

Each fish sample will be individually bagged and labeled. The sample label will include information such as sub-area from which the sample was collected, species, specimen number, sample date, collector, and associated collection permit.

2.4.4.7 Sample Shipping. All samples will be frozen prior to shipment to the analytical laboratory. A large cooler will be used as a shipping container for the specimens. Ice will be added to the cooler to ensure that the specimens remain frozen. A chain-of-custody form that contains all of the sample identification numbers, collection dates, and requested analyses shall accompany the samples during shipment to the laboratory.

2.4.4.8 Analytical Schedule/Methods. Analyses of fish fillets, organs, and the carcasses will be conducted at an off-site laboratory in accordance with the analytical methods proposed for the fish sampling provided in Table 2-7.

The laboratory will provide detection limits prior to sample collection to ensure that they are consistent with the DQOs associated with performing the human health risk assessment. Detection limits associated with the individual analytes for each of the chemical parameters above are provided in Section 3.0 of this SAP.

2.4.5 Contingencies

Preparation for contingency sampling is necessary in the event that planned scheduling or collection activities are not met. For example, limited sediment recovery from a deep core sample may result in insufficient sample mass for all proposed analyses. If insufficient mass is obtained for a particular sample, the field team leader may continue sampling until sufficient sample mass is obtained, if possible. If sufficient mass of sediment, soil, or fish cannot be obtained in a reasonable time, the analytes will be analyzed in the following general priority order: metals and radionuclides, then PCBs and pesticides.

2.5 SAMPLING AND ONSITE ENVIRONMENTAL MEASUREMENT PROCEDURES

Procedures for field measurements are specified in the manufacturer's manuals. The sampling and onsite environmental measurement procedures to be implemented in the field will be consistent with protocols developed.

2.6 SAMPLE MANAGEMENT

Sample management activities will be consistent with established procedures. Any laboratory performing work will be compliant with *Hanford Analytical Services Quality Assurance Requirements Document* (HASQARD), Section 4.2, "Management of Samples" (DOE/RL-96-68), which complies with SW-846 requirements.

2.7 MANAGEMENT OF INVESTIGATION-DERIVED WASTE

Waste generated by sampling activities will be managed in accordance with a waste control plan that will be prepared and approved by Ecology and EPA before field work is initiated. The waste control plan will be written in accordance with the *Environmental Restoration Program Strategy for Management of Investigation Derived Waste* (Ecology et al. 1999).

3.0 QUALITY ASSURANCE PROJECT PLAN

3.1 INTRODUCTION

This quality assurance project plan (QAPP) establishes the quality requirements for sampling and was prepared in accordance with *EPA Requirements for Quality Assurance Project Plans* (EPA 2001). This plan complies with the requirements of QA-1, *Quality Assurance*, and sections of the HASQARD, Vols. 1 and 2 (DOE/RL-96-68), which apply specifically to sampling groups. The plan is supplemented by environmental investigation procedures in ENV-1, *Environmental Monitoring & Management*, which document sampling practices. The QAPP provides the policies and procedures necessary to ensure that the data obtained from environmental sampling and analysis are of the type and quality needed to support the data needs identified in the DQO Summary Report (WCH-265). The QAPP identifies the organizations participating in the implementation of this SAP and the quality assurance (QA) and quality control (QC) requirements for conducting the sampling and analysis activities.

3.1.1 Purpose

The purpose of this environmental field sampling QAPP is as follows:

- Provide a management policy and system to ensure that field sample collection activities result in the generation of analytical data of a known quality to meet the requirements of the customer
- Provide consistent sampling techniques and level of effort in meeting DQOs
- Serve as the implementation plan for the requirements of the applicable sections of the HASQARD, Vols. 1 and 2 (DOE/RL-96-68)
- Serve to implement QA-1, *Quality Assurance.*

3.1.2 Scope

WCH expects a uniform level of quality in work supporting the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1989). This field sampling QAPP has been written to provide a set of requirements and guidelines for sampling activities. The quality requirements of this plan are also consistent with the requirements in other regulatory-based statutes not included in the Tri-Party Agreement (Ecology et al. 1989).

This plan has been prepared to support and substantiate the defensibility of data generated from sampling activities and supplements the individual sampling and analysis instructions (SAIs), SAPs, work instructions (WIs), and other approved work-controlling sampling documents. The development of project-specific DQOs is outside the scope of this document but is addressed in the DQO Summary Report (WCH-265).

Sample collection under RCRA, CERCLA, and the "Hazardous Waste Management Act" (RCW 70.105), as delineated in the Tri-Party Agreement (Ecology et al. 1989), shall meet the regulatory requirements as defined in work-controlling documents and procedures and the QA protocols described in this QAPP.

3.1.3 Description

This plan outlines the organizational structure for the project, summarizes functional responsibilities, describes and depicts lines of authority, and lists the duties within WCH. Subcontractor responsibilities are defined in the subcontract under Exhibit D, Scope of Work. The QA elements for sampling activities that should be addressed in project documents used to conduct field sampling are also identified.

3.2 ORGANIZATION AND RESPONSIBILITY

This section addresses the basic components of project management and will ensure that the project has a defined goal, that the participants understand the goal and the approach to be used, and that the planned outputs have been appropriately documented.

3.2.1 Management Policy

It is the policy of WCH to provide high-quality environmental remediation services to the DOE-Richland Operations Office (DOE-RL). The WCH management and staff are fully committed to meet or exceed the DOE-RL quality system requirements and performance standards for the management of environmental remediation work at the Hanford Site. WCH is also committed to building a culture that makes continuous improvement a normal part of doing business and is committed to the highest ethical standards and quality performance in all operations.

3.2.2 Project/Task Organization

The project will be managed by the River Corridor Closure Contractor (RCCC), which has an assigned project manager and technical lead. Radiological control, environmental, safety and health, QC, and waste management field support will be provided by the RCCC. In accordance with the Environmental Control Plan (ECP) for the project (WCH-97), the following describes the various job positions responsible for implementation and compliance.

The Mission Completion Project Manager: The Mission Completion Project Manager has overall responsibility for this project including oversight of the project schedule and budget. The manager makes final project decisions with the authority to commit the necessary resources to conduct the project.

Level 2 Supervisor/Responsible Manager: The Level 2 supervisor/responsible manager has overall responsibility for the project scope, schedule, and budget. This includes ensuring that all work is performed in compliance with applicable requirements. The responsible manager reports to the project manager.

Environmental Project Lead (EPL): The EPL is responsible for ensuring environmental compliance for project-related activities. This includes identifying and resolving environmental issues associated with the Mission Completion Project and assisting with environmental compliance. The EPL is also responsible for preparing and overseeing implementation of the ECP, and reports to the project engineer.

Project Engineer: The project engineer is responsible for defining the technical scope of work to be performed and for providing overall technical direction within the Mission Completion Project. This includes ensuring compliance with WCH procedures, environmental laws, regulations, permit conditions, and subcontracts as identified by the EPL.

Subcontract Technical Representative (STR): The STR is responsible for environmental compliance by ensuring that the subcontractor performs all of the work in accordance with specific requirements identified in the subcontracts, such as the ECP and WCH environmental procedures and/or documents.

Technical Lead (in this case, also the STR): The technical lead is responsible for coordination and oversight of all environmental data collection activities, including sampling and field analytical measurements. The technical lead is responsible for tracking and reporting the progress of field work and laboratory analysis and interfacing with the project QA representative to ensure work is performed in accordance with project objectives and requirements specified in this SAP.

Waste Management Specialist: The waste management specialist is responsible for development of the site-specific waste management instruction (SSWMI), SSWMI training project personnel, coordinating setup and routine inspection of the waste container storage area, developing waste profiles, and coordinating disposal of investigation-derived waste.

Other Project Personnel: Other project personnel have a role in supporting environmental compliance by following applicable project procedures and/or documents. This includes WCH personnel assigned to the project and/or subcontractor personnel.

Sample collection and field measurements will be performed by qualified RCCC project staff or qualified subcontractors in accordance with this SAP and internal or subcontractor procedures. Subcontractor and RCCC field personnel will provide periodic status during field activities and report problems in the field to the RCCC Project Technical Lead.

Laboratory analysis will be performed by qualified RCCC subcontracted laboratories in accordance with this SAP. All laboratory QA plans and procedures will be reviewed and concurred with by the RCCC.

3.2.3 Project Schedule

A tentative schedule for the completion of the task activities associated with developing and implementing the RI, associated sampling program, performance of laboratory analyses, performance of a data quality assessment (DQA), evaluation and reporting of investigation results, and subsequent risk assessment is presented in Section 7.0 of the RI work plan.

3.2.4 Quality Objectives and Criteria for Measurement Data

The quantitation limits and precision and accuracy requirements for each of the analyses to be performed are summarized separately for water (Table 3-1), soil/sediment (Table 3-2), and tissue (Table 3-3). These tables are included in a separate section at the end of this SAP. These requirements were derived as part of Step 6 in the DQO process as described in *Guidance for the Data Quality Objectives Process* (EPA 2000b). The process for determining these requirements is documented in the DQO Summary Report (WCH-265). SW-846 provides a definition for laboratory reporting limits (RLs) as the lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. This is generally 5 to 10 times the method detection limit. However, it may be nominally chosen within these guidelines to simplify data reporting. For many analytes the RL concentration is selected as the lowest nonzero standard in the calibration curve. There is no real distinction between the practical quantitation limit and RLs as they are applied to analytical requirements. In practice, the laboratories will report compound detections between the method detection limit (nominally one-fifth to one-tenth of the reporting limit) and the RL as estimated concentrations ("J" flagged results). Compound identification is routinely confirmed for volatile organic analysis and semivolatile organic analysis via mass-spectral "fingerprint" matching with a high degree of confidence. In some cases, laboratory detection limits are above available cleanup levels or ecological or human health benchmark values, and therefore other lines of evidence will be used to support the risk characterization.

3.3 PERSONNEL QUALIFICATIONS AND TRAINING

All personnel assigned to perform tasks and functions supporting sampling activities shall have received the necessary education, training, and experience commensurate with their responsibilities and duties. Particular attention is given to training newly recruited personnel and personnel transferred to new assignments. Personnel are provided with continuing training, as needed, to ensure that job performance is maintained. Training provides an understanding of the fundamentals and context of the work to be performed. Training shall be performed and documented in accordance with WCH training requirements.

3.3.1 Personnel Qualifications

WCH is responsible for performing an initial evaluation of the capabilities and qualifications of assigned personnel. Personnel qualifications should be verified routinely (i.e., monthly).

NOTE: See the "Sampling and Analysis Plan Figures and Tables" section located at the end of this SAP for the following tables:

Table 3-1. Analytical Performance Requirements for Contaminants in Water.
Table 3-2. Analytical Performance Requirements for Contaminants in Soil and Sediment.
Table 3-3. Analytical Performance Requirements of Contaminants in Tissue.

3.3.2 Personnel Training

Training records shall be maintained in Training Department files. Because of the nature and off-site location of samples collected for this RI, subcontractors will most likely collect the samples. The subcontractor will need to be specifically trained and/or certified in boat/vessel operation, sediment coring, and surface water collection in addition to First Aid and cardiopulmonary resuscitation (CPR).

Training or certification requirements needed by field and analytical personnel shall be in accordance with the requirements of the HASQARD, Vol. 1, "Administrative Requirements" (DOE/RL-96-68). In addition, field personnel will typically have completed the following training before starting work:

- Hanford General Employee Training
- First Aid/CPR Training
- Cultural Resource Awareness Training.

Qualifications of field personnel must be forwarded to the RCCC Project Technical Lead and must be verified prior to beginning work.

3.3.3 Documentation and Records

Project documentation and records include work packages, field logbooks, field measurement records, chain-of-custody records, analytical data packages, and validation reports. At the direction of the Technical Lead, all data packages and/or validation reports shall be subject to technical review before submittal to regulatory agencies or inclusion in reports/technical memoranda. When appropriate, electronic access shall be through computerized databases (e.g., Environmental Restoration [ENRE] database). Where electronic data are not available, hard copies will be provided in accordance with Section 9.6 of the Tri-Party Agreement (Ecology et al. 1989).

3.4 MEASUREMENT/DATA ACQUISITION

The following subsections present the sampling process design and requirements for sampling methods, sample handling and custody, and analytical methods. The requirements for instrument calibration and maintenance, supply inspections, and data management are also addressed.

3.4.1 Sampling Process Design

The sample design reflects the project work scope developed using the EPA DQO process (WCH-265). The FSP in Section 2.0 presents additional sample design details, summary tables, and figures that address sampling locations, sampling frequencies, and required field and laboratory analytical methods per each sampling media.

3.4.2 Sampling Methods Requirements

Procedures for documentation, sample preservation, shipment, and chain-of-custody requirements are described in RCCC procedures or RCCC-reviewed subcontractor procedures. Sampling will be performed in accordance with this SAP and the field instructions guide that will describe the individual sample collection details. Specific sample collection requirements in terms of media type, collection containers, target sample volumes, and analytical methods are described in Table 3-4, which is included in a separate section located at the end of this SAP.

3.4.3 Sample Handling and Custody Requirements

The sample handling and custody requirements are identified in RCCC procedures (e.g., ENV-1). The sample containers will be chosen using *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods* (SW-846) (EPA 1986) as a guideline to ensure the materials of construction are compatible with the sample material and do not interfere with laboratory analysis of the samples. Sample containers for radiological samples will be of appropriate material and volume to meet shipping and transportation requirements. Immediately after a sample bottle has been filled, it must be preserved as specified by this QAPP.

The sample transport containers must maintain the sample temperature at approximately 4 °C as recommended by SW-846 (EPA 1986) to maintain sample integrity (see Table 3-4 for additional handling requirements). The sample transport containers must be custody sealed and shipped with the appropriate documentation to the analytical laboratory. Sample traceability is maintained via the chain-of-custody forms. The sampling team shall initiate a chain-of-custody form for all samples. The chain-of-custody form shall accompany each sample container.

Each sample will be shipped to the laboratory in an approved shipping container per approved procedure. The sampling team shall use sample custody seals to demonstrate that samples have reached the laboratory without alteration.

The information documented on the chain-of-custody forms should match the instructions within this SAP. The sampling activities are documented in the field logbooks, and any deviations from the SAP instructions and the justification for the deviations will be captured there.

3.4.4 Analytical Methods Requirements

Target analytes and methods are listed in Tables 3-1, 3-2, and 3-3 for water, sediment/soil, and tissue, respectively. Chemical field screening and radiological field survey data used for site characterization will be performed in accordance with RCCC-approved procedures. Laboratory analyses will be performed in accordance with the referenced analytical methods identified in Tables 3-1 through 3-3 and the associated laboratory QA management plan and applicable standard operating procedures (SOPs). The laboratory quality management plan and SOPs will be reviewed and concurred with by the Technical Lead and QA Representative prior to sample analysis. For water samples, field parameters including pH, temperature, dissolved oxygen, and specific conductivity may be measured to facilitate the interpretation of results. Changes to or addition of analytical methods identified in this SAP will be implemented in page changes, addenda, or revisions to this SAP, as appropriate.

Appendix A — Sampling and Analysis Plan

NOTE: See the "Sampling and Analysis Plan Figures and Tables" section located at the end of this SAP for the following table:

Table 3-4. Sample Volume, Preservation, and Hold Time Requirements.

3.5 QUALITY SYSTEMS

A number of systems exist to ensure that activities meet a satisfactory level of quality. These systems have been identified as physical facilities systems, technical systems, and administrative systems.

3.5.1 Data Acquisition Requirements (Nondirect Measurements)

Nondirect data are obtained from database information management systems, which may include the Waste Information Data System database, the Hanford Geographic Information System database, and the Hanford Environmental Information System database. The Waste Information Data System database is the official Hanford Site resource for waste site name, waste type, site description, past-practice history, and documentation available for each waste site, including documents, drawings, photographs, etc. The baseline maps for the Hanford Site are maintained in the Hanford Geographic Information System database. Maps of the waste sites, facilities, services, and key environmental features are maintained. The Hanford Environmental Information System database is used to maintain electronic access to the available chemical and radiochemical analytical data for the Hanford waste sites and for the Hanford Site groundwater.

3.5.2 Physical Facilities Systems

The following requirements shall be met:

- The WCH Sample Storage and Shipping Facility (SS&SF) shall have controlled access limited to authorized personnel.

- Sampling equipment and safety equipment shall be maintained to ensure proper working order and shall be kept secure when not in use. Sampling equipment shall be decontaminated before use or otherwise demonstrated to be free of contamination that would compromise sample integrity.

- Sampling operations and sample storage areas shall be maintained to prevent the spread of contamination. Adequate storage areas shall be available for reagents, solvents, standards, and reference materials to prevent cross-contamination or degradation. An area at the SS&SF shall be controlled as a radioactive materials area (in accordance with DOE radiological control requirements) for the receipt and storage of potentially radioactive samples.

- The return and disposal of laboratory samples are managed as part of the laboratory's statement of work. The WCH Waste Management and Transportation organization shall be contacted to make disposal arrangements for any samples that are collected.

- Project-specific facility guidelines and requirements are found in work plans, site-specific health and safety plans, and other work control documents. It is the responsibility of personnel to review these requirements before initiating project-specific sampling. This is achieved through site-specific planning and safety meetings provided by the projects and are documented in the site-specific field records.

3.5.3 Technical Systems

3.5.3.1 Investigative Design. The initial design of a field sampling effort should be performed as part of the DQO process. Details on the design of the field sampling investigation should then be integrated into the corresponding SAP. The formal DQO process is not required to be performed to support the preparation of SAI and WI documents; thus, specific details on the sampling design should be incorporated into the SAI or WI.

To ensure efficient and timely completion of tasks, minor changes can be made to the original work scope outlined in the SAI, SAP, or WI in the field by the Technical Lead (or designee), provided that these changes do not impact the technical adequacy of the job. These changes will be documented as revisions to the appropriate work-controlling documents or with justification(s) in a field logbook, per requirements specified in the HASQARD (DOE/RL-96-68). The Technical Lead (or designee) shall notify the Project QA Representative that the changes have been implemented. If the Technical Lead (or designee) anticipates that a proposed field change will require the approval of DOE-RL and the lead regulatory agency, appropriate notifications shall be made before implementing the change. The Technical Lead (or designee) will then take the necessary steps to revise the SAP as agreed upon by DOE and the lead regulatory agency.

3.5.3.2 Sampling Methods and Standard Operating Procedures. Documentation of sampling procedures is critical to the technical defensibility and the legal defensibility/admissibility of the resulting data. The generally accepted practice is that, whenever possible, industry-recognized sampling methods from agency-published source documents shall be employed. Agencies publishing such source documents include DOE, EPA, and the American Society for Testing Materials (ASTM). Sample collection and processing procedures may also use methods published by the U.S. Geological Survey, the U.S. Department of Agriculture, and professional groups such as the American Water Works Association.

Current DOE, EPA, and ASTM methods are detailed in the following sources:

- *A Compendium of Superfund Field Operations Methods* (EPA 1987)
- *DOE Methods for Evaluating Environmental and Waste Management Samples* (DOE 1997a)
- *EML Procedures Manual* (DOE 1997b)
- *Environmental Survey Manual*, Appendix E, "Field Sampling Protocols and Guidance" (DOE 1987)

- *Sampling of Water and Wastewater* (EPA 1977)
- *Sampling Surface Soils for Radionuclides* (ASTM 1983)
- *Soil Sampling Quality Assurance User's Guide* (EPA 1995a)
- *Standard Practices for Sampling Water* (ASTM 1977)
- *Superfund Program Representative Sampling Guidance*, Vol. 1, "Soil" (EPA 1995b)
- *Test Methods for Evaluating Solid Waste* (EPA 1986)
- *Washington Administrative Code* (WAC) 173-303-110(2), "Dangerous Waste Regulations, Sampling and Testing Methods"
- WAC 173-340-830, "Analytical Procedures."

Complete and well-documented references shall be available for all methods. If specific method references do not exist, project-specific sampling procedures shall be prepared and approved prior to sampling. Appropriate chapters of documents such as suppliers' manuals, equipment manufacturers' instructions, and instrumentation specifications can be used in place of a formal sampling procedure. Such documents shall include adequate descriptions and criteria to ensure the required quality of work.

Sampling methods are described in the procedures found in ENV-1. Project-specific sample collection activities are described in WIs, SAIs, or SAPs. These documents are prepared by the project organizations and reference applicable procedures found in ENV-1 and other WCH controlled manuals, following the requirements specified in the HASQARD (DOE/RL-96-68). Sampling methods not covered in the ENV-1 procedures will be detailed in project-specific documentation. Each sampling method performed in the field shall have an applicable procedure that describes the equipment necessary and the collection steps required for the media and target analyte to be sampled. However, unique media- or method-specific sampling can be detailed in other approved documentation. Sampling shall be performed in accordance with established procedures unless specific needs dictate a temporary and immediate variation from the approved procedure. Deviation from an approved procedure should be approved by WCH project management in advance. When advanced variance approval is not possible, WCH project management shall be notified of the variation by the sampling team at the earliest possible opportunity. The reason for the variation and all of the specific actions associated with the variations to the approved procedure shall be documented.

3.5.3.3 Corrective Action and Quality Improvement. Items, services, and processes that do not meet established requirements shall be identified as nonconformances. Nonconformances shall be controlled and corrected according to the importance of the problem and the work that is affected. For significant problems, correction shall include identifying the cause(s) of the problem and working to prevent recurrence.

3.5.4 Administrative Systems

3.5.4.1 Document Control and Records Requirements. Records will be controlled, protected, and retained in accordance with approved Records Inventory and Disposition Schedules and the requirements of BSC-1, *Business Services and Communications*.

3.5.4.2 Data Correction. Changes or corrections to information (including data entries and logbook entries) shall be made by drawing a single line through the incorrect information, writing a new entry, and initialing and dating the new entry. Correction tape or correction fluid shall not be used. Data corrections for field documentation will be performed as outlined in the HASQARD (DOE/RL-96-68).

3.5.5 Assessments

Sampling design, documentation, sample preservation, shipment, and chain-of-custody requirements will comply with *Guidance for the Data Quality Objectives Process* (EPA 2000b), as revised; *EPA Requirements for Quality Assurance Project Plans* (EPA 2001), as revised; and *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (EPA 1986).

Assessments are evaluations intended to provide an increased understanding of the program or system being evaluated and to provide a basis for improving the programs or systems. The assessment program should address each of the following items:

- Management system assessments
- Technical system assessments
- Performance evaluation assessments
- Data quality assessments
- External assessments.

The RCCC QA organization may conduct surveillance and assessments to verify compliance with the requirements outlined in this SAP, project work packages, the project quality management plan, and procedures and regulatory requirements. Deficiencies shall be reported to the Technical Lead in accordance with approved reporting procedures. The Technical Lead will take appropriate corrective actions in accordance with RCCC procedures.

Assessments should be scheduled according to the importance of the activity to be assessed and should be carried out by personnel independent of those having direct responsibility for the activities being evaluated.

3.5.6 Inspections and Tests

Inspections should be performed routinely during field sampling efforts to ensure that materials (e.g., sample bottles, distilled water, and preservation solutions) and equipment (e.g., refrigerators, temperature recorders, and eye wash stations) used to support field sampling activities meet the minimum quality requirements for the project. Inspections should be performed on field logbooks to ensure the accuracy of data entries and on satellite accumulation areas to ensure proper maintenance. All testing performed for the purpose of providing analytical data should comply with the HASQARD (DOE/RL-96-68).

3.6 SOFTWARE SYSTEMS QUALITY ASSURANCE

Data will be managed and stored by the RCCC Sample and Data Management Group in accordance with RCCC procedures. The contract laboratories will report analytical results in an electronic and hardcopy format.

All validated reports and supporting analytical data packages shall be subject to final technical review by qualified reviewers (before their submittal to regulatory agencies or inclusion in reports or technical memoranda). Electronic data access, when appropriate, shall be through environmental information systems computerized databases (i.e., ENRE). Where electronic data are not available, hard copies will be provided in accordance with Section 9.6 of the Tri-Party Agreement (Ecology et al. 1989). Preliminary data and report briefings/distributions (subject to technical review) to EPA and Ecology will be provided as requested. Regulatory agency updates will typically be conducted at unit manager meetings as requested.

3.7 SAMPLING OPERATIONS

3.7.1 Site/Field Documentation

A site logbook is the master reference document for all activities performed at a site, whereas a field logbook provides a daily handwritten record of all field activities at an investigation site and is the primary record for all sampling activities. All logbooks will be completed and managed in accordance with requirements specified in the HASQARD (DOE/RL-96-68).

Field logbooks shall be permanently bound, highly resistant to water and chemicals, and ruled and printed with sequentially numbered pages. All logbook entries shall be made in black indelible ink by authorized personnel. Changes or corrections to information shall be made by drawing a single line through the incorrect information, writing a new entry, and initiating and dating the new entry. Correction tape, correction fluid, or erasers shall not be used. Pages shall not be removed from the site or field logbooks for any reason. Blank pages shall be marked "PAGE INTENTIONALLY LEFT BLANK."

It is often convenient to document field information on pre-made data forms. The data form will be permanently attached to the field logbook or will be managed as specified in the SAI, SAP, or WI.

The following items shall be recorded in the logbooks:

- The day, date, time arrived on site, and weather conditions; names, titles, and organizations of personnel present at the site; and the individuals responsible for field logbooks shall be listed with their assigned logbook number.
- The name, title, organization represented, and the purpose of the visit.
- Forms, including computer data files or logbooks, that register the details of tasks performed on site.
- All site activities, including field tests; the site logbook will provide a summary of activities, and the field logbook will list the activities in detail.
- Chain-of-custody details and all activities and variances relating to chain-of-custody.
- Lot numbers for all commercially pre-cleaned bottles used for sample collection.
- Details of field calibrations and surveys that were conducted will be listed in the field logbook, including an annotation of results.
- Details of samples collected (e.g., media collected, sample identification number, preservation methods used) will be contained in the field logbook, including preparation of QC samples.
- Equipment decontaminated, number of decontaminations, and the decontamination procedures followed when different from the QAPP or SOP; the site log references the field logbook that documents specific information.
- Equipment failures or breakdowns, a brief description of repairs or replacements, and indications of the impact of the equipment failure.
- Deviations from the QAPP or SOP, including reasons for the change, the detail of the change, and a discussion of the possible impacts of the change.
- A record of telephone calls relating to field activities; if a separate telephone log is maintained, the site log shall reference the page containing the specific details.
- The field manager, supervisor, or cognizant scientist/engineer shall review entries and document the review with his/her signature and the date.

3.7.2 Management of Samples

3.7.2.1 Sample Identification. Each sample has a unique identification number. This number is issued in accordance with requirements specified in the HASQARD (DOE/RL-96-68). Each sample is identified by a gummed label or standardized tag affixed to the container. This label or tag shall contain the sample identification number, the date and time of collection, project identification, the source of the sample (e.g., name and location), field data (e.g., pH), the preservative used, the analysis required, and the collector's name.

3.7.2.2 Sample Preservation. Samples should be preserved in a manner consistent with regulatory requirements, which are identified on the sample authorization form (SAF) for the project. Sample preservation and extension of holding times may be negotiated with the regulators to support the cost-effective collection of data with known and controlled sources of variability. Methods of preservation are relatively limited and are intended to (1) retard biological action, (2) retard hydrolysis and radiolysis of chemical compounds and complexes, (3) reduce volatility of constituents, and (4) reduce absorption and adsorption effects. Preservation methods are generally limited to pH control, chemical addition, refrigeration, and freezing.

The method of preservation shall be recorded on the SAF or in the field logbook. If a preservative is used, it should be documented on the sample label and chain-of-custody form. Preservatives shall be tracked by lot number, date of receipt, and date opened.

3.7.2.3 Sample Storage. The field samples are stored at the SS&SF in accordance with requirements specified in the HASQARD (DOE/RL-96-68). The field sampler will maintain custody of collected samples by placing the samples in a storage area that can only be accessed by authorized field sampling personnel and by following the appropriate sample custody procedures. Storage areas are controlled to prevent the damage and loss of samples, to maintain sample container and identification integrity, and to avoid sample contamination during storage. Measures are taken to contain and avoid material spills during storage. Daily verification and documentation of storage temperature are maintained in accordance with requirements specified in the HASQARD (DOE/RL-96-68). The sample storage area of the SS&SF is to be dedicated to samples only.

3.7.2.4 Sample Handling and Transfer. The number of persons involved in collecting and handling samples should be kept to a minimum. One member of the sampling team should be identified as the sample custodian and will document sample collection and possession on the chain-of-custody form, in accordance with requirements specified in the HASQARD (DOE/RL-96-68). Precaution should be taken to prevent contamination of samples or field personnel. Samples shall be preserved in the field at the time of collection as required by the SAF. The outside of the container shall be cleaned after the sample media has been placed into the container. Custody seals shall be placed on the containers to prevent opening without breaking the seal. The sample identification number shall be marked on the sample container and written on the chain-of-custody form, which documents all changes in custody of the sample. The sample container shall be placed in a plastic bag to ensure that the outside of the container does not become contaminated. Samples requiring cooling shall be placed on wet ice in

the field. Samples shall be stored at the SS&SF by the team members who collected the samples prior to transport to the analytical laboratory. The sample custodian will document each transaction on the chain-of-custody form.

Samples are shipped from the SS&SF to the designated laboratory in accordance with requirements specified in the HASQARD (DOE/RL-96-68). Trip blanks, as specified in site-specific sampling documents, are used instead of storage blanks to provide assurance that sample contamination during storage does not occur. When a sample requires cooling to 4 °C (±2 °C), the sample container(s) should be packed in leak-proof plastic bags and placed in an insulated container with either synthetic ice or wet ice. Samples to be shipped should be packed so they will not break, and the package should be sealed so any tampering can be readily detected. Custody seals should be used to verify that sample integrity has been maintained during transport. Custody tape should be selected that is not removable from the shipping container without breaking the seal. All changes in possession of the samples shall be documented on the chain-of-custody form.

Samplers are responsible for properly packaging and dispatching samples to the appropriate laboratory or facility. This responsibility includes filling out, dating, and signing the appropriate portion of the chain-of-custody form and the sample transfer and shipping forms (as applicable). When transferring the samples, the person who accepts the samples must sign and record the date and time on the chain-of-custody form. Custody in the field should account for each sample, although samples may be transferred as a group. Verification of sample identification and integrity should be performed before releasing a sample to another organization for testing or analysis. Sample packaging and transportation environmental investigation procedures have been established for the proper screening, packaging, and shipping of samples according to applicable Occupational Safety and Health Administration and Washington State regulations for the protection of personnel and the environment.

The transportation of samples must be accomplished not only in a manner designed to protect the integrity of the sample, but also to prevent any detrimental effects from potentially hazardous samples. Regulations for packaging, marking, labeling, and shipping of hazardous materials, hazardous substances, and hazardous waste are mandated by the U.S. Department of Transportation (DOT) (49 CFR 171-177) in association with the International Air Transportation Authority. All packaging and transportation of Hanford Site materials along public roads or in the public domain should be in compliance with DOT regulations and DOE requirements.

All samples from the Hanford Site will be accompanied with documentation attesting to the radiological status of the samples to determine proper shipping and handling requirements and to provide data for laboratory acceptance. Shipment of samples will be conducted according to the current DOT regulations and labeling requirements, as appropriate. This documentation may be from historical data, if appropriate, or from screening-level activity determinations. Tissue samples and samples recovered from outside the boundary of the Hanford Site will be considered to be exempt from radiological controls. Unless exempted from radiological controls, any samples that are to be submitted to a laboratory that does not possess either a U.S. Nuclear Regulatory Commission or state agreement radioactive material license to possess and analyze

samples with radioactive contamination will require an unconditional release from radiological control by Health Physics.

3.7.2.4.1 Nonradioactive Hazardous Samples. Samples that are expected to contain hazardous constituents should be considered hazardous materials and transported according to applicable DOT requirements. If the sample constituents are known or can be identified, the sample should be packaged, marked, labeled, and shipped according to the DOT hazard class for that material. If the sample constituents are unknown but the sample is considered potentially hazardous, it will be assigned the highest applicable hazard class based on the knowledge available.

3.7.2.4.2 Radioactive Samples. The DOT classifies "radioactive material" as any material that contains radionuclides where both the activity concentration and the total activity consignment exceed the values specified in Table 1 within 49 CFR 173.436 values that are derived according to the instructions contained within 49 CFR 173.433 (*Federal Register*, January 26, 2004). A sample that exceeds the activities noted in Table 1 should be transported according to DOT requirements found in 49 CFR 172.310 for marking; 49 CFR 172.436, 49 CFR 172.438, and 49 CFR 172.440 for labeling; and 49 CFR 172.556 for placarding and shipping.

3.7.3 Chain-of-Custody

A major consideration for the legal credibility of analytical data generated from a field sampling activity is the ability to demonstrate that samples have been obtained and have reached the laboratory without alteration. Documentation is accomplished through a chain-of-custody form that will be completed and managed as specified in the HASQARD (DOE/RL-96-68).

The following information is required on the chain-of-custody form:

- Project name
- Name and signature of sampler
- Sample location
- Sample number
- Date and time of collection
- Matrix
- Preservatives
- Signature of individuals involved in sample transfer.

3.7.4 Subsampling and Compositing

Processing, compositing, and subsampling of bulk materials collected in the field are key links in the sampling and analytical chain and can have a substantial impact on the usability of resulting analytical data. When the entire content of a sample container is subjected to analysis by a single method, processing and subsampling in the laboratory are not required. When more than the analytical sample size is collected, processing and subsampling in the laboratory is required. It is important that participants in a sampling effort are aware of proposed and implemented field compositing and subsampling methods, including their impact on data usability and the

achievement of DQOs. The collection of samples from a population for the purpose of compositing is generally used as a cost-saving method. Proper attention to population variability, sample collection techniques, compositing, and subsampling for submission to the analytical laboratory enhances the representativeness of the data.

Collection of composite samples shall be in accordance with requirements specified in the HASQARD (DOE/RL-96-68) or project-specific sampling procedures. During the pre-planning stages, consideration will be provided for the laboratory analysis volume requirements. This information is to ensure that sufficient sample volume is submitted to the laboratory to analyze for the associated analyte and QC parameters and to minimize excess material generated as waste. Information on the volume of sample material aids in determining the proper choice of compositing and/or subsampling methods.

3.7.5 Holding Times

Holding times should be identified on the SAF. Sample shipment and delivery should be coordinated between Sample Management and the laboratory to meet these holding times. The sample holding time begins at the time and date that the bulk sample is collected in the field. The use of preservatives may extend the acceptable holding time. This approach can be negotiated with the regulators to support the collection of cost-effective data of known and controlled variability. Applicable holding times for the requested analyses are provided in Table 3-4.

3.7.6 Sample Containers

The type of containers required is project-specific and are outlined in the SAI, SAP, WI, and on the SAF. When commercially pre-cleaned bottle are used, boxes containing the bottles shall be opened and inspected at the time of use. The certifications found in each box shall routinely (weekly) be transmitted to Document Control.

Sampling activities using commercially pre-cleaned bottles shall have the lot number of the bottle recorded with the sample number within the field logbook to ensure traceability of samples to bottle lots, and bottle lots to certifications.

As an added verification that bottles are within the procurement specifications, blanks consisting of demineralized water or silica sand shall be processed in accordance with the applicable SAI, SAP, WI, or SAF.

When required, commercially pre-cleaned containers are used in the field, and the name of the manufacturer, the lot identification, and certification are retained for documentation. All containers are stored in a secure and contaminant-free area. Samples in glass containers shall be transported using secondary containment (e.g., coolers) according to DOT requirements.

3.8 QUALITY CONTROL DURING THE SAMPLING PROCESS

The QC procedures must be followed in the field and laboratory to ensure that reliable data are obtained. The QC parameters are evaluated through laboratory checks (e.g., matrix spikes, laboratory blanks) and duplicate sampling and analysis. Acceptance criteria have been established for each of these parameters based on guidance from the EPA (EPA 1996). When a parameter is outside the QC criterion, corrective actions are taken to prevent a future occurrence and affected data are qualified and flagged in the database. QA will be conducted in accordance with this QAPP and RCCC-approved laboratory QA plans.

Several control samples are introduced into the collection system to monitor the adequacy of the sampling system and the integrity of samples during their journey from the field collection point through laboratory analysis. The frequency and type of QC samples to be collected are specified in SAI, SAP, or WI. These samples are defined, as mentioned in the following subsections, with their mode of collection and purpose. The deionized water used in blanks shall meet the electrical resistivity requirements of ASTM Type II water and shall be analyte-free.

Field QC requirements are used to monitor and ensure the quality of the field results. Field QC samples will be collected during fieldwork to monitor the performance of sample collection and measure the effects of sampling bias or variability. When performing this field sampling effort, care shall be taken to prevent the cross-contamination of sampling equipment, sample bottles, and other equipment that could compromise sample integrity.

3.8.1 Calibration

This section establishes the controls for calibration and/or activities associated with calibration requirements for all onsite measurement equipment. Equipment testing, inspections, and maintenance for the laboratory are described in the laboratory QA plans reviewed and concurred by the RCCC. All field instrumentation shall be tested, inspected, and maintained in accordance with RCCC-approved internal, manufacturer, or equivalent subcontractor procedures. The results from all instrument/equipment testing, inspection, and maintenance activities shall be recorded in a bound logbook or as detailed in laboratory or subcontractor procedures.

The performance of testing equipment is checked through validation of a successful initial calibration and periodic checks to verify that the equipment remains within calibration criteria. All instruments and equipment with operations and functions that directly affect quality are calibrated or inspected as specified in procedures consistent with the associated analytical methods. Calibration results that indicate instrument problems (i.e., periodic instrument checks out of calibration criteria) and associated corrective action shall be communicated to the technical lead.

It may be necessary to periodically use an instrument or piece of equipment that has not been calibrated to meet the project goals. In such cases, and with prior concurrence from the customer, corrective action will be performed to ensure that an acceptable calibration has been obtained. Results of the calibration and associated corrective action shall be documented, and any anomalies will be communicated to the customer.

3.8.2 Equipment Rinsate Blanks

Equipment rinsate blanks will be collected to evaluate the decontamination process effectiveness and the cleanliness of the sampling equipment used for collection of soil, sediment, and water samples. Equipment rinsates are samples of deionized water or analyte-free silica sand (if specified) that are passed through decontaminated sampling equipment before use of the equipment. Rinsates are used to measure the effectiveness of the equipment decontamination process. Equipment rinsates should be collected in the field and at the rate specified in the SAI, SAP, or WI. An equipment rinsate should be collected from each type of sampling equipment used to ensure that the decontamination procedures are applicable to all equipment types.

Equipment rinsates are analyzed for the same chemical analytes (no radionuclide analysis required) as samples collected using that equipment. All sample results should be evaluated to determine the possible effects of any contamination detected in the equipment rinsate blank.

3.8.3 Field Duplicates

The purpose of collecting field duplicates is to evaluate the potential variability and bias introduced from field handing procedures. It is expected that the potential variability introduced through field sieving will be minor and the matrix spike/matrix spike duplicate will allow a complete evaluation of field handling, subsampling, and laboratory analysis procedures.

Field duplicates are two samples produced from material collected in the same location that are submitted to the sample laboratory for analysis. Each sample will be numbered uniquely. Field duplicates provide information regarding the homogeneity of the matrix. A matrix constitutes soil, sediment, or water from a given site. A field duplicate may also provide an evaluation of the precision of the analysis process. Field duplicates will be collected at a frequency of 5% of the samples collected per matrix.

Field duplicates shall be sent to the laboratory in the same manner as the routine site samples; they may or may not be identified to the laboratory as field duplicates. The utility of information may be maximized when extra samples from the field splits are submitted for the laboratory to use as duplicates, which will help to distinguish between variability resulting from sample heterogeneity and variability resulting from laboratory manipulation. Field duplicate data shall be reviewed for agreement.

3.8.4 Field Splits

Field split samples are two uniquely numbered samples produced through homogenizing a field sample and separating the sample material into two separate aliquots. Field split samples are usually routed to separate laboratories for independent analysis, generally for the purposes of auditing the performance of the primary laboratory relative to a particular sample matrix and analytical method. Field split samples may be collected at a frequency of 5% of the samples collected per matrix.

3.8.5 Field Blanks

Field blanks are samples of analyte-free media similar to the sample matrix transferred from one vessel to another at the sampling site. This blank is preserved and processed in the same manner as the associated samples and is used to document contamination during the sampling and analysis process. Field blanks will be collected at at a frequency of 5% of the samples collected per matrix.

3.8.6 Trip Blanks

Trip blanks are used to detect contamination during sample shipping and handling. A trip blank is an analyte sample container filled with deionized water or analyte-free silica sand (if specified) that is transported to the sampling site and then returned to the laboratory with the samples. Trip blanks are filled in the laboratory or at the SS&SF and are not to be opened in the field. Each trip blank should be stored at the laboratory with associated samples and should be analyzed with those samples.

Trip blanks will only be used when samples are to be analyzed for volatile organic compounds. However, trip blanks may be used for any parameter when there is concern that concentration of the parameter is biased by contamination. A trip blank will not only detect contamination during the shipping and handling of the containers, but will also serve to detect contamination from containers (i.e., will function as a bottle blank), which is important if noncertified sample containers are being used.

3.9 ANALYTICAL SERVICES

Onsite laboratories and onsite measurement groups performing analyses for WCH in support of the Tri-Party Agreement (Ecology et al. 1989) are required to comply with the HASQARD (DOE/RL-96-68). WCH staff perform quality oversight of onsite and contract laboratories used by WCH and onsite measurement groups. Contract statements of work for offsite laboratories should invoke requirements similar to those specified in HASQARD (DOE/RL-96-68).

3.10 QUALITY CONTROL DURING THE LABORATORY ANALYSIS PROCESS

Laboratory QC requirements will meet or exceed the requirements identified in the HASQARD (DOE/RL-96-68). The requirements in this document are implemented through the analytical service statement of work (RFS 1999) and are as follows:

- One laboratory method blank for every 20 samples (5% of all samples), analytical batch, or sample delivery group (whichever is most frequent) will be carried through the complete sample preparation and analytical procedure. The method blank will be used to document contamination resulting from the analytical process.

- One laboratory control sample or blank spike will be performed for every analytical batch and each analytical method criterion to monitor the effectiveness of the sample preparation process. The results from the analysis are used to assess laboratory performance.

- As appropriate, a matrix spike sample will be prepared and analyzed for every 20 samples of the same matrix or sample preparation batch, whichever is most frequent. The matrix spike results are used to document the bias of an analytical process in a given matrix.

- Laboratory duplicates or matrix spike duplicates will be used to assess precision and will be analyzed at the same frequency as the matrix spikes.

Tables 3-1, 3-2, and 3-3 summarize laboratory QC requirements for water, sediment/soil, and fish, respectively. QC requirements for toxicity tests will be performed in accordance with applicable ASTM standard guide test methods.

3.11 SAMPLING DATA

3.11.1 Sampling Data Review

Quality control in the sampling process is typically provided by frequent (i.e., daily) review of the site and field logs and by comparison with the data quality requirements of the project plan. The selection of sampling points and/or samples for more detailed examination is frequently based on field analytical data (qualitative and/or semiquantitative), so it is necessary to review the field analytical results as well. The principal acceptance criteria for the QC review of sampling activities are as follows:

- The correct number and locations of the sampling points were documented
- Selected sampling points indicate the presence/absence of the target analytes
- Samples were collected and shipped properly
- Field records and documents are complete
- Data reporting requirements for the day's activity were met.

The data in the field logbook are reviewed and signed by the person generating the data. A project representative should review the data in the field logbook (in association with the laboratory analytical data) and then evaluate the field data against the project objectives.

3.12 USABILITY, VALIDATION, AND VERIFICATION REQUIREMENTS

Data verification and validation are performed on all analytical data packages, primarily to confirm that sampling and chain-of-custody documentation is complete, sample numbers can be tied to the specific sampling location, samples were analyzed in accordance with the required holding times, and analyses met the data quality requirements specified in the sampling and analysis instruction.

3.12.1 Data Usability

Data collected in support of an RI must be both consistent with the objectives of the investigation and defensible for decision-making purposes. The DQO process is designed to ensure that the type, quantity, and quality of environmental data used in decision making will be appropriate for the intended application, resulting in environmental decisions that are technically and scientifically sound and legally defensible. In addition, the DQO process guards against committing resources to data collection efforts that do not support a defensible decision.

Data used in a baseline risk assessment will be evaluated against the data usability criteria listed in Table 3-5. Data that have not met these criteria are not eligible for unqualified use in risk quantification, but may be addressed qualitatively in the Columbia River Component of the RCBRA. Data are usable if they meet the intended end-use as specified in the DQO process.

Table 3-5. Data Usability Criteria.

Data	Usability Criteria
Data sources	Potential data sources may include the results of field screens, field analyses, or fixed laboratory analyses.
Documentation data	Collection and analysis procedures will be accurately documented to substantiate the analysis of the sample, conclusions derived from the data, and the reliability of the analytical data reported. Required documentation will include geographic location, chain-of-custody records, standard operating procedures, field records (including physical and temporal attributes of the sampling period), and analytical results records.
Analytical method and detection limit	Routinely accepted methods will be used to analyze target analytes. When detection limits do not meet the concentration levels of concern in applicable matrices, alternative methods may be considered.
Data quality indicators	Data quality will be measured by completeness, comparability, representativeness, precision, and accuracy. Sampling variability will be quantified for each analyte; quality control samples will be used to quantify accuracy and precision; sampling and analytical precision and accuracy will also be quantified.
Data review	Critical analytes and data used for the quantitative risk assessment will undergo a complete data review.
Data reporting	Data reviewers will report data in a format that provides readability, as well as clarifying information. Qualifiers will be clearly explained.

3.12.2 Data Review, Validation, and Verification Requirements

Data verification and validation are performed on analytical data sets to confirm that sampling and chain-of-custody documentation are complete, sample numbers can be tied to the specific sampling location, samples were analyzed within the required holding times, and analyses met the data quality requirements specified in this SAP. Validation procedures will not be used for onsite measurements, and quick-turnaround analysis data will not undergo a formal validation. Routine verification of the data packages will be conducted. The QA/QC process used in the SOPs will be followed to ensure that the data are useable. Quality control data are evaluated against the criteria listed in the project QA plan, and data flags are assigned when appropriate. If necessary, the laboratory may be asked to check calculations or reanalyze a sample, or the media may be resampled.

For standard fixed laboratory analyses, a minimum of 5% of the data packages will be validated in accordance with the RCCC procedures (e.g., ENV-1) and EPA's national functional guidelines for organic or inorganic data review (EPA 1999, 2004a). All coordination of validation services, execution of data validation activities, and handling storage of deliverables will be in accordance with requirements specified in the HASQARD (DOE/RL-96-68). The validated data results, including applicable qualifiers, shall be entered into the ENRE database and other project-specific databases. Onsite and quick-turnaround laboratory data reviews will be according to method requirements. The validated data qualifier results shall be entered into the ENRE database. The field measurements and quick-turnaround laboratory analysis data will not undergo formal validation. The QA/QC processes used in SOPS will be followed to ensure that data are useable.

These QA/QC processes include the use of blanks, duplicates, splits, and measurements of known standards. The remaining data will be reviewed by analytical personnel and the project team using the same EPA criteria. The data will be reviewed by analytical personnel and the project team. Survey measurement systems will be validated by reviewing 5% of the documentation to ensure that calibration and operational checks are performed according to the method used, to ensure that the dates of the survey are documented, and to ensure that sample locations are properly documented.

3.12.3 Validation and Verification Methods

Routine data verification shall be performed in accordance with requirements specified in the HASQARD (DOE/RL-96-68). Data validation of the standard fixed laboratory will be in accordance with *Data Validation Procedure for Radiochemistry Analyses* (HNF-20434) and *Data Validation Procedures for Chemical Analyses* (HNF-20433). Data will be validated to Level C, as defined in these reference documents. Field and quick-turnaround laboratory data reviews will be in accordance with method requirements.

Prior to sample collection activities, the validator and/or the laboratory should document the validation procedure. A qualified laboratory representative should review the validation procedure to ensure that the laboratory is capable of meeting the requirements specified. The following elements should be assessed in the validation procedure:

- Initial calibration
- Continuing calibration
- Method blanks, instrument blanks, and/or backgrounds
- Duplicates
- Matrix spikes and/or tracer or carrier yields
- Laboratory control sample results
- Holding times
- Identification of analyte(s) of interest
- Verification of tentatively identified compound(s)
- Analytical interferences
- Quantitation criteria
- Instrument performance and counter efficiency
- Criteria for validation of detection limits
- Criteria for accuracy and precision assessment.

3.13 DATA QUALITY ASSESSMENT

A DQA will be performed to verify that the data are suitable for their intended purpose to support site interim closure. The DQA shall include a review of the data validation results and a review of the data to the PARCC parameters (i.e., precision, accuracy, representativeness, completeness, and comparability). As a minimum, the laboratory QA/QC data shall be evaluated for adequacy to meet the requirements for precision, accuracy, completeness, and required detection limits.

A DQA shall be performed on the resulting analytical data in accordance with EPA's *Guidance for Data Quality Assessment* (EPA 2000a). This evaluation includes the following:

- Reviewing the DQOs, including study objectives, statistical hypotheses, decision error, and sample design
- Reviewing analytical data, including data packages, QA reports, calculating statistically based quantities, and graphical representation
- Selecting and performing statistical hypothesis tests
- Verifying the assumptions of the statistical hypothesis tests
- Determining corrective actions

- Drawing conclusions from the data
- Interpreting and communicating the test results.

The DQA process compares completed field sampling activities to those proposed in corresponding sampling documents and provides an evaluation of the resulting differences. The purpose of the evaluation is to determine if quantitative data are of the correct type and are of adequate quality and quantity to meet the project DQOs.

3.13.1 Data Quality Assessment of Fish Data

Because the analytical results form the bases for performing a meaningful human health risk assessment, an assessment will be performed to determine the quality of the reported data. The DQA will focus on the results of QC parameters including blanks, matrix spikes, laboratory control samples, calibration checks, and field duplicates.

Blank results will be reviewed to determine if there are any positive detections of target analytes. Detections of these compounds or elements in blanks could indicate interferences introduced during tissue preparation or analysis at the laboratory rather than being present in the tissue itself. The data quality assessment will address these potential interferences in the event of blank detections.

Matrix spike samples will be analyzed to determine if there is any material in the fish tissue itself that could interfere with the extraction or analysis of target analytes. Known concentrations of the analytes are added to the fish tissue and processed using the same procedures as a regular sample. The reported concentration is divided by the known concentration to obtain a percent recovery. The percent recoveries will be compared against EPA or method-specific criteria to determine compliance. Noncompliant results will be assessed to determine the impact on reported concentrations and ultimately risk assessment results.

Laboratory control samples are analyzed to measure the accuracy of the initial calibrations for the respective analytical methods. Known concentrations of the target analytes are added to deionized water. The reported concentrations are divided by the known concentrations to obtain a percent recovery. The percent recoveries are compared against EPA, method-specific, or laboratory-generated criteria to determine compliance. Noncompliant results will be reviewed to determine the impact on the associated data.

Calibration results will be reviewed to ascertain the quality and accuracy of the initial calibration from which sample concentrations are obtained. Continuing calibration results will be reviewed to determine the accuracy of the reported sample concentrations. Action with respect to noncompliant results may involve qualification of the sample results as estimated or rejection of the data.

Field duplicate results will be analyzed to determine the variability of concentrations of target analytes between different specimens of the same species of fish collected from the same sub-area. Field duplicate samples will be collected at a rate of 1 per 20 samples (5%). If sample collection goals are achieved, a total of five field duplicate samples will be taken during the course of fish sample collection activities. The same approximate sized specimens will be used for the sample and corresponding duplicate so that results from analyses of fish that are approximately the same age will be compared. The relative percent difference (RPD) between the sample and the duplicate concentrations will be calculated by dividing the absolute value of the difference of the results by the average of the reported concentrations.

$$RPD = \left| \text{sample result - duplicate result} \right| / \frac{\text{sample result + duplicate result}}{2}$$

The criteria for the tissue concentrations to "compare well" will be an RPD of 50% or less. The variability of the results will be a consideration when the risk assessment results are calculated.

