River Corridor Closure Contract

100 Area and 300 Area Component of the River Corridor Baseline Risk Assessment Spring 2006 Data Compilation

November 2006

Washington Closure Hanford

Prepared for the U.S. Department of Energy, Richland Operations Office
Office of Assistant Manager for River Corridor

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REVISION HISTORY

Revision	Date	Reason for revision	Revision initiator
0	11/2006	Initial issuance	NA

ACRONYMS

APEL	Applied Process Engineering Laboratory
ASL	Analytical Services Laboratory
ASTM	<i>American Society for Testing and Materials</i>
CERCLA	<i>Comprehensive Environmental Response, Compensation, and Liability Act of 1980</i>
cfs	cubic feet per second
COPEC	contaminant of potential ecological concern
EAS	Environmental Assessment Services
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FETAX	Frog Embryo Teratogenesis Assay-Xenopus
GPS	global positioning system
HEPA	high-efficiency particulate air
MIS	multi-increment sampling
OU	operable unit
RCBRA	River Corridor Baseline Risk Assessment
SAF	Sample Authorization Form
SAI	sampling and analysis instructions
SAP	sampling and analysis plan
STL	Severn-Trent Laboratories
SVOA	semivolatile organic analyses
TLD	Thermoluminescent Dosimeter
T & E	threatened and endangered
VSP	Visual Sample Plan
WCH	Washington Closure Hanford, LLC

1.0 INTRODUCTION

1.1 PURPOSE

This report has been prepared in support of the 100 Area and 300 Area Component of the River Corridor Baseline Risk Assessment (RCBRA). The general scope of the 100 Area and 300 Area component is to evaluate contaminant exposure pathways and consequent human health and ecological risks to receptors in the upland, riparian, and near-shore river zones of 100 Area and 300 Area source operable units (OUs) and associated plumes, based on a range of reasonably anticipated and "bounding" (e.g., rural-residential) future land uses. The baseline risk assessment will be conducted under guidance established in the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA). A key to establishing final cleanup decisions and proceeding toward final CERCLA closeout of the river corridor is the completion of quantitative baseline risk assessment activities. The baseline risk assessment is necessary to determine whether cleanup actions are protective of human health and the environment and to identify any course corrections needed to ensure that current and future cleanup actions are protective.

Environmental data to be used for the baseline risk assessment will be derived from several historical sources, including verification samples previously collected and analyzed following cleanup actions at individual waste sites; selected groundwater data; and from supplemental environmental sampling and analysis activities by Washington Closure Hanford, LLC (WCH). The first of two sampling activities was initiated October 2005 and concluded December 2005. During this time, a portion of the multi-increment sampling (MIS) of soil and groundwater samples were collected. A summary of the fall 2005 effort is presented in *100 Area and 300 Area Component of the RCBRA Fall 2005 Data Compilation* (WCH 2006a). The second activity of sampling is referred to as the "spring 2006" sampling effort.

The purpose of this report is to describe the sampling approaches, modifications made to the *100 Area and 300 Area Component of the RCBRA Sampling and Analysis Plan* (DOE-RL 2006a), herein referred to as the "SAP," summarize validation efforts, and provide sample identification numbers. This spring 2006 sampling report is intended as a follow-on document to the fall 2005 data compilation (WCH 2006b) and provides a synopsis of the field work conducted from January 2006 to September 2006. Together, the fall and spring data compilation reports describe the supplemental data collection effort in support of the 100 Area and 300 Area Component of the RCBRA.

1.2 SCOPE

The scope of the 100 Area and 300 Area Component of the RCBRA includes riparian and near-shore river zones near the 100-K, 100-D, 100-H, and 100-F Reactor areas; the Hanford Townsite (100-IU-6 OU); the White Bluffs Townsite (100-IU-2 OU) and the 300 Area. Upland areas are located at the 100-B/C, 100-K, 100-N, 100-D, 100-H, and 100-F Reactor areas; the White Bluffs and Hanford Townsites; and the 300 Area.

2.0 SAMPLING OVERVIEW

Since January 1, 2006, additional sites were sampled for groundwater and soil (multi-incremental sampling [MIS]). Exclusive to the spring 2006 sampling effort (Figure 2-1), discrete soils (grab samples), sediment, pore water (aquifer tube water), surface water, and biota were also sampled (Figures 2-2 and 2-3). Soils were characterized using physical parameters such as texture, moisture, angularity, and color. Biota data collected included herbaceous and shrub vegetation cover estimation as well as identification of threatened and endangered plant species. Biota sampled includes dominant plant species, small mammals, kingbirds, aquatic invertebrates, clams, terrestrial invertebrates, and sculpin. Bioassays were performed on pore water, surface water, sediment samples, and soil. Thermoluminescent Dosimeters (TLDs) were collected and analyzed for site-specific levels of total background radiation. Sampling was conducted in accordance with the *Sampling and Analysis Instructions for the 100 Area and 300 Area Component of the RCBRA Project* (WCH 2006a) (herein referred to as the “SAI”). The SAI describes the detailed sampling and analysis activities that were performed.

Table 2-1 provides the effort (sample collection or information gathering) type and associated start and end dates. The sampling effort and any modifications to the SAP (DOE-RL 2006a) or SAI (WCH 2006a) are described further in the following sections.

2.1 SITE PREPARATION

As part of the fall 2005 activities, 20 upland and 10 riparian study sites were staked with metal posts; the upland sites were staked at each corner and center, and the riparian sites were staked at each end and center point. These sites were chosen based on several factors, including the type of remediation (e.g., complete excavation and backfill, or spot cleanup with no backfill), amount of vegetation, amount of residual contaminants left after meeting the cleanup criteria, and geographic distribution throughout the study area. In addition, 10 upland reference and 5 riparian reference sites were staked and chosen based on their similarities in soil and vegetation characteristics, distribution across the Hanford Site, and distance from the waste sites. TLDs were placed at each stake during the fall 2005 effort for collection in the spring after remaining for at least 6 months at each site. The upland sites were positioned with the intent to maximize both relative homogeneity of habitat and regularity of shape (as rectangular as possible) to ease the planning, collection, and reporting subsequent sampling. The riparian sites were pin flagged at the upper and lower boundaries of the riparian zone to help delineate the borders within which to sample. Small mammal and invertebrate sampling was conducted by use of live traps distributed near the center of the sites. The mammal traps were placed to accommodate the shape of the investigation area at 10 m (33 ft) intervals near the center.

Figure 2-1. Multi-Increment Sampling Locations for Spring 2006 Effort.

Figure 2-2. Discrete Soil Sampling Locations for the Spring 2006 Effort.

Figure 2-3. Sediment, Pore and Surface Water Sampling Locations for the Spring 2006 Effort.

Table 2-1. Spring 2006 Effort Type, Start, and Completion Dates.

Effort	Sample/Survey Start Date	Completion Date
Multi-incremental Sampling of Soil	3/13/2006	7/28/2006
Groundwater (Samples)	6/1/2006	6/26/2006
Discrete Soil (Samples)	6/19/2006	6/20/2006
River Sediment (Samples)	2/5/2006	2/27/2006
Pore (Aquifer Tube) Water (Samples)	1/16/2006	9/17/2006
Surface Water (Samples)	1/16/2006	2/6/2006
Plant Cover Estimation	4/27/2006	7/30/2006
Threatened and Endangered Plant Surveys	10/24/2005	5/30/2006
Dominant Plant Species (Samples)	4/24/2006	8/10/2006
Small Mammals (Samples)	3/14/2006	4/21/2006
Kingbirds (Samples)	6/19/2006	8/8/2006
Kingbird Nesting Success Survey	5/23/2006	8/1/2006
Aquatic Invertebrates (Samples)	7/23/2006	7/31/2006
Aquatic Invertebrate Community Structure Survey	7/23/2006	7/31/2006
Terrestrial Invertebrates (Samples)	3/16/2006	8/9/2006
Asiatic Clams (Samples)	7/23/2006	7/31/2006
Asiatic Clam Histopathology	8/8/2006	8/10/2006
Sculpin (Samples)	2/6/2006	2/23/2006
Sculpin Histopathology	2/27/2006	6/30/2006
Dosimeter Collection	4/24/2006	5/8/2006

Thirty aquatic sites were selected based on the known uranium, chromium, and strontium-90 groundwater plumes, results of the 2005 conductivity survey, and past biota sampling locations and results (especially clams). The sampling sites were located throughout the 300 Area (uranium plume), 100-D and 100-K Areas (chromium plumes), and 100-N Area (strontium-90 plume) to capture a range of conditions. An additional seven reference aquatic sites were chosen, with two upriver of the 300 Area uranium plume and an additional five upriver of the 100-B/C Area on both sides of the river. Pore water was collected out of horizontal and vertical aquifer tubes. These tubes were installed in hand-dug trenches to a depth of 10 cm (6 in.) below the riverbed. Clam tubes and rock baskets were co-located with the aquifer tubes. Clam tubes were placed on the riverbed surface and anchored by use of surrounding rocks or staking. Rock baskets were placed halfway into the unconsolidated substrate by hand digging a hole and backfilling against them. The locations of all the upland, riparian, and aquatic sites are presented in Appendix A.

2.2 SOIL

Two soil sampling events occurred during the spring 2006 effort: MIS of soil and grab sampling of discrete soil. Details regarding methodology for sample collection and associated bioassay testing are discussed below.

2.2.1 Multi-Increment Sampling (MIS) Methodology

MIS is a sampling methodology used to more accurately estimate the true average concentrations of constituents in an investigation area through the collection of a limited number of samples. The RCBRA used MIS to evaluate residual contaminant concentrations in the soil fraction less than or equal to 2 mm (0.8 in.) in size, consistent with the “Model Toxics Control Act – Cleanup” regulation (*Washington Administrative Code* 173-340). Samples were collected in accordance with the *Instruction for Multi-Incremental Soil Sampling and Laboratory Subsampling for 100 Area and 300 Area Component of the River Corridor Baseline Risk Assessment* (WCH 2005).

For each sample, approximately 50 increments were collected within the identified upland and riparian zone investigation areas. Five samples were collected from each upland area (approximately 1 hectare [2.5 acres]) and riparian investigation area (200 m [656 ft] long of varying width). A map showing MIS spring sampling locations is provided in Figure 2-1. The shapes of the investigation areas varied depending on site-specific conditions and the shape of the associated waste site. The coordinates and area of each site are presented in Appendix A. Organic matter (e.g., vegetation and scat) of varying amounts was present at the sites and was removed prior to sample collection or during the sieving process after capturing any attached soil. To facilitate the sieving process, a stiff nylon bristle brush was used to break apart clumps of soil. Once the samples were collected, they were transported to the sample receiving facility (Building 3728) where they were logged in with a chain of custody and stored in a secured refrigerator at 4°C, prior to preparation for shipment.

Samples were sent to the CH2M HILL Analytical Services Laboratory (ASL) in Corvallis, Oregon, for drying and subsampling prior to being sent for chemical and radiological analyses. The chemical samples were sent to Lionville Laboratory, Inc. in Exton, Pennsylvania (Lionville) and the radiological samples were sent to Eberline Services in Richmond, California (Eberline). Samples for toxicity bioassays remained at ASL for subsequent Sandberg bluegrass (*Poa sandbergii*) and nematode (*Caenorhabditis elegans*) testing. Samples had an approximate 45-day turnaround time.

Additional sampling was conducted at one location that was previously sampled in fall 2005. Fall results from the MIS of soil at Riparian #13, an upriver reference area (west of Vernita Bridge on the south side of the river), showed elevated chromium-VI (Cr-VI), in addition to other metals such as zinc, tin, arsenic, and uranium. The probable cause of the elevated Cr-VI was due to the dilution factor applied to the samples causing a method detection problem. The site was re-sampled and analyzed for both Cr-VI and the entire metals suite (excluding mercury) during the spring 2006 effort. To validate these additional laboratory results, a split sample with the Washington State Department of Ecology (Ecology) was performed. The five samples were sent to CH2M HILL ASL in Corvallis, Oregon, where the split was performed after drying. Ecology's samples were sent to Paragon Analytics, Inc. in Fort Collins, Colorado. Washington Closure Hanford's samples were sent to Lionville.

2.2.1.1 Bioassays. Bioassays of MIS of soil were conducted on Sandberg bluegrass and nematodes. The chronic test methods for Sandberg bluegrass were performed according to the “Standard Guide for Conducting Terrestrial Plant Toxicity Tests”, *American Society for Testing and Materials* (ASTM) E1963-02. Bluegrass seeds were obtained from Native Grass Seeds, Cornville, Arizona, and all test conditions were maintained during planting, germination, and growth phases of the test as prescribed by the ASTM protocol. Hydration was accomplished via subirrigation. The concentration tested in the bluegrass tests were 100% test sample with control soil (70 grade silica) alone for the control. For the bluegrass tests, 50 seeds per concentration were used with five replicate test chambers per concentration and 10 seeds planted per chamber.

Following germination, test chambers were thinned as needed to a maximum five seedlings per replicate. Tests were terminated 14 days post germination. The number of seedlings, shoot appearance and height, and root appearance and length was recorded. Percent survival, wet and dry weight for shoots, roots and total mass, shoot height and root length were recorded. Statistical analyses for each measurement were calculated from each replicate; each replicate was also compared to the laboratory control.

The chronic test methods for nematodes (*Caenorhabditis elegans*) were performed according to the “Standard Guide for Conducting Laboratory Soil Toxicity Tests with the Nematode *Caenorhabditis elegans*,” ASTM E2172-01. The nematodes used were obtained from CH2M HILL’s in-house cultures and were age synchronized as 4-day-old organisms at test initiation. All organisms tested were fed and maintained during culturing, acclimation, and testing as prescribed by the ASTM protocol. The concentrations tested in the nematode test were 100% test sample with control soils (70 grade silica) alone for the control. For the nematode test, 30 organisms per concentration were used with 3 test chambers per concentration and 10 organisms per chamber. Tests were terminated after 24 hours. The endpoint measured was percent survival over the 24-hour exposure period. Statistical analyses for each result were obtained comparing the survival data between the control and each test soil.

2.2.2 Multi-Increment Sampling Collection

Table 2-2 presents the investigation area, habitat type, parent sample identification number used to generate the bioassay sample, the bioassay sample identification number and date the parent mass was collected.

**Table 2-2. Summary of Multi Incremental Soil Samples Collected During Spring 2006.
(3 Pages)**

Investigation Area	Habitat Type	Parent Mass Sample ID Numbers	Bioassay Sample ID Numbers	Date Parent Mass was Collected
100-D-48:2	Upland	J11JT1 – J11JT5	J11JT0	19-Apr-06
100-D-49:2	Upland	J11JV9, J11JW0 – J11JW3	J11JV8	20-Apr-06
116-F-1	Upland	J11JW5 – J11JW9	J11JW4	25-26-Apr-06

**Table 2-2. Summary of Multi Incremental Soil Samples Collected During Spring 2006.
(3 Pages)**

Investigation Area	Habitat Type	Parent Mass Sample ID Numbers	Bioassay Sample ID Numbers	Date Parent Mass was Collected
116-N-3	Upland	J11JV3 – J11JV7	J11JV2	23-May-06
1607-D2:1	Upland	J11JY3 – J11JY7	J11JY2	24-25-Apr-06
1607-H2	Upland	J11JT7 – J11JT9, J11JV0, J11JV1	J11JT6	23-May-06
300-44/618-4	Upland	J11JX1 – J11JX5	J11JX0	5-Jun-06
300-49	Upland	J11JX7 – J11JX9, J11JY0, J11JY1	J11JX6	18-Apr-06
600-132/600-190	Upland	J11K29 – J11K33	J11K28	12-Apr-06
600-139	Upland	J11K35 – J11K39	J11K34	10-11-Apr-06
600-171	Upland	J11K68 – J11K72	J11K67	1-May-06
600-181	Upland	J11K56 – J11K60	J11K55	2-May-06
600-204	Upland	J11K41 – J11K45	J11K40	17-Apr-06
600-208	Upland	J11K47 – J11K51	J11K46	26-Apr-06
600-23	Upland	J11K23 – J11K27	J11K22	24-May-06
628-1	Upland	J11K62 – J11K66	J11K61	13-Apr-06
Pit 14	Upland	J11K05 – J11K09	J11K04	8-May-06
Pit 18	Upland	J11K11 – J11K15	J11K10	4-May-06
Pit 24	Upland	J11K17 – J11K21	J11K16	30-May-06
Pit 9	Upland	J11JY9, J11K01 – J11K03	J11JY8	31-May-06
McGee Ranch	Upland	J11K98, J11K99, J11KB0 – J11KB2	J11K97	18-May-06
Saddle Mountain	Upland	J11KC6 – J11KC9, J11KD0	J11KC5	3-May-06
Vernita Upriver South	Upland	J11K80 – J11K84	J11K79	31-May-06
Yakima Ridge II	Upland	J11K74 – J11K78	J11K73	27-Apr-06
Riparian #1	Riparian	J11JB9, J11JC4 – J11JC7	J11JB4	27-28-29-Mar-06
Riparian #2	Riparian	J11JC0, J11JD8, J11JD9, J11JF0, J11JF1, J11VD5, J11VD6	J11JB5	24-25-27-Mar-06
Riparian #4	Riparian	J11JC2, J11JF2 – J11JF5	J11JB7	16-18-Mar-06
Riparian #5	Riparian	J11JC3, J11JF6 – J11JF9	J11JB8	22-Mar-06
Riparian #6	Riparian	J11C1, J11JH0 – J11JH3	J11JB6	6-Apr-06
Riparian #7	Riparian	J11JJ1 – J11JJ5	J11JH4	23-24-Mar-06
Riparian #8	Riparian	J11JJ6 – J11JJ9, J11JK0	J11JH5	20-21-Mar-06

**Table 2-2. Summary of Multi Incremental Soil Samples Collected During Spring 2006.
(3 Pages)**

Investigation Area	Habitat Type	Parent Mass Sample ID Numbers	Bioassay Sample ID Numbers	Date Parent Mass was Collected
Riparian #9	Riparian	J11JK1 – J11JK5	J11JH6	29-30-Mar-06
Riparian #11	Riparian	J11JK6 – J11JK9, J11JL0	J11JH7	5-Apr-06
Riparian #12	Riparian	J11JL1 – J11JL5	J11JH8	22-23-Mar-06
Riparian #14	Riparian	J11JL6 – J11JL9, J11JM0	J11JH9	4-5-Apr-06
Riparian #16	Riparian	J11JN2 – J11JN6	J11JJ0	30-Mar-06; 3-Apr-06

2.2.3 Discrete Soil Sampling Methodology

Surveys for threatened and endangered (T & E) plant species were conducted at each of the upland and riparian sites. Based on the confirmation of T & E species, discrete soil samples were to be collected at each confirmed location. However, the plant surveys did not confirm the presence of T & E species. Therefore, known locations of historic (1997) T & E species were surveyed for comparison. These locations also lacked the presence of the T & E vegetation. Since many of these species rely on spring rain events, the lack of confirmed presence at both known locations and study sites could potentially be a result of low-effective rainfall during the past year. Effective rainfall is that which occurs at the correct timing and in the appropriate amount for individual plant species. Although the Hanford Site had above average precipitation in 2006, specific timing is critical for plant growth; it is assumed that rain events did not coincide with other factors that assist in germination (Table 2-3).

