0059440

DOE/RL-2003-08
Draft A

100-B/C Area Ecological Risk Assessment Sampling and Analysis Plan

RECEIVED
MAY 19 2003
EDMC

United States
Department of Energy

For External Review

TRADEMARK DISCLAIMER

Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

This report has been reproduced from the best available copy.

Printed in the United States of America

DISCLM-4.CHP (1-91)

DOE/RL-2003-08
Draft A

100-B/C Area Ecological Risk Assessment Sampling and Analysis Plan

March 2003

United States Department of Energy

P.O. Box 550, Richland, Washington 99352

For External Review

TABLE OF CONTENTS

1.0 INTRODUCTION 1-1

1.1 BACKGROUND 1-1

1.1.1 100-B/C Area Operable Unit Background 1-3
1.1.2 Status of 100-B/C Area Waste Sites 1-4
1.1.3 Previous Investigations in the 100-B/C Area 1-5
1.1.4 Scope of the 100-B/C Pilot Project 1-5

1.2 CONTAMINANTS OF POTENTIAL CONCERN 1-7

1.3 DATA QUALITY OBJECTIVES 1-10

1.3.1 Statement of the Problem 1-11
1.3.2 Inputs Needed to Develop Decision Rules 1-13
1.3.3 Decision Rules 1-16
1.3.4 Error Tolerance and Decision Consequences 1-17
1.3.5 Sample Design Summary 1-19

2.0 QUALITY ASSURANCE PROJECT PLAN 2-1

2.1 PROJECT MANAGEMENT 2-1

2.1.1 Project/Task Organization 2-1
2.1.2 Project Schedule 2-1
2.1.3 Quality Objectives and Criteria for Measurement Data 2-1
2.1.4 Special Training Requirements/Certification 2-2
2.1.5 Documentation and Records 2-2

2.2 MEASUREMENT/DATA ACQUISITION 2-8

2.2.1 Sampling Process Design 2-8
2.2.2 Sampling Methods Requirements 2-8
2.2.3 Sample Handling and Custody Requirements 2-8
2.2.4 Analytical Methods Requirements 2-8

2.3 QUALITY CONTROL REQUIREMENTS 2-9

2.3.1 Field Quality Control 2-9
2.3.2 Fixed Laboratory Quality Control 2-10
2.3.3 Instrument/Equipment Testing, Inspection, and Maintenance Requirements 2-10
2.3.4 Instrument Calibration and Frequency 2-10
2.3.5 Data Management 2-10

2.3.6 Field Documentation 2-11

2.4 ASSESSMENT/OVERSIGHT 2-11

2.4.1 Assessments and Response Actions 2-11
2.4.2 Reports to Management 2-11

2.5 DATA VALIDATION AND USABILITY 2-11

2.5.1 Data Review, Validation, and Verification Requirements 2-11
2.5.2 Reconciling Results with Data Quality Objectives 2-12

3.0 FIELD SAMPLING PLAN 3-1

3.1 SAMPLING OBJECTIVES 3-1

3.2 SAMPLING DESIGN 3-3

3.2.1 Abiotic Sampling Procedures 3-5
3.2.2 Biota Sampling Procedures 3-5

3.3 UPLAND ZONE 3-5

3.3.1 Abiotic Sampling 3-6
3.3.2 Biotic Sampling 3-6

3.4 RIPARIAN ZONE 3-12

3.4.1 Abiotic Sampling 3-12
3.4.2 Riparian Biota Sampling 3-14

3.5 NEAR-SHORE RIVER ZONE 3-17

3.5.1 Abiotic Sampling 3-19
3.5.2 Biota Sampling 3-22

3.6 SAMPLE HANDLING, SHIPPING, AND CUSTODY REQUIREMENTS 3-26

3.7 SAMPLING AND ONSITE ENVIRONMENTAL MEASUREMENT PROCEDURES 3-27

3.8 SAMPLE MANAGEMENT 3-27

3.9 MANAGEMENT OF INVESTIGATION-DERIVED WASTE 3-27

4.0 HEALTH AND SAFETY 4-1

5.0 REFERENCES 5-1

APPENDICES

A SOIL SCREENING VALUES FOR PROTECTION OF ECOLOGICAL AND HUMAN RECEPTORS IN THE 100-B/C AREA ..... A-i

B 100-B/C AREA ECOLOGICAL RISK ASSESSMENT SAMPLING AND DATA EVALUATION SCHEDULE ..... B-i

FIGURES

1-1. Hanford Site Map 1-2
1-2. 100-B/C Area Pilot Study Geographical Boundary 1-6
3-1. 100-B/C Sampling Pilot Project Sampling Zones. 3-2
3-2. Upland Sampling Locations 3-8

TABLES

1-1. 100-B/C Area Final COC List 1-7
1-2. Summary Principal Study Questions, Alternative Actions, and Decision Statements .. 1-11
1-3. Inputs Needed to Develop 100 Area Decision Rules 1-14
1-4. Decision Rules 1-16
1-5. Justification for Sampling Design 1-18
1-6. Sampling Design Methodology, Objectives, Features, and Basis 1-20
2-1. Milestone Dates. 2-2
2-2. Analytical Performance Requirements 2-3
3-1. Methods for Survey/Sample Collection. 3-4
3-2. Upland Zone Sampling of Soil from Rooting Zone of Russian Thistle. 3-6
3-3. Upland Zone Vegetation Sampling for Combined Shoots-Roots, and Shoots Only. 3-9
3-4. Upland Zone Pitfall Sampling of Soil Invertebrates (Whole Body of Beetles, Ants, and Spiders). 3-11
3-5. Upland Zone Small Mammal (Deer Mouse) Sampling for Carcass (C), Liver (L), And Brain (Br). 3-12
3-6. Riparian Zone Composite Soil Sample from Rooting Zone of Shrubs or Trees 3-13
3-7. Riparian Zone Plant Sampling for Combined Shoots and Roots. 3-15
3-8. Riparian Zone Pitfall Sampling of Soil Invertebrates (Whole Body of Beetles, Ants, and Spiders). 3-16
3-9. Riparian Zone Small Mammal (Deer Mouse) Sampling for Carcass (C), Liver (L), and Brain (Br). 3-17
3-10. Near-Shore River Water Sampling 3-19

3-11. Near-Shore River Sediment Samples.....3-22
3-12. Near-Shore River Zone Sampling for Sculpin (Carcass [C], Liver [L], Brain [Br]).....3-23
3-13. Near-Shore River Zone Sampling of Benthic Invertebrates Including Clams (Shell Composite [SC], Soft Tissue Composite [STC], Crayfish [Hepatopancreas = H and Carcass C]), and Caddisfly (Whole Body = WB).....3-24
3-14. Near-Shore River Zone Sampling for Macrophytes and Periphyton.....3-26

ACRONYMS AND ABBREVIATIONS

AA	alternative action
AEA	alpha energy analysis
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
COC	contaminant of concern
COPC	contaminant of potential concern
CVP	cleanup verification package
DQO	data quality objective
DR	decision rule
DS	decision statement
EPA	U.S. Environmental Protection Agency
FSP	Field Sampling Plan
GPS	global positioning system
HEIS	Hanford Environmental Information System
ICP-MS	inductively coupled plasma-mass spectrometry
LFI	limited field investigation
OU	operable unit
PCB	polychlorinated biphenyl
PNNL	Pacific Northwest National Laboratory
PSQ	principal study question
QA	quality assurance
QC	quality control
ROD	record of decision
SAP	sampling and analysis plan
SESP	Surface Environmental Surveillance Project
SOP	standard operating procedure
SVOA	semivolatile organic analyte
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
VOA	volatile organic analyte
WAC	*Washington Administrative Code*

METRIC CONVERSION CHART

Into Metric Units			Out of Metric Units		
If You Know	*Multiply By*	*To Get*	*If You Know*	*Multiply By*	*To Get*
Length			**Length**		
inches	25.4	millimeters	millimeters	0.039	inches
inches	2.54	centimeters	centimeters	0.394	inches
feet	0.305	meters	meters	3.281	feet
yards	0.914	meters	meters	1.094	yards
miles	1.609	kilometers	kilometers	0.621	miles
Area			**Area**		
sq. inches	6.452	sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.093	sq. meters	sq. meters	10.76	sq. feet
sq. yards	0.836	sq. meters	sq. meters	1.196	sq. yards
sq. miles	2.6	sq. kilometers	sq. kilometers	0.4	sq. miles
acres	0.405	hectares	hectares	2.47	acres
Mass (weight)			**Mass (weight)**		
ounces	28.35	grams	grams	0.035	ounces
pounds	0.454	kilograms	kilograms	2.205	pounds
ton	0.907	metric ton	metric ton	1.102	ton
Volume			**Volume**		
teaspoons	5	milliliters	milliliters	0.033	fluid ounces
tablespoons	15	milliliters	liters	2.1	pints
fluid ounces	30	milliliters	liters	1.057	quarts
cups	0.24	liters	liters	0.264	gallons
pints	0.47	liters	cubic meters	35.315	cubic feet
quarts	0.95	liters	cubic meters	1.308	cubic yards
gallons	3.8	liters			
cubic feet	0.028	cubic meters			
cubic yards	0.765	cubic meters			
Temperature			**Temperature**		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius	Celsius	multiply by 9/5, then add 32	Fahrenheit
Radioactivity			**Radioactivity**		
picocuries	37	millibecquerel	millibecquerels	0.027	picocuries

1.0 INTRODUCTION

This sampling and analysis plan (SAP) presents the rationale and strategy for the sampling and analysis activities of the 100-B/C Pilot Project. The purpose of the pilot study is to begin the process of evaluating the effectiveness of the remedial action projects in the 100-B/C Area of the Hanford Site for protecting human health and the environment. The 100-B/C Area of the Hanford Site is located along the southern shore of the Columbia River in southeastern Washington State (Figure 1-1). A portion of the 100-B/C Area upland, riparian, and near-shore river soil, water, and biota will be sampled to evaluate protectiveness of human health and ecological receptors in this area. Contaminant concentrations in soil and biota will be compared to endpoint criteria specified by Washington State regulations, U.S. Department of Energy technical guidance, or as supported by the scientific literature.

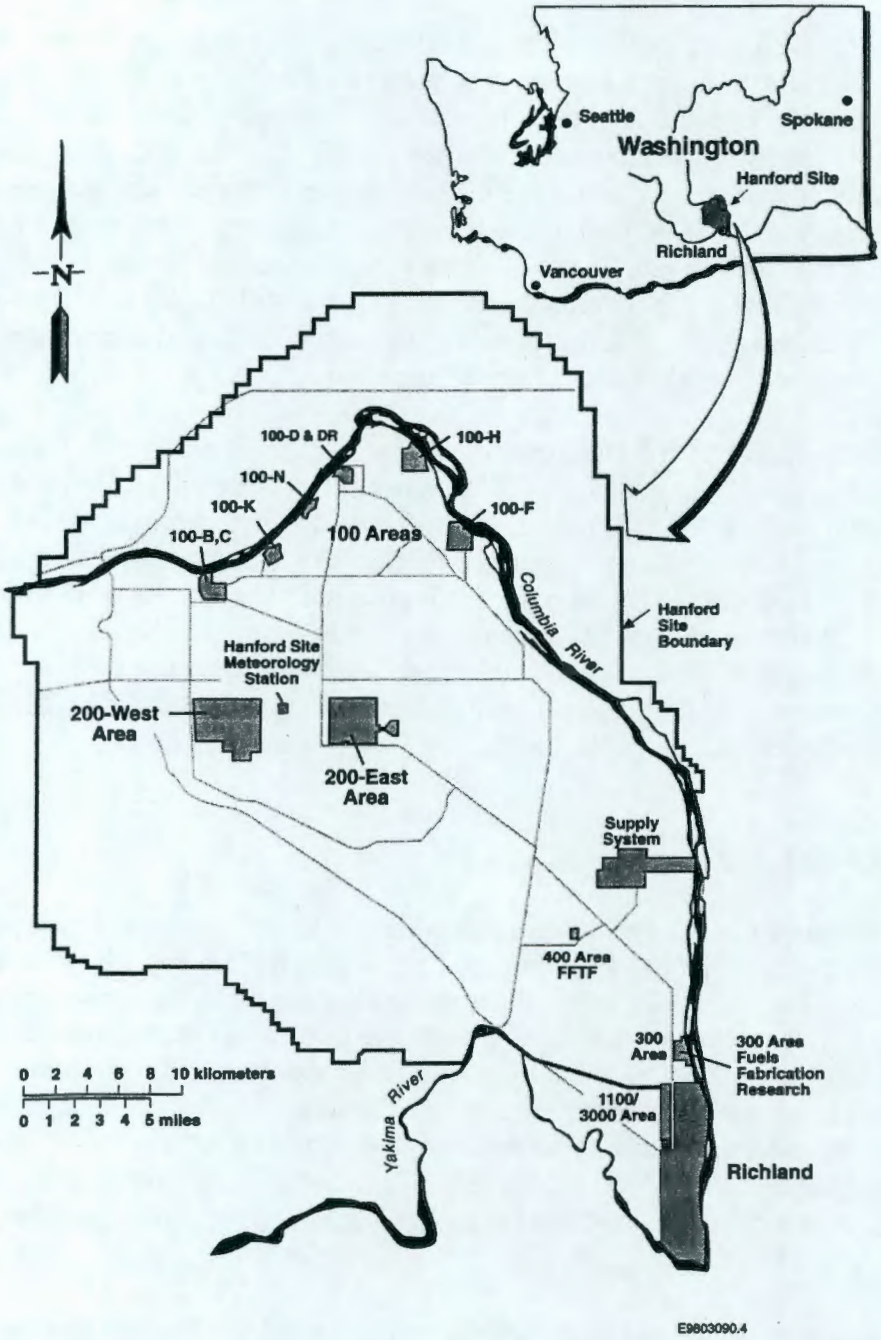
This section provides background information about the project, a discussion of previous sampling within the 100-B/C Operable Units (OUs), a list of the contaminants of concern (COCs), and a summary of the 100-B/C risk assessment data quality objectives (DQOs). The 100-B/C Area ecological risk assessment supported by this SAP will serve as a test case and provide ideas for facilitating discussion with the Tri-Parties (i.e., the U.S. Environmental Protection Agency [EPA], Washington State Department of Ecology, and U.S. Department of Energy, Richland Operations Office), Tribal Nations, and stakeholders. The sampling and analysis strategy presented in this SAP was initially identified in the *100-B/C Ecological Risk Assessment Data Quality Objectives* (BHI 2003).

1.1 BACKGROUND

The Hanford Site became a Federal facility in 1943 when the U.S. Government took possession of the land to produce nuclear materials for defense purposes. The Hanford Site's production mission continued until the late 1980s, when the mission changed from producing nuclear materials to cleaning up the radioactive and hazardous wastes that had been generated during the previous years. In 1989, the 100 Area (encompassing the former plutonium production reactors along the Columbia River) was one of four areas at the Hanford Site that was placed on the National Priorities List under the authority of the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA). Placement on the National Priorities List initiated the CERCLA process that would lead to cleanup of contaminated areas on the Hanford Site.

Since the 100 Area cleanup began, the largest of the contaminated waste sites have been remediated and the structures demolished. The rest of the contaminated sites are scheduled to be remediated by 2018. As remedial actions are nearing completion, the next step is to begin gathering information to support final records of decision (RODs). One of the key pieces of evidence needed to support a final ROD is the demonstration that the remedial action is protective of human health and the environment. The protection of terrestrial ecological

Figure 1-1. Hanford Site Map.



receptors, which is not explicitly addressed in the interim RODs (e.g., *Record of Decision for the 100-BC-1, 100-DR-1 and 100-HR-1 Operable Units, Hanford Site, Benton County, Washington* [EPA 1995], and *Interim Action Record of Decision: 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6 and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington* [EPA 1999]), has become a state regulation under a revision to the *Model Toxics Control Act* (*Washington Administrative Code* [WAC] 173-340-7490 through 7494) that became effective in August 2001.

In an effort to assess protectiveness of remedial actions within the 100-B/C Area, *A Preliminary Evaluation of Post-Remediation Protectiveness of Humans and the Environment at the 100-B/C Area* (BHI 2002) was written to identify information gaps and data needs. Five areas of protectiveness were specifically addressed:

- Protection of humans from surface exposures
- Protection of groundwater for human uses
- Protection of surface water for human and aquatic receptors
- Protection of terrestrial ecological receptors
- Protection of the riparian zone for human and ecological receptors.

Protection of humans from surface exposure and groundwater and protection of human and aquatic receptors from surface water are currently addressed in the RODs (EPA 1996, 1999). Protection of terrestrial ecological receptors and protection of human and ecological receptors in the riparian zone are not addressed in current RODs.

1.1.1 100-B/C Area Operable Unit Background

Three OUs are associated with the 100-B/C Area of the Hanford Site. Two OUs, 100-BC-1 and 100-BC-2, are source OUs. The third OU, 100-BC-5, is the groundwater OU for the 100-B/C Area. The 100-B/C Area contains two reactors: the B Reactor within the 100-BC-1 OU and the C Reactor within the 100-BC-2 OU. The B Reactor operated from 1944 to 1968, and the C Reactor operated from 1952 to 1969. Interim remedial actions for the 100-B/C Area have been performed for several waste sites listed in the 1996 and 1999 RODs. These removal actions were documented in cleanup verification package (CVP) reports.

The 100-BC-1 OU consists of approximately 1.8 km^2 (0.7 mi^2) of land immediately adjacent to the Columbia River. The 100-BC-1 OU contains waste units associated with the original plant facilities constructed to support operation of the B Reactor, as well as the retention basins for the B and C Reactors. Detailed information about the operation and waste streams of the 100-BC-1 OU can be found in the *Remedial Investigation/Feasibility Study Work Plan for the 100-BC-1 Operable Unit* (DOE 1992) and the *Limited Field Investigation Report for the 100-BC-1 Operable Unit* (DOE-RL 1994a).

The 100-BC-2 OU consists of approximately 1.7 km^2 (0.6 mi^2) of land within the 100-B/C Area. The 100-BC-2 OU contains waste units associated with the original plant facilities constructed to

support operation of the C Reactor, and liquid, sludge, and solid waste units. Detailed information about the 100-BC-2 OU operation and waste streams can be found in the *Remedial Investigation/Feasibility Study Work Plan for the 100-BC-2 Operable Unit* (DOE 1993b) and the *Limited Field Investigation Report for the 100-BC-2 Operable Unit* (DOE-RL 1994b). An interim action ROD for additional sites in the 100-BC-1 and 100-BC-2 OUs was issued in 1999 (EPA 1999). The final selected remedy for these sites is to remove, treat if necessary, and dispose of the contaminated soil at the Environmental Restoration Disposal Facility (EPA 1995, 1999).

The 100-BC-5 OU consists of contaminated groundwater beneath the 100-BC-1 and 100-BC-2 OUs (an area of approximately 2.5 km^2 [0.96 mi^2], or 250 ha [618 ac]). The 100-BC-5 Groundwater OU is described in *Remedial Investigation/Feasibility Study Work Plan for the 100-BC-5 Groundwater Operable Unit* (DOE-RL 1993a). Groundwater in the 100-B/C Area flows in a northerly direction towards the Columbia River.

1.1.2 Status of 100-B/C Area Waste Sites

The remediation of wastes sites in the 100 Areas was prioritized such that sites having the most potential impact to groundwater, sites closest to the Columbia River, and sites that contributed the most to surface radiation exposure would be remediated first (DOE-RL 2002b). Some low-priority sites were included in the initial phase of remediation because of their close proximity to the high-priority sites. In the 100-B/C Area, remedial action activities began in 1996. Remediation activities are currently in progress at the effluent pipelines from the reactors to the retention basins, the pipelines from the retention basins to the outfall structures, and the outfall structures. The outfall structure excavation does not include the buried pipes that discharge to the river. The facilities currently being remediated are projected to be complete by the end of fiscal year 2004 (BHI 2002).

Remediated waste sites in the upland area within the scope of this pilot study are as follows:

- 116-B-1 Liquid Waste Disposal Trench
- 116-B-11 Retention Basin
- 116-B-13 Sludge Trench
- 116-B-14 Sludge Trench
- 116-C-1 Liquid Waste Disposal Trench
- 116-C-5 Retention Basins
- 116-B-7 Outfall Structure
- 132-B-6 Outfall Structure
- 132-C-2 Outfall Structure
- Pipelines currently undergoing remediation.

Information for the sites listed above, including process history, COCs, excavation volumes, and residual excavation floor and sidewall contamination levels, are detailed in waste-site specific CVP documents (e.g., BHI 1999).

The next phase of remediation is currently planned to address two types of sites: (1) the burial grounds and (2) the remaining sites. The burial grounds are solid waste sites that received contaminated materials such as equipment, used parts, and construction debris from reactor operation activities. These sites are a lower priority than the liquid sites because contamination is generally fixed to the solid waste materials and has a low potential to affect groundwater. The remaining sites have the least potential threat of release to the environment. They include sites such as septic systems, burn pits, and below-grade structural elements of facilities demolished under the decontamination and decommissioning program.