3.13.2 Data Analysis/Risk Characterization

Analysis of the data starts with the approaches described in Section 5.5 of the RI work plan. Data analysis will evaluate results from all investigation areas, including upstream areas. The data from the investigation areas will be assessed for concentration trends and outliers, as well as for differences in concentration between the river sections within the study area and the upstream areas. (See the Baseline Human Health Risk Assessment work plan in the RI work plan [Section 4.7] for a discussion on comparative statistics for site and reference areas.)

During the data review process, graphical representation (e.g., plots, barcharts, scatter plots) will assist in determining the presence of outliers[4] or other anomalous data that might affect statistical results and interpretations. Graphical representation of analytical results will be generated for use in data interpretation. Exploratory data analysis plots allow for visual inspection and summary of the data. The choice of plotting procedure(s) depends on the hypothesis being tested and may include and/or depend on the following:

- The type of difference that is to be displayed, such as an overall shift in concentration (shift of central location)
- When the centers are nearly equal, a difference between the upper tails of the two distributions (elevated concentrations in a small fraction of one distribution).

[4] An outlier is an observation that lies an abnormal distance from other values in a random sample from a population. Outliers will be investigated to determine potential reason for occurrence or the likelihood that such values will continue to occur.

The plotting method chosen will accommodate characteristics of the data sets (e.g., the rate of detection or censoring) or the amount of overlap or multiplicity of results reported at a few values.

When there are both detects and nondetects (censored results) in a data set, usability of nondetects will be evaluated. If censored data meet DQOs and are determined to be suitable for characterization purposes, then the censored data will be evaluated with respect to the size of the dataset, the number of censored results, and data distribution. Parametric and nonparametric statistical approaches other than substitution (e.g., use of one-half the detection limit) may be employed as a means of calculating summary statistics. Such approaches may include Kaplan-Meier method, Maximum Likelihood estimation, or regression-on-order statistics. Additional information on these graphs and statistical tests are provided in the DQO Summary Report (WCH-265).

4.0 HEALTH AND SAFETY

Field operations will be performed in accordance with applicable health and safety requirements as described in Section 5.3.4 of the RI work plan.

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Appendix A – Sampling and Analysis Plan

Figure 2-2. Proposed Sampling Locations – Wanapum Dam.

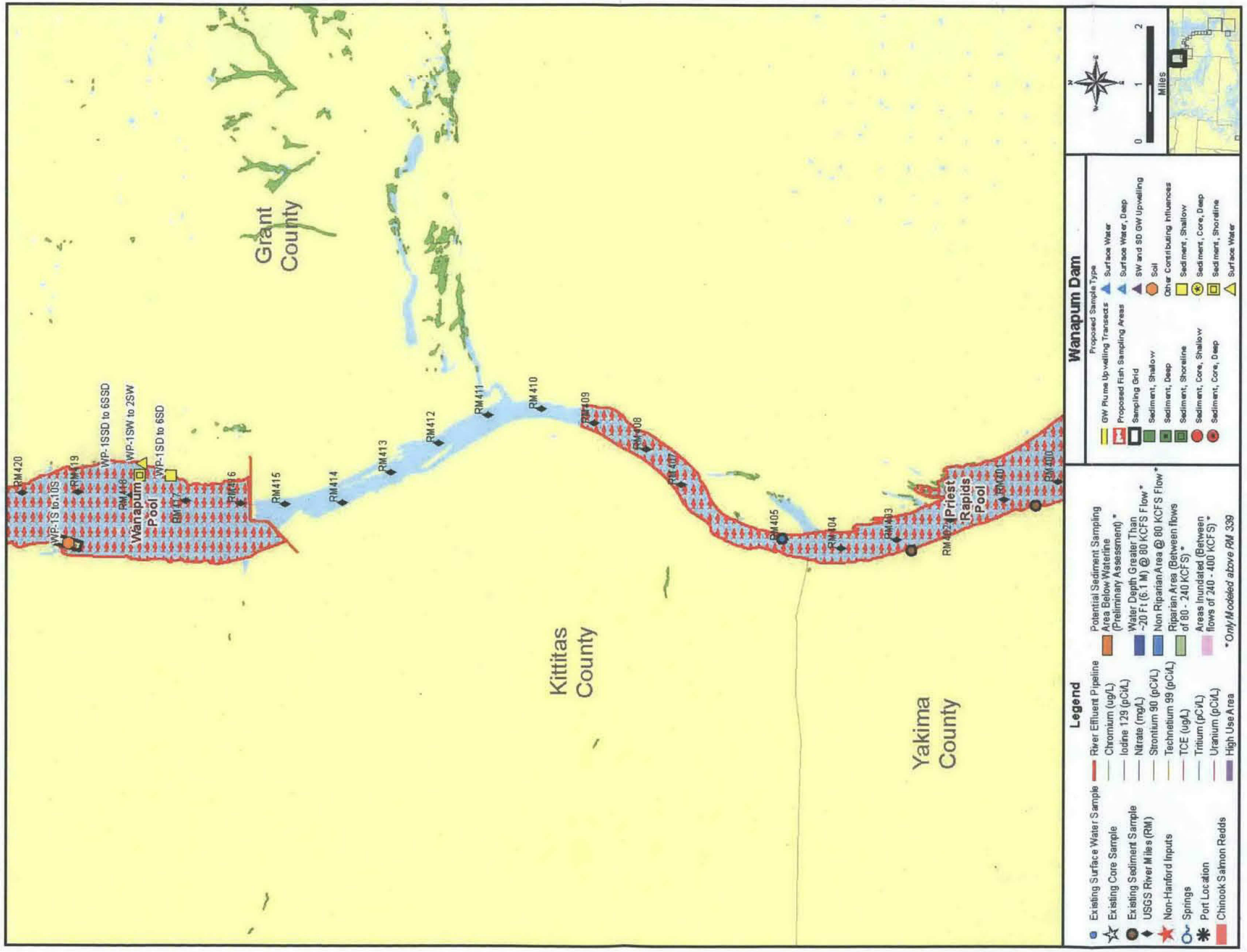


Figure 2-3. Proposed Sampling Locations – Upriver Sub-Area.

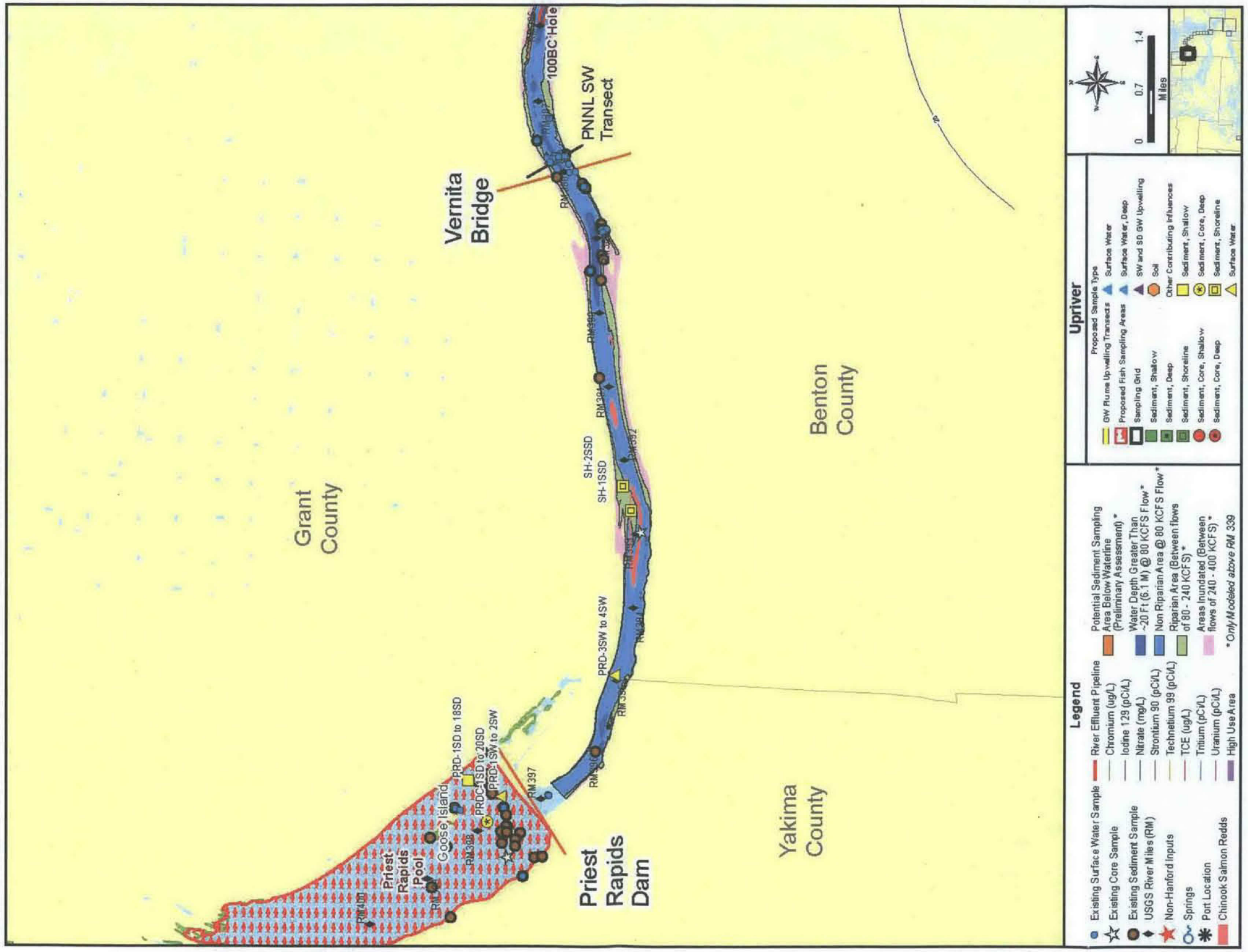


Figure 2-4. Proposed Sampling Locations – 100 Area Sub-Area (100-B/C).

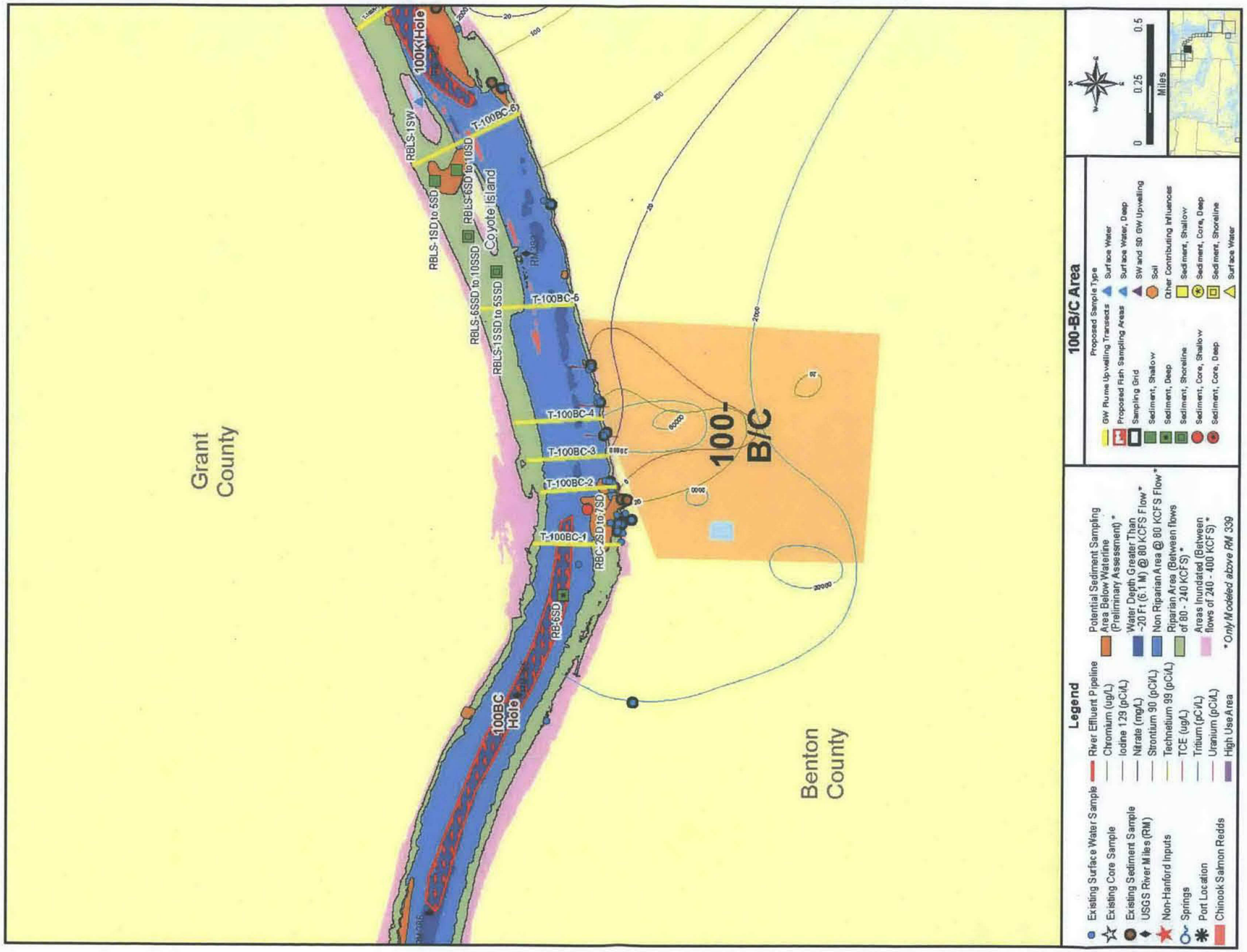


Figure 2-5. Proposed Sampling Locations – 100 Area Sub-Area (100-K).

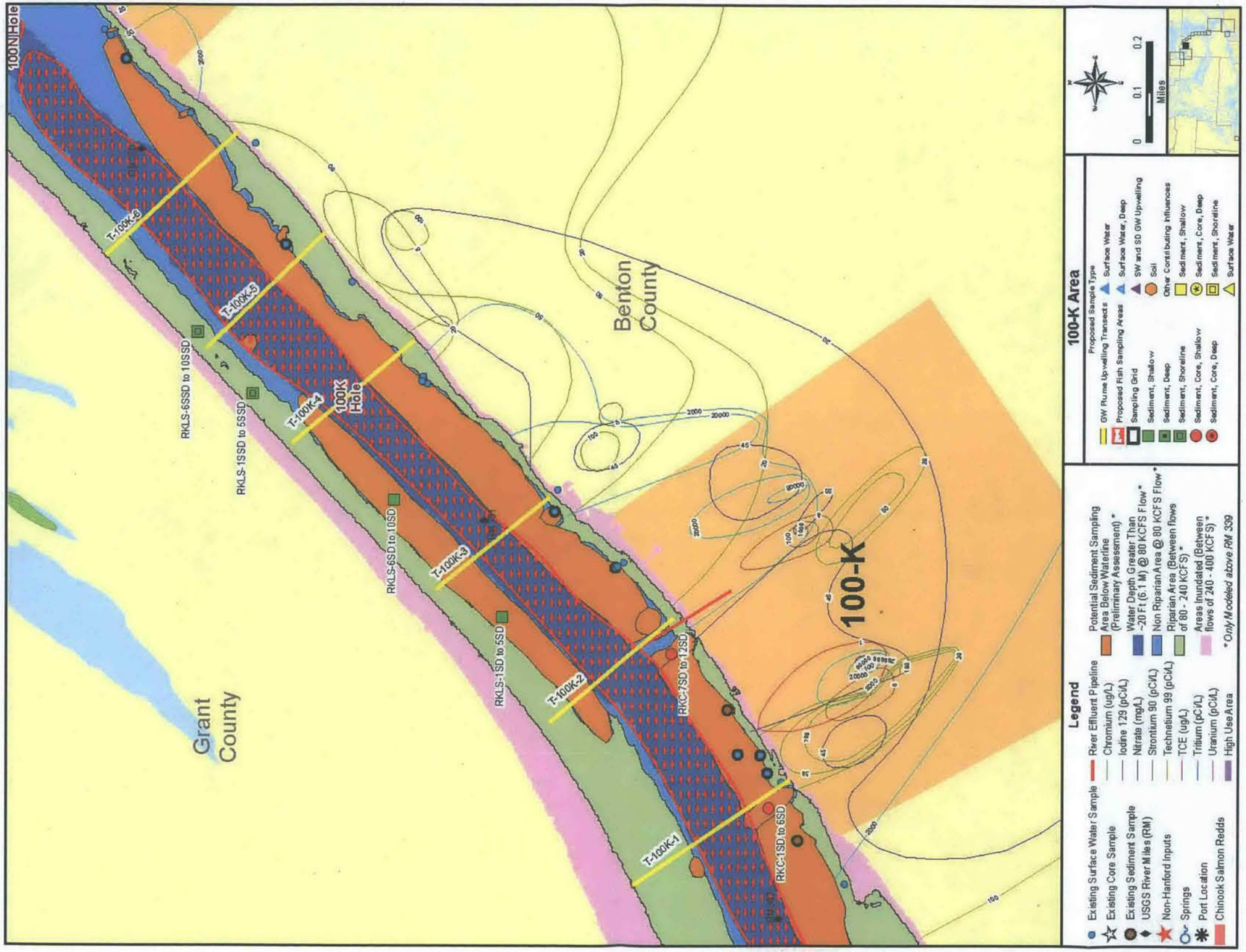


Figure 2-6. Proposed Sampling Locations – 100 Area Sub-Area (100-N).

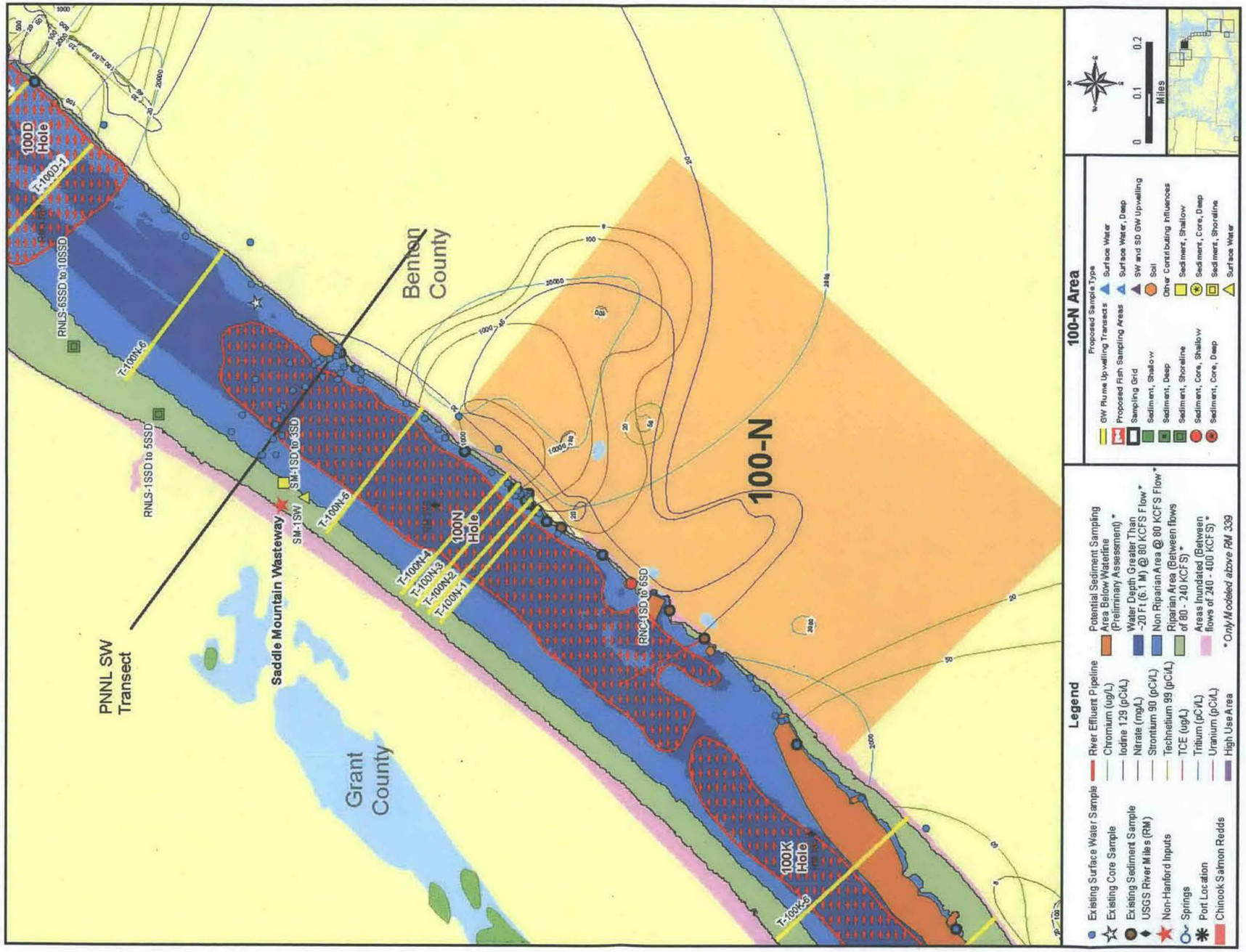


Figure 2-7. Proposed Sampling Locations – 100 Area Sub-Area (100-D).

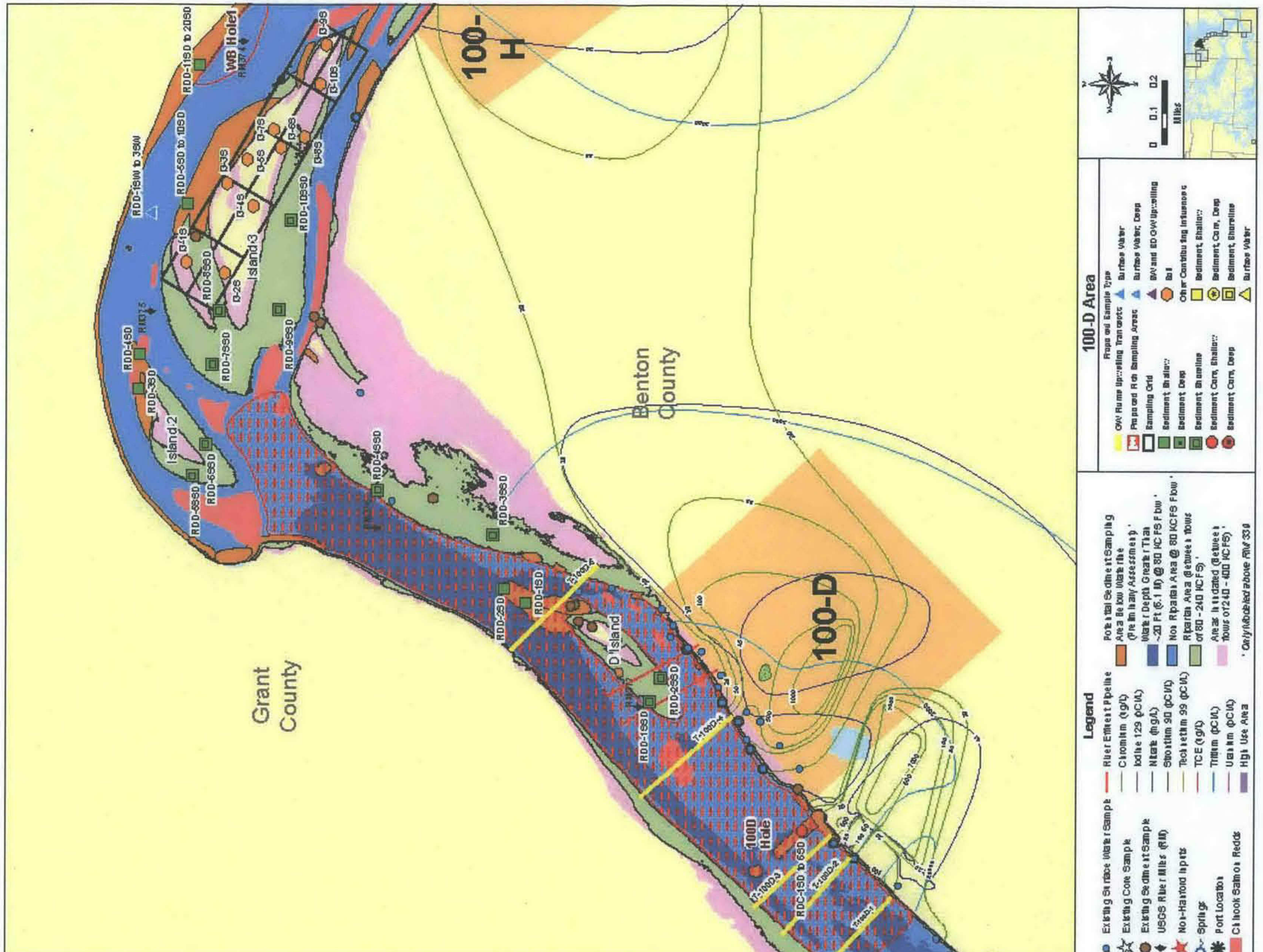
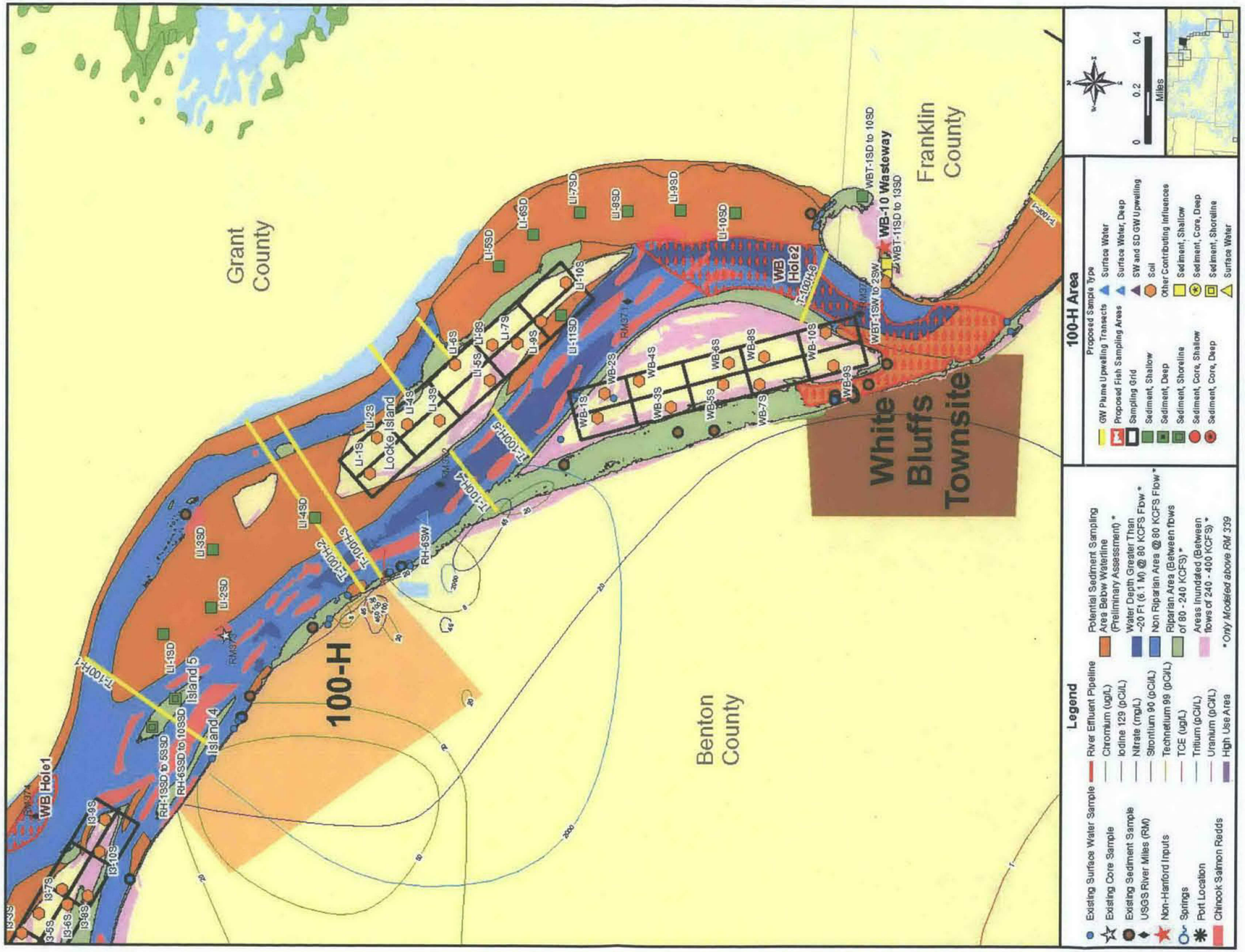


Figure 2-8. Proposed Sampling Locations – 100 Area Sub-Area (100-H).



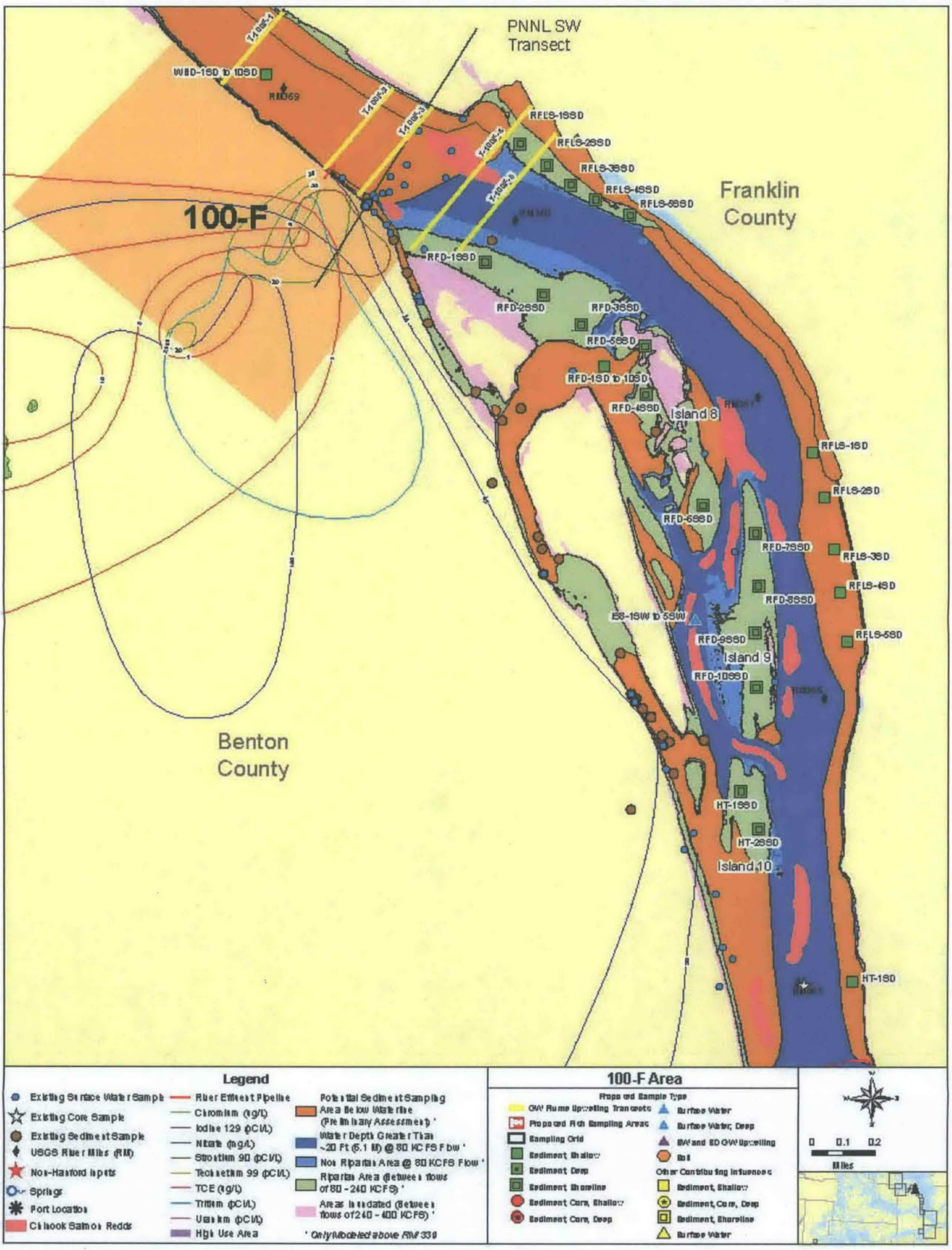


Figure 2-9. Proposed Sampling Locations – 100 Area Sub-Area (100-F).

Figure 2-10. Proposed Sampling Locations – 300 Area Sub-Area (Hanford Townsite (1)).

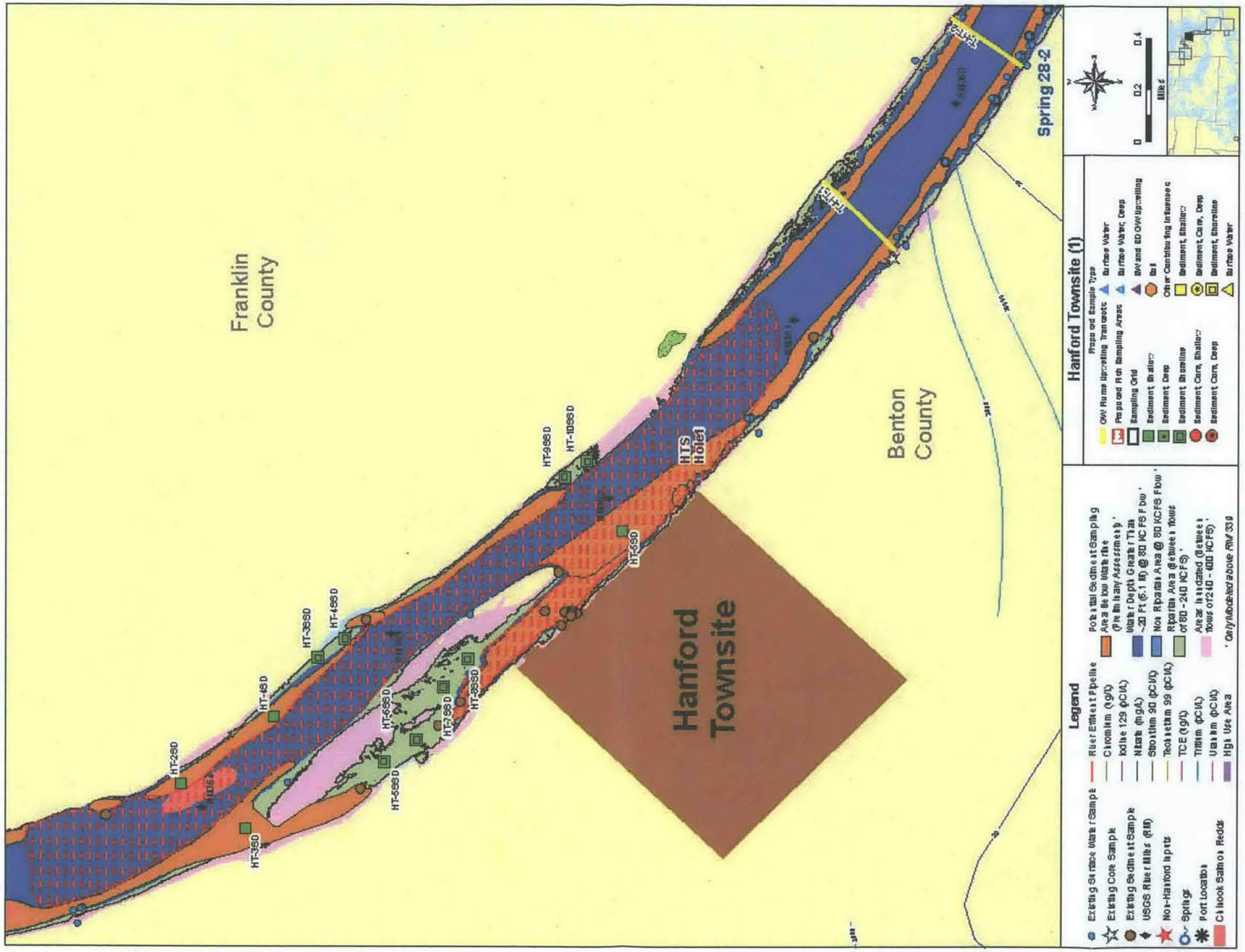


Figure 2-11. Proposed Sampling Locations – 300 Area Sub-Area (Hanford Townsite (2)).

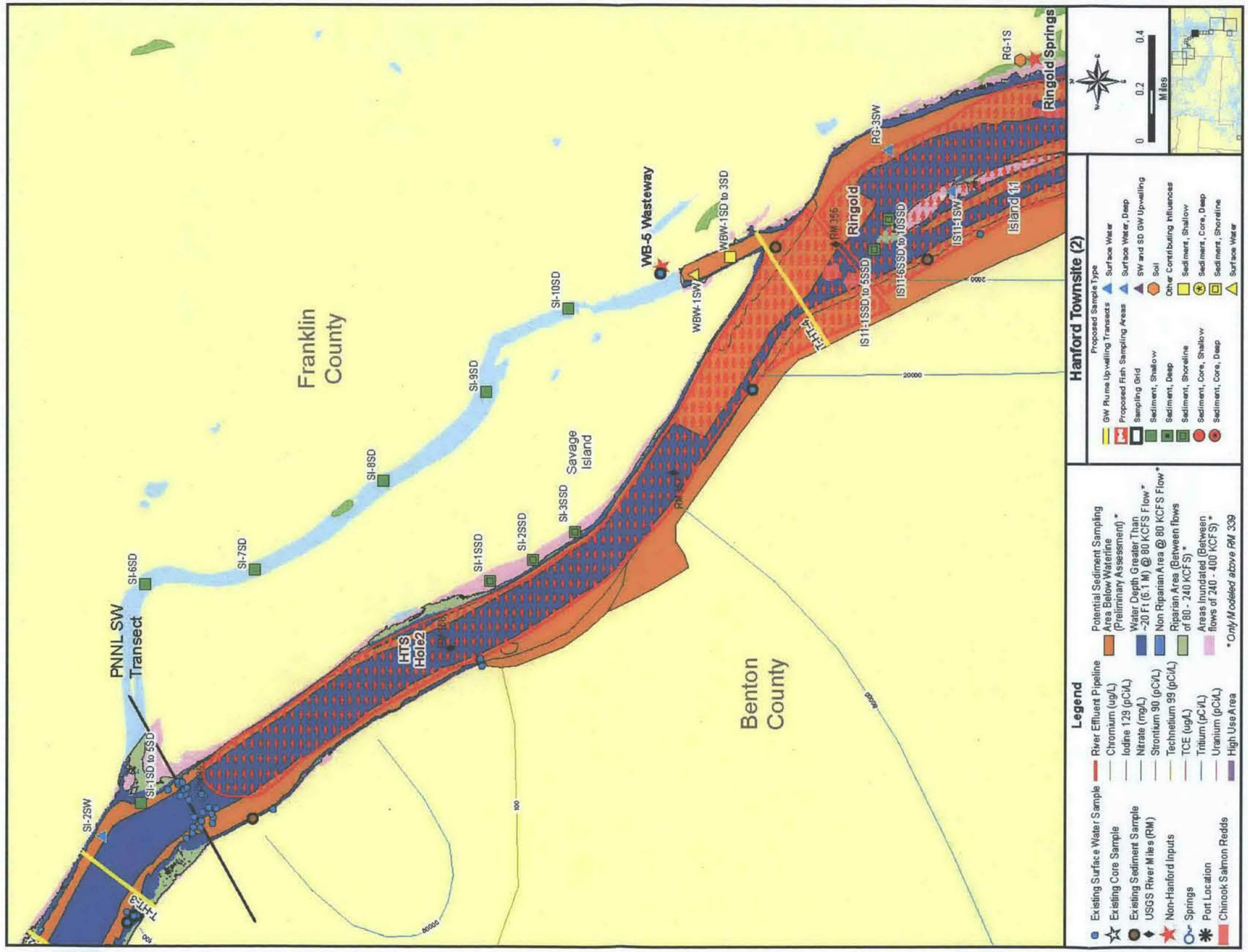


Figure 2-12. Proposed Sampling Locations – 300 Area Sub-Area (Hanford Townsite (3)).

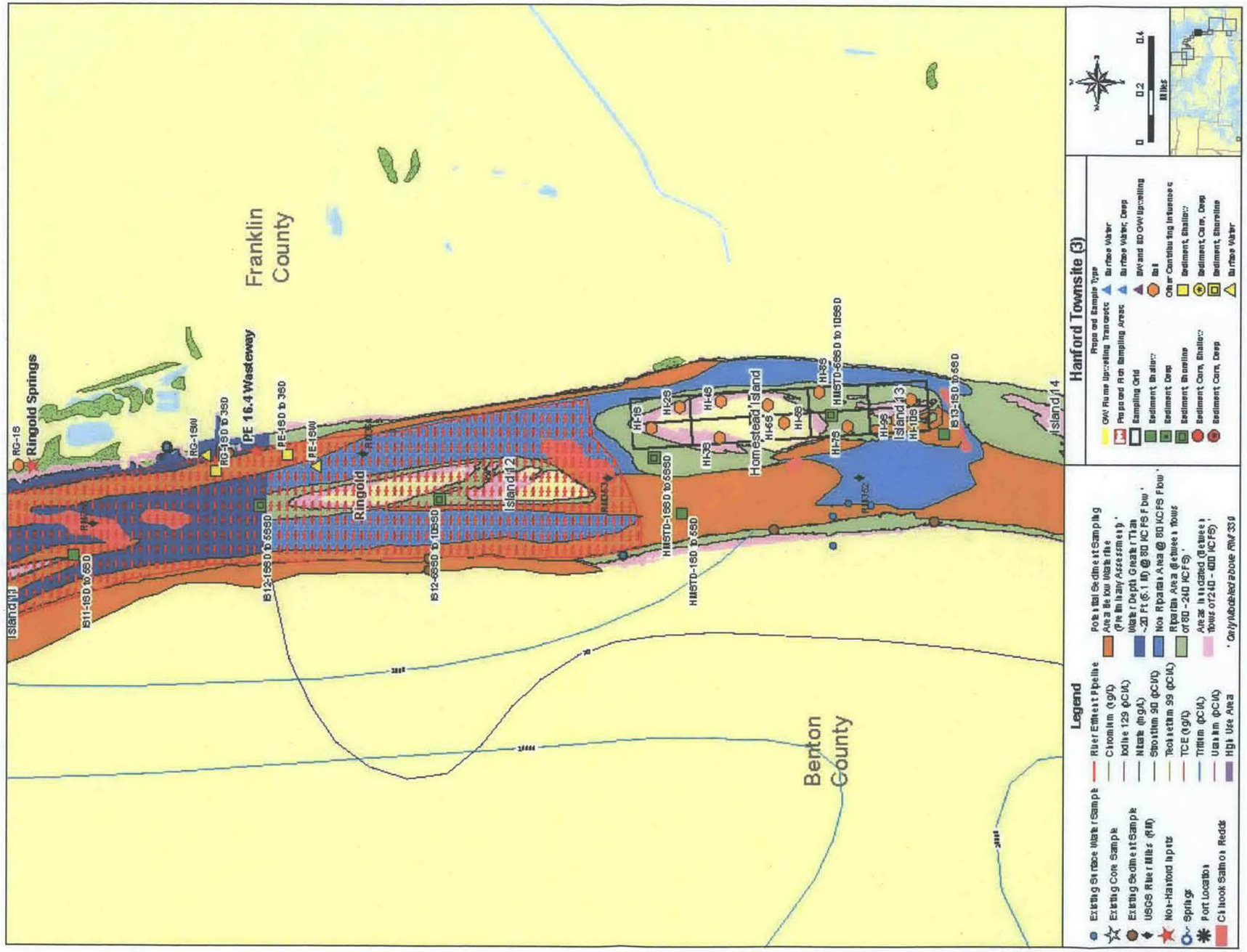


Figure 2-13. Proposed Sampling Locations – 300 Area Sub-Area (Hanford Townsite (4)).

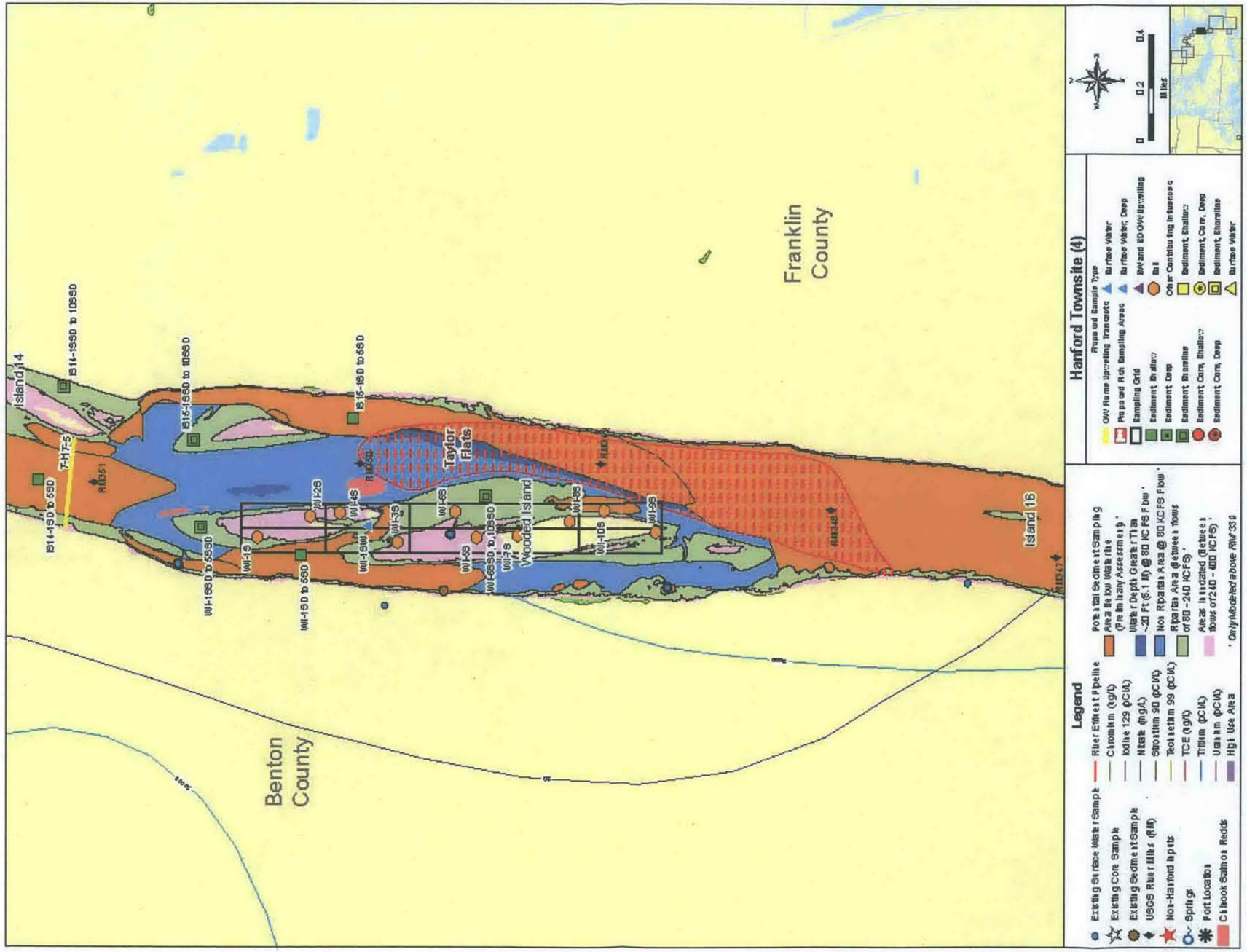


Figure 2-14. Proposed Sampling Locations –300 Area Sub-Area (1).

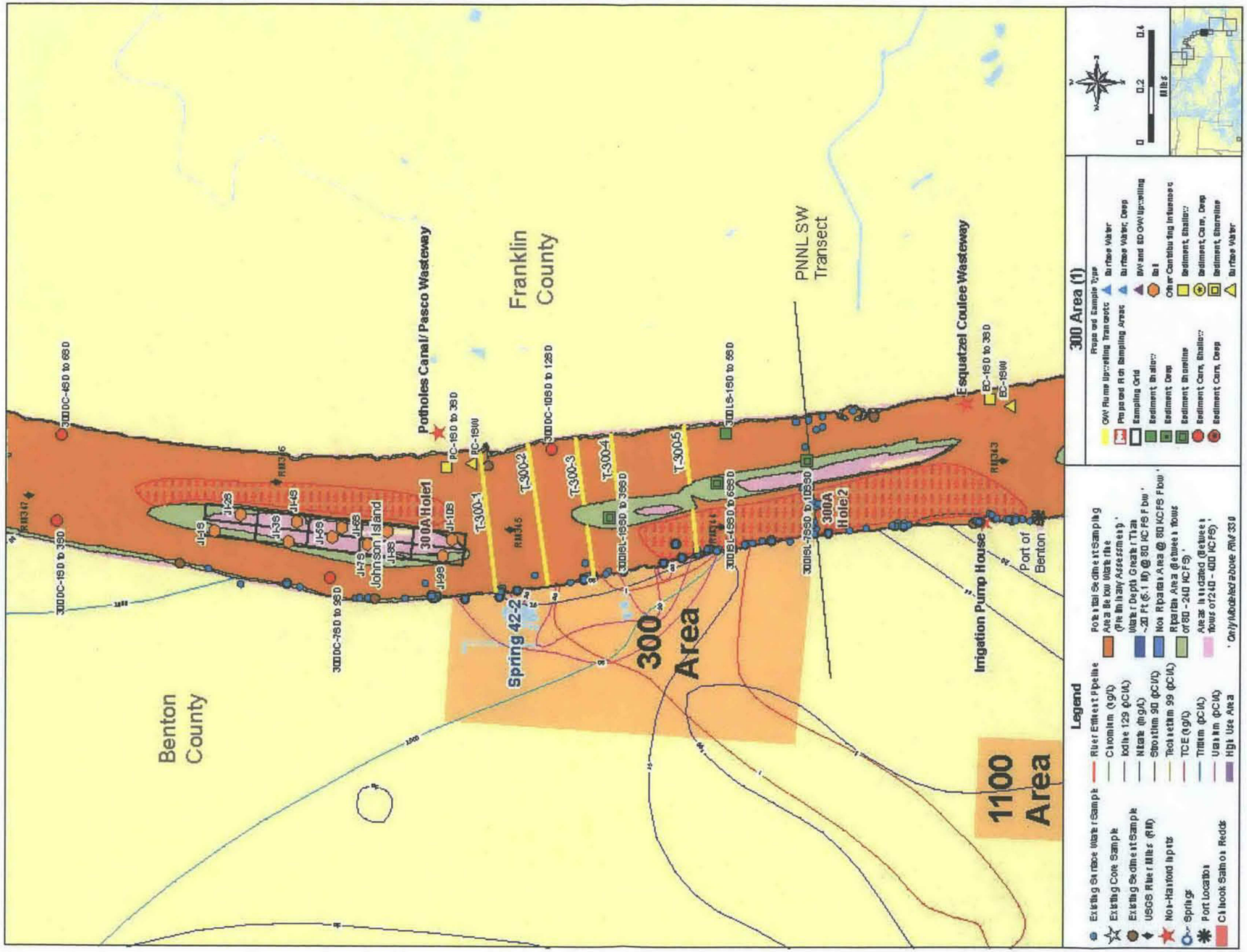


Figure 2-15. Proposed Sampling Locations –300 Area Sub-Area (2).