Sites, therefore, were evaluated for their potential to support the species based factors such as location, water source, aspect, soil type and existing vegetation. Portions of the following upland sites were identified as capable of supporting T & E plant species: 1607-D2:1, 116-DR-1 & 2, 600-139, 600-171, 600-181, and 300-44/618-4. For the upland zone, once the potential habitats were identified, 14 random sampling locations (13 samples + 1 duplicate) were distributed among the six sites. These locations were recorded using a global positioning system (GPS). A map showing discrete soil sample locations is provided in Figure 2-2.

Riparian habitat was determined unsuitable for listed species due to a combination of factors including current plant structure, aspect and soil type. However, T & E plants (*Rorippa columbiae*) were found in the near-shore zone above the 'green line.' The nearby discrete sediment samples will be used to evaluate habitat conditions for these species.

Table 2-3. Rainfall (inches) between 1996 and 2006^a.

Year	Jan – Mar	Apr – Jun	Jul – Sep	Oct - Dec
1996	3.47	1.1	0.38	7.24
1997	2.46	1.12	0.57	2.24
1998	2.89	1.07	0.48	2.01
1999	1.65	0.65	0.64	0.81
2000	3.15	1.59	1.02	2.32
2001	1.38	2.18	0.26	2.84
2002	1.28	1.1	0.17	2.86
2003	2.95	2.31	0.7	2.18
2004	3.4	1.92	1.12	1.52
2005	1.28	1.11	0.81	3.19
2006	1.83	1.87	Not available	Not available
Average ^b	2.09	1.51	0.75	2.45

^a Data from the Hanford Meteorological Station operated by the Pacific Northwest National Laboratory

^b Average is compiled from data over 59 years (1947 – 2005).

The sampling team used a stainless steel trowel to obtain samples from 0 cm to a maximum depth of 15 cm (6 in.). After removing rocks, vegetation, and debris from the surrounding area, the team used a 2 mm (0.8 in.) stainless steel soil sieve to remove all particles greater than this dimension. The parent soil sample was placed in a pre-cleaned 1-L (0.3 gal) amber glass wide-mouth bottle. The soil depths at which samples were obtained were recorded in the field logbook. Instruments were washed with Liqui-Nox® solution and deionized (deionized) water before collecting samples at a new location. Samples were sent to ASL for preparation to be sent to Lionville (chemical constituents) or Eberline (radiological constituents). Samples had an approximate 45-day turnaround time. Samples for a bluegrass toxicity bioassay were sent to ASL.

The chronic test methods for Sandberg bluegrass (*Poa sandbergii*) were performed according to ASTM E1963-02 as described in as described in Section 2.2.1.1. Because the objective of these samples was to evaluate the potential toxicity to T & E plants, the nematode bioassay was not run.

2.2.4 Discrete Soil Collection

The investigation area, parent sample identification number, bioassay sample identification number and parent sample collection date for each discrete soil sample is listed in Table 2-4.

Table 2-4. Summary of Discrete Soil Samples Collected During Spring 2006.

Investigation Area	Parent Sample ID Numbers	Bioassay Sample ID Numbers	Parent Sample Date Collected
116-DR 1 & 2	J12N81	J12N99	6/19/2006
1607-D2:1	J12N79, J12N80	J12N97, J12N98	6/19/2006
300-44/618-4	J12N90-J12N92	J12NB8, J12NB9, J12NC0	6/19/2006
600-139	J12N82	J12NB0	6/19/2006
600-171	J12N83 – J12N85	J12NB1 – 12NB3	6/20/2006
600-181	J12N86 – J12N89	J12NB4 – J12NB7	6/20/2006

2.2.5 Soil Classification

Soils were classified at each site was described using “Standard Practice for Description and Identification of Soils (Visual – Manual Procedure)” (ASTM D2488–00). Physical parameters such as soil color, moisture condition, consistency, percent cover by rock fragments (e.g., gravel, cobble, boulder), gradation, angularity, shape, and cementation were recorded. Soil type was determined using a textural triangle and the texture-by-feel procedure (Thein 1979.). Soil color was determined using Munsell Soil Color Charts. Moisture condition descriptions included dry (absence of moisture), moist (damp with no visible water), and wet (visible free water) conditions. Consistency varied from very soft, soft, firm, hard, and very hard. Percent cover by rock fragments was estimated as percent gravel, cobbles, and boulders. Gradation of coarse-grained particles ranged from well-graded to poorly graded. Angularity descriptions of coarse-grained particles included angular (sharp edges with relatively plane sides with unpolished surfaces, subangular (particles are similar to angular description, but have rounded edges), subrounded (particles have nearly plane sides, but have well-rounded corners and edges), and rounded (particles have smoothly curved sides and no edges). Shape of coarse-grained particles were flat (width: thickness >3), elongated (length: width >3), or both. Cementation was based on finger pressure amount: weak (crumbles or breaks with handling), moderate (crumbles or breaks with considerable finger pressure), and strong (will not crumble or break with finger pressure). Appendix B provides a summary of information collected during the soil texture surveys.

2.3 RIVER SEDIMENT

Sample collection of fine-grained near-shore Columbia River sediment locations were co-located with the aquatic biota and pore water sample locations. A map showing sediment (pore water and surface water) sample locations is in Figure 2-3.

Sediment grab samples were collected along the water’s edge of the shoreline. The upper and lower boundaries of this area corresponded to the approximately 70,000 cubic feet per second (cfs) to approximately 120,000 cfs flow of the Columbia River. The sediments were collected from between the rocks using pre-cleaned stainless steel scoops and transferred into a

plastic-lined Rubbermaid® tub where the entire contents were then mixed thoroughly with the scoops for approximately 1 minute. The subsamples of sediment were obtained by spreading out sediment from the tub onto a large stainless steel tray. The tray was then gridded (6 rows of 5 squares each) and 30 multi-incremental scoops of sediment were systematically collected and transferred to appropriate containers. All containers were labeled with collection location, date, and time and then immediately placed into a chilled cooler. In some cases, gravels and pebbles were screened out with a 2-mm (1-in.) stainless steel sieve that was decontaminated between each sample.

Sediment samples were used for analysis of the following groups: organic chemicals, inorganic chemicals (metals), radionuclides, quality indicators (e.g., pH and total organic carbon), and physical characteristics (e.g., particle size analysis). Samples were sent to ASL for preparation to be sent to Lionville (chemical constituents) or Eberline (radiological constituents). Samples for toxicity bioassays remained at ASL for the amphipod and Pak Choi tests. Samples had an approximate 45-day turnaround time.

2.3.1 Bioassays

Bioassays of MIS of sediment were conducted on Amphipod (*Hyalella azteca*) and Pak Choi (*Brassica chinensis*). The amphipod (*Hyalella azteca*) test methods were performed according to the “Standard Test Method for Measuring the Toxicity of Sediment-Associated Contaminants with Freshwater Invertebrates” (ASTM E1706-05) and “Methods for Measuring the Toxicity and Bioaccumulation of Sediment-Associated Contaminants with Freshwater Invertebrates – Second Edition (2000)” (EPA 600/R-99/064). The amphipods used in the sediment tests were obtained from Chesapeake Cultures, Naves, Virginia, and were 7 to 8 days old at test initiation. All organisms tested were fed and maintained during culturing, acclimation, and testing as prescribed by ASTM and the U.S. Environmental Protection Agency (EPA). The concentration in the *Hyalella azteca* tests was 100% sample sediment, with Beaver Creek sediment as laboratory control.

The effects measured during the amphipod chronic test included survival and growth over a 28-day exposure period. The amphipod tests were monitored at initiation and termination for dissolved oxygen, pH, conductivity, total hardness, alkalinity, ammonia, and temperature. During the tests, dissolved oxygen and pH were monitored every 3 days, conductivity measured every 7 days, and temperature was monitored every 24 hours. Statistical analyses for each result were obtained comparing the survival data between the control and each test sediment.

The Pak Choi (*Brassica chinensis*) test method was adapted from the *Phytotoxicity of Dredged Sediment from Urban Canal as Land Application*, Environmental Pollution 117 (2002) 233-241 (Chen et al.). Additional guidance was provided by *The Water-Culture Method for Growing Plants without Soil*, California Agricultural Experiment Station Circular No. 347 (Hoagland and Amon 1950). The Pak Choi seeds were obtained from Snow Seed Organic, Salinas, California. The control sediment was artificial sediment comprised of 70 grade silica sand, kaolin clay, and peat moss. Calcium carbonate was added to adjust soil pH to 7.0 ± 0.5 . Hydration was accomplished with deionized water and supplemental nutrients were supplied in accordance with test methods. The concentrations tested were 100% sample with artificial control sediment as the laboratory control.

Following sample preparation, four Pak Choi seeds were planted into each test chamber. Seeds were planted and water was sprayed onto the sediment surface to ensure seeds received moisture. Sediment pH was taken at test initiation and termination and temperature was monitored continuously throughout the 22-day testing period. On day 18, seedlings were transplanted in those test concentrations that had one or more test replicates with no germinated seeds and at least one replicate with more than one germinated seed. On day 22, test chambers that had more than one seedling growing were thinned to reduce the number of seedlings to one. For each test chamber, shoots were measured at wet and dry weights. Statistical analysis for each endpoint comprised of entering the data obtained from each replicate chamber of test sediment and comparing the result to the data from the replicate chambers of the laboratory control.

2.3.2 Sediment Collection

Sediment samples from two of the sites in the strontium plume (SR7 and SR8) did not have sufficient amounts for a sample. The sample identification numbers for Amphipod and Pak Choi bioassays, radiological and chemical constituents, and Cr-VI, date collected, and investigation area for each sediment sample collected is listed in Table 2-5.

Table 2-5. Summary of Sediment Samples Collected During Spring 2006.
(2 Pages)

Investigation Area	Bioassay Sample ID Numbers	Radiological ^a and Chemical ^b Sample ID	CR-VI ^c Sample ID Numbers	Date Collected
300-1	J11749	J11740	J11758	19-Feb-06
300-2	J11144	J11140	J11148	8-Feb-06
CR1	J112B3	J11298	J112B8	21-Feb-06
CR2	J112B4	J11299	J112B9	21-Feb-06
CR3	J112B5	J112B0	J112C0	21-Feb-06
CR4	J112B6	J112B1	J112C1	21-Feb-06
CR5	J112B7	J112B2	J112C2	12-Feb-06
CR6	J116M8	J116L8	J116N8	12-Feb-06
CR7	J116M6	J116L6	J116N6	21-Feb-06
CR8	J116M7	J116L7	J116N7	21-Feb-06
CR8	J11734	J11733	J11735	21-Feb-06
CR9	J116M4	J116L4	J116N4	12-Feb-06
CR10	J116M5	J116L5	J116N5	12-Feb-06
SR1	J116W9	J116V8	J116Y0	27-Feb-06
SR2	J116X3	J116W2	J116Y1	27-Feb-06
SR3	J116X2	J116W1	J116Y2	27-Feb-06

**Table 2-5. Summary of Sediment Samples Collected During Spring 2006.
(2 Pages)**

Investigation Area	Bioassay Sample ID Numbers	Radiological ^a and Chemical ^b Sample ID	CR-VI ^c Sample ID Numbers	Date Collected
SR4	J116X1	J116W0	J116Y3	27-Feb-06
SR5	J116X0	J116V9	J116Y4	27-Feb-06
SR6	J116X6	J116W5	J116Y7	27-Feb-06
SR9	J116W7	J116V6	J116X8	27-Feb-06
SR10	J116W8	J116V7	J116X9	27-Feb-06
U1	J11145	J11141	J11149	8-Feb-06
U2	J11146	J11142	J11150	8-Feb-06
U3	J11751	J11742	J11760	13-Feb-06
U4	J11746	J11737	J11755	19-Feb-06
U5	J11752	J11743	J11761	13-Feb-06
U6	J11745	J11736	J11754	13-Feb-06
U7	J11753	J11744	J11762	13-Feb-06
U8	J11750	J11741	J11759	13-Feb-06
U9	J11747	J11738	J11756	19-Feb-06
U10	J11748	J11739	J11757	19-Feb-06
Riparian #11	J11731	J11730	J11732	9-Feb-06
Riparian #12	J116N1	J116M1	J116P1	9-Feb-06
Riparian #12	J116N2	J116M2	J116P2	9-Feb-06
Riparian #13	J116N3	J116M3	J116P3	9-Feb-06
Riparian #14	J116N0	J116M0	J116P0	9-Feb-06
Riparian #16	J11143	J11139	J11147	5-Feb-06

^a Analyzed by Eberline Services.^b Analyzed by Lionville Laboratory.^c Analyzed by Severn Trent Laboratory.

2.4 WATER

Horizontal pore water sampling tubes were placed at each of the 37 aquatic sites, 10 to 15 cm (4 to 6 in.) below the riverbed and allowed to settle for at least a week before sampling began. Vertical pore water tubes were installed at two of the sites for comparison to historical values. Unfiltered surface water samples were collected to evaluate the wildlife drinking water pathway and to evaluate the human health casual recreational user scenario. Groundwater samples

were also collected from 63 existing groundwater wells to augment data required for the human health risk assessment

2.4.1 Pore Water Sampling

Pore water (aquifer tube) data collection locations were identified and staked by the Field Technical Lead prior to installation. Horizontal pore water sampling devices were co-located with the aquatic biota, near-shore, and pore water sample locations and coincide with, or are just below, the estimated low-water mark. A map depicting pore water (surface water and sediment) sample locations is in Figure 2-3. Horizontal pore water sampling devices were installed into the near-shore substrate at a depth of 10 cm (6 in.) by placing them in carefully dug trenches in selected locations. The polyethylene tube was uncoiled so that at least 0.3 m (1 ft) of the tube was above surface. Making sure the end of the tube was capped and tapped with waterproof Teflon® tape, the trench was backfilled with excavated sediments. Two vertical pore water sampling devices were also installed at the U4 and CR6 sites.

Pore water samples were collected at a minimum of 29 days (December 19, 2005 to January 16, 2006) after the devices were installed, allowing the substrate to stabilize. The end of the tubing was rinsed to remove potential contributors to contamination. The tubing was connected to a peristaltic pump to pull water from the devices. One volume of the horizontal sampling device (approximately 1.7 L [0.45 gal]) of water was purged into a bucket and conductance was monitored. Sample containers were then filled and the polyethylene tube was recapped using waterproof Teflon® tape.

Most pore water samples were collected during Priest Rapids Dam flows ranging from approximately 70,000 cfs (the minimum allowed during winter and spring 2006) to 120,000 cfs, allowing for travel time of the flow to reach the sampling site. The yearly average flow of the river is 120,000 cfs. Due to the relatively low conductivity of pore water sampled during the initial spring effort (January 16 – February 6, 2006), additional samples were collected at the U1 and U4 sites on September 5, 2006 and CR1 and SR5 on September 17 during very low river-flow conditions for comparison.

Collection of pore water samples was used for analysis of the following groups: organic chemicals, inorganic chemicals (e.g., metals and ions), radionuclides, quality indicators (e.g., total organic carbon), and field-measured parameters (e.g., pH, nitrate, temperature, dissolved oxygen, and conductivity). From January 16 to 19, 2006 samples were analyzed for Cr-VI by Severn-Trent Laboratories (STL); after January 19, samples were analyzed by Energy Northwest using field equipment in a North Richland laboratory in order to meet the short holding time associated with this analysis. Approval of this deviation from the SAP was received by the regulators prior to performing the onsite analysis. Samples were sent to the ASL for preparation to be sent to Lionville (chemical constituents) or Eberline (radiological constituents). Samples for water flea toxicity bioassays remained at ASL. Samples for Frog Embryo Teratogenesis Assay-Xenopus (FETAX) toxicity bioassays were sent to Fort Environmental Laboratories, Oklahoma. Samples had an approximate 45-day turnaround time.