1.1.3 Previous Investigations in the 100-B/C Area

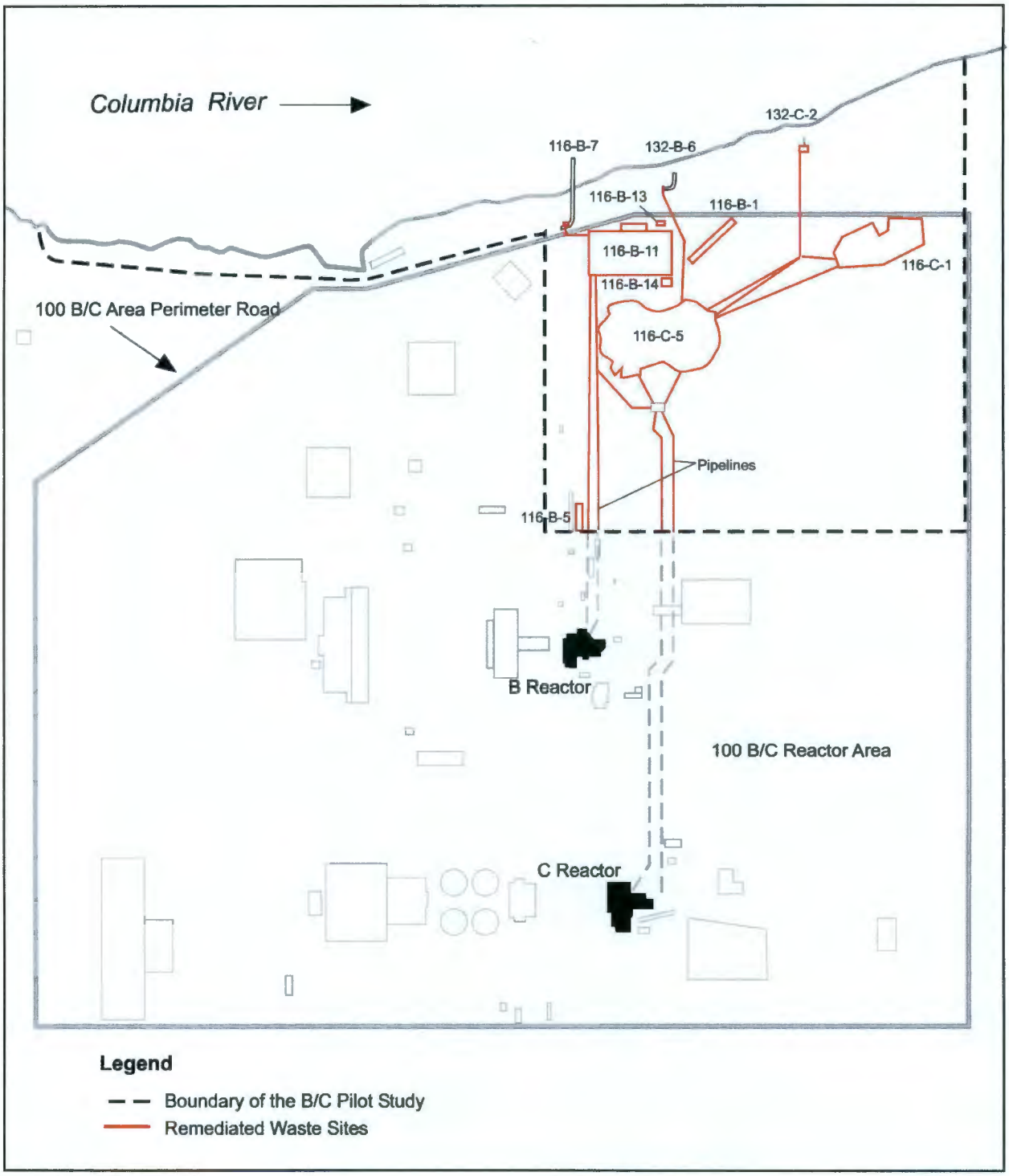
Previous investigations related to biological sampling include *Fiscal Year 1991 100 Areas CERCLA Ecological Investigations* (Landeen et al. 1992) and *A Synthesis of Ecological Data from the 100 Areas of the Hanford Site* (Weiss and Mitchell 1992). Soil samples have been collected in the 100-B/C Area during the limited field investigations (LFIs), remedial investigation/feasibility studies, and CVPs. The 100 Area LFIs were conducted for more than 200 analytes, including radionuclides, metals, general chemistry constituents, pesticides, as well as volatile organic analytes (VOAs) and semivolatile organic analytes (SVOAs) (DOE-RL 1994a, 1994b, 1994c). The list resulting from the LFI is comprehensive and includes contaminants not known to be present in the 100-B/C Area but that were included for completeness. The list of constituents was further streamlined in the DQO process (BHI 2003) to determine the radiological and chemical contaminants most likely to pose risk to ecological and human health in the 100-B/C Area. The identification of COCs is presented in Section 1.2.

1.1.4 Scope of the 100-B/C Pilot Project

This SAP is intended to identify and fulfill sampling requirements for a preliminary baseline risk assessment for the 100-B/C Area. The scope of the pilot project, was previously described in *A Preliminary Evaluation of Post-Remediation Protectiveness of Humans and the Environment at the 100-B/C Area* (BHI 2002), and further refined in the *100-B/C Ecological Risk Assessment Data Quality Objectives* (BHI 2003). Remedial action activities have been completed for several high-priority sites in the 100-B/C Area. This assessment will help determine whether or not the remedial actions taken are protective of ecological and human receptors in the 100-B/C Area and associated upland, riparian, and Columbia River near-shore river environments.

The geographical boundary of the 100-B/C Pilot Project study area encompasses the remediated high-priority waste sites (Figure 1-2). The eastern boundary of the study area is the 100-B/C Area eastern perimeter road from B Avenue north to the Columbia River. The southern boundary of the study area extends along B Avenue from the eastern perimeter road to the road paralleling the 116-B-7 (1904-B-1) Outfall. The western boundary of the study area extends north from B Avenue to the 116-B-7 (1904-B-1) Outfall. The western boundary then extends an additional ~1 km westward (upstream) along the Columbia River shoreline to the western 100-B/C Area perimeter road (Figure 1-2).

Figure 1-2. 100-B/C Area Pilot Study Geographical Boundary.



E0212032.2

Three general sampling areas are defined within the scope of the 100-B/C Pilot Project: (1) upland, (2) riparian, and (3) near-shore river environment. Because the intent of this study is to examine the protectiveness of the cleanup process, sampling in the upland environment consists only of CERCLA remediated waste sites. The riparian zone, and specifically groundwater seeps where contaminated groundwater interfaces with surface soils, is investigated for potential exposure to ecological receptors. The near-shore river environment associated with the Columbia River shoreline adjacent to the 100-B/C Area shoreline is also evaluated to determine the influence of contaminated groundwater on aquatic ecological receptors and to determine potential external radionuclide exposure from shoreline contamination. These three areas are referred to as sampling zones.

1.2 CONTAMINANTS OF POTENTIAL CONCERN

The results from previous investigations and/or process knowledge have identified radionuclides and/or chemicals as contaminants of potential concern (COPCs) in soil, groundwater, and surface water. A list of more than 200 COPCs for the 100-B/C Area was obtained from the LFI studies from the 100-BC-1, 100-BC-2, and 100-BC-5 OUs (DOE-RL 1994a, 1994b, 1994c). These COPCs were then evaluated against a set of exclusion criteria to determine if they should be retained as COPCs or excluded from further consideration. The evaluation of COPCs against exclusion criteria is documented in the DQO summary report (BHI 2003). The final list of COCs resulting from the exclusion process includes 100 Area contaminants identified by process knowledge and historical sampling and analyses. Final COCs for media of concern are presented in Table 1-1.

Table 1-1. 100-B/C Area Final COC List. (2 Pages)

Media	COCs
Soils	Americium-241, gamma emitters (cesium-137, cobalt-60, europium-152, europium-154, europium-155, silver-108m[a]), nickel-63, carbon-14, plutonium-238, plutonium-239/240, strontium-90, technetium-99, thorium-232 (ICP-MS), barium, cadmium, chromium (III & VI), lead, mercury, nickel, selenium, silver, uranium (ICP-MS), Aroclor-1254, Aroclor-1260
Surface water	Gamma emitters (cesium-137, cobalt-60, europium-152, europium-154, europium-155, silver-108m[a]), strontium-90, thorium-232 (ICP-MS), tritium, barium, cadmium, chromium (VI), lead, mercury, nickel, selenium, silver, uranium (ICP-MS), semivolatile organic analytes (SVOAs), volatile organic analytes (VOAs)
Seep water and associated sediment	Americium-241, gamma emitters (cesium-137, cobalt-60, europium-152, europium-154, europium-155, silver-108m[a]), plutonium-238, plutonium-239/240, strontium-90, technitium-99, thorium-232 (ICP-MS), tritium, barium, cadmium, chromium (VI), lead, mercury, nickel, selenium, silver, uranium (ICP-MS), SVOAs, VOAs
Biota (tissue)	Gamma emitters (cesium-137, cobalt-60, europium-152, europium-154, europium-155, silver-108m[a]), strontium-90, technetium-99, thorium-232 (ICP-MS), tritium, barium, cadmium, chromium, lead, mercury, nickel, selenium, silver, uranium (ICP-MS), Aroclor-1254, Aroclor-1260

Table 1-1. 100-B/C Area Final COC List. (2 Pages)

Media	COCs
Groundwater[b]	Nitrate, chromium (VI), strontium-90, tritium, technetium-99

[a] 100 Area contaminant uniquely associated with the burial grounds (DOE-RL 2001).
[b] Contaminants historically detected in groundwater and either currently, or in the recent past, at levels above the drinking water standards.
ICP-MS = inductively coupled plasma-mass spectrometry

The specific COPC exclusion rationales resulting from the DQO process are summarized as follows:

- Short-lived radionuclides with half-lives less than 3 years
- Naturally occurring isotopes that were not created as a result of Hanford Site operations
- Contaminants not detected, or detected at low rates, in LFI sampling
- Contaminants that are not regulated under WAC 173-340
- Naturally occurring elements present at background concentrations
- Chemicals in the gaseous state that cannot accumulate in soil
- Chemicals that are not persistent in the soil environment due to chemical instability, volatilization, biological degradation, or other natural mitigating features.

The rationale for the assignment of COCs to specific media in the pilot study is based on numerous factors and considerations. These considerations as they apply to specific media are described for each COC and provide the framework for establishing a schedule for contingency sampling.

Gamma analysis allows for the simultaneous analysis of cobalt-60, cesium-137, europium-152, europium-154, europium-155, and silver-108m. A drawback for gamma analysis is that it generally requires large sample mass (>150 g); hence, it is unrealistic to use for some biota samples where organism size is a limiting factor. Gamma analysis is scheduled for soil; sediment; water; riparian and aquatic plants; and most upland, riparian, and aquatic biota.

Plutonium will be measured in soil and sediment using alpha energy analysis (AEA). Past Hanford Site research and surveillance efforts indicate plutonium is not very mobile in the environment and has a low potential to accumulate in both aquatic and terrestrial biota. Contingency sampling in biota will be evaluated if there is an elevated presence in soils/sediment and seep-drive point samples.

Americium-241 requires AEA, is not very mobile, and past Hanford Site research and surveillance efforts indicate a low potential to accumulate in both aquatic and terrestrial biota. Contingency sampling in biota will be evaluated if there is an elevated presence in soils/sediment and seep-drive point samples.

Nickel-63 is a soft (weak) beta emitter and is a physiologically regulated trace metal associated with soil in remediated liquid sites. Nickel-63 has a high distribution coefficient (K_d) in soil and a low propensity to accumulate in biota. Sampling will focus on the outfall structures in sediment and in seep or drive point water samples. Contingency sampling in biota will be evaluated if there is an elevated presence in soils/sediment and seep-drive point samples.

Tritium is a natural and man-made radionuclide that most commonly exists in the environment as tritiated water. Tritium is measured in water samples and a select group of riparian plants. Measurement of tritium in riparian plants may serve as an indication that the plants roots are influenced by shallow groundwater. Tritium is not sampled in other forms of biota or soil because of technical difficulties in obtaining the sample. Tritium in biota is in equilibrium with river or seep water for aquatic organisms, and drinking water and food for terrestrial and riparian animals. In soil, tritium would be present as soil moisture in equilibrium with seep or groundwater tritium. Under normal sample processing, tritium would be lost during drying of soil samples.

Carbon-14 is a natural and man-made radionuclide that exists as both inorganic and organic carbon. It is a pure beta emitter with a relatively weak emission. The abundance of carbon in the environment naturally dilutes carbon-14 to levels that greatly reduce radiological risk. Carbon-14 will be sampled in outfall soils and in seep water to determine maximum potentially available concentrations. Contingency sampling in biota will be evaluated if there is an elevated presence in soils/sediment and drive point samples at the seeps.

Strontium-90 is a strong beta emitter. It is biologically active and ecologically mobile. It is also present as a groundwater contaminant and will be sampled in all media.

Technetium-99 is present as a groundwater contaminant in the 100-B/C Area. It may behave as a phosphorus or sulfur analog and is sampled in all aquatic biota, water samples, and sediment. Technetium-99 will be sampled in riparian samples; all biota and soil; and in upland zone, mice, and invertebrates.

Uranium isotopes are not sampled as radiological constituents (i.e., using AEA), but have been included in the inductively coupled plasma-mass spectrometry (ICP-MS) suite of metals analytes. As such, uranium will be analyzed in all media. Isotopic concentrations will be derived using known isotopic ratios from CVP sampling data.

Thorium is not sampled as a radiological constituent (AEA), but has been included in the ICP-MS suite of analytes. As such, thorium will be analyzed in all media.

Chromium exists in two states, water soluble (chromium-VI) and solid phase (chromium-III). Chromium measured in water samples for all practical purposes is assumed to be chromium-VI. Chromium in soil or sediment may be a mix of both chromium-VI and chromium-III. Chromium-VI measurements will be made on selected soil and sediment samples to augment ICP-MS analyses of total chromium. All biota and water samples will be analyzed by ICP-MS for total chromium.

Ten metal COCs will be analyzed by ICP-MS for the 100-B/C Pilot Project. The key metals included mercury, chromium, lead, uranium, and thorium. By including uranium and thorium in the ICP-MS suite of metals, considerable savings are incurred over separate AEA analysis. ICP-MS metals analyses are scheduled for all media. ICP-MS provides the low detection limits that are critical for human and ecological risk assessment.

Polychlorinated biphenyls (PCBs) are persistent chlorinated organic compounds that have the potential to accumulate up the food chain. PCBs are very insoluble in water. PCBs, as Aroclor 1254 and 1260, will be measured in riparian soil; river sediment; and in selected upland, riparian, and aquatic animals because of their propensity to accumulate in lipid-rich tissue.

Organic constituents (VOAs and SVOAs) were retained as COCs in the DQO contaminant screen. Reconnaissance efforts and a review of the *300-FF-5 Operable Unit Sampling and Analysis Plan* (DOE-RL 2002a) sampling results and soil data in Table 1-8 of the DQO summary report (BHI 2003) indicated that VOAs were not detected in any of the soil screening samples. SVOAs will be sampled in sediment at the outfall structures. VOAs will be sampled in seep water or drive point samples at the outfalls. Contingency sampling in other abiotic media and biota will be evaluated if there is an elevated presence in sediment and seep-drive point samples of SVOAs and VOA.

This sampling approach provides a cost-effective screening-level approach for evaluating the exposure pathways identified in the DQO summary report (BHI 2003) and provides the basis for subsequent sampling. Details of the sampling design are discussed in the text and provided in tables in Section 3.0, "Field Sampling Plan."

1.3 DATA QUALITY OBJECTIVES

The EPA's DQO process (EPA 1994) was used to support the development of this SAP. The DQO process is a strategic planning approach that provides a systematic procedure for defining the criteria that a data collection design should satisfy. Using the DQO process ensures that the type, quantity, and quality of environmental data used in decision making will be appropriate for the intended application.

This section presents a summary of the key outputs resulting from the implementation of the seven-step DQO process. For additional details, refer to the DQO summary report (BHI 2003).

1.3.1 Statement of the Problem

This SAP process is being developed to determine if the residual radiological and chemical contamination levels in the 100-B/C Area are protective of human health in both rural-residential, avid recreationalist, and Native American land-use scenarios and protective of the upland, riparian, and near-shore river biota.

The data needed to address these items of concern are the focus of this SAP. Table 1-2 presents the principal study questions (PSQs), alternative actions (AAs), and resulting decision statements (DSs) associated with the problem statement. It also provides a qualitative assessment of the consequences of implementing an incorrect alternative action. This assessment takes into consideration human health and the environment (flora/fauna) and political, economic, and legal ramifications. The severity of the consequences is expressed as low, moderate, or severe.

Table 1-2. Summary Principal Study Questions, Alternative Actions, and Decision Statements. (3 Pages)

PSQ-AA#	Alternative Action	Description of Consequences of Implementing the Wrong Alternative Action	Severity of Consequences (Low/Moderate/ Severe)
PSQ #1 – Is the soil radiologically contaminated?			
1-1	Remove radiologically contaminated soil.	The 100-B/C Area may be inappropriately remediated, resulting in unnecessary expenditure of funds and/or destruction of habitat.	Moderate
1-2	Provide institutional controls to prevent access to contaminated soils.	Access to the 100-B/C Area would be inappropriately restricted.	Low
1-3	Initiate closeout of the 100-B/C Area without further action.	The 100-B/C Area may be inappropriately closed without remedial actions beyond those already taken. This could result in risk of potential exposure to humans and environment.	Moderate
1-4	Monitor conditions in the 100-B/C Area until land transfer.	The 100-B/C Area land ownership may be inappropriately transferred without remedial actions beyond those already taken. This could result in risk of potential exposure to humans and environment.	Moderate
DS #1 – Determine if the residual soil is radiologically contaminated and remove additional contaminated soil, provide institutional controls to prevent access to contaminated soils, perform additional investigation, or monitor conditions in the 100-B/C Area until land transfer.			

Table 1-2. Summary Principal Study Questions, Alternative Actions, and Decision Statements. (3 Pages)

PSQ-AA#	Alternative Action	Description of Consequences of Implementing the Wrong Alternative Action	Severity of Consequences (Low/Moderate/ Severe)
PSQ #2 – Is the soil chemically contaminated?			
2-1	Remove chemically contaminated soil.	The 100-B/C Area may be inappropriately remediated resulting in unnecessary expenditure of funds and/or destruction of habitat.	Moderate
2-2	Provide institutional controls to prevent access to contaminated soils.	Access to the 100-B/C Area would be inappropriately restricted.	Low
2-3	Initiate closeout of the 100-B/C Area without further action.	The 100-B/C Area may be inappropriately closed without remedial actions beyond those already taken. This could result in risk of potential exposure to humans and environment.	Moderate
2-4	Monitor conditions in the 100-B/C Area until land transfer.	The 100-B/C Area land ownership may be inappropriately transferred without remedial actions beyond those already taken. This could result in risk of potential exposure to humans and environment.	Moderate
DS #2 – Determine if the residual soil is chemically contaminated and remove additional contaminated soil, provide institutional controls to prevent access to contaminated soils, perform additional investigation, or monitor conditions in the 100-B/C Area until land transfer.			
PSQ #3 – Are biota radiologically contaminated?			
3-1	Perform additional soil remediation.	The 100-B/C Area may be inappropriately remediated resulting in unnecessary expenditure of funds and/or destruction of habitat.	Moderate
3-2	Construct bio-barriers.	Access to area could be inappropriately restricted; habitat could be degraded and unnecessary expenditure of funds.	Moderate
3-3	Initiate closeout of the 100-B/C Area without further action.	The 100-B/C Area may be inappropriately closed without remedial actions beyond those already taken. This could result in risk of potential exposure to humans and environment.	Moderate
3-4	Monitor conditions in the 100-B/C Area until land transfer.	The 100-B/C Area land ownership may be inappropriately transferred without remedial actions beyond those already taken. This could result in risk of potential exposure to humans and environment.	Moderate
DS #3 – Determine if the biota are radiologically contaminated, and perform additional soil remediation, construct bio-barriers, perform additional investigation, or monitor conditions in the 100-B/C Area until land transfer.			

Table 1-2. Summary Principal Study Questions, Alternative Actions, and Decision Statements. (3 Pages)

PSQ-AA#	Alternative Action	Description of Consequences of Implementing the Wrong Alternative Action	Severity of Consequences (Low/Moderate/ Severe)
PSQ #4 – Are biota chemically contaminated?			
4-1	Perform additional soil remediation.	The 100-B/C Area may be inappropriately remediated resulting in unnecessary expenditure of funds and/or destruction of habitat.	Moderate
4-2	Construct bio-barriers.	Access to could be inappropriately restricted; habitat could be degraded and unnecessary expenditure of funds.	Moderate
4-3	Perform additional investigation.	Remedial decisions would be made without a complete data set.	Moderate
4-4	Monitor conditions in the 100-B/C Area until land transfer.	The 100-B/C Area land ownership may be inappropriately transferred without remedial actions beyond those already taken. This could result in risk of potential exposure to humans and environment.	Moderate
DS #4 – Determine if the biota are chemically contaminated, and perform additional soil remediation, construct bio-barriers, perform additional investigation, or monitor conditions in the 100-B/C Area until land transfer.			

1.3.2 Inputs Needed to Develop Decision Rules

Decision rules (DRs) are developed for the decision statements in the form of "IF…THEN…" statements that incorporate the parameters of interest, the scale of the decision, the action levels, and the alternative actions that would result from resolving the decision statements. Table 1-3 presents the information needed to formulate the decision rules. This information includes the decision statements and alternative actions identified in DQO Step 2, the scale of the decision from DQO Step 4, the statistical parameters of interest, and the action levels for the COCs (BHI 2003).