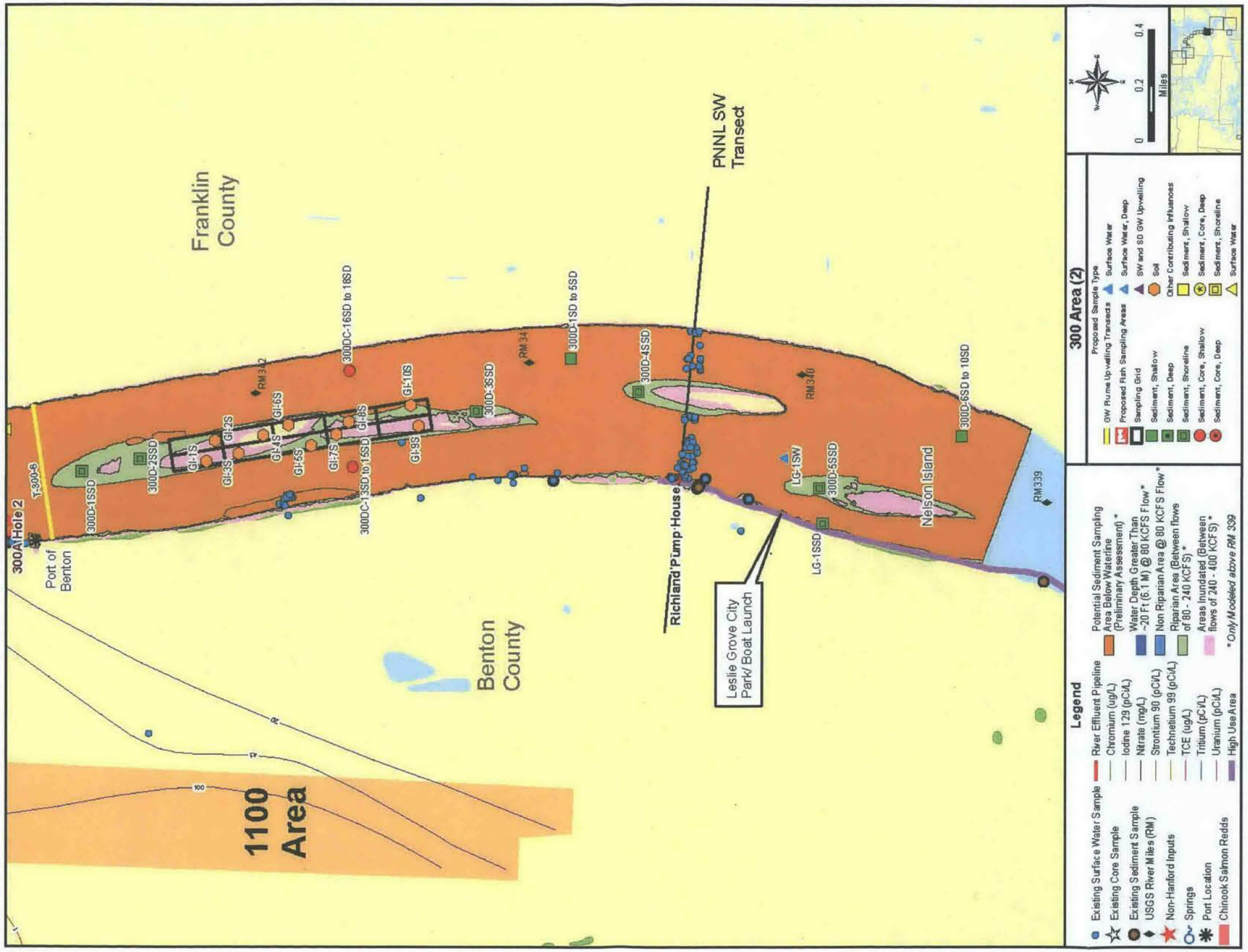
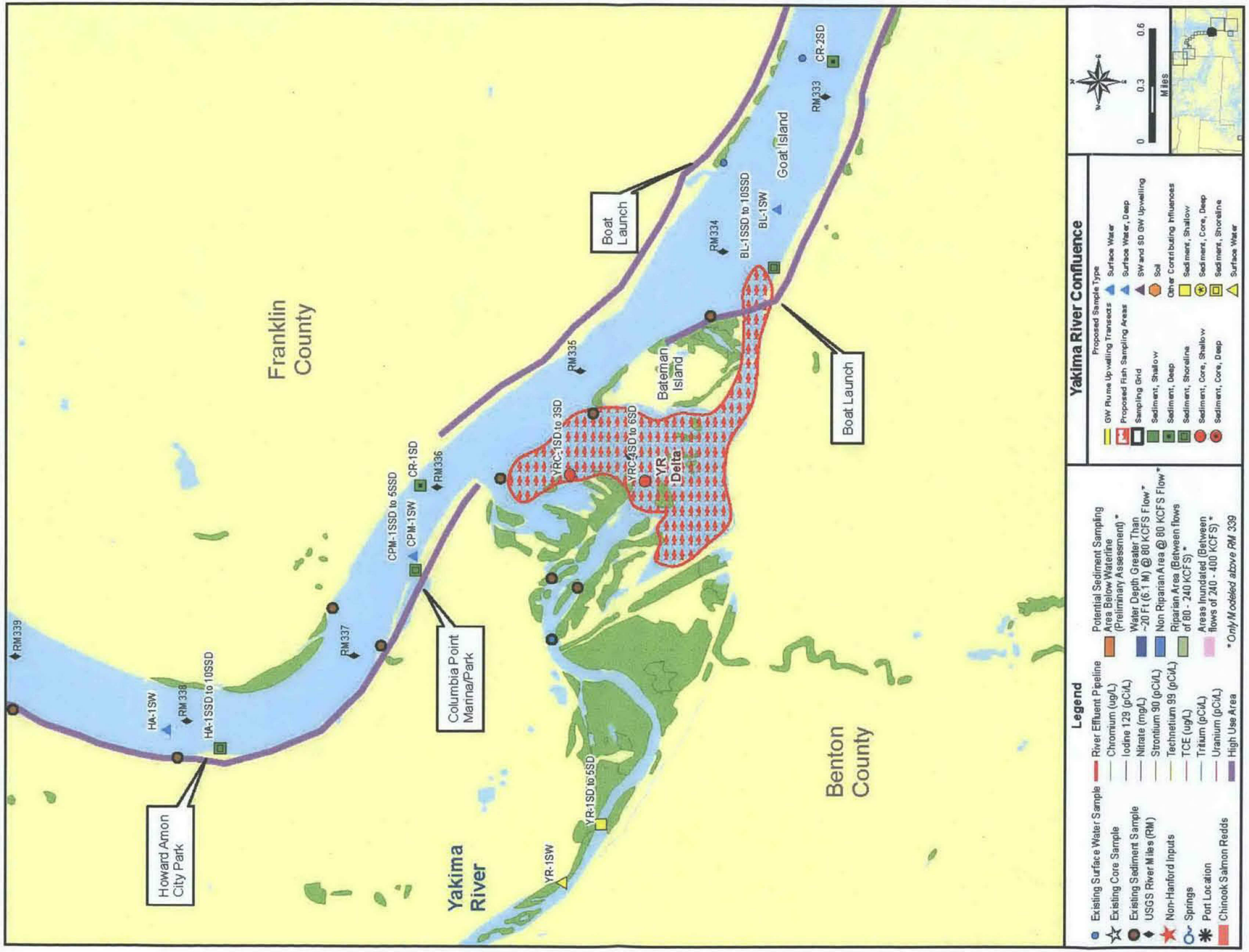


Figure 2-16. Proposed Sampling Locations – Lake Wallula Sub-Area (Yakima River Confluence).



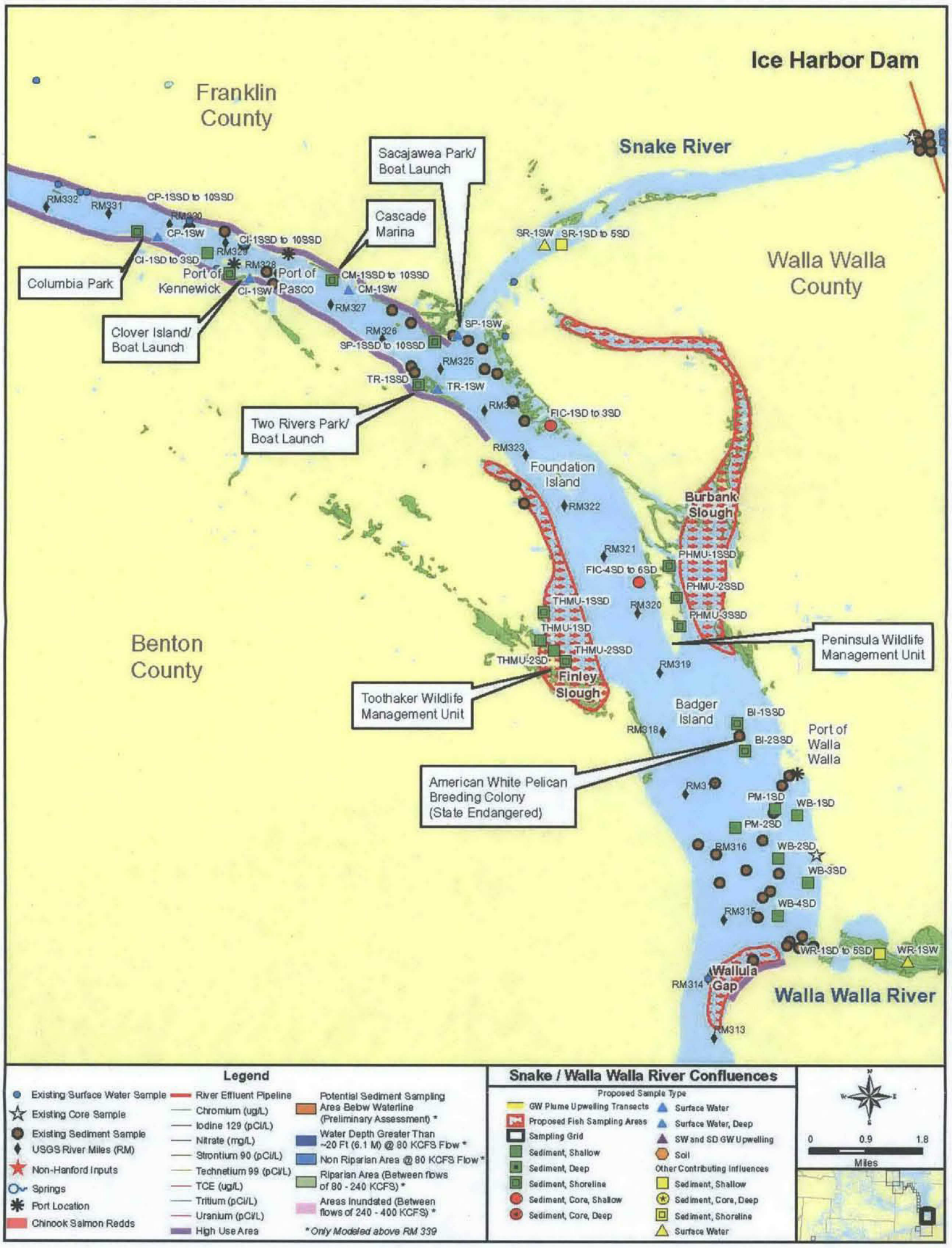


Figure 2-17. Proposed Sampling Locations – Lake Wallula Sub-Area (Snake/Walla Walla River Confluences).

Figure 2-18. Proposed Sampling Locations – Lake Wallula Sub-Area (Lake Wallula).

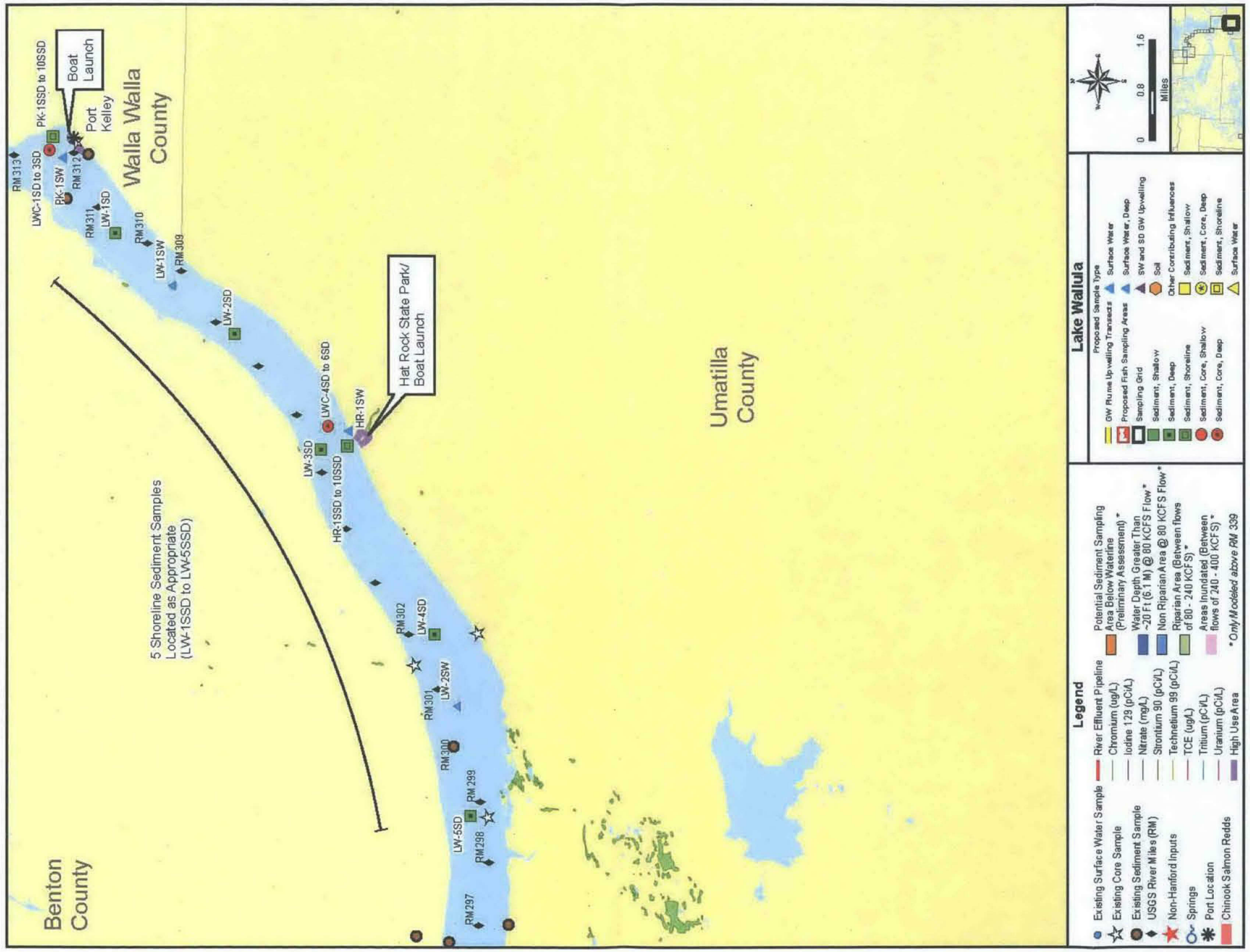


Figure 2-19. Proposed Sampling Locations – Lake Wallula Sub-Area (McNary Dam).

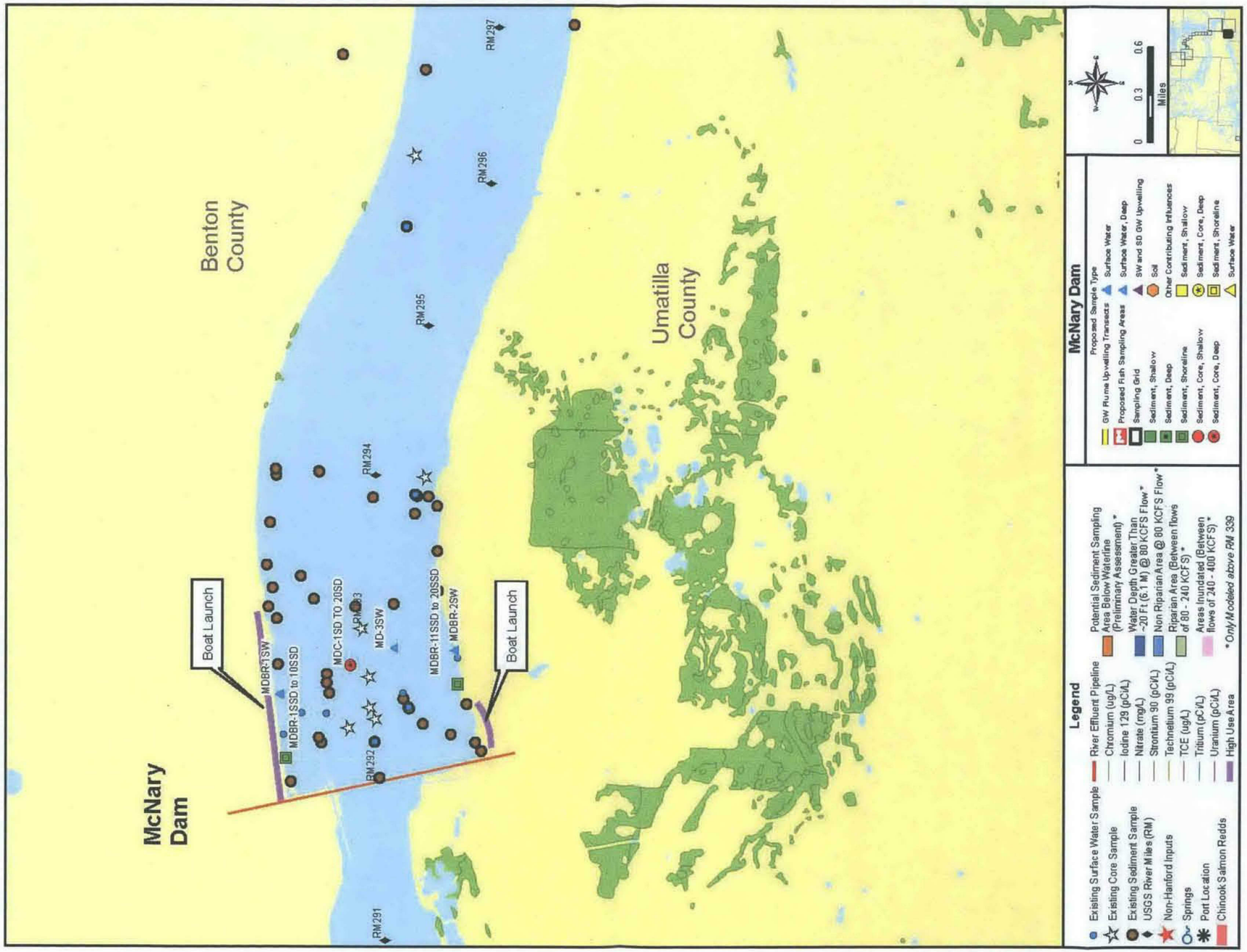


Figure 2-20. Proposed Sampling Locations – Bonneville Dam Pool Sub-Area.

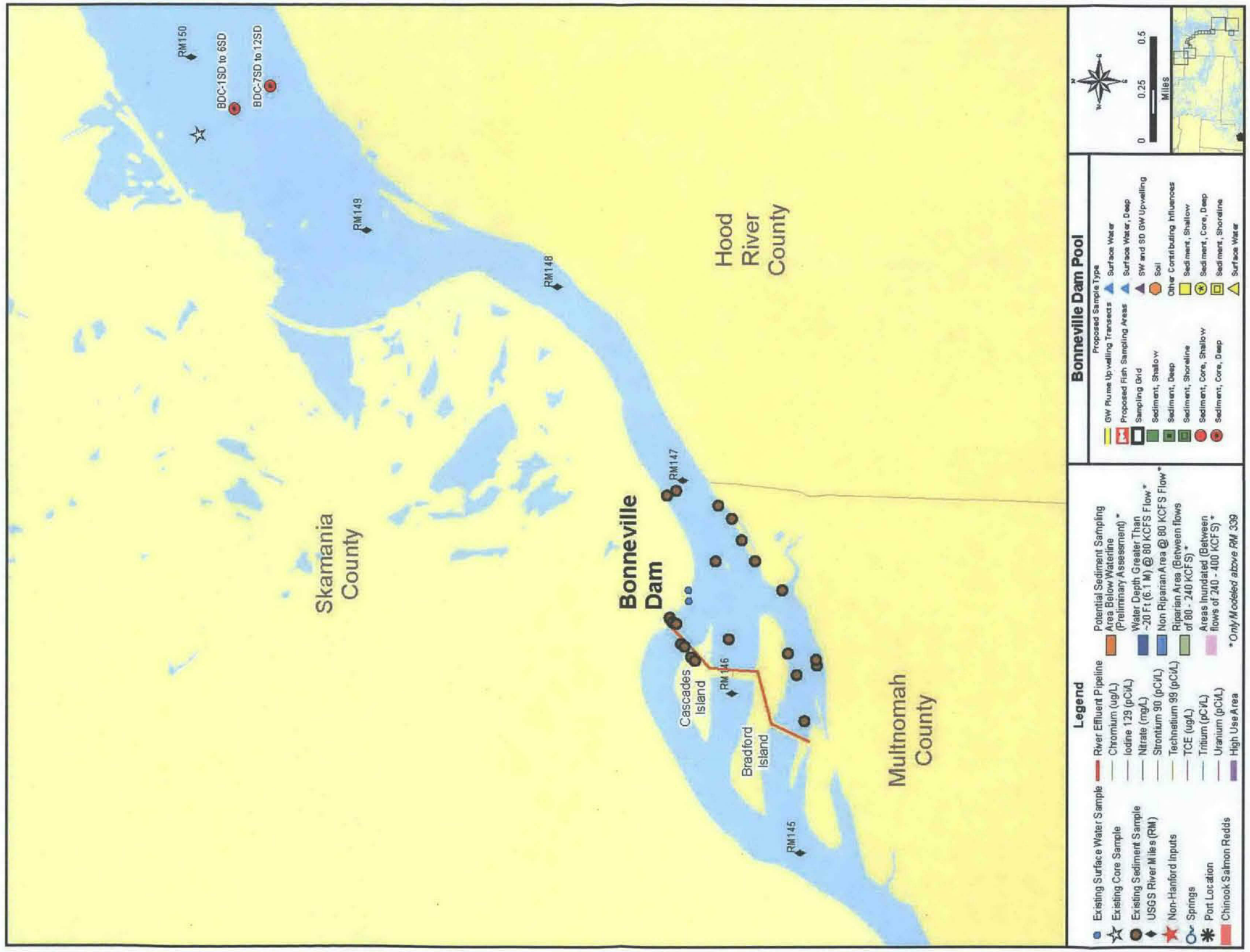


Table 2-2. Proposed Sampling and Analytical Plan for the Upriver Sub-Area. (2 Pages)

Sample Description									Analyses*/EPA Method																		
Figure	Designation	Sample Type	Collection Method	Sampling Location	Temporary Sample ID	Sample Design	Sample Depth	Number of Samples	VOCs - 8260B	SVOCs - 8270C	Metals (Filtered)[6] - 6010/6020/7471	Metals (Unfiltered) - 6010/6020/7471	Cr+6 - 7196A	Pesticides - 8081	PCBs - 8082	PCB Congeners - 1668A[5]	TOC/Grain Size - 9060/ASTM D4222	PHC - 8115	AVS/SEM - 200.8	Nitrate - 300.0	Radionuclides - GEA/AEA	Hardness\DOC\ Alkalinity - 130.1\415.1\310.1	% Lipids[7]	Field Parameters[3]	Rationale
Figure 2-2	OCI	Fish[2]	See Note 1	Wanapum Dam Pool	KH-FS1 to KH-FS5	Focused	NA	5	--	--	--	5	--	5	--	5	--	--	--	--	5	--	5	--	Sturgeon samples will be taken from Wanapum Dam Pool.
	OCI	Soil	Grab	Above Wanapum Dam	WP-1S to WP-10S	Random/ Stratified	0-0.5 ft	10	--	--	--	10	--	10	10	--	--	--	--	--	10	--	--	--	Surface soil samples will be taken from an island above Wanapum Dam (TBD). The samples will supplement previous sampling events and provide additional data for ecological and human evaluations. The samples will be collected from a random/stratified grid.
	OCI	Surface Water	Grab	Wanapum Dam Pool	WP-1SW to WP-2SW	Random/ Stratified	2/3 surface water depth	4	4	4	4	4	4	4	4	--	--	--	--	--	4	4	--	4	Upriver/background SW samples will be collected from Wanapum Dam (Pool). Limited to two samples SW should be well mixed and uniform. Used to augment existing data. Two samples will be collected in the spring, and two will be collected in the fall.
	OCI	Sediment, Shoreline	Grab	Wanapum Dam Pool	WP-1SSD to WP-6SSD	Random/ Stratified	0 - 0.3 ft	6	6	6	--	6	--	6	6	--	6	--	--	--	6	--	--	--	Upriver/background sediment samples will be collected from the lower riparian zone to provide background data for site characterization and the impacts to ecological receptors and humans.
	OCI	Sediment, Shallow	Ponar	Wanapum Dam Pool	WP-1SD to WP-6SD	Random/ Stratified	0 - 0.3 ft	6	6	6	--	6	6	6	6	--	6	6	--	--	6	--	--	--	Upriver/background shallow sediment samples will be collected. Locations to be determined after fine-grained sediment survey.
Figure 2-3	OCI	Sediment, Shallow	Ponar	Priest Rapids Dam	PRD-1SD to PRD-18SD	Random/ Stratified	0 - 0.3 ft	18	4	18	--	18	18	18	18	--	18	4	--	--	18	--	--	--	Upriver/background shallow sediment samples will be collected. Locations to be determined after fine-grained sediment survey. Eighteen samples to develop robust 95% UCL values.
	OCI	Sediment, Shoreline	Grab	Below Priest Rapids Dam	SH-1SSD to SH-2SSD	Random/ Stratified	0 - 0.3 ft	2	2	2	--	2	--	2	2	--	2	--	--	--	2	--	--	--	Upriver/background sediment samples will be collected from the lower riparian zone to provide background data for site characterization and the impacts to ecological receptors and humans.
	OCI	Surface Water	Grab	Priest Rapids Dam	PRD-1SW to PRD-2SW	Random/ Stratified	2/3 surface water depth	4	4	4	4	4	4	4	4	--	--	--	--	--	4	4	--	4	Upriver/background SW samples will be collected from Priest Rapids Dam (Pool). Limited to two samples SW should be well mixed and uniform. Used to augment existing data. Two samples will be collected in the spring, and two will be collected in the fall.
	OCI	Surface Water	Grab	Below Priest Rapids Dam	PRD-3SW to PRD-4SW	Random/ Stratified	2/3 surface water depth	4	4	4	4	4	4	4	4	--	--	--	--	--	4	4	--	4	Upriver/background SW samples (moving water) will be collected. Limited to two samples SW should be well mixed and uniform. Used to augment existing data. Two samples will be collected in the spring, and two will be collected in the fall.
	OCI	Fish[2]	See Note 1	Priest Rapids Dam Pool	WP-FS1 to WP-FS25	Focused	NA	25	--	--	--	25	--	25	--	25	--	--	--	--	25	--	25	--	Fish samples will be collected from upriver of the Priest Rapids Dam. Number and type of fish may vary depending on availability of fish at time of sampling.
	OCI	Core, Deep (4-inch diameter)	Drill Rig	Priest Rapids Dam	PRDC-1SD to PRDC-20SD (1 core subdivided into approx. 20 sed. samples)[4]	Focused	1 to refusal (8 inch subsamples)	20	--	--	20	--	--	--	--	--	20	--	--	--	--	--	--	--	Based on the findings of the sonar survey, single core will be collected in area of deep sediment. Estimate 15 feet of sediment, one sample every eight inches. Estimated sample mass of approximately 2,400 grams per sample interval. Used to supplement existing core data.

Table 2-2. Proposed Sampling and Analytical Plan for the Upriver Sub-Area. (2 Pages)

Sample Description									Analyses*/EPA Method																		Rationale
Figure	Designation	Sample Type	Collection Method	Sampling Location	Temporary Sample ID	Sample Design	Sample Depth	Number of Samples	VOCs - 8260B	SVOCs - 8270C	Metals (Filtered)[6] - 6010/6020/7471	Metals (Unfiltered) - 6010/6020/7471	Cr+6 - 7196A	Pesticides - 8081	PCBs - 8082	PCB Congeners - 1668A[5]	TOC/Grain Size - 9060/ASTM D4222	PHC - 8115	AVS/SEM - 200.8	Nitrate - 300.0	Radionuclides - GEA/AEA	Hardness\DOC\ Alkalinity - 130.1\415.1\310.1	% Lipids[7]	Field Parameters[3]	

Notes:
1 Fish collection method shall be either:
- electrofishing (off limits in spring due to presence of juvenile steelhead), effective for whitefish, carp, bass, and suckers; long-line;
- hook and line (effective for whitefish, walleye, and sturgeon)

2 Arsenic for both organic and inorganic speciation - fish tissue only
3 Field parameters for surface water samples are measured in the field and consist of temperature, specific conductivity, dissolved oxygen, and pH
4 The actual number of core subsamples will depend on the volume of sediment recovered.
5 Every 10th surface water and sediment sample analyzed for PCB Aroclors by 8082 will also be analyzed for PCB congeners. All fish samples will be analyzed for congeners only.
6 Filtered applies to water only. Solids (i.e., sediment and soil) are not filtered.
7 Bligh-Dyer (1959).
-- Sample not analyzed for given parameter
AEA = Alpha energy analysis
ASTM = American Society for Testing and Materials
AVS/SEM = acid volatile sulfides/simultaneously extracted metals by EPA Method 200.8
BERA = Baseline Ecological Risk Assessment
BHHRA = Baseline Human Health Risk Assessment
OCI = other contributing influence (i.e., non-Hanford)
Pesticides = by EPA Method 8081
PCE = tetrachloroethylene
PCBs = pesticides/polychlorinated biphenyls by EPA Method 8082
PHC = petroleum hydrocarbon by EPA Method 8115
SD = sediment
SVOCs = semivolatile organic compounds by EPA Method 8270C
SW = surface water
TOC = total organic carbon by EPA Method 9060
UCL = upper confidence limit
VOCs = volatile organic compounds by EPA Method 8260B

Table 2-3. Proposed Sampling and Analytical Plan for the 100 Area Sub-Area. (10 Pages)

Sample Description								Analyses*/EPA Method																	
Figure	Designation	Sample Type	Collection Method	Temporary Sample ID	Sample Design	Sample Depth	Number of Samples	VOCs - 8260B	SVOCs - 8270C	Metals (Filtered)[6] - 6010/6020/7471	Metals (Unfiltered) - 6010/6020/7471	Cr+6 - 7196A	Pesticides - 8081	PCBs - 8082	PCB Congeners - 1668A	TOC/Grain Size - 9060/ASTM D422	PHC - 8115	AVS/SEM - 200.8	Nitrate - 300.0	Radionuclides - GEA/AEA	Hardness\DOC\ Alkalinity - 130.1\415.1\310.1	% Lipids[9]	Field Parameters[3]	Rationale
Figure 2-4	Reactor Area	Pore Water, GU	Grab	RB-1PW to RB-6PW[7]	Focused	1 ft below mudline	6	--	--	--	6	6	--	--	--	--	--	--	6	6	--	--	6	Focus to characterize GW plume discharge to river. Major use will be ecological impacts. Five samples are budgeted; the actual number will depend on results of pore water sampling in the hyporheic zone adjacent to reactor area.
	Reactor Area	Pore Water, Screening	Grab	RB-6PW to RB-41PW[8]	Focused	1 ft below mudline	36	--	--	--	--	36	--	--	--	--	--	--	--	--	--	--	36	Focus to characterize GW plume discharge to river. Major use will be ecological impacts. Thirty samples are budgeted; the actual number will depend on results of pore water sampling in the hyporheic zone adjacent to reactor area.
	Reactor Area	Sediment, GU	Ponar	RB-1SD to RB-6SD[7]	Focused	0 - 0.3 ft	6	--	--	--	6	6	--	--	--	6	--	6	--	6	--	--	--	Focus to characterize GW plume discharge to river. Major use will be ecological impacts. Five samples are budgeted; the actual number will depend on results of pore water sampling in the hyporheic zone adjacent to reactor area.
	Reactor Area	Surface Water, GU	Grab	RB-1SW to RB-6SW[7]	Focused	1 ft above sediment surface	6	--	--	6	6	6	--	--	--	--	--	--	--	6	6	--	6	Focus to characterize GW plume discharge to river. Major use will be ecological impacts. Five samples are budgeted; the actual number will depend on results of pore water sampling in the hyporheic zone adjacent to reactor area.
	Reactor Area	Sediment, Shallow	Ponar	RBLS-1SD to RBLS-10SD	Random/ Stratified	0 - 0.3 ft	10	4	4	--	10	10	4	4	--	10	--	2	--	10	--	--	--	Based on sonar survey results, 10 samples will be collected on a sample grid on the far shore directly down river of Coyote Island as a potential depositional area for 100-B/C reactor releases.
	Reactor Area	Sediment, Shoreline	Grab	RBLS-1SSD to RBLS-10SSD	Random/ Stratified	0 - 0.3 ft	10	4	4	--	10	10	4	4	--	10	--	--	--	10	--	--	--	Based on an ecological habitat survey, ten samples will be collected on a sample grid on the far shore upriver of Coyote Island as a potential depositional area for 100-B/C reactor releases.
	Reactor Area	Sediment, Deep	Ponar	RB-6SD	Random/ Stratified	0 - 0.3 ft	1	--	--	--	1	1	--	--	--	1	--	--	--	--	--	--	--	One deep sediment sample will be taken from 100-B/C Hole. The upper 4 inches will be used for evaluating ecological impacts.
	Reactor Area	Surface Water	Grab	RBLS-1SW	Random/ Stratified	2/3 surface water depth	1	1	1	1	1	1	1	1	--	--	--	--	--	1	1	--	1	One SW sample will be collected from far shore to augment near shore RCBRA SW sampling.
	Reactor Area	Fish[2]	See Note 1	RB-FS1 to RB-FS5	Focused	NA	5	--	--	--	5	--	5	--	5	--	--	--	--	5	--	5	--	Fish samples will be collected from the 100-B/C Hole. Number and type of fish may vary depending on availability of fish at time of sampling.

Table 2-3. Proposed Sampling and Analytical Plan for the 100 Area Sub-Area. (10 Pages)

Sample Description								Analyses*/EPA Method																
Figure	Designation	Sample Type	Collection Method	Temporary Sample ID	Sample Design	Sample Depth	Number of Samples	VOCs - 8260B	SVOCs - 8270C	Metals (Filtered)[6] - 6010/6020/7471	Metals (Unfiltered) - 6010/6020/7471	Cr+6 - 7196A	Pesticides - 8081	PCBs - 8082	PCB Congeners - 1668A	TOC/Grain Size - 9060/ASTM D422	PHC - 8115	AVS/SEM - 200.8	Nitrate - 300.0	Radionuclides - GEA/AEA	Hardness\DOC\ Alkalinity - 130.1\415.1\310.1	% Lipids[9]	Field Parameters[3]	Rationale
Figure 2-4 (cont.)	Reactor Area	Core, Shallow (2-inch diameter)	Vibracore	RBC-2SD to RBC-7SD (1 core location subdivided into approx. 6 sed. samples)[4]	Focused	0 - Refusal (1 ft subsamples)	6	1	1	--	6	6	1	1	--	6	1	1	--	6	--	--	--	One core will be completed within the water intake trench/structure. Samples will be divided into 6 one foot samples (2-in core = ~ 600 gms per 1 foot). Evaluate historic deposition of Hanford contamainates (e.g., sediment trap).
Figure 2-5	Reactor Area	Pore Water, GU	Grab	RK-1PW to RK-6PW[7]	Focused	1 ft below mudline	6	--	--	--	6	6	--	--	--	--	--	--	6	--	--	--	6	Focus to characterize GW plume discharge to river. Major use will be ecological impacts. Five samples are budgeted; the actual number will depend on results of pore water sampling in the hyporheic zone adjacent to reactor area.
	Reactor Area	Pore Water, Screening	Grab	RK-6PW to RK-41PW[8]	Focused	1 ft below mudline	36	--	--	--	--	36	--	--	--	--	--	--	--	--	--	--	36	Focus to characterize GW plume discharge to river. Major use will be ecological impacts. Thirty samples are budgeted; the actual number will depend on results of pore water sampling in the hyporheic zone adjacent to reactor area.
	Reactor Area	Sediment, GU	Ponar	RK-1SD to RK-6SD[7]	Focused	1 - 0.3 ft	6	--	--	--	6	6	--	--	--	6	--	6	--	6	--	--	--	Focus to characterize GW plume discharge to river. Major use will be ecological impacts. Five samples are budgeted; the actual number will depend on results of pore water sampling in the hyporheic zone adjacent to reactor area.
	Reactor Area	Surface Water, GU	Grab	RK-1SW to RK-6SW[7]	Focused	1 ft above sediment surface	6	--	--	6	6	6	--	--	--	--	--	--	--	6	6	--	6	Focus to characterize GW plume discharge to river. Major use will be ecological impacts. Five samples are budgeted; the actual number will depend on results of pore water sampling in the hyporheic zone adjacent to reactor area.
	Reactor Area	Sediment, Shallow	Ponar	RKLS-1SD to RKLS-10SD	Random/ Stratified	0 - 0.3 ft	10	4	4	--	10	10	4	4	--	10	--	2	--	10	--	--	--	Based on sonar survey results, ten samples will be collected on a sample grid on the far shore across from and downriver of 100-K as a potential depositional area for reactor releases.
	Reactor Area	Sediment, Shoreline	Grab	RKLS-1SSD to RKLS-10SSD	Random/ Stratified	0 - 0.3 ft	10	4	4	--	10	10	4	4	--	10	--	--	--	10	--	--	--	Based on an ecological habitat survey, ten samples will be collected on a sample grid on the far shore downriver of 100-K as a potential depositional area for 100-K reactor releases.

Table 2-3. Proposed Sampling and Analytical Plan for the 100 Area Sub-Area. (10 Pages)

Sample Description								Analyses*/EPA Method																
Figure	Designation	Sample Type	Collection Method	Temporary Sample ID	Sample Design	Sample Depth	Number of Samples	VOCs - 8260B	SVOCs - 8270C	Metals (Filtered)[6] - 6010/6020/7471	Metals (Unfiltered) - 6010/6020/7471	Cr+6 - 7196A	Pesticides - 8081	PCBs - 8082	PCB Congeners - 1668A	TOC/Grain Size - 9060/ASTM D422	PHC - 8115	AVS/SEM - 200.8	Nitrate - 300.0	Radionuclides - GEA/AEA	Hardness\DOC\ Alkalinity - 130.1\415.1\310.1	% Lipids[9]	Field Parameters[3]	Rationale
Figure 2-5 (cont.)	Reactor Area	Fish[2]	See Note 1	RK-FS1 to RK-FS5	Focused	NA	5	--	--	--	5	--	5	--	5	--	--	--	--	5	--	5	--	Fish samples will be collected from the 100-K Hole. Number and type of fish may vary depending on availability of fish at time of sampling.
	Reactor Area	Core, Shallow (2-inch diameter)	Vibracore	RKC-1SD to RKC-6SD (1 core location subdivided into approx. 6 sed. samples)[4]	Focused	0 - Refusal (1 ft subsamples)	6	1	1	--	6	6	1	1	--	6	--	1	--	6	--	--	--	One core will be completed within the water intake trench/structure. Samples will be divided into 6 one foot samples (2-in core = ~ 600 gms per 1 foot). Used to evaluate historic deposition of Hanford contaminants (e.g., sediment trap).
	Reactor Area	Core, Shallow (2-inch diameter)	Vibracore	RKC-7SD to RKC-12SD (1 core location subdivided into approx. 6 sed. samples)[4]	Focused	0 - Refusal (1 ft subsamples)	6	1	1	--	6	6	1	1	--	6	--	1	--	6	--	--	--	One core will be completed within the water intake trench/structure. Samples will be divided into 6 one foot samples (2-in core = ~ 600 gms per 1 foot). Used to evaluate historic deposition of Hanford contaminants (e.g., sediment trap).
Figure 2-6	Reactor Area	Pore Water, GU	Grab	RN-1PW to RN-6PW[7]	Focused	1 ft below mudline	6	--	--	--	6	6	--	--	--	--	--	--	6	6	--	--	6	Focus to characterize GW plume discharge to river. Major use will be ecological impacts. Five samples are budgeted the actual number will depend on results of pore water sampling in the hyporheic zone adjacent to reactor area. Radionuclides for analysis consist of Sr-90.
	Reactor Area	Pore Water, Screening	Grab	RN-6PW to RN-41PW[8]	Focused	1 ft below mudline	36	--	--	--	--	--	--	--	--	--	--	--	--	36	--	--	36	Focus to characterize GW plume discharge to river. Major use will be ecological impacts. Thirty samples are budgeted; the actual number will depend on results of pore water sampling in the hyporheic zone adjacent to reactor area.
	Reactor Area	Sediment, GU	Ponar	RN-1SD to RN-6SD[7]	Focused	0 - 0.3 ft	6	--	--	--	6	6	--	--	--	6	--	6	--	6	--	--	--	Focus to characterize GW plume discharge to river. Major use will be ecological impacts. Five samples are budgeted; the actual number will depend on results of pore water sampling in the hyporheic zone adjacent to reactor area.
	Reactor Area	Surface Water, GU	Grab	RN-1SW to RN-6SW[7]	Focused	1 ft above sediment surface	6	--	--	6	6	6	--	--	--	--	--	--	--	6	6	--	6	Focus to characterize GW plume discharge to river. Major use will be ecological impacts. Five samples are budgeted; the actual number will depend on results of pore water sampling in the hyporheic zone adjacent to reactor area.

Table 2-3. Proposed Sampling and Analytical Plan for the 100 Area Sub-Area. (10 Pages)

Sample Description								Analyses*/EPA Method																	
Figure	Designation	Sample Type	Collection Method	Temporary Sample ID	Sample Design	Sample Depth	Number of Samples	VOCs - 8260B	SVOCs - 8270C	Metals (Filtered)[6] - 6010/6020/7471	Metals (Unfiltered) - 6010/6020/7471	Cr+6 - 7196A	Pesticides - 8081	PCBs - 8082	PCB Congeners - 1668A	TOC/Grain Size - 9060/ASTM D422	PHC - 8115	AVS/SEM - 200.8	Nitrate - 300.0	Radionuclides - GEA/AEA	Hardness\DOC\ Alkalinity - 130.1\415.1\310.1	% Lipids[9]	Field Parameters[3]	Rationale
Figure 2-6 (cont.)	OCI	Sediment, Shallow	Ponar	SM-1SD to SM-3SD	Focused	0 - 0.3 ft	3	3	3	--	3	3	3	3	--	3	--	--	--	--	--	--	--	--	Three samples will be collected on the far shore down river of 100-N and at Saddle Mountain Wasteway to evaluate potential reactor depositions as well as other contributing influences.
	Reactor Area	Sediment, Shoreline	Grab	RNLS-1SSD to RNLS-10SSD	Random/ Stratified	0 - 0.3 ft	10	4	4	--	10	10	4	4	--	10	10	--	--	10	--	--	--	Based on an ecological habitat survey, ten samples will be collected on a sample grid on the far shore downriver of 100-N as a potential depositional area for 100-N reactor releases.
	OCI	Surface Water	Grab	SM-1SW (1 sample in spring, 1 sample in fall)	Focused	2/3 surface water depth	2	2	2	2	2	2	2	2	--	--	--	--	--	2	2	--	2	Two surface water samples (one each in spring and fall) to augment the evaluation of other contributing influences on the far (left) shore across and downriver from Area 100-N at the Saddle Mountain Wasteway.
	Reactor Area	Fish[2]	See Note 1	RN-FS1 to RN-FS5	Focused	NA	5	--	--	--	5	--	5	--	5	--	--	--	--	5	--	5	--	Fish samples from the 100-N Hole. Number and type of fish may vary depending on availability of fish at time of sampling.
	Reactor Area	Core, Shallow (2-inch diameter)	Vibracore	RNC-1SD to RNC-6SD (1 core location subdivided. into approx. 6 sed. samples)[4]	Focused	0 - Refusal (1 ft subsamples)	6	1	1	--	6	6	1	1	--	6	1	1	--	6	--	--	--	One core will be completed within the water intake trench/structure. Samples will be divided into 6 one foot samples (2-in core = ~ 600 gms per 1 foot). Used to evaluate historic deposition of Hanford contamainates (e.g., sediment trap).
Figure 2-7	Reactor Area	Pore Water, GU	Grab	RD-1PW to RD-5PW[7]	Focused	1 ft below mudline	5	--	--	--	5	5	--	--	--	--	--	--	--	5	--	--	--	5	Focus to characterize GW plume discharge to river. Major use will be ecological impacts. Five samples are budgeted; the actual number will depend on results of pore water sampling in the hyporheic zone adjacent to reactor area.
	Reactor Area	Pore Water, Screening	Grab	RD-6PW to RD-35PW[8]	Focused	1 ft below mudline	30	--	--	--	--	30	--	--	--	--	--	--	--	--	--	--	--	30	Focus to characterize GW plume discharge to river. Major use will be ecological impacts. Thirty samples are budgeted; the actual number will depend on results of pore water sampling in the hyporheic zone adjacent to reactor area.

Table 2-3. Proposed Sampling and Analytical Plan for the 100 Area Sub-Area. (10 Pages)

Sample Description								Analyses*/EPA Method																
Figure	Designation	Sample Type	Collection Method	Temporary Sample ID	Sample Design	Sample Depth	Number of Samples	VOCs - 8260B	SVOCs - 8270C	Metals (Filtered)[6] - 6010/6020/7471	Metals (Unfiltered) - 6010/6020/7471	Cr+6 - 7196A	Pesticides - 8081	PCBs - 8082	PCB Congeners - 1668A	TOC/Grain Size - 9060/ASTM D422	PHC - 8115	AVS/SEM - 200.8	Nitrate - 300.0	Radionuclides - GEA/AEA	Hardness\DOC\ Alkalinity - 130.1\415.1\310.1	% Lipids[9]	Field Parameters[3]	Rationale
Figure 2-7 (cont.)	Reactor Area	Sediment, GU	Ponar	RD-1SD to RD-5SD[7]	Focused	0 - 0.3 ft	5	--	--	--	5	5	--	--	--	5	--	5	--	5	--	--	--	Focus to characterize GW plume discharge to river. Major use will be ecological impacts. Five samples are budgeted; the actual number will depend on results of pore water sampling in the hyporheic zone adjacent to reactor area.
	Reactor Area	Surface Water, GU	Grab	RD-1SW to RD-5SW[7]	Focused	1 ft above sediment surface	5	--	--	5	5	5	--	--	--	--	--	--	--	5	5	--	5	Focus to characterize GW plume discharge to river. Major use will be ecological impacts. Five samples are budgeted; the actual number will depend on results of pore water sampling in the hyporheic zone adjacent to reactor area.
	Reactor Area	Sediment, Shallow	Ponar	RDD-1SD to RDD-10SD	Random/ Stratified	0 - 0.3 ft	10	4	4	--	10	10	4	4	--	10	--	4	--	10	--	--		Based on sonar survey results, two samples will be collected from the shallow area downriver and adjacent to D Island; another two samples will be collected from the shallow area downriver and adjacent to Island 2; the remaining samples will be collected from the shallow area on the far (left) side of Island 3.
	Reactor Area	Sediment, Shallow	Ponar	RDD-11SD to RDD-20SD	Random/ Stratified	0 - 0.3 ft	10	4	4	--	10	10	4	4	--	10	4	4	--	10	--	--		Based on sonar survey results, ten samples will be collected on the far (left) shore across from Island 3 and in the shore area of WB Hole 1
	Reactor Area	Sediment, Shoreline	Grab	RDD-1SSD to RDD-10SSD	Random/ Stratified	0 - 0.3 ft	10	4	4	--	10	10	4	4	--	10	4	--	--	10	--	--		Based on an ecological habitat survey, ten samples will be collected. Two samples will be collected from the shallow area upriver and adjacent to D Island; two more samples will be collected from the shallow area on the near shore (right) downriver from D Island; two samples will be collected from the shallow area upriver and adjacent to Island 2; the remaining samples will be collected upriver and adjacent to Island 3 on the near shore side.
	Reactor Area	Surface Water	Grab	RDD-1SW to RDD-3SW	Random/ Stratified	2/3 surface water depth	3	1	1	3	3	3	1	1	--	--	--	--	--	3	3	--	3	Three surface water samples will be taken between the upriver portion of Island 3 and the far (left) shore to augment near shore RCBRA sampling.
	Reactor Area	Fish[2]	See Note 1	RD-FS1 to RD-FS5	Focused	NA	5	--	--	--	5	--	5	--	5	--	--	--	--	5	--	5	--	Fish samples will be collected from the 100-D Hole. Number and type of fish may vary depending on availability of fish at time of sampling.

Table 2-3. Proposed Sampling and Analytical Plan for the 100 Area Sub-Area. (10 Pages)

Sample Description								Analyses[a]/EPA Method																
Figure	Designation	Sample Type	Collection Method	Temporary Sample ID	Sample Design	Sample Depth	Number of Samples	VOCs - 8260B	SVOCs - 8270C	Metals (Filtered)[6] - 6010/6020/7471	Metals (Unfiltered) - 6010/6020/7471	Cr+6 - 7196A	Pesticides - 8081	PCBs - 8082	PCB Congeners - 1668A	TOC/Grain Size - 9060/ASTM D422	PHC - 8115	AVS/SEM - 200.8	Nitrate - 300.0	Radionuclides - GEA/AEA	Hardness\DOC\ Alkalinity - 130.1\415.1\310.1	% Lipids[9]	Field Parameters[3]	Rationale
	Reactor Area	Fish[2]	See Note 1	WB1-FS1 to WB1-FS5	Focused	NA	5	--	--	--	5	--	5	--	5	--	--	--	--	5	--	5	--	Fish samples will be collected from WB Hole 1. Number and type of fish may vary depending on availability of fish at time of sampling.
	Reactor Area	Soil	Grab	I3-1S to I3-10S	Random/ Stratified	0 - 0.5 ft	10	--	4	--	10	10	4	4	--	10	4	--	--	10	--	--	--	Surface soil samples will be randomly taken from Island 3 from a 10 cell grid. The samples will supplement previous sampling events and provide additional data for ecological and human evaluations.
	Reactor Area	Core, Shallow	Vibracore	RDC-1SD to RDC-6SD (1 core location subdivided into approx. 6 sed. samples)[4]	Focused	0 - Refusal (1 ft subsamples)	6	1	1	--	6	6	1	1	--	6	--	1	--	6	--	--	--	One core will be completed within the water intake trench/structure. Samples will be divided into 6 one foot samples (2-in core = ~ 600 gms per 1 foot). Used to evaluate historic deposition of Hanford contaminants (e.g., sediment trap).
Figure 2-8	Reactor Area	Pore Water, GU	Grab	RH-1PW to RH-6PW[7]	Focused	1 ft below mudline	6	--	--	--	6	6	--	--	--	--	--	--	6	6	--	--	6	Focus to characterize GW plume discharge to river. Major use will be ecological impacts. Five samples are budgeted; the actual number will depend on results of pore water sampling in the hyporheic zone adjacent to reactor area. Radionuclides for analysis consist of Sr-90.
	Reactor Area	Pore Water, Screening	Grab	RH-6PW to RH-41PW[8]	Focused	1 ft below mudline	36	--	--	--	--	36	--	--	--	--	--	--	--	--	--	--	36	Focus to characterize GW plume discharge to river. Major use will be ecological impacts. Thirty samples are budgeted; the actual number will depend on results of pore water sampling in the hyporheic zone adjacent to reactor area.
	Reactor Area	Sediment, GU	Ponar	RH-1SD to RH-6SD[7]	Focused	0 - 0.3 ft	6	--	--	--	6	6	--	--	--	6	--	6	--	6	--	--	--	Focus to characterize GW plume discharge to river. Major use will be ecological impacts. Five samples are budgeted; the actual number will depend on results of pore water sampling in the hyporheic zone adjacent to reactor area.