2.4.1.1 Bioassay Methodology. Bioassays of pore water were conducted with the water flea (*Ceriodaphnia dubia*) and FETAX tests. The water flea (*Ceriodaphnia dubia*) chronic three brood toxicity test method is adapted from the “Standard Guide for Conducting Three-Brood, Renewal Toxicity Tests with *Ceriodaphnia dubia*” (ASTM E1295-01) and *Short-Term Methods*

for *Estimating the Chronic Toxicity of Effluent and Receiving Waters to Freshwater Organisms*, EPA Method 1002.0 “*Ceriodaphnia* Survival and Reproduction Test,” (EPA 821/R-02/013). Additional guidance for the test interpretation was provided by: *Understanding and Accounting for Method Variability in Whole Effluent Toxicity Applications Under the National Pollutant Discharge Elimination System Program* (EPA 833/R-00/003) and *Method Guidance and Recommendations for Whole Effluent Toxicity (WET) Testing* (EPA 821/B-00/004) (40 CFR 136).

The water fleas were obtained from ASL’s in-house cultures. All organisms were fed and maintained during culturing, acclimation, and testing as prescribed by the EPA. The concentrations tested in the chronic tests were 100% pore water samples with dilution water alone for the control. For the *C. dubia* chronic test, 1 organism per chamber with 10 chambers per concentration for a total of 10 organisms per concentration was used.

For the chronic tests, pre- and post-renewal solutions were monitored for dissolved oxygen and pH daily in the control and all concentrations tested. Conductivity was measured at test initiation. Temperature was monitored continuously throughout the testing period. *C. dubia* survival and neonate production were measured daily in the chronic tests. The effects measured during the tests included survival and reproduction over the exposure period. Statistical analyses were used to compare the survival data between the control and each sample treatment.

The 96-hour whole frog embryo assay was performed in accordance with *Standard Guided for Conducting the Frog Embryo Teratogenesis Assay-Xenopus (FETAX)* (ASTM E1493-98) with minor modification. The *Xenopus laevis* (South African clawed frog) larvae used for the FETAX screens were obtained from in-house cultures originally purchased from *Xenopus I*, Dexter, Michigan. FETAX screens were conducted using 100% sample volumes without dilution. General water chemistry (e.g., pH, dissolved oxygen, hardness, conductivity, alkalinity, ammonia-nitrogen, and residual oxidants) was initially performed while temperature, pH and dissolved oxygen were measured daily. Mortality and malformation frequencies were determined for each sample tested; length was measured as an index of growth. A total of five FETAX tests performed over a 21-day period were required to screen the 39 pore water samples. Statistical analyses were used to compare the survival and malformation data between the control and each sample treatment.

2.4.2 Pore Water Collection

The investigation area, sample identification numbers for water flea and FETAX bioassays, radiological and chemical constituents, Cr-VI analyzed by STL, and Cr-VI analyzed by Energy Northwest, date collected, and investigation area for each pore water sample collected are listed in Table 2-6.

2.4.3 Surface Water Sampling

Unfiltered surface water samples were collected 6 cm (approximately 2.5 in.) above the riverbed to evaluate the drinking water exposure pathway for wildlife and for the recreational exposure scenarios for human health. Surface water samples were co-located with pore water tubes and sediment samples. A map depicting surface water (pore water and sediment) sample locations is in Figure 2-3. Sample volume, sample containers, and sample preservation for each analyte

group are described in the 100 Area and 300 Area SAP (DOE-RL 2006a) and Sample Authorization Form (SAF).

Table 2-6. Summary of Pore Water Samples Collected During Spring 2006. (2 Pages)

Investigation Area	Bioassay Sample ID Numbers	Radiological ^a and Chemical ^b Sample ID Number	CR-VI ^c Sample ID Numbers	CR-VI ^d Sample ID Numbers	Date Collected
300-1	J11114	J11156, J11110, J11122	J11112	---	16-Jan-06
300-2	J11115	J11111	J11123	---	16-Jan-06
CR1	J11222	J11218	---	J11226	25-Jan-06
CR1	J13DR6	J13DR8	---	J13DT0	17-Sep-06
CR2	J11223	J11219, J11232	---	J11227	25-Jan-06
CR3	J11225	J11221	---	J11224	6-Feb-06
CR4	J11233	J11232	---	J11231	29-Jan-06
CR5	J11251	J11245	---	J11257	29-Jan-06
CR6	J112X5	J112X3, J112C3	---	J112D2, J112X7	1-Feb-06
CR7	J11253	J11247	---	J11259	1-Feb-06
CR8	J11254, J116D8	J11248, J116C8	---	J11260, J116F8	6-Feb-06
CR9	J11255	J11249	---	J11261	6-Feb-06
CR10	J11256	J11250	---	J11262	1-Feb-06
SR1	J116D0	J116C0	---	J116F0	3-Feb-06
SR2	J116D1	J116C1	---	J116F1	2-Feb-06
SR3	J116D3	J116C3	---	J116F3	2-Feb-06
SR4	J116D6	J116C6	---	J116F6	2-Feb-06
SR5	J116D5	J116C5	---	J116F5	3-Feb-06
SR5	J13DR7	J13DR7	---	J13DT1	17-Sep-06
SR6	J116C9	J116B9	---	J116D9	3-Feb-06
SR7	J116D7	J116C7	---	J116F7	2-Feb-06
SR8	J112X6	J112X4	---	J112X8	6-Feb-06
SR9	J116D4	J116C4	---	J116F4	2-Feb-06
SR10	J116D2	J116C2	---	J116F2	3-Feb-06
U1	J11116	J11112	J11124	J111M6	17-Jan-06
U1	J135X7	J135W9	---	J135Y0	5-Sep-06

Table 2-6. Summary of Pore Water Samples Collected During Spring 2006. (2 Pages)

Investigation Area	Bioassay Sample ID Numbers	Radiological ^a and Chemical ^b Sample ID Number	CR-VI ^c Sample ID Numbers	CR-VI ^d Sample ID Numbers	Date Collected
U2	J11117	J11113	J11125	---	17-Jan-06
U3	J11189	J11182	J11191	---	17-Jan-06
U4	J11190, J111B0	J11183, J11198, J11199	J111B2, J11192, J111B3	---	18-Jan-06
U4	J135X8	J135X0	---	J135Y1	5-Sep-06
U5	J111K5	J111K4	J111K7	---	19-Jan-06
U6	J111L7	J111L2	J111M7	---	19-Jan-06
U7	J111L8	J111L3	J111M8	---	19-Jan-06
U8	J111L9	J111L4	---	J111M4	22-Jan-06
U9	J111M0	J111L5	---	J111M5	22-Jan-06
U10	J111M1	J111L6	---	J11201	24-Jan-06
Riparian #11	J111W8	J111W2	---	J111W4	25-Jan-06
Riparian #12	J111W9	J111W3	---	J111W5	23-Jan-06
Riparian #13	J111X3	J111X0	---	J111X1	23-Jan-06
Riparian #14	J111Y9	J111Y7	---	J11201	24-Jan-06
Riparian #16	J11200	J111Y8	---	J11202	24-Jan-06

^a Analyzed by Eberline Services.^b Analyzed by Lionville Laboratory.^c Analyzed by Severn Trent Laboratory.^d Analyzed by Energy Northwest using field equipment (Hach kits).

As with the pore water, from January 16 to 19, 2006 surface water samples were analyzed for Cr-VI by STL; after January 19, samples were analyzed by Energy Northwest using field equipment in a laboratory. Samples were measured for Cr-VI by Environmental Assessment Services (EAS) at Applied Process Engineering Laboratories (APEL). Samples were sent to Lionville for chemical constituent analysis and Eberline for radiological constituent analysis. Samples had an approximate 45-day turnaround time.

2.4.4 Surface Water Collection

The investigation area, sample identification numbers for radiological and chemical constituents, Cr-VI analyzed by STL, and Cr-VI analyzed by Energy Northwest, and date collected for each pore water sample collected are listed in Table 2-7.

**Table 2-7. Summary of Surface Water Samples Collected During Spring 2006.
(2 Pages)**

Investigation Area	Radiological ^a and Chemical ^b Sample ID	CR-VI ^c Sample ID Numbers	CR-VI ^d Sample ID Numbers	Date Collected
300-1	J11126	J11135	---	16-Jan-06
300-2	J11127, J11157	J11136	---	16-Jan-06
CR1	J11235	---	J11240	25-Jan-06
CR2	J11236	---	J11241	25-Jan-06
CR3	J11238	---	J11243	29-Jan-06
CR4	J11239	---	J11244	29-Jan-06
CR5	J11279	---	J11281	29-Jan-06
CR6	J112X9	---	J112Y1	1-Feb-06
CR7	J112F6	---	J112F6	1-Feb-06
CR8	J112F7, J11280	---	J11282, J112V7	6-Feb-06
CR9	J112F8	---	J112V8	6-Feb-06
CR10	J112F9	---	J112V9	1-Feb-06
SR1	J116H0	---	J116K0	3-Feb-06
SR2	J116H8	---	J116K8	2-Feb-06
SR3	J116H3	---	J116K3	2-Feb-06
SR4	J116H5	---	J116K5	2-Feb-06
SR5	J116H6	---	J116K6	3-Feb-06
SR6	J116F9	---	J116J9	3-Feb-06
SR7	J116H4	---	J116K4	2-Feb-06
SR8	J112Y0	---	J112Y2	6-Feb-06
SR9	J116H7	---	J116K7	2-Feb-06
SR10	J116H1	---	J116K1	3-Feb-06
U1	J11128	J11137	---	17-Jan-06
U2	J11129	J11138	---	17-Jan-06
U3	J11193, J111B4	J11195	---	17-Jan-06
U4	J11194, J111B4	J11196, J111B5	---	18-Jan-06
U5	J111K8	J111L0	---	19-Jan-06
U6	J111N2	J111P7	---	19-Jan-06
U7	J111N3	J111P8	---	19-Jan-06
U8	J111N4	---	J111P4	22-Jan-06

**Table 2-7. Summary of Surface Water Samples Collected During Spring 2006.
(2 Pages)**

Investigation Area	Radiological ^a and Chemical ^b Sample ID	CR-VI ^c Sample ID Numbers	CR-VI ^d Sample ID Numbers	Date Collected
U9	J111N5	---	J111P5	22-Jan-06
U10	J111N6	---	J111P6	24-Jan-06
Riparian #11	J111X4	---	J111X7	25-Jan-06
Riparian #12	J111X5	---	J111X8	23-Jan-06
Riparian #13	J111X6	---	J111X9	23-Jan-06
Riparian #14	J11205	---	J11207	24-Jan-06
Riparian #16	J11206	---	J11208	24-Jan-06

^a Analyzed by Eberline Services.^b Analyzed by Lionville Laboratory.^c Analyzed by Severn Trent Laboratory.^d Analyzed by Energy Northwest using field equipment (Hach kits).

2.4.5 Groundwater Sampling

A total of 29 groundwater samples were collected in this spring sampling event (see Table 2-8). The groundwater samples were collected as “co-samples” during the performance of routine Sitewide groundwater monitoring program activities by other site contractors. Samples were unable to be collected from several of the wells identified in the SAP (DOE-RL 2006a) for various reasons. For wells where samples could not be collected, alternate wells were identified and sampled where available.

Sampling was conducted in accordance with Duratek Technical Services Procedure Number SP3-1, “Groundwater Sampling.” Prior to sampling the wells were purged and monitored for stabilized aquifer conditions. This was done by measuring the depth to water to the nearest 1 mm (0.04 in.) to calculate the purge volumes. Data collected during purging included pH, conductivity, and temperature to ensure aquifer stabilization prior to sampling. All sampling information was captured on the groundwater sample report, in the field logbook, and on the Groundwater Measurement form. A map of the groundwater wells sampled during the spring effort is presented in Figure 2-4.

After the wells were purged, unfiltered samples were collected and placed in appropriate containers with volatile and semivolatile organic constituents collected first. The sample bottles were slowly filled, minimizing agitation by placing the inner side of the sample bottle near the sampling manifold drop leg. Samples were then preserved, placed in coolers with ice, and transported to the receiving facility (Building 3728) in accordance with the SAP. Once at the receiving facility the samples were stored in a refrigerator at 4°C, and prepared for shipment to the offsite laboratories. Samples were sent to Lionville for chemical constituent analysis, Eberline for radiological constituent analysis and STL in Richland, Washington (Cr-VI).

Table 2-8. Summary of Groundwater Samples Collected During Spring 2006. (2 Pages)

Reactor Area	Well Name	Radiological ^a and Chemical ^b Sample ID	Cr- VI ^c Sample ID	Date Collected
100-F	199-F8-3	J111V9	J111W1	08-Feb-06
100-F	199-F5-42	J12696	J12683	01-Jun-06
100-F	199-F5-45	J12698	J12685	01-Jun-06
100-F	199-F7-1	J126B1	J12688	01-Jun-06
100-F	199-F5-47	J12699	J12686	01-Jun-06
100-F	199-F5-43B	J12697	J12684	01-Jun-06
100-F	199-F7-2	J126B2	J12689	07-Jun-06
100-F	199-F7-3	J126B3	J12690	07-Jun-06
100-F	199-F5-48	J126B0	J12687	26-Jun-06
100-H	199-H4-48	J126B4	J12691	26-Jun-06
100-H	199-H4-48	J126B8	J12695	26-Jun-06
100-K	199-K-32A	J10LT1	J10LT5	10-Jan-06
100-K	199-K-34	J10LT2	J10LT6	10-Jan-06
100-K	199-K-36	J10V27	J10V22	10-Jan-06
100-K	199-K-132	J10M59	J10M61	17-Jan-06
100-K	199-K-132	J10M15	J10M19	17-Jan-06
100-K	199-K-22	J12681	J12682	26-Jun-06
100-N	199-N-73	J11162	J11165	17-Jan-06
100-N	199-N-32	J118T7	J118T9	01-Mar-06
100-N	199-N-32	J118T8	J118V0	01-Mar-06
100-N	199-N-3	J111V8	J111W0	01-Mar-06
100-N	199-N-28	J11J29	J11J35	02-Mar-06
100-N	199-N-16	J11J27	J11J33	02-Mar-06
100-N	199-N-92A	J11J26	J11J32	02-Mar-06
100-N	199-N-74	J11J31	J11J37	06-Mar-06
100-N	199-N-26	J11J28	J11J34	20-Mar-06
100-N	199-N-80	J126B6	J12693	07-Jun-06
100-N	199-N-70	J126B7	J12694	07-Jun-06
300	399-1-1	J11163	J11166	19-Jan-06
300	399-4-12	J10M57	J10M53	19-Jan-06

Table 2-8. Summary of Groundwater Samples Collected During Spring 2006. (2 Pages)

Reactor Area	Well Name	Radiological ^a and Chemical ^b Sample ID	Cr- VI ^c Sample ID	Date Collected
300	399-4-9	J10M56	J10M52	19-Jan-06
300	399-3-11	J10VH6	J10VH3	30-Jan-06

^a Analyzed by Eberline Services.^b Analyzed by Lionville Laboratory.^c Analyzed by Severn Trent Laboratory.

2.4.6 Groundwater Collection

The reactor area, well name, sample identification numbers, and date collected for each groundwater sample collected is listed in Table 2-8.

2.5 BIOTA

Biota sampled included plants, small mammals, kingbirds, invertebrates, clams and sculpin. Amphibians were planned as part of the sampling effort and were found soon after hatching in some of the study area sloughs, but were too small for harvest at that time. Shortly afterwards, high river flows washed the tadpoles out of the sloughs. Thus, the amphibian sample effort will be attempted again during the 2007 Inter-areas evaluation.

2.5.1 Plant Sampling Methodology

Vegetation was evaluated for multiple parameters: estimation of herbaceous and shrub cover, identification of threatened and endangered species and their habitat. A map showing plant sample (TLDs, mice, and invertebrates) and data collection locations is depicted in Figure 2-5.

Plants were collected for contaminant analysis to support dose assessment for herbivorous and omnivorous receptors. Ideally, the dominant plants in an investigation area were common to all investigation areas, and at least one dominant species was representative of deep-rooted plants. Given the relative homogeneity in many of the vegetation communities to be sampled, tissue concentrations of the top two dominant plants represented the majority of vegetation at a given investigation area. The dominant plant species were collected within the investigation area using decontaminated snipping shears and cutting the current year's growth. After removing excess dirt, the vegetation was rinsed thoroughly with deionized water, and placed directly into plastic bags. Samples were combined into separate bags for each sampled species, resulting in two composite samples for each investigation area. Vegetation samples were rinsed with deionized water and homogenized and analyzed exclusive of external concentrations. Samples were sent to Lionville (chemical constituents) and Eberline (radiological constituents).

Figure 2-4. Groundwater Sampling Locations for the Spring 2006 Effort.

Figure 2-5. Thermoluminescent Dosimeter, Mice, Invertebrate and Plant Sampling Locations for the Spring 2006 Effort.

2.5.2 Plant Collection

Table 2-9 presents a summary of the dominant plant samples collected including investigation area, sample identification number, and date collected. Dominant herbaceous species collected consisted of cheatgrass (*Bromus tectorum*), tumble mustard (*Sisymbrium altissimum*), reed canarygrass (*Phalaris arundinaceae*), bulbous bluegrass (*Poa bulbosa*), and bluebunch wheatgrass (*Pseudoroegneria spicata*). Dominant shrub species collected consisted of grey rabbitbrush (*Chrysothamnus nauseosus*), mulberry (*Morus alba*), wormwood (*Artemisia ludoviciana*), and rubber rabbitbrush (*Ericameria nauseosa*). At some of the reference areas, tumble mustard was collected as the dominant deeper-rooted plant to better align with the dominant species collected at many of the remediated waste sites.