Table 1-3. Inputs Needed to Develop 100 Area Decision Rules. (2 Pages)

DS #	COCs	Statistical Parameter of Interest	Decision Units[a]	Action Levels	Alternative Actions
1	Radiological COCs	95% UCL of the mean, average, or maximum detected value, as appropriate	***Upland abiotic*** – No decision units	***Human health*** – Direct radiological exposure dose rate limit of 15 mrem/yr above background. Groundwater[b] radiological exposure dose rate limit of 4 mrem/yr above background, based on site contaminant distribution model and RESRAD modeling, or leach rate testing. ***Ecological protection*** – BCG values from Table A-1 of Appendix A.	Remove radiologically contaminated soil, provide institutional controls to prevent access, perform additional investigation, or monitor conditions in the 100-B/C Area until land transfer.
			Riparian abiotic		
			Areas outside waste sites		
			Discharge pipelines and outfall spillways		
			Frequent river inundation zone		
			Persistent riparian community zone		
			Near-shore river abiotic		
			Riverbed		
			• Substrate #1		
			Seep groundwater		
			Rivershore		
2	Chemical COCs	95% UCL of the mean[c], maximum detected values, or detected value, as appropriate	***Riparian abiotic***	***Human health*** – Human health values from Table A-2 of Appendix A; or the site contaminant distribution model and RESRAD modeling, or leach rate testing relative to drinking water or surface water criteria; and cumulative risk not to exceed 10^{-5}. ***Ecological protection*** –Ecological screening values from Table A-2 of Appendix A.	Remove chemically contaminated soil, provide institutional controls to prevent access to contaminated soils, perform additional investigation, or monitor conditions in the 100-B/C Area until land transfer.
			Areas outside waste sites		
			Discharge pipelines and outfall spillways		
			Frequent river inundation zone		
			Persistent riparian community zone		
			Near-shore river abiotic		
			Riverbed		
			• Substrate #1		
			Seep groundwater		
			Rivershore		

Table 1-3. Inputs Needed to Develop 100 Area Decision Rules. (2 Pages)

DS #	COCs	Statistical Parameter of Interest	Decision Units[a]	Action Levels	Alternative Actions
3	Radiological COCs	95% UCL of the mean, average, or maximum detected value, as appropriate	***Upland biota***	Contaminants in the 100-B/C Area biota tissue samples exceed tissue concentrations from the noncontaminated reference areas, and unfavorable evaluation results from the weight of evidence determination.	Perform additional soil remediation, construct bio-barriers, perform additional investigation, or monitor conditions in the 100-B/C Area until land transfer.
			Vertebrates in buffer zone		
			Invertebrates in buffer zone		
			Plants in buffer zone		
			Riparian biota		
			Vertebrates		
			Invertebrates		
			Plants		
			Near-shore river biota		
			Vertebrates		
			Invertebrates		
			Plants		
4	Chemical COCs	95% UCL of the mean, average, or maximum detected value, as appropriate	***Upland biota***	Contaminants in the 100-B/C Area biota tissue samples exceed tissue concentrations from the noncontaminated reference areas, and unfavorable evaluation results from the weight of evidence determination.	Perform additional soil remediation, construct bio-barriers, perform additional investigation, or monitor conditions in the 100-B/C Area until land transfer.
			Vertebrates in buffer zone		
			Invertebrates in buffer zone		
			Plants in buffer zone		
			Riparian biota		
			Vertebrates		
			Invertebrates		
			Plants		
			Near-shore river biota		
			Vertebrates		
			Invertebrates		
			Plants		

[a] Reference areas are not included in this table because they are not decision units. Decision units are the geographic locations in which the decisions apply. Data obtained from reference areas will be used to support decision making in the decision units, not the reference areas.

[b] The groundwater portion of the radiological criteria uniquely applies to the rural-residential exposure scenario.

[c] Satisfaction of WAC 173-340 criteria requires a three-part test. However, the Washington State Department of Ecology considers the 95% UCL as the statistical parameter of interest. The maximum and detected values support hot spot evaluations, which are a necessary aspect of site closeout under WAC 173-340.

BCG = Biota Concentration Guide (DOE-ORNL 2002)
RESRAD = RESidual RADioactivity (dose model) (ANL 2002)
UCL = upper confidence limit

1.3.3 Decision Rules

The output of DQO Step 5 and the previous DQO steps are combined into "IF...THEN" decision rules that incorporate the parameter of interest, the scale of decision making, the action level, and the actions that would result from resolution of the decision (BHI 2003). The decision rules are listed in Table 1-4.

Table 1-4. Decision Rules. (2 Pages)

DR #		Decision Rule
1	a	If the mean activity (as estimated by the 95% UCL on sample mean, average, or maximum detected value, as appropriate) of radionuclides within the soil samples in each of the applicable strata[a] results in a direct human health radiological exposure dose greater than or equal to 15 mrem/yr above background, or a groundwater[b] radiological dose greater than or equal to 4 mrem/yr above background (based on the site contaminant distribution model and RESRAD modeling, or leach rate testing), then remove radiologically contaminated soil, provide institutional controls to prevent access to contaminated soils, or perform additional investigation. Otherwise, monitor conditions in the 100-B/C Area until land transfer.
	b	If the mean activity (as estimated by the 95% UCL on sample mean, average, or maximum detected value, as appropriate) of radionuclides within the soil samples in each of the applicable strata[a] results in a direct radiological exposure greater than or equal to that represented by the ecological BCG values in Table A-1 of Appendix A, then remove radiologically contaminated soil, provide institutional controls to prevent access to contaminated soils, or perform additional investigation. Otherwise, monitor conditions in the 100-B/C Area until land transfer.
2	a	If the mean concentrations (as estimated by the 95% UCL on sample mean, average, or maximum detected value, as appropriate) of chemical constituents within the soil samples in each of the applicable strata[a] is greater than or equal to the human health values in Table A-2 of Appendix A, or values determined from the site contaminant distribution model and RESRAD modeling, or leach rate testing exceed drinking water or surface water criteria, or if the cumulative risk value for all detected constituents exceeds cumulative risk criteria (10^{-5}), then remove chemically contaminated soil, provide institutional controls to prevent access to contaminated soils, or perform additional investigation. Otherwise, monitor conditions in the 100-B/C Area until land transfer.
	b	If the mean concentrations (as estimated by the 95% UCL on sample mean, average, or maximum detected value, as appropriate) of chemical constituents within the soil samples in each of the applicable strata[a] is greater than or equal to the limiting of the ecological screening values in Table A-2 of Appendix A, then remove chemically contaminated soil, provide institutional controls to prevent access to contaminated soils, or perform additional investigation. Otherwise, monitor conditions in the 100-B/C Area until land transfer.
3		If the mean activity (as estimated by the 95% UCL on sample mean, average, or maximum detected value, as appropriate) of radionuclides within the tissue samples from each of the applicable biota[c] exceed the respective biota tissue samples from noncontaminated reference areas and unfavorable evaluation results from the weight of evidence determination, then perform additional soil remediation, construct bio-barriers, or perform additional investigation. Otherwise, monitor conditions in the 100-B/C Area until land transfer.

Table 1-4. Decision Rules. (2 Pages)

DR #	Decision Rule
4	If the mean concentrations (as estimated by the 95% UCL on sample mean, average, or maximum detected value, as appropriate) of chemical constituents within the tissue samples from each of the applicable biota[c] exceed the respective biota tissue samples from noncontaminated reference areas and unfavorable evaluation results from the of weight of evidence determination, then perform additional soil remediation, construct bio-barriers, or perform additional investigation. Otherwise, monitor conditions in the 100-B/C Area until land transfer.

[a] The applicable strata are the decision units identified in Table 5-2 of the DQO summary report (BHI 2003).
[b] The groundwater portion of the radiological criteria uniquely applies to the rural-residential exposure scenario.
[c] Specific biota selected for sampling are identified in DQO Step 7 and Section 3.0, the Field Sampling Plan.

1.3.4 Error Tolerance and Decision Consequences

Error tolerance and decision consequences are specified for statistical sampling designs in Step 6 of the DQO process. Based on information developed in the DQO process, a judgmental (nonstatistical) sampling design was specified for environmental characterization. Consequently, error tolerances and decision consequences are not defined for environmental characterization purposes. Table 1-5 provides a summary of the information used to support the selection between a statistical versus a nonstatistical sampling design for each DS. The factors that were taken into consideration to make this selection included the qualitative consequences of an inadequate sampling design, and the accessibility of the site if resampling is required.

Table 1-5 indicates that nonstatistical, judgmental sampling designs are proposed because of the low and moderate consequences of inadequate sampling designs. In addition, ecological sampling activities have inherent sampling limitations, such as abundance and availability of biota that generally do not support the use of statistical sampling designs. This assessment is based on an application of the DQO process with consideration of the status of the 100-B/C Area waste sites, which have been remediated by removal of contaminated soils and engineered structures. The majority of the contaminated material in the 100-B/C Area has been removed from the waste sites and disposed in the Environmental Restoration Disposal Facility. Therefore, the potential risks associated with erroneous actions at these remediated waste sites are considered to be low to moderate. Through the CVP process, the residual contamination status of these sites has been well documented, meeting the site closeout criteria for radiological and chemical contamination.

Table 1-5. Justification for Sampling Design.

DS #	PSQ Summary	Alternative Action Summary		Consequence Severity	Resampling Access After Remediation	Preliminary Step 6 Sample Design Basis
1	Is the soil radiologically contaminated?	1	Remove radiologically contaminated soil.	Low	Accessible	Judgmental sampling
		2	Provide institutional controls to prevent access to contaminated soils.	Low	Accessible	
		3	Perform additional investigation	Moderate	Accessible	
		4	Monitor conditions in the 100-B/C Area until land transfer.	Moderate	Accessible	
2	Is the soil chemically contaminated?	1	Remove chemically contaminated soil.	Low	Accessible	Judgmental sampling
		2	Provide institutional controls to prevent access to contaminated soils.	Low	Accessible	
2	Is the soil chemically contaminated?	3	Perform additional investigation.	Moderate	Accessible	Judgmental sampling
		4	Monitor conditions in the 100-B/C Area until land transfer.	Moderate	Accessible	
3	Are biota in the 100-B/C Area radiologically contaminated?	1	Perform additional soil remediation.	Low	Accessible	Judgmental sampling
		2	Implement bio-barriers.	Moderate	Accessible	
		3	Perform additional investigation.	Moderate	Accessible	
		4	Monitor conditions in the 100-B/C Area until land transfer.	Moderate	Accessible	
4	Are biota in the 100-B/C Area chemically contaminated?	1	Perform additional soil remediation.	Low	Accessible	Judgmental sampling
		2	Implement bio-barriers.	Moderate	Accessible	
		3	Perform additional investigation.	Moderate	Accessible	
		4	Monitor conditions in the 100-B/C Area until land transfer.	Moderate	Accessible	

1.3.5 Sample Design Summary

Three zones have been identified for sampling within the 100-B/C Area. These zones include the upland, riparian, and near-shore river zones. Reconnaissance surveys, including radionuclide surveys in all zones, and conductivity surveys within the near-shore river, will be performed prior to any sampling. Samples will consist of abiotic and biotic media. Abiotic media will include soil sample collection in all zones, and river water within the near-shore river zone. Biotic media collection will include the sampling of appropriate resident species (i.e., plants and animals) within each zone.

A variety of sampling methods are required to ensure that the proper characterization data are collected from abiotic and biotic media within the 100-B/C Area. The sampling methods considered for the 100-B/C Pilot Project are described in detail in the Field Sampling Plan (FSP) (Section 3.0). The sample design objectives, methods, features, and bases are presented in Table 1-6.

Table 1-6. Sampling Design Methodology, Objectives, Features, and Basis. (10 Pages)

Sample Collection Methodology	Sampling Objectives	Population	Key Features of Design	Basis for Sampling Design
Upland, Riparian, Near-Shore River Areas				
Reconnaissance surveys	Determine locations, abundance and availability of sampling populations.	Abiotic and biotic sampling populations	Review existing information and maps. Site visits for visual observations and mapping reconnaissance.	Initial activity for refinement of the sampling design.
Upland Abiotic				
Radiological surveys	Area-wide surveys for site closeout.	Excavated waste sites	N/A – Rely on existing data.	Scope of the pilot study in the upland area is limited to the waste sites being remediated. Therefore, radiological surveys and soil sampling are not necessary because they were performed during waste site verification process. Clean backfill material in remediated waste sites was chosen in accordance with the 100 Area Remedial Design Report/Remdial Action Work Plan (DOE-RL 2002b) and does not need characterization. CVP soil sampling is complete for all but WAC 173-340-900, Table 749-3-unique COCs, which may be analyzed in 100-B/C Area pipeline CVPs.
Soil sampling	Cleanup verification sampling for site closeout.	Excavated waste sites	N/A – Rely on existing data.	
	Coincident soil sampling to root zone.	Excavated waste site buffer zone	See upland biota sampling.	

Table 1-6. Sampling Design Methodology, Objectives, Features, and Basis. (10 Pages)

Sample Collection Methodology	Sampling Objectives	Population	Key Features of Design	Basis for Sampling Design
Upland Biota (Buffer Zone Sampling)				
Biota sampling	Determine radioactive and chemical exposure to species, provide screening-level assessment of biota health.	Deer mouse/house mouse (vertebrate)	Stratified sampling for resident species in the upland buffer zone. Number of samples to meet analytical mass requirements and/or statistical data needs. Sampling based on availability of biota. Captures biological health metrics based on screening-level assessments.	Deer/house mouse represents closest fit to mammalian predator guild, satisfies sentinel organism criteria. Collect vertebrates influenced by waste site. Samples will be analyzed for Table 1-1 contaminants and as appropriate, biological health metrics in accordance with Table 3-2 of the DQO summary report (BHI 2003).
		Darkling beetles, harvester ants, spiders (invertebrates)		Ground-dwelling invertebrate/soil biota guild satisfies sentinel organism criteria. Samples will be analyzed for Table 1-1 contaminants and as appropriate, biological health metrics in accordance with Table 3-2 of the DQO summary report (BHI 2003).
		Russian thistle, cheatgrass, shrubs, forbs (shallow and deep-rooted plants) and coincident soil sampling	Opportunistic biota sampling in buffer zone based on abundance and availability of plant populations. Collect soil samples at locations coincident with biota samples from ground surface to rooting depth (maximum of 2 m [6 ft]). Soil samples will be archived for possible later use. Sample in spring/early summer for plant maturity.	Plant guild, deep-rooted vegetation, satisfies sentinel organism criteria. Samples will be analyzed for Table 1-1 contaminants and as appropriate, biological health metrics in accordance with Table 3-2 of the DQO summary report (BHI 2003). Roots and vegetation (deep and shallow rooted) will be analyzed for specific exposure scenarios (ecological and human risk). Soil samples may be used to determine contaminant distribution.

Table 1-6. Sampling Design Methodology, Objectives, Features, and Basis. (10 Pages)

Sample Collection Methodology	Sampling Objectives	Population	Key Features of Design	Basis for Sampling Design
Upland Reference Area Biota				
Biota sampling	Duplicate upland biota sampling in reference area (to be identified) for comparison with the 100-B/C Area.	Same as upland biota	Same as upland biota (includes coincident soil samples).	Same as upland biota.
Riparian Abiotic				
Radiological surveys	Area-wide surveys.	Riparian surface soils to a depth of 45.7 cm (18 in.)	Reconnaissance of existing radiological surveys and thermoluminescent dosimetry measurements.	Provides minimum of 20% areal coverage for gamma emitting radionuclides to 15 mrem/yr above background (input to human health exposure scenarios from shoreline uses).
	Potentially contaminated areas.	Discharge pipeline and outfall spillways soils, cobbles, concrete surfaces	Systematic grid radiological surveys along transect lines.	Establish transect lines over these potentially contaminated features and survey transect lines.

Table 1-6. Sampling Design Methodology, Objectives, Features, and Basis. (10 Pages)

Sample Collection Methodology	Sampling Objectives	Population	Key Features of Design	Basis for Sampling Design
Soil sampling	Characterization sampling	Riparian soils coincident with plant receptors, from surface to rooting depth (maximum of 2 m [6 ft])	Sampling coincident with riparian biota samples. Soil sample depths based on professional judgment.	Determine COC concentrations in areas not contaminated and not remediated. Desired rooting depth based on river stage at low flow "green line." Analyze samples for Table 1-1 contaminants. Soil samples determine contaminant distribution.
	Potentially contaminated areas.	Discharge pipeline and outfall spillways soils, riprap, concrete surfaces	Stratified sampling along transects. Collect four samples of soils (where available) along transects at each pipeline/spillway site. Collect samples from sediments and soils between rocks in riprap zones. Collect surface samples from concrete spillways.	Sample media may be difficult to locate in these areas because of the presence of interfering materials. If sampling conditions are poor, best available samples will be collected. Sampling may be directed by indications of radiological hot spots during radiological surveys. Concrete samples collected by drilling "*n*" number of co-located holes to a depth of 0.6 cm (0.25 in.) to meet sampling mass requirements. Samples will be analyzed for Table 1-1 contaminants.

Table 1-6. Sampling Design Methodology, Objectives, Features, and Basis. (10 Pages)

Sample Collection Methodology	Sampling Objectives	Population	Key Features of Design	Basis for Sampling Design
Riparian Biota				
Biota sampling	Determine radioactive and chemical exposure to species; provide screening-level assessment of biota health.	Deer mouse/house mouse (vertebrates)	Stratified sampling for resident species in the riparian zone. Systematic grid to determine sampling locations. Default to opportunistic sampling based on availability and abundance of biota using professional judgment. Number of samples to meet analytical mass requirements and/or statistical data needs. Captures biological health metrics based on screening-level assessments. Sampling timeframes based on availability.	Deer/house mouse represents closest fit to mammalian predator guild, satisfies sentinel organism criteria, reference material available. Samples will be analyzed for Table 1-1 contaminants and as appropriate, biological health metrics in accordance with Table 3-2 of the DQO summary report (BHI 2003).
		Darkling beetle, harvester ants, spiders (invertebrates)		Ground-dwelling invertebrate/soil biota guild. Satisfies sentinel organism criteria. Samples will be analyzed for Table 1-1 contaminants and as appropriate, biological health metrics in accordance with Table 3-2 of the DQO summary report (BHI 2003).
		Mulberry, willow trees (plants) Wormwood, sweetclover shrubs (plants) Reed canary grass, cheatgrass (plants)	Stratified sampling for resident species in the riparian zone. Systematic grid to determine sampling locations. Default to opportunistic sampling based on availability and abundance of biota using professional judgment. Number of samples to meet analytical mass requirements and/or statistical data needs. Captures biological health metrics based on screening-level assessments. Sample from spring through fall to allow a full growing season (COC accumulation).	Plant guild, deep/shallow rooted exposure pathway; satisfies sentinel organism criteria, primary producer plant pathways. Samples will be analyzed for Table 1-1 contaminants and as appropriate, biological health metrics in accordance with Table 3-2 of the DQO summary report (BHI 2003). Roots and vegetation (deep and shallow rooted) will be analyzed for specific exposure scenarios (ecological and human risk).

Table 1-6. Sampling Design Methodology, Objectives, Features, and Basis. (10 Pages)

Sample Collection Methodology	Sampling Objectives	Population	Key Features of Design	Basis for Sampling Design
Riparian Reference Area Biota				
Biota sampling	Duplicate riparian biota sampling in reference area (to be identified) for comparison with 100-B/C study area.	Same as riparian biota	Same as riparian biota (includes coincident soil sampling).	Same as riparian biota.
Near-Shore River Abiotic				
River water conductivity survey	Determine where groundwater is upwelling to identify primary and secondary seep transect locations as a means of directing abiotic and biotic sampling activities.	River water at sediment/water interface	Step 1 – Reconnaissance (review) of existing seeps, groundwater plume maps, aquifer tube locations, and outfall/pipe discharge information, as well as upstream and downstream reference locations.	Primary transects aligned with existing riverbank seeps, outfall structures (riprap-covered overflow structures and buried pipelines), and point conductivity measurements to sample groundwater where it emerges into the river. Reference locations selected to match general substrate or habitat types.
			Step 2 – Mapping of potential upwelling by field measurements of conductivity at sediment/water interface. Mapping includes systematic grid sampling using GPS positioning.	Systematic grids along the shoreline, and along and adjacent to seep transect lines into the river. This provides the basis for tracking emergence of seeps into the river. GPS provides accurate position indication.

Table 1-6. Sampling Design Methodology, Objectives, Features, and Basis. (10 Pages)

Sample Collection Methodology	Sampling Objectives	Population	Key Features of Design	Basis for Sampling Design
River water conductivity survey (Step 2 continued)	Determine where the groundwater is upwelling to identify primary and secondary seep transect locations as a means of directing abiotic and biotic sampling activities.	River water at sediment/water interface	Collect river water conductivity measurements along transects from the shoreline, to a depth of 2 m (6.6 ft). Potential locations include upstream reference transect (TBD), as many as six primary transects in the study area, and a downstream transect (TBD). Up to six sampling points will be identified for each primary transect (starting at the "green line") and extending towards the main channel, e.g., sample points may be located at depths of 0.00 (green line), and at 0.25, 0.5, 1.0, 1.5 and 2.0 m depths using the green line elevation as reference point. Conductivity sampling performed in the fall to coincide with low river stage (refer to Figure 4-3 in BHI 2003).	Suggested primary and secondary locations based on reconnaissance, conductivity measurements, and professional judgment. Water samples collected at the sediment/water interface along the study area shoreline and, where practical, into deeper water along the shoreline. Fall sampling assures that biota are collected below the "green line" and have not been influenced by river-level fluctuation.
Drive point water sampling or multilevel sampling (MLS)	Determine interstitial mixing of groundwater and river water.	Seep groundwater below sediment/water interface	Stratified sampling along transects. Specific sampling locations based upon information and decisions made during reconnaissance and conductivity surveys. Collect up to five samples (to a depth of at least 0.3 m) along primary transects (or 10-cm increments to 1.0-m depth for MLS). Consider sampling along intermittent seep transects based on river water conductivity surveys.	Sampling along primary and intermittent seep transects captures hyporheic flow of mixed groundwater and river water. Sampling at intermittent seep transects and MLS based on professional judgment. Spatial relationship to former outfall structures. Samples will be analyzed for groundwater contaminants listed in Table 1-1.