Table 2-3. Proposed Sampling and Analytical Plan for the 100 Area Sub-Area. (10 Pages)

Sample Description								Analyses*/EPA Method																	
Figure	Designation	Sample Type	Collection Method	Temporary Sample ID	Sample Design	Sample Depth	Number of Samples	VOCs - 8260B	SVOCs - 8270C	Metals (Filtered)[6] - 6010/6020/7471	Metals (Unfiltered) - 6010/6020/7471	Cr+6 - 7196A	Pesticides - 8081	PCBs - 8082	PCB Congeners - 1668A	TOC/Grain Size - 9060/ASTM D422	PHC - 8115	AVS/SEM - 200.8	Nitrate - 300.0	Radionuclides - GEA/AEA	Hardness\DOC\ Alkalinity - 130.1\415.1\310.1	% Lipids[9]	Field Parameters[3]	Rationale
Figure 2-8 (cont.)	Reactor Area	Surface Water, GU	Grab	RH-1SW to RH-6SW[7]	Focused	1 ft above sediment surface	6	--	--	6	6	6	--	--	--	--	--	--	--	6	6	--	6	Focus to characterize GW plume discharge to river. Major use will be ecological impacts. Five samples are budgeted; the actual number will depend on results of pore water sampling in the hyporheic zone adjacent to reactor area.
	Reactor Area	Sediment, Shallow	Ponar	LI-1SD to LI-10SD	Random/ Stratified	0 - 0.3 ft	10	4	4	--	10	10	4	4	--	10	4	4	--	10	--	--	--	Based on sonar survey results, four samples will be collected from the shallow area upriver and adjacent to Locke Island and across from area 100-H ; the remaining six samples will be collected from the shallow area on the far (left) side of the river. Three samples will be on the far (left) side of the river across from the downriver half of Locke Island with the remaining three continuing downriver of Locke Island along the same side.
	Reactor Area	Sediment, Shallow	Ponar	LI-11SD	Random/ Stratified	0 - 0.3 ft	1	--	--	--	1	1	1	1	--	1	1	1	--	1	--	--	--	One shallow sediment sample was added on the west side of Locke Island.
	Reactor Area	Sediment, Shallow	Ponar	WBT-1SD to WBT-10SD	Random/ Stratified	0 - 0.3 ft	10	4	4	--	10	10	4	4	--	10	4	4	--	10	--	--	--	Based on sonar survey results, ten samples will be collected from a shallow area on the far (left) shore across from White Bluffs Townsite and at the WB-10 Wasteway.
	OCI	Sediment, Shallow	Ponar	WBT-11SD to WBT-13SD	Focused	0 - 0.3 ft	3	3	3	--	3	3	3	3	--	3	--	--	--	--	--	--	--	Three samples will be collected from the shallow sediments downriver of the WB-10 Wasteway to evaluate other contributing influences.
	Reactor Area	Sediment, Shoreline	Grab	RH-1SSD to RH-10SSD	Random/ Stratified	0 - 1 ft	10	4	4	--	10	10	4	4	--	10	4	--	--	10	--	--	--	Based on an ecological habitat survey, ten samples will be collected. Five samples will be collected from the shallow area upriver and adjacent to Island 5; another five samples will be collected from the shallow area on the downriver portion of Island 5.
	Reactor Area	Surface Water	Grab	RH-6SW	Random/ Stratified	2/3 surface water depth	1	--	--	1	1	1	--	--	--	--	--	--	--	1	1	--	1	One surface water sample will be taken between Locke Island and the near (right) shore to augment near shore RCBRA sampling.
	OCI	Surface Water	Grab	WBT-1SW to WBT-2SW (1 sample in spring, 1 sample in fall)	Random/ Stratified	2/3 surface water depth	2	2	2	2	2	2	2	2	--	--	2	--	--	2	2	--	2	Two surface water samples will be taken near the far (left) shore across from White Bluffs Township, near the WB-10 Wasteway, to augment near shore RCBRA sampling.

Table 2-3. Proposed Sampling and Analytical Plan for the 100 Area Sub-Area. (10 Pages)

Sample Description								Analyses*/EPA Method																	
Figure	Designation	Sample Type	Collection Method	Temporary Sample ID	Sample Design	Sample Depth	Number of Samples	VOCs - 8260B	SVOCs - 8270C	Metals (Filtered)[6] - 6010/6020/7471	Metals (Unfiltered) - 6010/6020/7471	Cr+6 - 7196A	Pesticides - 8081	PCBs - 8082	PCB Congeners - 1668A	TOC/Grain Size - 9060/ASTM D422	PHC - 8115	AVS/SEM - 200.8	Nitrate - 300.0	Radionuclides - GEA/AEA	Hardness\DOC\ Alkalinity - 130.1\415.1\310.1	% Lipids[9]	Field Parameters[3]	Rationale
Figure 2-8 (cont.)	Reactor Area	Fish[2]	See Note 1	WB2-FS1 to WB2-FS5	Focused	NA	5	--	--	--	5	--	5	--	5	--	--	--	--	5	--	5	--	Fish samples will be collected from WB Hole 2. Number and type of fish may vary depending on availability of fish at time of sampling.
Figure 2-9	Reactor Area	Soil	Grab	LI-1S to LI-10S	Random/ Stratified	0 - 1 ft	10	--	4	--	10	10	4	4	--	10	4	--	--	10	--	--	--	Ten surface soil samples will be randomly taken from Locke Island using a 10 cell grid to minimize cultural impacts. The samples will supplement previous sampling events and provide additional data for ecological and human evaluations.
	Reactor Area	Pore Water, GU	Grab	RF-1PW to RF-5PW[7]	Focused	1 ft below mudline	5	--	--	--	5	5	--	--	--	--	--	--	5	5	--	--	5	Focus to characterize GW plume discharge to river. Major use will be ecological impacts. Five samples are budgeted; the actual number will depend on results of pore water sampling in the hyporheic zone adjacent to reactor area.
	HT	Pore Water, Screening	Grab	RF-6PW to RF-35PW[8]	Focused	1 ft below mudline	30	--	--		--	30	--	--	--	--	--	--	--	--	--	--	30	Focus to characterize GW plume discharge to river. Major use will be ecological impacts. Thirty samples are budgeted; the actual number will depend on results of pore water sampling in the hyporheic zone adjacent to reactor area.
	HT	Sediment, GU	Ponar	RF-1SD to RF-5SD[7]	Focused	0 - 0.3 ft	5	--	--	--	5	5	--	--	--	5	--	5	--	5	--	--	--	Focus to characterize GW plume discharge to river. Major use will be ecological impacts. Five samples are budgeted; the actual number will depend on results of pore water sampling in the hyporheic zone adjacent to reactor area.
	Reactor Area	Surface Water, GU	Grab	RF-1SW to RF-5SW[7]	Focused	1 ft above sediment surface	5	--	--	5	5	5	--		--	--	--	--	--	5	5	--	5	Focus to characterize GW plume discharge to river. Major use will be ecological impacts. Five samples are budgeted; the actual number will depend on results of pore water sampling in the hyporheic zone adjacent to reactor area.
	Reactor Area	Sediment, Shallow	Ponar	HT-1SD	Random/ Stratified	0 - 0.3 ft	1	1	1	--	1	1	1	1	--	1	1	1	--	1	--	--	--	Based on sonar survey results, one sample will be collected from the shallow area on the far (left) side and downriver of Island 10.

Table 2-3. Proposed Sampling and Analytical Plan for the 100 Area Sub-Area. (10 Pages)

Sample Description								Analyses*/EPA Method																	
Figure	Designation	Sample Type	Collection Method	Temporary Sample ID	Sample Design	Sample Depth	Number of Samples	VOCs - 8260B	SVOCs - 8270C	Metals (Filtered)[6] - 6010/6020/7471	Metals (Unfiltered) - 6010/6020/7471	Cr+6 - 7196A	Pesticides - 8081	PCBs - 8082	PCB Congeners - 1668A	TOC/Grain Size - 9060/ASTM D422	PHC - 8115	AVS/SEM - 200.8	Nitrate - 300.0	Radionuclides - GEA/AEA	Hardness\DOC\ Alkalinity - 130.1\415.1\310.1	% Lipids[9]	Field Parameters[3]	Rationale
Figure 2-9 (cont.)	HT	Sediment, Shallow	Ponar	RFLS-1SD to RFLS-5SD	Random/ Stratified	0 - 0.3 ft	5	2	2	--	5	5	2	2	--	5	2	2	--	5	--	--	--	Based on sonar survey results, five samples will be collected from the shallow area on the far (left) side of the river and downriver of Island 8 extending downriver with the last sample across from Island 9.
	Reactor Area	Sediment, Shallow	Ponar	WBD-1SD to WBD-10SD	Random/ Stratified	0 - 0.3 ft	10	4	4	--	10	10	4	4	--	10	4	4	--	10	--	--	--	Based on sonar survey results, ten samples will be collected from the shallow area adjacent to Area 100-F.
	Reactor Area	Soil	Grab	WB-1S to WB-10S	Random/ Stratified	0 - 0.3 ft	10	--	4	--	10	10	4	4	--	10	4	--	--	10	--	--	--	Ten surface soil samples will be randomly taken from the island across from White Bluffs townsite using a 10 cell grid to minimize cultural impacts. The samples will supplement previous sampling events and provide additional data for ecological and human evaluations.
	Reactor Area	Sediment, Shallow	Ponar	RFD-1SD to RFD-10SD	Random/ Stratified	0 - 0.3 ft	10	4	4	--	10	10	4	4	--	10	4	4	--	10	--	--	--	Based on sonar survey results, ten samples will be collected from the shallow area between the upriver end of Island 8 and the near (right) shore.
	HT	Sediment, Shoreline	Grab	HT-1SSD to HT-2SSD	Random/ Stratified	0 - 0.3 ft	2	1	1	--	2	2	1	1	--	2	1	--	--	2	--	--	--	Based on an ecological habitat survey, two samples will be collected from the riparian area upriver and adjacent to Island 10.
	Reactor Area	Sediment, Shoreline	Grab	RFD-1SSD to RFD-10SSD	Random/ Stratified	0 - 0.3 ft	10	4	4	--	10	10	4	4	--	10	4	--	--	10	--	--	--	Based on an ecological habitat survey, ten samples will be collected from riparian areas; three just upriver of Island 8; one sample between the upriver portion of Island 8 and the near (right) shore; two downriver and adjacent to Island 8; two upriver of Island 9 and two adjacent to Island 9 on its near (right) shore side.
	Reactor Area	Sediment, Shoreline	Grab	RFLS-1SSD to RFLS-5SSD	Random/ Stratified	0 - 0.3 ft	5	2	2	--	5	5	2	2	--	5	2	--	--	5	--	--	--	Based on an ecological habitat survey, five samples will be collected from the riparian area just downriver of Area 100-F and on the far (left) shore.
	HT	Surface Water	Grab	IS8-1SW to IS8-5SW	Random/ Stratified	2/3 surface water depth	5	1	1	5	5	5	1	1	--	--	1	--	--	5	5	--	5	Five surface water samples taken between Island 8 and Island 9 and the near (right) shore to augment near shore RCBRA sampling.

Table 2-3. Proposed Sampling and Analytical Plan for the 100 Area Sub-Area. (10 Pages)

Sample Description								Analyses*/EPA Method																	
Figure	Designation	Sample Type	Collection Method	Temporary Sample ID	Sample Design	Sample Depth	Number of Samples	VOCs - 8260B	SVOCs - 8270C	Metals (Filtered)[6] - 6010/6020/7471	Metals (Unfiltered) - 6010/6020/7471	Cr+6 - 7196A	Pesticides - 8081	PCBs - 8082	PCB Congeners - 1668A	TOC/Grain Size - 9060/ASTM D422	PHC - 8115	AVS/SEM - 200.8	Nitrate - 300.0	Radionuclides - GEA/AEA	Hardness\DOC\ Alkalinity - 130.1\415.1\310.1	% Lipids[9]	Field Parameters[3]	Rationale

Notes:

1 Fish collection method shall be either:
- electrofishing (off limits in spring due to presence of juvenile steelhead), effective for whitefish, carp, bass, and suckers; long-line;
- hook and line (effective for whitefish, walleye, and sturgeon)

2 Arsenic for both organic and inorganic speciation - fish tissue only

3 Field parameters for surface water samples are measured in the field and consist of temperature, specific conductivity, dissolved oxygen, and pH. Field parameters for pore water samples consist of specific conductivity and temperature.

4 The actual number of core subsamples will depend on the volume of sediment recovered.

5 Every 10th surface water and sediment sample analyzed for PCB Aroclors by 8082 will also be analyzed for PCB congeners. All fish samples will be analyzed for congeners only

6 Filtered applies to water only. Solids (i.e., sediment and soil) are not filtered.

7 Groundwater plume upwelling sample locations will be finalizd once the reconnaissance survey has been completed and the final design has been approved by the Tri-Parties.

8 Groundwater plume upwelling transects (not discrete samples) are depicted on the figure.

9 Bligh-Dyer (1959).

– Sample not analyzed for given parameter

AEA = Alpha energy analysis

ASTM = American Society for Testing and Materials

AVS/SEM = acid volatile sulfides/simultaneously extracted metals by EPA Method 200.8

BERA = Baseline Ecological Risk Assessment

BHHRA = Baseline Human Health Risk Assessment

Core = Sediment core

Cr+6 = hexavalent chromium by EPA Method 7196A

DOC = dissolved organic carbon

EPA = United States Environmental Protection Agency

GEA = Gamma energy analysis

gms = grams

GU = Groundwater Plume Upwelling

GW = groundwater

HMU = Habitat Management Unit

HT = Hanford Townsite

Metals = by EPA Methods 6010/6020 and 7471

MIS = Multiple Incremental Sampling

OCI = other contributing influence (i.e., non-Hanford)

Pesticides = by EPA Method 8081

PCE = tetrachloroethylene

PCBs = pesticides/polychlorinated biphenyls by EPA Method 8082

PHC = petroleum hydrocarbon by EPA Method 8115

SD = sediment

SVOCs = semivolatile organic compounds by EPA Method 8270C

SW = surface water

TOC = total organic carbon by EPA Method 9060

VOCs = volatile organic compounds by EPA Method 8260B

Table 2-4. Proposed Sampling and Analytical Plan for the 300 Area Sub-Area. (9 Pages)

Sample Description									Analyses*/EPA Method																	
Figure	Designation	Sample Type	Collection Method	Sampling Location	Temporary Sample ID	Sample Design	Sample Depth	Number of Samples	VOCs - 8260B	SVOCs - 8270C	Metals (Filtered)[6] - 6010/6020/7471	Metals (Unfiltered) - 6010/6020/7471	Cr+6 - 7196A	Pesticides - 8081	PCBs - 8082	PCB Congeners - 1668A[5]	TOC/Grain Size - 9060/ASTM D422	PHC - 8115	AVS/SEM - 200.8	Nitrate - 300.0	Radionuclides - GEA/AEA	Hardness\DOC\ Alkalinity - 130.1\415.1\310.1	% Lipids[9]	Field Parameters[3]	Rationale
Figure 2-10	HT	Sediment, Shoreline	Grab	Hanford Townsite Shoreline Sediments	HT-3SSD to HT-10SSD	Random/ Stratified	0 - 0.3 ft	8	3	3	--	8	8	3	3	--	8	3	--	--	8	--	--	--	Based on sonar survey results, eight samples will be collected.
	HT	Sediment, Shallow	Ponar	Hanford Townsite Left Side Sediments	HT-2SD to HT-5SD	Random/ Stratified	0 - 0.3 ft	4	1	1	--	4	4	1	1	--	4	1	1	--	4	--	--	--	Based on sonar survey results, four samples will be collected from the shallow area; one sample from the near shore in front of the Hanford Townsite; one sample from the near (right) shore just downriver from river mile 384; two samples from the far (left) shore around river mile 384.
	HT	Fish[2]	See Note 1	HTS Hole 1	HTS1-FS1 to HTS1-FS5	Focused	NA	5	--	--	--	5	--	5	--	5	--	--	--	--	5	--	5	--	Fish samples from HTS Hole 1 will be collected. Number and type of fish may vary depending on availability of fish at time of sampling.
	HT	Pore Water, GU	Grab	Hanford Townsite Tritium GW Plume	HT-1PW to HT-5PW[7]	Focused	1 ft below mudline	5	--	--	--	5	--	--	--	--	--	--	--	--	5	--	--	--	5	Focus to characterize GW plume discharge to river. Major use will be ecological impacts. Five samples are budgeted; the actual number will depend on results of pore water sampling in the hyporheic zone adjacent to tritium discharge area.
	HT	Pore Water, Screening	Grab	Hanford Townsite Tritium GW Plume	HT-6PW to HT-35PW[8]	Focused	1 ft below mudline	30	--	--	--	--	--	--	--	--	--	--	--	--	30	--	--	30	Focus to characterize GW plume discharge to river. Major use will be ecological impacts. Thirty samples are budgeted; the actual number will depend on results of pore water sampling in the hyporheic zone adjacent to reactor area. Samples will be analyzed for tritium only.

Table 2-4. Proposed Sampling and Analytical Plan for the 300 Area Sub-Area. (9 Pages)

Sample Description									Analyses*/EPA Method																	
Figure	Designation	Sample Type	Collection Method	Sampling Location	Temporary Sample ID	Sample Design	Sample Depth	Number of Samples	VOCs - 8260B	SVOCs - 8270C	Metals (Filtered)[6] - 6010/6020/7471	Metals (Unfiltered) - 6010/6020/7471	Cr+6 - 7196A	Pesticides - 8081	PCBs - 8082	PCB Congeners - 1668A[5]	TOC/Grain Size - 9060/ASTM D422	PHC - 8115	AVS/SEM - 200.8	Nitrate - 300.0	Radionuclides - GEA/AEA	Hardness\DOC\ Alkalinity - 130.1\415.1\310.1	% Lipids[9]	Field Parameters[3]	Rationale
Figure 2-11	HT	Sediment, GU	Ponar	Hanford Townsite Tritium GW Plume	HT-1SD to HT-5SD[7]	Focused	0 - 0.3 ft	5	--	--	--	5	--	--	--	--	5	--	5	--	5	--	--	--	Focus to characterize GW plume discharge to river. Major use will be ecological impacts. Five samples are budgeted; the actual number will depend on results of pore water sampling in the hyporheic zone adjacent to tritium discharge area.
	HT	Surface Water, GU	Grab	Hanford Townsite Tritium GW Plume	HT-1SW to HT-5SW[7]	Focused	1 ft above sediment surface	5	--	--	5	5	--	--	--	--	--	--	--	5	5	--	--	--	Focus to characterize GW plume discharge to river. Major use will be ecological impacts. Five samples are budgeted; the actual number will depend on results of pore water sampling in the hyporheic zone adjacent to tritium discharge area.
	HT	Sediment, Shoreline	Grab	Island 11 Shoreline Sediment	IS11-1SSD to IS11-10SSD	Random/ Stratified	0 - 0.3 ft	10	4	4	--	10	10	4	4	--	10	4	--	--	10	--	--	--	Based on an ecological habitat survey, ten samples will be collected from the riparian area; samples are from the upriver end of Island 11 just downriver from the WB-5 Wasteway.
	HT	Sediment, Shoreline	Grab	Savage Island Shoreline Sediment	SI-1SSD to SI-3SSD	Random/ Stratified	0 - 0.3 ft	3	1	1	--	3	3	1	1	--	3	1	--	--	3	--	--	--	Samples will be collected from the riparian area on the left shore at Savage Island
	HT	Sediment, Shallow	Ponar	Depositional Area top of Savage Island	SI-1SD to SI-5SD	Random/ Stratified	0 - 0.3 ft	5	1	1	--	5	5	1	1	--	5	1	1	--	5	--	--	--	Based on sonar survey results, five samples will be collected from the shallow area on the far (left) shore just upriver from river mile 359.
	HI	Sediment, Shallow	Ponar	Savage Island	SI-6SD to SI-10SD	Random/ Stratified	0 - 0.3 ft	5	1	1	--	5	5	1	1	--	5	1	1		5	--	--	--	Five shallow sediment samples have been added behind Savage Island.
	OCI	Sediment, Shallow	Ponar	WB-5 Wasteway	WBW-1SD to WBW-3SD	Focused	0 - 0.3 ft	3	3	3	--	3	3	3	3	--	3	--	--	--	--	--	--	--	Three samples will be collected from the shallow area on the far (left) shore just upriver from river mile 356 in the WB-5 Wasteway to evaluate other contributing influences.
	OCI	Surface Water	Grab	WB-5 Wasteway	WBW-1SW (1 sample in spring, 1 sample in fall)	Focused	2/3 surface water depth	2	2	2	2	2	2	2	2	--	--	--	--	--	2	--	--	--	Two surface water samples will be taken at the WB-5 Wasteway to augment near shore RCBRA sampling and evaluate other contributing influences.

Table 2-4. Proposed Sampling and Analytical Plan for the 300 Area Sub-Area. (9 Pages)

Sample Description									Analyses*/EPA Method																	
Figure	Designation	Sample Type	Collection Method	Sampling Location	Temporary Sample ID	Sample Design	Sample Depth	Number of Samples	VOCs - 8260B	SVOCs - 8270C	Metals (Filtered)[6] - 6010/6020/7471	Metals (Unfiltered) - 6010/6020/7471	Cr+6 - 7196A	Pesticides - 8081	PCBs - 8082	PCB Congeners - 1668A[5]	TOC/Grain Size - 9060/ASTM D422	PHC - 8115	AVS/SEM - 200.8	Nitrate - 300.0	Radionuclides - GEA/AEA	Hardness\DOC\ Alkalinity - 130.1\415.1\310.1	% Lipids[9]	Field Parameters[3]	Rationale
Figure 2-11 (cont.)	HT	Soil	Grab	Ringold Recreational	RG-1S to RG-10S	Random/ Stratified	0 - 0.3 ft	10	--	4	--	10	10	4	4	--	10	4	--	--	10	--	--	--	Based on Trustee comments, these samples will supplement previous sampling events and provide additional data for HHRA. The samples will be collected from a 10 cell random/stratified grid.
	HT	Surface Water	Grab	Depositional Area top of Savage Island	SI-2SW	Random/ Stratified	2/3 surface water depth	1	1	1	1	1	1	1	1	--	--	1	--	--	1	--	--	--	One surface water sample will be taken at the upriver end of Savage Island to augment near shore RCBRA sampling.
	OCI	Surface Water	Grab	Island 11 Sloughs Surface Water	IS11-1SW	Random/ Stratified	2/3 surface water depth	1	1	1	1	1	1	1	1	--	--	1	--	--	1	--	--	--	One surface water sample will be taken at the Island 11 Sloughs to augment near shore RCBRA sampling.
	HT	Surface Water	Grab	Ringold Recreational	RG-3SW	Random/ Stratified	2/3 surface water depth	1	1	1	1	1	1	1	1	--	--	1	--	--	1	--	--	--	One surface water sample will be taken between Ringold Springs and the WB-5 Wasteway to augment near shore RCBRA sampling.
	HT	Fish[2]	See Note 1	HTS Hole 2	HTS2-FS1 to HTS2-FS5	Focused	NA	5	--	--	--	5	--	5	--	5	--	--	--	--	5	--	5	--	Fish samples will be collected from HTS Hole 2. Number and type of fish may vary depending on availability of fish at time of sampling.
Figure 2-12	HT	Sediment, Shoreline	Grab	Island 12 Shoreline Sediment	IS12-1SSD to IS12-10SSD	Random/ Stratified	0 - 0.3 ft	10	4	4	--	10	10	4	4	--	10	4	--	--	10	--	--	--	Based on an ecological habitat survey, ten samples will be collected from the riparian area. Samples taken include five samples on the upriver end of Island 12 and five samples near the middle and on the near (right) shore side of Island 12.
	HT	Sediment, Shoreline	Grab	Homestead Island	HMSTD-1SSD to HMSTD-10SSD	Random/ Stratified	0 - 0.3 ft	10	4	4	--	10	10	4	4	--	10	4	--	--	10	--	--	--	Based on an ecological habitat survey, ten samples will be collected from the riparian area. Samples taken include five samples near the upriver end of Homestead Island and five samples near the downriver end of Homestead Island.
	HT	Sediment, Shallow	Ponar	Island 11 Sediment	IS11-1SD to IS11-5SD	Random/ Stratified	0 - 0.3 ft	5	2	2	--	5	5	2	2	--	5	2	2	--	5	--	--	--	Based on sonar survey results, five samples will be collected from the shallow area from the downriver end of Island 11 across from Ringold Springs.

Table 2-4. Proposed Sampling and Analytical Plan for the 300 Area Sub-Area. (9 Pages)

Sample Description									Analyses*/EPA Method																		
Figure	Designation	Sample Type	Collection Method	Sampling Location	Temporary Sample ID	Sample Design	Sample Depth	Number of Samples	VOCs - 8260B	SVOCs - 8270C	Metals (Filtered)[6] - 6010/6020/7471	Metals (Unfiltered) - 6010/6020/7471	Cr+6 - 7196A	Pesticides - 8081	PCBs - 8082	PCB Congeners - 1668A[5]	TOC/Grain Size - 9060/ASTM D422	PHC - 8115	AVS/SEM - 200.8	Nitrate - 300.0	Radionuclides - GEA/AEA	Hardness\DOC\ Alkalinity - 130.1\415.1\310.1	% Lipids[9]	Field Parameters[3]	Rationale
Figure 2-12 (cont.)	HT	Sediment, Shallow	Ponar	Homestead Island	HMSTD-1SD to HMSTD-5SD	Random/ Stratified	0 - 0.3 ft	5	2	2	--	5	5	2	2	--	5	2	2	--	5	--	--	--	Based on sonar survey results, five samples will be collected from the shallow area between the near (right) shore and Homestead Island.
	HT	Sediment, Shallow	Ponar	Island 13	IS13-1SD to IS13-5SD	Random/ Stratified	0 - 0.3 ft	5	2	2	--	5	5	2	2	--	5	2	2	--	5	--	--	--	Based on sonar survey results, five samples will be collected from the shallow area just downriver on the near (right) shore side of Island 13.
	OCI	Sediment, Shallow	Ponar	Ringold Irrigation Return	RG-1SD to RG-3SD	Focused	0 - 0.3 ft	3	3	3	--	3	3	3	3	--	3	--	--	--	--	--	--	--	Three samples will be collected from shallow sediment downriver of the Ringold Irrigation Return Area to evaluate other contributing influences.
	OCI	Sediment, Shallow	Ponar	PE 16.4 Wasteway	PE-1SD to PE-3SD	Focused	0 - 0.3 ft	3	3	3	--	3	3	3	3	--	3	--	--	--	--	--	--	--	Three samples will be collected from shallow sediment downriver of the PE 16.4 Wasteway area to evaluate other contributing influences.
	OCI	Surface Water	Grab	Ringold Irrigation Return	RG-1SW (1 sample in spring, 1 sample in fall)	Focused	2/3 surface water depth	2	2	2	2	2	2	2	2	--	--	--	--	--	2	--	--	--	Two surface water samples (one each in spring and fall) will be taken at the Ringold Irrigation Return to augment near shore RCBRA sampling and evaluate other contributing influences.
	OCI	Surface Water	Grab	PE 16.4 Wasteway	PE-1SW (1 sample in spring, 1 sample in fall)	Focused	2/3 surface water depth	2	2	2	2	2	2	2	2	--	--	--	--	--	2	--	--	--	Two surface water samples (one each in the spring and fall) will be taken at the PE 16.4 Wasteway to augment near shore RCBRA sampling and evaluate other contributing influences.
	HT	Fish[2]	See Note 1	Ringold	RG-FS1 to RG-FS5	Focused	NA	5	--	--	--	5	--	5	--	5	--	--	--	--	5	--	5	--	Fish samples from Ringold will be collected. Number and type of fish may vary depending on availability of fish at time of sampling.
	HT	Soil	Grab	Homestead Island soil	HI-1S to HI-10S	Random/ Stratified	0 - 0.5 ft	10	--	4	--	10	10	4	4	--	10	4	--	--	10	--	--	--	Surface soil samples will be taken from Homestead Island. The samples will supplement previous sampling events and provide additional data for ecological and human evaluations. The samples will be collected from a 10 cell random/stratified grid.

Table 2-4. Proposed Sampling and Analytical Plan for the 300 Area Sub-Area. (9 Pages)

Sample Description									Analyses*/EPA Method																		
Figure	Designation	Sample Type	Collection Method	Sampling Location	Temporary Sample ID	Sample Design	Sample Depth	Number of Samples	VOCs - 8260B	SVOCs - 8270C	Metals (Filtered)[6] - 6010/6020/7471	Metals (Unfiltered) - 6010/6020/7471	Cr+6 - 7196A	Pesticides - 8081	PCBs - 8082	PCB Congeners - 1668A[5]	TOC/Grain Size - 9060/ASTM D422	PHC - 8115	AVS/SEM - 200.8	Nitrate - 300.0	Radionuclides - GEA/AEA	Hardness\DOC\ Alkalinity - 130.1\415.1\310.1	% Lipids[9]	Field Parameters[3]	Rationale
Figure 2-13	HT	Sediment, Shoreline	Grab	Island 14	IS14-1SSD to IS14-10SSD	Random/ Stratified	0 - 0.3 ft	10	4	4	--	10	10	4	4	--	10	4	--	--	10	--	--	--	Based on an ecological habitat survey, ten samples will be collected from the riparian area; samples are from between the far (left) shore and Island 14.
	HT	Sediment, Shoreline	Grab	Island 15	IS15-1SSD to IS15-10SSD	Random/ Stratified	0 - 0.3 ft	10	4	4	--	10	10	4	4	--	10	4	--	--	10	--	--	--	Based on an ecological habitat survey, ten samples will be collected from the riparian area; samples are from the upriver end of Island 15.
	HT	Sediment, Shoreline	Grab	Wooded Island	WI-1SSD to WI-10SSD	Random/ Stratified	0 - 0.3 ft	10	4	4	--	10	10	4	4	--	10	4	--	--	10	--	--	--	Based on an ecological habitat survey, ten samples will be collected from the riparian area; five samples are from the upriver end of Wooded Island and five samples are from the mid-area of the island on the far (left) shore side.
	HT	Sediment, Shallow	Ponar	Island 14	IS14-1SD to IS14-5SD	Random/ Stratified	0 - 0.3 ft	5	2	2	--	5	5	2	2	--	5	2	2	--	5	--	--	--	Based on sonar survey results, five samples will be collected from shallow sediment between Island 14 and the near (right) shore.
	HT	Sediment, Shallow	Ponar	Island 15	IS15-1SD to IS15-5SD	Random/ Stratified	0 - 0.3 ft	5	2	2	--	5	5	2	2	--	5	2	2	--	5	--	--	--	Based on sonar survey results, five samples will be collected from shallow sediment downriver of Island 15 on the far (left) shore.
	HT	Sediment, Shallow	Ponar	Wooded Island	WI-1SD to WI-5SD	Random/ Stratified	0 - 0.3 ft	5	2	2	--	5	5	2	2	--	5	2	2	--	5	--	--	--	Based on sonar survey results, five samples will be collected from shallow sediment between Wooded Island and the near (right) shore.
	HT	Surface Water	Grab	Wooded Island	WI-1SW	Random/ Stratified	2/3 surface water depth	1	1	1	1	1	1	1	1	--	--	1	--	--	1	--	--	--	One surface water sample will be taken adjacent to Wooded Island to augment near shore RCBRA sampling.
	HT	Fish[2]	See Note 1	Taylor Flats	TF-FS1 to TF-FS5	Focused	NA	5	--	--	--	5	--	5	--	5	--	--	--	--	5	--	5	--	Fish samples will be collected from Taylor Flats. Number and type of fish may vary depending on availability of fish at time of sampling.

Table 2-4. Proposed Sampling and Analytical Plan for the 300 Area Sub-Area. (9 Pages)

Sample Description									Analyses*/EPA Method																		Rationale
Figure	Designation	Sample Type	Collection Method	Sampling Location	Temporary Sample ID	Sample Design	Sample Depth	Number of Samples	VOCs - 8260B	SVOCs - 8270C	Metals (Filtered)[6] - 6010/6020/7471	Metals (Unfiltered) - 6010/6020/7471	Cr+6 - 7196A	Pesticides - 8081	PCBs - 8082	PCB Congeners - 1668A[5]	TOC/Grain Size - 9060/ASTM D422	PHC - 8115	AVS/SEM - 200.8	Nitrate - 300.0	Radionuclides - GEA/AEA	Hardness\DOC\ Alkalinity - 130.1\415.1\310.1	% Lipids[9]	Field Parameters[3]	
Figure 2-13 (cont.)	HT	Soil	Grab	Wooded Island soil	WI-1S to WI-10S	Random/ Stratified	0 - 0.5 ft	10	--	4	--	10	10	4	4	--	10	4	--	--	10	--	--	--	Surface soil samples will be taken from Wooded Island. The samples will supplement previous sampling events and provide additional data for ecological and human evaluations. The samples will be collected from a 10 cell random/stratified grid.
Figure 2-14	300 Area	Pore Water, GU	Grab	300 Area GW Plume (PCE, tritium, U)	300A-1PW to 300A-6PW[7]	Focused	1 ft below mudline	6	--	--	--	6	6	--	--	--	--	--	--	6	--	--	--	6	Focus to characterize GW plume discharge to river. Major use will be ecological impacts. Five samples are budgeted; the actual number will depend on results of pore water sampling in the hyporheic zone adjacent to 300 Area VOC/uranium discharge.
	300 Area	Pore Water, Screening	Grab	300 Area GW Plume (PCE, tritium, U)	300A-6PW to 300A-41PW[8]	Focused	1 ft below mudline	36	36	--	--	36	--	--	--	--	--	--	--	--	--	--	--	--	36	Focus to characterize GW plume discharge to river. Major use will be ecological impacts. Thirty samples are budgeted; the actual number will depend on results of pore water sampling in the hyporheic zone adjacent to reactor area. Metals will include elemental uranium only.
	300 Area	Sediment, GU	Ponar	300 Area GW Plume (PCE, tritium, U)	300A-1SD to 300A-6SD[7]	Focused	0 - 0.3 ft	6	6	--	--	6	6	--	--	--	6	--	6	--	6	--	--	--	Focus to characterize GW plume discharge to river. Major use will be ecological impacts. Five samples are budgeted; the actual number will depend on results of pore water sampling in the hyporheic zone adjacent to 300 Area VOC/uranium discharge.
	300 Area	Surface Water, GU	Grab	300 Area GW Plume (PCE, tritium, U)	300A-1SW to 300A-6SW[7]	Focused	1 ft above sediment surface	6	6	--	6	6	6	--	--	--	--	--	--	--	6	--	--		Focus to characterize GW plume discharge to river. Major use will be ecological impacts. Five samples are budgeted; the actual number will depend on results of pore water sampling in the hyporheic zone adjacent to 300 Area VOC/uranium discharge.

Table 2-4. Proposed Sampling and Analytical Plan for the 300 Area Sub-Area. (9 Pages)

Sample Description									Analyses*/EPA Method																
Figure	Designation	Sample Type	Collection Method	Sampling Location	Temporary Sample ID	Sample Design	Sample Depth	Number of Samples	VOCs - 8260B	SVOCs - 8270C	Metals (Filtered)[6] - 6010/6020/7471	Metals (Unfiltered) - 6010/6020/7471	Cr+6 - 7196A	Pesticides - 8081	PCBs - 8082	PCB Congeners - 1668A[5]	TOC/Grain Size - 9060/ASTM D422	PHC - 8115	AVS/SEM - 200.8	Nitrate - 300.0	Radionuclides - GEA/AEA	Hardness\DOC\ Alkalinity - 130.1\415.1\310.1	% Lipids[9]	Field Parameters[3]	Rationale
Figure 2-14 (cont.)	300 Area	Sediment, Shoreline	Grab	300 Area Island	300ISL-1SSD to 10SSD	Random/ Stratified	0 - 0.3 ft	10	10	10	–	10	10	4	4	--	10	4	–	--	10	--	--	--	Based on an ecological habitat survey, ten samples will be collected from the riparian area; three samples are from the upriver end of 300 Island; three samples are from the upper third of the island; the remaining samples from the mid-area of the island on the far (left) shore side.
	300 Area	Sediment, Shallow	Ponar	300 Area Left Side	300LS-1SD to 300LS-5SD	Random/ Stratified	0 - 0.3 ft	5	5	2	–	5	5	2	2	--	5	2	2	--	5	--	--	--	Based on sonar survey results, five samples will be collected from shallow sediment on the far (left) shore across from 300 Island.
	OCI	Sediment, Shallow	Ponar	Potholes Canal Wasteway	PC-1SD to PC-3SD	Focused	0 - 0.3 ft	3	3	3	–	3	3	3	3	--	3	--	--	--	--	--	--	--	Three samples will be collected from shallow sediment downriver of the Potholes Canal/Pasco Wasteway area to evaluate other contributing influences.
	OCI	Sediment, Shallow	Ponar	Esquatzel Coulee Wasteway	EC-1SD to EC-3SD	Focused	0 - 0.3 ft	3	3	3	–	3	3	3	3	--	3	--	--	--	--	--	--	--	Three samples will be collected from shallow sediment downriver of the Esquatzel Coulee Wasteway area to evaluate other contributing influences.
	OCI	Surface Water	Grab	Potholes Canal Wasteway	PC-1SW (1 sample in spring, 1 sample in fall)	Focused	2/3 surface water depth	2	2	2	2	2	2	2	2	--	--	--	--	--	2	--	--	--	Two surface water samples (one each in the spring and fall) will be taken at the Potholes Canal Wasteway to augment near shore RCBRA sampling and evaluate other contributing influences.
	OCI	Surface Water	Grab	Esquatzel Coulee Wasteway	EC-1SW (1 sample in spring, 1 sample in fall)	Focused	2/3 surface water depth	2	2	2	2	2	2	2	2	--	--	--	--	--	2	--	--	--	Two surface water samples (one each in the spring and fall) will be taken at the Esquatzel Coulee Wasteway to augment near shore RCBRA sampling and evaluate other contributing influences.
	HT	Fish[2]	See Note 1	300A Hole 1	300A1-FS1 to 300A1-FS5	Focused	NA	5	--	--	--	5	--	5	--	5	--	--	--	--	5	--	5	--	Fish samples will be collected from 300A Hole 1. Number and type of fish may vary depending on availability of fish at time of sampling.

Table 2-4. Proposed Sampling and Analytical Plan for the 300 Area Sub-Area. (9 Pages)

Sample Description									Analyses*/EPA Method																	Rationale
Figure	Designation	Sample Type	Collection Method	Sampling Location	Temporary Sample ID	Sample Design	Sample Depth	Number of Samples	VOCs - 8260B	SVOCs - 8270C	Metals (Filtered)[6] - 6010/6020/7471	Metals (Unfiltered) - 6010/6020/7471	Cr+6 - 7196A	Pesticides - 8081	PCBs - 8082	PCB Congeners - 1668A[5]	TOC/Grain Size - 9060/ASTM D422	PHC - 8115	AVS/SEM - 200.8	Nitrate - 300.0	Radionuclides - GEA/AEA	Hardness\DOC\ Alkalinity - 130.1\415.1\310.1	% Lipids[9]	Field Parameters[3]	
Figure 2-14 (cont.)	300 Area	Fish[2]	See Note 1	300A Hole 2	300A2-FS1 to 300A2-FS5	Focused	NA	5	--	--	--	5	--	5	--	5	--	--	--	--	5	--	5	--	Fish samples will be collected from 300A Hole 2. Number and type of fish may vary depending on availability of fish at time of sampling.
	300 Area	Soil	Grab	Johnson Island soil	JI-1S to JI-10S	Random/ Stratified	0 - 0.5 ft	10	--	10	--	10	10	4	4	--	10	4	--	--	10	--	--	--	Surface soil samples will be taken from Johnson Island. The samples will supplement previous sampling events and provide additional data for ecological and human evaluations. The samples will be collected randomly from a 10 cell grid.
	300 Area	Core, Shallow (2-inch diameter)	Vibracore	300 Area downriver	300DC-1SD to 300DC-12SD (4 core locations; approx. 3 sed. samples per core)[4]	Focused	0 - Refusal (1 ft subsamples)	12	4	4	--	12	12	4	4	--	12	--	4	--	12	--	--	--	Four locations to characterize: both sides of river above Johnson Island; adjacent to (right side) of Johnson Island; downriver of Johnson Island (left side); downriver of Potholes Canal/Pasco Wasteway. These were placed at the head of the Wallua Pool to evaluate potential depositional area.
Figure 2-15	300 Area	Sediment, Shoreline	Grab	300 Area downriver	300D-1SSD to 5SSD	Random/ Stratified	0 - 0.3 ft	5	5	2	--	5	5	2	2	--	5	2	2	--	5	--	--	--	Based on an ecological habitat survey, five samples will be collected from the riparian area; two samples are from the upriver end of the Island at river mile 342; one sample is from the lower end of that island; one sample is from the upriver end of the island across from the Richland pump House; and the remaining sample is from the upriver end of Nelson island.
	300 Area	Sediment, Shallow	Ponar	300 Area	300D-1SD to 300D-10SD	Random/ Stratified	0 - 0.3 ft	10	10	4	--	10	10	4	4	--	10	4	4	--	10	--	--	--	Based on sonar survey results, ten samples will be collected from shallow areas near the far (left) shore just downriver from river mile 341.
	300 Area	Sediment, Shoreline	Grab	Leslie Grove City Park (5 replicate)	LG-1SSD	MIS	0 - 0.5 ft	5	5	5	--	5	5	5	5	--	5	5	--	--	5	--	--	--	MIS samples will be collected from shoreline area of Leslie Grove City Park. These samples will be collected as 5 replicates.

Table 2-4. Proposed Sampling and Analytical Plan for the 300 Area Sub-Area. (9 Pages)

Sample Description									Analyses*/EPA Method																		Rationale
Figure	Designation	Sample Type	Collection Method	Sampling Location	Temporary Sample ID	Sample Design	Sample Depth	Number of Samples	VOCs - 8260B	SVOCs - 8270C	Metals (Filtered)[6] - 6010/6020/7471	Metals (Unfiltered) - 6010/6020/7471	Cr+6 - 7196A	Pesticides - 8081	PCBs - 8082	PCB Congeners - 1668A[5]	TOC/Grain Size - 9060/ASTM D422	PHC - 8115	AVS/SEM - 200.8	Nitrate - 300.0	Radionuclides - GEA/AEA	Hardness\DOC\ Alkalinity - 130.1\415.1\310.1	% Lipids[9]	Field Parameters[3]	
Figure 2-15 (cont.)	300 Area	Island Soil	Grab	Gull Island	GI-1S to GI-10S	Random/ Stratified	0 - 0.5 ft	10	10	4	--	10	10	4	4	--	10	4	4	--	10	--	--	--	Ten sediment samples will be randomly collected from Gull Island from a 10 cell grid.
	Recreational	Surface Water	Grab	Leslie Grove City Park	LG-1SW	Focused	2/3 surface water depth	1	1	1	1	1	1	1	1	--	--	1	--	--	1	--	--	--	One surface water sample will be taken offshore from Leslie Grove City Park/Boat Launch to augment existing data.
	300 Area	Core, Shallow (2-inch diameter)	Vibracore	300 Area downriver	300DC-13SD to 300DC-18SD (2 core locations; approx. 3 sed. samples per core)[4]	Focused	0 - Refusal (1 ft subsamples)	6	2	2	--	6	2	2	2	--	6	--	2	--	6	--	--	--	Characterize the sediments ~ 1/2 way between the Port of Benton and the Richland Pump House on both sides of island. Data to be used in the ecological evaluation.

Notes:

1 Fish collection method shall be either:
- electrofishing (off limits in spring due to presence of juvenile steelhead), effective for whitefish, carp, bass, and suckers; long-line;
- hook and line (effective for whitefish, walleye, and sturgeon)

2 Arsenic for both organic and inorganic speciation - fish tissue only

3 Field parameters for surface water samples are measured in the field and consist of temperature, specific conductivity, dissolved oxygen, and pH
Field parameters for pore water samples consist of specific conductivity and temperature.

4 The actual number of core subsamples will depend on the volume of sediment recovered.

5 Every 10th surface water and sediment sample analyzed for PCB Aroclors by 8082 will also be analyzed for PCB congeners. All fish samples will be analyzed for congeners only.

6 Filtered applies to water only. Solids (i.e., sediment and soil) are not filtered.

7 Groundwater plume upwelling sample locations will be finalizd once the reconnaissance survey has been completed and the final design has been approved by the Tri

8 Groundwater plume upwelling transects (not discrete samples) are depicted on the figure.

9 Bligh-Dyer (1959).

-- Sample not analyzed for given parameter
AEA = Alpha energy analysis
ASTM = American Society for Testing and Materials
AVS/SEM = acid volatile sulfides/simultaneously extracted metals by EPA Method 200.8
BERA = Baseline Ecological Risk Assessment
BHHRA = Baseline Human Health Risk Assessment
Core = Sediment core
Cr+6 = hexavalent chromium by EPA Method 7196A
DOC = dissolved organic carbon
EPA = United States Environmental Protection Agency
GEA = Gamma energy analysis
GU = Groundwater Plume Upwelling
GW = groundwater
HMU = Habitat Management Unit
HT = Hanford Townsite
Metals = by EPA Methods 6010/6020 and 7471
MIS = Multiple Incremental Sampling
OCI = other contributing influence (i.e., non-Hanford)
Pesticides = by EPA Method 8081
PCE = tetrachloroethylene
PCBs = pesticides/polychlorinated biphenyls by EPA Method 8082
PHC = petroleum hydrocarbon by EPA Method 8115
SD = sediment
SVOCs = semivolatile organic compounds by EPA Method 8270C
SW = surface water
TOC = total organic carbon by EPA Method 9060
VOCs = volatile organic compounds by EPA Method 8260B

Table 2-5. Proposed Sampling and Analytical Plan for Lake Wallula Sub-Area. (6 Pages)

Sample Description									Analyses*/EPA Method																
Figure	Designation	Sample Type	Collection Method	Sampling Location	Temporary Sample ID	Sample Design	Sample Depth	Number of Samples	VOCs - 8260B	SVOCs - 8270C	Metals (Filtered)[6] - 6010/6020/7471	Metals (Unfiltered) - 6010/6020/7471	Cr+6 - 7196A	Pesticides - 8081	PCBs - 8082	PCB Congeners - 1668A	TOC/Grain Size - 9060/ASTM D422	PHC - 8115	AVS/SEM - 200.8	Nitrate - 300.0	Radionuclides - GEA/AEA	Hardness\DOC\ Alkalinity - 130.1\415.1\310.1	% Lipids[7]	Field Parameters[3]	Rationale
Figure 2-16	OCI	Sediment, Shallow	Ponar	Yakima River	YR-1SD to YR-5SD	Random/ Stratified	0 - 0.3 ft	5	1	5	--	5	5	5	5	--	5	1	--	--	5	--	--	--	Based on sonar survey results, five samples will be collected from shallow sediments in the Yakima River prior to its confluence with the Columbia River to evaluate other contributing influences.
	OCI	Surface Water	Grab	Yakima River	YR-1SW	Random/ Stratified	2/3 surface water depth	2	2	2	2	2	2	2	2	--	--	2	--	--	2	--	2	2	Two surface water samples will be taken (spring and fall) from the Yakima River to augment existing data and evaluate other contributing influences.
	Recreational	Sediment, Shoreline	Grab	Howard Amon City Park	HA-1SSD to HA-10SSD	Random/ Stratified	0 - 0.3 ft	10	10	10	--	10	10	10	10	--	10	10	--	--	10	--	--	--	Ten sediment samples will be randomly collected from the shoreline area of Howard Amon City Park from a 10 cell grid.
	Recreational	Sediment, Shoreline	Grab	Columbia Point Marina	CPM-1SSD to CPM-5SSD	Random/ Stratified	0 - 0.3 ft	5	5	5	--	5	5	5	5	--	5	5	--	--	5	--	--	--	Five sediment samples will be randomly collected from the shoreline area of Columbia Point Marina from a 5 cell grid.
	Recreational	Sediment, Shoreline	Grab	Bateman Island Boat Launch	BL-1SSD to BL-10SSD	Random/ Stratified	0 - 0.3 ft	10	10	10	--	10	10	10	10	--	10	10	--	--	10	--	--	--	Sediment samples will be randomly collected from the shoreline area of Bateman Island Boat Launch from a 10 cell grid.
	Yakima River	Sediment, Deep	Ponar	Above confluence of Yakima and Columbia (deep Columbia River sediment)	CR-1SD	Random/ Stratified	0 - 0.3 ft	1	1	1	--	1	1	1	1	--	1	1	1	--	1	--	--	--	Based on sonar survey results, one deep sediment sample will be collected at the confluence of Yakima and Columbia Rivers.
	Yakima River	Sediment, Deep	Ponar	Below confluence of Yakima and Columbia (deep Columbia River sediment)	CR-2SD	Random/ Stratified	0 - 0.3 ft	1	1	1	--	1	1	1	1	--	1	1	1	--	1	--	--	--	Based on sonar survey results, one deep core sample will be collected from the Columbia River (in the vicinity of river mile 333) below its confluence with the Yakima River. The upper ten inches of the core will be used to evaluate ecological impacts.
	Recreational	Surface Water	Grab	Howard Amon City Park	HA-1SW	Random/ Stratified	2/3 surface water depth	1	1	1	1	1	1	1	1	--	--	1	--	--	1	--	1	1	One surface water sample will be taken from near Howard Amon City Park to augment existing data.

Table 2-5. Proposed Sampling and Analytical Plan for Lake Wallula Sub-Area. (6 Pages)

Sample Description									Analyses*/EPA Method																	
Figure	Designation	Sample Type	Collection Method	Sampling Location	Temporary Sample ID	Sample Design	Sample Depth	Number of Samples	VOCs - 8260B	SVOCs - 8270C	Metals (Filtered)[6] - 6010/6020/7471	Metals (Unfiltered) - 6010/6020/7471	Cr+6 - 7196A	Pesticides - 8081	PCBs - 8082	PCB Congeners - 1668A	TOC/Grain Size - 9060/ASTM D422	PHC - 8115	AVS/SEM - 200.8	Nitrate - 300.0	Radionuclides - GEA/AEA	Hardness\DOC\ Alkalinity - 130.1\415.1\310.1	% Lipids[7]	Field Parameters[5]	Rationale
Figure 2-16 (cont.)	Recreational	Surface Water	Grab	Columbia Point Marina	CPM-1SW	Random/ Stratified	2/3 surface water depth	1	1	1	1	1	1	1	1	--	--	1	--	--	1	--	1	1	One surface water sample will be taken from near Columbia Point Marina to augment existing data.
	Recreational	Surface Water	Grab	Bateman Island Boat Launch	BL-1SW	Random/ Stratified	2/3 surface water depth	1	1	1	1	1	1	1	1	--	--	1	--	--	1	--	1	1	One surface water sample will be taken from near Bateman Island Boat Launch to augment existing data.
	Yakima River	Fish[2]	See Note 1	Yakima River Delta	YR-FS1 to YR-FS10	Focused	NA	10	--	--	--	10	--	10	--	10	--	--	--	--	10	10	--	--	Fish samples will be collected from Yakima River Delta. Number and type of fish may vary depending on availability of fish at time of sampling.
	Yakima River	Core, Shallow (2-inch diameter)	Vibracore	Yakima delta cores	YRC-1SD to YRC-3SD (1 core location subdivided. into approx. 3 sed. samples)[4]	Focused	0 - Refusal (1 ft subsamples)	3	1	1	--	3	3	--	--	--	3	--	1	--	3	--	--	--	Characterize sediments adjacent to the western shore of Bateman Island. Utilize data to evaluate historic deposition and potential ecological impacts.
	Yakima River (OCI)	Core, Shallow (2-inch diameter)	Vibracore	Yakima delta cores	YRC-4SD to YRC-6SD (1 core location subdivided. Into approx. 3 sed. samples)[4]	Focused	0 - Refusal (1 ft subsamples)	3	1	1	--	3	3	--	--	--	3	--	1	--	3	--	--	--	Characterize sediments adjacent to the western shore of Bateman Island. Utilize data to evaluate historic deposition and potential ecological impacts.
Figure 2-17	McNary Dam	Sediment, Shoreline	Grab	Peninsula HMU	PHMU-1SSD to PHMU-3SSD	Random/ Stratified	0 - 0.3 ft	3	--	1	--	3	--	--	--	--	3	--	--	--	3	--	--	--	Based on an ecological habitat survey, three samples will be collected from the riparian area; spaced along the Peninsula Wildlife Management Unit Area which is on the far (left) shore.
	McNary Dam	Sediment, Shoreline	Grab	Toothaker HMU	THMU-1SSD to THMU-2SSD	Random/ Stratified	0 - 0.3 ft	2	--	--	--	2	--	--	--	--	2	--	--	--	2	--	--	--	Based on an ecological habitat survey, two samples will be collected from the riparian area; spaced along the Toothaker Wildlife Management Unit Area which is on the near (right) shore.
	McNary Dam	Sediment, Shoreline	Grab	Badger Island	BI-1SSD to 2SSD	Random/ Stratified	0 - 0.3 ft	2	--	--	--	2	--	--	--	--	2	--	--	--	--	--	--	--	Based on an ecological habitat survey, two samples will be collected from the riparian area on Badger Island.
	McNary Dam	Sediment, Shallow	Ponar	Paper Mill Channel	PM-1SD to 2SD	Random/ Stratified	0 - 0.3 ft	2	2	2	--	2	2	2	2	--	2	2	2	--	2	--	--	--	Based on sonar survey results, two samples will be collected from shallow sediments in the Paper Mill Channel to evaluate potential future dredging impacts on upland human exposure.