**Table 2-9. Summary of Dominant Plant Samples Collected During Spring 2006.
(2 Pages)**

Investigation Area	Species collected	Sample ID Number	Date Collected
100-D-48:2	Rabbitbrush, cheatgrass	J11X42, J11X43	18-May-06
100-D-49:2	Rabbitbrush, cheatgrass	J11X54, J11X55	18-May-06
100-F-2	Tumble mustard, cheatgrass	J11X60, J11X61	10-May-06
116-DR:1&2	Rabbitbrush, cheatgrass	J11X56, J11X57	19-May-06
116-F-1	Tumble mustard, bulbous bluegrass	J11X48, J11X49	16-May-06
116-N-3	Tumble mustard, cheatgrass	J11X46, J11X47	19-May-06
1607-D2:1	Rabbitbrush, cheatgrass	J11X58, J11X59	22-May-06
1607-H2	Rabbitbrush, cheatgrass	J11X44, J11X45	12-May-06
300-44/618-4	Tumble mustard, cheatgrass	J11X50, J11X51	12-May-06
300-49	Tumble mustard, cheatgrass	J11X52, J11X53	26-Apr-06
600-131	Tumble mustard, cheatgrass	J11X84, J11X85	12-May-06
600-132/600-190	Tumble mustard, cheatgrass	J11X76, J11X77	12-May-06
600-139	Rabbitbrush, cheatgrass	J11X78, J11X79	16-May-06
600-171	Rabbitbrush, cheatgrass	J11X90, J11X91	16-May-06
600-181	Tumble mustard, cheatgrass	J11X86, J11X87	18-May-06
600-204	Rabbitbrush, cheatgrass	J11X80, J11X81	18-May-06
600-208	Tumble mustard, cheatgrass	J11X82, J11X83	15-May-06
600-23	Rabbitbrush, bluebunch wheatgrass	J11X72, J11X73	12-May-06
628-1	Tumble mustard, cheatgrass	J11X88, J11X89	12-May-06
Central Plateau	Tumble mustard, cheatgrass	J11X92, J11X93	19-May-06

**Table 2-9. Summary of Dominant Plant Samples Collected During Spring 2006.
(2 Pages)**

Investigation Area	Species collected	Sample ID Number	Date Collected
JA Jones	Rabbitbrush, bluebunch wheatgrass	J11X74, J11X75	10-May-06
McGee Ranch	Tumble mustard, cheatgrass (2)	J11X98, J11XP1, J11X99	18-May-06
Borrow Pit 9	Rabbitbrush, cheatgrass	J11X64, J11X65	12-May-06
Borrow Pit 14	Rabbitbrush, cheatgrass	J11X66, J11X67	15-May-06
Borrow Pit 16	Rabbitbrush, cheatgrass	J11X68, J11X69	18-May-06
Borrow Pit 23	Rabbitbrush, cheatgrass	J11X62, J11X63	22-May-06
Borrow Pit 24	Rabbitbrush, cheatgrass	J11X70, J11X71	19-May-06
Saddle Mountain	Tumble mustard, cheatgrass	J11XB0, J11XB1	18-May-06
Vernita Upriver South	Tumble mustard, cheatgrass	J11X96, J11X97	15-May-06
Yakima Ridge II	Tumble mustard, cheatgrass	J11X94, J11X95	16-May-06
Riparian #1	Wormwood, reed canarygrass	J11WX1, J11WX2	16-May-06
Riparian #2	Mulberry, reed canarygrass	J11WX3, J11WX4	19-May-06
Riparian #3	Mulberry, reed canarygrass	J11WX5, J11WX6	9-May-06
Riparian #4	Mulberry, reed canarygrass	J11WW5, J11WW6	9-May-06
Riparian #5	Mulberry, reed canarygrass	J11WW7, J11WW8	9-May-06
Riparian #6	Mulberry (2), reed canarygrass	J11WX7, J11XP0, J11WX8	22-May-06
Riparian #7	Mulberry, reed canarygrass	J11WX9, J11WY0	9-May-06
Riparian #8	Wormwood, bulbous bluegrass	J11WY1, J11WY2	16-May-06
Riparian #9	Mulberry, reed canarygrass	J11WY3, J11WY4	16-May-06
Riparian #10	Mulberry, reed canarygrass	J11WY5, J11WY6	9-May-06
Riparian #11	Mulberry, reed canarygrass	J11WY7, J11WY8	9-May-06
Riparian #12	Mulberry, reed canarygrass	J11WW9, J11WX0	10-May-06
Riparian #13	Mulberry, reed canarygrass	J11WY9, J11X00	10-Aug-06
Riparian #14	Mulberry, reed canarygrass	J11X01, J11X02	9-May-06
Riparian #16	Mulberry, reed canarygrass	J11X03, J11X04	9-May-06

2.5.2.1 Cover Estimation. Vegetative cover on the upland and riparian zone study grids consisted of grasses, forbs, shrubs, and trees. For grasses and forbs, vegetative cover found in each upland and riparian study plot was estimated using a series of modified Daubenmire plot frames (Daubenmire 1959) to determine the percent coverage by species found within 20-cm

[8-in.] by 50-cm [20-in.] plots that were gridded into 10-cm (4-in.) squares. A species inventory list was prepared for each study grid. Canopy cover was estimated using finite values for all plant species with at least 2% aerial coverage. Plant species encountered in each plot with $\geq 2\%$ aerial cover were listed. The aerial extent of cryptogamic crust, bare ground, litter and rocks was visually estimated after spraying the ground surface with a mist of water to ensure accurate ocular estimations were made. Plot points were systematically located throughout each investigation area for a total of approximately 25 samples per grid. The systematic sampling strategy varied between sites, depending on the site configuration and size.

The line intercept method was used to estimate the canopy cover of the shrubs and trees found in each sample grid. Total canopy for shrubs was measured using line intercept techniques systematically along four lines (e.g., each 50 m [164 ft] long for a total of 200 m [656 ft]) within each investigation area. The length of each line varied depending on the shape and size of each investigation area. The maximum height (± 0.1 m [0.33 ft]) of each shrub intercepted along each line was measured. In addition, a 3-dimensional intercept (± 0.05 m [0.16 ft]) of live and dead shrubs was measured and recorded separately to help assess the overall health of the shrubs (determine the percent dead). Shrub species were determined and canopy cover estimates were separately identified for each shrub species encountered. A complete listing of all shrub species observed within the grid was also recorded.

2.5.2.2 Threatened and Endangered Species. Surveys were performed for federal and state threatened and endangered species on all non-reference upland and riparian sites, and the adjacent exposed near-shore zones above the “green line” where allowed by low flow conditions. T & E plants were not confirmed at any of the upland or riparian investigation areas, but were found in the ‘wetted’ zone between the riparian and near-shore aquatic zone. The report associated with that effort is provided in Appendix C.

2.5.3 Small Mammal Sampling

Small mammal sampling of the Great Basin pocket mice and deer mice (*Perognathus parvus* and *Peromyscus maniculatus*, respectively) were accomplished using Sherman live-traps placed throughout the center of the investigation area. A map depicting small mammal (in addition to TLDs, plant, and invertebrate) sample locations is depicted in Figure 2-5. In late May 2006, after initial mouse and upland invertebrate samples were collected, Riparian Site #7 was relocated 200 m (656 ft) (south) due to potential conflicts with field remediation activities. Therefore, new traps were placed within the relocated Riparian #7 in June. After lack of trapping success, caused by the lateness of the season and high river levels shifting the mice farther inland, the effort was cancelled and the collection at the original site will be used for analysis.

Typically, two trap lines, each consisting of seven Sherman live traps (8 cm [3 in.] wide by 9 cm [3.5 in.] high by 23 cm [9 in.] long) were placed parallel with the edges of an array set up to accommodate the shape of the investigation area. Trap grids were spaced systematically 10 m (33 ft) apart in one or more trap lines and located near the grid nodes of the study sites. Traps were spaced systematically, and the number of trap lines varied according to the habitat being sampled. Trapping arrays were limited to one habitat type, if possible. Traps were placed nearby or underneath vegetation/rocks to reduce likelihood of heat/cold stress; if natural cover was insufficient then a trap shade was placed over the top of the trap. Traps were baited with an oatmeal-peanut butter mixture.

Traps were checked daily; at least six mice were obtained from each investigation area. When traps were tripped, collectors donned a high-efficiency particulate air (HEPA) mask and rubber gloves prior to removing the mice. The mice were placed into plastic bags and the species, age, sex, reproductive status, weight, and anomalies were recorded in logbooks. If selected for collection, the mouse was euthanized via the American Veterinary Medical Association (AVMA 1986) approved cervical dislocation technique. If the mouse was not sacrificed, the ventral portion of its tail was marked with a nontoxic permanent marker to ensure all marked animals can be identified later if recaptured. When complete, the trap was reset and baited. Afterwards, gloved hands were sprayed with Lysol® solution, HEPA mask removed, and gloves removed. To the extent possible, the same species were sampled at all investigation areas.

The mammals were rinsed with deionized water to remove most exterior soil. Sample preparation included dissecting organs (liver/kidney) from the carcass (including the gastrointestinal tract) with pre-cleaned stainless steel scissors and forceps. The carcass and liver/kidney were weighed and homogenized separately. Whole organism subsamples were prepared by blending whole organisms in a laboratory-grade blender with dry ice for 30 seconds to 1 minute to allow homogenization of the entire organism. Samples were sent to Lionville (chemical constituents) and Eberline (radiological constituents).

2.5.4 Small Mammal Collection

Table 2-10 presents a summary of mouse samples collected including the investigation area, offal and kidney/liver sample identification numbers, and date of collection.

Table 2-10. Summary of Mouse Samples Collected and Separated into Offal and Kidney/Liver During Spring 2006. (3 Pages)

Investigation Area	Offal Sample ID Number	Kidney/Liver Sample ID Number	Date Collected
100-D-48:2	J11KV1	J11KV3	5-Apr-06
100-D-49:2	J11KV2	J11KV4	5-Apr-06
100-F-2	J11L22	J11L27	21-Apr-06
116-DR-1,DR-2	J11L21	J11L26	3-Apr-06
116-F-1	J11KL7	J11KN9	20-Apr-06
116-N-3	J11KL6	J11KN8	3-Apr-06
1607-D2:1	J11KM0	J11KP2	5-Apr-06
1607-H2	J11KL5	J11KN7	5-Apr-06
300-44/618-4	J11KL8	J11KP0	21-Apr-06
300-49	J11KL9	J11KP1	21-Apr-06
300-A Riparian #6	J11XY1	J11XY2	20-Apr-06
600-131	J11L25	J11L30	5-Apr-06
600-132/190	J11KK8	J11KN0	5-Apr-06

Table 2-10. Summary of Mouse Samples Collected and Separated into Offal and Kidney/Liver During Spring 2006. (3 Pages)

Investigation Area	Offal Sample ID Number	Kidney/Liver Sample ID Number	Date Collected
600-139	J11KK9	J11KN1	20-Apr-06
600-171	J11KL4	J11KN6	20-Apr-06
600-181	J11KL2	J11KN4	20-Apr-06
600-204	J11KL0	J11KN2	20-Apr-06
600-208	J11KL1	J11KN3	20-Apr-06
600-23	J11KK7	J11KM9	21-Apr-06
628-1	J11KL3	J11KN5	20-Apr-06
Central Plateau	J11L36	J11L37	3-Apr-06
JA JONES	J11L24	J11L29	21-Apr-06
McGee Ranch	J11KM5	J11KP7	3-Apr-06
PIT 14	J11KK5	J11KM7	20-Apr-06
PIT 14	J11XY3	J11KK6	20-Apr-06
PIT 18	J11KM8	J11L23	20-Apr-06
PIT 23	J11L28	J11KM2	3-Apr-06
PIT 24	J11KP4	J11KM1	3-Apr-06
PIT 9	J11KP3	J11916	21-Apr-06
Riparian #1	J11935	J11923	21-Mar-06
Riparian #2	J11917	J11936	21-Mar-06
Riparian #3	J11918	J11937	22-Mar-06
Riparian #4	J11910	J11938	22-Mar-06
Riparian #5	J11911	J11939	22-Mar-06
Riparian #6	J11919	J11940	20-Apr-06
Riparian #7	J11920	J11941	22-Mar-06
Riparian #8	J11921	J11942	22-Mar-06
Riparian #9	J11922	J11943	22-Mar-06
Riparian #10	J11944	J11924	22-Mar-06
Riparian #11	J11945	J11912	22-Mar-06
Riparian #12	J11946	J11913	23-Mar-06
Riparian #13	J11913	J11947	23-Mar-06
Riparian #14	J11925	J11948	23-Mar-06

Table 2-10. Summary of Mouse Samples Collected and Separated into Offal and Kidney/Liver During Spring 2006. (3 Pages)

Investigation Area	Offal Sample ID Number	Kidney/Liver Sample ID Number	Date Collected
Riparian #16	J11914	J11949	23-Mar-06

2.5.5 Kingbird Sampling Methodology

Surveys were performed to identify eastern and western kingbird (*Tyrannus tyrannus* and *T. verticalis*, respectively) nests in trees in 5-km (3-mi)-long sections of onsite riparian areas. The reference locations were located upstream of the Hanford Site in the Vernita Bridge area (Riparian #11 – 14 and 16). Kingbird study areas were located in the 100 Area and the 300 Area shorelines along sites Riparian #2 - 10. A map depicting kingbird survey and sampling locations is presented in Figure 2-6. Sample locations may or may not have been within the 200 m (656 ft) of a particular site; therefore, the site name was not placed on the map in Figure 2-6.

Juvenile kingbird tissues and diets (crop content) were sampled for contaminants based on the expectation that the diet of these kingbirds will be at least partially reflective of insects emerging from the Columbia River. Observations included the total number of eggs per clutch and the number of young successfully hatched per nest. In addition, breeding success of kingbirds was surveyed to obtain a sufficient sample population size. Measures such as kingbird nesting success will provide a qualitative evaluation of contaminant effects on aerial insectivores. Hatching success (number of young hatched per nest) was observed for an estimate of kingbird reproductive success. Downstream nest success was compared to upstream success as well as to measures of kingbird exposure.

Intrusive activity intensity was correlated to appropriate stages in avian reproductive cycles. The least intensive surveying occurred during mating and the most intensive sampling occurred when nestlings were almost ready to leave the nest. Once hatching success was determined, a single specimen was collected from the nest for radionuclide and chemical analyses. After sacrificing the nestling, it was rinsed with deionized water to remove excess debris. The samples were placed into a 1-L (0.3-gal) amber glass bottle and stored frozen in locked storage until samples could be prepared for submission to the analytical laboratories.

At the laboratory facility, samples were removed from locked storage; surgical gloves were donned, washed with Liqui-Nox® solution, and rinsed with deionized water. Specimens were removed from the field bottle and weighed. After rinsing the specimen with deionized water and placing on an absorbent towel, the condition of the specimen was performed prior to dissection. Crop (the crop is a muscular pouch used to temporarily store food) contents were removed, weighed, inspected, and placed in an amber glass container. Depending on the mass of the crop, only certain analytes were tested for. The remaining specimen was rinsed with deionized water and placed in a pre-cleaned 250 mL (8 oz) stainless steel blender with approximately equal fractions of dry ice. The blended contents were emptied onto a pre-cleaned aluminum tray and allow dry ice to evaporate. The desired number and mass of subsamples were placed in containers consistent with individual SAFs. Samples were sent to Lionville (chemical constituents) and Eberline (radiological constituents).

Figure 2-6. Kingbird Sampling Locations for the Spring 2006 Effort.

2.5.6 Kingbird Collection

A summary of the Eastern and Western Kingbird samples including the nearest investigation area whole body and crop sample identification numbers, and date collected are provided in Table 2-11.

Table 2-11. Summary of Kingbird Samples Collected During Spring 2006.

Nearest Investigation Area to Sample Collection	Whole Body Sample ID Number	Crop Sample ID Number	Date Collected
Riparian #2	J125V5	J125W6	15-Aug-06
Riparian #3	J125V6	J125W7	15-Aug-06
Riparian #4	J125T6	J125T9	16-Aug-06
Riparian #5	J125T7	J125V0	16-Aug-06
Riparian #6	J125V2	J125V3	16-Aug-06
Riparian #10	J125W0	J125X1	14-Aug-06
Riparian #12	J125V4	J125W5	14-Aug-06
Riparian #13	J125W2	J125X3	15-Aug-06
Riparian #14	J125W3	J125X4	16-Aug-06
Riparian #16	J125W4	J125X5	16-Aug-06

2.5.7 Aquatic Invertebrates and Asiatic Clam Sampling Methodology

Rock baskets and clam tubes were placed at locations selected for pore water sampling with horizontal aquifer tubes in the aquatic zone. They were composed of a standardized matrix that was left in aquatic locations for the same amount of time. These devices provide a standardized way to measure bioaccumulation in these organisms. Rock baskets were colonized by aquatic insects and provided measures of contaminant uptake and of invertebrate diversity, abundance, and biomass. Clam tubes provided measures of contaminant uptake and survival of Asiatic clams. Neither clam tubes nor macroinvertebrate baskets were placed at the 100-N Area because the 100-NR-2 risk evaluation previously sampled the river biota during 2005. A map depicting aquatic invertebrates and clam sampling locations is provided in Figure 2-7.