Table 1-6. Sampling Design Methodology, Objectives, Features, and Basis. (10 Pages)

Sample Collection Methodology	Sampling Objectives	Population	Key Features of Design	Basis for Sampling Design
Sediment sampling in or adjacent to seeps	Determine contaminant concentrations in sediments adjacent to seeps.	Riverbed sediments adjacent to seeps; clays to coarse sands (Substrate #1)	Stratified sampling. Specific locations based on information and decisions made during reconnaissance and conductivity surveys. Based on availability of sediment.	Sampling along primary and intermittent seep transects for sediments near groundwater emergence into the river. Sampling at intermittent seep transects based on best professional judgment. Substrate type will determine the dominant type of biota in a certain location and help define key characteristics of reference locations. Samples will be analyzed for groundwater contaminants listed in Table 1-1.
River water sampling	Determine contaminant concentrations in river water.	River water column grab sample	Stratified sampling with transects. Specific locations based on information and decisions made during reconnaissance and conductivity surveys. Collect grab samples along transect lines within the water column immediately above the river bottom.	Sampling along primary and secondary transects for river water near groundwater emergence into the river. Sampling at secondary transects based on best professional judgment. Conservative measure of water quality in the river bottom-mixing zone created by groundwater upwelling. Samples will be analyzed for groundwater contaminants (Table 1-1), pH, conductivity, and dissolved oxygen.
Rivershore radiological surveys	Determine radiological exposure along river shoreline.	Riverbed shoreline	Whole-body radiological surveys performed from a boat along shoreline. Reconnaissance of existing surveys and thermoluminescent dosimetry installations.	Provides dose rate measurements in μR/hr (input to human health exposure scenarios for recreational boater).

Table 1-6. Sampling Design Methodology, Objectives, Features, and Basis. (10 Pages)

Sample Collection Methodology	Sampling Objectives	Population	Key Features of Design	Basis for Sampling Design
Near-Shore River Biota				
Biota sampling	Determine radioactive and chemical exposure to species, provide screening-level assessment of biota health. Determine spatial extent of near-shore areas with "elevated exposure" scenarios.	Sculpin (vertebrates)	Specific locations along transects (linked to reconnaissance and conductivity surveys). Stratified sampling for resident species in the near-shore river environment. Number of samples to meet analytical mass requirements and/or statistical data needs. Captures biological health metrics based on screening-level assessments.	Sculpin represents closest fit to aquatic vertebrate predator guild. Satisfies sentinel organism criteria. Samples will be analyzed for groundwater contaminants (Table 1-1) and, as appropriate, biological health metrics in accordance with Table 3-2 of the DQO summary report (BHI 2003).
		Crayfish, clams, mayfly, caddisfly (invertebrates)	Specific locations based on information and decisions made during reconnaissance and conductivity surveys. Default to opportunistic sampling based on professional judgment and availability of biota (coincident sediment samples will also be taken based on availability at default biota sampling locations). Stratified sampling for resident species in the 100-B/C Area. Number of samples to meet analytical mass requirements and/or statistical data needs. Captures biological health metrics based on screening-level assessments.	Aquatic invertebrate represents benthic (corresponds to "soil biota") guild. Satisfies sentinel organism criteria. Samples will be analyzed for groundwater contaminants (Table 1-1) and, as appropriate, biological health metrics in accordance with Table 3-2 of the DQO summary report (BHI 2003). Adult mayfly and caddisfly – contaminant concentrations are indicative of aquatic contaminant exposure.

Table 1-6. Sampling Design Methodology, Objectives, Features, and Basis. (10 Pages)

Sample Collection Methodology	Sampling Objectives	Population	Key Features of Design	Basis for Sampling Design
Biota sampling (Continued)	Determine radioactive and chemical exposure to species, provide screening-level assessment of biota health. Determine spatial extent of near-shore areas with "elevated exposure" scenarios.	Milfoil (macrophytes) Potentially sample periphyton/algae		Aquatic plant guild. Satisfies sentinel organism criteria. Samples will be analyzed for groundwater contaminants (Table 1-1) and as appropriate, biological health metrics in accordance with Table 3-2 of the DQO summary report (BHI 2003).
Near-Shore River Reference Area Biota				
Biota sampling	Duplicate near-shore riverine biota sampling in reference area (to be identified) for comparison with the 100-B/C study area.	Same as near-shore riverine biota	Same as near-shore riverine biota (includes sediment sampling).	Same as near-shore riverine biota.
Upland, Riparian, Near-Shore River Areas				
Long-term monitoring	Verify long-term human health and ecological protectiveness.	Abiotic and biotic sampling populations	Visual observations and specific sampling and analyses (TBD).	A multi-year sampling approach assures collection of data to identify adverse impacts to human and ecological receptors.

GPS = global positioning system
N/A = not applicable
TBD = to be determined

2.0 QUALITY ASSURANCE PROJECT PLAN

This section identifies the organizations participating in the implementation of this SAP and discusses specific roles and responsibilities of the staff performing the work.

2.1 PROJECT MANAGEMENT

This section addresses the basic areas 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.

2.1.1 Project/Task Organization

The project will be managed by Bechtel Hanford, Inc. through the Natural Resources and Environmental Site Closure group, which has an assigned project manager and task leads. Bechtel Hanford, Inc. may subcontract this work to qualified subcontractors in accordance with the requirements of this SAP. Pacific Northwest National Laboratory (PNNL) will be responsible for collection, packaging, and shipment of soil and biota samples to the laboratory. The sampling task lead will provide oversight for all sampling and field analytical measurements. Radiological control, health and safety, and waste support will be obtained from the Hanford Site contractor responsible for all field activities. Quality assurance (QA) assessments will be performed on sample collection and analysis activities.

2.1.2 Project Schedule

A *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) commitment (Ecology et al. 2002) was established for the completion of the 100-B/C Pilot Project by July 29, 2005. The information from the DQO summary report (BHI 2003) and any subsequent sampling data will be used to support the Tri-Party Agreement milestone. Table 2-1 presents the tentative schedule for the completion of the task activities associated with developing and implementing the pilot study, associated sampling program, performance of laboratory analyses, performance of a data quality assessment, and evaluation and reporting of investigation results.

2.1.3 Quality Objectives and Criteria for Measurement Data

The detection limits and precision and accuracy requirements for each of the analyses to be performed are summarized in Table 2-2. These requirements were derived as part of Step 6 in the DQO process (BHI 2003).

Table 2-1. Milestone Dates.

Task Activities	Milestone Date
DQO workbook development	08/01/02 to 02/11/03
SAP development	11/08/02 to 03/19/03
Sampling (Round 1)	03/21/03 to 12/15/03
Analyze and review sampling data	04/18/03 to 12/31/03
Develop Native American scenarios	11/15/02 to 09/30/03
Sampling (Round 2)	03/22/04 to 11/15/04
Analyze and review sampling data	04/19/04 to 11/15/04
Data quality assessment	03/21/03 to 11/15/04
Prepare risk assessment report	01/03/05 to 07/25/05
Issue final risk assessment report to DOE	07/26/05

2.1.4 Special Training Requirements/Certification

Training or certification requirements needed by sampling personnel shall be in accordance with the requirements of the *Hanford Analytical Services Quality Assurance Requirements Documents*, Vol. 1, "Administrative Requirements" (DOE-RL 1998). Field personnel will typically have completed the following training before starting work:

- Occupational Safety and Health Administration 40-hour hazardous waste worker training and supervised 24-hour hazardous waste site experience
- 8-hour hazardous waste worker refresher training (as required)
- Hanford general employee radiation training
- Radiological worker training.

2.1.5 Documentation and Records

At the direction of the project 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., Hanford Environmental Information System [HEIS]). 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. 2002).

Table 2-2. Analytical Performance Requirements. (5 Pages)

COCs	CAS #	Preliminary Action Level[a]	Name/Analytical Technology	Target Required Quantitation Limits			Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
		Rural-Residential 15 mrem/yr[b] (pCi/g)		Biota (pCi/g)	Soil (pCi/g)	Water (pCi/L)				
Americium-241	14596-10-2	31.1	Americium isotopic – AEA	--	1	1	±30%	70-130[c]	±30%	70-130[c]
Carbon-14	14762-75-5	2.0	Chemical separation – liquid scintillation	--	1	--	±30%	70-130[c]	±30%	70-130[c]
Cesium-137	10045-97-3	6.2	GEA	--	0.1	15	±30%	70-130[c]	±30%	70-130[c]
Cobalt-60	10198-40-0	1.4	GEA	--	0.05	25	±30%	70-130[c]	±30%	70-130[c]
Europium-152	14683-23-9	3.3	GEA	--	0.1	--	±30%	70-130[c]	±30%	70-130[c]
Europium-154	15585-10-1	3.0	GEA	--	0.1	--	±30%	70-130[c]	±30%	70-130[c]
Europium-155	14391-16-3	125	GEA	--	0.1	--	±30%	70-130[c]	±30%	70-130[c]
Nickel-63	13981-37-8	4,026	Chemical separation – liquid scintillation	--	30	--	±30%	70-130[c]	±30%	70-130[c]
Plutonium-238	13981-16-3	37.4	Plutonium isotopic – AEA	--	1	1	±30%	70-130[c]	±30%	70-130[c]
Plutonium-239/240	Pu-239/240	33.9	Plutonium isotopic – AEA	--	1	1	±30%	70-130[c]	±30%	70-130[c]
Silver-108m		2.38	GEA	--	0.5	--	±30%	70-130[c]	±30%	70-130[c]
Strontium-90	Rad-Sr	4.5	Total radioactive strontium – GPC	--	1	2	±30%	70-130[c]	±30%	70-130[c]

Table 2-2. Analytical Performance Requirements. (5 Pages)

COCs	CAS #	Preliminary Action Level[a]	Name/Analytical Technology	Target Required Quantitation Limits			Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
		Rural-Residential 15 mrem/yr[b] (pCi/g)		Biota (pCi/g)	Soil (pCi/g)	Water (pCi/L)				
Technetium-99	14133-76-7	15[d]	Technetium-99 – liquid scintillation	--	15	15	±30%	70-130[c]	±30%	70-130[c]
Thorium-232	Th-232	1.3	Thorium isotopic – AEA (pCi) ICPMS (μg)	--	1	1	±30%	70-130[c]	±30%	70-130[c]
Tritium (H-3)	10028-17-8	35.5	Tritium – liquid scintillation	--	10	400	±30%	70-130[c]	±30%	70-130[c]
Uranium-233/234	13966-29-5	1.1[e]	Uranium isotopic – AEA (pCi)	--	1	1	±30%	70-130[c]	±30%	70-130[c]
Uranium-235	15117-96-1	1.0[d]	Uranium isotopic – AEA (pCi)	--	1	1	±30%	70-130[c]	±30%	70-130[c]
Uranium-238	U-238	1.1[e]	Uranium isotopic – AEA (pCi)	--	1	1	±30%	70-130[c]	±30%	70-130[c]

Table 2-2. Analytical Performance Requirements. (5 Pages)

COCs	CAS #	Preliminary Action Level[a] Method B[f] and Eco Screening Values (mg/kg)	Name/Analytical Technology	Target Required Quantitation Limits: Biota (mg/kg)	Target Required Quantitation Limits: Soil Low Conc. (mg/kg)	Target Required Quantitation Limits: Water[d] Low Conc. (mg/L)	Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
Metals										
Barium	7440-39-3	132	Metals – 6010 – ICP	--	0.5	--	g	g	g	g
		132	EPA 200.8 – ICPMS	0.1	--	--				
Cadmium	7440-43-9	0.81	Metals – 6010 – ICP	--	0.5	0.005	g	g	g	g
			Metals – 6010 – ICP (trace)	--	0.2	0.002				
		4	EPA 200.8 – ICP	0.01	--	--				
Chromium (total)	7440-47-3	18.5[e]	Metals – 6010 – ICP	--	1	0.01	g	g	g	g
			Metals – 6010 – ICP (trace)	--	1	0.01				
		42	EPA 200.8 – ICP	0.1	--	--				
Chromium VI	18540-29-9	2.2[h]	Chromium (hexavalent) – 7196 – colorimetric	--	0.5	0.01	g	g	g	g
		N/A	--	N/A	--	--				
Lead	7439-92-1	10.2	Metals – 6010 – ICP	--	5	0.05	g	g	g	g
			Metals – 6010 – ICP (trace)	--	0.5	0.005				
		N/A	EPA 200.8 – ICP	0.03	--	--				
Manganese	7439-96-5	512	Metals – 6010 – ICP	--	5	--	g	g	g	g
		1,100	EPA 200.8 – ICP	0.05	--	--				
Mercury	7439-97-6	0.33	Mercury – 7470 – CVAA	--	N/A	0.0005	g	g	g	g
			Mercury – 7471 – CVAA	--	0.2	N/A				
		0.33	EPA 245.6 – CVAA	0.05	--	--				

Table 2-2. Analytical Performance Requirements. (5 Pages)

COCs	CAS #	Preliminary Action Level[a] Method B[f] and Eco Screening Values (mg/kg)	Name/Analytical Technology	Target Required Quantitation Limits: Biota (mg/kg)	Target Required Quantitation Limits: Soil Low Conc. (mg/kg)	Target Required Quantitation Limits: Water[d] Low Conc. (mg/L)	Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
Nickel	--	130	Metals – 6010 – ICP	--	4	--	g	g	g	g
		30	EPA 200.8 – ICP	0.05	--	--				
Selenium	7782-49-2	400	Metals – 6010 – ICP	--	10	0.1	g	g	g	g
			Metals – 1610 – ICP (trace)	--	1	0.1				
		0.78	EPA 200.8 – ICP	0.2	--	--				
Silver	7440-22-4	400	Metals – 6010 – ICP	--	1	0.01	g	g	g	g
			Metals – 6010 – ICP (trace)	--	0.2	0.002				
		2	EPA 200.8 – ICP	0.01	--	--				
Uranium	--	3	Uranium total – kinetic phosphorescence analysis	--	1	--	g	g	g	g
		5	EPA 200.8 – ICP	0.01	--	--				
Organics										
Aroclor-1254	--	0.5[i]	PCBs-8082-GC	--	0.0165	--	g	g	g	g
		0.65	EPA – 645 – GC	0.001	--	--				
Aroclor-1260	--	0.5[i]	PCBs-8082-GC	--	0.0165	--	g	g	g	g
		0.65	EPA – 645 – GC	0.001	--	--				

Table 2-2. Analytical Performance Requirements. (5 Pages)

COCs	CAS #	Preliminary Action Level[a]	Name/Analytical Technology	Target Required Quantitation Limits			Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
		Method B[f] and Eco Screening Values (mg/kg)		Biota (mg/kg)	Soil Low Conc. (mg/kg)	Water[d] Low Conc. (mg/L)				
Phthalates	--	Compound-specific	Semi-Volatile organics – 8270 – GCMS	--	0.66[j]	--	g	g	g	g
		N/A	--	0.010	--	--				
SVOAs	--	Compound-specific	Semi-Volatile organics – 8270 – GCMS	--	0.005[j]	0.005[j]	g	g	g	g
VOAs	--	Compound-specific	Volatile organics – 8260 – GCMS	--	0.005[j]	0.005[j]	g	g	g	g

[a] The preliminary action level is the regulatory or risk-based value used to determine appropriate analytical requirements (e.g., detection limits).
[b] The radiological cleanup criteria for the rural-residential exposure scenario is 15 mrem/yr above background. These numerical values are limiting for both human health and ecological receptors. Therefore, the ecological values are not listed in this table.
[c] Accuracy criteria for associated batch laboratory control sample percent recoveries. Except for GEA, additional analysis-specific evaluations also performed for matrix spikes, tracers, and carriers as appropriate to the method. Precision criteria for batch laboratory replicate sample analyses.
[d] The remedial action goal is below the target required quantitation limit. The value presented is the target required quantitation limit.
[e] The remedial action goal is below background. The value presented is background.
[f] WAC 173-340 Method B soil values for direct exposure.
[g] Accuracy criteria for associated batch matrix spike percent recoveries. Evaluation based on statistical control of laboratory control samples also performed. Precision criteria for batch laboratory replicate matrix spike analyses or replicate sample analysis.
[h] River protection ambient water quality criteria derived value.
[i] Compliance is based on the sum of all aroclors detected.
[j] Phthalates, SVOA, and VOA detection limits are for "typical" analytes. Some analytes may have different detection limits and precision/accuracy values.

AEA = alpha energy analysis
CAS = Chemical Abstract Services
CVAA= cold vapor atomic absorption
GC = gas chromatograph
GCMS= gas chromatograph/mass spectrometry
GEA = gamma energy analysis
GPC = gas proportional counter
ICP = inductively coupled plasma
ICPMS = inductively coupled plasma mass spectrometer
N/A = not applicable

2.2 MEASUREMENT/DATA ACQUISITION

The following subsections present the requirements for sampling methods, sample handling and custody, analytical methods, and field and laboratory quality control. The requirements for instrument calibration and maintenance, supply inspections, and data management are also addressed.

2.2.1 Sampling Process Design

Procedures for sampling, documentation, sample preservation, shipment, and chain-of-custody requirements are described in PNNL or subcontractors' manuals. All procedures performed by PNNL will be performed in compliance with *Environmental Investigations Procedure* (BHI-EE-01), *Field Screening Procedures* (BHI-EE-05), and the *Surface Environmental Surveillance Procedures Manual* (PNNL 2000).

The FSP in Section 3.0 presents additional details, summary tables, and figures that address sampling procedures, sampling locations, sampling frequencies, and analytical methods.

2.2.2 Sampling Methods Requirements

Procedures for sampling, documentation, sample preservation, shipment, and chain-of-custody requirements are described in PNNL or subcontractors' manuals. The procedures to be implemented in the field will be consistent with those outlined in the *Surface Environmental Surveillance Procedures Manual* (PNNL 2000) and the *Quality Assurance Project Plan for the Hanford Site Surface Environmental Surveillance Project (SESP) and the Drinking Water Monitoring Project (DWMP)* (PNNL 2002).

The sampling procedures that will be used during implementation of this SAP are outlined in the FSP in Section 3.0.

2.2.3 Sample Handling and Custody Requirements

The sample handling and custody requirements are identified in the FSP in Section 3.0.

2.2.4 Analytical Methods Requirements

Analytical parameters and methods are listed in Table 2-2. Laboratory-specific standard operating procedures (SOPs) for the analytical methods are in place or will be prepared as necessary. An overview of proposed methods for sample analysis for the 100-B/C Area waste sites is presented in the following subsections. Changes to or addition of methods identified in this SAP will be implemented in page changes, addenda, or revisions to this SAP, as appropriate.

2.2.4.1 Field Analysis. Chemical field screening and radiological surveys used for site characterization or sample collection will be performed in accordance with applicable procedures in the subcontractor's or manufacturer's manuals (e.g., BHI-EE-01, BHI-EE-05, PNNL 2000).

2.2.4.2 Laboratory Analysis. The standard fixed laboratory analyses will be used for all verification samples and will be performed in accordance with the reference methods identified in Table 2-2 and the associated laboratory SOPs. The standard fixed laboratory SOPs will also be available prior to analysis.

2.3 QUALITY CONTROL REQUIREMENTS

Quality control (QC) procedures must be followed in the field and laboratory to ensure that reliable data are obtained. 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.

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), replicate sampling and analysis, analysis of blind standards and blanks, and interlaboratory comparisons. Acceptance criteria have been established for each of these parameters based on guidance from the EPA (EPA 1986a, 1986b). When a parameter is outside the criteria, corrective actions are taken to prevent a future occurrence and affected data are flagged in the database. Quality assurance will be conducted in accordance with *Quality Assurance Project Plan for the Hanford Site Surface Environmental Surveillance Project (SESP) and the Drinking Water Monitoring Project (DWMP)* (PNNL 2002).

2.3.1 Field Quality Control

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.

Field QC requirements will consist of the following:

- Equipment blanks: Equipment blanks for soil and water samples will be collected. One equipment blank consisting of clean silica sand will be collected and submitted for offsite analysis. The equipment blank for soil and water will be collected by pouring silica sand and deionized water, respectively, over the surfaces of a set of soil sampling equipment prior to use and collecting the blank media in clean sample jars for analyses. The sample results will be used to evaluate the cleanliness of the sampling equipment and the decontamination procedure.

- Field duplicate samples: One field duplicate sample will be collected and analyzed using field screening. The duplicate sample will be collected from the same media as the primary sample and will be uniquely numbered. The field duplicate provides information concerning the homogeneity of the media and may also provide an evaluation of the precision of the analysis process.

- Split samples: Twenty percent of samples will have a subsample collected as described in Section 3.1.3 and stored on site until a decision is made to submit split samples for fixed laboratory analysis. The selection of these samples for split analysis is discussed in Section 3.4.

No field QC samples will be collected to evaluate biota sampling because the availability of sufficient sample media is limited.

2.3.2 Fixed Laboratory Quality Control

Laboratory QC requirements will be performed as specified in the analytical services statement of work for the selected laboratory and will consist of a laboratory method blank, laboratory control sample, matrix spike, and laboratory duplicate or matrix spike duplicate. Table 2-2 summarizes laboratory quality control requirements.

2.3.3 Instrument/Equipment Testing, Inspection, and Maintenance Requirements

All onsite environmental instruments shall be tested, inspected, and maintained in accordance with PNNL or subcontractor procedures. The results from all instrument/equipment testing, inspection, and maintenance activities shall be recorded in a bound logbook.