Table 2-5. Proposed Sampling and Analytical Plan for Lake Wallula Sub-Area. (6 Pages)

Sample Description									Analyses*/EPA Method																
Figure	Designation	Sample Type	Collection Method	Sampling Location	Temporary Sample ID	Sample Design	Sample Depth	Number of Samples	VOCs - 8260B	SVOCs - 8270C	Metals (Filtered)[6] - 6010/6020/7471	Metals (Unfiltered) - 6010/6020/7471	Cr+6 - 7196A	Pesticides - 8081	PCBs - 8082	PCB Congeners - 1668A	TOC/Grain Size - 9060/ASTM D422	PHC - 8115	AVS/SEM - 200.8	Nitrate - 300.0	Radionuclides - GEA/AEA	Hardness\DOC\ Alkalinity - 130.1\415.1\310.1	% Lipids[7]	Field Parameters[3]	Rationale
Figure 2-17 (cont.)	McNary Dam	Sediment, Shallow	Ponar	Toothaker HMU	THMU-1SD to 2SD	Random/ Stratified	0 - 0.3 ft	2	--	--	--	2	--	--	--	--	2	--	2	--	2	--	--	--	Based on sonar survey results, two samples will be collected from shallow areas from the near (right) shore in the area of Toothaker Wildlife Management Unit.
	McNary Dam	Sediment, Shallow	Ponar	"Wallula Bay"	WB-1SD to 4SD	Random/ Stratified	0 - 0.3 ft	4	--	2	--	4	--	--	4	--	4	--	2	--	4	--	--	--	Based on sonar survey results, four samples will be collected from shallow areas from the far (left) shore between the Port of Wall Walla and the confluence with the Walla Wall River.
	OCI	Sediment, Shallow	Ponar	Snake River	SR-1SD to SR-5SD	Random/ Stratified	0 - 0.3 ft	5	1	5	--	5	5	5	5	--	5	1	--	--	5	--	--	--	Based on sonar survey results, five samples will be collected from shallow sediments in the Walla Walla River prior to its confluence with the Columbia River to evaluate other contributing influences.
	OCI	Sediment, Shallow	Ponar	Walla Walla River	WR-1SD to WR-5SD	Random/ Stratified	0 - 0.3 ft	5	1	5	--	5	5	5	5	--	5	1	--	--	5	--	--	--	Based on sonar survey results, five samples will be collected from shallow sediments in the Snake River prior to its confluence with the Columbia River to evaluate other contributing influences.
	Recreational	Sediment, Shoreline	Grab	Columbia Park	CP-1SSD to CP-10SSD	Random/ Stratified	0 - 0.3 ft	10	10	10	--	10	10	10	10	--	10	10	--	--	10	--	--	--	Ten sediment samples will be randomly collected from the shoreline area of Columbia Park from a 10 cell grid.
	Recreational	Sediment, Shoreline	Grab	Clover Island	CI-1SSD to CI-10SSD	Random/ Stratified	0 - 0.3 ft	10	10	10	--	10	10	10	10	--	10	10	--	--	10	--	--	--	Ten sediment samples will be randomly collected from the shoreline area of Clover Island from a 10 cell grid.
	Recreational	Sediment, Shallow	Grab	Clover Island	CI-1SD to CI-3SD	Random/ Stratified	0 - 0.3 ft	3	3	3	--	3	3	3	3	--	3	3	--	--	3	--	--	--	Three sediment samples will be randomly collected from the shoreline area of Clover Island from a 3 cell grid.
	Recreational	Sediment, Shoreline	Grab	Two Rivers Park	TR-1SSD (5 replicate)	MIS	0 - 0.3 ft	1	1	1	--	1	1	1	1	--	1	1	--	--	1	--	--	--	One MIS sample will be collected at 5 replicate from the shoreline area of Two Rivers Park.

Table 2-5. Proposed Sampling and Analytical Plan for Lake Wallula Sub-Area. (6 Pages)

Sample Description									Analyses*/EPA Method																	
Figure	Designation	Sample Type	Collection Method	Sampling Location	Temporary Sample ID	Sample Design	Sample Depth	Number of Samples	VOCs - 8260B	SVOCs - 8270C	Metals (Filtered)[6] - 6010/6020/7471	Metals (Unfiltered) - 6010/6020/7471	Cr+6 - 7196A	Pesticides - 8081	PCBs - 8082	PCB Congeners - 1668A	TOC/Grain Size - 9060/ASTM D422	PHC - 8115	AVS/SEM - 200.8	Nitrate - 300.0	Radionuclides - GEA/AEA	Hardness\DOC\ Alkalinity - 130.1\415.1\310.1	% Lipids[7]	Field Parameters[3]	Rationale
Figure 2-17 (cont.)	Recreational	Sediment, Shoreline	Grab	Cascade Marina	CM-1SSD to CM-10SSD	Random/ Stratified	0 - 0.3 ft	10	10	10	--	10	10	10	10	--	10	10	--	--	10	--	--	--	Ten sediment samples will be randomly collected from the shoreline area of Cascade Marina from a 10 cell grid.
	Recreational	Sediment, Shoreline	Grab	Sacajawea Park	SP-1SSD to SP-10SSD	Random/ Stratified	0 - 0.3 ft	10	10	10	--	10	10	10	10	--	10	10	--	--	10	--	--	--	Ten sediment samples will be randomly collected from the shoreline area of Sacajawea Park from a 10 cell grid.
	OCI	Surface Water	Grab	Snake River	SR-1SW	Random/ Stratified	2/3 surface water depth	2	2	2	2	2	2	2	2	--	--	2	--	--	2	--	2	2	Two surface water samples taken (spring and fall) from the Snake River to augment existing data and evaluate other contributing influences.
	OCI	Surface Water	Grab	Walla Walla River	WR-1SW (spring and fall)	Random/ Stratified	2/3 surface water depth	2	2	2	2	2	2	2	2	--	--	2	--	--	2	--	2	2	Two surface water samples will be taken (spring and fall) from the Walla Walla River to augment existing data and evaluate other contributing influences.
	Recreational	Surface Water	Grab	Columbia Park	CP-1SW (spring and fall)	Random/ Stratified	2/3 surface water depth	1	1	1	1	1	1	1	1	--	--	1	--	--	1	--	1	1	One surface water sample will be taken from near Columbia Park to augment existing data.
	Recreational	Surface Water	Grab	Clover Island	CI-1SW	Random/ Stratified	2/3 surface water depth	1	1	1	1	1	1	1	1	--	--	1	--	--	1	--	1	1	One surface water sample will be taken from near Clover Island Boat Launch to augment existing data.
	Recreational	Surface Water	Grab	Two Rivers Park	TR-1SW	Random/ Stratified	2/3 surface water depth	1	1	1	1	1	1	1	1	--	--	1	--	--	1	--	1	1	One surface water sample will be taken from near Two Rivers Park to augment existing data.
	Recreational	Surface Water	Grab	Cascade Marina	CM-1SW	Random/ Stratified	2/3 surface water depth	1	1	1	1	1	1	1	1	--	--	1	--	--	1	--	1	1	One surface water sample will be taken from near Cascade Marina to augment existing data.
	Recreational	Surface Water	Grab	Sacajawea Park	SP-1SW	Random/ Stratified	2/3 surface water depth	1	1	1	1	1	1	1	1	--	--	1	--	--	1	--	1	1	One surface water sample will be taken from near Sacajawea Park to augment existing data.
	McNary Dam	Fish[2]	See Note 1	Burbank Slough	BS-FS1 to BS-FS7	Focused	NA	7	--	--	--	7	--	7	--	7	--	--	--	--	7	7	--	--	Fish samples will be collected from Burbank Slough. Number and type of fish may vary depending on availability of fish at time of sampling.

Table 2-5. Proposed Sampling and Analytical Plan for Lake Wallula Sub-Area. (6 Pages)

Sample Description									Analyses*/EPA Method																
Figure	Designation	Sample Type	Collection Method	Sampling Location	Temporary Sample ID	Sample Design	Sample Depth	Number of Samples	VOCs - 8260B	SVOCs - 8270C	Metals (Filtered)[6] - 6010/6020/7471	Metals (Unfiltered) - 6010/6020/7471	Cr+6 - 7196A	Pesticides - 8081	PCBs - 8082	PCB Congeners - 1668A	TOC/Grain Size - 9060/ASTM D422	PHC - 8115	AVS/SEM - 200.8	Nitrate - 300.0	Radionuclides - GEA/AEA	Hardness\DOC\ Alkalinity - 130.1\415.1\310.1	% Lipids[7]	Field Parameters[3]	Rationale
Figure 2-17 (cont.)	McNary Dam	Fish[2]	See Note 1	Finley Slough	FS-FS1 to FS-FS7	Focused	NA	7	--	--	--	7	--	7	--	7	--	--	--	--	7	7	--	--	Fish samples will be collected from Finley Slough. Number and type of fish may vary depending on availability of fish at time of sampling.
	McNary Dam	Fish[2]	See Note 1	Wallula Gap	WG-FS1 to WG-FS6	Focused	NA	6	--	--	--	6	--	6	--	6	--	--	--	--	6	6	--	--	Fish samples will be collected from Wallula Gap. Number and type of fish may vary depending on availability of fish at time of sampling.
	McNary Dam	Core, Shallow (2-inch diameter)	Vibracore	Foundation Island (Snake River Sediment)	FIC-1SD to FIC-6SD (2 core locations; approx. 3 sed. samples per core)[4]	Focused	0 - Refusal (1 ft subsamples)	6	1	1	--	6	--	--	--	--	6	--	1	--	6	--	--	--	Characterize sediments (left side) downriver of the confluence of the Snake and Columbia Rivers. Used to evaluate potential historic deposition of Hanford releases.
Figure 2-18	McNary Dam	Sediment, Shoreline	Grab	Lake Wallula Shoreline Sediments	LW-1SSD to LW-5SSD	Random/ Stratified	0 - 0.3 ft	5	--	--	--	5	--	--	--	--	5	--	--	--	5	--	--	--	Based on an ecological habitat survey, five samples will be collected from the riparian area; spaced along the Lake Wallula Shoreline.
	Recreational	Sediment, Shoreline	Grab	Port Kelley Boat Ramp	PK-1SSD to PK-10SSD	Random/ Stratified	0 - 0.3 ft	10	10	10	--	10	10	10	10	--	10	10	--	--	10	--	--	--	Ten sediment samples will be randomly collected from the shoreline area of Port Kelley Boat Ramp from a 10 cell grid.
	Recreational	Sediment, Shoreline	Grab	Hat Rock State Park	HR-1SSD to HR-10SSD	Random/ Stratified	0 - 0.3 ft	10	10	10	--	10	10	10	10	--	10	10	--	--	10	--	--	--	Ten sediment samples will be randomly collected from the shoreline area of Hat Rock State Park from a 10 cell grid.
	McNary Dam	Sediment, Deep	Ponar	Lake Wallula Sediments	LW-1SD to 5SD	Random/ Stratified	0 - 0.3 ft	5	--	--	--	5	--	--	--	--	5	--	5	--	5	--	--	--	Based on sonar survey results, five deep core samples will be collected from Lake Wallula; one between river mile 310 and 311; one in the area off shore from Hat Rock State Park/Boat Launch; one near river mile 302 and one between river mile 298 and 299. The upper ten inches of the cores will be used to evaluate ecological impacts.
	Recreational	Surface Water	Grab	Port Kelley Boat Ramp	PK-1SW	Random/ Stratified	2/3 surface water depth	1	1	1	1	1	1	1	1	--	--	1	--	--	1	--	1	1	One surface water sample will be taken from near Port Kelley Boat Ramp to augment existing data.
	Recreational	Surface Water	Grab	Hat Rock State Park	HR-1SW	Random/ Stratified	2/3 surface water depth	1	1	1	1	1	1	1	1	--	--	1	--	--	1	--	1	1	One surface water sample will be taken from near Hat Rock State Park/Boat Launch to augment existing data.
	McNary Dam	Surface Water, Deep	Grab	Lake Wallula SW	LW-1SW to LW-2SW	Random/ Stratified	1 ft above sediment surface	2	--	--	2	2	--	--	--	--	--	--	--	--	2	--	2	2	One deep water sample will be taken between river mile 300 and river mile 301 to augment existing data.

Table 2-5. Proposed Sampling and Analytical Plan for Lake Wallula Sub-Area. (6 Pages)

Sample Description									Analyses*/EPA Method																	
Figure	Designation	Sample Type	Collection Method	Sampling Location	Temporary Sample ID	Sample Design	Sample Depth	Number of Samples	VOCs - 8260B	SVOCs - 8270C	Metals (Filtered)[6] - 6010/6020/7471	Metals (Unfiltered) - 6010/6020/7471	Cr+6 - 7196A	Pesticides - 8081	PCBs - 8082	PCB Congeners - 1668A	TOC/Grain Size - 9060/ASTM D422	PHC - 8115	AVS/SEM - 200.8	Nitrate - 300.0	Radionuclides - GEA/AEA	Hardness\DOC\ Alkalinity - 130.1\415.1\310.1	% Lipids[7]	Field Parameters[3]	Rationale
Figure 2-18 (cont.)	McNary Dam	Core, Deep (4-inch diameter)	Drill Rig	Lake Wallula	LWC-1SD to LWC-3SD (1 core location subdivided. into approx. 3 sed. samples)[4]	Focused	0 - Refusal (8 inch subsamples)	3	1	1	--	3	1	1	1	--	3	--	1	--	3	--	--	--	Characterize sediments just upriver of Port Kelley and a boat launch (left side). Used to augment existing core data. Upper portion of sample to be used to evaluate ecological impacts.
	McNary Dam	Core, Deep (4-inch diameter)	Drill Rig	Lake Wallula	LWC-4SD to LWS-6SD (1 core location subdivided. into approx. 3 sed. samples)[4]	Focused	0 - Refusal (8 inch subsamples)	3	1	1	--	3	3	1	1	--	3	--	1	--	3	--	--	--	Characterize sediments just upriver of Hat Rock State Park/Boat Launch (left side). Used to augment existing core data. Upper portion of sample to be used to evaluate ecological impacts.
Figure 2-19	Recreational	Sediment, Shoreline	Grab	McNary Dam Boat Ramps	MDBR-1SSD to MDBR-20SSD	Random/ Stratified	0 - 0.3 ft	20	20	20	--	20	20	20	20	--	20	20	--	--	20	--	--	--	Ten samples will be randomly collected from the shoreline area of two (WA & OR side) McNary Dam Boat Ramps from a 10 cell grid each.
	Recreational	Surface Water	Grab	McNary Dam Boat Ramps	MDBR-1SW to MDBR-2SW	Random/ Stratified	2/3 surface water depth	2	2	2	2	2	2	2	2	--	--	2	--	--	2	--	2	2	Surface water samples will be collected from the shoreline area of McNary Dam Boat Ramp.
	McNary Dam	Surface Water, Deep	Grab	McNary Dam SW	MD-3SW	Random/ Stratified	1 ft above sediment surface	1	--	--	1	1	--	--	--	--	--	--	--	--	1	--	1	1	One deep water sample will be taken between river mile 292 and river mile 293 to augment existing data.
	McNary Dam	Core, Deep (4-inch diameter)	Drill Rig	McNary Dam	MDC-1SD to MDC-20SD (1 core location subdivided. into approx. 20 sed. samples)[4]	Focused	0 - Refusal (8 inch subsamples)	20	1	1	--	20	20	1	1	--	20	--	1	--	20	--	--	--	Characterize the sediments ~3/4 mile above McNary Dam (center of river). Used to augment existing core data. Upper portion of sample to be used to evaluate ecological impacts.

Notes:
1 Fish collection method shall be either:
- electrofishing (off limits in spring due to presence of juvenile steelhead), effective for whitefish, carp, bass, and suckers; long-line;
- hook and line (effective for whitefish, walleye, and sturgeon)

2 Arsenic for both organic and inorganic speciation - fish tissue only
3 Field parameters for surface water samples are measured in the field and consist of temperature, specific conductivity, dissolved oxygen, and pH
4 The actual number of core subsamples will depend on the volume of sediment recovered.
5 Every 10th surface water and sediment sample analyzed for PCB Aroclors by 8082 will also be analyzed for PCB congeners. All fish samples will be analyzed for congeners only.
6 Filtered applies to water only. Solids (i.e., sediment and soil) are not filtered.
7 Bligh-Dyer (1959).
-- Sample not analyzed for given parameter
AEA = Alpha energy analysis
ASTM = American Society for Testing and Materials
AVS/SEM = acid volatile sulfides/simultaneously extracted metals by EPA Method 200.8
BERA = Baseline Ecological Risk Assessment
BHHRA = Baseline Human Health Risk Assessment
Core = Sediment core
Cr+6 = hexavalent chromium by EPA Method 7196A
DOC = dissolved organic carbon
EPA = United States Environmental Protection Agency
GEA = Gamma energy analysis
GU = Groundwater Plume Upwelling
GW = groundwater
HMU = Habitat Management Unit
HT = Hanford Townsite
Metals = by EPA Methods 6010/6020 and 7471
MIS = Multiple Incremental Sampling
OCI = other contributing influence (i.e., non-Hanford)
Pesticides = by EPA Method 8081
PCE = tetrachloroethylene
PCBs = pesticides/polychlorinated biphenyls by EPA Method 8082
PHC = petroleum hydrocarbon by EPA Method 8115
SD = sediment
SVOCs = semivolatile organic compounds by EPA Method 8270C
SW = surface water
TOC = total organic carbon by EPA Method 9060
VOCs = volatile organic compounds by EPA Method 8260B

Table 2-6. Proposed Sampling and Analytical Plan for Bonneville Dam Pool Sub-Area.

Sample Description									Analyses*/EPA Method																	
Figure	Designation	Sample Type	Collection Method	Sampling Location	Temporary Sample ID	Sample Design	Sample Depth	Number of Samples	VOCs - 8260B	SVOCs - 8270C	Metals (Filtered)[2] - 6010/6020/7471	Metals (Unfiltered) - 6010/6020/7471	Cr+6 - 7196A	Pesticides - 8081	PCBs - 8082	PCB Congeners - 1668A	TOC/Grain Size - 9060/ASTM D422	PHC - 8115	AVS/SEM - 200.8	Nitrate - 300.0	Radionuclides - GEA/AEA	Hardness\DOC\Alkalinity - 130.1\415.1\310.1	% Lipids[3]	Field Parameters	Rationale:
Figure 2-20	Bonneville Dam	Core, Deep (4-inch diameter)	Drill Rig	Bonneville Dam	BDC-1SD to BDC-6SD (1 core subdivided. Into approx. 6 sed. samples)[1]	Focused	0 - Refusal (8 inch subsamples)	6	--	--	--	6	--	--	--	--	6	--	1	--	6	--	--	--	Characterize the sediments in the Bonneville Dam Pool with two additional locations to complement an existing core sample on the right side of the river. This location is on the left side of the river. Note: data used for Hanford Rad characterization only.
	Bonneville Dam	Core, Deep (4-inch diameter)	Drill Rig	Bonneville Dam	BDC-7SD to BDC-12SD (1 core subdivided. into approx. 6 sed. samples)[1]	Focused	0 - Refusal (8 inch subsamples)	6	--	--	--	6	--	--	--	--	6	--	1	--	6	--	--	--	Characterize the sediments in the Bonneville Dam Pool with two additional locations to complement an existing core sample on the right side of the river. This location is on the left side of the river. Note: data used for Hanford Rad characterization only.

Notes:
1 The actual number of core subsamples will depend on the volume of sediment recovered.
2 Filtered applies to water only. Solids (i.e., sediment and soil) are not filtered.
3 Bligh-Dyer (1959).
-- Sample not analyzed for given parameter
AEA = Alpha energy analysis
ASTM = American Society for Testing and Materials
AVS/SEM = acid volatile sulfides/simultaneously extracted metals by EPA Method 200.8
BERA = Baseline Ecological Risk Assessment
BHHRA = Baseline Human Health Risk Assessment
Core = Sediment core
Cr+6 = hexavalent chromium by EPA Method 7196A
DOC = dissolved organic carbon
EPA = United States Environmental Protection Agency
GEA = Gamma energy analysis
GU = Groundwater Plume Upwelling
GW = groundwater
HMU = Habitat Management Unit
HT = Hanford Townsite

Table 3-1. Analytical Performance Requirements for Contaminants in Water. (7 Pages)

Indicator Contaminant	Target Analyte?	Chemical Abstracts Service Number	Analytical Instrument and/or Method	Water Reference Values for the Protection of Human Health (µg/L or pCi/L)	Human Health Benchmark Source	Water Reference Values for the Protection of Aquatic Life (µg/L or pCi/L)	Ecological Benchmark Source	Laboratory Reporting Limit Requirement[a] (pCi/L or µg/L)	Precision (%)	Accuracy (%)
VOLATILE ORGANICS										
1,1,1-Trichloroethane		71-55-6	EPA Method 8260B	200	MCL	11	Suter and Tsao 1996	5	±20%[b]	50-150[b]
1,1,2,2-Tetrachloroethane		**79-34-5**	**EPA Method 8260B**	**0.055**	**Region 6**	**240**	**ODEQ 2001**	**5**	**±20%[b]**	**50-150[b]**
1,1,2-Trichloroethane (TCA)	√	**79-00-5**	**EPA Method 8260B**	**0.2**	**Region 6**	**1,200**	**Suter and Tsao 1996**	**5**	**±20%[b]**	**50-150[b]**
1,1-Dichloroethane		75-34-3	EPA Method 8260B	122	Region 6	47	Suter and Tsao 1996	10	±20%[b]	50-150[b]
1,1-Dichloroethene		75-35-4	EPA Method 8260B	NE	NE	NE	NE	5	±20%[b]	50-150[b]
1,2-Dichloroethane (DCA)	√	**107-06-2**	**EPA Method 8260B**	**0.123**	**Region 6**	**910**	**Suter and Tsao 1996**	**5**	**±20%[b]**	**50-150[b]**
1,2-Dichloropropane		**78-87-5**	**EPA Method 8260B**	**0.165**	**Region 6**	**5,700**	**ODEQ 2001**	**5**	**±20%[b]**	**50-150[b]**
2-Butanone		78-93-3	EPA Method 8260B	710	Region 6	14,000	Suter and Tsao 1996	10	±20%[b]	50-150[b]
2-Hexanone		591-78-6	EPA Method 8260B	200	Region 6	NA	NA	20	±20%[b]	50-150[b]
Acetone		67-64-1	EPA Method 8260B	548	Region 6	1,500	Suter and Tsao 1996	20	±20%[b]	50-150[b]
Benzene		**71-43-2**	**EPA Method 8260B**	**0.354**	**Region 6**	**130**	**Suter and Tsao 1996**	**5**	**±20%[b]**	**50-150[b]**
Bromodichloromethane		75-27-4	EPA Method 8260B	NE	NE	NE	NE	5	±20%[b]	50-150[b]
Bromoform		74-25-2	EPA Method 8260B	NE	NE	NE	NE	5	±20%[b]	50-150[b]
Bromomethane		75-83-9	EPA Method 8260B	NE	NE	NE	NE	10	±20%[b]	50-150[b]
Carbon disulfide		**75-15-0**	**EPA Method 8260B**	**NA**	**NA**	**0.92**	**ODEQ 2001**	**5**	**±20%[b]**	**50-150[b]**
Carbon tetrachloride	√	**56-23-5**	**EPA Method 8260B**	**0.171**	**Region 6**	**9.8**	**Suter and Tsao 1996**	**5**	**±20%[b]**	**50-150[b]**
Chlorobenzene		108-90-7	EPA Method 8260B	9.13	Region 6	64	Suter and Tsao 1996	5	±20%[b]	50-150[b]
Chloroethane		75-00-3	EPA Method 8260B	NE	NE	NE	NE	10	±20%[b]	50-150[b]
Chloroform	√	**67-66-3**	**EPA Method 8260B**	**0.167**	**Region 6**	**28**	**Suter and Tsao 1996**	**5**	**±20%[b]**	**50-150[b]**
Chloromethane		74-87-3	EPA Method 8260B	NE	NE	NE	NE	10	±20%[b]	50-150[b]
Dibromochloromethane		124-48-1	EPA Method 8260B	NE	NE	NE	NE	5	±20%[b]	50-150[b]
Cis-1,2-Dichloroethylene		156-59-2	EPA Method 8260B	6.08	Region 6	47	Suter and Tsao 1996	5	±20%[b]	50-150[b]
Dichloroethylene - 1,2 (total)	√	**540-59-0**	**EPA Method 8260B**	**1.9**	**MTCA SW B**	**25**	**ODEQ 2001**	**5**	**±20%[b]**	**50-150[b]**
Ethylbenzene		100-41-4	EPA Method 8260B	134	Region 6	7.3	Suter and Tsao 1996	5	±20%[b]	50-150[b]
Methyl isobutyl ketone		108-10-1	EPA Method 8260B	199	Region 6	170	Suter and Tsao 1996, ODEQ 2001	10	±20%[b]	50-150[b]
Methylene/Chloride		**75-09-2**	**EPA Method 8260B**	**4.28**	**Region 6**	**2,200**	**Suter and Tsao 1996**	**5**	**±20%[b]**	**50-150[b]**
Styrene		**100-42-5**	**EPA Method 8260**	**1.5**	**MTCA GW B**	**NA**	**NA**	**5**	**±20%[b]**	**50-150[b]**
Tetrachloroethene	√	**127-18-4**	**EPA Method 8260B**	**0.081**	**MTCA GW B**	**840**	**ODEQ 2001**	**5**	**±20%[b]**	**50-150[b]**
Toluene		108-88-3	EPA Method 8260B	228	Region 6	9.8	Suter and Tsao 1996	5	±20%[b]	50-150[b]
trans-1,2-Dichloroethylene		156-60-5	EPA Method 8260B	10.7	Region 6	47	Suter and Tsao 1996	5	±20%[b]	50-150[b]
Trichloroethene (TCE)	√	**79-01-6**	**EPA Method 8260B**	**0.028**	**Region 6**	**47**	**Suter and Tsao 1996**	**5**	**±20%[b]**	**50-150[b]**
Vinyl Chloride		**75-01-4**	**EPA Method 8260B**	**0.015**	**Region 6**	**1300**	**ODEQ 2001**	**10**	**±20%[b]**	**50-150[b]**
Xylenes (total)		1330-20-7	EPA Method 8260B	20.3	Region 6	13	Suter and Tsao 1996	10	±20%[b]	50-150[b]
cis-1,3-Dichloropropene		10061-01-5	EPA Method 8260B	NE	NE	NE	NE	5	±20%[b]	50-150[b]

Table 3-1. Analytical Performance Requirements for Contaminants in Water. (7 Pages)

Indicator Contaminant	Target Analyte?	Chemical Abstracts Service Number	Analytical Instrument and/or Method	Water Reference Values for the Protection of Human Health (µg/L or pCi/L)	Human Health Benchmark Source	Water Reference Values for the Protection of Aquatic Life (µg/L or pCi/L)	Ecological Benchmark Source	Laboratory Reporting Limit Requirement[a] (pCi/L or µg/L)	Precision (%)	Accuracy (%)
trans-1,3-Dichloropropene		10061-02-6	EPA Method 8260B	NE	NE	NE	NE	5	±20%[b]	50-150[b]
SEMIVOLATILE ORGANICS										
1,2,4-Trichlorobenzene		**120-82-1**	**EPA Method 8270**	**0.816**	**Region 6**	**110**	**Suter and Tsao 1996**	**10**	**±20%[b]**	**50-150[b]**
1,2-Dichlorobenzene		**95-50-1**	**EPA Method 8270**	**4.93**	**Region 6**	**14**	**ODEQ 2001**	**10**	**±20%[b]**	**50-150[b]**
1,3-Dichlorobenzene		**541-73-1**	**EPA Method 8270**	**1.45**	**Region 6**	**71**	**ODEQ 2001**	**10**	**±20%[b]**	**50-150[b]**
1,4-Dichlorobenzene		**106-46-7**	**EPA Method 8270**	**0.467**	**Region 6**	**15**	**Suter and Tsao 1996**	**10**	**±20%[b]**	**50-150[b]**
2,4,5-Trichlorophenol		95-95-4	EPA Method 8270	365	Region 6	NA	NA	10	±20%[b]	50-150[b]
2,4,6-Trichlorophenol		**88-06-2**	**EPA Method 8270**	**1.4**	**NRWQC**	**970**	**ODEQ 2001**	**10**	**±20%[b]**	**50-150[b]**
2,4-Dichlorophenol		120-83-2	EPA Method 8270	11	Region 6	3,650	ODEQ 2001	10	±20%[b]	50-150[b]
2,4-Dimethylphenol		105-67-9	EPA Method 8270	73	Region 6	42	ODEQ 2001	10	±20%[b]	50-150[b]
2,4-Dinitrophenol		**51-28-5**	**EPA Method 8270**	**7.3**	**Region 6**	**NA**	**NA**	**25**	**±20%[b]**	**50-150[b]**
2,4-Dinitrotoluene		**121-14-2**	**EPA Method 8270**	**0.11**	**NRWQC**	**230**	**ODEQ 2001**	**10**	**±20%[b]**	**50-150[b]**
2,6-Dinitrotoluene		**606-20-2**	**EPA Method 8270**	**3.65**	**Region 6**	**230**	**ODEQ 2001**	**10**	**±20%[b]**	**50-150[b]**
2-Chloronaphthalene		91-58-7	EPA Method 8270	48.7	Region 6	32	ODEQ 2001	10	±20%[b]	50-150[b]
2-Chlorophenol		**95-57-8**	**EPA Method 8270**	**3.04**	**Region 6**	**2,000**	**ODEQ 2001**	**10**	**±20%[b]**	**50-150[b]**
2-Methylnaphthalene		**91-57-6**	**EPA Method 8270**	**0.62**	**Region 6**	**2.1**	**ODEQ 2001**	**10**	**±20%[b]**	**50-150[b]**
2-Methylphenol (cresol, o-)		95-48-7	EPA Method 8270	1,825	Region 9	13	ODEQ 2001	10	±20%[b]	50-150[b]
2-Nitroaniline		88-74-4	EPA Method 8270	NE	NE	NE	NE	10	±20%[b]	50-150[b]
2-Nitrophenol		88-75-5	EPA Method 8270	29.2	Region 6	150	ODEQ 2001	20	±20%[b]	50-150[b]
3+4 Methylphenol (cresol, m+p)		65794-96-9	EPA Method 8270	NE	NE	NE	NE	10	±20%[b]	50-150[b]
3,3'-Dichlorobenzidine		91-94-1	EPA Method 8270	NE	NE	NE	NE	10	±20%[b]	50-150[b]
3-Nitroaniline		99-09-2	EPA Method 8270	NE	NE	NE	NE	10	±20%[b]	50-150[b]
4,6-Dinitro-2-methylphenol		534-52-1	EPA Method 8270	NE	NE	NE	NE	10	±20%[b]	50-150[b]
4-Bromophenylphenyl ether		101-55-3	EPA Method 8270	NE	NE	NE	NE	10	±20%[b]	50-150[b]
4-Chloro-3-methylphenol		59-50-7	EPA Method 8270	NE	NE	NE	NE	10	±20%[b]	50-150[b]
4-Chloroaniline		106-47-8	EPA Method 8270	NE	NE	NE	NE	10	±20%[b]	50-150[b]
4-Chlorophenylphenyl ether		7005-72-3	EPA Method 8270	NE	NE	NE	NE	10	±20%[b]	50-150[b]
4-Nitroaniline		100-01-6	EPA Method 8270	NE	NE	NE	NE	10	±20%[b]	50-150[b]
4-Nitrophenol		100-02-7	EPA Method 8270	29.2	Region 6	150	ODEQ 2001	20	±20%[b]	50-150[b]
Acenaphthene	√	83-32-9	EPA Method 8270	36.5	Region 6	520	ODEQ 2001	10	±20%[b]	50-150[b]
Acenaphthylene		208-96-8	EPA Method 8270	37	Region 6	NA	NA	10	±20%[b]	50-150[b]
Anthracene	√	120-12-7	EPA Method 8270	182.5	Region 6	13	ODEQ 2001	10	±20%[b]	50-150[b]
Benzo(a)anthracene	√	**56-55-3**	**EPA Method 8270**	**0.0038**	**NRWQC**	**0.027**	**ODEQ 2001**	**10**	**±20%[b]**	**50-150[b]**
Benzo(a)pyrene	√	**50-32-8**	**EPA Method 8270**	**0.00295**	**Region 6**	**0.014**	**ODEQ 2001**	**10**	**±20%[b]**	**50-150[b]**
Benzo(b)fluoranthene	√	**205-99-2**	**EPA Method 8270**	**0.0038**	**NRWQC**	**NA**	**NA**	**10**	**±20%[b]**	**50-150[b]**
Benzo(ghi)perylene	√	191-24-2	EPA Method 8270	180	Region 6	NA	NA	10	±20%[b]	50-150[b]
Benzo(k)fluoranthene	√	**207-08-9**	**EPA Method 8270**	**0.0038**	**NRWQC**	**NA**	**NA**	**10**	**±20%[b]**	**50-150[b]**
Bis(2-ethylhexyl)phthalate	√	**117-81-7**	**EPA Method 8270**	**1.2**	**NRWQC**	**3**	**ODEQ 2001**	**10**	**±20%[b]**	**50-150[b]**

Table 3-1. Analytical Performance Requirements for Contaminants in Water. (7 Pages)

Indicator Contaminant	Target Analyte?	Chemical Abstracts Service Number	Analytical Instrument and/or Method	Water Reference Values for the Protection of Human Health (µg/L or pCi/L)	Human Health Benchmark Source	Water Reference Values for the Protection of Aquatic Life (µg/L or pCi/L)	Ecological Benchmark Source	Laboratory Reporting Limit Requirement[a] (pCi/L or µg/L)	Precision (%)	Accuracy (%)
Butylbenzylphthalate		85-68-7	EPA Method 8270	730	Region 6	19	ODEQ 2001	10	±20%[b]	50-150[b]
Carbazole		**86-74-8**	**EPA Method 8270**	**3.4**	**Region 6**	**NA**	**NA**	**10**	**±20%[b]**	**50-150[b]**
Chrysene	√	**218-01-9**	**EPA Method 8270**	**0.0038**	**NRWQC**	**NA**	**NA**	**10**	**±20%[b]**	**50-150[b]**
Dibenz[a,h]anthracene	√	**53-70-3**	**EPA Method 8270**	**0.00295**	**Region 6**	**NA**	**NA**	**10**	**±20%[b]**	**50-150[b]**
Dibenzofuran		**132-64-9**	**EPA Method 8270**	**1.22**	**Region 6**	**37**	**ODEQ 2001**	**10**	**±20%[b]**	**50-150[b]**
Diethylphthalate		84-66-2	EPA Method 8270	2,920	Region 6	210	ODEQ 2001	10	±20%[b]	50-150[b]
Dimethyl phthalate		**131-11-3**	**EPA Method 8270**	**16,000**	**MTC GW B**	**3**	**ODEQ 2001**	**10**	**±20%[b]**	**50-150[b]**
Di-n-butylphthalate		84-74-2	EPA Method 8270	365	Region 6	35	ODEQ 2001	10	±20%[b]	50-150[b]
Di-n-butylphthalate		84-74-2	EPA Method 8270	365	Region 6	35	ODEQ 2001	10	±20%[b]	50-150[b]
Di-n-octylphthalate		117-84-0	EPA Method 8270	1500	Region 9	NA	NA	10	±20%[b]	50-150[b]
Fluoranthene	√	**206-44-0**	**EPA Method 8270**	**90**	**MTCA SW B**	**6.16**	**ODEQ 2001**	**10**	**±20%[b]**	**50-150[b]**
Fluorene		**86-73-7**	**EPA Method 8270**	**24.3**	**Region 6**	**3.9**	**ODEQ 2001**	**10**	**±20%[b]**	**50-150[b]**
Hexachlorobenzene		**118-74-1**	**EPA Method 8270**	**0.00028**	**NRWQC**	**NA**	**NA**	**10**	**±20%[b]**	**50-150[b]**
Hexachlorobutadiene		**87-68-3**	**EPA Method 8270**	**0.44**	**NRWQC**	**9.3**	**ODEQ 2001**	**10**	**±20%[b]**	**50-150[b]**
Hexachlorocyclopentadiene		**77-47-4**	**EPA Method 8270**	**21.9**	**Region 6**	**5.2**	**ODEQ 2001**	**10**	**±20%[b]**	**50-150[b]**
Hexachloroethane		**67-72-1**	**EPA Method 8270**	**1.4**	**NRWQC**	**540**	**ODEQ 2001**	**10**	**±20%[b]**	**50-150[b]**
Indeno(1,2,3-cd)pyrene	√	**193-39-5**	**EPA Method 8270**	**0.0038**	**NRWQC**	**NA**	**NA**	**10**	**±20%[b]**	**50-150[b]**
Isophorone		78-59-1	EPA Method 8270	35	NRWQC	2,340	ODEQ 2001	10	±20%[b]	50-150[b]
Naphthalene	√	**91-20-3**	**EPA Method 8270**	**0.620**	**Region 6**	**NA**	**NA**	**10**	**±20%[b]**	**50-150[b]**
Nitrobenzene		**98-95-3**	**EPA Method 8270**	**0.34**	**Region 6**	**540**	**ODEQ 2001**	**10**	**±20%[b]**	**50-150[b]**
N-Nitroso-di-n-dipropylamine		**621-64-7**	**EPA Method 8270**	**0.005**	**NRWQC**	**117**	**ODEQ 2001**	**10**	**±20%[b]**	**50-150[b]**
N-Nitrosodiphenylamine		**86-30-6**	**EPA Method 8270**	**3.3**	**NRWQC**	**210**	**ODEQ 2001**	**10**	**±20%[b]**	**50-150[b]**
Pentachlorophenol		**87-86-5**	**EPA Method 8270**	**0.27**	**NRWQC**	**15**	**ODEQ 2001**	**10**	**±20%[b]**	**50-150[b]**
Phenanthrene	√	**85-01-8**	**EPA Method 8270**	**37**	**Region 6**	**6.3**	**ODEQ 2001**	**10**	**±20%[b]**	**50-150[b]**
Phenol	√	108-95-2	EPA Method 8270	1,095	Region 6	110	ODEQ 2001	10	±20%[b]	50-150[b]
Pyrene	√	129-00-0	EPA Method 8270	18.3	Region 6	NA	NA	10	±20%[b]	50-150[b]
Total petroleum hydrocarbons - Diesel range + oils	√	TPHDIESEL & TPH/OILH	NWTPH-D	NA	NA	Not evaluated	NA	500	±20%[c]	80-120[c]
METALS										
Aluminum	√	7429-90-5	Metals[d]	3,650	Region 6	87	EPA 2006	50	±20%[c]	80-120[c]
Antimony	√	**7440-36-0**	**Metals[d]**	**1.46**	**Region 6**	**30**	**Suter and Tsao 1996**	**60/6[e]**	**±20%[c]**	**80-120[c]**
Arsenic	√	**7440-38-2**	**Metals[d]**	**0.018**	**NRWQC**	**150**	**EPA 2006**	**100/10[e]**	**±20%[c]**	**80-120[c]**
Barium	√	**7440-39-3**	**Metals[d]**	**730**	**Region 6**	**4**	**Suter and Tsao 1996**	**20/5.0[e]**	**±20%[c]**	**80-120[c]**
Beryllium	√	**7440-41-7**	Metals[d]	**4**	**MCL**	**0.66**	**Suter and Tsao 1996**	**5.0/2.0[e]**	**±20%[c]**	**80-120[c]**
Bismuth		7440-69-9		NE	NE	NE	NE	100	±20%[c]	80-120[c]
Boron	√	**7440-42-8**	**Metals[d]**	**730**	**Region 6**	**1.6**	**ODEQ 2001**	**20**	**±20%[c]**	**80-120[c]**
Cadmium	√	**7440-43-9**	**Metals[d]**	**1.83**	**Region 6**	**0.25**	**EPA 2006**	**5.0/2.0[e]**	**±20%[c]**	**80-120[c]**

Table 3-1. Analytical Performance Requirements for Contaminants in Water. (7 Pages)

Indicator Contaminant	Target Analyte?	Chemical Abstracts Service Number	Analytical Instrument and/or Method	Water Reference Values for the Protection of Human Health (µg/L or pCi/L)	Human Health Benchmark Source	Water Reference Values for the Protection of Aquatic Life (µg/L or pCi/L)	Ecological Benchmark Source	Laboratory Reporting Limit Requirement[a] (pCi/L or µg/L)	Precision (%)	Accuracy (%)
Calcium		7440-70-2	Metals[d]	NA	NA	116,000	Suter and Tsao 1996	1000	±20%[c]	80-120[c]
Chromium (total)	√	7440-47-3	Metals[d]	11	Region 6	74	EPA 2006	10/2.0[e]	±20%[c]	80-120[c]
Chromium (VI)	√	**18540-29-9**	**Method 7196A**	**11**	**Region 6**	**10**	**Ecology 2006**	**10**	**±20%[c]**	**80-120[c]**
Cobalt		7440-48-4	Metals[d]	73	Region 6	23	Suter and Tsao 1996	20	±20%[c]	80-120[c]
Copper	√	**7440-50-8**	**Metals[d]**	**136**	**Region 6**	**9**	**EPA 2006**	**10**	**±20%[c]**	**80-120[c]**
Cyanide (total)		57-12-5	EPA Method 9010	73	Region 6	5.2	LANL 2005	5	±20%[c]	80-120[c]
Iron	√	7439-89-6	Metals[d]	300	NRWQC	1,000	EPA 2006	50	±20%[c]	80-120[c]
Lead	√	**7439-92-1**	**Metals[d]**	**15**	**MCL/MTCA GW**	**2.5**	**Ecology 2006**	**50/5.0[e]**	**±20%[c]**	**80-120[c]**
Lithium	√	**7439-93-2**	**Metals[d]**	**730**	**Region 9**	**14**	**ODEQ 2001**	**25**	**±20%[c]**	**80-120[c]**
Magnesium		7439-95-4	Metals[d]	NA	NA	82,000	Suter and Tsao 1996	750	±20%[c]	80-120[c]
Manganese	√	7439-96-5	Metals[d]	50	NRWQC	120	Suter and Tsao 1996	5	±20%[c]	80-120[c]
Mercury	√	**7439-97-6**	**Method 7470**	**0.0626**	**Region 6**	**0.012**	**Ecology 2006**	**0.5**	**±20%[c]**	**80-120[c]**
Molybdenum		**7439-98-7**	**Metals[d]**	**18.3**	**Region 6**	**370**	**ODEQ 2001**	**20**	**±20%[c]**	**80-120[c]**
Nickel	√	7440-02-0	Metals[d]	73	Region 6	52	EPA 2006	40	±20%[c]	80-120[c]
Phosphorous		**7723-14-0**	**Metals[d]**	**0.073**	**Region 6**	**NE**	**NE**	**50**	**±20%[c]**	**80-120[c]**
Potassium		7440-09-7	Metals[d]	NA	NA	53,000	Suter and Tsao 1996	4000	±20%[c]	80-120[c]
Selenium	√	**7782-49-2**	**Metals[d]**	**18.3**	**Region 6**	**5**	**Ecology 2006**	**100/10[e]**	**±20%[c]**	**80-120[c]**
Silicon		7440-21-3	Metals[d]	NE	NE	NE	NE	20	±20%[c]	80-120[c]
Silver		**7440-22-4**	**Metals[d]**	**18.3**	**Region 6**	**0.36**	**Suter and Tsao 1996**	**10/2.0[e]**	**±20%[c]**	**80-120[c]**
Sodium		7440-23-5	Metals[d]	NA	NA	680,000	Suter and Tsao 1996	500	±20%[c]	80-120[c]
Strontium	√	7440-24-6	Metals[d]	2,190	Region 6	1,500	Suter and Tsao 1996	10	±20%[c]	80-120[c]
Thallium	√	**7440-28-0**	**Metals[d]**	**0.24**	**NRWQC**	**12**	**Suter and Tsao 1996**	**50/5.0**	**±20%[c]**	**80-120[c]**
Tin		**7440-31-5**	**Metals[d]**	**2,190**	**Region 6**	**73**	**Suter and Tsao 1996**	**100**	**±20%[c]**	**80-120[c]**
Uranium	√	**7440-61-1**	**Metals[d]**	**2.19**	**Region 9***	**2.6**	**Suter and Tsao 1996**	**3000/500[e]**	**±20%[c]**	**80-120[c]**
Vanadium	√	**7440-62-2**	**Metals[d]**	**18.3**	**Region 6**	**20**	**Suter and Tsao 1996**	**25**	**±20%[c]**	**80-120[c]**
Zinc	√	7440-66-6	Metals[d]	1,100	Region 6	105	Ecology 2006	10	±20%[c]	80-120[c]
RADIONUCLIDES										
Americium-241		**14596-10-2**	**GEA**	**15**	**MCL-rad**	**438**	**ANL 2006**	**50**	**±20%[f]**	**80-120[f]**
Antimony-125		14234-35-6	GEA	300	MCL-rad	400,000	ANL 2006	50	±20%[f]	80-120[f]
Beryllium-7		13966-02-4	GEA	NE	NE	NE	NE	50	±20%[f]	80-120[f]
Carbon-14[g]	√	14762-75-5	Carbon-14	2,000	MCL-rad	609	ANL 2006	50	±20%[f]	80-120[f]
Cesium-134		13967-70-9	GEA	80	MCL-rad	21.1	ANL 2006	15	±20%[f]	80-120[f]
Cesium-137	√	10045-97-3	GEA	200	MCL-rad	42.6	ANL 2006	15	±20%[f]	80-120[f]
Cobalt-60	√	10198-40-0	GEA	100	MCL-rad	3,760	ANL 2006	25	±20%[f]	80-120[f]
Curium-244		13981-15-2	Isotopic Cm - AEA	15	MCL-rad	66.3	ANL 2006	1	±20%[f]	80-120[f]
Europium-152	√	14683-23-9	GEA	200	MCL-rad	25,500	ANL 2006	50	±20%[f]	80-120[f]

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Europium-154	√	15585-10-1	GEA	60	MCL-rad	20,000	ANL 2006	50	±20%[f]	80-120[f]
Europium-155		14391-16-3	GEA	600	MCL-rad	264,000	ANL 2006	50	±20%[f]	80-120[f]
Iodine-129		**15046-84-1**	**LEPS**	**1**	**MCL-rad**	**40,000**	**ANL 2006**	**5**	**±20%[f]**	**80-120[f]**
Neptunium-237		13994-20-2	Np-237 - AEA	15	MCL-rad	NA	NA	1	±20%[f]	80-120[f]
Nickel-63		13981-37-8	LSC	50	MCL-rad	NA	NA	15	±20%[f]	80-120[f]
Plutonium-238		13981-16-3	Isotopic Pu-AEA	15	MCL-rad	176	ANL 2006	1	±20%[f]	80-120[f]
Plutonium-239/240		PU-239/240	Isotopic Pu-AEA	15	MCL-rad	187	ANL 2006	1	±20%[f]	80-120[f]
Plutonium-241		14119-32-5	AEA	NA	NA	NA	NA	15	±20%[f]	80-120[f]
Potassium-40		**13966-00-2**	**GEA**	**NA**	**NA**	**250**	**ANL 2006**	**400[h]**	**±20%[f]**	**80-120[f]**
Radium-226		13982-63-3	Total radium-isotopic	5 (total of Ra-226 and Ra-228)	MCL-rad	4	ANL 2006	1	±20%[f]	80-120[f]
Radium-228		15262-20-1	Total radium-isotopic	5 (total of Ra-226 and Ra-228)	MCL-rad	3	ANL 2006	3	±20%[f]	80-120[f]
Ruthenium-106		13967-48-1	GEA	NE	NE	NE	NE	50	±20%[f]	80-120[f]
Strontium-90	√	10098-97-2	Total Rad Sr – GPC	8	MCL-rad	300	ANL 2006	1	±20%[f]	80-120[f]
Technetium-99	√	14133-76-7	Technetium -99	900	MCL-rad	700,000	ANL 2006	15	±20%[f]	80-120[f]
Thorium-232		14274-82-9	Isotopic Th-AEA	15	MCL-rad	300	ANL 2006	1	±20%[f]	80-120[f]
Tritium	√	10028-17-8	H-3	20,000	MCL-rad	300,000,000	ANL 2006	400	±20%[f]	80-120[f]
Uranium-234	√	13966-29-5	Isotopic U-AEA	30	MCL-rad	200	ANL 2006	1	±20%[f]	80-120[f]
Uranium-235	√	15117-96-1	Isotopic U-AEA	30	MCL-rad	200	ANL 2006	1	±20%[f]	80-120[f]
Uranium-238	√	7440-61-1	Isotopic U-AEA	30	MCL-rad	200	ANL 2006	1	±20%[f]	80-120[f]
PESTICIDES/POLYCHLORINATED BIPHENYLS										
77 3,3',4,4'-tetrachlorobiphenyls		**32598-11-1**	**EPA Method 1668A**	**4.50E-03**	**Region 6**	**NA**	**NA**	**0.02**	**tbd**	**tbd**
81 3,4,4',5-tetrachlorobiphenyl		**70362-50-4**	**EPA Method 1668A**	**1.50E-03**	**Region 6**	**NA**	**NA**	**0.02**	**tbd**	**tbd**
105 2,3,3',4,4'- pentachlorobiphenyls		**32598-14-4**	**EPA Method 1668A**	**1.50E-02**	**Region 6**	**NA**	**NA**	**0.02**	**tbd**	**tbd**
114 2,3,4,4',5- pentachlorobiphenyls		**74472-38-1**	**EPA Method 1668A**	**1.50E-02**	**Region 6**	**NA**	**NA**	**0.02**	**tbd**	**tbd**
118 2,3',4,4',5- pentachlorobiphenyls		**31508-00-6**	**EPA Method 1668A**	**1.50E-02**	**Region 6**	**NA**	**NA**	**0.02**	**tbd**	**tbd**
123 2',3,4,4',5- pentachlorobiphenyls		**65510-44-3**	**EPA Method 1668A**	**1.50E-02**	**Region 6**	**NA**	**NA**	**0.02**	**tbd**	**tbd**
126 3,3',4,4',5-pentachlorobiphenyls		**57465-28-8**	**EPA Method 1668A**	**4.50E-06**	**Region 6**	**NA**	**NA**	**0.02**	**tbd**	**tbd**
156 2,3,3',4,4',5- hexachlorobiphenyls		**38380-08-4**	**EPA Method 1668A**	**1.50E-02**	**Region 6**	**NA**	**NA**	**0.02**	**tbd**	**tbd**
157 2,3,3',4,4',5'- hexachlorobiphenyls		**69782-90-7**	**EPA Method 1668A**	**1.50E-02**	**Region 6**	**NA**	**NA**	**0.02**	**tbd**	**tbd**
167 2,3',4,4',5,5'-hexachlorobiphenyls		**52663-72-6**	**EPA Method 1668A**	**1.50E-02**	**Region 6**	**NA**	**NA**	**0.02**	**tbd**	**tbd**
169 3,3',4,4',5,5'-hexachlorobiphenyls		**32774-16-6**	**EPA Method 1668A**	**1.50E-05**	**Region 6**	**NA**	**NA**	**0.02**	**tbd**	**tbd**
189 2,3,3',4,4',5,5'-heptachlorobiphenyls		**39635-31-9**	**EPA Method 1668A**	**1.50E-02**	**Region 6**	**NA**	**NA**	**0.02**	**tbd**	**tbd**
Aldrin		**309-00-2**	**EPA Method 8081**	**0.000082**	**MTCA SW B**	**0.0019**	**Ecology 2006**	**0.05**	**±20%[b]**	**50-150[b]**
Alpha-BHC		**319-84-6**	**EPA Method 8081**	**0.0079**	**MTCA SW B**	**2.2**	**ODEQ 2001**	**0.05**	**±20%[b]**	**50-150[b]**
alpha-Chlordane		**5103-71-9**	**EPA Method 8081**	**0.0008**	**NRWQC**	**0.0043**	**Ecology 2006**	**0.5**	**±20%[b]**	**50-150[b]**
Aroclor-1016	√	**12674-11-2**	**EPA Method 8082**	**0.000064**	**NRWQC**	**NA**	**NA**	**0.5**	**±20%[b]**	**50-150[b]**

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Aroclor-1221	√	**11104-28-2**	**EPA Method 8082**	**0.000064**	**NRWQC**	**0.28**	**ODEQ 2001**	**0.5**	**±20%[b]**	**50-150[b]**
Aroclor-1232	√	**11141-16-5**	**EPA Method 8082**	**0.000064**	**NRWQC**	**0.58**	**ODEQ 2001**	**0.5**	**±20%[b]**	**50-150[b]**
Aroclor-1242	√	**53469-21-9**	**EPA Method 8082**	**0.000064**	**NRWQC**	**0.053**	**ODEQ 2001**	**0.5**	**±20%[b]**	**50-150[b]**
Aroclor-1248	√	**12672-29-6**	**EPA Method 8082**	**0.000064**	**NRWQC**	**0.081**	**ODEQ 2001**	**0.5**	**±20%[b]**	**50-150[b]**
Aroclor-1254	√	**11097-69-1**	**EPA Method 8082**	**0.000064**	**NRWQC**	**0.033**	**ODEQ 2001**	**0.5**	**±20%[b]**	**50-150[b]**
Aroclor-1260	√	**11096-82-5**	**EPA Method 8082**	**0.000064**	**NRWQC**	**94**	**ODEQ 2001**	**0.5**	**±20%[b]**	**50-150[b]**
beta-1,2,3,4,5,6-Hexachlorocyclohexane		**319-85-7**	**EPA Method 8081**	**0.0091**	**NRWQC**	**0.08**	**Ecology 2006**	**0.05**	**±20%[b]**	**50-150[b]**
Delta-BHC		319-86-8	EPA Method 8081	0.052	Region 6	2.2	Suter and Tsao 1996	0.05	±20%[b]	50-150[b]
Dichlorodiphenyl-dichloroethane		**72-54-8**	**EPA Method 8081**	**0.00031**	**NRWQC**	**0.001**	**Ecology 2006**	**0.1**	**±20%[b]**	**50-150[b]**
Dichlorodiphenyl-dichloroethylene		**72-55-9**	**EPA Method 8081**	**0.00022**	**NRWQC**	**0.001**	**Ecology 2006**	**0.1**	**±20%[b]**	**50-150[b]**
Dichlorodiphenyl-trichloroethane		**50-29-3**	**EPA Method 8081**	**0.00022**	**NRWQC**	**0.001**	**Ecology 2006**	**0.1**	**±20%[b]**	**50-150[b]**
Dieldrin		**60-57-1**	**EPA Method 8081**	**0.000052**	**NRWQC**	**0.0019**	**Ecology 2006**	**0.1**	**±20%[b]**	**50-150[b]**
Endosulfan II		**33213-65-9**	**EPA Method 8081**	**22**	**Region 6**	**0.056**	**LANL 2005**	**0.1**	**±20%[b]**	**50-150[b]**
Endosulfan sulfate		**1031-07-8**	**EPA Method 8081**	**22**	**Region 6**	**0.056**	**LANL 2005**	**0.1**	**±20%[b]**	**50-150[b]**
Endosulfan I		959-98-8	EPA Method 8081	22	Region 6	0.056	LANL 2005	0.05	±20%[b]	50-150[b]
Endrin		**72-20-8**	**EPA Method 8081**	**0.059**	**NRWQC**	**0.0023**	**Ecology 2006**	**0.1**	**±20%[b]**	**50-150[b]**
Endrin aldehyde		7421-93-4	EPA Method 8081	0.2	MTCA SW B	NA	NA	0.1	±20%[b]	50-150[b]
Endrin ketone		**53494-70-5**	**EPA Method 8081**	**0.2**	**MTCA SW B**	**0.0023**	**Ecology 2006**	**0.1**	**±20%[b]**	**50-150[b]**
Gamma-BHC (Lindane)		**58-89-9**	**EPA Method 8081**	**0.038**	**MTCA SW B**	**0.08**	**Ecology 2006**	**0.05**	**±20%[b]**	**50-150[b]**
Gamma-chlordane		**5103-74-2**	**EPA Method 8081**	**0.0008**	**NRWQC**	**0.0043**	**Ecology 2006**	**0.5**	**±20%[b]**	**50-150[b]**
Heptachlor		**76-44-8**	**EPA Method 8081**	**0.000079**	**NRWQC**	**0.0038**	**Ecology 2006**	**0.05**	**±20%[b]**	**50-150[b]**
Heptachlor epoxide		**1024-57-3**	**EPA Method 8081**	**0.000039**	**NRWQC**	**0.0000038**	**ODEQ 2001**	**0.05**	**±20%[b]**	**50-150[b]**
Hexachlorobenzene[i]		**118-74-1**	**NA**	**0.00028**	**NRWQC**	**NA**	**NA**	**0.05**	**±20%[b]**	**50-150[b]**
Methoxychlor		**72-43-5**	**EPA Method 8081**	**8.4**	**MTCA SW B**	**0.03**	**EPA 2006**	**0.5**	**±20%[b]**	**50-150[b]**
Toxaphene		8001-35-2	EPA Method 8081	NE	NE	NE	NE	5	±20%[b]	50-150[b]
OTHER ANALYTES										
Alkalinity[k]		ALKALINITY	EPA Method 310.1	NA	NA	NA	NA	5,000	±20%[c]	80-120[c]
Hardness[k]		HARDNESS	EPA Method 130.1	NA	NA	NA	NA	10,000	±20%	None
Nitrate[k]		NO3-N	EPA Method 300.0	NA	NA	NA	NA	75	±20%[c]	80-120[c]
DOC		COD	EPA Method 415.1 Modified	NE	NE	NE	NE	1000	±20%[c]	80-120[c]
TKN[k]		N-KJELDAHL	EPA Method 351.1	NA	NA	NA	NA	50	±20%[c]	80-120[c]

Notes:

Entries in bold indicate analytes for which the reporting limit exceeds associated benchmark concentration.