Figure 2-7. Clam and Aquatic Invertebrate Sampling Locations for the Spring 2006 Effort.

2.5.7.1 Aquatic Invertebrates. Six artificial substrate baskets containing standard size gravel-pebble were placed in the continuously submerged, unconsolidated substrate for at least 6 months, allowing for the colonization of hyporheic organisms. Each basket contained 3.8 L (1 gal) of gravel-pebble size rocks, and six replicates of each basket were placed at each aquatic sampling location. Three substrate baskets were connected together using stainless steel clips and 68-kg (150-lb) strength rope with approximately 0.3-m (1-ft) spacing between substrate baskets. Rock baskets were installed together at the location of the aquifer tube and placed parallel to the river flow. Three baskets were placed upstream of the horizontal pore water sampling device and three baskets downstream of the horizontal pore water sampling device. Baskets were deployed during low-flow periods (November-December) at 0.5 m (1.6 ft) below the green line at each site. The green line represents the area along the shoreline that generally corresponds to the low-water mark and is visually recognized by the zone where persistent periphyton is growing on the rock surfaces. Baskets were surrounded with unconsolidated substrate to help simulate natural conditions observed at each site.

Rock baskets were recovered, taking great care to minimize disturbance to the baskets while retrieving. Rock baskets were unfastened from each other, covered in mosquito netting and brought to the surface of the water and placed immediately in separate plastic tubs. The baskets were opened inside the tub and individual rocks were scrubbed clean with a brush to ensure that colonized macro-invertebrates were consistently collected. The tub contents were then poured out onto a pre-cleaned 500-micron sized stainless steel sieve and the contents were transferred to a labeled container using tweezers or stainless steel scoopula. Three baskets (every other one) were hand-picked with pre-cleaned stainless steel tweezers and the invertebrates were all placed into a single pre-cleaned container for contaminants of potential ecological concern (COPEC) analyses. Samples were then placed in an iced cooler and transferred to a refrigerator at the laboratory. The other three baskets were evaluated for diversity and abundance measures.

Benthic community composition and abundance analyses were performed on all organisms greater than 500 microns that were obtained from three of the baskets. Invertebrates were identified using a dissecting microscope and reference manuals with keys to family and genera (except for midges). The number of individuals in each family (or genera or species if possible) was recorded. For baskets picked for COPEC analyses, the total mass of each general taxa and number of individuals per taxa were recorded. Organisms were rinsed with deionized water and placed into sample containers consistent with SAF and Subcontract Technical Representative consultation. Macro-invertebrates were rinsed with deionized water, segregated by general taxa, enumerated, and weighed by taxa prior to submitting the samples to the analytical laboratories. If multiple laboratories or analyses methods were used for COPEC analyses, then the specimens were homogenized in a pre-cleaned 250 mL (8 oz) stainless steel blender with approximately equal fractions of dry ice. The blended contents were emptied onto a pre-cleaned aluminum tray to allow the dry ice to evaporate. The desired number and mass of subsamples were placed in containers consistent with the SAF.

2.5.7.2 Aquatic Invertebrate Collection. The rock baskets and clam tubes placed at site CR8 were lost to either high river flows or vandalism. A summary of aquatic invertebrates including sample identification number, date collected and investigation area is provided in Table 2-12.

Table 2-12. Summary of Aquatic Invertebrate Samples Collected During Spring 2006.

Investigation Area	Sample ID Number	Date Collected
300-1	J12XP6	8/1/2006
300-2	J12XP7	8/1/2006
CR1	J12XM5	8/2/2006
CR10	J12XN4	8/2/2006
CR2	J12XM6	8/2/2006
CR3	J12XM7	8/2/2006
CR4	J12XM8	8/2/2006
CR5	J12XM9	8/2/2006
CR6	J12XN0	8/2/2006
CR7	J12XN1	8/2/2006
CR9	J12XN3	8/2/2006
U1	J12XN5	8/1/2006
U10	J12XP4	8/2/2006
U2	J12XN6	8/1/2006
U3	J12XN7	8/1/2006
U4	J12XN8	8/2/2006
U5	J12XN9	8/2/2006
U6	J12XP0	8/2/2006
U7	J12XP1	8/2/2006
U8	J12XP2	8/2/2006
U9	J12XP3	8/2/2006
RIPARIAN #11	J12XH8	8/1/2006
RIPARIAN #12	J12XP8	8/1/2006
RIPARIAN #13	J12XP9	8/1/2006
RIPARIAN #14	J12XR0	8/1/2006
RIPARIAN #16	J12XR1	8/1/2006

2.5.8 Asiatic Clams

Asiatic clam (*Corbicula fluminea*) tubes were prepared using six replicates of each clam tube (with 25 clams each) co-located with horizontal aquifer tubes in the matrix. The clams were collected from three locations below Priest Rapids Dam and represent the same life stage. One

hundred and fifty clams were inserted into six mesh tubes, 25 per tube, that were placed at each of 27 aquatic sites for a total of 4,050 clams in 162 tubes. Live clams from 15 mm (0.6 in.) to 22 mm (0.8 in.) were used in the tubes.

Sample site conditions, predominant and subdominant substrates, substrate embeddedness, and relative abundance of macrophyte populations were recorded. Clam tubes were nestled down into the matrix substrate. The unconsolidated rocks were placed back near the clam tubes, but not directly onto the clams. Three clam tubes were placed upstream and three placed downstream of the horizontal pore water sampling device. Clam tubes were recovered at the end of the 6-month exposure period and survival measures were evaluated for each replicate. Each tube was then placed in an iced cooler in open plastic bags covered with a wetted absorbent towel.

Clam preparation in the laboratory began with removal from field coolers or refrigerators. Clam tubes were opened from the end and clams removed consecutively (1-25). Survival and observations such as appearance of parasites or whether the clam had recently died were noted. Up to 10 individual clams were systematically removed from the clam tubes (those nearest the artificial substrate baskets) and shipped overnight to a certified histologist for a histological interpretation of their conditions. The surface of the shell of all clams retained for COPEC analyses were cleaned in deionized water and placed into a single container. Soft tissue was separated from the shell tissue using flash-steam (5 to 30 seconds) of deionized water in pre-cleaned stainless steel colander and pot.

Soft and hard tissues were submitted separately for contaminant analyses. Shell samples were sent to Eberline (Strontium-90) and soft tissue samples were sent to Lionville (chemical constituents; uranium at the 300 Area and carbon-14 at 100-K). Clams were also sent and to Dr. Ralph Elston of AquaTechnics/Pacific Shellfish Institute, Washington for histopathology.

2.5.8.1 Asiatic Clam Collection. The rock baskets and clam tubes placed at site CR8 were lost to either high river flows or vandalism. A summary of Asiatic clams including sample tissue and shell identification number, date collected and investigation area is provided in Table 2-13.

Table 2-13. Summary of Clam Samples Collected During Spring 2006. (2 Pages)

Tissue Sample ID Number	Shell Sample ID Number	Date Collected	Investigation Area
J12Y44	J12NK0	8/9/2006	300-1
J12Y45	J12NK1	8/9/2006	300-2
J12Y19	J12NH0	8/10/2006	CR1
J12Y33	J12NH9	8/10/2006	CR10
J12Y20	J12NH1	8/10/2006	CR2
J12Y21	J12NH2	8/10/2006	CR3
J12Y22	J12NH3	8/10/2006	CR4

Table 2-13. Summary of Clam Samples Collected During Spring 2006. (2 Pages)

J12Y25	J12NH4	8/10/2006	CR5
J12Y26	J12NH5	8/10/2006	CR6
J12Y27	J12NH6	8/10/2006	CR7
J12Y29	J12NH8	8/10/2006	CR9
J12Y34	J12NJ0	8/9/2006	U1
J12Y43	J12NJ9	8/9/2006	U10
J12Y35	J12NJ1	8/9/2006	U2
J12Y36	J12NJ2	8/9/2006	U3
J12Y37	J12NJ3	8/9/2006	U4
J12Y38	J12NJ4	8/9/2006	U5
J12Y39	J12NJ5	8/9/2006	U6
J12Y40	J12NJ6	8/9/2006	U7
J12Y41	J12NJ7	8/9/2006	U8
J12Y42	J12NJ8	8/9/2006	U9
J12Y60	J12NK2	8/9/2006	Riparian #11
J12Y61	J12NK3	8/9/2006	Riparian #12
J12Y62	J12NK4	8/9/2006	Riparian #13
J12Y64	J12NK5	8/9/2006	Riparian #14
J12Y63	J12NK6	8/9/2006	Riparian #16

2.5.9 Terrestrial Invertebrates Sampling Methodology

Terrestrial invertebrates such as darkling beetles, harvester ants, and spiders represent the soil biota guild specified in *Washington Administrative Code* 173-340-7493, "Site-Specific Terrestrial Ecological Evaluation Procedures." These invertebrates were collected in each of the study sites to measure selected COPEC levels found in their tissues. A map showing invertebrate (in addition to TLDs, small mammals and plant) sample locations is depicted in Figure 2-5. Terrestrial invertebrates were sampled at all upland sites and correspond to MIS of soil and dominant plant species collection sites.

Pitfall traps and hand-collection techniques were used to collect samples. Pitfall traps were placed near the center of each waste site investigation area (see Figures 1-3 through 1-5 of DOE-RL 2006a) to reduce the possibility of sampling organisms from outside of the investigation area. In some remediated waste site areas, rectangular grids were used instead of square grids to better overlay the dimensions of the site. In these areas, the grid for the pitfall traps was centered in the larger rectangle and included appropriate setbacks from the outer grid boundary to help reduce any edge effects. All invertebrates caught during trapping were

collected, weighed by major taxonomic group, and then composited for each sampling area for contaminant analyses.

Pitfall traps were buried level to the ground surface, ensuring the edge of each does not extend above ground level. A wooden lid was then placed over the top of the pitfall trap. Invertebrates were handpicked out of the pitfall traps using stainless steel tweezers and sample containers prescribed in the SAF. Sample mass was weighed to determine whether sufficient sample mass was collected. Pitfall traps were left open until sufficient sample mass was obtained, or until the pitfall traps no longer collected invertebrates. If a sufficient sample mass was not obtained from the pitfall traps, ground-dwelling invertebrates were opportunistically collected. In the event that alternate methods were used for invertebrate collection, each major group was sorted, weighed, and separated, and an approximate effort (person-days) for each collection method was recorded. Invertebrate samples were placed in refrigerated locked storage at the laboratory facility between sample collection events. The number of trap-days were recorded for a relative measure of invertebrate abundance.

Invertebrate samples collected from the field were taken back to the subcontractor's laboratory facility for general taxa identifications and sample preparation for submission to the analytical laboratories. Samples were segregated into major groups (e.g., beetles, spiders, crickets) and weighed. Invertebrate samples were rinsed with deionized water to remove exterior contamination and to minimize any bias introduced from soil on the organisms. Large water droplets were shaken off of invertebrates and invertebrates were placed into pre-cleaned and tared sample bottles. Samples were added into each bottle until desired sample masses were attained. Samples were sent to Lionville (chemical constituents) and Eberline (radiological constituents).

2.5.9.1 Terrestrial Invertebrate Collection. In late May, after initial upland invertebrate and mouse samples were collected, Riparian Site #7 was relocated 200 m (656 ft) (south) due to field remediation activities. Due to the relocation of Riparian #7, efforts to collect invertebrates at the new location were made for 3 weeks, but insufficient invertebrates could be collected because of the lateness of the season and high river flows limiting the amount of riparian zone above water. Therefore, the original collection at Riparian #7 will be used for analysis. A summary of upland invertebrates including sample identification number, date collected and sample location is provided in Table 2-14.

Table 2-14. Summary of Terrestrial Invertebrate Samples Collected During Spring 2006. (3 Pages)

Investigation Area	Sample ID	Date Collected
100-D-48:2	J11KV5	3-Apr-06
100-D-49:2	J11KV6	3-Apr-06
100-F-2	J11L32	25-Apr-06
116-DR:1& 2	J11L31	3-Apr-06
116-F-1	J11KT1	17-Apr-06
116-N-3	J11KT0	3-Apr-06

Table 2-14. Summary of Terrestrial Invertebrate Samples Collected During Spring 2006. (3 Pages)

Investigation Area	Sample ID	Date Collected
1607-D2:1	J11KT4	3-Apr-06
1607-H2	J11KR9	3-Apr-06
300-44/618-4	J11KT2	26-Apr-06
300-49	J11KT3	25-Apr-06
600-131	J11L35	3-Apr-06
600-132/190	J11KR2	3-Apr-06
600-139	J11KR3	25-Apr-06
600-171	J11KR8	17-Apr-06
600-171	J11XX9	25-Apr-06
600-181	J11KR6	17-Apr-06
600-204	J11KR4	25-Apr-06
600-208	J11KR5	25-Apr-06
600-23	J11KR1	25-Apr-06
628-1	J11KR7	17-Apr-06
628-1	J11XX8	25-Apr-06
Central Plateau	J11L38	3-Apr-06
JA Jones	J11L34	25-Apr-06
McGee Ranch	J11KT9	3-Apr-06
Pit 9	J11KT5	25-Apr-06
Pit 14	J11KP9	17-Apr-06
Pit 18	J11KR0	17-Apr-06
Pit 23	J11L33	3-Apr-06
Pit 24	J11KT6	3-Apr-06
Riparian #1	J11950	16-Mar-06
Riparian #2	J11951	16-Mar-06
Riparian #3	J11952	16-Mar-06
Riparian #4	J11953	16-Mar-06
Riparian #5	J11954	16-Mar-06
Riparian #6	J11955	25-Apr-06
Riparian #7	J11956	16-Mar-06
Riparian #8	J11957	16-Mar-06

Table 2-14. Summary of Terrestrial Invertebrate Samples Collected During Spring 2006. (3 Pages)

Investigation Area	Sample ID	Date Collected
Riparian #9	J11958	16-Mar-06
Riparian #10	J11959	16-Mar-06
Riparian #11	J11960	20-Mar-06
Riparian #12	J11961	20-Mar-06
Riparian #13	J11962	20-Mar-06
Riparian #14	J11963	20-Mar-06
Riparian #16	J11964	20-Mar-06
Saddle Mt.	J11KV0	3-Apr-06
Vernita Upriver	J11KT8	3-Apr-06
Yakima Ridge II	J11KT7	3-Apr-06

Initially, pitfall traps collected upland invertebrates for chemical and radionuclide analyses not including semivolatile organic analyses (SVOAs). However, after reviewing the MIS soil sampling results, several sites that showed elevated levels of SVOAs in soil had additional upland invertebrates hand collected (100-D-49:2, 1607-D2:1, 600-131, 600-139, 600-171, JA Jones, and Riparian #9) for subsequent analyses (Table 2-15).

Table 2-15. Terrestrial Invertebrate Samples Collected During Spring 2006 for Additional Semivolatile Organic Analysis.

Investigation Area	Sample ID	Date Collected
100-D-49:2	J12Y65	1-Aug-06
1607-D2:1	J12Y66	1-Aug-06
600-131	J12XF1	20-Jul-06
600-139	J12XF2	20-Jul-06
600-171	J12Y67	1-Aug-06
JA Jones	J12XF3	20-Jul-06
Riparian #9	J12XF4	20-Jul-06

2.5.10 Sculpin Sampling Methodology

Sculpin (*Cottus bairdi*) were evaluated for contaminant concentrations as well as measured for biological condition and histopathology. Sculpin tissue contaminant concentrations will be used for addressing human health data gaps and for calculating dose to piscivorous wildlife. Although sculpin are not typically consumed by the public, they have a relatively limited home

range and are a strict benthic species. In contrast to far-ranging lotic fish species, sculpin will provide a conservative measure of tissue concentrations potentially resulting from Hanford Site operations or potential upstream sources.

Electro-fishing sculpin involves targeting a general vicinity, not necessarily targeting a specific sampling site. As such, general sculpin collection areas or zones were used to characterize sculpin exposure to the groundwater contaminant plumes. This approach to spatial delineation in sculpin collection combined with the limited home range of sculpin helps ensure that harvested sculpin reflect distinct exposure conditions. Sculpin were analyzed for aquatic contaminants and for screening health metrics and collected in triplicate at the locations targeted for horizontal aquifer tube deployment along the river.

Multiple spatial replicates were collected in each zone (chromium and uranium plume areas) to provide an estimate of the variability in sculpin tissue concentrations. Because the 100-NR-2 ecological risk assessment (*Aquatic and Riparian Receptor Impact Information for the 100-NR-2 Groundwater Operable Unit*, (DOE-RL 2006b), collected sculpin for tissue strontium contaminant concentrations, sculpin-tissue data from that project will be employed in the 100 Area and 300 Area risk assessment. Reference samples of sculpin were collected upstream of the 300 Area and upriver of Vernita Bridge. A map depicting sculpin sampling locations is provided in Figure 2-8.

Collected sculpin were analyzed for aquatic contaminants and for screening biological condition metrics. Sample concentrations of aquatic contaminants were based on the whole body and on livers. Any gross and/or tissue-level abnormalities were noted in the harvested sculpin. Sample concentrations of aquatic contaminants in sculpin were based on the whole body. Histopathological analyses of target tissues (kidney, liver, gills, bone, and muscle) were performed in addition to chemical and radiological analyses.