2.3.4 Instrument Calibration and Frequency

All onsite environmental instruments shall be calibrated in accordance with PNNL or subcontractor procedures. The results from all instrument calibration activities shall be recorded in a bound logbook. Tags will be attached to all field screening and onsite analytical instruments, noting the date when the instrument was last calibrated and the calibration expiration date.

2.3.5 Data Management

Data resulting from the implementation of this SAP will be managed and stored by PNNL or subcontractors in accordance with applicable procedures. The contract laboratories report analytical results electronically. The results are loaded into the HEIS database. Field-measured parameters are entered manually or through electronic transfer. 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) at the direction of the project task lead. Electronic data access, when appropriate, shall be through environmental information systems computerized databases (i.e., HEIS). Where electronic data are not available, hard copies will be provided in accordance Section 9.6 of the Tri-Party Agreement (Ecology et al. 2002). Preliminary data and report briefings/distributions (subject to technical review) to EPA and the Washington State Department of Ecology will be provided as requested. Regulatory agency updates for projects such as this are typically conducted at unit manager meetings.

2.3.6 Field Documentation

The field documentation requirements and procedures are presented in the FSP (Section 3.0).

2.4 ASSESSMENT/OVERSIGHT

2.4.1 Assessments and Response Actions

The Surface Environmental Surveillance Project (SESP) compliance and quality programs group 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 Environmental Monitoring Supervisor or SESP management. When appropriate, corrective actions will be taken by the task lead in accordance with DOE-RL (1998), Vol. 1.

Deficiencies identified by one of these assessments shall be reported in accordance with PNNL self-assessment reporting procedures (PNNL 2000). When appropriate, corrective actions will be taken by the project engineer in accordance with the *Hanford Analytical Services Quality Assurance Requirements Document,* Vol. 1, Section 4.0 (DOE-RL 1998), to minimize recurrence.

2.4.2 Reports to Management

Management shall be made aware of all deficiencies identified by self-assessments. Identified deficiencies shall be reported to the Environmental Monitoring Supervisor or SESP manager.

2.5 DATA VALIDATION AND USABILITY

2.5.1 Data Review, Validation, and Verification Requirements

Data verification and validation are performed on analytical data sets, 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 within the required holding times, and analyses met the data quality requirements specified in the sampling and analysis instruction.

A minimum of 5% of all data will be validated. Onsite measurements and quick-turnaround analysis data will not undergo a formal validation. The QA/QC processes used in SOPs will be followed to ensure useable data. These include the use of blanks, duplicates, splits, and measurement of known standards. The data will be reviewed by analytical personnel and the project team. QC 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. The validated data results, including applicable qualifiers, shall be entered into the HEIS database.

2.5.2 Reconciling Results with Data Quality Objectives

A data quality assessment shall be performed on the resulting analytical data in accordance with EPA's *Guidance for Data Quality Assessment* (EPA 1996). The data quality assessment is a scientific and statistical evaluation of the data set to determine if the data are the right type, quality, and quantity to support the intended use. 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 statistical-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.

3.0 FIELD SAMPLING PLAN

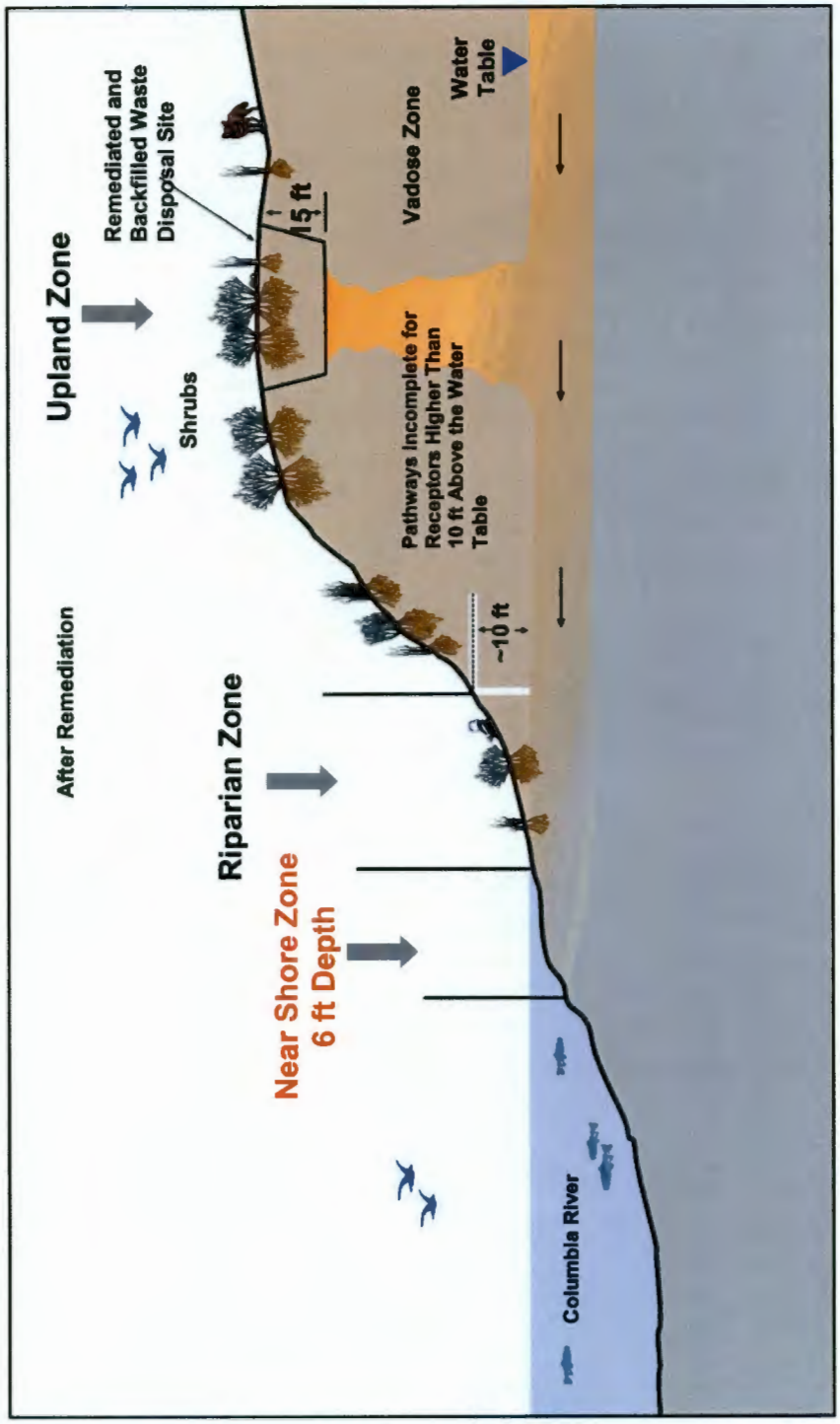
The Field Sampling Plan (FSP) addresses the study scope defined through the DQO process and implements an iterative approach to a screening-level investigation. This sampling design addresses financial constraints by utilizing a tiered sample collection framework. A screening-level approach is used to match COCs with the media that have the greatest potential of occurrence. In some sampling zones, the occurrence of a COC in an abiotic exposure media may trigger future sampling in biota. For example, some COCs are not very mobile in the abiotic environment and hence may not be easily transported to the biota. In such cases, decisions were made to sample only in the media where they would likely be found (e.g., PCBs in sediment as opposed to water). If the COCs are found in the preliminary screening step, then a decision will be made whether to expand the sampling for those COCs in a second year of sampling. Tables presented in the FSP contain a complete suite of analyses for easy comparison between media and sampling zones. Sampling and data evaluation schedules for abiotic and biotic media are presented in Appendix B.

The FSP defines sampling objectives (Section 3.1), sampling design (Section 3.2), and descriptions of the three distinct sampling zones: upland (Section 3.3), riparian (Section 3.4), and near-shore river (Section 3.5). Administrative matters include sample handling (Section 3.6), environmental measurements (Section 3.7) sample management (Section 3.8), and waste management (Section 3.9). Figure 3-1 depicts the three sampling zones: upland, riparian, and near-shore river.

3.1 SAMPLING OBJECTIVES

The objective of the FSP is to clearly identify the sampling and analysis activities needed to resolve the decision rules identified in Step 5 of the DQO process. The specific fiscal year 2003 objectives include sampling soil, seep water, river water, sediment, and biota. The FSP uses the sampling design proposed in Step 7 of the DQO process and presents this design using figures and tables whenever possible to identify sampling locations, total number of samples to be collected, sampling procedures to be implemented, analyses to be performed, and sample container requirements.

Figure 3-1. 100-B/C Sampling Pilot Project Sampling Zones.



3.2 SAMPLING DESIGN

The approach for this study is to collect samples in the three major ecological zones within the 100-B/C Area: the upland zone, the riparian zone, and the near-shore river zone. The 100-B/C Pilot Project includes diverse geographical areas and sampling media (upland terrestrial soil and biota, riparian terrestrial soil and biota, river shoreline soil, riverbed soils and biota, and river water). Samples will be collected under conditions where potential uptake by biota is expected to be maximized in each sampling zone (i.e., during the growing season for upland plants, during low river stage for riparian and near-shore river zone sampling).

A variety of sampling methods are required to ensure that the proper characterization data are collected from these diverse areas and media. The sampling methods considered for the 100-B/C Pilot Project include the following:

- **Reconnaissance Surveys** – Reconnaissance surveys (visual observations, conductivity measurements, and mapping) will be conducted for the three primary study zones to determine locations, abundance, and availability of abiotic and biotic sampling populations. This initial field activity for each zone is needed for refinement of the sampling design. Conductivity measurements will be used to locate persistent and intermittent seeps within the near-shore river zone and areas where upwelling of groundwater occurs within the Columbia River bottom.

  In association with each study zone, an upstream reference site will be identified for detailed complementary sampling and evaluations of ecological health. To the extent possible, all media sampled in the study zones will also be sampled in the reference zones. The near-shore river zone will have two reference sites, one upstream and one downstream between the 100-B/C Area and the 100-K Area. The downstream reference location is intended to characterize the downstream influence of effluent releases from the 100-B/C Area.

- **Systematic Grid Sampling and Surveys** – Systematic grid sampling (and surveys) is based on a specified pattern with samples taken at regular intervals along that defined pattern. This method is used to assure that the target population is fully and uniformly represented in the sample. The regular assignment of locations to the sample provides assurance that the sample truly represents the overall characteristics of the target population. To make systematic sampling a probability-based design, the initial unit for the first sample of a sample of size n is chosen at random, then the remaining (n-1) units are chosen so all n are located according to the pattern.

  Samples may be selected in one, two, or three dimensions if the population characteristic of interest has a spatial component. Sampling along a line or transect represents sampling in one dimension. Sampling every node on a grid laid over an area of interest is sampling two dimensions. Sampling representative of a depth profile at a sampling node would represent third-dimension sampling.

- **Stratified Sampling** – Stratified sampling is a sampling design in which prior information about the population is used to determine groups (called strata) that are sampled independently. Each possible sampling population member must belong to exactly one stratum. A stratified sampling design can also be used to obtain estimates for desired subpopulations or to ensure that important subpopulations have a sufficient number of sampling units in the samples. One of the most common uses of stratification is to account for spatial variability by defining geographic strata. Sampling by spatial strata may also be useful when study results need to be reported separately for particular geographic areas or regions.

- **Combination of Systematic Grid and Stratified Sampling** – Combinations of sampling designs may be used to suit particular needs. The systematic grid sampling design is well suited for combination with the stratified sampling method to provide uniform sampling in a geographic location (grids or transects) for stratified sampling.

The sample design objectives, methods, features, and bases presented in Table 1-6 are discussed in the following subsections. Procedures used in sample collection are detailed in PNL-MA-580, *Surface Environmental Surveillance Procedures Manual* (PNNL 2000) and are reported in Table 3-1.

Table 3-1. Methods for Survey/Sample Collection.

Survey/Sampling Media	Description
Soils	Direct reading radiological survey detectors for alpha, beta, and gamma detection.
	A soil surface sampler (1-in. corer) is used to collect surface samples to a depth of 2.54 cm (1 in.) (PNNL 2000, Section 5.1). Collect rooting zone samples by a soil corer or hand shovels.
Sediment	Grab samples (Patton et al. 2002, Section 3.5).
Periphyton	Plastic scraper (Patton et al. 2002, Section 3.6).
Surface water	Conductivity measurement (PNNL 2000, Section 4.0; Patton et al. 2002, Section 3.4).
Groundwater	Drive points (Patton et al. 2002, Section 3.4.4).
Plants	Stainless steel snipping shears, by species at each sample site (PNNL 2000, Section 5.2; Patton et al. 2002, Section 3.6).
Invertebrates	Pitfall traps along transect within each sample site, hand-pick bivalves and crayfish (procedure presently in draft form).
Small mammals	Live traps systematically placed along transects within each sample site (PNNL 2000, Section 7.1; Patton et al. 2002, Section 3.6).
Fish	Backpack electrofisher (PNNL 2000, Section 7.1; Patton et al. 2002, Section 3.6).

3.2.1 Abiotic Sampling Procedures

Sampling locations will be distributed along transects over the study area in an effort to characterize residual chemical and radionuclide concentrations. A reference transect will be established and sample collection locations will be surveyed using a global positioning system (GPS) prior to sample collection.

In addition, the field testing results will be evaluated to determine if surface soil contamination may extend beyond the waste site boundaries in the upland areas. This process will be used to evaluate the lateral extent of contamination.

Sediment samples will be collected adjacent to seeps within the riparian zone, and where elevated concentrations are indicated during radionuclide field screening. Sediment samples will include clay to coarse sand substrate. Water samples will be collected from seeps, river water, and interstitial spaces of river bottom substrate.

If COCs are detected in abiotic samples, then additional analyses may be performed on biota if screening levels are exceeded. Several COCs are not planned for analysis in the biota; however, biota samples will be archived, and if elevated concentrations of the COCs are found in abiotic media (soils, sediment, and water), then those COCs will be analyzed for, or supplemental biota samples will be collected in the second year of the study.

3.2.2 Biota Sampling Procedures

Biota samples (i.e., plants, invertebrates, and small mammals) will be collected for laboratory analysis of chemical and radionuclide constituents to supplement soil analytical results. Sample media-specific arrangements will be made for the required analysis and to ensure that adequate sample media are collected to perform the analysis.

3.3 UPLAND ZONE

Sampling of the upland areas includes the abiotic and biotic sampling associated with those dryland areas above the river and riparian zone that include remediated waste sites located south of the riparian zone in the northeast quadrant of the 100-B/C Area. Because the upland zone has been highly disturbed by remedial action activities, very little habitat is available for use by ecological receptors. Available vegetation in the study area is associated with small patches of habitat around the perimeter of waste sites (buffer zone), or those species that were planted as part of a restorative revegetation effort. Vegetative samples collected during this effort will be collected where available, on or within close proximity to the remediated sites. The rationale for the assignment of COCs to specific media is described in Section 1.2 and reflected in the subsequent sampling tables. Requirements for abiotic and biotic sampling have been considered for the upland zone of the 100-B/C Area pilot study and are scheduled as described below.

3.3.1 Abiotic Sampling

The scope of the 100-B/C Pilot Project in the upland area is limited to remediated waste sites and those currently undergoing remediation. Radiological surveys and soil sampling are not deemed necessary in these areas because the residual soils were sampled, surveyed, and verified to meet the remedial action goals. The resulting data reside in site-specific CVPs. The remediated sites were then covered with clean backfill.

Where roots of vegetation are sampled near the remediated sites, coincident soil samples may be collected and stored for later analysis (see Section 3.3.2). The detailed soil sampling plan has four sampling locations associated with the rooting zone soil of Russian thistle. The four sampling locations identified in Table 3-2 correspond to vegetation sampling locations described in Section 3.3.2. Soil samples will also be collected from an upstream reference location in addition to the four sites identified in Table 3-2.

Table 3-2. Upland Zone Sampling of Soil from Rooting Zone of Russian Thistle.

Location	Radionuclides								Chemicals		
	Americium-241	Plutonium-238, 239/240	Carbon-14	Nickel-63	Strontium-90	Tritium (H-3)	Technetium-99	Gamma	Semi-VOAs	Metals	PCBs
Reference location [a]	-	-	1	-	1	-	-	1	-	1	-
South side 116-C-5	-	-	1	-	1	-	-	1	-	1	-
North side 116-B-1	-	-	1	-	1	-	-	1	-	1	-
South border 116-C-1	-	-	1	-	1	-	-	1	-	1	-
North border 116-C-1	-	-	1	-	1	-	-	1	-	1	-
Total	**0**	**0**	**5**	**0**	**5**	**0**	**0**	**5**	**0**	**5**	**0**

[a] Upstream reference location west of 100-B/C Area.

- = Not sampled

3.3.2 Biotic Sampling

The objective of sampling biota in the upland zone is to determine radioactive and chemical exposure to resident organisms and provide a screening-level assessment of the health of resident biota in the areas of highest potential exposure. The area of highest potential exposure in the upland area is believed to be the perimeter of the remediated waste sites (buffer areas) where some residual contamination may be present (see Figure 1-1 of BHI 2003). These buffer areas have been heavily disturbed by excavation activities. Much of the surface consists of

unconsolidated cobbles and gravels, with sparse or no vegetation to provide habitat for species of interest. Samples of key biota will be obtained in the immediate vicinity of the remediated sites, but will be focused where the buffer areas are less disturbed. Sampling areas will be located near the interface between the vegetated and nonvegetated surfaces to maximize the potential of acquiring samples. These sampling areas are shown in Figure 3-2 and described below:

- South and adjacent to the 116-C-5 retention basins in vegetation dominated by rabbitbrush with bunchgrass and cheatgrass
- North and immediately adjacent to 116-B-11 in habitat dominated by sparse rabbitbrush with Russian thistle and cheatgrass
- South border of the 116-C-1 remediated area in habitat dominated by sparse rabbitbrush with Russian thistle and cheatgrass
- The north border of the 116-C-1 remediated area in habitat dominated by sparse rabbitbrush with Russian thistle and cheatgrass
- At a reference area upstream of the 100-B/C Operable Units (reference site to be located approximately 0.5 to 1 km upstream of the 100-B/C Area western boundary).

Sampling is planned to occur from the spring through the fall to accommodate the collection of plants and animals identified in the DQO process. Because the size of the area of interest is limited to the buffer areas, no further stratification of sampling sites by vegetation cover types will be attempted. Reference sites will be established in similar habitats near the 100-B/C Area in locations not affected by the reactor area operations.

The sampling design focuses on obtaining samples representative of specific feeding guilds that are consistent with WAC 173-340-7493 ecological evaluation procedures. Sampling designs for the upland zone will be constructed to address the three types of sample populations identified in Table 1-6 to the extent that these organisms are available at the sites: (1) plants including Russian thistle, cheatgrass, and shrubs; (2) invertebrates including darkling beetles, harvester ants, and spiders; and (3) deer mouse/house mouse as the closest fit for small mammal predator receptor guild. A primary sampling constraint is obtaining sufficient mass for the analysis of COCs to quantify contaminant levels. It is possible that sample populations identified in the DQO process may not be present in sufficient quantities to meet sampling objectives.

3.3.2.1 Plants. The plant species selected for sampling in this pilot study are representative of relatively deep-rooted vegetation (rooting depth $\geq$ 0.5 m) (Table 3-3). Plant roots and vegetative tissue for the three identified species, cheatgrass (*Bromus tectorum*), Russian thistle (*Salsola tragus*, formerly *Salsola kali*), and rabbitbrush (*Ericameria nauseosus*), will be collected in the vicinity of the small mammal sampling transects for each of the sampling areas. In support of specific human risk exposure scenarios, other plant species may be sampled opportunistically if found within the sampling areas (e.g., selection based on Tribal input).

Figure 3-2. Upland Sampling Locations.

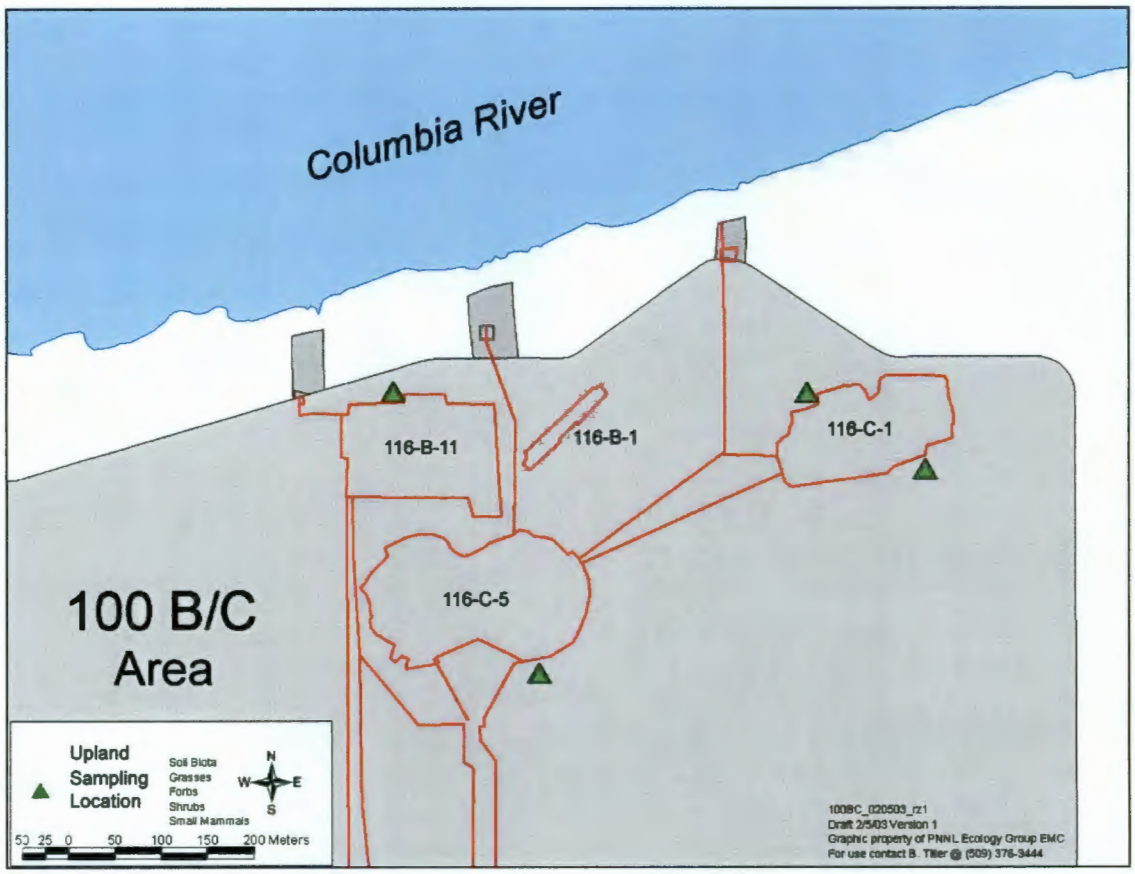


Table 3-3. Upland Zone Vegetation Sampling for Combined Shoots-Roots, and Shoots Only.