Human Health Benchmark Sources:

MCL-rad = EPA Soil Screening Guidance for Radionuclides, Technical Background Document. Table 2.3-Radionuclide Drinking Water MCLs. EPA Office of Radiation and Indoor Air, Office of Solid Waste and Emergency Response, October 2000. (For Uranium isotopes, values are the December 2000 Federal MCL)

NRWQC = National Recommended Water Quality Criteria, Human Health for Consumption of Water + Organism values. EPA Office of Water/Office of Science and Technology, 2006.

MCL = Federal Maximum Contaminant Levels (MCLs), National Primary Drinking Water Regulations, EPA, June 2003, EPA 816-F-03-016.

Table 3-1. Analytical Performance Requirements for Contaminants in Water. (7 Pages)

Indicator Contaminant	Target Analyte?	Chemical Abstracts Service Number	Analytical Instrument and/or Method	Water Reference Values for the Protection of Human Health (µg/L or pCi/L)	Human Health Benchmark Source	Water Reference Values for the Protection of Aquatic Life (µg/L or pCi/L)	Ecological Benchmark Source	Laboratory Reporting Limit Requirement[a] (pCi/L or µg/L)	Precision (%)	Accuracy (%)

Model Toxics Control Act (MTCA), Method B Surface Water Standards (lowest between carcinogenic and noncarcinogenic values). Values obtained from Washington State Department of Ecology (WADOE) Cleanup Levels and Risk Calculation (CLARC).

MTCA Method B Ground Water Standards (lowest between carcinogenic and noncarcinogenic values). Values obtained from Washington State Department of Ecology (WADOE) Cleanup Levels and Risk Calculation (CLARC).

Region 6 = EPA Region 6 Human Health Medium-Specific Screening Levels, December 2007. Dallas, Texas 75202.

Region 9 = EPA Region 9 Preliminary Remediation Goals (PRGs) for Tapwater. October 2004. http://www.epa.gov/region09/waste/sfund/prg/files/prgtable2004.xls

Region 9* = (adjusted by 3 to account for revised Office of Water RfD of 0.0006 mg/kg-d)

Ecological Benchmark Sources:

See BERA Methodology benchmark table for use of surrogates.

Ecology 2006 = WAC 173-201A, "Water Quality Standards for Surface Waters of the State of Washington," Washington State Department of Ecology, Olympia, Washington.

Suter and Tsao 1996 = Suter, G.W. and C.L. Tsao, *Toxicological Benchmarks for Screening of Potential Contaminants of Concern for Effects on Aquatic*

EPA 2006 = *National Recommended Water Quality Criteria,* Office of Water, Washington, D.C.

ANL 2006 = Argonne National Laboratory, *RESRAD Biota for Windows*, Version 1.21 (http://web.ead.anl.gov/resrad/home2/).

LANL 2005 = Los Alamos National Laboratory, Ecorisk Database (Release 2.2).

ODEQ 2001 = Oregon Department of Environmental Quality, *Guidance for Ecological Risk Assessment,* Level II Screening Level Values, December 2001 Update.

[a] Values for radionuclide analysis are minimum detectable activity requirements. Other values are laboratory reporting limits, nominally 5 to 10 times sample detection limits and functionally useable as PQLs.

[b] The accuracy criteria shown are the minimum for associated batch laboratory control sample percent recoveries. Laboratories must meet statistically-based controls if more stringent. Additional accuracy criteria include analyte-specific evaluation performed for matrix spike and surrogate recoveries as appropriate to the method. The precision criteria shown are for batch laboratory replicate matrix spike analysis.

[c] Accuracy criteria for associated batch matrix spike percent recoveries. Evaluation criteria based on laboratory statistical limits or fixed limits as defined in the referenced methods. Precision criteria for batch laboratory replicate matrix spike analyses or replicate sample analysis.

[d] SW-846 Method 6010 or 6020 or EPA Method 200.8 and extraction Method 3050B.

[e] First value shown is via routine inductively coupled plasma (ICP), second value via "trace" inductively coupled plasma.

[f] Accuracy criteria for associated batch laboratory control sample percent recoveries. For some radionuclide analytical methods, additional analysis-specific evaluations also are performed for matrix spikes, tracers, and carriers as appropriate to the method. Precision criteria for batch laboratory replicate sample analyses.

[g] Carbon-14 will be measured in the 100-K Area only.

[h] Isotopes not specifically addressed by existing contracts. The detection limits shown are estimates.

[i] Analysis for hexachlorobenzenes and chlordane will be reported as specific isomers. The reporting limit shown is for each isomer.

[k] Evaluate as a general chemistry parameter of water; see Table 2.3 for specific samples.

AEA = alpha energy analysis
DOC = dissolved organic carbon
EPA = U.S. Environmental Protection Agency
GEA = gamma energy analysis
GPC = gas proportional counter
LEPS = low energy photon spectroscopy
MCL = maximum contaminant level
NA = No reference value available, but contaminant concentration will be evaluated for exposure modeling, comparison to other media types, or descriptive purposes.
NE = For compounds that have not been previously detected, benchmarks were not evaluated. If this compound is detected during sampling, benchmarks will be provided, if available.
PQL = practical quantitaion limit
tbd = to be determined
TKN = total nitrogen

Table 3-2. Analytical Performance Requirements for Contaminants in Soil and Sediment. (10 Pages)

Indicator Contaminant	Target Analyte?	Chemical Abstracts Service Number	Analytical Instrument and/or Method	Reference Values for the Protection of Human Health Receptors (mg/kg or pCi/g)	Human Health Benchmark Source	Sediment Reference Values for the Protection of Ecological Receptors (mg/kg or pCi/g)	Sediment Ecological Benchmark Source	Soil Reference Values for the Protection of Ecological Receptors (mg/kg or pCi/g)	Soil Ecological Benchmark Source	Laboratory Reporting Limit Requirements (mg/kg or pCi/g)[a]	Laboratory Precision (%)	Laboratory Accuracy (%)
VOLATILE ORGANICS												
1,1,1-Trichloroethane		71-55-6	EPA Method 8260	57	MTCA-Leaching	0.03	ORNL 1997	NA	NA	0.001	±30%[b]	50-150[b]
1,1,2,2-Tetrachloroethane		**79-34-5**	**EPA Method 8260**	**0.00136**	**MTCA-Leaching**	**1.4**	**ORNL 1997**	**NA**	**NA**	**0.005**	**±30%[b]**	**50-150[b]**
1,1,2-Trichloroethane		**79-00-5**	**EPA Method 8260**	**0.00428**	**MTCA-Leaching**	**1.2**	**ORNL 1997**	**NA**	**NA**	**0.005**	**±30%[b]**	**50-150[b]**
1,1-Dichloroethane		75-34-3	EPA Method 8260	8.73	MTCA-Leaching	0.27	ORNL 1997	NA	NA	0.01	±30%[b]	50-150[b]
1,1-Dichloroethene		75-35-4	EPA Method 8260	NE	NE	NE	NE	NE	NE	0.005	±30%[b]	50-150[b]
1,2-Dichloroethane		**107-06-2**	**EPA Method 8260**	**0.00232**	**MTCA-Leaching**	**0.25**	**ORNL 1997**	**NA**	**NA**	**0.005**	**±30%[b]**	**50-150[b]**
1,2-Dichloropropane		**78-87-5**	**EPA Method 8260**	**0.00329**	**MTCA-Leaching**	**NA**	**NA**	**700**	**Ecology 2001**	**0.005**	**±30%[b]**	**50-150[b]**
2-Butanone		78-93-3	EPA Method 8260	20	MTCA-Leaching	0.27	ORNL 1997	NA	NA	0.01	±30%[b]	50-150[b]
2-Hexanone	√	591-78-6	EPA Method 8260	NA	NA	0.022	ORNL 1997	NA	NA	0.02	±30%[b]	50-150[b]
Acetone		**67-64-1**	**EPA Method 8260**	**3**	**MTCA-Leaching**	**0.0087**	**ORNL 1997**	**NA**	**NA**	**0.02**	**±30%[b]**	**50-150[b]**
Benzene		**71-43-2**	**EPA Method 8260**	**0.00451**	**MTCA-Leaching**	**0.16**	**ORNL 1997**	**20**	**Ecology 2001**	**0.005**	**±30%[b]**	**50-150[b]**
Bromodichloromethane		75-27-4	EPA Method 8260	NE	NE	NE	NE	NE	NE	0.005	±30%[b]	50-150[b]
Bromoform		75-25-2	EPA Method 8260	NE	NE	NE	NE	NE	NE	0.005	±30%[b]	50-150[b]
Bromomethane		75-83-9	EPA Method 8260	NE	NE	NE	NE	NE	NE	0.01	±30%[b]	50-150[b]
Carbon disulfide		**75-15-0**	**EPA Method 8260**	**4.034**	**MTCA-Leaching**	**0.00085**	**ORNL 1997**	**NA**	**NA**	**0.005**	**±30%[b]**	**50-150[b]**
Carbon tetrachloride		**56-23-5**	**EPA Method 8260**	**0.00304**	**MTCA-Leaching**	**0.047**	**ORNL 1997**	**NA**	**NA**	**0.005**	**±30%[b]**	**50-150[b]**
Chlorobenzene		108-90-7	EPA Method 8260	1.39	MTCA-Leaching	0.41	ORNL 1997	40	Ecology 2001	0.005	±30%[b]	50-150[b]
Chloroethane		75-00-3	EPA Method 8260	NE	NE	NE	NE	NE	NE	0.01	±30%[b]	50-150[b]
Chloroform		67-66-3	EPA Method 8260	0.0383	MTCA-Leaching	0.022	ORNL 1997	NA	NA	0.005	±30%[b]	50-150[b]
Chloromethane		74-87-3	EPA Method 8260	NE	NE	NE	NE	NE	NE	0.01	±30%[b]	50-150[b]
Dibromochloromethane		124-48-1	EPA Method 8260	NE	NE	NE	NE	NE	NE	0.005	±30%[b]	50-150[b]
Dichloroethylene		25323-30-2	EPA Method 8260	0.414	MTCA-Leaching	0.4	ORNL 1997	NA	NA	0.005	±30%[b]	50-150[b]
Ethylbenzene		100-41-4	EPA Method 8260	11.93	MTCA-Leaching	0.089	ORNL 1997	NA	NA	0.005	±30%[b]	50-150[b]
Methylene chloride		75-09-2	EPA Method 8260	0.0257	MTCA-Leaching	0.37	ORNL 1997	1,600	LANL 2005	0.005	±30%[b]	50-150[b]

Table 3-2. Analytical Performance Requirements for Contaminants in Soil and Sediment. (10 Pages)

Indicator Contaminant	Target Analyte?	Chemical Abstracts Service Number	Analytical Instrument and/or Method	Reference Values for the Protection of Human Health Receptors (mg/kg or pCi/g)	Human Health Benchmark Source	Sediment Reference Values for the Protection of Ecological Receptors (mg/kg or pCi/g)	Sediment Ecological Benchmark Source	Soil Reference Values for the Protection of Ecological Receptors (mg/kg or pCi/g)	Soil Ecological Benchmark Source	Laboratory Reporting Limit Requirements (mg/kg or pCi/g)[a]	Laboratory Precision (%)	Laboratory Accuracy (%)
Styrene		100-42-5	EPA Method 8260	0.0336	MTCA-Leaching	NA	NA	300	Ecology 2001	0.005	±30%[b]	50-150[b]
Tetrachloroethene	√	**127-18-4**	**EPA Method 8260**	**0.000854**	**MTCA-Leaching**	**0.057**	**ODEQ 2001**	**10**	**LANL 2005**	**0.005**	**±30%[b]**	**50-150[b]**
Toluene		108-88-3	EPA Method 8260	4.65	MTCA-Leaching	0.05	ORNL 1997	200	Ecology 2001	0.005	±30%[b]	50-150[b]
Trichloroethene	√	**79-01-6**	**EPA Method 8260**	**0.000723**	**MTCA-Leaching**	**0.22**	**ORNL 1997**	**NA**	**NA**	**0.005**	**±30%[b]**	**50-150[b]**
Vinyl Chloride		**75-01-4**	**EPA Method 8260**	**0.000182**	**MTCA-Leaching**	**0.03**	**ODEQ, 1998**	**NA**	**NA**	**0.01**	**±30%[b]**	**50-150[b]**
Xylenes (total)	√	1330-20-7	EPA Method 8260	21.33	MTCA-Leaching	0.16	ORNL 1997	40	Ecology 2001	0.01	±30%[b]	50-150[b]
cis-1,3-Dichloropropene		10061-01-5	EPA Method 8260	NE	NE	NE	NE	NE	NE	0.005	±30%[b]	50-150[b]
trans-1,3-Dichloropropene		10061-02-6	EPA Method 8260	NE	NE	NE	NE	NE	NE	0.005	±30%[b]	50-150[b]
SEMIVOLATILE ORGANICS												
1,2,4-Trichlorobenzene		120-82-1	EPA Method 8270	1.476	MTCA-Leaching	9.6	ORNL 1997	20	Ecology 2001	0.33	±30%[b]	50-150[b]
1,2-Dichlorobenzene		95-50-1	EPA Method 8270	8.43	MTCA-Leaching	0.33	ORNL 1997	20	Ecology 2001	0.33	±30%[b]	50-150[b]
1,3-Dichlorobenzene		541-73-1	EPA Method 8270	6.85	MTCA-Leaching	1.7	ORNL 1997	20	Ecology 2001	0.33	±30%[b]	50-150[b]
1,4-Dichlorobenzene		**106-46-7**	**EPA Method 8270**	**0.0297**	**MTCA-Leaching**	**0.34**	**ORNL 1997**	**20**	**Ecology 2001**	**0.33**	**±30%[b]**	**50-150[b]**
2,4,5-Trichlorophenol		**95-95-4**	**EPA Method 8270**	**22.18**	**MTCA-Leaching**	**0.003**	**ODEQ 2001**	**4**	**Ecology 2001**	**0.33**	**±30%[b]**	**50-150[b]**
2,4,6-Trichlorophenol		**88-06-2**	**EPA Method 8270**	**0.111**	**MTCA-Leaching**	**0.006**	**ODEQ 2001**	**10**	**Ecology 2001**	**0.33**	**±30%[b]**	**50-150[b]**
2,4-Dichlorophenol		120-83-2	EPA Method 8270	0.440	MTCA-Leaching	NA	NA	20	Ecology 2001	0.33	±30%[b]	50-150[b]
2,4-Dimethylphenol		**105-67-9**	**EPA Method 8270**	**2.94**	**MTCA-Leaching**	**0.018**	**ODEQ 2001**	**4**	**Ecology 2001**	**0.33**	**±30%[b]**	**50-150[b]**
2,4-Dinitrophenol		51-28-5	EPA Method 8270	0.361	MTCA-Leaching	NA	NA	20	Ecology 2001	0.825	±30%[b]	50-150[b]
2,4-Dinitrotoluene		121-14-2	EPA Method 8270	0.361	MTCA-Leaching	NA	NA	4	Ecology 2001	0.33	±30%[b]	50-150[b]
2,6-Dinitrotoluene		**606-20-2**	**EPA Method 8270**	**0.183**	**MTCA-Leaching**	**NA**	**NA**	**4**	**Ecology 2001**	**0.33**	**±30%[b]**	**50-150[b]**
2-Chloronaphthalene		91-58-7	EPA Method 8270	40.67	MTCA-Leaching	NA	NA	4	Ecology 2001	0.33	±30%[b]	50-150[b]
2-Chlorophenol		95-57-8	EPA Method 8270	0.515	MTCA-Leaching	NA	NA	7	Ecology 2001	0.33	±30%[b]	50-150[b]

Table 3-2. Analytical Performance Requirements for Contaminants in Soil and Sediment. (10 Pages)

Indicator Contaminant	Target Analyte?	Chemical Abstracts Service Number	Analytical Instrument and/or Method	Reference Values for the Protection of Human Health Receptors (mg/kg or pCi/g)	Human Health Benchmark Source	Sediment Reference Values for the Protection of Ecological Receptors (mg/kg or pCi/g)	Sediment Ecological Benchmark Source	Soil Reference Values for the Protection of Ecological Receptors (mg/kg or pCi/g)	Soil Ecological Benchmark Source	Laboratory Reporting Limit Requirements (mg/kg or pCi/g)[a]	Laboratory Precision (%)	Laboratory Accuracy (%)
2-Methylnaphthalene		**91-57-6**	**EPA Method 8270**	**2.034**	**MTCA-Leaching**	**0.02**	**ODEQ 2001**	**3**	**Hill AFB 2005**	**0.33**	**±30%[b]**	**50-150[b]**
2-Methylphenol (cresol, o-)		**95-48-7**	**EPA Method 8270**	**5**	**MTCA-Leaching**	**0.008**	**ODEQ 2001**	**20**	**Ecology 2001**	**0.33**	**±30%[b]**	**50-150[b]**
2-Nitroaniline		88-74-4	EPA Method 8270	NE	NE	NE	NE	NE	NE	0.33	±30%[b]	50-150[b]
2-Nitrophenol		88-75-5	EPA Method 8270	49	Region 6/Region 9 Values	NA	NA	7	Ecology 2001	0.66	±30%[b]	50-150[b]
3+4 Methylphenol (cresol, m+p)		65794-96-9	EPA Method 8270	NE	NE	NE	NE	NE	NE	0.33	±30%[b]	50-150[b]
3,3'-Dichlorobenzidine		91-94-1	EPA Method 8270	NE	NE	NE	NE	NE	NE	0.33	±30%[b]	50-150[b]
3-Nitroaniline		99-09-2	EPA Method 8270	NE	NE	NE	NE	NE	NE	0.33	±30%[b]	50-150[b]
4,6-Dinitro-2-methylphenol		534-52-1	EPA Method 8270	NE	NE	NE	NE	NE	NE	0.33	±30%[b]	50-150[b]
4-Bromophenylphenyl ether		101-55-3	EPA Method 8270	NE	NE	NE	NE	NE	NE	0.33	±30%[b]	50-150[b]
4-Chloro-3-methylphenol		59-50-7	EPA Method 8270	NE	NE	NE	NE	NE	NE	0.33	±30%[b]	50-150[b]
4-Chloroaniline		106-47-8	EPA Method 8270	NE	NE	NE	NE	NE	NE	0.33	±30%[b]	50-150[b]
4-Chlorophenylphenyl ether		7005-72-3	EPA Method 8270	NE	NE	NE	NE	NE	NE	0.33	±30%[b]	50-150[b]
4-Nitroaniline		100-01-6	EPA Method 8270	NE	NE	NE	NE	NE	NE	0.33	±30%[b]	50-150[b]
4-Nitrophenol		100-02-7	EPA Method 8270	48.88	Region 6/Region 9 Values	NA	NA	7	Ecology 2001	0.66	±30%[b]	50-150[b]
Acenaphthene		83-32-9	EPA Method 8270	97.89	MTCA-Leaching	1.06	Michelsen 2003	20	Ecology 2001	0.33	±30%[b]	50-150[b]
Acenaphthylene		208-96-8	EPA Method 8270	97.90	MTCA-Leaching	0.47	Michelsen 2003	2.3	Hill AFB 2005	0.33	±30%[b]	50-150[b]
Anthracene	√	120-12-7	EPA Method 8270	2,190	Region 6 Values	1.23	Michelsen 2003	1.2	Hill AFB 2005	0.33	±30%[b]	50-150[b]
Benzo(a)anthracene	√	**56-55-3**	**EPA Method 8270**	**0.14**	**MTCA-Direct Contact**	**4.26**	**Michelsen 2003**	**18**	**LANL 2005**	**0.33**	**±30%[b]**	**50-150[b]**
Benzo(a)pyrene	√	**50-32-8**	**EPA Method 8270**	**0.0148**	**Region 6 Values**	**3.3**	**Michelsen 2003**	**12**	**Ecology 2001**	**0.33**	**±30%[b]**	**50-150[b]**
Benzo(b)fluoranthene	√	**205-99-2**	**EPA Method 8270**	**0.14**	**MTCA-Direct Contact**	**1.8**	**ODEQ 2001**	**18**	**LANL 2005**	**0.33**	**±30%[b]**	**50-150[b]**
Benzo(ghi)perylene	√	191-24-2	EPA Method 8270	230	Region 6 Values	4.02	Michelsen 2003	1.2	Hill AFB 2005	0.33	±30%[b]	50-150[b]
Benzo(k)fluoranthene	√	**207-08-9**	**EPA Method 8270**	**0.14**	**MTCA-Direct Contact**	**0.027**	**ODEQ 2001**	**1.2**	**Hill AFB 2005**	**0.33**	**±30%[b]**	**50-150[b]**
Bis(2-Chloroethoxy)methane		111-91-1	EPA Method 8270	NE	NE	NE	NE	NE	NE	0.33	±30%[b]	50-150[b]
Bis(2-chloro-1-methylethyl)ether		108-60-1	EPA Method 8270	NE	NE	NE	NE	NE	NE	0.33	±30%[b]	50-150[b]

Table 3-2. Analytical Performance Requirements for Contaminants in Soil and Sediment. (10 Pages)

Indicator Contaminant	Target Analyte?	Chemical Abstracts Service Number	Analytical Instrument and/or Method	Reference Values for the Protection of Human Health Receptors (mg/kg or pCi/g)	Human Health Benchmark Source	Sediment Reference Values for the Protection of Ecological Receptors (mg/kg or pCi/g)	Sediment Ecological Benchmark Source	Soil Reference Values for the Protection of Ecological Receptors (mg/kg or pCi/g)	Soil Ecological Benchmark Source	Laboratory Reporting Limit Requirements (mg/kg or pCi/g)[a]	Laboratory Precision (%)	Laboratory Accuracy (%)
Bis(2-chloroethyl) ether		111-44-4	EPA Method 8270	NE	NE	NE	NE	NE	NE	0.33	±30%[b]	50-150[b]
Bis(2-ethylhexyl)phthalate	√	117-81-7	EPA Method 8270	20.87	MTCA-Direct Contact	2.52	Michelsen 2003	100	Ecology 2001	0.33	±30%[b]	50-150[b]
Butylbenzylphthalate		**85-68-7**	**EPA Method 8270**	**240**	**Region 6 Values**	**0.26**	**Michelsen 2003**	**10**	**Hill AFB 2005**	**0.33**	**±30%[b]**	**50-150[b]**
Carbazole		86-74-8	EPA Method 8270	1.011	MTCA-Direct Contact	0.923	Michelsen 2003	NA	NA	0.33	±30%[b]	50-150[b]
Chrysene	√	**218-01-9**	**EPA Method 8270**	**0.14**	**MTCA-Direct Contact**	**5.94**	**Michelsen 2003**	**1.2**	**Hill AFB 2005**	**0.33**	**±30%[b]**	**50-150[b]**
Dibenz[a,h]anthracene	√	**53-70-3**	**EPA Method 8270**	**0.0148**	**Region 6 Values**	**0.8**	**Michelsen 2003**	**1.2**	**Hill AFB 2005**	**0.33**	**±30%[b]**	**50-150[b]**
Dibenzofuran		132-64-9	EPA Method 8270	14.5	Region 6 Values	0.399	Michelsen 2003	6.1	LANL 2005	0.33	±30%[b]	50-150[b]
Diethylphthalate	√	84-66-2	EPA Method 8270	73	MTCA-Direct Contact	0.6	ORNL 1997	100	Ecology 2001	0.33	±30%[b]	50-150[b]
Dimethyl phthalate		**131-11-3**	**EPA Method 8270**	**90**	**MTCA-Direct Contact**	**0.311**	**Michelsen 2003**	**200**	**Ecology 2001**	**0.33**	**NA**	**NA**
Di-n-butylphthalate	√	**84-74-2**	**EPA Method 8270**	**56.54**	**MTCA-Direct Contact**	**0.103**	**Michelsen 2003**	**200**	**Ecology 2001**	**0.33**	**±30%[b]**	**50-150[b]**
Di-n-octylphthalate		**117-84-0**	**EPA Method 8270**	**1.28**	**MTCA-Direct Contact**	**0.011**	**Michelsen 2003**	**100**	**Ecology 2001**	**0.33**	**±30%[b]**	**50-150[b]**
Fluoranthene	√	206-44-0	EPA Method 8270	229	Region 6 Values	11.1	Michelsen 2003	4.7	Hill AFB 2005	0.33	±30%[b]	50-150[b]
Fluorene		86-73-7	EPA Method 8270	101.21	MTCA-Leaching	1.07	Michelsen 2003	30	Ecology 2001	0.33	±30%[b]	50-150[b]
Hexachlorobenzene		118-74-1	EPA Method 8270	0.088	MTCA-Leaching	0.1	ODEQ 2001	17	Ecology 2001	0.0017	±30%[b]	50-150[b]
Hexachlorobutadiene		**87-68-3**	**EPA Method 8270**	**0.0138**	**MTCA-Leaching**	**0.001**	**ODEQ 2001**	**10**	**Ecology 2001**	**0.33**	**±30%[b]**	**50-150[b]**
Hexachlorocyclopentadiene		77-47-4	EPA Method 8270	1.88	MTCA-Leaching	NA	NA	10	Ecology 2001	0.33	±30%[b]	50-150[b]
Hexachloroethane		**67-72-1**	**EPA Method 8270**	**0.027**	**MTCA-Leaching**	**1**	**ORNL 1997**	**10**	**Ecology 2001**	**0.33**	**±30%[b]**	**50-150[b]**

Table 3-2. Analytical Performance Requirements for Contaminants in Soil and Sediment. (10 Pages)

Indicator Contaminant	Target Analyte?	Chemical Abstracts Service Number	Analytical Instrument and/or Method	Reference Values for the Protection of Human Health Receptors (mg/kg or pCi/g)	Human Health Benchmark Source	Sediment Reference Values for the Protection of Ecological Receptors (mg/kg or pCi/g)	Sediment Ecological Benchmark Source	Soil Reference Values for the Protection of Ecological Receptors (mg/kg or pCi/g)	Soil Ecological Benchmark Source	Laboratory Reporting Limit Requirements (mg/kg or pCi/g)[a]	Laboratory Precision (%)	Laboratory Accuracy (%)
Indeno-(1,2,3-cd)pyrene	√	**193-39-5**	**EPA Method 8270**	**0.14**	**MTCA-Direct Contact**	**4.12**	**Michelsen 2003**	**NA**	**NA**	**0.33**	**±30%[b]**	**50-150[b]**
Isophorone		**78-59-1**	**EPA Method 8270**	**0.238**	**MTCA-Leaching**	**NA**	**NA**	**NA**	**NA**	**0.33**	**±30%[b]**	**50-150[b]**
Naphthalene		91-20-3	EPA Method 8270	4.46	MTCA-Leaching	0.529	Michelsen 2003	2	Hill AFB 2005	0.33	±30%[b]	50-150[b]
Nitrobenzene		**98-95-3**	**EPA Method 8270**	**0.0313**	**MTCA-Leaching**	**0.021**	**ODEQ 2001**	**40**	**Ecology 2001**	**0.33**	**±30%[b]**	**50-150[b]**
N-Nitroso-di-n-dipropylamine		**621-64-7**	**EPA Method 8270**	**0.0695**	**Region 6/9**	**0.028**	**ODEQ 2001**	**20**	**Ecology 2001**	**0.33**	**±30%[b]**	**50-150[b]**
N-Nitrosodiphenylamine		86-30-6	EPA Method 8270	99	SSL	NA	NA	20	Ecology 2001	0.33	±30%[b]	50-150[b]
Pentachlorophenol	√	**87-86-5**	**EPA Method 8270**	**0.0523**	**MTCA-Leaching**	**0.017**	**ODEQ 2001**	**2.1**	**Ecology 2001**	**0.33**	**±30%[b]**	**50-150[b]**
Phenanthrene	√	85-01-8	EPA Method 8270	97.89	MTCA-Leaching	6.1	Michelsen 2003	2.1	Hill AFB 2005	0.33	±30%[b]	50-150[b]
Phenol	√	**108-95-2**	**EPA Method 8270**	**45**	**MTCA-Leaching**	**0.048**	**Ecology 1997**	**30**	**Ecology 2001**	**0.33**	**±30%[b]**	**50-150[b]**
Pyrene	√	129-00-0	EPA Method 8270	231	Region 6 Values	8.79	Michelsen 2003	1.3	Hill AFB 2005	0.33	±30%[b]	50-150[b]
Total petroleum hydrocarbons - Diesel range + oils	√	TPHDIESEL & TPH/OILH	NWTPH-D	NA	NA	NA	NA	NA	NA	5	±30%[c]	70-130[c]
METALS												
Aluminum	√	7429-90-5	Metals[d]	7,730	Region 6 Values	14000	Ingersoll 1996	50	Ecology 2001	5	±30%[c]	70-130[c]
Antimony[e]	√	**7440-36-0**	**Metals[d]**	**3.13**	**Region 6 Values**	**0.6**	**Michelsen 2003**	**0.27**	**EPA SSL**	**6/0.6[f]**	**±30%[c]**	**70-130[c]**
Arsenic	√	**7440-38-2**	**Metals[d]**	**0.39**	**Region 6 Values**	**31.4**	**Michelsen 2003**	**10**	**Ecology 2001**	**10/1[f]**	**±30%[c]**	**70-130[c]**
Barium	√	7440-39-3	Metals[d]	1,560	Region 6 Values	48	ODEQ 2001	102	Ecology 2001	2/0.5[f]	±30%[c]	70-130[c]
Beryllium		7440-41-7	Metals[d]	15.6	Region 6 Values	0.46	Michelsen 2003	10	Ecology 2001	0.5/0.2[f]	±30%[c]	70-130[c]
Bismuth		7440-69-9	Metals[d]	NE	NE	NE	NE	NE	NE	10	±30%[c]	70-130[c]
Boron		**7440-42-8**	**Metals[d]**	**NA**	**NA**	**NA**	**NA**	**0.5**	**Ecology 2001**	**2**	±30%[c]	70-130[c]
Cadmium	√	**7440-43-9**	**Metals[d]**	**3.9**	**Region 6 Values**	**2.39**	**Michelsen 2003**	**0.36**	**EPA SSL**	**0.5/0.2[f]**	**±30%[c]**	**70-130[c]**
Calcium		7440-70-2	Metals[d]	NE	NE	NA	NA	NA	NA	10	±30%[c]	70-130[c]
Chromium (total)	√	7440-47-3	Metals[d]	30	Region 6 Values	95	Michelsen 2003	26	EPA SSL	1	±30%[c]	70-130[c]
Chromium (VI)	√	18540-29-9	Method 7196A	30	Region 6 Values	NA	NA	81	EPA SSL	0.5	±30%[c]	70-130[c]

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Cobalt		7440-48-4	Metals[d]	903	Region 6 Values	50	Persaud et. al. 1993	13	EPA SSL	2	±30%[c]	70-130[c]
Copper	√	7440-50-8	Metals[d]	291	Region 6 Values	619	Michelsen 2003	28	EPA SSL	1	±30%[c]	70-130[c]
Iron	√	7439-89-6	Metals[d]	5,480	Region 6 Values	200,000	Ingersoll 1996	NA	NA	5	±30%[c]	70-130[c]
Lead	√	7439-92-1	Metals[d]	250	MTCA-Direct Contact	335	Michelsen 2003	11	EPA SSL	5/0.5[f]	±30%[c]	70-130[c]
Lithium	√	7439-93-2	Metals[d]	1,560	Region 9 PRGs	NA	NA	35	Ecology 2001	2.5	±30%[c]	70-130[c]
Magnesium		7439-95-4	Metals[d]	NA	NA	NA	NA	NA	NA	75	±30%[c]	70-130[c]
Manganese	√	7439-96-5	Metals[d]	347	Region 6 Values	1,800	Ecology 1997	220	EPA SSL	5	±30%[c]	70-130[c]
Mercury	√	**7439-97-6**	**Method 7471**	**2.3**	**Region 6 Values**	**0.8**	**Michelsen 2003**	**0.1**	**Ecology 2001**	**0.2**	**±30%[c]**	**70-130[c]**
Molybdenum		7439-98-7	Metals[d]	39.1	Region 6 Values	NA	NA	2	Ecology 2001	2	±30%[c]	70-130[c]
Nickel	√	7440-02-0	Metals[d]	156	Region 6 Values	53.1	Michelsen 2003	30	Ecology 2001	4	±30%[c]	70-130[c]
Phosphorus [g]		7723-14-0	Metals[d]	[g]	NA	NA	NA	[g]	NA	5	±30%[c]	70-130[c]
Potassium[g]		7440-09-7	Metals[d]	[g]	NA	NA	NA	[g]	NA	400	±30%[c]	70-130[c]
Selenium	√	**7782-49-2**	**Metals[d]**	**39.1**	**Region 6 Values**	**1**	**ODEQ 2001**	**0.3**	**Ecology 2001**	**10/10[f]**	**±30%[c]**	**70-130[c]**
Silver		**7440-22-4**	**Metals[d]**	**39.1**	**Region 6 Values**	**0.545**	**Michelsen 2003**	**2**	**Ecology 2001**	**1/0.2.0[f]**	**±30%[c]**	**70-130[c]**
Sodium		7440-23-5	Metals[d]	NA	NA	NA	NA	NA	NA	50	±30%[c]	70-130[c]
Strontium	√	7440-24-6	Metals[d]	4,690	Region 6 Values	NA	NA	NA	NA	1	±30%[c]	70-130[c]
Thallium		**7440-28-0**	**Metals[d]**	**0.548**	**Region 6 Values**	**NA**	**NA**	**1**	**Ecology 2001**	**5**	**±30%[c]**	**70-130[c]**
Tin		7440-31-5	Metals[d]	4,690	Region 6 Values	NA	NA	50	Ecology 2001	10	±30%[c]	70-130[c]
Uranium	√	**7440-61-1**	**Metals[d]**	**4.68**	**Region 9 PRGs***	**NA**	**NA**	**5**	**Ecology 2001**	**30/5[f]**	**±30%[c]**	**70-130[c]**
Vanadium	√	**7440-62-2**	**Metals[d]**	**39.1**	**Region 6 Values**	**57**	**ODEQ 2001**	**2**	**Ecology 2001**	**2.5**	**±30%[c]**	**70-130[c]**
Zinc	√	7440-66-6	Metals[d]	2,350	Region 6 Values	683	Michelsen 2003	86	Ecology 2001	1	±30%[c]	70-130[c]

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RADIONUCLIDES												
Americium-241		14596-10-2	GEA	3.66	SSL-rad	5,150	ANL 2006	3,890	ANL 2006	0.3	±30%[h]	70-130[h]
Antimony-125		**14234-35-6**	**GEA**	**0.0617**	**SSL-rad**	**7,000**	**ANL 2006**	**3,520**	**ANL 2006**	**0.3**	**±30%[h]**	**70-130[h]**
Beryllium-7		13966-02-4	GEA	NE	NE	NE	NE	NE	NE	0.3	±30%[h]	70-130[h]
Carbon-14	√	14762-75-5	LSC	284	SSL-rad	59,000	ANL 2006	760	ANL 2006	50	±30%[h]	70-130[h]
Cesium-134		**13967-70-9**	**GEA**	**0.0157**	**SSL-rad**	**1,480**	**ANL 2006**	**11.3**	**ANL 2006**	**0.1**	**±30%[h]**	**70-130[h]**
Cesium-137	√	**10045-97-3**	**GEA**	**0.0438**	**SSL-rad**	**3,120**	**ANL 2006**	**20.8**	**ANL 2006**	**0.1**	**±30%[h]**	**70-130[h]**
Cobalt-60	√	**10198-40-0**	**GEA**	**0.009**	**SSL-rad**	**1,460**	**ANL 2006**	**692**	**ANL 2006**	**0.05**	**±30%[h]**	**70-130[h]**
Europium-152	√	**14683-23-9**	**GEA**	**0.0211**	**SSL-rad**	**3,040**	**ANL 2006**	**1,520**	**ANL 2006**	**0.1**	**±30%[h]**	**70-130[h]**
Europium-154	√	**15585-10-1**	**GEA**	**0.0191**	**SSL-rad**	**3,000**	**ANL 2006**	**1,290**	**ANL 2006**	**0.1**	**±30%[h]**	**70-130[h]**
Europium-155		14391-16-3	GEA	0.9	SSL-rad	31,600	ANL 2006	15,800	ANL 2006	0.1	±30%[h]	70-130[h]
Plutonium-238		13981-16-3	Isotopic Pu - AEA	NA	NA	5,730	ANL 2006	5270	ANL 2006	1	±30%[h]	70-130[h]
Plutonium-239/240	√	PU-239/240	Isotopic Pu - AEA	2.87	SSL-rad	5,860	ANL 2006	6,110	ANL 2006	1	±30%[h]	70-130[h]
Potassium-40		13966-00-2	GEA	NA	NA	4,430	ANL 2006	NA	NA	4	±30%[h]	70-130[h]
Radium-226		**13982-63-3**	**GEA**	**0.0131**	**SSL-rad**	**100**	**ANL 2006**	**50.6**	**ANL 2006**	**0.1**	**±30%[h]**	**70-130[h]**
Radium-228		**15262-20-1**	**GEA**	**0.0246**	**SSL-rad**	**90**	**ANL 2006**	**43.9**	**ANL 2006**	**0.2**	**±30%[h]**	**70-130[h]**
Ruthenium-106		13967-48-1	GEA	NE	NE	NE	NE	NE	NE	0.3	±30%[h]	70-130[h]
Strontium-90	√	10098-97-2	Total Rad Sr – GPC	5.51	SSL-rad	600	ANL 2006	22.5	ANL 2006	1	±30%[h]	70-130[h]
Technetium-99	√	14133-76-7	Technetium -99	104	SSL-rad	42,200	ANL 2006	4,490	ANL 2006	15	±30%[h]	70-130[h]
Thorium-232		14274-82-9	Isotopic Th-AEA	3.44	SSL-rad	1,000	ANL 2006	1,510	ANL 2006	1	±30%[h]	70-130[h]
Tritium		14119-32-5	LSC	510	SSL-rad	374,000	ANL 2006	174,000	ANL 2006	400	±30%[h]	70-130[h]
Uranium-234	√	13966-29-5	Isotopic U-AEA	5.02	SSL-rad	5,000	ANL 2006	5,130	ANL 2006	1	±30%[h]	70-130[h]
Uranium-235	√	**15117-96-1**	**Isotopic U-AEA**	**0.206**	**SSL-rad**	**4,000**	**ANL 2006**	**2,770**	**ANL 2006**	**1**	**±30%[h]**	**70-130[h]**
Uranium-238	√	**7440-61-1**	**Isotopic U-AEA**	**0.979**	**SSL-rad**	**2,000**	**ANL 2006**	**1,580**	**ANL 2006**	**1**	**±30%[h]**	**70-130[h]**
PESTICIDES/POLYCHLORINATED BIPHENYLS												
77 3,3',4,4'-tetrachlorobiphenyls		32598-11-1	EPA Method 1668A	3.90E-02	Region 6 Values	NA	NA	NA	NA	0.00002	tbd	tbd
81 3,4,4',5-tetrachlorobiphenyl		70362-50-4	EPA Method 1668A	1.30E-02	Region 6 Values	NA	NA	NA	NA	0.00002	tbd	tbd
105 2,3,3',4,4'- pentachlorobiphenyls		32598-14-4	EPA Method 1668A	1.30E-01	Region 6 Values	NA	NA	NA	NA	0.00002	tbd	tbd
114 2,3,4,4',5- pentachlorobiphenyls		74472-38-1	EPA Method 1668A	1.30E-01	Region 6 Values	NA	NA	NA	NA	0.00002	tbd	tbd
118 2,3',4,4',5- pentachlorobiphenyls		31508-00-6	EPA Method 1668A	1.30E-01	Region 6 Values	NA	NA	NA	NA	0.00002	tbd	tbd
123 2',3,4,4',5- pentachlorobiphenyls		65510-44-3	EPA Method 1668A	1.30E-01	Region 6 Values	NA	NA	NA	NA	0.00002	tbd	tbd

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126 3,3',4,4',5-pentachlorobiphenyls		57465-28-8	**EPA Method 1668A**	**3.90E-05**	**Region 6 Values**	**NA**	**NA**	**NA**	**NA**	**0.00002**	tbd	tbd
156 2,3,3',4,4',5- hexachlorobiphenyls		38380-08-4	EPA Method 1668A	1.30E-01	Region 6 Values	NA	NA	NA	NA	0.00002	tbd	tbd
157 2,3,3',4,4',5'- hexachlorobiphenyls		69782-90-7	EPA Method 1668A	1.30E-01	Region 6 Values	NA	NA	NA	NA	0.00002	tbd	tbd
167 2,3',4,4',5,5'- hexachlorobiphenyls		52663-72-6	EPA Method 1668A	1.30E-01	Region 6 Values	NA	NA	NA	NA	0.00002	tbd	tbd
169 3,3',4,4',5,5'-hexachlorobiphenyls		32774-16-6	EPA Method 1668A	1.30E-04	Region 6 Values	NA	NA	NA	NA	0.00002	tbd	tbd
189 2,3,3',4,4',5,5'-heptachlorobiphenyls		39635-31-9	EPA Method 1668A	1.30E-01	Region 6 Values	NA	NA	NA	NA	0.00002	tbd	tbd
Aldrin		309-00-2	EPA Method 8081	0.00254	MTCA-Leaching	0.04	ODEQ 2001	0.1	Ecology 2001	0.0017	±30%[b]	50-150[b]
Alpha-BHC		319-84-6	EPA Method 8081	0.000549	MTCA-Leaching	0.006	Persaud et. al. 1993	6	Ecology 2001	0.00165	±30%[b]	50-150[b]
alpha-Chlordane		**5103-71-9**	**EPA Method 8081**	**0.258**	**MTCA-Leaching**	**0.01**	**ODEQ 2001**	**1**	**Ecology 2001**	**0.0165**	**±30%[b]**	**50-150[b]**
Aroclor-1016	√	12674-11-2	EPA Method 8082	0.393	Region 6 Values	NA	NA	40	Ecology 2001	0.0165	±30%[b]	50-150[b]
Aroclor-1221	√	11104-28-2	EPA Method 8082	0.222	Region 6 Values	NA	NA	40	Ecology 2001	0.0165	±30%[b]	50-150[b]
Aroclor-1232	√	11141-16-5	EPA Method 8082	0.222	Region 6 Values	NA	NA	40	Ecology 2001	0.0165	±30%[b]	50-150[b]
Aroclor-1242	√	53469-21-9	EPA Method 8082	0.222	Region 6 Values	NA	NA	40	Ecology 2001	0.0165	±30%[b]	50-150[b]
Aroclor-1248	√	12672-29-6	EPA Method 8082	0.222	Region 6 Values	0.021	Ecology 1997	40	Ecology 2001	0.0165	±30%[b]	50-150[b]
Aroclor-1254	√	11097-69-1	EPA Method 8082	0.222	Region 6 Values	0.23	Michelsen 2003	40	Ecology 2001	0.0165	±30%[b]	50-150[b]
Aroclor-1260	√	11096-82-5	EPA Method 8082	0.222	Region 6 Values	0.138	Michelsen 2003	40	Ecology 2001	0.0165	±30%[b]	50-150[b]
beta-1,2,3,4,5,6-Hexachlorocyclohexane		319-85-7	EPA Method 8081	0.00351	MTCA-Leaching	NA	NA	10	Ecology 2001	0.00165	±30%[b]	50-150[b]
Delta-BHC		**319-86-8**	EPA Method 8081	0.00208	MTCA-Leaching	0.12	ORNL 1997	6	Ecology 2001	0.0017	±30%[b]	50-150[b]
Dichlorodiphenyl-dichloroethane		**72-54-8**	EPA Method 8081	1.099	MTCA-Leaching	NA	NA	NA	NA	0.0033	±30%[b]	50-150[b]
Dichlorodiphenyl-dichloroethylene		**72-55-9**	EPA Method 8081	0.794	MTCA-Leaching	NA	NA	NA	NA	0.0033	±30%[b]	50-150[b]
Dichlorodiphenyl-trichloroethane		50-29-3	EPA Method 8081	1.147	MTCA-Leaching	NA	NA	3.7	LANL 2005	0.0033	±30%[b]	50-150[b]

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Dieldrin	√	60-57-1	**EPA Method 8081**	**0.00283**	**MTCA-Leaching**	**0.003**	**ODEQ 2001**	**0.0049**	**EPA SSL**	**0.0033**	**±30%[b]**	**50-150[b]**
Endosulfan II		33213-65-9	EPA Method 8081	4.301	MTCA-Leaching	0.006	LANL 2005	NA	NA	0.0033	±30%[b]	50-150[b]
Endosulfan sulfate		1031-07-8	EPA Method 8081	4.301	MTCA-Leaching	0.006	LANL 2005	NA	NA	0.0033	±30%[b]	50-150[b]
Endosulfan-I		959-98-8	EPA Method 8081	4.301	MTCA-Leaching	0.006	LANL 2005	NA	NA	0.0017	±30%[b]	50-150[b]
Endrin		72-20-8	**EPA Method 8081**	**1.057**	**MTCA-Leaching**	**0.003**	**ODEQ 2001**	**0.2**	**Ecology 2001**	**0.0033**	**±30%[b]**	**50-150[b]**
Endrin aldehyde		**7421-93-4**	**EPA Method 8081**	**1.057**	**MTCA-Leaching**	**0.003**	**ODEQ 2001**	**0.0034**	**LANL 2005**	**0.0033**	**±30%[b]**	**50-150[b]**
Endrin ketone		53494-70-5	EPA Method 8081	1.057	MTCA-Leaching	NA	NA	0.0034	LANL 2005	0.0033	±30%[b]	50-150[b]
Gamma-BHC (Lindane)	√	58-89-9	**EPA Method 8081**	**0.4**	**SSL**	**0.0009**	**ODEQ 2001**	**0.1**	**LANL 2005**	**0.0017**	**±30%[b]**	**50-150[b]**
Gamma-chlordane		5103-74-2	**EPA Method 8081**	**0.0021**	**MTCA-Leaching**	**0.0045**	**ODEQ 2001**	**2.2**	**LANL 2005**	**0.017**	**±30%[b]**	**50-150[b]**
Heptachlor		76-44-8	EPA Method 8081	0.2576	MTCA-Leaching	0.01	ODEQ 2001	0.4	LANL 2005	0.00165	±30%[b]	50-150[b]
Heptachlor epoxide		1024-57-3	**EPA Method 8081**	**0.0037**	**MTCA-Leaching**	**0.0006**	**ODEQ 2001**	**0.4**	**Ecology 2001**	**0.00165**	**±30%[b]**	**50-150[b]**
Methoxychlor		72-43-5	EPA Method 8081	30.6	Region 6 Values	0.019	ORNL 1997	NA	NA	0.0165	±30%[b]	50-150[b]
Toxaphene		8001-35-2	EPA Method 8081	NE	NE	NE	NE	NE	NE	0.165	±30%[b]	50-150[b]
OTHER ANALYSES												
Nitrogen in nitrate		NO3-N	EPA Method 300.0	NA	NA	NA	NA	NA	NA	0.75	±30%[c]	70-130[c]
Particle size[g]		N/A	ASTM D4222	NA	NA	NA[g]	NA	NA	NA	NA	NA	NA
TOC[g]		TOC	EPA Method 9060	NA	NA	10%	Michelsen 2003	NA	NA	25	±30%[c]	70-130[c]

Notes:
Entries in bold indicate analytes for which the reporting limit exceeds associated benchmark concentration.