Sculpin were collected between 0.0 and 2.0 m (0.0 and 6.6 ft) in depth from approximately the low water mark using electro-fishing techniques consistent with state and federal scientific collection permit conditions and the *Threatened and Endangered Species Management Plan, Salmon and Steelhead* (DOE-RL 2000). Start and stop points of the waters electro-fished were recorded and all specimens observed/stunned during the collection events were recorded. The number of seconds shocked, surface water conductivity, and electro-fisher settings used for the collection periods were also recorded. Sculpin were netted, euthanized, and immediately placed into sample bottles and placed on ice. Sculpin collected for histological analyses were euthanized, their abdomen was opened with a scalpel and immediately placed in 10% phosphate-buffered formalin. The first 10 sculpin stunned and captured at any given site were selected for histopathology interpretation.

Using pre-cleaned stainless steel forceps, sculpin samples were placed on pre-cleaned tared Teflon® weighing tray. Whole-body length (fork length) (± 1 mm [0.04 in.]) and weight (± 0.1 g) were measured and recorded. A gross external body condition inspection was conducted and results recorded on the laboratory processing form or in the laboratory record book. After donning surgical gloves and washing the gloves with Liqui-Nox® solution and deionized water, the whole liver was removed and weighed. After noting if the gall bladder was full or empty, the kidney was removed and placed in the weighing tray with the liver. Subsamples were prepared by blending whole organisms in laboratory-grade blender with dry ice for approximately 30 seconds to 1 minute to allow homogenization of the tissues.

Figure 2-8. Sculpin Sampling Locations for the Spring 2006 Effort.

2.5.10.1 Sculpin Collection. Sculpin were collected between February 8 and 23, 2006. A summary of sculpin samples including sample, liver, and kidney identification numbers, date collected and investigation area is provided below in Table 2-16.

Table 2-16. Summary of Sculpin Samples Collected During Spring 2006.

Whole body Sample ID Number	Liver Sample ID Number	Kidney Sample ID Number	Date Collected	Investigation Area
J11873	J118C6	J118D3	22-Feb-06	100-D
J11874	J118C7	J118D4	22-Feb-06	100-D
J11875	J118C8	J118D5	22-Feb-06	100-D
J11876	J118C9	J118D6	20-Feb-06	100-D
J11877	J118D0	J118D7	20-Feb-06	100-D
J11878	J118D1	J118D8	20-Feb-06	100-D
J11863	J11897	J118B3	23-Feb-06	100-K Elevated
J11864	J11898	J118B4	23-Feb-06	100-K Elevated
J11865	J11896	J118B2	23-Feb-06	100-K Elevated
J11866	J11894	J118B0	23-Feb-06	100-K Elevated
J11867	J11895	J118B1	23-Feb-06	100-K Elevated
J11868	---	---	23-Feb-06	100-K Low
---	J11899	J118B5	23-Feb-06	100-K Elevated
J117R6	J118D9	J118H0	8-Feb-06	300 Elevated
J117R7	J118F0	J118H1	8-Feb-06	300 Elevated
J117R8	J118F1	J118H2	10-Feb-06	300 Elevated
J11807	J118F2	J118H3	23-Feb-06	300 Elevated
J117R9	---	---	10-Feb-06	300 Low
J117R3	J118F7	J118H8	10-Feb-06	300-1
J117R4	J118F8	J118H9	10-Feb-06	300-1
J117R5	J118F9	J118J0	10-Feb-06	300-1
J11869	---	J118C0	13-Feb-06	Vernita
J11870	J118B7	J118C1	13-Feb-06	Vernita
J11871	J118B8	J118C2	13-Feb-06	Vernita
J11872	---	---	13-Feb-06	Vernita
---	J118B6	---	14-Feb-06	Vernita

--- Samples were unable to be processed due to limited amount of sample

Samples were sent to Lionville (chemical constituents) and Eberline (radiological constituents), and to Dr. Ralph Elston of AquaTechnics/Pacific Shellfish Institute, Washington (histopathology).

2.5.10.2 Sculpin Histopathology. Tables 2-17 and 2-18 describe the general and specific key components for presence and conditions of each organ and those conditions that apply to specific lesions.

Table 2-17. Sculpin Histopathology General Key Components for Presence and Conditions of Each Organ and those that Apply to Specific Lesions.

<i>Those that apply to Presence and Condition columns for each organ:</i>	
Blank cell	Organ or tissue was not present in sample ^a
1	Organ is present in histological sections
9	Organ is present in histological sections but is characterized by artifact, which consists of either poor fixation, post mortem change prior to fixation, and may have artifactual compression or tissues ^b
<i>Those that apply to specific lesion columns, other than Presence and Condition:</i>	
Blank cell	Organ or tissue was not present in sample
0	The specific lesion for that column was not found in the specimen
1 or other number except 9	The specific lesion was present in the particular specimen, as described for that lesion in the key
9	The post mortem change listed under the Presence and condition column for the specific organ precluded diagnosis of the condition

^a The exception is the column for Peritoneal Cavity - Protozoan Granulomas. This column is for enumeration of prespore and sporulating protozoan granulomas found in the peritoneal cavity. A blank space indicates that none were found.

^b For sculpins, this condition is listed for each organ, if there were any examples of post-mortem artifact for that particular organ. Post-mortem change is a limiting factor in making histological interpretation. However, post-mortem change does not occur at the same rate in all organs and tissues and some observations may be possible, even with a degree of post-mortem change present.

Table 2-18. Sculpin Histopathology Specific Key Components for Presence and Conditions of Each Organ and those that Apply to Specific Lesions. (5 Pages)

<i>Integument - Skin (epithelium), scales (where present in species)</i>	
Conditions	
1	Integument - Presence and condition, rated according to definitions under General Key Components
<i>Connective tissue underlying integument</i>	
Conditions	
1	Connective tissue - multifocal areas of lymphocyte infiltration

Table 2-18. Sculpin Histopathology Specific Key Components for Presence and Conditions of Each Organ and those that Apply to Specific Lesions. (5 Pages)

Respiratory and Circulatory System		
Gills		
Conditions		
1	Presence and condition, rated according to definitions under General	
2	Encysted protozoan parasite. Can be rated as:	
	a	Focal
	b	Several focal areas of infection
	c	Multifocal areas of infection
3	Focal to multifocal clubbing and fusion of lamellae, some with telangiectasis. Can be rated as:	
	a	Focal
	b	Several focal areas of infection
	c	Multifocal areas of infection
Blood and blood vessels		
Conditions		
1	Blood and blood vessels - Presence and condition, rated according to definitions under General Key Components	
2	Blood and blood vessels - endothelialitis (inflammation of arteries or veins, see explanatory notes on spreadsheet)	
Spleen		
Conditions		
1	Presence and condition, rated according to definitions under General Key Components	
Hematopoietic tissue (interstitial tissue of excretory kidney)		
Conditions		
1	Presence and condition, rated according to definitions under General Key Components	
Excretory System - Kidney		
Conditions		
1	Presence and condition, rated according to definitions under General Key Components	
2	Parasite granuloma around encysted presumed digenetic trematode, number of observed sites indicated in box on spreadsheet	
3	Tubular epithelial sloughing	

Table 2-18. Sculpin Histopathology Specific Key Components for Presence and Conditions of Each Organ and those that Apply to Specific Lesions. (5 Pages)

Skeletal Muscle and supporting structures	
Conditions	
1	Presence and condition, rated according to definitions under General Key Components
2	Presumed digenetic trematode metacercaria infection, rated as follows:
a	Viable appearing parasites in tissue, 1 to 3 parasites
b	Viable appearing parasites in tissue, 3 or more parasites
c	Granuloma that indicates resolving lesion, intact parasite structure not present
Cartilage and bone	
Conditions	
1	Presence and condition, rated according to definitions under General Key Components
2	Bone - osteitis – inflammation of bone cells
3	Cartilage – chondritis – inflammation of cartilage
Nervous System	
Spinal cord	
Conditions	
1	Presence and condition, rated according to definitions under General Key Components
Notocord and Vertebrae	
Conditions	
1	Presence and condition, rated according to definitions under General Key Components
Ganglia and peripheral nerves	
Conditions	
1	Presence and condition, rated according to definitions under General Key Components
Digestive System	
Stomach	
Conditions	
1	Presence and condition, rated according to definitions under General Key Components
Pancreas	
Conditions	
1	Presence and condition, rated according to definitions under General Key Components
Pyloric caecae, intestine and rectum	
Conditions	
1	Presence and condition, rated according to definitions under General Key Components

Table 2-18. Sculpin Histopathology Specific Key Components for Presence and Conditions of Each Organ and those that Apply to Specific Lesions. (5 Pages)

*Liver		
1	Presence and condition, rated according to definitions under General Key Components	
2	Liver vacuolation index scale 0 (no fat or glycogen, based on hematoxylin and eosin sections), then scale from 1 to 3 for degree of storage vacuoles in liver:	
	a	Few
	b	Indicting moderate
	c	Indicating abundant and prominent storage vacuoles in all hepatocytes
3	Liver parasite. Granuloma around encysted presumed digenetic trematode, number of observed sites indicated in box on spreadsheet	
4	Presumed viral infection. Multifocal coagulation necrosis of hepatocytes associated with the portal triads. Foci are infiltrated by macrophage-type cells and some neutrophils. Some foci with eosinophilic infiltration and necrotic hepatocytes. Consistent with a systemic viral infection.	
5	Inflammation – liver granuloma, no parasites noted. A granuloma is a resolving encystment, usually of a parasite. No identifiable parasitic structures were observed in the liver inside the granulomas. The numbers under this column indicate the number of granuloma structures seen in the liver of each specimen.	
Reproductive System		
Presence and condition and gender		
Conditions		
1	Female	
2	Male	
3	Undifferentiated reproductive track. In the case of sculpins in AQ06-33, presence of reproductive tissue was noted both at necropsy and histology. Lack of developing reproductive tissue indicates lack of differentiation and development.	
Blank Space	Reproductive tissue not present	
Stage of Reproductive Development		
Conditions-Females – Ovary		
1	Oogonia and oocytes	
2	Cortical alveolus state oocytes	
3	Early vitellogenic oocytes	
4	Late vitellogenic oocytes	
5	Spawned out condition	
Conditions-Males - Seminiferous tubules		
1	Primary and secondary spermatogonia	
2	Primary spermatocyte	

Table 2-18. Sculpin Histopathology Specific Key Components for Presence and Conditions of Each Organ and those that Apply to Specific Lesions. (5 Pages)

3	Secondary spermatocyte
4	Spermatids
5	Mature sperm cells
Peritoneal Cavity	
The number of protozoan granulomas found in section in each individual sculpin are recorded in this column. No entry means no protozoan granulomas were found. These are spheroidal granulomas surrounding a multitude of protozoa that appear to be in pre-spore and rarely in sporulating stages. The granulomas are visible at necropsy as white spheroidal structures up to about 1.5 mm in diameter. They appear to be either free or loosely adhered in the peritoneal cavity. They may be microsporidia but further identification work would be required to place them taxonomically. They appear similar to the protozoans found only occasionally in other tissues, as reported in the NOTES sections of the results.	

* Note: This category has previously been labeled "liver fat index" consistent with common practice. However, a precise interpretation indicates that special stains are needed to definitively differentiate glycogen from fat. The index is still equally useful because it indicates the relative degree of energy storage products in the liver.

2.6 DOSIMETERS

External radiation was measured at each of the 45 upland and riparian study sites using TLD-700 (LiF) chips to determine the average environmental dose rates measured at each station. Five TLDs were placed within each upland investigation area and three were placed within each riparian investigation area. For upland areas, TLDs were affixed to the t-post stakes approximately 1.2 m (4 ft) off the ground surface at each corner of the study plot plus one in the center of the study plot. For riparian areas, TLDs were located at each of the three metal posts; one at each end and one in the center.

A map showing the investigation areas where TLDs were located (in addition to plants, small mammals and invertebrates) is depicted in Figure 2-5. The TLDs were placed in plastic envelopes and hung in a vertical position facing the study plot. During collection it was discovered that some TLDs had been disturbed by wildlife (e.g., chewed on, rubbed and torn from poles) or had leaks in the plastic envelopes. These were noted in the logbooks and in the dosimeter analysis performed by Pacific Northwest National Laboratory. The average daily exposure was determined by dividing the average total exposure for each set of five chips, divided by the number of days the TLDs were exposed at the study site.

Table 2-19. Summary of Dosimeters Collected During Spring 2006. (2 Pages)

Dosimeter ID Number	Date Collected	Investigation Area
WH156 - WH160	2-May-06	100-D-48:2
WH161 - WH165	2-May-06	100-D-49:2
WH006 - WH010	25-Apr-06	100-F-2

**Table 2-19. Summary of Dosimeters Collected During Spring 2006.
(2 Pages)**

Dosimeter ID Number	Date Collected	Investigation Area
WH011 - WH015	24-Apr-06	116-DR-1 & 2
WH061 - WH065	24-Apr-06	116-N-3
WH182 - WH187	2-May-06	116-F-1
WH166 - WH170	2-May-06	1607-D2:1
WH171 - WH175	2-May-06	1607-H2
WH194 - WH199	8-May-06	300-49
WH016 - WH020	24-Apr-06	600-131
WH151 - WH155	1-May-06	600-132 and 600-190
WH116 - WH120	25-Apr-06	600-139
WH136 - WH140	1-May-06	600-171
WH111 - WH115	25-Apr-06	600-181
WH146 - WH150	1-May-06	600-204
WH131 - WH135	1-May-06	600-208
WH066 - WH070	25-Apr-06	600-23
WH188 - WH193	8-May-06	618-4
WH141 - WH145	2-May-06	628-1
WH021 - WH025	24-Apr-06	CP Ref2
WH032 - WH036	25-Apr-06	JA Jones
WH087 - WH091	25-Apr-06	McGee Ranch
WH176 - WH181	2-May-06	Saddle Mountain
WH121 - WH125	25-Apr-06	Vernita South
WH082 - WH086	24-Apr-06	Yakima Ridge II
WH037 - WH041	25-Apr-06	Pit 9
WH051 - WH055	2-May-06	Pit 14
WH042 - WH05	25-Apr-06	Pit 18
WH001 - WH005	24-Apr-06	Pit 23
WH056 - WH060	2-May-06	Pit 24
WH050 - WH075	1-May-06	Riparian #1
WH076 - WH078	1-May-06	Riparian #2
WH079 - WH081	1-May-06	Riparian #3
WH095 - WH097	1-May-06	Riparian #4

**Table 2-19. Summary of Dosimeters Collected During Spring 2006.
(2 Pages)**

Dosimeter ID Number	Date Collected	Investigation Area
WH098 - WH100	1-May-06	Riparian #5
WH026 - WH028	25-Apr-06	Riparian #6
WH092 - WH094	1-May-06	Riparian #7
WH047 - WH049	1-May-06	Riparian #8
WH029 - WH031	1-May-06	Riparian #9
WH071 - WH073	1-May-06	Riparian #10
WH128 - WH130	1-May-06	Riparian #11
WH110, WH126, WH127	1-May-06	Riparian #12
WH107 - WH109	1-May-06	Riparian #13
WH101 - WH103	1-May-06	Riparian #14
WH104 - WH106	1-May-06	Riparian #16

3.0 DATA VALIDATION

As stated in the SAP validation by a contractor outside of WCH is required for at least 5% of risk assessment data. In practice, however, a larger percentage will be validated because complete sample delivery groups, with often multiple sample identification numbers, are submitted to the validator at one time. For example, all avian samples were processed and sent to the laboratory in one shipment as a single data package. As a result, 100% of the avian sample data was validated. In addition, a data package from each media type will be sent for validation. The result of these logistical factors is that some percentage larger than 5% will be validated.

The framework for validation procedures for data used in decision-making is based on *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (EPA 540/R-04/004), and *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review* (EPA 540/R-99/008). The principles in the national functional guidelines, which are written for inductively coupled plasma metals and mercury, are expanded to apply to other inorganic analyses (e.g., anions) and radiological contaminants based on industry standards, laboratory methodology, and professional judgment. Specific parameters relevant to the RCBRA data are identified in Tables 2-2, 2-3, and 2-4 of the SAP, along with the WCH validation procedure where parameters are not specified in the SAP document.

The decision logic and criteria for validating and assessing data quality are summarized in a Figure 3-1. Data that is not validated is evaluated using the same criteria. Persons performing data validation or quality assessment review the data looking for results within the categories in the flow diagram that are outside the required parameters. Data validation is done at Level C in accordance with validation procedures (FH 2004a and FH 2004b). This level of data validation includes the following:

- Verification of required deliverables
- Requested versus reported analyses
- Evaluation of requested versus achieved analyte detection limits
- Evaluation and qualification of results based on analytical holding times and sample preservation
- Verification of transcription errors
- Evaluation and qualification of results based on method blank result criteria
- Qualification of sample results based on matrix spike (as appropriate to the method)
- Laboratory control sample and laboratory duplicate or matrix spike/matrix spike duplicate (as appropriate to the method)
- Evaluation and qualification of sample results based chemical or tracer recovery criteria (as appropriate to the method).

Figure 3-1. Data Sample Delivery Group Validation Procedure.

Modified from the *Data Validation Procedure for Chemical Analysis* (BHI 2000)

When a potential data issue is recognized, the data reviewer determines if the issue indicates a systematic problem, or if the issue is characteristic of a random error. Multiple low surrogate or matrix spike recoveries are examples of a systematic error that would indicate a problem needing more extensive evaluation of how a given laboratory is performing. The response is to begin looking at larger bodies of data to help identify the potential for a widespread impact. Heterogeneity in the sample matrix can be a cause of random errors in analytical results.