Location	Radionuclides								Chemicals		
	Americium-241	Plutonium-238, 239.240	Carbon-14	Nickel-63	Strontium-90	Tritium (H-3)	Technetium-99	Gamma	Semi-VOAs	Metals	PCBs
Deep Rooted Annual (Russian thistle) **(combined shoots and roots)**											
Reference location[a]	-	-	-	-	1	-	-	1	-	1	-
South side 116-C-5	-	-	-	-	1	-	-	1	-	1	-
North side 116-B-1	-	-	-	-	1	-	-	1	-	1	-
South border 116-C-1	-	-	-	-	1	-	-	1	-	1	-
North border 116-C-1	-	-	-	-	1	-	-	1	-	1	-
Subtotal	**0**	**0**	**0**	**0**	**5**	**0**	**0**	**5**	**0**	**5**	**0**
Annual Grass (cheatgrass or bunchgrass) **(combined shoots and roots)**											
Reference location[a]	-	-	-	-	1	-	-	1	-	1	-
South side 116-C-5	-	-	-	-	1	-	-	1	-	1	-
North side 116-B-1	-	-	-	-	1	-	-	1	-	1	-
South border 116-C-1	-	-	-	-	1	-	-	1	-	1	-
North border 116-C-1	-	-	-	-	1	-	-	1	-	1	-
Subtotal	**0**	**0**	**0**	**0**	**5**	**0**	**0**	**5**	**0**	**5**	**0**
Perennial Shrub (rabbitbrush) **(shoots only)**											
Reference location[a]	-	-	-	-	1	-	-	1	-	1	-
South side 116-C-5	-	-	-	-	1	-	-	1	-	1	-
North side 116-B-1	-	-	-	-	1	-	-	1	-	1	-
South border 116-C-1	-	-	-	-	1	-	-	1	-	1	-
North border 116-C-1	-	-	-	-	1	-	-	1	-	1	-
Subtotal	**0**	**0**	**0**	**0**	**5**	**0**	**0**	**5**	**0**	**5**	**0**

[a] Upstream/west of 100-B/C Area near backfill material source.

- = Not sampled

Sampling methods will be tailored to each species. Cheatgrass and Russian thistle are annual species, and vegetative or root tissue samples represent the contaminant exposure, uptake, and accumulation during the season of growth. Rabbitbrush is a long-lived perennial shrub and depending on the age of the tissue collected, samples may represent the uptake and accumulation of contaminants over longer time periods. Plant sampling for COCs in buffer zones is based on abundance and availability of target plant populations. At each of the upland sampling locations, vegetation samples will be collected by species and composited by species for that site. Identical sampling methods will be employed in similar habitat at the reference locations.

Shoot material and root material, to a depth of 30 to 45 cm, will be collected for the annual species, cheatgrass and Russian thistle. Soils will be rinsed from roots before samples are composited. For the perennial species, rabbitbrush, only shoot material will be collected (includes both woody stems and leaves). Cheatgrass samples will be collected between April 15 and May 15 to ensure that seeds have developed and are included in the sample. Russian thistle and rabbitbrush will be sampled between mid-July and the end of August. Russian thistle is a summer annual, and most vegetative growth occurs between late May and September. Sampling in mid- to late summer allows a longer growth period to ensure that adequate vegetative material is available. Later sampling also allows development of reproductive tissue for the perennial rabbitbrush shrubs. Vegetative material will be clipped using stainless steel shears, and plant material will be bagged for transport and analysis.

If elevated levels of COCs are indicated as a result of sample analysis, subsequent sampling may include the collection of health metrics for plants. Examination of those traits related to reproduction and fitness (seed size/biomass, seed viability) would require collection of seeds and vegetative tissue during follow-on sampling activities. Sampling constraints or protocols will be species and contaminant specific.

3.3.2.2 Terrestrial Invertebrates. Pitfall traps will be used to capture invertebrates in upland areas for COC analysis (Table 3-4). Ground-dwelling invertebrates such as darkling beetles, harvester ants, and spiders represent the soil biota guild specified in WAC 173-340-7493. Seven pitfall traps will be used at each of the upland sampling areas to collect invertebrates. The traps will be located in association with the small mammal sampling grid to facilitate trapping activities. Pitfall traps consist of 38-L (1-gal) metal cans buried at grade with covers that can be opened during trapping periods. Pitfall traps will be left open five nights at each sampling area. Invertebrates caught during trapping will be collected and composited for each sampling area for contaminant analysis. Pitfall traps may also unintentionally/opportunistically capture amphibians, small reptiles, or shrews. Should such opportunistic capture occur, the organisms will be examined for physical abnormalities, and data on species, weight, sex, and reproductive condition will be recorded before releasing the animals. Samples may be retained for analysis if minimum sample size criteria are met. Coordinates for each pitfall trap location will be recorded using a GPS unit.

Table 3-4. Upland Zone Pitfall Sampling of Soil Invertebrates (Whole Body of Beetles, Ants, and Spiders).

Location	Radionuclides								Chemicals		
	Americium-241	Plutonium-238, 239/240	Carbon-14	Nickel-63	Strontium-90	Tritium (H-3)	Technetium-99	Gamma	Semi-VOAs	Metals	PCBs
Reference location[a]	-	-	-	-	1	-	1	-	-	1	-
South side 116-C-5	-	-	-	-	1	-	1	-	-	1	-
North side 116-B-1	-	-	-	-	1	-	1	-	-	1	-
South border 116-C-1	-	-	-	-	1	-	1	-	-	1	-
North border 116-C-1	-	-	-	-	1	-	1	-	-	1	-
Subtotal	**0**	**0**	**0**	**0**	**5**	**0**	**5**	**0**	**0**	**5**	**0**

[a] Upstream/west of 100-B/C near backfill material source.
- = Not sampled

3.3.2.3 Small Mammals. Deer mice and house mice are likely present in the upland area, particularly where adequate vegetation exists. These mice are omnivores, but are considered the best representative for the mammalian predator guild (as recommended in WAC 173-340-7490 et seq.) because the upland study areas are too small in size to support a higher trophic level predator. Deer mouse and house mouse sampling will be accomplished using live traps laid in grids along transects at the perimeters of the buffer zones. Small mammal trapping will be conducted between April and September when animals are most likely to be active.

Typically, two trap lines, each consisting of approximately seven Sherman live traps (3 in. wide by 3.5 in. high by 9 in. length) will be placed parallel with the edges of the buffer areas. Identical trapping methods will be employed in similar habitat at the reference locations. The number of trap lines, number of traps per line, line spacing, and trap spacing may be varied to maintain comparable trapping efforts between sites and ensure that results are comparable between the areas of concern and reference locations. Such adjustments will be made as a function of the size of the area and type of the plant community trapped. Exact locations for each trap will be recorded using a GPS unit.

Biological measures relevant to the health of individuals and the population will be recorded for each animal captured. Histological examinations will be conducted on kidney, liver, and testes. Weight, length, and sex will be recorded. Population parameters include live density estimates, percentage of lactating females, and percentage of sexually active males. Approximately five samples of target tissues (carcass, liver, and brain) from individual animals will be analyzed for metals and PCBs (as Aroclor-1254 and -1260) at each sampling location. Remaining whole-body tissue will be composited to provide samples from each general area for analysis of

radionuclides (Table 3-5). Sample weights required for laboratory analysis will be collected in accordance with the laboratory-specific statements of work.

Table 3-5. Upland Zone Small Mammal (Deer Mouse) Sampling for Carcass (C), Liver (L), And Brain (Br).

Location	Radionuclides								Chemicals		
	Americium-241	Plutonium-238, 239/240	Carbon-14	Nickel-63	Strontium-90	Tritium (H-3)	Technetium-99	Gamma	Semi-VOAs	Metals	PCBs
Reference location[a]	-	-	-	-	1C	-	1C	1C	-	5L	5Br
South side 116-C-5	-	-	-	-	1C	-	1C	1C	-	1L	1Br
North side 116-B-1	-	-	-	-	1C	-	1C	1C	-	1L	1Br
South border 116-C-1	-	-	-	-	1C	-	1C	1C	-	1L	1Br
North border 116-C-1	-	-	-	-	1C	-	1C	1C	-	1L	1Br
Subtotal	**0**	**0**	**0**	**0**	**5**	**0**	**5**	**5**	**0**	**9**	**9**

[a] Upstream near Vernita - corresponds with riparian reference location.
- = Not sampled

3.4 RIPARIAN ZONE

The riparian zone adjacent to the 100-B/C Area lies between the upland CERCLA remedial action area and the Columbia River shoreline. Both abiotic and biotic sampling are scheduled for the riparian zone. Riparian zone sampling will likely be conducted in the spring through the fall to accommodate the collection of specific plants and animals. Key sampling locations within the riparian zone will include shoreline areas adjacent to persistent and intermittent groundwater seeps along the Columbia River shorelines, and outfall structures where effluents were released during reactor operations in the 100-B/C Area. The rationale for the assignment of COCs to specific media is described in Section 1.2 and reflected in the subsequent sampling tables.

3.4.1 Abiotic Sampling

Abiotic sampling in the riparian zone will include radiological surveys and soil sampling. Reconnaissance of existing radiological surveys and thermoluminescent dosimeter measurements will be performed to assist in the final study design. Radiological surveys of the riparian zone and the adjacent upland area will be conducted along transect lines parallel to the shoreline for the entire length of the study area using GPS linked detectors. This survey will provide a minimum of 20% areal coverage for gamma-emitting radionuclides to a sensitivity of 15 mrem/yr above background. Outfall structure discharge areas will be surveyed with 100%

coverage (to the extent practicable). This survey will be used to provide input to the human health exposure evaluation and to select biota sampling locations.

Soil sampling in the riparian zone addresses two primary objectives, characterization in nonimpacted soils and evaluation of soils associated with facility elements (i.e., discharge pipelines, outfall spillway soils, riprap, and concrete surfaces). Soil sampling locations may be modified if indications of radiological hot spots are found during the radiological surveys associated with this effort. The stratified design based on hot spot identification is complemented by a grid design to ensure that portions of the riparian zone are not overlooked. Sampling will default to opportunistic sampling as necessary, adapting to the abundance and availability of plant populations.

Potentially contaminated soil may occur at a variety of locations including soil near discharge pipelines, outfall spillways, riprap, and concrete surfaces. The initial sampling design in this area is stratified to capture occurrences of 100-B/C facility elements as described above, which will be sampled using a systematic grid or transect based design (Table 3-6). Sample media may be difficult to locate in these areas because of the presence of interfering materials such as large riprap boulders and concrete. If sampling conditions are poor, the best available samples will be collected. Four samples of soils (where available) will be collected along transects at each pipeline/spillway site. Samples may be collected between rocks in riprap zones. Samples collected from concrete spillways will be sampled by drilling a series of co-located holes to a depth of 0.6 cm to meet sampling mass requirements.

Soil samples may be obtained from the rooting zone of deep-rooted trees or shrubs (up to 1.0 m depth). Subsamples of soil may be collected in 10-cm increments to characterize contaminant concentrations in the rooting zone.

Table 3-6. Riparian Zone Composite Soil Sample from Rooting Zone of Shrubs or Trees. (2 Pages)

Location	Radionuclides								Chemicals		
	Americium-241	Plutonium-238, 239/240	Carbon-14	Nickel-63	Strontium-90	Tritium (H-3)	Technetium-99	Gamma	Semi-VOAs	Metals	PCBs
Reference location[a]	1	1	-	-	1	-	1	1	-	1	1
Seep 037-1/038-1	1	1	-	-	1	-	1	1	-	1	-
Seep 039-1	1	1	-	-	1	-	1	1	-	1	-
Outfall 1	1	1	1	1	1	-	1	1	-	1	1
Outfall 2	1	1	1	1	1	-	1	1	-	1	1
Outfall 3	1	1	1	1	1	-	1	1	-	1	1

Table 3-6. Riparian Zone Composite Soil Sample from Rooting Zone of Shrubs or Trees. (2 Pages)

Location	Radionuclides								Chemicals		
	Americium-241	Plutonium-238, 239/240	Carbon-14	Nickel-63	Strontium-90	Tritium (H-3)	Technetium-99	Gamma	Semi-VOAs	Metals	PCBs
Reference location [b]	1	1	-	-	1	-	1	1	-	1	-
Subtotal	**7**	**7**	**3**	**3**	**7**	**0**	**7**	**7**	**0**	**7**	**4**

[a] Reference location upstream near Vernita - corresponds with riparian reference location.
[b] Reference location downstream of 100-B/C Area.
- = Not sampled

3.4.2 Riparian Biota Sampling

The sampling design for the riparian biota will be stratified based on data gathered through reconnaissance surveys within the river shoreline and the riparian zone. Biota sampling is aligned with primary and secondary transects that will be established for the near-shore river environment (see Section 3.5). However, the design will default to opportunistic sampling if biota are not available along or within the vicinity of these transects. All sampling locations will be identified and mapped using a GPS unit. The number of samples will be set to meet analytical mass requirements and statistical data needs. Media-appropriate biological health metrics will be measured as a screening-level assessment during the first year of sample collection.

3.4.2.1 Plants. The plant species selected for sampling in the riparian zone are representative of several plant functional types including shallow and deep-rooted perennial vegetation. Potential species that may be sampled include mulberry (*Morus alba*), coyote willow (*Salix exigua*), northern wormwood (*Artemisia campestris*), sweet clover (*Melilotus alba* or *M. officinalis*), and reed canary grass (*Phalaris arundinaceae*). Plant sampling for COCs in the riparian zone will be based on abundance and availability of target plant populations (Table 3-7). In support of specific human risk exposure scenarios, other plant species may be sampled opportunistically if found within the sampling areas (e.g., selection based on Tribal input). Tissue of the key plant species identified for each of the sampling areas will be collected at or in the vicinity of the sampling transects. At each of the riparian transect sampling locations, vegetation samples will be collected and composited by species for that location. Identical sampling methods will be employed in similar habitat at the reference locations.

Table 3-7. Riparian Zone Plant Sampling for Combined Shoots and Roots.

Location	Radionuclides								Chemicals		
	Americium-241	Plutonium-238, 239/240	Carbon-14	Nickel-63	Strontium-90	Tritium (H-3)	Technetium-99	Gamma	Semi-VOAs	Metals	PCBs
***Deep Rooted (mulberry/willow/wormwood)* (shoots)**											
Reference location [a]	-	-	-	-	1	1	1	1	-	1	-
Seep 037-1/038-1	-	-	-	-	1	1	1	1	-	1	-
Seep 039-1	-	-	-	-	1	1	1	1	-	1	-
Outfall 1	-	-	-	-	1	1	1	1	-	1	-
Outfall 2	-	-	-	-	1	1	1	1	-	1	-
Outfall 3	-	-	-	-	1	1	1	1	-	1	-
Reference location [b]	-	-	-	-	1	1	1	1	-	1	-
Subtotal	**0**	**0**	**0**	**0**	**7**	**7**	**7**	**7**	**0**	**7**	**0**
***Perennial Herb (sweet clover, reed canary grass)* (combined shoots and roots)**											
Reference location [a]	-	-	-	-	1	1	1	1	-	1	-
Seep 037-1/038-1	-	-	-	-	1	1	1	1	-	1	-
Seep 039-1	-	-	-	-	1	1	1	1	-	1	-
Outfall 1	-	-	-	-	1	1	1	1	-	1	-
Outfall 2	-	-	-	-	1	1	1	1	-	1	-
Outfall 3	-	-	-	-	1	1	1	1	-	1	-
Reference location	-	-	-	-	1	1	1	1	-	1	-
Subtotal	**0**	**0**	**0**	**0**	**7**	**7**	**7**	**7**	**0**	**7**	**0**

[a] Upstream near Vernita - corresponds with riparian reference location.
[b] Reference location downstream of 100-B/C Area.
- = Not sampled

Sampling methods will be appropriate for each species. For the woody perennial species, only shoot material will be collected (includes both woody stems and leaves). For specified herbaceous or semi-woody target species, a combined root and vegetative tissue sample may be collected for analysis. Shoot material and root material, up to a depth of 30 cm, will be collected for these species. Soils will be rinsed from roots before samples are composited. Vegetative material will be clipped using stainless steel shears. Plant material will be bagged for transport and analysis.

General conditions of plants will be observed in the field at each sampling location. Plants will be inspected for overall vigor and where appropriate, screening-level health measures may be collected. If elevated levels of COCs are indicated, subsequent sampling may include the collection of health metrics for plants. Examination of those traits related to reproduction and fitness (seed size/biomass, seed viability, or photosynthetic parameters susceptible to chemical or herbicide effects) would require collection of seeds and vegetative tissue during follow-on sampling activities. Laboratory analysis of berry/shoot mass could be examined under such a

follow-on sampling activity. Sampling constraints or protocols will be species and contaminant specific.

3.4.2.2 Riparian Invertebrates. Pitfall traps and ultraviolet insect traps will be used to capture invertebrates in riparian areas for COC analysis (Table 3-8). Pitfall traps will be used to capture ground-dwelling invertebrates such as darkling beetles to satisfy the soil biota guild specified in WAC 173-340-7493. Pitfall traps may also capture amphibians, small reptiles, or shrews. These samples may be retained for analysis if minimum sample size criteria are met. Ultraviolet insect traps capture flying insects at night and will provide samples of moths and emergent aquatic insects such as midge, mayfly, and caddisfly. Pitfall traps and ultraviolet insect traps will be operated for five nights. Pitfall traps will be baited with sardines as needed. Each trap location will be recorded using a GPS unit. Sample weights required for laboratory analysis will be collected in accordance with the laboratory-specific statements of work.

Captured organisms will be inspected for abnormalities; however, collection of other health metrics are not planned for invertebrates.

Table 3-8. Riparian Zone Pitfall Sampling of Soil Invertebrates (Whole Body of Beetles, Ants, and Spiders).

Location	Radionuclides						Chemicals		
	Americium-241	Plutonium-238, 239./240	Strontium-90	Tritium (H-3)	Technetium-99	Gamma	Semi-VOAs	Metals	PCBs
Reference location [a]	-	-	1	-	1	-	-	1	-
Seep 037-1/038-1	-	-	1	-	1	-	-	1	-
Seep 039-1	-	-	1	-	1	-	-	1	-
Outfall 1	-	-	1	-	1	-	-	1	-
Outfall 2	-	-	1	-	1	-	-	1	-
Outfall 3	-	-	1	-	1	-	-	1	-
Reference location [b]	-	-	1	-	1	-	-	1	-
Subtotal	**0**	**0**	**7**	**0**	**7**	**0**	**0**	**7**	**0**

[a] Reference location upstream near Vernita - corresponds with riparian reference location.

[b] Reference location downstream of 100-B/C Area.

- = Not sampled

3.4.2.3 Small Mammal Sampling. Deer mice and house mice are likely present in the riparian area, particularly where adequate vegetation exists. These mice are omnivores, but are considered representative of the mammalian predator guild (as recommended in WAC 173-340-7490 et seq.) because the riparian study area is too small to support upper trophic-level predators in numbers that could support sampling design requirements. Mice also satisfy the sentinel

organism criteria as defined in the DQO process (BHI 2003). Samples will be collected using the trap line method described earlier (see Section 3.3.2.3). Live trapping will be conducted in the riparian zone. Samples will be individually analyzed for metals and PCBs (as Aroclor-1254 and -1260) in target tissues (carcass, liver, and brain). Remaining whole-body tissue composite samples from each general area will be analyzed for radionuclides (Table 3-9).

Table 3-9. Riparian Zone Small Mammal (Deer Mouse) Sampling for Carcass (C), Liver (L), and Brain (Br).