Human Health Benchmark Sources:

Region 6 Values = EPA Region 6 Human Health Medium-Specific Screening Levels, December 2007. Dallas, Texas 75202.
Region 9 PRGs = Region 9 Preliminary Remediation Goals, Residential Soil. October 2004. http://www.epa.gov/region09/waste/sfund/prg/files/prgtable2004.xl
Region 9 PRGs* = Region 9 (adjusted by 3 to account for revised Office of Water RfD of 0.0006 mg/kg-d)
SSL = USEPA Soil Screening Levels, Exhibit A-1 Generic SSLs for Residential Scenario. From "Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites", EPA Office of Emergency and Remedial Response, December 2002.
SSL-rad = USEPA Soil Screening Guidance for Radionuclides, Technical Background Document. Table A-1 Generic (no accounting for decay) SSLs for Radionuclides (minimum between direct ingestion of soil and external radiation exposure). EPA Office of Radiation and Indoor Air, Office of Solid Waste and Emergency Response, October 2000.
MTCA Direct Contact = Model Toxics Control Act (MTCA), Method B unrestricted land use-direct contact (lowest between carcinogenic and noncarcinogenic values). Values obtained from Washington State Department of Ecology (WADOE) Cleanup Levels and Risk Calculation (CLARC).

Table 3-2. Analytical Performance Requirements for Contaminants in Soil and Sediment. (10 Pages)

Indicator Contaminant	Target Analyte?	Chemical Abstracts Service Number	Analytical Instrument and/or Method	Reference Values for the Protection of Human Health Receptors (mg/kg or pCi/g)	Human Health Benchmark Source	Sediment Reference Values for the Protection of Ecological Receptors (mg/kg or pCi/g)	Sediment Ecological Benchmark Source	Soil Reference Values for the Protection of Ecological Receptors (mg/kg or pCi/g)	Soil Ecological Benchmark Source	Laboratory Reporting Limit Requirements (mg/kg or pCi/g)[a]	Laboratory Precision (%)	Laboratory Accuracy (%)

MTCA Leaching = MTCA Method B Soil Concentrations for Groundwater Protection. Values derived in accordance with WAC 173-340-747 (eq. 747-1) using Method B groundwater values and default soil and chemical/physical parameters. Where default chemical parameters were not available, values obtained from Oak Ridge National Laboratory (ORNL) table of Chemical Specific Parameters (June 12, 2008). If no MTCA Method B groundwater value available, then no leaching standard calculated.

Ecological Benchmark Sources:

Ecological Sediment Benchmark Sources

ODEQ 2001 = *Guidance for Ecological Risk Assessment,* Level II Screening Level Values, December 2001 Update.

ANL 2006 = Argonne National Laboratory, *RESRAD Biota for Windows*, Version 1.21 (http://web.ead.anl.gov/resrad/home2/).

Ingersoll 1996 = Ingersoll, et al., Calculation and evaluation of sediment effect concentrations for the amphipod *Hyalella azteca* and the midge *Chironomus riparius.* J.Great Lakes REs. 22(3): 602-623.

Ecology 1997 = Creation and Analysis of Freshwater Sediment Quality Values in Washington State, Publication 97-232a.

Persaud et al. 1993 = *Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario,* Ontario Ministry of the Environment.

LANL 2005 = Los Alamos National Laboratory, Ecorisk Database (Release 2.2).

ORNL 1997 = Oak Ridge National Laboratory, *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment –Associated Biota:* 1997 Revision, ES/ER/TM-95/R4.

Michelsen 2003 = Michealsen, T., Development of Freshwater Sediment Quality Values for Use in Washington State. Prepared for the Washington Dept. of Ecology, Publication No. 03-09-088.

Ecological Soil Benchmark Sources

Ecology 2001 = Ecological Indicator Soil Concentrations for the Protection of Terrestrial Plants and Animals. WAC 173-340, Table 749-3. See Table 2-1 in BERA Methodology for use of surrogates.

EPA SSL = Soil Screening Levels various dates, Office of Solid Waste and Emergency Response, Washington, D.C.

LANL 2005 = Los Alamos National Laboratory, Ecorisk Database (Release 2.2).

ANL 2006 = *RESRAD Biota for Windows*, Version 1.21 (http://web.ead.anl.gov/resrad/home2/).

Hill AFB 2005 = Hill Air Force Base, *Thermal Treatment Unit Ecological Risk Screen*, Hill Air Force Base, Utah.

[a] Values for radionuclide analysis are minimum detectable activity requirements. Other values are laboratory reporting limits, nominally 5-10 times sample detection limits and functionally useable as PQLs.

[b] Accuracy criteria is the minimum for associated batch laboratory control sample percent recoveries. Laboratories must meet statistically based control if more stringent. Additional analyte-specific evaluations also performed for matrix spikes and surrogates as appropriate to the method. Precision criteria for batch laboratory replicate matrix spike analyses.

[c] Accuracy criteria for associated batch matrix spike percent recoveries. Evaluation criteria based on laboratory statistical limits or fixed limits as defined in the referenced methods. Precision criteria for batch laboratory replicate matrix spike analyses or replicate sample analysis.

[d] SW-846 Method 6010 or 6020 or EPA Method 200.8 and extraction Method 3050B.

[e] Reference value is less than detection limit. Additional lines of evidence will be evaluated to determine potential risk to ecological receptors.

[f] First value shown is via routine inductively coupled plasma (ICP), second value via "trace" ICP.

[g] Evaluated as sediment chemical properties only.

[h] Accuracy criteria for associated batch laboratory control sample percent recoveries. For some radionuclide analytical methods, additional analysis-specific evaluations also are performed for matrix spikes, tracers, and carriers as appropriate to the method. Precision criteria for batch laboratory replicate sample analyses.

AEA = alpha energy analysis
EPA = U.S. Environmental Protection Agency
GEA = gamma energy analysis
GPC = gas proportional counter
PQL = practical quantitation limit
tbd = to be determined
TOC = total organic carbon

NA = No reference value available, but contaminant concentration will be evaluated for exposure modeling, comparison to other media types, or descriptive purposes.

NE = For compounds that have not been previously detected, benchmarks were not evaluated. If this compound is detected during sampling, benchmarks will be provided, if available.

Table 3-3. Analytical Performance Requirements of Contaminants in Tissue. (8 Pages)

Indicator Contaminant	Chemical Abstracts Service Number	Analytical Instrument and/or Method	Fish Tissue Benchmark Concentration (pCi/g or mg/kg)*	Laboratory Reporting Limit Requirement[a] (pCi/g or mg/kg)	Precision	Accuracy
SEMIVOLATILE ORGANIC COMPOUNDS						
1,2,4-Trichlorobenzene	**120-82-1**	**EPA Method 8270**	**0.0504**	**0.33**	**±30%[b]**	**50-150[b]**
1,2-Dichlorobenzene	95-50-1	EPA Method 8270	0.4540	0.33	±30%[b]	50-150[b]
1,3-Dichlorobenzene	**541-73-1**	**EPA Method 8270**	**0.0151**	**0.33**	**±30%[b]**	**50-150[b]**
1,4-Dichlorobenzene	**106-46-7**	**EPA Method 8270**	**0.0049**	**0.33**	**±30%[b]**	**50-150[b]**
2,4,5-Trichlorophenol	95-95-4	EPA Method 8270	0.5044	0.33	±30%[b]	50-150[b]
2,4,6-Trichlorophenol	**88-06-2**	**EPA Method 8270**	**0.0107**	**0.33**	**±30%[b]**	**50-150[b]**
2,4-Dichlorophenol	**120-83-2**	**EPA Method 8270**	**0.0151**	**0.33**	**±30%[b]**	**50-150[b]**
2,4-Dimethylphenol	**105-67-9**	**EPA Method 8270**	**0.1009**	**0.33**	**±30%[b]**	**50-150[b]**
2,4-Dinitrophenol	**51-28-5**	**EPA Method 8270**	**0.0101**	**0.825**	**±30%[b]**	**50-150[b]**
2,4-Dinitrotoluene	**121-14-2**	**EPA Method 8270**	**0.0101**	**0.33**	**±30%[b]**	**50-150[b]**
2,6-Dinitrotoluene	**606-20-2**	**EPA Method 8270**	**0.0050**	**0.33**	**±30%[b]**	**50-150[b]**
2-Chloronaphthalene	91-58-7	EPA Method 8270	0.4035	0.33	±30%[b]	50-150[b]
2-Chlorophenol	**95-57-8**	**EPA Method 8270**	**0.0252**	**0.33**	**±30%[b]**	**50-150[b]**
2-Methylnaphthalene	**91-57-6**	**EPA Method 8270**	**0.0202**	**0.33**	**±30%[b]**	**50-150[b]**
2-Methylphenol (cresol, o-)	**95-48-7**	**EPA Method 8270**	**0.2522**	**0.33**	**±30%[b]**	**50-150[b]**
2-Nitroaniline	88-74-4	EPA Method 8270	NE	0.33	±30%[b]	50-150[b]
2-Nitrophenol	88-75-5	EPA Method 8270	NE	0.66	±30%[b]	50-150[b]
3+4 Methylphenol (cresol, m+p)	65794	EPA Method 8270	0.2522 and 0.02522, respectively	0.33	±30%[b]	50-150[b]
3,3'-Dichlorobenzidine	**91-94-1**	**EPA Method 8270**	**0.0003**	**0.33**	**±30%[b]**	**50-150[b]**
3-Nitroaniline	99-09-2	EPA Method 8270	NE	0.33	±30%[b]	50-150[b]
4,6-Dinitro-2-methylphenol	534-52-1	EPA Method 8270	NE	0.33	±30%[b]	50-150[b]

Table 3-3. Analytical Performance Requirements of Contaminants in Tissue. (8 Pages)

Indicator Contaminant	Chemical Abstracts Service Number	Analytical Instrument and/or Method	Fish Tissue Benchmark Concentration (pCi/g or mg/kg)*	Laboratory Reporting Limit Requirement[a] (pCi/g or mg/kg)	Precision	Accuracy
4-Bromophenylphenyl ether	101-55-3	EPA Method 8270	NE	0.33	±30%[b]	50-150[b]
4-Chloro-3-methylphenol	59-50-7	EPA Method 8270	NE	0.33	±30%[b]	50-150[b]
4-Chloroaniline	**106-47-8**	**EPA Method 8270**	**0.0202**	**0.33**	**±30%[b]**	**50-150[b]**
4-Chlorophenylphenyl ether	7005-72-3	EPA Method 8270	NE	0.33	±30%[b]	50-150[b]
4-Nitroaniline	100-01-6	EPA Method 8270	NE	0.33	±30%[b]	50-150[b]
4-Nitrophenol	100-02-7	EPA Method 8270	NE	0.66	±30%[b]	50-150[b]
Acenaphthene	**83-32-9**	**EPA Method 8270**	**0.3027**	**0.33**	**±30%[b]**	**50-150[b]**
Acenaphthylene	208-96-8	EPA Method 8270	NE	0.33	±30%[b]	50-150[b]
Anthracene	120-12-7	EPA Method 8270	1.5133	0.33	±30%[b]	50-150[b]
Benzo(a)anthracene	**56-55-3**	**EPA Method 8270**	**0.00016**	**0.33**	**±30%[b]**	**50-150[b]**
Benzo(a)pyrene	**50-32-8**	**EPA Method 8270**	**0.000016**	**0.33**	**±30%[b]**	**50-150[b]**
Benzo(b)fluoranthene	**205-99-2**	**EPA Method 8270**	**0.00016**	**0.33**	**±30%[b]**	**50-150[b]**
Benzo(ghi)perylene	191-24-2	EPA Method 8270	NE	0.33	±30%[b]	50-150[b]
Benzo(k)fluoranthene	**207-08-9**	**EPA Method 8270**	**0.0016**	**0.33**	**±30%[b]**	**50-150[b]**
Bis(2-Chloroethoxy)methane	111-91-1	EPA Method 8270	NE	0.33	±30%[b]	50-150[b]
Bis(2-chloro-1-methylethyl)ether	**108-60-1**	**EPA Method 8270**	**0.0017**	**0.33**	**±30%[b]**	**50-150[b]**
Bis(2-chloroethyl) ether	**111-44-4**	**EPA Method 8270**	**0.0001**	**0.33**	**±30%[b]**	**50-150[b]**
Bis(2-ethylhexyl)phthalate	**117-81-7**	**EPA Method 8270**	**0.0084**	**0.33**	**±30%[b]**	**50-150[b]**
Butylbenzylphthalate	85-68-7	EPA Method 8270	1.0088	0.33	±30%[b]	50-150[b]
Carbazole	**86-74-8**	**EPA Method 8270**	**0.0059**	**0.33**	**±30%[b]**	**50-150[b]**
Chrysene	**218-01-9**	**EPA Method 8270**	**0.0161**	**0.33**	**±30%[b]**	**50-150[b]**
Dibenz[a,h]anthracene	**53-70-3**	**EPA Method 8270**	**0.000016**	**0.33**	**±30%[b]**	**50-150[b]**

Table 3-3. Analytical Performance Requirements of Contaminants in Tissue. (8 Pages)

Indicator Contaminant	Chemical Abstracts Service Number	Analytical Instrument and/or Method	Fish Tissue Benchmark Concentration (pCi/g or mg/kg)*	Laboratory Reporting Limit Requirement[a] (pCi/g or mg/kg)	Precision	Accuracy
Dibenzofuran	**132-64-9**	**EPA Method 8270**	**0.0050**	**0.33**	**±30%[b]**	**50-150[b]**
Diethylphthalate	84-66-2	EPA Method 8270	4.0354	0.33	±30%[b]	50-150[b]
Dimethyl phthalate	131-11-3	EPA Method 8270	NE	0.33	±30%[b]	50-150[b]
Di-n-butylphthalate	84-74-2	EPA Method 8270	0.5044	0.33	±30%[b]	50-150[b]
Di-n-octylphthalate	117-84-0	EPA Method 8270	NE	0.33	±30%[b]	50-150[b]
Fluoranthene	**206-44-0**	**EPA Method 8270**	**0.2018**	**0.33**	**±30%[b]**	**50-150[b]**
Fluorene	**86-73-7**	**EPA Method 8270**	**0.2018**	**0.33**	**±30%[b]**	**50-150[b]**
Hexachlorobenzene	**118-74-1**	**EPA Method 8270**	**0.0001**	**0.33**	**±30%[b]**	**50-150[b]**
Hexachlorobutadiene	**87-68-3**	**EPA Method 8270**	**0.0015**	**0.33**	**±30%[b]**	**50-150[b]**
Hexachlorocyclopentadiene	**77-47-4**	**EPA Method 8270**	**0.0303**	**0.33**	**±30%[b]**	**50-150[b]**
Hexachloroethane	**67-72-1**	**EPA Method 8270**	**0.0084**	**0.33**	**±30%[b]**	**50-150[b]**
Indeno(1,2,3-cd)pyrene	**193-39-5**	**EPA Method 8270**	**0.0002**	**0.33**	**±30%[b]**	**50-150[b]**
Isophorone	**78-59-1**	**EPA Method 8270**	**0.1239**	**0.33**	**±30%[b]**	**50-150[b]**
Naphthalene	**91-20-3**	**EPA Method 8270**	**0.1009**	**0.33**	**±30%[b]**	**50-150[b]**
Nitrobenzene	**98-95-3**	**EPA Method 8270**	**0.0025**	**0.33**	**±30%[b]**	**50-150[b]**
N-Nitroso-di-n-dipropylamine	**621-64-7**	**EPA Method 8270**	**0.000017**	**0.33**	**±30%[b]**	**50-150[b]**
N-Nitrosodiphenylamine	**86-30-6**	**EPA Method 8270**	**0.0240**	**0.33**	**±30%[b]**	**50-150[b]**
Pentachlorophenol	**87-86-5**	**EPA Method 8270**	**0.0010**	**0.33**	**±30%[b]**	**50-150[b]**
Phenanthrene	85-01-8	EPA Method 8270	NE	0.33	±30%[b]	50-150[b]
Phenol	108-95-2	EPA Method 8270	1.5133	0.33	±30%[b]	50-150[b]
Pyrene	**129-00-0**	**EPA Method 8270**	**0.1513**	**0.33**	**±30%[b]**	**50-150[b]**
PESTICIDES/POLYCHLORINATED BIPHENYLS						
Aldrin	**309-00-2**	**EPA Method 8081**	**0.000007**	**0.0017**	**±30%[b]**	**50-150[b]**

Table 3-3. Analytical Performance Requirements of Contaminants in Tissue. (8 Pages)

Indicator Contaminant	Chemical Abstracts Service Number	Analytical Instrument and/or Method	Fish Tissue Benchmark Concentration (pCi/g or mg/kg)*	Laboratory Reporting Limit Requirement[a] (pCi/g or mg/kg)	Precision	Accuracy
Alpha-BHC	319-84-6	EPA Method 8081	NE	0.00165	±30%[b]	50-150[b]
alpha-Chlordane	5103-71-9	EPA Method 8081	NE	0.0165	±30%[b]	50-150[b]
Aroclor-1016	**12674-11-2**	**EPA Method 8082**	**0.0017**	**0.0165**	**±30%[b]**	**50-150[b]**
Aroclor-1221	**11104-28-2**	**EPA Method 8082**	**0.0001**	**0.0165**	**±30%[b]**	**50-150[b]**
Aroclor-1232	**11141-16-5**	**EPA Method 8082**	**0.0001**	**0.0165**	**±30%[b]**	**50-150[b]**
Aroclor-1242	**53469-21-9**	**EPA Method 8082**	**0.0001**	**0.0165**	**±30%[b]**	**50-150[b]**
Aroclor-1248	**12672-29-6**	**EPA Method 8082**	**0.0001**	**0.0165**	**±30%[b]**	**50-150[b]**
Aroclor-1254	**11097-69-1**	**EPA Method 8082**	**0.0001**	**0.0165**	**±30%[b]**	**50-150[b]**
Aroclor-1260	**11096-82-5**	**EPA Method 8082**	**0.0001**	**0.0165**	**±30%[b]**	**50-150[b]**
beta-1,2,3,4,5,6-Hexachlorocyclohexane	319-85-7	EPA Method 8081	NE	0.00165	±30%[b]	50-150[b]
Chlordane[c]	**57-74-9**	**NA**	**0.0003**	**0.017**	**±30%[b]**	**50-150[b]**
Delta-BHC	319-86-8	EPA Method 8081	NE	0.0017	±30%[b]	50-150[b]
Dichlorodiphenyl-dichloroethane	**72-54-8**	**EPA Method 8081**	**0.0005**	**0.0033**	**±30%[b]**	**50-150[b]**
Dichlorodiphenyl-dichloroethylene	**72-55-9**	**EPA Method 8081**	**0.0003**	**0.0033**	**±30%[b]**	**50-150[b]**
Dichlorodiphenyl-trichloroethane	**50-29-3**	**EPA Method 8081**	**0.0003**	**0.0033**	**±30%[b]**	**50-150[b]**
Dieldrin	**60-57-1**	**EPA Method 8081**	**0.000007**	**0.0033**	**±30%[b]**	**50-150[b]**
Endosulfan II	33213-65-9	EPA Method 8081	NE	0.0033	±30%[b]	50-150[b]
Endosulfan sulfate	1031-07-8	EPA Method 8081	NE	0.0033	±30%[b]	50-150[b]
Endosulfan-I	959-98-8	EPA Method 8081	NE	0.0017	±30%[b]	50-150[b]
Endrin	**72-20-8**	**EPA Method 8081**	**0.0015**	**0.0033**	**±30%[b]**	**50-150[b]**

Table 3-3. Analytical Performance Requirements of Contaminants in Tissue. (8 Pages)

Indicator Contaminant	Chemical Abstracts Service Number	Analytical Instrument and/or Method	Fish Tissue Benchmark Concentration (pCi/g or mg/kg)*	Laboratory Reporting Limit Requirement[a] (pCi/g or mg/kg)	Precision	Accuracy
Endrin aldehyde	7421-93-4	EPA Method 8081	NE	0.0033	±30%[b]	50-150[b]
Endrin ketone	53494-70-5	EPA Method 8081	NE	0.0033	±30%[b]	50-150[b]
Gamma-BHC (Lindane)	**58-89-9**	**EPA Method 8081**	**0.0001**	**0.0017**	**±30%[b]**	**50-150[b]**
Gamma-chlordane	5103-74-2	EPA Method 8081	NE	0.017	±30%[b]	50-150[b]
Heptachlor	**76-44-8**	**EPA Method 8081**	**0.000026**	**0.0165**	**±30%[b]**	**50-150[b]**
Heptachlor epoxide	**1024-57-3**	**EPA Method 8081**	**0.000013**	**0.0165**	**±30%[b]**	**50-150[b]**
Hexachlorobenzene[c]	**118-74-1**	**NA**	**0.0001**	**0.0017**	**±30%[b]**	**50-150[b]**
Methoxychlor	**72-43-5**	**EPA Method 8081**	**0.0252**	**0.0165**	**±30%[b]**	**50-150[b]**
Toxaphene	**8001-35-2**	**EPA Method 8081**	**0.0001**	**0.165**	**±30%[b]**	**50-150[b]**
RADIONUCLIDES						
Carbon-14	**14762-75-5**	**LSC**	**0.0316**	**50**	**±30%[d]**	**70-130[d]**
Americium-241	**14596-10-2**	**GEA**	**0.0005**	**0.3**	**±30%[d]**	**70-130[d]**
Cesium-134	**13967-70-9**	**GEA**	**0.0012**	**0.1**	**±30%[d]**	**70-130[d]**
Cesium-137	**10045-97-3**	**GEA**	**0.0017**	**0.1**	**±30%[d]**	**70-130[d]**
Cobalt-60	**10198-40-0**	**GEA**	**0.0028**	**0.05**	**±30%[d]**	**70-130[d]**
Europium-152	**14683-23-9**	**GEA**	**0.0073**	**0.1**	**±30%[d]**	**70-130[d]**
Europium-154	**15585-10-1**	**GEA**	**0.0042**	**0.1**	**±30%[d]**	**70-130[d]**
Europium-155	**14391-16-3**	**GEA**	**0.0228**	**0.3**	**±30%[d]**	**70-130[d]**
Plutonium-238	**13981-16-3**	**Isotopic Pu - AEA**	**0.0004**	**1**	**±30%[d]**	**70-130[d]**
Potassium-40	**13966-00-2**	**GEA**	**0.0018**	**4**	**±30%[d]**	**70-130[d]**
Radium-226	**13982-63-3**	**GEA**	**0.0001**	**0.1**	**±30%[d]**	**70-130[d]**
Radium-228	**15262-20-1**	**GEA**	**0.000044**	**0.2**	**±30%[d]**	**70-130[d]**
Ruthenium-106	13967-48-1	GEA	NE	0.3	±30%[d]	70-130[d]

Table 3-3. Analytical Performance Requirements of Contaminants in Tissue. (8 Pages)

Indicator Contaminant	Chemical Abstracts Service Number	Analytical Instrument and/or Method	Fish Tissue Benchmark Concentration (pCi/g or mg/kg)*	Laboratory Reporting Limit Requirement[a] (pCi/g or mg/kg)	Precision	Accuracy
Strontium-90	**10098-97-2**	**Total Rad Sr – GPC**	**0.0007**	**1**	**±30%[d]**	**70-130[d]**
Technetium-99	**14133-76-7**	**GPC**	**0.0158**	**15**	**±30%[d]**	**70-130[d]**
Thorium-228	**14274-82-9**	**Isotopic Th-AEA**	**0.00015**	**1**	**±30%[d]**	**70-130[d]**
Thorium-232	**14274-82-9**	**Isotopic Th-AEA**	**0.00047**	**1**	**±30%[d]**	**70-130[d]**
Tritium		**LSC**	**0.4384**	**400**	**±30%[d]**	**70-130[d]**
Uranium-234	**13966-29-5**	**Isotopic U-AEA**	**0.00066**	**1**	**±30%[d]**	**70-130[d]**
Uranium-235	**15117-96-1**	**Isotopic U-AEA**	**0.00065**	**1**	**±30%[d]**	**70-130[d]**
Uranium-238	**7440-61-1**	**Isotopic U-AEA**	**0.00052**	**1**	**±30%[d]**	**70-130[d]**
Metals						
Aluminum	7429-90-5	6010/3050B	5.0442	5.0	±30%[e]	70-130[e]
Antimony	**7440-36-0**	**Metals[f]**	**0.0020**	**6.0/0.6**	**±30%[e]**	**70-130[e]**
Arsenic	**7440-38-2**	**Metals[f]**	**0.0001**	**10/1.0**	**±30%[e]**	**70-130[e]**
Barium	7440-39-3	Metals[f]	1.0088	2.0/0.5	±30%[e]	70-130[e]
Beryllium	**7440-41-7**	**Metals[f]**	**0.0101**	**.05**	**±30%[e]**	**70-130[e]**
Bismuth	7440-69-9	Metals[f]	NE	10	±30%[e]	70-130[e]
Boron	7440-42-8	Metals[f]	1.0088	2	±30%[e]	70-130[e]
Cadmium	**7440-43-9**	**Metals[f]**	**0.0050**	**0.5/0.2**	**±30%[e]**	**70-130[e]**
Calcium	7440-70-2	Metals[f]	NE	10	±30%[e]	70-130[e]
Chromium	7440-47-3	Metals[f]	NE	1/0.2	±30%[e]	70-130[e]
Chromium (VI)	**1854-29-9**	**Method 7196A**	**0.0151**	**0.5**	**±30%[e]**	**70-130[e]**
Copper	**7440-50-8**	**Metals[f]**	**0.2018**	**1**	**±30%[e]**	**70-130[e]**
Iron	**7439-89-6**	**Metals[f]**	**3.5310**	**5.0**	**±30%[e]**	**70-130[e]**
Lead	7439-92-1	Metals[f]	NE	5/0.5	±30%[e]	70-130[e]

Table 3-3. Analytical Performance Requirements of Contaminants in Tissue. (8 Pages)

Indicator Contaminant	Chemical Abstracts Service Number	Analytical Instrument and/or Method	Fish Tissue Benchmark Concentration (pCi/g or mg/kg)*	Laboratory Reporting Limit Requirement[a] (pCi/g or mg/kg)	Precision	Accuracy
Lithium	**7439-93-2**	**Metals[f]**	**0.1009**	**2.0**	**±30%[e]**	**70-130[e]**
Magnesium	7439-95-4	Metals[f]	NE	75	±30%[e]	70-130[e]
Manganese	**7439-96-5**	**Metals[f]**	**0.7062**	**5.0**	**±30%[e]**	**70-130[e]**
Total Mercury	7439-97-6	Method 7471	NE	0.2	±30%[e]	70-130[e]
Nickel	**7440-02-0**	**Metals[f]**	**0.1009**	**40**	**±30%[e]**	**70-130[e]**
Phosphorus	**7723-14-0**	**Metals[f]**	**0.0001**	**5**	**±30%[e]**	**70-130[e]**
Potassium	7440-09-7	Metals[f]	NE	40	±30%[e]	70-130[e]
Selenium	**7782-49-2**	**Metals[f]**	**0.0252**	**10/10[f]**	**±30%[e]**	**70-130[e]**
Silicon	7440-21-3	Metals[f]	NE	2	±30%[e]	70-130[e]
Silver	**7440-22-4**	**Metals[f]**	**0.0252**	**1/0.2**	**±30%[e]**	**70-130[e]**
Sodium	7440-23-5	Metals[f]	NE	50	±30%[e]	70-130[e]
Strontium	7440-24-6	Metals[f]	3.0265	1	±30%[e]	70-130[e]
Thallium	**7440-28-0**	**Metals[f]**	**0.0004**	**5**	**±30%[e]**	**70-130[e]**
Tin	**7440-31-5**	**Metals[f]**	**3.0265**	**5.0**	**±30%[e]**	**70-130[e]**
Uranium (soluble salts)	**7440-61-1**	**Metals[f]**	**0.0151**	**30/5**	**±30%[e]**	**70-130[e]**
Vanadium	**7440-62-2**	**Metals[f]**	**0.0050**	**2.5**	**±30%[e]**	**70-130[e]**
Zinc	7440-66-6	Metals[f]	1.5133	1	±30%[e]	70-130[e]
OTHER ANALYSES						
% Lipids	NA	Extraction	NE	0.10%	NA	NA

Notes:

*Sources: EPA Region 3 Risk-Based Concentration, October 2007, divided by 11.5 to account for CTUIR fishing rate of 620 grams/day (g/d) vs. default of 54 g/d. Uranium benchmark further adjusted downward by 5 to account for revised Office of Water oral reference dose of 0.0006 mg/kg-d.

EPA, 2001c, Health Effects Assessment Summary Tables (HEAST): Radionuclides, U.S. Environmental Protection Agency, Office of Radiation Protection, Washington, D.C. Available online at: http://www.epa.gov/radiation/heast/.

Table 3-3. Analytical Performance Requirements of Contaminants in Tissue. (8 Pages)

Indicator Contaminant	Chemical Abstracts Service Number	Analytical Instrument and/or Method	Fish Tissue Benchmark Concentration (pCi/g or mg/kg)*	Laboratory Reporting Limit Requirement[a] (pCi/g or mg/kg)	Precision	Accuracy

Entries in bold indicate analytes for which the reporting limit exceeds the benchmark concentration.

Tissue analysis will include wet weights.

a Values for radionuclide analysis are minimum detectable activity requirements. Other values are laboratory reporting limits, nominally 5-10 times sample detection limits and functionally useable as PQLs. Limited sample availability and/or matrix interferences may dramatically affect sample-specific quantitation limits for biota materials.

b The accuracy criteria shown are the minimum for associated batch laboratory control sample percent recoveries. Laboratories must meet statistically-based controls if more stringent Additional accuracy criteria include analyte-specific evaluation performed for matrix spike and surrogate recoveries as appropriate to the method. The precision criteria shown are for batch laboratory replicate matrix spike analysis.

c Analysis for hexachlorobenzenes and chlordane will be reported as specific isomers. The reporting limit shown is for each isomer.

d Accuracy criteria for associated batch laboratory control sample percent recoveries. For some radionuclide analytical methods, additional analysis-specific evaluations also are performed for matrix spikes, tracers, and carriers as appropriate to the method. Precision criteria for batch laboratory replicate sample analyses.

e Accuracy criteria for associated batch matrix spike percent recoveries. Evaluation criteria based on laboratory statistical limits or fixed limits as defined in the referenced methods. Precision criteria for batch laboratory replicate matrix spike analyses or replicate sample analysis.

f SW-846 Method 6010 or 6020 or EPA Method 200.8 and extraction Method 3050B. First value shown is via routine inductively coupled plasma (ICP), second value via "trace" ICP.

AEA = alpha energy analysis
CTUIR = Confederated Tribes of the Umatilla Indian Reservation
EPA = United States Environmental Protection Agency
GEA = gamma energy analysis
GPC = gas proportional counter
LSC = liquid scintillation counter
NA = not available
NE = For compounds that have not been previously detected, benchmarks were not evaluated. If this compound is detected during sampling, benchmarks will be provided, if available.
PQL = practical quantitation limit

Table 3-4. Sample Volume, Preservation, and Hold Time Requirements. (3 Pages)

Analysis	Matrix	Bottle Type	# Bottles	Units	Volume	Cooling	Preservation	Holding Time
TPH	Soil/Sediment	G	1	g	125	Cool 4C	None	14 Days
TOC	Soil/Sediment	aG	1	g	125	Cool 4C	None	28 Days
Metals	Soil/Sediment	G/P	1	g	250	None	None	6 Months
AVS/SEM	Soil/Sediment	G	1	g	125	Cool 4C	None	14 Days
Mercury	Soil/Sediment	G	1	g	125	Cool 4C	None	28 Days
Hexavalent Chromium	Soil/Sediment	G/P	1	g	125	Cool 4C	None	30 Days
SVOAs	Soil/Sediment	aG	1	g	250	Cool 4C	None	14/40 Days
VOAs	Soil/Sediment	G	1	g	250	Cool 4C	None	14 Days
Pesticides	Soil/Sediment	aG	1	g	120	Cool 4C	None	14/40 Days
PCBs	Soil/Sediment	aG	1	g	250	Cool 4C	None	14/40 Days
PCB Congeners	Soil/Sediment	aG	1	g	125	Cool 4C	None	14/40 Days
GEA	Soil/Sediment	G/P	1	g	1500	None	None	6 Months
Am/Cm	Soil/Sediment	G/P	1	g	10	None	None	6 Months
Iodine-129	Soil/Sediment	G/P	1	g	2	None	None	6 Months
Nickle-63	Soil/Sediment	G/P	1	g	2	None	None	6 Months
Neptunium-237	Soil/Sediment	G/P	1	g	10	None	None	6 Months
Plutonium-Iso	Soil/Sediment	G/P	1	g	10	None	None	6 Months
Strontium-90	Soil/Sediment	G/P	1	g	10	None	None	6 Months
Technetium-99	Soil/Sediment	G/P	1	g	10	None	None	6 Months
Thorium-iso	Soil/Sediment	G/P	1	g	10	None	None	6 Months
Tritium	Soil/Sediment	G	1	g	100	None	None	6 Months
Uranium-iso	Soil/Sediment	G/P	1	g	10	None	None	6 Months
Particle Size	Soil/Sediment	G/P	1	g	1000	None	None	None

Table 3-4. Sample Volume, Preservation, and Hold Time Requirements. (3 Pages)

Analysis	Matrix	Bottle Type	# Bottles	Units	Volume	Cooling	Preservation	Holding Time
Alkalinity	Water	G/P	1	mL	200	Cool 4C	None	14 Days
TPH	Water	G	2	mL	1000	Cool 4C	HCl to pH <2	14 Days
Hardness	Water	G/P	1	mL	250	None	HNO3 or H2SO4 to pH <2	6 Months
Total Kjeldahl Nitrogen	Water	G/P	1	mL	300	Cool 4C	H2SO4 to pH <2	28 Days
DOC	Water	G	1	ml	125	Cool 4C	HCl or H2SO4 to pH <2	28 Days
Metals	Water	G/P	1	mL	500	None	HNO3 to pH <2	6 Months
Mercury	Water	G	1	mL	500	None	HNO3 to pH <2	28 Days
Hexavalent Chromium	Water	G/P	1	mL	500	Cool 4C	None	24 Hours
SVOA	Water	aG	2	mL	1000	Cool 4C	None	7/40 Days
VOA	Water	aGs*	3	mL	40	Cool 4C	HCl or H2SO4 to pH <2	14 Days
Pesticides	Water	aG	4	mL	1000	Cool 4C	None	7/40 Days
PCBs	Water	aG	4	mL	1000	Cool 4C	None	7/40 Days
PCB Congeners	Water	aG	4	mL	1000	Cool 4C	None	7/40 Days
GEA	Water	G/P	1	mL	1000	None	HNO3 to pH <2	6 Months
Am/Cm	Water	G/P	1	mL	1000	None	HNO3 to pH <2	6 Months
Nickel-63	Water	G/P	1	mL	1000	None	HNO3 to pH <2	6 Months
Neptuium-237	Water	G/P	1	mL	1000	None	HNO3 to pH <2	6 Months
Plutonium-Iso	Water	G/P	1	mL	1000	None	HNO3 to pH <2	6 Months
Strontium-90	Water	G/P	2	mL	1000	None	HNO3 to pH <2	6 Months
Thorium-iso	Water	G/P	1	mL	1000	None	HNO3 to pH <2	6 Months
Uranium-iso	Water	G/P	2	mL	1000	None	HNO3 to pH <2	6 Months
Technetium-99	Water	G/P	1	mL	250	None	HCl to pH <2	6 Months
Iodine-129	Water	G/P	4	mL	1000	None	None	6 Months

Table 3-4. Sample Volume, Preservation, and Hold Time Requirements. (3 Pages)

Analysis	Matrix	Bottle Type	# Bottles	Units	Volume	Cooling	Preservation	Holding Time
Tritium	Water	P	1	mL	125	None	None	6 Months
Metals	Fish Tissue	G/P	1	g	15	Cool 4C	None	6 Months
Mercury	Fish Tissue	G/P	1	g	15	Cool 4C	None	28 Days
Pesticides	Fish Tissue	G/P	1	g	50	Cool 4C	None	14/40 Days
PCB Congeners	Fish Tissue	G/P	1	g	75	Cool 4C	None	14/40 Days
GEA	Fish Tissue	G/P	1	g	250	None	None	6 Months
Alpha Spec	Fish Tissue	G/P	1	g	10	None	None	6 Months
% Lipids	Fish Tissue	G	1	g	250	Cool 4C	None	14Days

aG = Amber Glass
aG/s = Amber Glass (Septum)
aGs* = Amber Glass (Septum) -- no headspace
ASAP = as soon as possible
C = Degrees Celsius
G = Glass
G/p = Glass or Plastic
GEA = gamma energy analysis
Gs* = Glass (Septum) - no headspace
P = Plastic
PCB = polychlorinated biphenyl
SVOA = semivolatile organic analyte
TOC = total organic carbon
DOC = dissolved organic carbon
TPH = total petroleum hydrocarbon
VOA = volatile organic analyte

Appendix A – Sampling and Analysis Plan

APPENDIX B

PRELIMINARY ASSESSMENT OF SEDIMENT DEPOSITION AREAS

A Preliminary Assessment of Sediment Deposition Areas in the Hanford Reach and McNary Pool of the Columbia River: A Test of Techniques and Preliminary Scoping Effort

Draft A
March 31, 2008

Prepared by:
Brett L. Tiller
James E. Bernhard
Environmental Assessment Services, LLC

&

John J. Nugent
Nugent GIS & Environmental

Prepared for:

Washington Closure Hanford, LLC
River Corridor Cleanup Contractor

DRAFT

Executive Summary

Washington Closure Hanford (WCH) is leading the development and implementation of a Columbia River Component (CRC) work plan aimed at characterizing Hanford Site-derived contaminant levels and associated risks in areas of the Columbia River that were not part of the River Corridor Baseline Risk Assessment's 100 Area and 300 Area and Inter-Areas projects. A paucity of information is currently available to help WCH identify areas where sediment containing Hanford-derived materials have come to reside and is available for sampling.

As such, a preliminary desk-top assessment of potential sediment deposition areas was made using river bathymetry and process knowledge of the riverine environments along the Hanford Reach and McNary pool of the Columbia River. Subsequently, a field scoping effort was performed to; 1) assess the accuracy of the initial sediment mapping effort, 2) evaluate the efficacy of using a single beam sonar to determine the presence of sediment deposits in the off-shore regions of the McNary pool and Hanford Reach, and 3) evaluate whether petit ponar sampling methods could be effectively employed in off-shore areas as part of the upcoming CRC sediment sampling efforts. Three complete sonar survey transects running perpendicular to the shoreline were performed in the McNary pool and three incomplete sonar survey transects were performed near the entrance of the Yakima River. Additionally, sonar surveys were performed near 100-D Area's water intake structure as well as a few off-shore locations near the 100-D island.

Mapping sediment deposits in the impounded regions of McNary pool were particularly effective due to relatively consistent riverbed characteristics and water velocities there. Surveys performed along pre-determined transects that extended from shoreline to shoreline provided a means to summarize and compare the proportion of riverbed that contained sediment. Approximately 50% of the riverbed surveyed near Port Kelly and Hat Rock State Park contained major sediment deposits, whereas nearly 90% of the riverbed surveyed near McNary dam contained major sediment deposits. Sonar surveys conducted near the mouth of the Yakima River indicated that sediment deposits were only prominent within approximately 100m of the shoreline of Bateman Island. Immediately downstream of Bateman Island near the boat launch and marina, sediment persisted off-shore approximately 200 meters. Sediment deposits were evident immediately adjacent to the 100-D water intake structure but were not evident in the excavation trench that extended across the main river channel. Sediment surveys in the main river channel near 100-D were more difficult due to the presence of hard-pan material that elicited soft bottom (i.e. sediment) sonar signals.

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The petite ponar sampler device was found to be an effective technique to obtain sediment from the off-shore locations in water depths between 3m (9 feet) and 35m (104 feet). The petite ponar sampler was effectively deployed in relatively fast moving waters off-shore but limited amounts of sediment were found in these regions during this initial scoping effort. A comparison of the areas suspected to contain sediment versus the areas actually found to contain sediment indicated that sediment deposition areas were more limited than what had been initially identified as part of the Columbia River Component workshop meetings held in February, 2008.

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1 Introduction

Washington Closure Hanford (WCH) is leading the development and implementation of a Columbia River Component (CRC) work plan aimed at characterizing Hanford Site-derived contaminant levels and associated risks in areas of the Columbia River that were not part of the River Corridor Baseline Risk Assessment's 100 Areas and 300 Areas and Inter-Areas projects. The CRC assessment areas are generally described as all off-shore (>2 m below the low water mark) areas of the Columbia River beginning near 100-BC and extends down river to where Hanford-derived contaminants have come to reside. Additionally, near-shore areas (areas between the low water and high water marks) along Franklin and Grant counties, the riverine islands, and all near shore areas downstream of the Hanford Site are part of the CRC boundaries.

Ultimately, it is expected that a number of sample sites will be selected and sediment samples will be collected using one or a combination of surface sediment sampling techniques (grab samplers such as petite ponar, van veen, or other) and coring or drilling sampling techniques in support of the CRC. The bulk of historical contaminant concentration data evaluated thus far indicate the down-river boundary for sampling in support of the CRC extends to the U.S. Corps of Engineer's McNary Dam. However, a paucity of information exists concerning the locations of sediment deposition areas in the proposed CRC sampling regions (Robertson and Fix 1977).

Initially, a preliminary desk-top assessment was made to describe areas where sediment is known and suspected to have been deposited in the Hanford Reach and McNary pool (Figure 1). By understanding the river flow patterns, land elevations, topographical features, and process knowledge of the Hanford Reach environs (river currents, major bank erosion areas, etc..), Environmental Assessment Services (EAS) staff generated geographical information systems (GIS) maps depicting Hanford Reach bathymetry data (previously unpublished) and the aquatic and riparian environments. Colorized maps were created using map scales consistent with Columbia River Component Data Gap Analysis for consistency (WCH 201 Rev 0). Known and suspected sediment deposit areas were digitized from hand-sketched drawings and displayed on the maps as well as major key features such as reactor intake structures, pipelines, landforms, and land erosion areas (e.g. Figure 1). The waterline (shoreline) and riparian areas identified on these maps were modeled using the Modular Aquatic Simulation System 1D unsteady flow model (Waichler et al. 2005) and reflected the river levels that occur when Priest Rapids discharge rates are approximately 80KCFS (waterline) and 240KCFS (upper boundary of riparian areas).

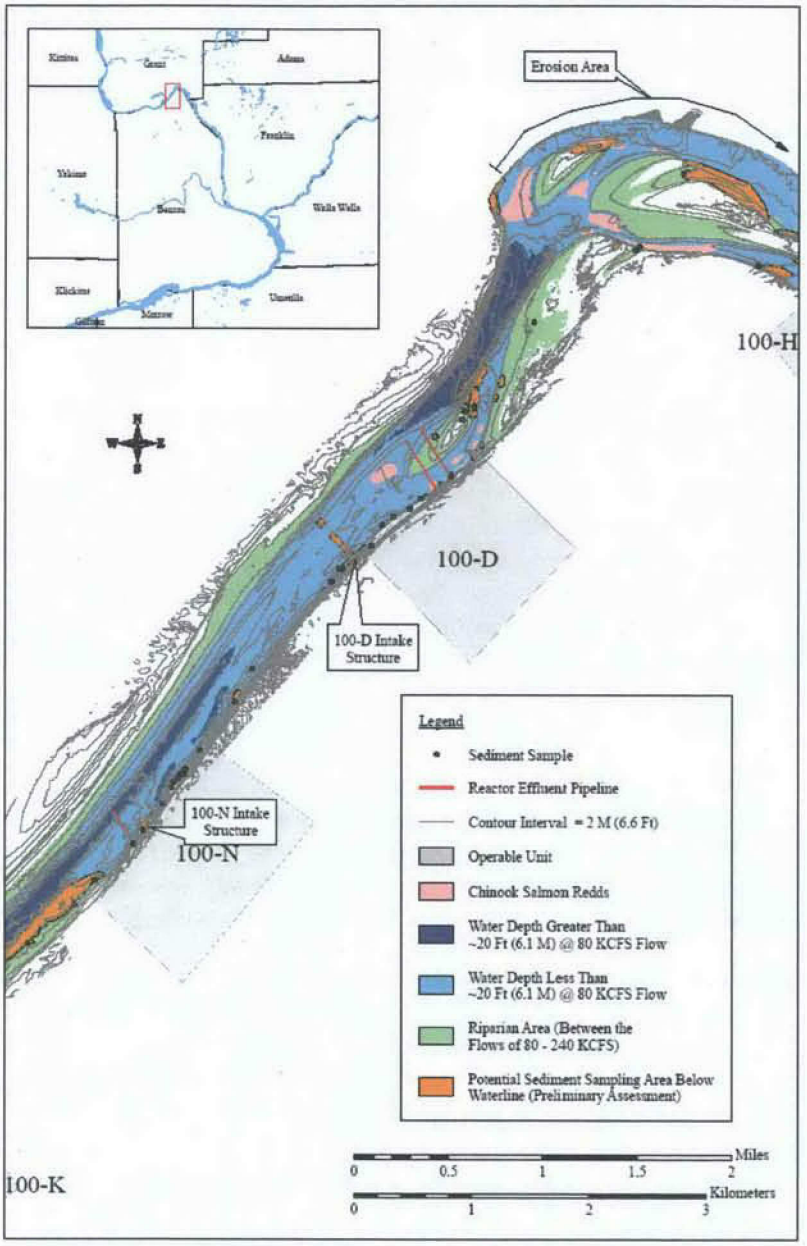

Figure 1. Map B2, near 100-N and 100-D Areas depicting Hanford Reach bathymetry, riparian areas, sediment deposits (known or suspected) and corresponding river levels that reflect ~80Kcfs and ~240Kcfs (steady state).

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Subsequently, a field scoping effort was needed to; 1) assess the accuracy of the initial sediment mapping effort, 2) evaluate the efficacy of using a single beam sonar to determine the presence of sediment deposits in the off-shore regions of the McNary pool and Hanford Reach, and 3) evaluate whether petit ponar sampling methods could be effectively employed in off-shore areas as part of the upcoming CRC sediment sampling efforts.

This report provides preliminary results of an effort that was performed to serve as "ground truthing" to determine the accuracy of predicted sediment deposition areas with the Hanford Reach.

2 Methods

Field scoping efforts were carried out from February 28 and March 10, 2008. The field survey approach included downloading GIS-derived transects onto the watercraft's GPS and then navigating along these transects with the aid of a TR1 Gold autopilot steering mechanism at a speed of ~3 km/hr. Observers calibrated the sonar signals using visual verification of soft bottom and armored bottom riverbeds (in shallow water areas) as well as using repeated deployments of a petite ponar sampler in deeper water areas (3 m to 35 m deep). This information was recorded on field survey sheets and daily summaries were provided in the field record book (EL-1625). GPS point features were obtained to help differentiate sediment and armored river bed areas. GIS illustrations of the regions defined as sediment and armored riverbed in each area were produced.

Three transects were selected in the impounded regions of McNary pool and four transects were established over the 100-D intake structure (Figure 2). The McNary pool transects coincided with previous efforts described by Robertson and Fix (1977). Additionally, sonar surveys were opportunistically performed (without pre-defined transects) near the Yakima River delta to provide an initial estimate of the extent of sediment deposits there (see Figure 2).

The sonar used was a module of the GARMIN® GPSMAP4208 using a 200 kHz signal frequency. In order to accurately differentiate between armored (rocky) riverbed and fine-grained riverbed the scale (or range) of the sonar was set between 2 times to 3 times the maximum depth encountered during the sonar survey for each transect. This expanded range setting allowed observers to see the primary bottom and 1 or 2 ghost signals that were used to identify riverbed areas containing fine-grained substrates and differentiate the armored riverbed (rocky substrates). The sonar gain settings were changed when sonar range settings were changed to accommodate the sensitivity of the sonar and allow observers with a systematic approach when delineating fine-grained riverbed areas. Sonar gain settings ranged from 1% in the relatively shallow water regions (water depths ≤ 10 m) to 4% in relatively deep water survey regions (water depths ranging from 10 m to 35 m) (Figure 3). Field observers found the most consistent method of delineating fine-grained riverbed material was to adjust the sonar settings so that the presence of red color in the 1st ghost signal coupled with an increase in blue backscatter of the primary river bottom signal was present when armored riverbed material was

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present. When this occurred along a given transect, a GPS position was obtained and qualifiers of the waypoint feature (e.g. "start of rock", etc..) were recorded.