Field blanks, field duplicates, and field splits (if information is provided) will be examined. The following equipment blanks were made: 1 sediment, 4 pore/surface water and 2 MIS of soil. The following replicates were made: 6 sediment, 4 biota, 9 pore/surface water. For the spring soil and water sampling, data packages were validated: 2 MIS of soil, 1 discrete soil, 1 sediment, 1 pore water, 1 surface water, and 1 groundwater well. For the spring biota sampling, data from 1 plant, 1 mouse, 1 kingbird, 1 aquatic invertebrate, 1 upland invertebrate, 1 clam, and 2 sculpin data packages were validated.

Table 3-1. Spring 2006 Sampling Effort Type, Start, Completion Dates, Validation/Verification SDG(s) and Validation/Verification Completion Date

Effort	Sample/ Information Gathering Date	Completion Date	Data Validation/ Verification SDG(s)	Data Validation/ Verification Completion Date	Percent Validated
Groundwater	6/1/2006	6/26/2006	K0188	6/6/2006	11.1%
MIS of Soil	3/13/2006	5/24/2006	K0274 –Riparian K0328- Upland	7/26/2006 8/28/2006	5.3%
Discrete Soil	6/19/2006	6/20/2006	K0445	9/18/2006	100%
Sediment	2/5/2006	2/27/2006	K0235	6/28/2006	14.3%
Pore Water	1/16/2006	9/5/2006	K0205	7/5/2006	14.3%
Surface Water	1/16/2006	2/6/2006	K0205	7/5/2006	14.3%
Dominant Plant Species	4/24/2006	5/22/2006	K0358	8/23/2006	25%
Small Mammals	3/14/2006	4/21/2006	K0270	9/12/2006	16.7%
Kingbirds	6/19/2006	8/23/2006	K0529	^a	65%
Aquatic Invertebrates	7/23/2006	7/31/2006	K0506	^a	100%
Terrestrial Invertebrates	3/16/2006	4/26/2006	K0331	9/18/2006	33%
Clams	7/23/2006	7/31/2006	K0519	^a	57.1%
Sculpin	2/6/2006	2/23/2006	K0229 K0238	7/5/2006 7/5/2006	28.6%
Dosimeter Collection	4/24/2006	5/8/2006	N/A	N/A	N/A

^a Data validation not complete as of the end of October 2006.
SDG = sample delivery group

4.0 ANALYTICAL DATA

Groundwater samples were analyzed for metals, radionuclides, semivolatile organic compounds, pesticides, and polychlorinated biphenyls. Tables 1-1 and 1-2 of the SAP (DOE-RL 2006a) show the analytical suites and indicator constituents for upland and riparian soil and groundwater samples, respectively. The bioassays for these soils are run on Sandberg's bluegrass (*Poa sandbergii*) under ASTM 1963-02 and on nematodes (*Caenorhabditis elegans*) under ASTM E2172-01. A compilation of the analytical and histopathology results will be available after January 2007.

5.0 PERFORMANCE ASSESSMENT

The goal of soil multi-increment sampling is to characterize the average contaminant concentrations within each investigation area. The MIS technique is an efficient way to characterize large upland and riparian locations for potential ecological risk to populations. The MIS technique also has been shown to be a robust indicator of the mean, because the influence of “nuggets” or otherwise atypical soils is better characterized. The fall sampling event, which assessed soil at 20% of the investigation areas (representing all nine environments and site type combinations), was conducted as a performance assessment. The purpose of the performance assessment was to provide information on the ‘between-sample’ and ‘between-investigation area’ variability in contaminant concentrations. The performance assessment on the fall MIS effort is in Appendix D.

5.1 RECOMMENDATIONS

The following recommendations were based on Visual Sample Plan (VSP) results, relative standard deviations, confidence levels of the data, and the values in the data relative to cleanup levels:

1. Collect three MIS samples at all riparian sites
 - a. Riparian sites have no other soil sample data for human health exposure analysis
 - b. Riparian sites, in particular the reference site, have the highest levels of many indicator contaminants
2. Collect two MIS samples at upland sites with no evidence of debris
 - a. Upland sites generally had low levels of indicator contaminants
 - b. Two is the minimum number of samples recommended by VSP
3. Collect five MIS samples at upland sites with evidence of lead-containing debris (e.g., batteries, paint chips) in the top 15 cm (6 in.)
 - a. These sites appear to have the greatest heterogeneity of contaminants, including at least one contaminant of significance to human health
 - b. Consider collecting additional increments (i.e., 100 increments per investigation area) at these plots

The final version of the performance assessment was completed in spring 2006. However, five MIS of soil were also collected at each of the spring sampling sites for consistency.

6.0 REFERENCES

- ASTM D2488–00, “Standard Practice for Description and Identification of Soils (Visual – Manual Procedure,” *American Society for Testing and Materials*, West Conshohocken, Pennsylvania.
- ASTM E1295-01, 2002, “Standard Guide for Conducting Three-Brood, Renewal Toxicity Tests with *Ceriodaphnia dubia*,” *American Society for Testing and Materials*, West Conshohocken, Pennsylvania.
- ASTM E1493-98 (Reapproved 2004), “Standard Guided for Conducting the Frog Embryo Teratogenesis Assay-Xenopus (FETAX),” *American Society for Testing and Materials*, West Conshohocken, Pennsylvania.
- ASTM E1706-05, “Standard Test Method for Measuring the Toxicity of Sediment-Associated Contaminants with Freshwater Invertebrates,” *American Society for Testing and Materials*, West Conshohocken, Pennsylvania.
- ASTM E1963-02, 2002, “Standard Guide for Conducting Terrestrial Plant Toxicity Tests,” *American Society for Testing and Materials*, West Conshohocken, Pennsylvania.
- ASTM E2172-01, 2001, “Standard Guide for Conducting Laboratory Soil Toxicity Tests with the Nematode *Caenorhabditis elegans*,” *American Society for Testing and Materials*, West Conshohocken, Pennsylvania.
- AVMA, 1986, “AVMA Panel on Euthanasia,” *Journal of the American Veterinary Medical Association*, Vol 188 (3).
- BHI, 2000, *Data Validation Procedure for Chemical Analysis*, BHI-01435, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.
- Chen et al., 2002, *Phytotoxicity of Dredged Sediment from Urban Canal as Land Application*, *Environmental Pollution* 117 (2002) 233-241
- Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 U.S.C. 9601, et seq.
- Daubenmire, R. 1959. A Canopy-Coverage Method of Vegetation Analysis. *Northwest Scientist* 33: 43-64.
- DOE-RL, 2000, *Threatened and Endangered Species Management Plan Salmon and Steelhead*, DOE/RL-2000-27, Rev. 0, U. S. Department of Energy, Richland, Washington.
- DOE-RL, 2006a, *100 Area and 300 Area Component of the RCBRA Sampling and Analysis Plan*, DOE/RL-2005-42, Rev. 0, U. S. Department of Energy, Richland, Washington.

References

- DOE-RL, 2006b, *Aquatic and Riparian Receptor Impact Information for the 100-NR-2 Groundwater Operable Unit*, DOE/RL-2006-26, Draft A Re-Issue, U. S. Department of Energy, Richland, Washington.
- EPA 540/R-99/008, 1999, *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review*, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C.
- EPA 540/R-04/004, 2004, *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review, Final*, Office of Superfund Remediation and Technology Innovation, U.S. Environmental Protection Agency, Washington, D.C.
- EPA 600/R-99/064, 2000, *Methods for Measuring the Toxicity and Bioaccumulation of Sediment-Associated Contaminants with Freshwater Invertebrates – Second Edition*, U.S. Environmental Protection Agency, Washington, D.C.
- EPA 821/B-00/004, 2002, *Method Guidance and Recommendations for Whole Effluent Toxicity (WET) Testing* (40 CFR Part 136), U.S. Environmental Protection Agency, Washington, D.C.
- EPA 821/R-02/013, 2002, *Short-Term Methods for Estimating the Chronic Toxicity of Effluent and Receiving Waters to Freshwater Organisms*, EPA Method 1002.0 "Ceriodaphnia Survival and Reproduction Test," U.S. Environmental Protection Agency, Washington, D.C.
- EPA 833/R-00/003, 2000, *Understanding and Accounting for Method Variability in Whole Effluent Toxicity Applications Under the National Pollutant Discharge Elimination System Program*, U.S. Environmental Protection Agency, Washington, D.C.
- FH, 2004a, *Data Validation Procedure for Chemical Analyses*, HNF-20433, Rev. 0, Fluor Hanford, Inc., Richland, Washington.
- FH, 2004b, *Data Validation Procedure for Radiochemical Analyses*, HNF-20434, Rev. 0, Fluor Hanford, Inc., Richland, Washington.
- Hoagland and Amon, 1950, "The Water-Culture Method for Growing Plants Without Soil," *California Agricultural Experiment Station*, Circular No. 347.
- <http://hms.pnl.gov/products.htm> The Hanford Meteorological Station. Pacific Northwest National Laboratory
- SP-3, "Groundwater Sampling," Duratek Federal Services of Hanford, Inc., Richland, Washington.
- Thein, S.J., 1979, A Flow Diagram for Teaching Texture-by-feel Analysis. *Journal of Agronomic Education*. 8:54-55.
- WAC 173-340, "Model Toxics Control Act -- Cleanup," *Washington Administrative Code*, as amended.

WCH, 2005, *Instruction for Multi-Incremental Soil Sampling and Laboratory Subsampling for 100 Area and 300 Area Component of the River Corridor Baseline Risk Assessment*, CCN 124510, Washington Closure Hanford, Richland, Washington.

WCH, 2006a, *Sampling and Analysis Instructions for the 100 Area and 300 Area Component of the RCBRA Project*, WCH-47, Washington Closure Hanford, Richland, Washington.

WCH, 2006b, *100 Area and 300 Area Component of the RCBRA Fall 2005 Data Compilation* WHC-085, Washington Closure Hanford, Richland, Washington.

APPENDIX A

**PLOT COORDINATES FOR UPLAND AND
RIPARIAN SAMPLING EFFORTS**

Table A-1. Plot Coordinates for Upland and Riparian Sampling Efforts.
(4 Pages)

Site ID	Fence Post	Northing	Easting	Area (ha)
100-D-48:2	A	151837.691	573812.643	1.0028
	B	151989.563	573804.016	
	C	151993.251	573869.714	
	D	151841.580	573878.656	
	Center	151914.538	573841.527	
100-D-49:2	A	151844.254	573917.393	1.0078
	B	152044.109	573909.421	
	C	152046.499	573959.870	
	D	151846.927	573967.668	
	Center	151944.123	573938.060	
100-F-2	A	146945.480	579678.933	0.9965
	B	147045.717	579683.083	
	C	147051.515	579782.564	
	D	146951.618	579779.074	
	Center	147001.117	579728.068	
116-DR-1 & 2	A	152190.013	573945.875	0.9882
	B	152339.401	574018.002	
	C	152309.220	574069.379	
	D	152161.022	573998.988	
	Center	152246.748	574007.817	
116-N-3	A	149766.799	571933.252	0.9937
	B	149876.444	571992.675	
	C	149830.367	572057.579	
	D	149719.501	571998.357	
	Center	149793.039	571995.702	
116-F-1	A	147777.690	579996.869	1.0041
	B	147945.253	580000.367	
	C	147943.949	580060.513	
	D	147777.573	580056.967	
	Center	147860.793	580028.502	
1607-D2:1	A	152184.548	573794.082	1.0045
	B	152335.866	573788.260	
	C	152339.272	573854.651	
	D	152187.539	573860.036	
	Center	152260.319	573823.924	
1607-H2	A	152947.405	577677.172	1.0007
	B	153143.662	577713.020	
	C	153134.090	577762.444	
	D	152938.586	577726.556	
	Center	153037.184	577719.171	
300-49	A	116764.666	594306.088	0.6250
	B	116887.731	594282.792	
	C	116896.701	594331.852	
	D	116773.764	594355.230	
	Center	116830.934	594318.994	
600-131	A	148885.055	577530.502	0.9873
	B	149182.311	577387.730	
	C	149197.469	577412.398	
	D	148895.645	577559.306	
	Center	149037.291	577475.261	

**Table A-1. Plot Coordinates for Upland and Riparian Sampling Efforts.
(4 Pages)**

Site ID	Fence Post	Northing	Easting	Area (ha)
600-132 and 600-190	A	148847.421	577567.358	0.9928
	B	148946.651	577575.758	
	C	148940.022	577675.024	
	D	148840.572	577666.855	
	Center	148894.409	577621.293	
600-139	A	147803.415	577359.226	0.9934
	B	147870.504	577433.290	
	C	147799.323	577503.551	
	D	147732.939	577430.007	
	Center	147799.591	577434.633	
600-171	A	147726.108	578148.617	0.9998
	B	147792.493	578074.267	
	C	147869.714	578138.377	
	D	147803.110	578212.748	
	Center	147797.960	578143.253	
600-181	A	147282.907	578241.409	0.9934
	B	147378.871	578269.174	
	C	147351.713	578364.537	
	D	147255.481	578337.123	
	Center	147316.698	578303.830	
600-204	A	144713.787	580080.033	0.9906
	B	144812.781	580078.862	
	C	144811.750	580178.104	
	D	144711.962	580180.164	
	Center	144762.219	580128.485	
600-208	A	138319.855	586296.216	1.0012
	B	138448.115	586141.175	
	C	138485.623	586173.732	
	D	138359.329	586327.577	
	Center	138403.691	586234.966	
600-23	A	130414.746	585502.734	0.9877
	B	130516.716	585461.167	
	C	130549.010	585541.808	
	D	130444.842	585587.376	
	Center	130481.377	585523.593	
618-4	A	116991.696	593883.982	1.0287
	B	117035.863	593858.132	
	C	117141.201	594029.415	
	D	117096.708	594054.938	
	Center	117064.473	593954.946	
628-1	A	148711.448	577737.083	0.9949
	B	148807.699	577761.831	
	C	148778.838	577856.838	
	D	148681.596	577833.019	
	Center	148745.681	577797.524	
CP Ref2	A	139745.965	563745.899	1.0109
	B	139845.162	563741.992	
	C	139845.253	563846.295	
	D	139746.033	563845.379	
	Center	139793.869	563789.959	

**Table A-1. Plot Coordinates for Upland and Riparian Sampling Efforts.
(4 Pages)**

Site ID	Fence Post	Northing	Easting	Area (ha)
JA Jones	A	119959.352	593844.220	0.5493
	B	119998.955	593815.944	
	C	120065.687	593905.098	
	D	120025.691	593934.574	
	Center	120013.908	593874.580	
McGee Ranch	A	137969.085	555580.508	0.9934
	B	138056.229	555532.400	
	C	138101.943	555621.492	
	D	138014.225	555668.979	
	Center	138034.185	555600.760	
Saddle Mountain	A	160564.755	578465.976	1.0066
	B	160664.726	578464.557	
	C	160665.726	578565.516	
	D	160565.612	578566.231	
	Center	160614.852	578514.983	
Vernita South	A	143284.611	555737.801	1.0031
	B	143382.701	555719.588	
	C	143403.872	555817.729	
	D	143305.741	555836.222	
	Center	143343.749	555777.783	
Yakima Ridge II	A	135510.153	559014.308	0.9961
	B	135595.824	558961.755	
	C	135642.157	559049.964	
	D	135558.007	559102.457	
	Center	135576.407	559031.557	
Pit 9	A	120540.634	592756.945	0.9987
	B	120641.630	592759.055	
	C	120634.535	592858.429	
	D	120534.665	592856.169	
	Center	120587.700	592807.103	
Pit 14	A	138842.058	580883.214	0.9933
	B	138940.671	580876.785	
	C	138942.662	580976.472	
	D	138843.207	580983.899	
	Center	138893.242	580928.233	
Pit 18	A	145252.125	580674.877	0.5486
	B	145371.508	580674.179	
	C	145371.145	580720.074	
	D	145251.210	580720.680	
	Center	145311.464	580697.058	
Pit 23	A	144806.051	572356.475	0.9830
	B	144895.480	572314.278	
	C	144943.846	572401.191	
	D	144854.642	572443.697	
	Center	144874.157	572381.012	
Pit 24	A	145105.937	563279.788	0.5815
	B	145131.682	563279.149	
	C	145134.000	563509.178	
	D	145109.281	563510.481	

**Table A-1. Plot Coordinates for Upland and Riparian Sampling Efforts.
(4 Pages)**

Site ID	Fence Post	Northing	Easting	Area (ha)
	Center	145119.007	563395.814	
Riparian #1	A	153609.723	577344.421	Transect
	B	153659.195	577251.869	
	C	153707.885	577166.460	
Riparian #2	A	152537.791	573679.730	Transect
	B	152471.600	573603.219	
	C	152412.176	573530.124	
Riparian #3	A	151713.927	572716.726	Transect
	B	151677.812	572639.650	
	C	151603.249	572594.851	
Riparian #4	A	149035.324	570644.037	Transect
	B	148981.547	570558.596	
	C	148900.504	570499.481	
Riparian #5	A	147595.103	569206.140	Transect
	B	147521.561	569141.025	
	C	147458.799	569067.236	
Riparian #6	A	116096.841	594504.078	Transect
	B	116194.209	594479.972	
	C	116290.810	594455.886	
Riparian #7	A	147735.178	581364.513	Transect
	B	147825.170	581326.914	
	C	147903.864	581268.653	
Riparian #8	A	152153.360	578757.079	Transect
	B	152233.645	578698.584	
	C	152294.563	578620.058	
Riparian #9	A	152714.739	578201.732	Transect
	B	152801.452	578153.643	
	C	152886.192	578105.881	
Riparian #10	A	153173.197	574031.855	Transect
	B	153082.190	573987.873	
	C	152990.041	573955.020	
Riparian #11	A	146513.111	559483.749	Transect
	B	146458.486	559400.735	
	C	146416.533	559314.464	
Riparian #12	A	145805.901	559285.307	Transect
	B	145747.542	559201.908	
	C	145705.228	559111.648	
Riparian #13	A	145404.948	558651.636	Transect
	B	145345.115	558572.809	
	C	145300.541	558483.780	
Riparian #14	A	145149.710	556815.254	Transect
	B	145144.848	556717.180	
	C	145149.384	556618.094	
Riparian #16	A	144869.822	557738.596	Transect
	B	144826.748	557650.029	
	C	144780.737	557558.772	