Location	Radionuclides								Chemicals		
	Americium-241	Plutonium-238, 239./240	Carbon-14	Nickel-63	Strontium-90	Tritium (H-3)	Technetium-99	Gamma	Semi-VOAs	Metals	PCBs
Reference location [a]	-	-	-	-	1C	-	1C	1C	-	5L	5Br
Seeps 037-1/038-1	-	-	-	-	1C	-	1C	1C	-	1L	1Br
Seep 039-1	-	-	-	-	1C	-	1C	1C	-	1L	1Br
Outfall 1	-	-	-	-	1C	-	1C	1C	-	1L	1Br
Outfall 2	-	-	-	-	1C	-	1C	1C	-	1L	1Br
Outfall 3	-	-	-	-	1C	-	1C	1C	-	1L	1Br
Reference location [b]	-	-	-	-	1C	-	1C	1C	-	1L	1Br
Total	**0**	**0**	**0**	**0**	**7**	**0**	**7**	**7**	**0**	**11**	**11**

[a] Reference location upstream near Vernita - corresponds with riparian reference location.
[b] Reference location downstream of 100-B/C Area.
- = Not sampled

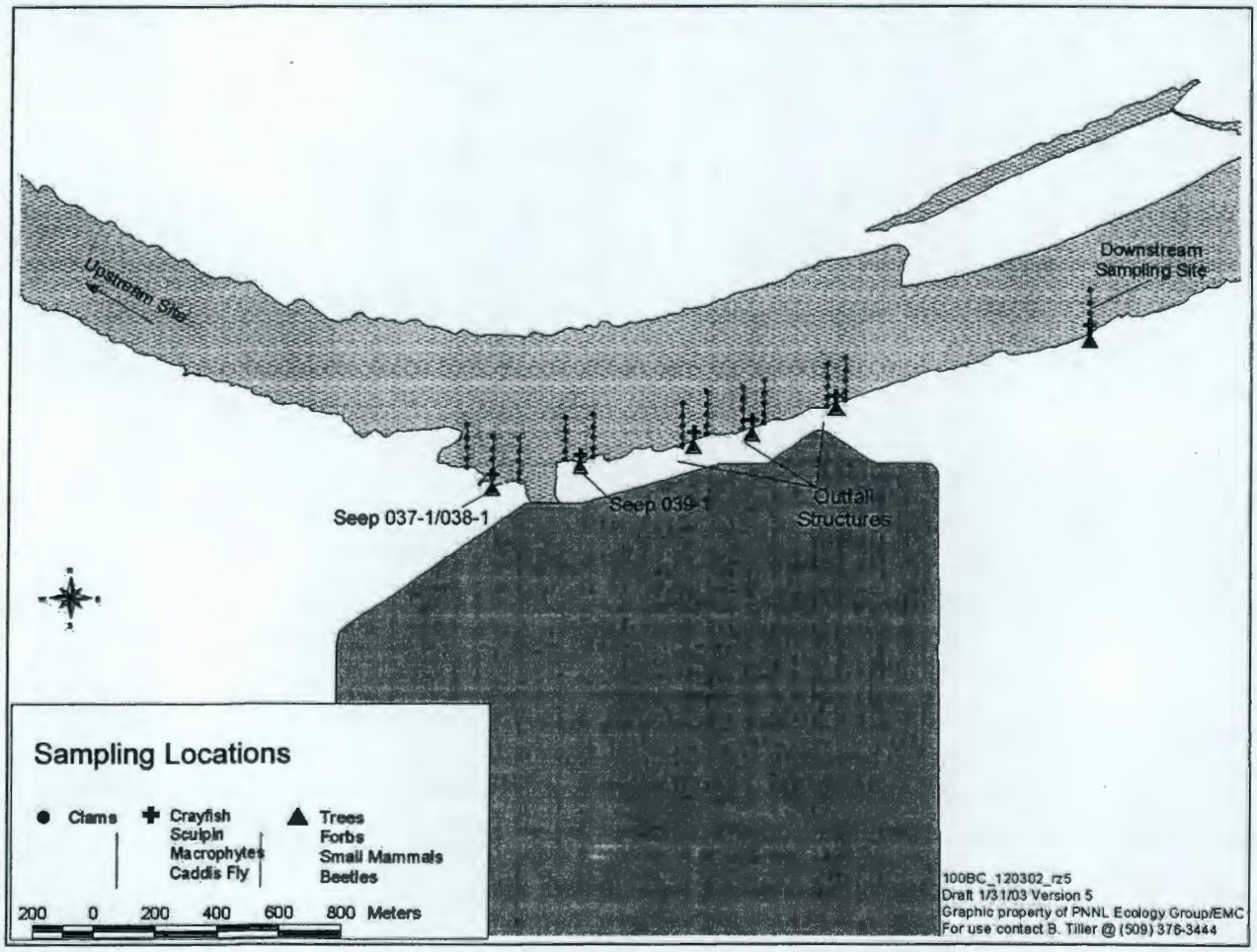
Biological measures relevant to the health of individuals and the population will be recorded for each animal captured. Histological examinations will be conducted on kidney, liver, and testes. Weight, length, and sex will be recorded Population parameters include live density estimates, percentage of lactating females, and percentage of sexually active males.

3.5 NEAR-SHORE RIVER ZONE

Abiotic and biotic sampling in the near-shore river zone of the 100-B/C Area pilot study has been evaluated and scheduled to coincide with the low flow of the river that occurs in late summer and fall. Low river flow corresponds to maximum availability and minimal dilution of contaminated groundwater. Of the three zones in the study, the greatest emphasis is on the near-shore river zone. Sampling locations in the near-shore river zone will be selected based on reconnaissance surveys to identify the areas along the shore and in the riparian zone that are most likely to contain COCs. In effect, the reconnaissance surveys provide information to stratify the

sampling area according to detection of contamination. The rationale for the assignment of COCs to specific media is described in Section 1.2 and reflected in the subsequent sampling tables. Figure 3-3 illustrates five potential sampling areas based on the current available information regarding river bank seeps and outfall structures associated with historic operations at the 100-B/C Area. At each identified site, at least one primary sampling transect will be sampled, and secondary transects will be sampled as feasible.

Figure 3-3. Map Depicting Biological Media Sampling Regions (Transects) in the Riparian and Near-Shore River Environment Along the 100-B/C Area.



3.5.1 Abiotic Sampling

Abiotic sampling in the near-shore river zone includes sediment, river water, and interstitial pore water (drive point) collected from the river substrate. The selection of study sites is predicated on reconnaissance investigations based on process knowledge, groundwater plumes, riverbank spring surveillance data, and water conductivity measurements along the shoreline. In addition, external radiological surveys will be conducted to address external radiation exposure under recreational boater scenarios.

3.5.1.1 River Conductivity Reconnaissance. The objective of conductivity reconnaissance is to locate and characterize the groundwater upwelling in the near-shore environment. The conductivity data will assist in the selection of primary and secondary locations for transect samples. The current design assumes the presence of five primary transects, an upstream reference transect, and a downstream transect (Figure 3-3). These transect locations may change based on results of the conductivity reconnaissance survey.

3.5.1.2 Radiological Survey (Boat). The objective of this sampling is to determine exposure rates (μR/hr) along the near-shore environment and compare to existing thermoluminescent dosimeter measurements. The exposure rate information will support recreational boater exposure scenarios.

3.5.1.3 Interstitial Pore Water Sampling. Water sampling consists of interstitial (pore) water sampling (drive point) and river water sampling for COCs, basic water quality, and conductivity (Table 3-10).

Table 3-10. Near-Shore River Water Sampling. (2 Pages)

Location	Radionuclides								Chemicals		
	Americium-241	Plutonium-238, 239/240	Carbon-14	Nickel-63	Strontium-90	Gamma	Tritium (H-3)	Tc-99	VOAs	Metals	Anions
Transect (primary) River Depths (0.25, 0.5, 1.0, & 2.0)											
Reference location [a]	-	-	-	-	4	4	4	4	4	4	4
Seep 037/038	-	-	-	-	1	1	4	4	4	4	4
Seep 039-1	-	-	-	-	1	1	4	4	4	4	4
Outfall 1	-	-	-	-	1	1	1	1	1	1	1
Outfall 2	-	-	-	-	1	1	1	1	1	1	1
Outfall 3	-	-	-	-	1	1	1	1	1	1	1
Reference location [b]	-	-	-	-	1	1	4	4	4	4	4
Subtotal	**0**	**0**	**0**	**0**	**10**	**10**	**19**	**19**	**19**	**19**	**19**

Table 3-10. Near-Shore River Water Sampling. (2 Pages)

Location	Radionuclides								Chemicals		
	Americium-241	Plutonium-238, 239/240	Carbon-14	Nickel-63	Strontium-90	Gamma	Tritium (H-3)	Tc-99	VOAs	Metals	Anions
Transect (secondary) (River Depths = 0.25, 0.5, 1.0, & 2.0)											
Seep 037/038	-	-	-	-	1	1	4	4	1	1	1
Seep 039-1	-	-	-	-	1	1	4	4	1	1	1
Outfall 1	-	-	-	-	-	-	-	-	-	-	-
Outfall 2	-	-	-	-	-	-	-	-	-	-	-
Outfall 3	-	-	-	-	-	-	-	-	-	-	-
Subtotal	**0**	**0**	**0**	**0**	**2**	**2**	**8**	**8**	**2**	**2**	**2**
Riverbank Springs											
Seep 037	1	1	1	1	1 [c]	1 [c]	1 [c]	1 [c]	1 [c]	1 [c]	1 [c]
Seep 038	1	1	1	1	1	1	1	1	1	1	1
Seep 039	1	1	1	1	1 [c]	1 [c]	1 [c]	1 [c]	1 [c]	1 [c]	1 [c]
Outfall 1	1	1	-	-	1	1	1	1	1	1	1
Outfall 2	1	1	-	-	1	1	1	1	1	1	1
Outfall 3	1	1	-	-	1	1	1	1	1	1	1
Subtotal	**6**	**6**	**3**	**3**	**6**	**6**	**6**	**6**	**6**	**6**	**6**
Drive Point (shallow interstitial groundwater)											
Reference location [a]	1	1	-	-	1	1	1	1	1	1	1
Seep 037	1	1	-	-	1	1	1	1	1	1	1
Seep 038	-	-	-	-	-	-	-	-	-	-	-
Seep 039	1	1	-	-	1	1	1	1	1	1	1
Outfall 1	1	1	1	1	1	1	1	1	1	1	1
Outfall 2	1	1	1	1	1	1	1	1	1	1	1
Outfall 3	-	-	1	1	-	-	-	-	-	-	-
Reference location [b]	1	1	-	-	1	1	1	1	1	1	1
Subtotal	**6**	**6**	**3**	**3**	**6**	**6**	**6**	**6**	**6**	**6**	**6**
Total	**12**	**12**	**6**	**6**	**24**	**24**	**39**	**39**	**33**	**33**	**33**

[a] Reference location upstream near Vernita.
[b] Reference location downstream of 100-B/C Area.
[c] Currently Hanford Site SESP routinely scheduled sample; gross alpha and beta are also scheduled.
- = Not sampled

Interstitial pore water is water that exists within the riverbed substrate. Along the shoreline, it exists as a mixture of varying proportions of groundwater and river water. Interstitial pore water is collected by one of two methods: (1) drive point sampling, or (2) multilevel sampling. Each of these methods involves installing a screened well point into the substrate, with the drive points providing a single depth sample and the multilevel samplers providing multiple depth samples. The drive points are easier to install, require minimal hardware, can be sampled during high river

stage, and are actively sampled, which allows for large volume samples. The multilevel samplers are more complex to install and can only be easily accessed during low river stages. They are passive samples with limited sample volumes; however, they have the advantage of providing more detailed concentration profiles at the groundwater/river water interface. Sampling interstitial water along primary and intermittent seep transects captures hyporheic flow of mixed groundwater and river water.

The amount of interstitial pore water sampling will be based on conductivity measurements, the spatial relationship to former outfall structures. If multilevel samplers are chosen to collect water samples within consolidated river bottom (0 to 10 cm depth), the samples will be collected at each transect area. Drive-point water samples will be collected by using a peristaltic pump to pull water from polyethylene tubing installed into the shallow aquifer and into appropriate sampling containers. Each drive point array in the study location will be sampled. At some locations, multiple drive points are available. Multiple drive points are typically an array of three polyethylene tubes at different depths. Drive point samples will be collected at low river stages with one sample from the tube yielding the highest conductivity for each drive point array location. All samples will be unfiltered water, except for metals that will be filtered with a 0.45 μm Geotech© high-volume filter. Specific conductivity, pH, and temperature measurements will be made for all drive point tubes in the arrays.

3.5.1.4 River Water Sampling. River water sampling consists of grab samples collected from just above the river bottom for analysis of COCs, basic water quality, and conductivity. Sampling is based on a stratified design oriented along primary and secondary transects and depth. The sampling provides a measure of water quality in the river bottom where the highest potential for groundwater upwelling occurs. River water will be collected from near the river bottom by using a peristaltic pump and Tygon® tubing with the sample inlet positioned <6 cm above the river bottom. At each location a set of four water samples will be collected at 0.25 m depth, 0.5 m, 1 m, 1.5 m, or at 2.0 m. Specific conductivity, pH, dissolved oxygen, and temperature measurements will be made for each water sample in addition to the analyses specified in Table 3-10. The number of sample and river water depths will be dependent on the results of the conductivity reconnaissance (Section 3.5.1.1).

3.5.1.5 Sediment. Sediment samples will be collected in or adjacent to riverbank springs for analysis of COCs (Table 3-11). Additional sampling at intermittent seep (secondary) transects will be based on results of reconnaissance surveys and substrate type. Substrate type will determine the dominant type of biota in a certain location and help define key characteristics of reference locations. Sediment samples for COC analysis will be restricted to a size fraction of very coarse sand and smaller.

Sediment samples will be collected using nylon ladles. Samples will be placed into doubled plastic bags (radiological COCs) or pre-cleaned glass jars (metal or organic COCs). If sediment samples are required at locations where they are covered by water, then a ponar-style sediment dredge will be used to obtain the samples.

Table 3-11. Near-Shore River Sediment Samples.

Location	Radionuclides								Chemicals		
	Strontium-90	Americium-241	Plutonium-238, 239/240	Carbon-14	Nickel-63	Gamma	Tritium (H-3)	Technetium-99	Semi-VOAs	Metals	PCBs
Reference location[a]	1	1	1	1	1	1	-	1	1	1	1
Seep 037	1[c]	1	1	-	-	1[c]	-	1	-	1[c]	-
Seep 038	1	1	1	-	-	1	-	1	-	1	-
Seep 039	1	1	1	-	-	1	-	1	-	1	-
Outfall 1	1	1	1	1	1	1	-	1	1	1	1
Outfall 2	1	1	1	1	1	1	-	1	1	1	1
Outfall 3	1	1	1	1	1	1	-	1	1	1	1
Reference location[b]	1	1	1	-	-	1	-	1	-	1	1
Total	**7**	**8**	**8**	**4**	**4**	**7**	**0**	**8**	**4**	**7**	**5**

[a] Reference location upstream near Vernita.
[b] Reference location downstream of 100-B/C Area.
[c] Currently Hanford Site SESP routinely scheduled sample; isotopic uranium is also scheduled.
- = Not sampled

3.5.2 Biota Sampling

The biotic sampling design assumes the presence of five primary transects, an upstream reference transect (location unspecified), and a downstream reference transect (Figure 3-3). These transect locations may change based on the conductivity reconnaissance surveys. At each of the primary transects, aquatic biota representative of the WAC 173-340-derived feeding guilds will be the target species for sampling. The target biota include a vertebrate predator, benthic invertebrates that represent a soil biota feeding guild, and aquatic macrophytes and periphyton that represent the plants.

3.5.2.1 Sculpin. Sculpin best represent the aquatic vertebrate predator guild and serve as a sentinel organism in this study design. Sculpins will be sampled for COCs and for screening health metrics (Table 3-12). For each sampling location, field observation will be performed in combination with histopathology of kidneys, gills, liver, muscle, and bones, and laboratory determination of body weight, length, and sex of each organism. Sampling will be stratified by transect and based on the abundance of sculpin in the study area. The resulting data may help define the spatial extent of contaminant influence on biota in the near-shore environment.

Table 3-12. Near-Shore River Zone Sampling for Sculpin (Carcass [C], Liver [L], Brain [Br]).

Location	Radionuclides								Chemicals		
	Americium-241	Plutonium-238, 239/240	Carbon-14	Nickel-63	Strontium-90	Tritium (H-3)	Technetium-99	Gamma	Semi-VOAs	Metals	PCBs
Reference location [a]	-	-	-	-	1C	-	1C	1C	-	5L	3 Br
Seep 037-1/038-1	-	-	-	-	1C	-	1C	1C	-	1L	1Br
Seep 039-1	-	-	-	-	1C	-	1C	1C	-	1L	1Br
Outfall 1	-	-	-	-	1C	-	1C	1C	-	1L	1Br
Outfall 2	-	-	-	-	1C	-	1C	1C	-	1L	1Br
Outfall 3	-	-	-	-	1C	-	1C	1C	-	1L	1Br
Downstream	-	-	-	-	1C	-	1C	1C	-	1L	1Br
Total	**0**	**0**	**0**	**0**	**7**	**0**	**7**	**7**	**0**	**11**	**9**

[a] Reference location upstream near Vernita.
[b] Reference point downstream near boat launch.
- = Not collected

Up to five sculpin will be collected using a backpack electrofisher or by hand during hand-collection of bivalves and crayfish from each of the primary transects, the upstream reference area, and downstream reference area. Target tissues from sculpin will be analyzed for selected chemical constituents, and a single composite sample of all carcasses will be prepared and submitted for radiological analyses. Biological measures relevant to the health of individuals and the population will be recorded for each animal captured. Histological examinations will be conducted on kidney, liver, gills, muscle, and bone. Weight, length, and sex will be recorded. Population parameters include live density estimates.

3.5.2.2 Benthic Invertebrates. The benthic invertebrates selected for sampling include caddisfly, crayfish, and clams. These bottom-dwelling aquatic invertebrates correspond to the terrestrial "soil biota" feeding guild and function as sentinel organisms. Benthic invertebrates will be sampled for COCs and for screening health metrics (Table 3-13). In particular, clam data will define the spatial extent of contaminant influence on biota in the near-shore environment. The health metrics that will be collected include a density estimate, body weights, length, and sex.

Single composite samples of caddisflies will be obtained from each primary transect area. Caddisfly will be collected using a combination of sweep-nets and/or ultraviolet traps. Whole body samples will be prepared and submitted for analyses. No health metrics will be collected on caddisfly samples.

Table 3-13. Near-Shore River Zone Sampling of Benthic Invertebrates Including Clams (Shell Composite [SC], Soft Tissue Composite [STC], Crayfish [Hepatopancreas = H and Carcass C]), and Caddisfly (Whole Body = WB).

Location	Radionuclides								Chemicals		
	Americium-241	Plutonium-238, 239/240	Carbon-14	Nickel-63	Strontium-90	Tritium (H-3)	Technetium-99	Gamma	Semi-VOAs	Metals	PCBs
Caddisfly (adult)											
Reference location [a]	-	-	-	-	1 WB	-	1 WB	1 WB	-	3WB	-
Seep 037-1/038-1	-	-	-	-	1 WB	-	1 WB	1 WB	-	1WB	-
Seep 039-1	-	-	-	-	1 WB	-	1 WB	1 WB	-	1WB	-
Outfall 1	-	-	-	-	1 WB	-	1 WB	1 WB	-	1WB	-
Outfall 2	-	-	-	-	1 WB	-	1 WB	1 WB	-	1WB	-
Outfall 3	-	-	-	-	1 WB	-	1 WB	1 WB	-	1WB	-
Reference location [b]	-	-	-	-	1 WB	-	1 WB	1 WB	-	1WB	-
Total	**0**	**0**	**0**	**0**	**7**	**0**	**7**	**7**	**0**	**9**	**0**
Crayfish											
Reference location [a]	-	-	-	-	1C	-	1C	1C	-	5 H	-
Seep 037-1/038-1	-	-	-	-	1C	-	1C	1C	-	1H	-
Seep 039-1	-	-	-	-	1C	-	1C	1C	-	1H	-
Outfall 1	-	-	-	-	1C	-	1C	1C	-	1H	-
Outfall 2	-	-	-	-	1C	-	1C	1C	-	1H	-
Outfall 3	-	-	-	-	1C	-	1C	1C	-	1H	-
Reference location [b]	-	-	-	-	1C	-	1C	1C	-	1H	-
Total	**0**	**0**	**0**	**0**	**7**	**0**	**7**	**7**	**0**	**11**	**0**
Clams											
Reference location [a]	-	-	-	-	1SC + 1STC	-	1STC	1STC	-	5STC	5STC
Seep 037-1/038-1	-	-	-	-	1SC + 1STC	-	1STC	1STC	-	1STC	-
Seep 039-1	-	-	-	-	1SC + 1STC	-	1STC	1STC	-	1STC	-
Outfall 1	-	-	-	-	1SC + 1STC	-	1STC	1STC	-	1STC	1STC
Outfall 2	-	-	-	-	1SC + 1STC	-	1STC	1STC	-	1STC	1STC
Outfall 3	-	-	-	-	1SC + 1STC	-	1STC	1STC	-	1STC	1STC
Reference location [b]	-	-	-	-	1SC + 1STC	-	1STC	1STC	-	1STC	1STC
Total	**0**	**0**	**0**	**0**	**14**	**0**	**7**	**7**	**0**	**11**	**9**

[a] Reference location upstream near Vernita.
[b] Reference location downstream from 100-B/C Area.
- = Not sampled

Up to five crayfish will be collected and separately analyzed for selected contaminants from each primary transect. Target tissues (whole body and hepatopancreas) will be prepared for chemical analyses; however, only one composite sample of crayfish carcass will be prepared and

submitted for radiological analysis. Biological measures relevant to the health of crayfish will be recorded for each animal captured. Histological examinations will be conducted on hepatopancreas, gonads, and gills. Weight, length, and sex will be recorded. Population parameters include live density estimates.