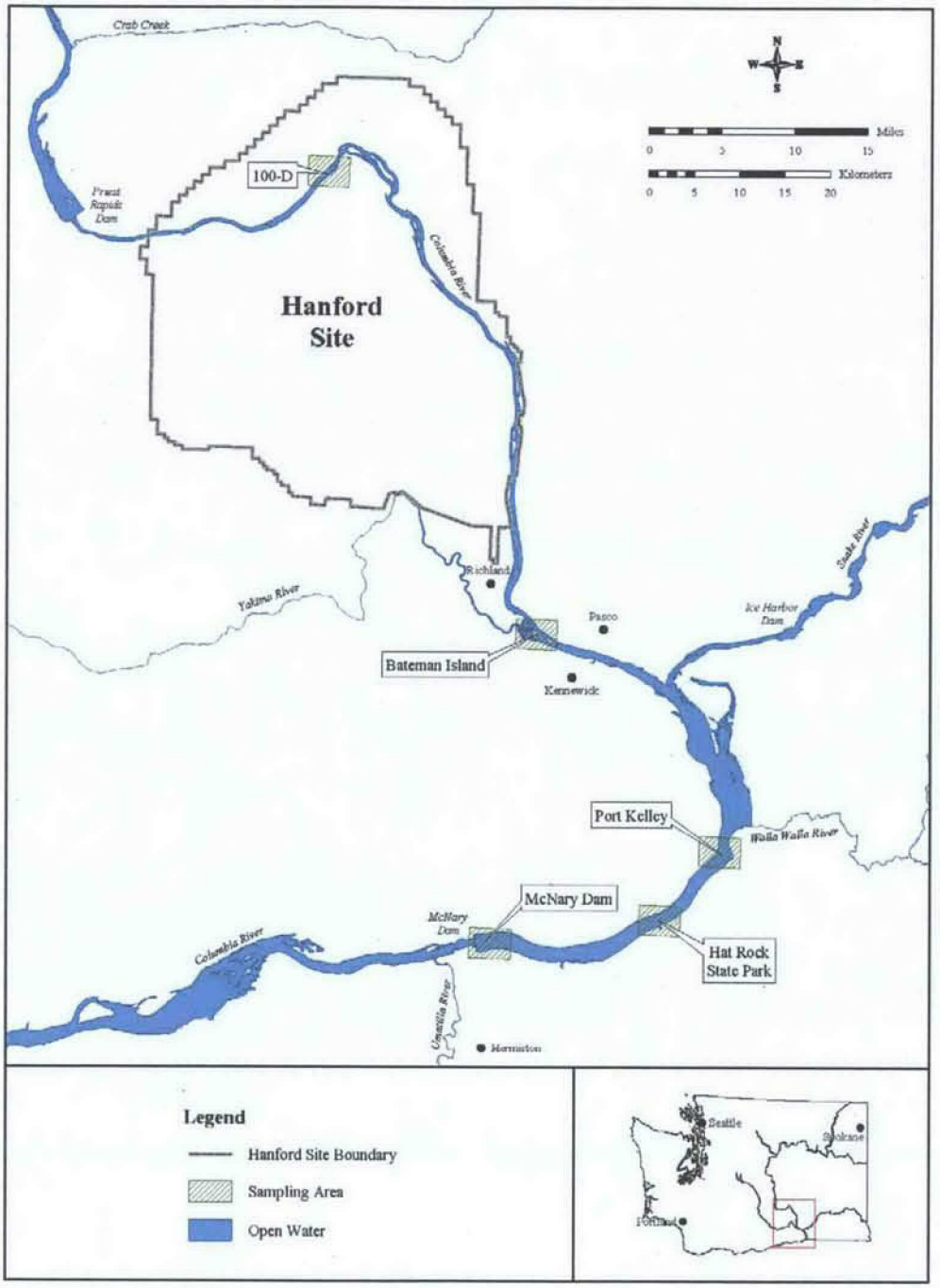

Figure 2. Sonar/Ponar survey regions selected in the McNary Pool and Hanford Reach.

Sonar calibrations using the petite ponar sampler to obtain samples of the riverbed material were key to this effort as river (water depth, water velocity) and riverbed conditions (e.g. substrate sizes, substrate embeddedness, presence of fine-grained hard-pan material) varied from area to area and resulted in slightly different sonar signals. The petite ponar was deployed several times prior to, and during the sonar surveys to calibrate and verify that the sonar signals being used to identify and differentiate fine-grained riverbed areas were accurate (Figure 4).

The quality of sediment sample obtained from the petite ponar device was classified as "poor", "good", or "excellent" depending on the amount (depth) of sediment in sample, substrate type, and amount of vegetation or debri in the sample (Table 1). The sonar signals indicating "good" or "excellent" sediment were generically classified as "Sediment" on the illustrations provided in this report. The depth of sediment in each sample taken was measured by opening the top of the ponar sampler and pushing a measuring device into the sample material. Visual inspection of the sample was used to estimate general substrate types and the amount of debri or vegetative matter in each sample. A more detailed description of the ponar deployment instructions and sample material assessment protocols are provided in Attachment A.

Table 1. Classification of sediment sample quality using the petite ponar grab sampler.

Sample Quality Rating	Depth of Sediment in Sample	General Substrate Types of Sample	Amount of Debri or Vegetative Matter in Sample
"Excellent"	8 to 10cm	Fines	Little to none
"Good"	4 to 8 cm	Fines & Sandy	~5% to 25% of sample
"Poor"	0 to 4 cm	Fines, Sand, Pebble, Gravel	Relatively abundant (~≥25% of sample)

The ponar sample results Figure 5 provides an example of "excellent" sediment sonar signal patterns and a ponar validation sample. Figure 6 provides an example of "poor" sediment sonar signal patterns and the ponar validation sample. Results of the sonar calibration efforts using the petite ponar sampler are provided in Attachment B.

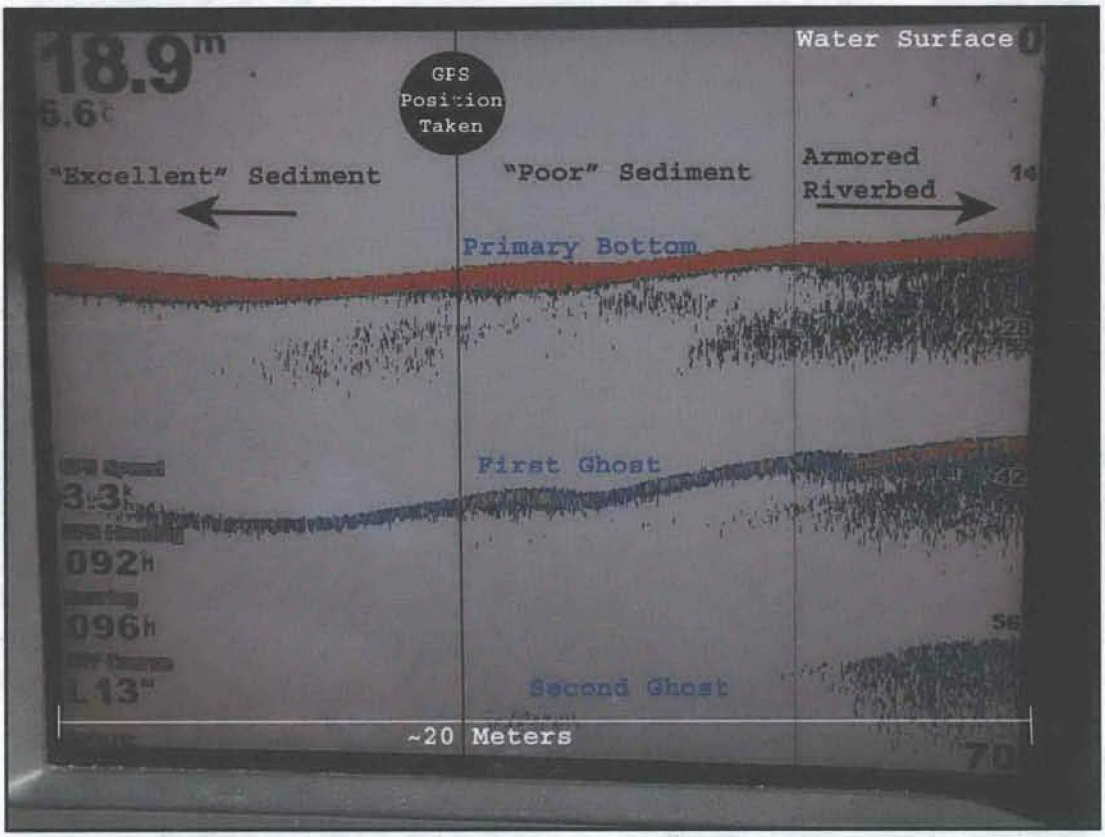

Figure 3. Sonar Image depicting primary bottom, 1st ghost signal, 2nd ghost signal, and key features used by observers to delineate fine-grained riverbed from armored riverbed areas.

Figure 4. Petite ponar sediment sampler used to calibrate and verify selected sonar signals that indicated the presence of fine-grained material and armored (rocky) riverbeds. The sampler is held open with a tension-activated pin (left). When tension is lost, the pin ejects and the jaws of the ponar close together (right).

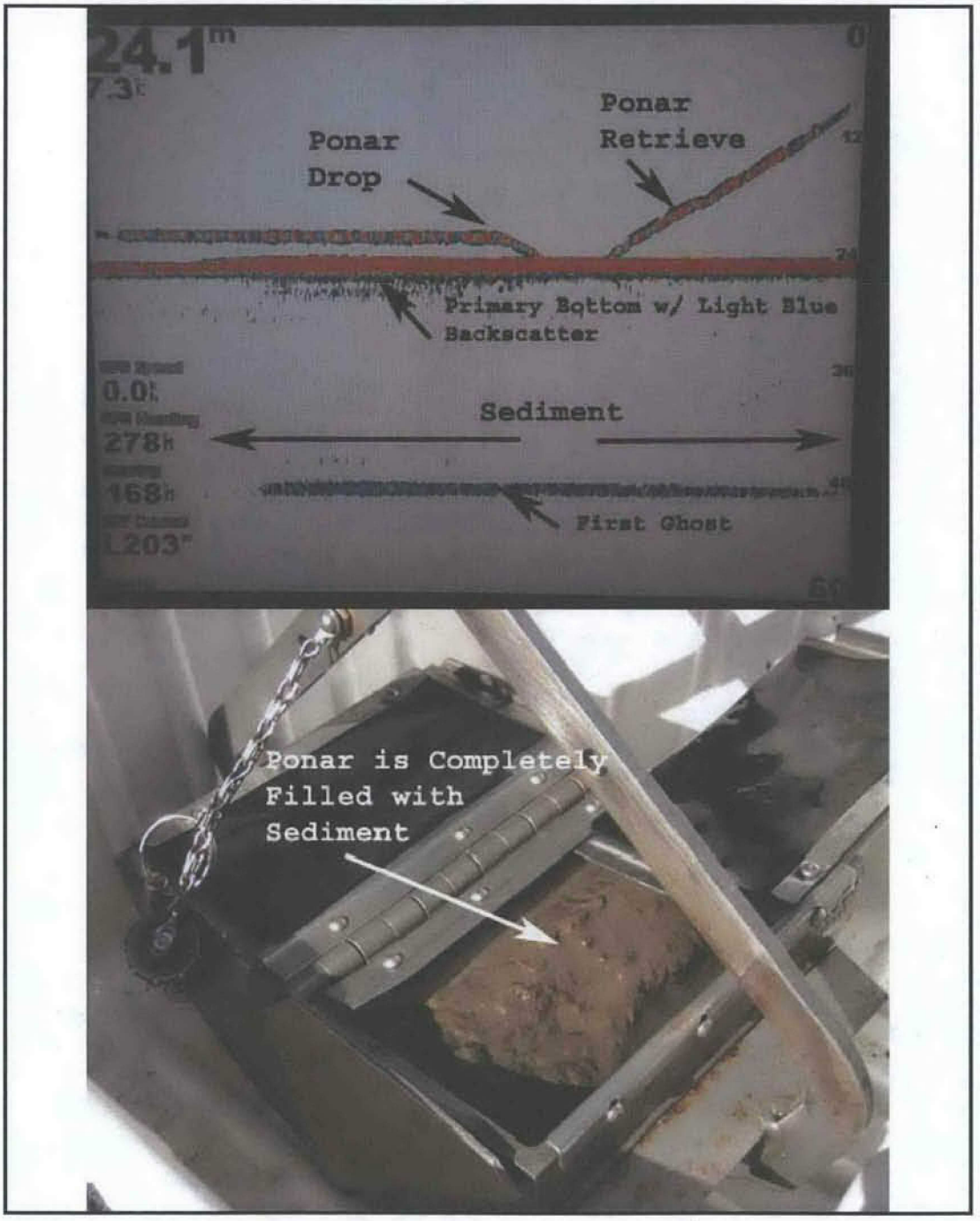

Figure 5. Sonar signal indicating "excellent" sediment (above) and petite ponar grab sample validation (below).

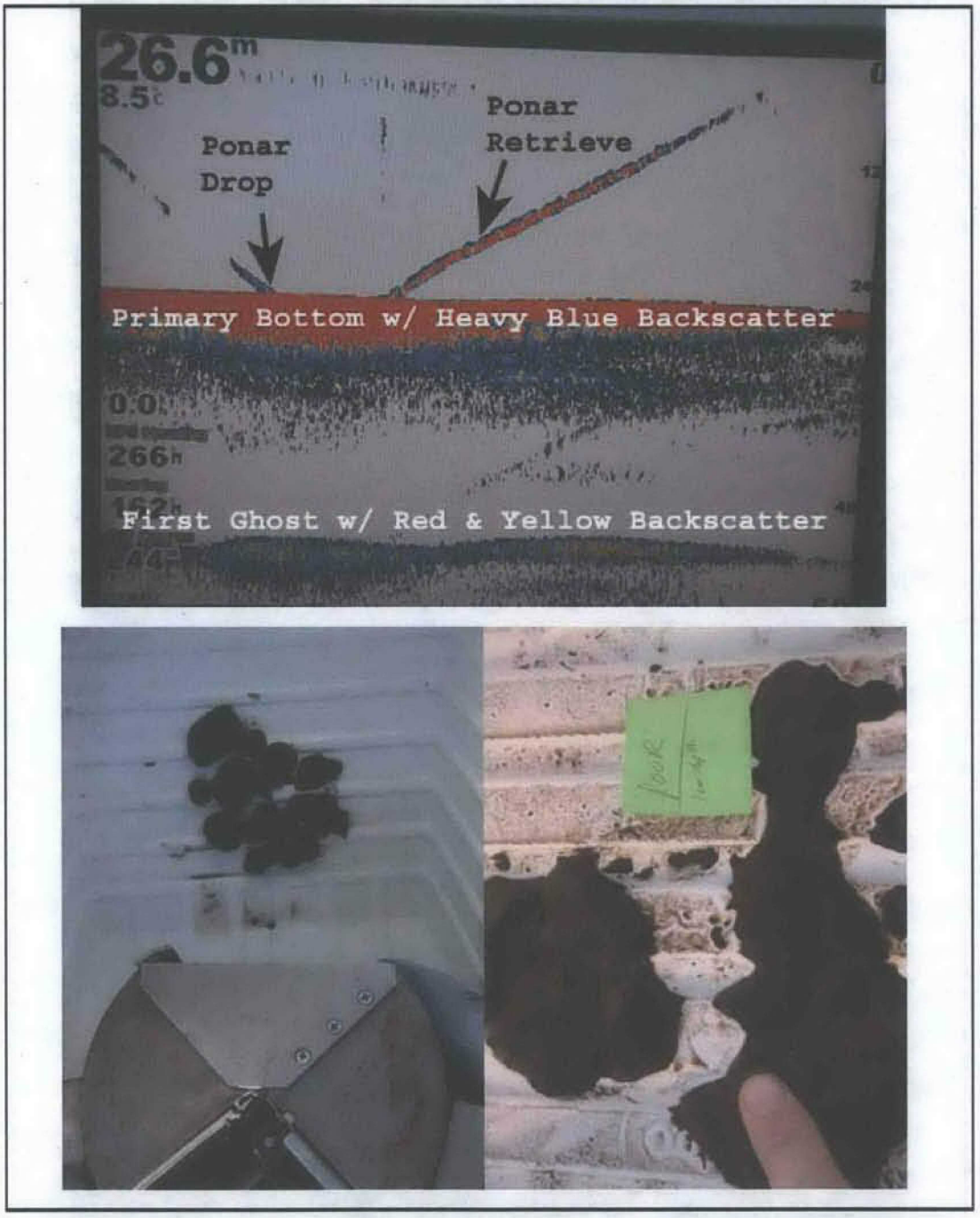

Figure 6. Sonar signal indicating "poor" sediment (above) and petite ponar grab sample validations (below).

3 Results & Discussion

A total of 10 transects (7 pre-determined transects and 3 opportunistic transects) were surveyed using the single beam sonar technique described above. A total of 40 petite ponar grab samples were performed to calibrate and/or verify the sonar signals that indicated the presence of sediment riverbed areas.

Figure 7 and Table 2 provides an overview of the extent of sediment deposition areas that were encountered along three transects (totaling ~5 km in length) in the Columbia River located between the Walla Walla River confluence and McNary Dam. The proportion of sediment encountered (length of transect where sediment was encountered per total transect length) was greatest near McNary Dam. Sediment comprised ~1.64 km (89%) of the 1.84 km long transect (Figure 8) located near McNary Dam. Four discontinuous sections of this transect were found to have an armored riverbed with the bulk of the armored riverbed being located near the center of this transect (see Figure 8). The maximum water depth recorded along this transect was ~35 m (114 ft).

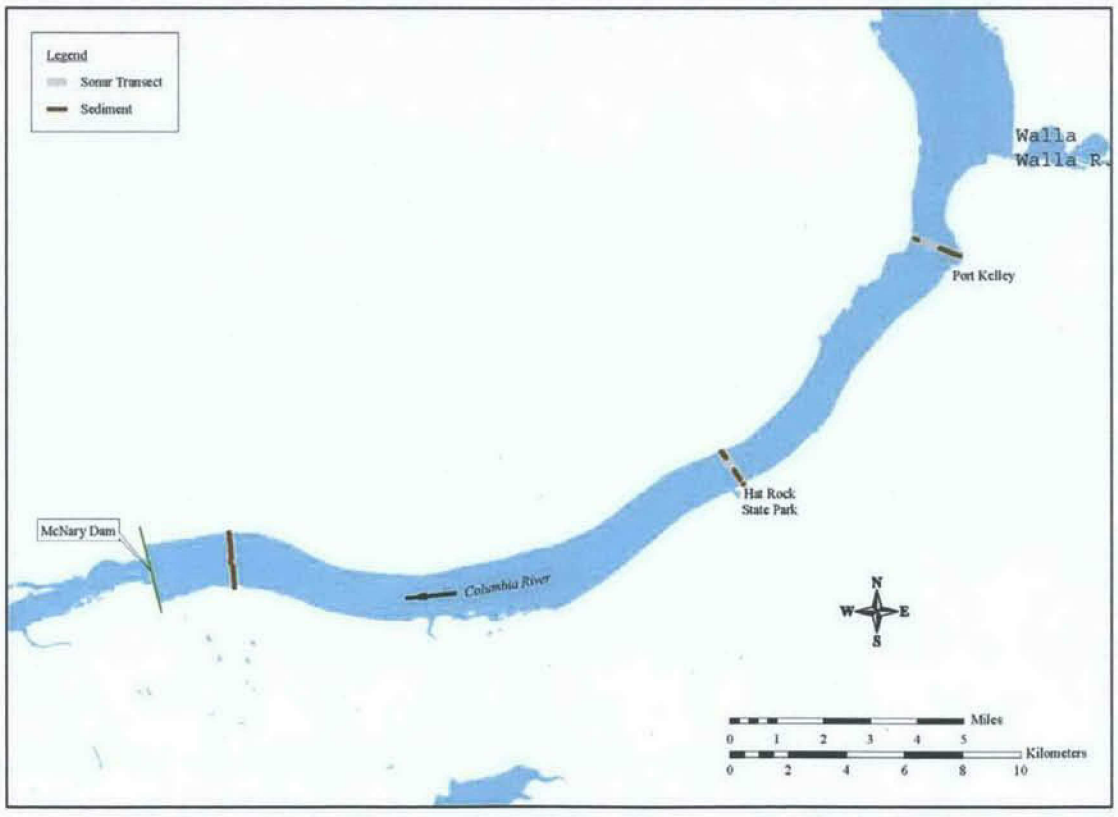

Figure 7. Summary figure depicting 3 pre-determined sonar transects in the McNary pool of the Columbia River and illustrating the sediment deposition areas mapped there during early March, 2008.

Table 2. Transect lengths (km) and amount (length and proportion) of each transect where sediment was encountered.

Location	Transect Total Length (Km)	Total Length of Transect Containing Sediment (Km)	Proportion of Transect Containing Sediment (%)
Port Kelly (Transect F)	1.85	0.95	51
Hat Rock State Park (Transect G)	1.3	0.6	46
McNary Dam (Transect H)	1.84	1.64	89

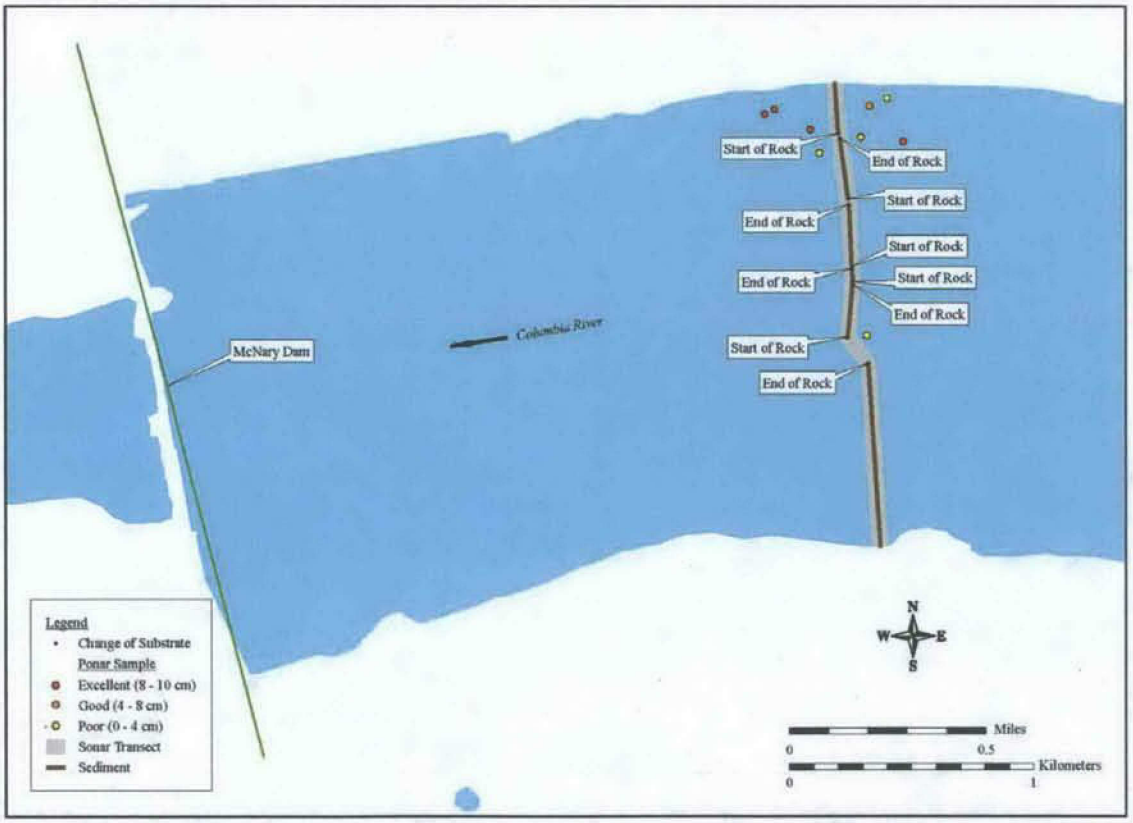

Figure 8. Sonar transect near McNary Dam (transect H) and sediment deposition areas mapped there during early March, 2008.

The 1.3 Km long sonar transect located near Hat Rock State Park (Transect G) was roughly equally split between armored riverbed and sediment deposition areas (see Figures 8, 9 and Table 2). Although the bulk of armored riverbed occurred near the center of the river, it was not continuous there, nor did it elicit a predictable pattern based on proximity to the shorelines or the bathymetry encountered (Figure 9). The 1.85 Km long sonar transect located near Port Kelly (Transect F) was also approximately equally split between armored riverbed (49%) and sediment depositions (51%), however, areas containing a sufficient amount of sediment for petite ponar sampling did not follow the same pattern as those elicted along the transect near Hat Rock State Park (Figure 10). High river velocities were most pronounced near the West side of the river and there was a corresponding lack of sediments that had deposited there. Nearly half of this transect was located in a large back water region that occurred along the eastern edge of the river and correspondingly contained the bulk of sediment encountered along this transect. It should also be noted that the Walla Walla River empties into the Columbia River from the eastern shoreline immediately upstream of this transect and likely plays a role in the amount of sediment that has been deposited along the eastern shorelines of the Columbia River.

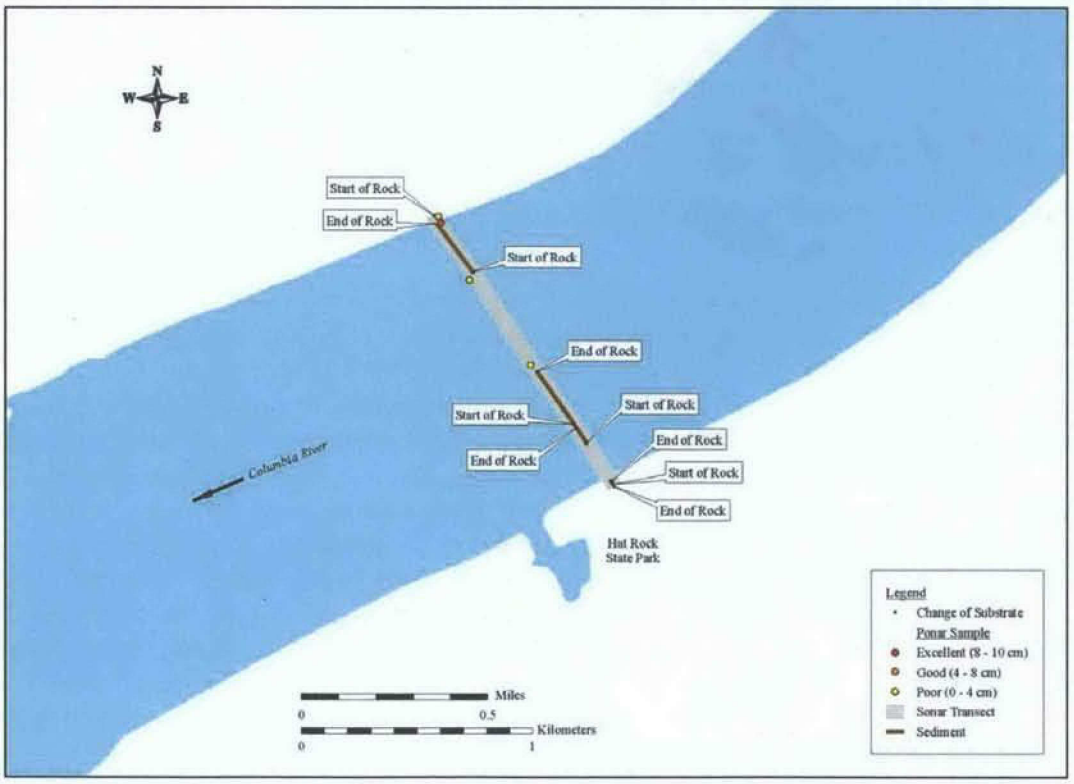

Figure 9. Sonar transect near Hat Rock State Park (transect G) and sediment deposition areas mapped there during early March, 2008.

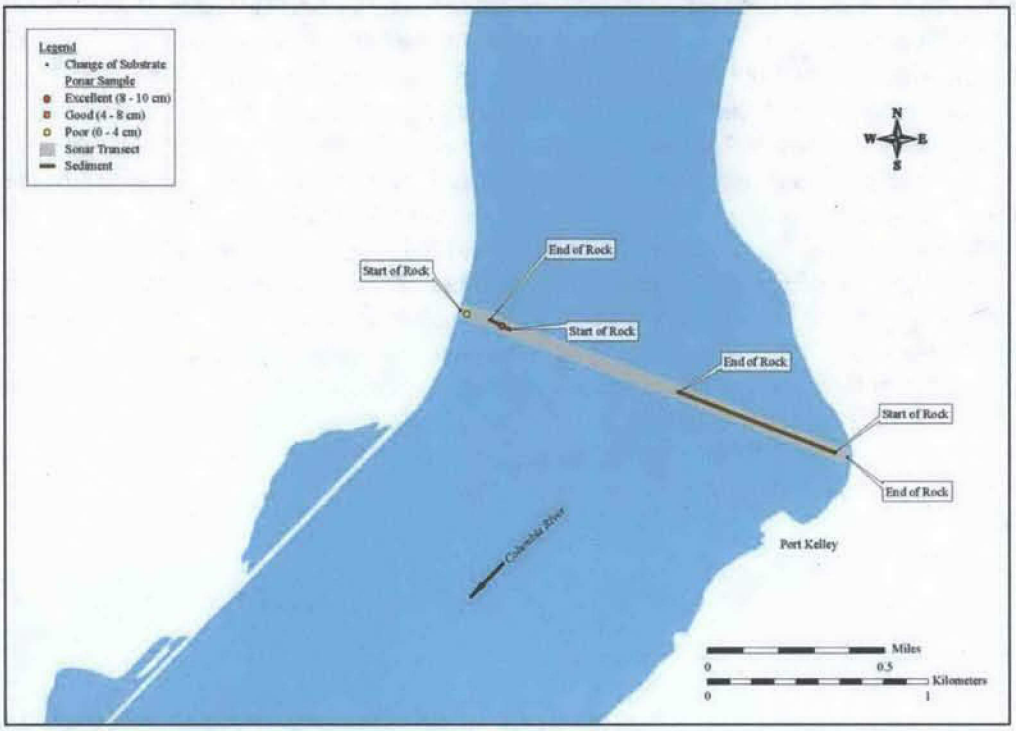

Figure 10. Sonar transect near Port Kelly (transect F) and sediment deposition areas mapped there during early March, 2008.

Riverbed sonar surveys for "good" or "excellent" sediment sampling areas were performed near the confluence of the Yakima River and the Columbia River. These survey areas were arbitrarily selected by the field team to help represent the sediment depositional areas that appear to extend beyond the mouth of the Yakima River (Figure 11). In this region, the sonar's range and gain was adjusted downward because maximum river depths (~15 m) in this region were much less than what had been encountered downriver between the confluence of the Walla Wall River and McNary Dam. The downriver-most transect shown on Figure 11 was selected because it is located near a marina and is in an area that receives relatively high recreational use throughout the year. Sediment mapping efforts in this region were not performed all the way across the river channel and therefore were not used to estimate the proportion of the transect that contained sediment deposits. Sediment mapping efforts shown on Figure 11 indicate that sediment deposits along the shoreline areas of Bateman Island generally only extend out about 100 m into the river. Sediment areas mapped near the high recreational use area (the down-river most transect) persisted off-shore for approximately 200 m, where river currents increased substantially. A number of petite ponar samples taken to calibrate/verify the sediment sonar signals in this region were qualified as "good" due to large amounts of vegetative matter and debri in the samples.

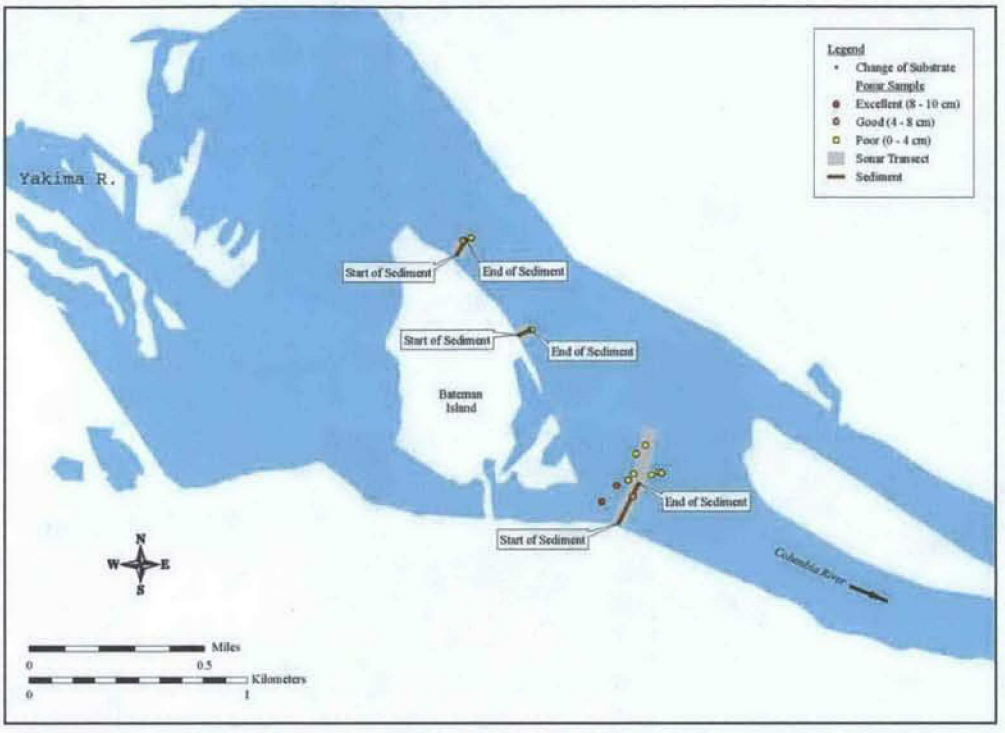

Figure 11. Sonar transects near the confluence of Yakima River and Columbia River and sediment deposition areas mapped there during early March, 2008.

Four pre-determined transects were surveyed near the 100-D intake structure to examine sediment deposition patterns in the trough that was excavated for the 100-D intake structure (Figure 12). One transect was positioned perpendicular to the shoreline (parallel to the 100-D intake trough) and three transects were positioned parallel to the shoreline (perpendicular to the 100-D intake trough).

A major sediment deposit was identified beginning near the wall of the intake structure and continued offshore approximately 150 m. Observers estimated that a mound of sediment approximately 4.5 m deep was present beginning about 80 m from the wall of the intake structure (Figure 13). The sonar signal produced over the hummock of sediment indicated the presence of armored riverbed (see Figure 13), however, verification sampling with the ponar device and visual examination of the riverbed there indicated the signal was produced by the presence of macrophytes (aquatic vegetation) and debri over a sediment deposit.

Conversely, sonar signals produced offshore and in the trough of the intake structure elicited the appearance of fine-grained materials (i.e. little to no backscatter of the primary rivebed and first ghost signals). However, verification sampling using the petite ponar sampling device consistently yielded "poor" sediment samples (Figure 14). The limited amounts of fine-grained material obtained from the edge of the ponar sampler had the appearance of reddish brown color and the texture was similar to coarse sand.

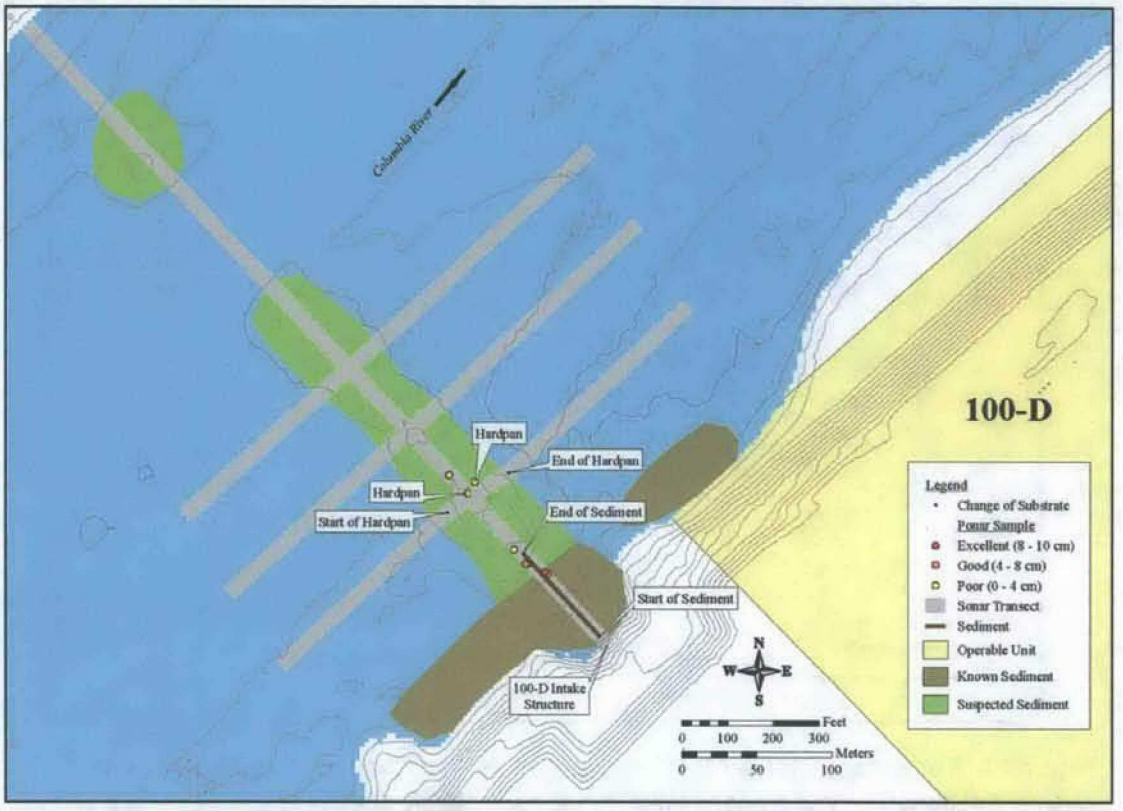

Figure 12. Sonar transects near 100-D intake structure and sediment deposition areas mapped there during early March 2008. Figure also illustrates areas that were previously identified as either "known" or "suspected" sediment deposition areas as part of a preliminary assessment of potential sediment sampling regions in support of the CRC.

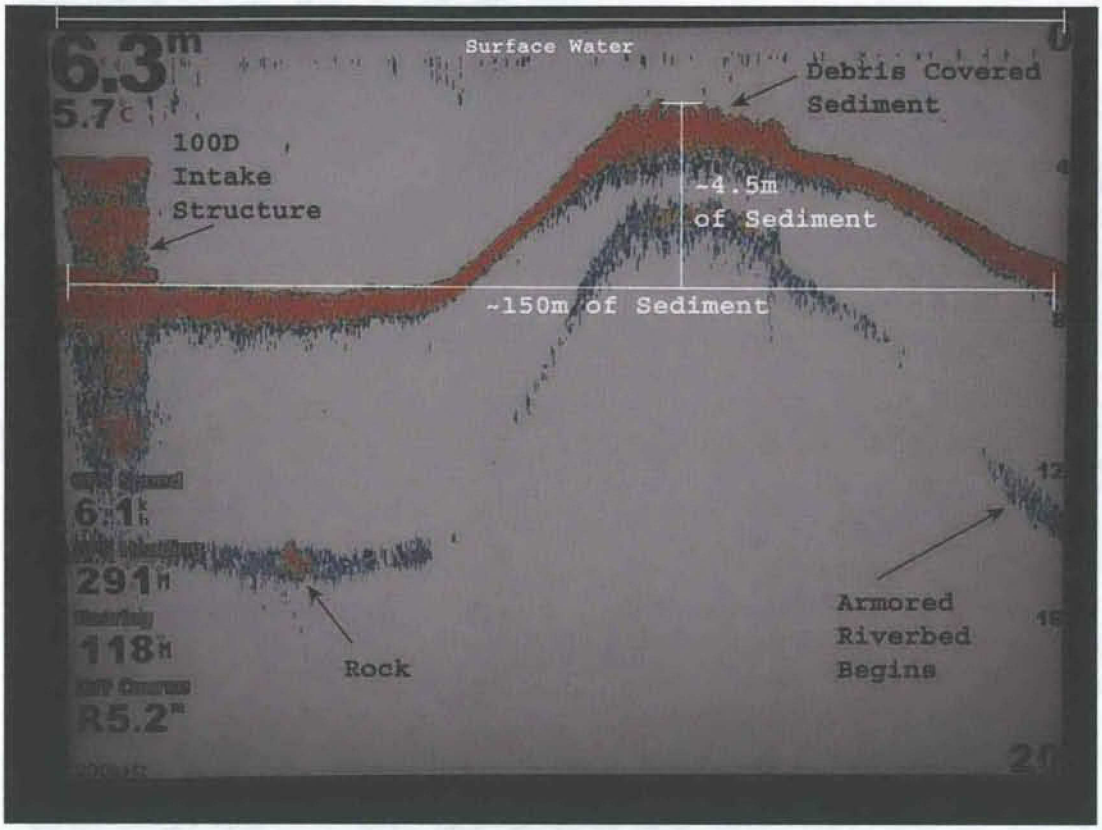

Figure 13. Sonar image near 100-D intake structure showing area of sediment deposition, March 2008.

Figure 14. Photograph of hard pan material (concretion of fine-grained materials) obtained in the riverbed of the Columbia River near 100-D.

In summary, the use of a single-beam sonar to rapidly map sediment deposition areas in the Columbia River was effective when the instruments were calibrated using a combination of visual observations and performing repeated deployments of the petite ponar sampler. Optimum ground speed of the water vessel was found to be 3 km/hr. Mapping sediment deposits in the impounded regions of McNary pool were particularly effective due to relatively consistent riverbed characteristics and water velocities there. Surveys performed along pre-determined transects that extended from shoreline to shoreline provided a means to summarize and compare the proportion of riverbed that contained sediment. Approximately 50% of the riverbed surveyed near Port Kelly and Hat Rock State Park contained major sediment deposits, whereas nearly 90% of the riverbed surveyed near McNary dam contained major sediment deposits. Sonar surveys conducted near the mouth of the Yakima River indicated that sediment deposits were only prominent within approximately 100m of the shoreline of Bateman Island. Immediately downstream of Bateman Island near the boat launch and marina, sediment persisted off-shore approximately 200 meters. Sediment deposits were evident immediately adjacent to the 100-D water intake structure but were not evident in the excavation trench that extended across the main river channel. Sediment surveys in the main river channel near 100-D were more difficult due to the presence of hard-pan material that elicited soft bottom (i.e. sediment) sonar signals. Conversely, large accumulations of debri such as vegetation, was found to have produced sonar signals indicative of the armored riverbed despite the fact that sediment was present around the debri. These confounding conditions emphasize the need to perform verification surveys using the petite ponar sampler when conducting sediment surveys using a single beam sonar. After surveying the riverbed areas near 100-D, near the confluence of Yakima River and Columbia River, and other impounded regions of the McNary pool, it appears that the number and extent of areas that contain major sediment deposits along the Hanford Reach and McNary pool is likely more limited than was initially estimated and illustrated on the maps prepared for the February 2008 CRC workshops.

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Attachment A

Standard Operating Procedure
Sediment Sampling Using a Petite Ponar Bottom Grab Sampler

Preparation:

Move sampling equipment and supplies to work vessel. The rope line should be attached to the sampler using a ball-bearing swivel or similar hardware to minimize twisting forces during deployment and retrieval. For safety, the rope, swivel, and shackles should have a load capacity at least three times the weight of the sampler. After assembly, secure the Petite Ponar Bottom Grab apparatus by placing it in the sampler tray and releasing the tension on the rope line.

NOTE: The Petite Ponar Bottom Grab apparatus should always be secured when the work vessel is in motion.

- Move work vessel to sampling location and anchor or hold on station using GPS data and navigation system.
- Record necessary data in site logbook, including date, time, and sampling station coordinates.

Procedure:

- Lock the sampler open with the safety pin and position over sampling location.
- Remove the safety pin, keeping hands and fingers outside the sampler. Deploy the sampler using the rope line, preferably near the back of the boat. The sampler should be lowered at a controlled rate of speed approximately equal to 1 foot per second (ft/sec).

  Note: Under no circumstances should the sampler be allowed to "free fall" to the bottom, as this may result in premature triggering, an excessive bow wake, or improper orientation of the sampler.
- After the sampler has triggered (check for stack wire), enclosing a sediment sample, retrieve the sampler at a controlled rate of speed approximately equal to 1 ft/sec.
- Lift the sampler carefully on board the work vessel and secure in large, flat pan or stand. Be careful not to swing or tip the sampler during retrieval.
- Open the sampler and evaluate the sample acceptability. The following acceptability criteria should be satisfied:
  1. The sampler is not over-filled so that sample is pressing against the top of the sampler.
  2. Overlying water is present (indicates minimal leakage).
  3. The overlying water is not excessively turbid (indicates minimal sample disturbance).
  4. The sediment surface is relatively flat (indicates minimal disturbance or winnowing).

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5. The desired penetration depth was achieved (10-cm deep surficial sample).

- For biological and chemical replicates, the difference in penetration depth between replicates within a station can be no more than 10 percent. Sampling must continue until the criteria are met. The following are minimum penetration depths.

Medium-coarse sand	4 to 5 centimeters (cm)
Fine sand	6 to 7 cm
Silt/clay	10 cm

- Remove the water overlying the sediment sample. The preferable method for removing the water is by slowly siphoning it off near one corner of the sampler.
- Record the physical description of the sample in the site logbook. This description should include:
  1. Gross characteristics of the surficial sediment such as texture, color, biological structures present (shells, tubes, macrophytes), debris present (wood chips, wood fiber, human artifacts), oily sheen present on the sample, and odor.
  2. Gross characteristics of the vertical sediment profile, such as changes in any of the surficial characteristics listed above.
  3. Penetration depth for the sample.
  4. Comments related to sample quality such as leakage when the sampler retrieved, the presence of winnowing, or visible disturbance of the sediment.
     Note: In order to obtain acceptable grab samples, it may be necessary to decrease the weight of the sampler (to reduce penetration). This can be done by removing the lead weights on the sampler and/or attaching metal (non-crush) floats to the frame. If weights are removed, the holes in the sampler should be plugged using stainless-steel nuts and bolts.
- Photograph the sediment.

Sonar and Ponar Calibration Records

COLUMBIA RIVER SEDIMENT SURVEY FIELD DATA

Long	Lat	WPT Number	Transect	Ponar Grab	Survey_Data	Other	Primary Bottom	First Ghost	Second Ghost
-119.2623	45.94616		H		start of rock				
-119.26222	45.94597		H		end of rock				
-119.26183	45.94373		H		start of rock				
-119.26181	45.94353		H		end of rock				
-119.2617	45.94123		H		start of rock				
-119.2617	45.94113		H		end of rock				
-119.2616779	45.9406654	14	H		start of rock				
-119.2616802	45.9405636	15	H		end of rock				
-119.2609708	45.9386784	22	H	X	poor			red	
-119.2619791	45.9386033	23	H		start of rock				
-119.2609203	45.9376496	24	H		end of rock				
-119.0422491	45.9703847	25	G	X	excellent		heavy red/lt. backscatter	thin blue	na
-119.0423955	45.9706253	26	G	X	poor		heavy red/hvy. Backscatter	heavy red	thin yellow/red
-119.0426456	45.9706566	28	G		start of rock	shoreline			
-119.0424555	45.9703246	29	G		end of rock				
-119.0407339	45.9681369	30	G	X	poor		blue/mod. Backscatter	thin red w/ lt. blue backscatter	na
-119.0405228	45.9684374	31	G		start of rock				
-119.0373761	45.9648053	32	G	X	poor		high backscatter	thin red w/ blue backscatter	slight backscatter
-119.0370185	45.964535	33	G		end of rock				
-119.0360092	45.9624699	34	G		start of rock				
-119.034889	45.9623499	35	G		end of rock				
-119.0343545	45.9617454	36	G		start of rock				
-119.0329726	45.9602465	37	G		end of rock				
-119.0328847	45.9601652	38	G		start of rock				
-119.0330172	45.9602559	39	G		end of rock				
-119.0329286	45.9601432	40	G		start of rock				
-119.0328473	45.9600358	41	G		end of rock	shoreline			
-118.9563151	46.0355229	42	F		start of rock	shoreline			
-118.9559347	46.0353535	43	F	X	poor		heavy red/heavy backscatter	thin red/yellow w/ heavy backscatter	na
-118.9545583	46.0350873	44	F		end of rock				
-118.9538575	46.0348205	45	F	X	excellent		thin backscatter	thin blue	na
-118.9534044	46.0346687	46	F		start of rock				
-118.9436802	46.031953	48	F		end of rock				
-118.9344965	46.029302	49	F		start of rock				
-118.9337659	46.0291035	50	F		end of rock	shoreline			
-119.2175194	46.2382881	51	Bateman Isle		start of sediment	shoreline			
-119.2166189	46.23937	52	Bateman Isle	X	good		high backscatter	red line marginal	no backscatter
-119.2155047	46.2402486	53	Bateman Isle	X	poor		high backscatter	solid red line	persistent backscatter
-119.2150638	46.2403859	54	Bateman Isle	X	poor		high backscatter	solid red line	persistent backscatter
-119.2148773	46.2403279	55	Bateman Isle	X	poor		high backscatter	thin red/mostly blue	no backscatter
-119.2165664	46.2403095	56	Bateman Isle	X	poor		high backscatter	thin red/mostly blue	light backscatter
-119.2175958	46.2398405	57	Bateman Isle	X	excellent		light backscatter	thin blue	na
-119.2169011	46.2400545	58	Bateman Isle	X	poor		high backscatter	scattered red/high backscatter	na
-119.2164017	46.2411443	59	Bateman Isle	X	poor		high backscatter	solid red/high backscatter	lots of backscatter
-119.2158394	46.2414961	60	Bateman Isle	X	poor		high backscatter	solid red/high backscatter	lots of backscatter
-119.2185069	46.2391806	61	Bateman Isle	X	excellent		high backscatter	very thin blue	na
-119.2162941	46.2398968	62	Bateman Isle		end of sediment				
-119.2155137	46.2421906	63	Bateman Isle			ended transect			
-119.2233378	46.246163	64	Bateman Isle		start of sediment	shoreline			
-119.2225501	46.2463742	65	Bateman Isle	X	poor		high backscatter	scattered red	na
-119.2226567	46.2463742	66	Bateman Isle		end of sediment				
-119.2269823	46.2495736	67	Bateman Isle		start of sediment	shoreline			
-119.2266122	46.2501402	68	Bateman Isle	X	good		high backscatter	blue backscatter	na
-119.2261087	46.2502504	69	Bateman Isle	X	poor		high backscatter	red (bottom of screen)	na
-119.2264126	46.2501769	70	Bateman Isle		end of sediment				
-119.26331	45.94545		H	X	poor			thick blue ghost-light backscatter & thick red	
-119.26376	45.94631		H	X	excellent	clams, gravel, & silt		Large Ghost w/ red, yellow & blue	
-119.26566	45.94708		H	X	excellent	clams		Blue Ghost	
-119.2662	45.94692		H	X	excellent			Blue Ghost/lt. backscatter & thick red	
-119.26112	45.94601		H	X	poor		Thick Red	Red	blue w/ lots backscatter
-119.25887	45.94582		H	X	excellent			light blue	na
-119.26063	45.94716		H	X	good			thick blue/yellow	
-119.2597	45.94744		H	X	poor			thick red	
-119.2597	45.94744		H	X	poor			thick red	
-119.5487798	46.6950485	71	100 D Intake	X	good		red w/ lt. backscatter	scattered red	na
-119.5489585	46.6951131	72	100 D Intake	X	poor		red w/ lt. backscatter	blue & red	blue scatter
-119.5488065	46.6950618	73	100 D Intake	X	excellent		red w/ lt. backscatter	blue band	na
-119.5489738	46.6951129	74	100 D Intake	X	good		red w/ lt. backscatter	thin blue	na
-119.5490725	46.6951995	75	100 D Intake	X	poor		red w/ lt. backscatter	red & thick blue	na
-119.5483336	46.6946689	79	E		start of sediment	at intake wall			
-119.5491093	46.6956642	81	D		start of hard pan				
-119.5496631	46.6954283	82	D		end of hard pan				
-119.549646	46.6956568	84	D	X	poor	gravel	red w/ lt. backscatter	blue	na
-119.5494051	46.6956149	85	D	X	poor	periphyton/hard pan	red w/ lt. backscatter	na	na
-119.5494806	46.6955429	86	D	X	poor	periphyton/hard pan	red w/ lt. backscatter	thin blue	na
-119.5489923	46.6951737	87	E		end of sediment				
-119.5363526	46.7073881	89	100 D Island	X	poor	periphyton/hard pan	red w/ lt. backscatter	thin blue	na
-119.5363801	46.7074698	90	100 D Island	X	poor	hard pan	red w/ lt. backscatter	thin blue	na
-119.535796	46.7081397	91	100 D Island	X	poor	gravel	red w/ lt. backscatter	thin blue	na

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Greg deBruler	PO Box 912 Bingen, WA 98605
Pam Larsen	P. O. Box 190 Richland, WA 99352
Maynard Plahuta	1822 Hunt Point Richland, WA 99354
Dick Smith	1520 W. 9th Ave. Kennewick, WA 99336