Bivalves, such as Asian clams (*Corbicula fluminea*), are assumed to be one of the best sentinel organisms in the aquatic environment on the Hanford Reach of the Columbia River. The organisms were found to be the most sensitive indicators of elevated contamination from Hanford Site sources in the biotic environment during the 300 Area near-shore characterization report (Patton et al. 2001). Clams are immobile and, as filter feeders, have the highest potential to accumulate both dissolved and particulate phase contaminants. Bivalves will be collected from each of the five primary transect areas along the 100-B/C Area shoreline and at the upstream and downstream reference areas for COC analysis and health screening. In addition, bivalves will be systematically collected (two to five individuals per sample) along a water depth gradient perpendicular to the shoreline beginning at the low-flow water mark and archived. On each transect, composites of bivalve shells will be collected for radiological analyses. Samples will be collected within each persistent spring at 0.0 m depth for COC analyses. A compass bearing from 0.0 will be taken perpendicular to the river channel, and the remaining samples will be collected along that subtransect at 0.25 m, 0.5 m, 1.0 m, 1.5 m, and 2.0 m depth, beginning at the low-water mark for archiving. Biological measures relevant to the health of clams will be recorded for each animal captured. Histological examinations will be conducted on whole organisms. Weight, length, and sex will be recorded. Population parameters include live density estimates.

3.5.2.3 Macrophytes and Periphyton. A number of different species of macrophytes exist throughout the Hanford Reach of the Columbia River. Macrophytes are most frequently found in areas associated with silt-covered substrate and low water velocities. Spike watermilfoil (*Myriophyllum spicatum*) may be the macrophyte most easily collected. Single composite samples of milfoil will be collected, if available, in the immediate vicinity of each primary transect and at the downstream and upstream reference locations (Table 3-14). Adequate sample masses of macrophytes can usually be collected for analysis wherever substrate and water velocities are suitable for macrophytic communities.

Periphyton consists primarily of a community of algae and diatoms that grow on solid substrate within the photic zone of the river shoreline. Small invertebrates and bacteria may reside in this community. Past sampling efforts of periphyton and evaluation of metals data suggest that the separation of biomass from sediment particles may be problematic. Periphyton is included in this sample plan (Table 3-14); however, efforts will be made to devise more effective means for sample collection and preparation to minimize or quantify sediment contamination. Only metal analyses will be performed for periphyton, as sample weights will likely be too low for radiological analyses.

Biological health metrics will not be collected on macrophytes or periphyton.

Table 3-14. Near-Shore River Zone Sampling for Macrophytes and Periphyton. (2 Pages)

Location	Radionuclides								Chemicals		
	Americium-241	Plutonium-238, 239/240	Carbon-14	Nickel-63	Strontium-90	Tritium (H-3)	Technetium-99	Gamma	Semi-VOAs	Metals	PCBs
Aquatic Plants (Milfoil)											
Reference location [a]	-	-	-	-	1	-	1	1	-	3	-
Seep 037-1/038-1	-	-	-	-	1	-	1	1	-	1	-
Seep 039-1	-	-	-	-	1	-	1	1	-	1	-
Outfall 1	-	-	-	-	1	-	1	1	-	1	-
Outfall 2	-	-	-	-	1	-	1	1	-	1	-
Outfall 3	-	-	-	-	1	-	1	1	-	1	-
Reference location [b]	-	-	-	-	1	-	1	1	-	1	-
Subtotal	**0**	**0**	**0**	**0**	**7**	**0**	**7**	**7**	**0**	**9**	**0**
Periphyton											
Reference location [a]	-	-	-	-	-	-	-	-	-	1	-
Seep 037-1/038-1	-	-	-	-	-	-	-	-	-	1	-
Seep 039-1	-	-	-	-	-	-	-	-	-	1	-
Outfall 1	-	-	-	-	-	-	-	-	-	1	-
Outfall 2	-	-	-	-	-	-	-	-	-	1	-
Outfall 3	-	-	-	-	-	-	-	-	-	1	-
Reference location [b]	-	-	-	-	-	-	-	-	-	1	-
Subtotal	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**7**	**0**
Total	**0**	**0**	**0**	**0**	**7**	**0**	**7**	**7**	**0**	**16**	**0**

[a] Reference location upstream near Vernita.
[b] Reference location downstream on 100-B/C Area.
- = Not sampled

3.6 SAMPLE HANDLING, SHIPPING, AND CUSTODY REQUIREMENTS

All field sample handling, shipping, and custody requirements will be consistent with established PNNL procedures (PNL-MA-580). Sample transportation shall be in compliance with applicable regulations for packaging, marking, labeling, and shipping of hazardous materials, hazardous substances, and hazardous waste mandated by the U.S. Department of Transportation (49 *Code of Federal Regulations* 171-177) in association with the International Air Transportation Authority, U.S. Department of Energy requirements, and applicable program-specific implementing procedures. Sample custody during laboratory analysis is addressed in the applicable laboratory SOPs. Laboratory custody procedures will ensure that sample integrity and identification are maintained throughout the analytical process.

3.7 SAMPLING AND ONSITE ENVIRONMENTAL MEASUREMENT PROCEDURES

Procedures for field measurements are specified in the subcontractor's or manufacturer's manuals. The sampling and onsite environmental measurement procedures to be implemented in the field will be consistent with established PNNL procedures (PNL-MA-580).

3.8 SAMPLE MANAGEMENT

Sample management activities shall be consistent with established PNNL procedures.

3.9 MANAGEMENT OF INVESTIGATION-DERIVED WASTE

Waste generated by sampling activities will be managed consistent with an established waste management plan. Unused samples and associated laboratory waste for analysis will be dispositioned in accordance with the laboratory contract and agreements for return to the Hanford Site. In accordance with 40 *Code of Federal Regulations* 300.440, Remedial Project Manager approval is required before returning unused samples or waste from offsite laboratories.

4.0 HEALTH AND SAFETY

All field operations will be performed consistent with PNNL health and safety requirements and the requirements of the *Hanford Site Radiological Control Manual* (DOE-RL 1996). Where necessary, a work planning package will be prepared that will further control site operations. The work planning package will include, as appropriate, a job hazard analysis, and/or a site-specific health and safety plan, and applicable radiological work permits.

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 the *Hanford Site Radiological Control Manual* (DOE-RL 1996).

5.0 REFERENCES

40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," *Code of Federal Regulations*, as amended.

49 CFR 171, "General Information, Regulations, and Definitions," *Code of Federal Regulations*, as amended.

49 CFR 172, "Office of Hazardous Materials Transportation Color Tolerance Charts and Tables," *Code of Federal Regulations*, as amended.

49 CFR 173, "Shipper's--General Requirements for Shipments and Packaging," *Code of Federal Regulations*, as amended.

49 CFR 174, "Carriage by Rail," *Code of Federal Regulations*, as amended.

49 CFR 175, "Carriage by Aircraft," *Code of Federal Regulations*, as amended.

49 CFR 176, "Carriage by Vessel," *Code of Federal Regulations*, as amended.

49 CFR 177, "Carriage by Public Highway," *Code of Federal Regulations*, as amended.

ANL, 2002, *RESRAD for Windows*, Version 6.21, Argonne National Laboratory, Environmental Assessment Division, Argonne, Illinois.

BHI-EE-01, *Environmental Investigations Procedures*, Bechtel Hanford, Inc., Richland, Washington.

BHI-EE-05, *Field Screening Procedures*, Bechtel Hanford, Inc., Richland, Washington.

BHI, 1999, *Cleanup Verification Package for the 116-C-1 Process Effluent Trench*, CVP-98-00006, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

BHI, 2002, *A Preliminary Evaluation of Post-Remediation Protectiveness of Humans and the Environment at the 100-B/C Area*, BHI-01669, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

BHI, 2003, *100-B/C Ecological Risk Assessment Data Quality Objectives*, BHI-01673, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 U.S.C. 601, et seq.

DOE-ORNL, 2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*, DOE-STD-1153-2002, U.S. Department of Energy, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

DOE-RL, 1992, *Remedial Investigation/Feasibility Study Work Plan for the 100-BC-1 Operable Unit*, DOE/RL-90-07 Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1993a, *Remedial Investigation/Feasibility Study Work Plan for the 100-BC-5 Groundwater Operable Unit*, DOE/RL-90-08, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1993b, *Remedial Investigation/Feasibility Study Work Plan for the 100-BC-2 Operable Unit*, DOE/RL-91-07, Rev.0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1994a, *Limited Field Investigation Report for the 100-BC-1 Operable Unit*, DOE/RL-94-42, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1994b, *Limited Field Investigation Report for the 100-BC-2 Operable Unit*, DOE/RL-97-01, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1994c, *Limited Field Investigation Report for the 100-BC-5 Operable Unit*, DOE/RL-93-37, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1996, *Hanford Site Radiological Control Manual* (HSRCM), DOE/RL-96-109, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1998, *Hanford Analytical Services Quality Assurance Requirements Documents*, DOERL-96-68, Rev. 2, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2001, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*, DOE/RL-92-24, Rev. 4, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2002a, *300-FF-5 Operable Unit Sampling and Analysis Plan*, DOE/RL-2002-11, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2002b, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, DOE/RL-96-17, Rev. 4, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Ecology, EPA, and DOE, 2002, *Hanford Federal Facility Agreement and Consent Order*, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

EPA, 1986a, *Test Methods for Evaluating Solid Waste: Physical and Chemical Methods*, SW-846, 3rd Edition, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1986b, *RCRA Ground Water Monitoring Technical Enforcement Guidance Document*, EPA 530/SW-86-055 (OSWER-9950.1), U. S. Environmental Protection Agency, Washington, D.C.

EPA, 1994, *Guidance for the Data Quality Objectives Process*, EPA QA/G-4, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1995, *Record of Decision for the 100-BC-1, 100-DR-1 and 100-HR-1 Operable Units, Hanford Site, Benton County, Washington*, U.S. Environmental Protection Agency, Region 10, Seattle, Washington.

EPA, 1996, *Guidance for Data Quality Assessment*, EPA QA/G-9, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1999, *Interim Action Record Of Decision: 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6 AND 200-CW-3 Operable Units, Hanford Site, Benton County, Washington*, U.S. Environmental Protection Agency, Region 10, Seattle, Washington

Landeen, D.S., M. R. Sackschewsky, and S. G. Weiss, 1992, *100 Area CERCLA Ecological Investigations*, WHC-EP-0620, Westinghouse Hanford Company, Richland, Washington.

Patton, G. W. S. P. Van Verst, B. L. Tiller, E. J. Antonio, and T. M. Poston, 2002, *Survey of Radiological and Chemical Contaminants in the Near-Shore Environment at the Hanford Site 300 Area*, PNNL-13692, Pacific Northwest National Laboratory, Richland, Washington.

PNNL, 2000, *Surface Environmental Surveillance Procedures Manual*, PNL-MA-580, Rev. 3, Pacific Northwest National Laboratory, Richland, Washington.

PNNL, 2002, *Quality Assurance Project Plan for the Hanford Site Surface Environmental Surveillance Project (SESP) and the Drinking Water Monitoring Project (DWMP)*, ETD-011, Rev. 4., Pacific Northwest National Laboratory, Richland, Washington.

WAC 173-340, "Model Toxics Control Act -- Cleanup," *Washington Administrative Code*.

Weiss, S. G. and R. M. Mitchell, 1992, *A Synthesis of Ecological Data from the 100 Areas of the Hanford Site*, WHC-EP-0601, Westinghouse Hanford Company, Richland, Washington.

APPENDIX A

SOIL SCREENING VALUES FOR PROTECTION OF ECOLOGICAL AND HUMAN RECEPTORS IN THE 100-B/C AREA

APPENDIX A

SOIL SCREENING VALUES FOR PROTECTION OF ECOLOGICAL AND HUMAN RECEPTORS IN THE 100-B/C AREA

Table A-1. Radionuclide Soil Screening Values.

Radionuclide	Hanford Site Background Value (pCi/g)[a]	BCG (pCi/g)[b]	Human Health Action Level (pCi/g)[c]
Americium-241	--	4,000	31.1
Carbon-14	--	--	50.0
Cesium-137	1.1	20	6.2
Cobalt-60	0.008	700	1.4
Europium-152	--	1,400	3.3
Europium-154	0.33	1,000	3.0
Europium-155	0.054	20,000	125
Nickel-63	--	--	4,026
Plutonium-238	0.004	5,400	37.4
Plutonium-239/240	0.025	6,000	33.9
Silver-108m	--	--	2.38
Strontium-90	0.18	20	4.5
Technetium-99	--	4,000	15.0
Thorium-232	1.3	2,000	1.3
Tritium	--	--	400
Uranium-233/234	1.1	5,000	1.1
Uranium-235	0.11	3,000	1.0
Uranium-238	1.1	2,000	1.1

[a]Background concentrations are the 90th percentile values of the lognormal distribution of sitewide soil background data. Source: *Hanford Site Background: Part 2. Soil Background for Radioactive Analytes* (DOE-RL 1996).
[b]Source: *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*, DOE-STD-1153-2002 (DOE 2002).
[c]The most conservative of direct exposure, groundwater, and river protection values is used. However, if that value is less than background, then the background value is used. Source: *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (DOE-RL 2002).
-- = Value not available
BCG = biota concentration guide DOE (2002)

Table A-2. Chemical Soil Screening Values.

Chemical COPC	Hanford Site Background Value (mg/kg)[a]	Ecological Soil Screening Values[b] (mg/kg)			Human Health Action Level[c] (mg/kg)	COPC Screening Value (mg/kg)	
		P	SB	WL		Eco[d]	HH[c]
Metals							
Barium	132	500	--	102	132	102	132
Cadmium	0.81[e]	4	20	14	0.81[e]	4	0.81[e]
Chromium	18.5[f]	42	42	67	18.5[f]	42	18.5[f]
Chromium (VI)	18.5[f]	--	--	--	2.2	--	2.2
Lead	10.2	50	100	118	10.2	50	10.2
Mercury (inorganic)	0.33	0.3	0.1	5.5	0.33	0.33	0.33
Mercury (organic)	--	--	--	0.4	--	0.4	--
Nickel	19.1	30	200	980	130	30	130
Selenium	0.78[e]	1	70	0.3	400	1	400
Silver	0.73	2	--	--	400	2	400
Uranium	TBD	5	--	--	3	5	3
Organics							
Aroclor-1254[g]	--	40[g]	--	0.65[g]	0.5[g,h]	0.65[g]	0.5[g,h]
Aroclor-1260[g]	--	40[g]	--	0.65[g]	0.5[g,h]	0.65[g]	0.5[g,h]

[a]Background concentrations are the 90th percentile values of the lognormal distribution of sitewide soil background data. Source: *Hanford Site Background: Part 2. Soil Background for Nonradionuclides* (DOE-RL 1995).
[b]Ecological soil screening values in accordance with WAC 173-340-900, Table 749-3.
[c]The most conservative of direct exposure, groundwater, and river protection values is used. However, if that value is less than background, then the background value is used. Source: *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (DOE-RL 2002).
[d]The most conservative of the plant, soil biota, and wildlife ecological screening levels. However, if that value is less than background, then the background value is used.
[e]Hanford Site-specific background value was not evaluated during the background study. The value shown is from Ecology (1994).
[f]Chromium is measured as total chromium.
[g]Values shown for aroclors are total values to be applied to all detected PCB mixtures within each category.
[h]PCB mixture values, calculated in accordance with WAC 173-340-740(3)(a)(iii)(B).
-- = Value not available.
BCG = biota concentration guide (DOE 2002)
Eco = ecological protection value
HH = human health protection value
P = plants
SB = soil biota
TBD = to be determined
WL = wildlife

REFERENCES

DOE, 2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*, DOE-STD-1153-2002, U.S. Department of Energy, Washington, D.C.

DOE-RL, 1995, *Hanford Site Background: Part 1. Soil Background for Nonradioactive Analytes,* DOE/RL-92-24, Rev. 3, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1996, *Hanford Site Background: Part 2. Soil Background for Radioactive Analytes,* DOE/RL-96-12, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2002, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, DOE/RL-96-17, Rev. 4, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

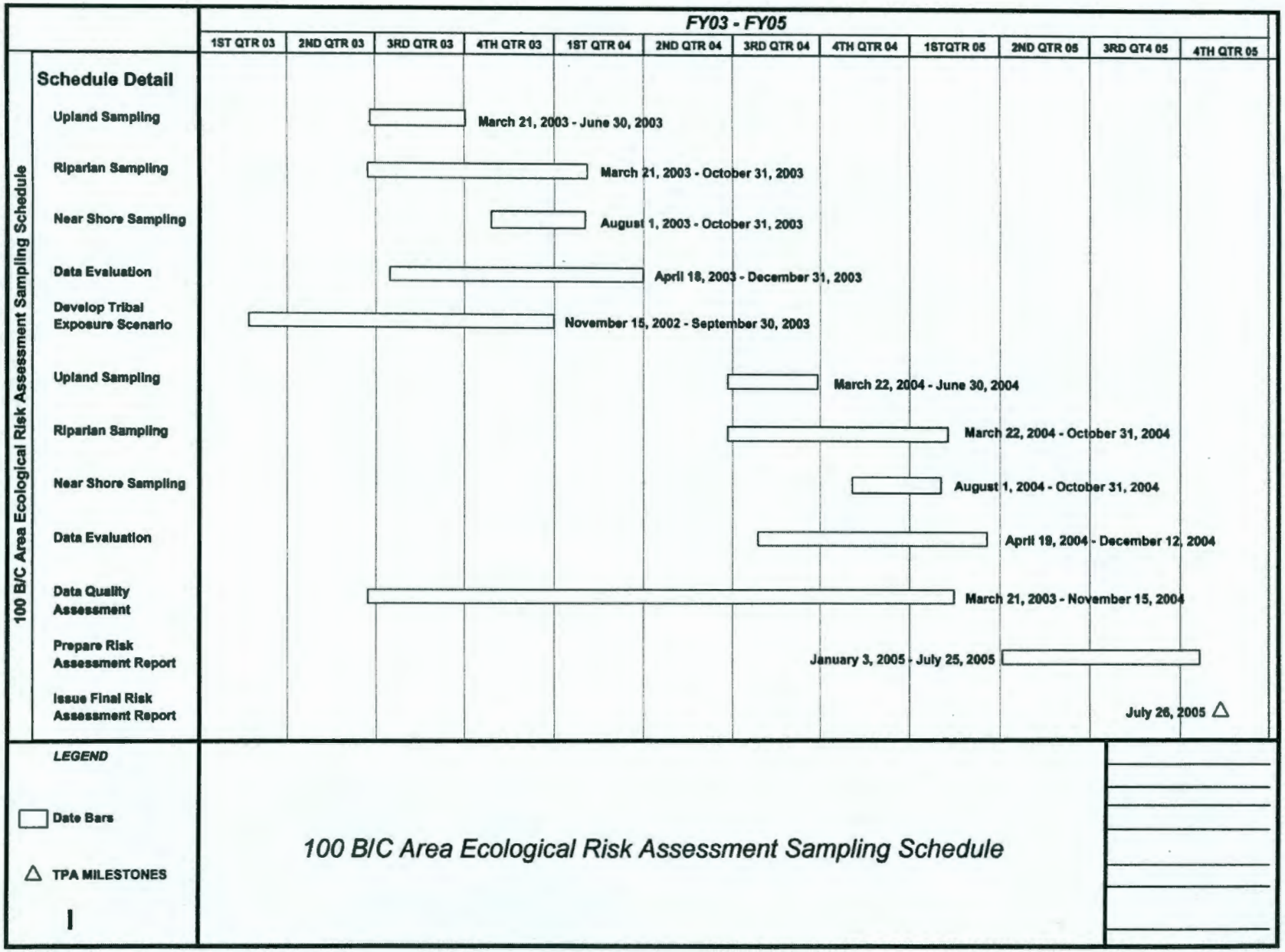
Ecology, 1994, *Natural Background Soil Metals Concentrations in Washington State*, Publication #94-115, Washington State Department of Ecology, Olympia, Washington.

WAC 173-340-740, "Unrestricted Land Use Soil Cleanup Standards," *Washington Administrative Code*, as amended.

WAC 173-340-7490, "Terrestrial Ecological Evaluation Procedures," *Washington Administrative Code*, as amended.

APPENDIX B

100-B/C AREA ECOLOGICAL RISK ASSESSMENT SAMPLING AND DATA EVALUATION SCHEDULE


FY03 - FY05
1ST QTR 03
2ND QTR 03
3RD QTR 03
4TH QTR 03
1ST QTR 04
2ND QTR 04
3RD QTR 04
4TH QTR 04
1STQTR 05
2ND QTR 05
3RD QT4 05
4TH QTR 05
100 B/C Area Ecological Risk Assessment Sampling Schedule
Schedule Detail
Upland Sampling
March 21, 2003 - June 30, 2003
Riparian Sampling
March 21, 2003 - October 31, 2003
Near Shore Sampling
August 1, 2003 - October 31, 2003
Data Evaluation
April 18, 2003 - December 31, 2003
Develop Tribal Exposure Scenario
November 15, 2002 - September 30, 2003
Upland Sampling
March 22, 2004 - June 30, 2004
Riparian Sampling
March 22, 2004 - October 31, 2004
Near Shore Sampling
August 1, 2004 - October 31, 2004
Data Evaluation
April 19, 2004 - December 12, 2004
Data Quality Assessment
March 21, 2003 - November 15, 2004
Prepare Risk Assessment Report
January 3, 2005 - July 25, 2005
Issue Final Risk Assessment Report
July 26, 2005
LEGEND
Date Bars
TPA MILESTONES
100 B/C Area Ecological Risk Assessment Sampling Schedule