APPENDIX B

SOIL TEXTURE REPORT

Survey Date	Site	Soil Type	Color	Moisture Cond.	Consistency	% Cover Rock Fragments (> 2mm particle size)			Gradation	Angularity	Shape	Cementation
						Gravel	Cobble	Boulder				
10/24/2005	Pit 18	Sandy Clay Loam	10YR 3/1	Wet	Very Soft	80	2	0	Poorly Graded	all	N/A	Weak
10/24/2005	W. Pit 9	Sandy Loam	5Y 2.5/1	Wet	Very Soft	95	0	0	Poorly Graded	all	N/A	Weak
10/25/2005	Pit 14	Sandy Clay Loam	2.5Y 3/1	Wet	Very Soft	50	10	<1	Poorly Graded	all	N/A	Weak
10/25/2005	Pit 24	Sandy Clay	10YR 3/2	Wet	Very Soft	50	3	<1	Poorly Graded	all	N/A	Weak
10/25/2005	116-N-3	Sandy Clay Loam	5Y 3/1	Wet	Very Soft	80	10	<1	Poorly Graded	all	N/A	Weak
10/26/2005	600-23	Sandy Loam	5Y 4/1	Wet	Very Soft	50	5	0	Poorly Graded	all	N/A	Weak
10/26/2005	JA Jones	Sandy Clay Loam	2.5Y 3/2	Wet	Very Soft	35	5	0	Poorly Graded	all	N/A	Weak
10/26/2005	Yak. Ridge II	Sandy Clay	2.5Y 4/2	Wet	Very Soft	1	<1	0	Poorly Graded	angular/subangular/sub rounded	N/A	Weak
10/27/2005	McGee Ranch	Sandy Clay	5Y 3/2	Wet	Very Soft	2	<1	<1	Poorly Graded	angular/subangular/sub rounded	N/A	Weak
10/27/2005	600-181	Sandy Clay	5Y 3/1	Wet	Very Soft	3	<1	0	Poorly Graded	subrounded/rounded	N/A	Weak
10/27/2005	600-139	Sandy Clay Loam	5Y 4/2	Wet	Very Soft	40	2	0	Poorly Graded	subrounded/rounded	N/A	Weak
10/27/2005	Vernita South	Sandy Clay	2.5Y 3/2	Wet	Very Soft	30	20	0	Poorly Graded	subrounded/rounded	N/A	Weak
10/31/2005	628-1	Sandy Clay	2.5Y 3/2	Wet	Very Soft	40	1	0	Poorly Graded	subrounded/rounded	N/A	Weak
10/31/2005	600-171	Sandy Clay Loam	2.5Y 3/2	Wet	Very Soft	40	1	0	Poorly Graded	all	N/A	Weak
10/31/2005	600-208	Sandy Clay	5Y 3/1	Wet	Very Soft	45	<1	0	Poorly Graded	all	N/A	Weak
11/1/2005	100-D-48:2	Sandy Clay Loam	5Y 3/2	Wet	Very Soft	45	10	<1	Poorly Graded	subrounded/rounded	N/A	Weak
11/1/2005	600-132&190	Sandy Clay	5Y 3/2	Wet	Very Soft	35	<1	0	Poorly Graded	subrounded/rounded	N/A	Weak
11/1/2005	600-204	Sandy Clay	5Y 3/2	Wet	Very Soft	40	<1	0	Poorly Graded	subrounded/rounded	N/A	Weak
11/2/2005	100-D-49:2	Sandy Clay Loam	5Y 3/2	Wet	Very Soft	40	2	0	Poorly Graded	subrounded/rounded	N/A	Weak
11/2/2005	1607-H2	Sandy Clay Loam	2.5Y 3/1	Wet	Very Soft	50	5	0	Poorly Graded	subrounded/rounded	N/A	Weak
11/2/2005	1607-D2:1	Sandy Clay Loam	5Y 4/1	Wet	Very Soft	40	2	0	Poorly Graded	subrounded/rounded	N/A	Weak
11/3/2005	Saddle Mtn.	Sandy Clay	10YR 4/2	Wet	Very Soft	20	1	<1	Poorly Graded	angular	N/A	Weak
11/4/2005	Riparian #1	Sandy Loam	5Y 3/2	Wet	Very Soft	50	25	0	Poorly Graded	subrounded/rounded	N/A	Weak
11/4/2005	Riparian #10	Silty Clay Loam	10YR 3/2	Wet	Very Soft	30	30	0	Poorly Graded	subrounded/rounded	N/A	Weak
11/4/2005	Riparian #4	Silty Clay	7.5YR 3/2	Wet	Very Soft	10	10	2	Poorly Graded	subrounded/rounded	N/A	moderate
11/4/2005	Riparian #11	Silty Loam	10YR 4/2	Wet	Very Soft	10	50	5	Poorly Graded	subrounded/rounded	N/A	moderate
11/4/2005	Riparian #16	Loam	10YR 3/2	Wet	Very Soft	10	5	0	Poorly Graded	subrounded/rounded	N/A	Weak
11/4/2005	Riparian #3	Sandy Loam	5YR 3/1	Wet	Very Soft	30	25	2	Poorly Graded	subrounded/rounded	N/A	Weak
11/4/2005	Riparian #9	Clay	7.5YR 3/1	Wet	Very Soft	30	65	0	Poorly Graded	subrounded/rounded	N/A	Weak
11/4/2005	Riparian #13	Sandy Loam	7.5YR 3/2	Wet	Very Soft	20	40	2	Poorly Graded	subrounded/rounded	N/A	Weak
11/4/2005	Riparian #12	Sandy Loam	7.5YR 3/2	Wet	Very Soft	25	25	2	Poorly Graded	subrounded/rounded	N/A	Weak
11/4/2005	Riparian #8	Clay	7.5YR 3/1	Wet	Very Soft	30	50	0	Poorly Graded	Rounded	N/A	Weak
11/4/2005	Riparian #7	Silty Clay	5YR 4/1	Wet	Very Soft	50	15	0	Poorly Graded	Rounded	N/A	Weak
11/4/2005	Riparian #2	Sandy Loam	10YR 3/2	Wet	Very Soft	30	15	0	Poorly Graded	subrounded/rounded	N/A	moderate
11/4/2005	Riparian #14	Silty Clay	10YR 3/2	Wet	Very Soft	10	50	20	Poorly Graded	subrounded/rounded	N/A	Weak
11/4/2005	Riparian #6	Silty Clay Loam	10YR 3/3	Wet	Very Soft	25	40	5	Poorly Graded	subrounded/rounded	N/A	moderate
11/4/2005	Riparian #5	Silty Clay	5YR 3/1	Wet	Very Soft	20	20	40	Poorly Graded	subrounded/rounded	N/A	moderate
11/7/2005	116-F-1	Sandy Clay Loam	10YR 4/2	Wet	Very Soft	5	3	<1	Poorly Graded	N/A	N/A	Weak
11/7/2005	300-49	Loamy Sand	5Y 4/1	Wet	Very Soft	10	<1	0	Poorly Graded	subrounded	N/A	Weak
11/7/2005	618-4	Loamy Sand	5Y 4/1	Wet	Very Soft	5	<1	0	Poorly Graded	subrounded	N/A	Weak
11/8/2005	CPR Ref II	Sandy Loam	10YR 4/2	Wet	Very Soft	<1	<1	0	Poorly Graded	subangular/subrounded	N/A	Weak
11/8/2005	600-131	Sandy Loam	7.5YR 4/2	Wet	Very Soft	20	5	0	Poorly Graded	subangular/subrounded	N/A	Weak
11/8/2005	100-F-2	Silty Clay Loam	7.5YR 3/2	Wet	Very Soft	<1	<1	0	Poorly Graded	subangular/subrounded	N/A	Weak
11/8/2005	116 DR 1&2	Sandy Loam	7.5YR 3/3	Wet	Very Soft	15	1	1	Poorly Graded	subangular/subrounded	N/A	Weak
11/8/2005	Pit 23	Sand	5Y 3/1	Wet	Very Soft	60	1	<1	Poorly Graded	angular/subangular	N/A	Weak

APPENDIX C

THREATENED AND ENDANGERED PLANT SPECIES REPORT

**THREATENED AND ENDANGERED/RARE PLANT INVENTORY
100 AREA AND 300 AREA COMPONENT OF THE
RIVER CORRIDOR BASELINE RISK ASSESSMENT**

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INTRODUCTION

This rare plant inventory is part of a multi-disciplinary study to address the potential impact of past management of the Hanford Nuclear Reservation on the flora and fauna of the site, and to assess whether the remediation activities have achieved the objective of restoring the landscape to pre-Hanford Reservation conditions. Representative plots were established within the remediated area and sampled intensively; this rare plant survey was part of that sampling under contract with Environmental Assessment Services.

Twenty upland plots at remediated sites¹ (which included both backfill and native soil sample sites) and ten riparian plots² were surveyed for this study; reference plots were not included in this inventory.

Landscape description

Upland

By the end of the Pleistocene, sand-dominated cobble-gravel-sands soils from Missoula Flood events dominated the Hanford Site at elevations below 240 meters (Stetler and Gaylord 1996). The stratigraphy of late-Pleistocene cataclysmic flood sediments are 'complex over a range of scales due to extremely rapid deposition and dynamic deposition processes during flooding;' as a result, rapid vertical and lateral changes may occur within a few meters (Bjornstad *et al.* 1994). Sediments have been variably sorted by wind, so that some areas have sand deposits of varying thickness overlying the Missoula flood deposits.

In addition, in the north portion of Central Hanford, the Columbia River migrated east to its present location during the late Pleistocene and early Holocene, creating a complicated set of fluvial landforms within a series of flood terraces that have been deciphered and described by Fecht *et al.* 2004. Several study plots occur within this series of ancient Columbia River terraces (sites at 100H, 100F and 300 Area) or just above the terraces in areas of cataclysmic flood bars (sites at 100D and 100N).

The site near 100H (1607-H-2) probably occurs along one of the channels within the third terrace that is armored with a boulder to cobble gravel lag. Elsewhere in the ancient third terrace channel setting at 100F (plot 116-F-1 and possibly plot 100-F-2) where, besides the boulder to cobble gravel lag within the channel, there is

“... a thin (<0.6 m) sequence of compact silty fine sand [that] is found overlying the gravel in places. The silty fine sand unit is interpreted to be a silt plug that was deposited when the ancient river channel was abandoned and the river established a new course further east near its present day position” (Fecht *et al.* 2004).

Sites to the south, west and northwest of the 100F facility (plots 600-204, 628-1, 600-131, 600-132, 600-190, 600-139, 600-171, 600-181) occur on the broad second terrace identified by Fecht *et al.* (2004). The upper and second terrace zones within “the sloughs” river segment contain

¹ Upland surveyed sites were 600-23, 600-208, 600-181, 600-171, 600-139, 600-131, 600-132/190, 628-1, 116-F-1, 100-F-2, 600-204, JA JONES, 300-49, 618-4, 1607-H-2, 116-N-3, 100D-48.2, 100D-149-2, 116-DR-1&2, 16-7-D2:1.

² Riparian surveyed sites were 1-10.

numerous ancient gravel-dominated overbank levee/slough landforms that stretch inland up to about 5.6 km from the current river channel (Fecht *et al.* 2004). These highest elevation fluvial landforms are a series of broad benches with narrow channelways. Within the area where these sites are located, the second bench is

“...broad and composed of pebble to cobble gravel. The terrace tread is about 1.6 km wide [in this area].... The tread has abundant ... channel bedforms that vary from 60-300 meters across and bar bedforms that are commonly 600m across and 1200 meters long. In places, fluvial sand sequences are encountered along the eastern edge of the bench at the end of gravel bar bedforms The sandbeds are interpreted as fluvial deposits from high stage flow in a low energy environment of an ancient Columbia River. The geomorphic forms suggest these sandbeds were deposited on the inside of river bends and as such, are interpreted as point bar bedforms. (Fecht *et al.* 2004).

Basalt-rich sand (slightly south of the study sites near 100F) may be eolian dunes that have migrated across the gravel bar bedforms (Marceau 2003, from Fecht *et al.* 2004). “Elsewhere, sand sheets apparently accumulated in vegetation or on the lee sides of terrace bars.” Sandy zones noted within these study sites are likely from these sand sheet and/or the aforementioned fluvial deposits.

The plot site near the 100N facility (plot 116-N-3) is located in giant ripples at the upstream toe of cataclysmic flood bar (Fecht *et al.* 2004). The downriver sites near the 300 area (JA JONES, 300-49, 618-4, 1607-H-2) occur along narrow river terrace steps that are “capped by about 0.6 meters of eolian sand sheets that in turn are capped by stabilized eolian parabolic dunes (Fecht *et al.* 2004).

Vegetation patterns of the upland portion of Central Hanford have been described by Easterly and Salstrom (1997). Known occurrences of rare plants in the upland portion of Central Hanford (WNHP occurrence records, accessed 2005) occur in a variety of open habitat with generally a low cover of vegetation. Substrates supporting the rare species include sand, gravel sorted by size class, fine-grained sediments (slackwater fines or overbank deposition), vernal pools on basalt and pockets of soil on basalt (WNHP occurrence records, accessed 2005). Species found on sandy substrate can be divided into those on active sand and those that occur in swales that may have some vernal moisture.

Riparian

Between the riffle/rapids of Coyote Rapids and D Island is a section of river that is characterized by a “single, straight channel ... (which) forms a single deep pool” that is entrenched up to about 12 meters into the bedrock of the Ringold Formation (Fecht *et al.* 2004). Study sites 2-5 occur along this stretch of river. Site 1 occurs at a location with similar characteristics, as does Site 6, which is located downriver near the 300 Area.

From D Island to the south end of Savage Island, the river has a series of riffles and pools, and includes a series of “large, bank-attached island-bar complexes [that] occur on the inside of river bends” (Fecht *et al.* 2004). Within this area, sites 7 and 8 occurs at the head of an island-bar complex in an area of shallow riffles, and Site 9 (just upriver from Site 8) also has a low-slope riparian zone and much smaller bars and associated small lee areas with emergent wetland habitat. Site 10, near D Island, has a comparable bar complex of very low slope.

Vegetation along the Hanford Reach riparian zone was described by Salstrom and Easterly (1995). On cobble along the riparian area, the vegetation occurs as semi-recognizable zones of

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associated species. Widths of the vegetation zones are directly related to the slope of the riparian zone, which compresses or expands each particular zone. In turn, the profile of the riparian zone can relate to the position of the shoreline relative to the trajectory of the river flow, where steep-sided riparian areas with compressed vegetation zones are located along channelized lateral flow. Broad riparian areas and corresponding broad vegetation zones are located at point bars, particularly at the large bank-attached island bar complexes at sites 7, 9 and 10.

Backwater areas and sloughs often form in the lee of cobble bars in low flow settings and where silt has been deposited. The emergent wetlands that occur in these areas are scattered throughout the length of the reach, occurring anywhere silt has been deposited and range in size from less than a meter square to approximately 15 acres. These systems are rich in species diversity, both within and between sites (Salstrom and Easterly 1995). The emergent wetlands are primarily in sites in which silt is still being deposited, which may occur as a mud patina on cobble or other substrate. The sites may be transitory in some areas, appearing in somewhat different settings from year to year depending on the flow volumes of the river, which is manipulated by upriver dam management.

Rare plants known from the Hanford Reach occur primarily in two habitat types. The first is in surge/riffle zones typically associated with cobble bars. The second type is the emergent wetlands, where several species of rare annuals occur. In addition, general riparian habitat along the river supports two rare plant species and may be potential habitat for several other rare species that have not yet been detected along the Reach (see Table 1).

METHODS

Rare plant species with the potential to occur in the study area were identified by assessing potential habitat of the landscape (above) and culling through rare species known in the Columbia Basin for those with similar habitat requirements. Within the study area, the highest potential habitat in the upland sites included sites with low cover of vegetation in sand-dominated substrate, fine-textured deposits, gravel sorted by size class, and occasional combinations of substrates. Potential habitats in the Columbia River riparian sites include cobble with gradual slopes and backwater areas with mud. Species with the likelihood to occur in the study area are listed in Table 1.

Field surveys to sites in the riparian zone of the Columbia River (Sites 1-10) were visited during October 24-November 1, 2005. With the exception of Site 6 (located in the lower reach), surveys were completed before 11 a.m. daily, when the upper riparian zone flooded due to water flow management by upriver dams. Several sites were revisited by 9:00 a.m. to confirm that all sites were thoroughly surveyed. Site 6 was surveyed in the afternoon, but because of its downstream location, the water level was still low and a revisit to the site was not necessary.

The upland survey visits coincided with when potential species were identifiable, with some sites visited multiple times to detect species with differing phenology. All plants were identified to the finest taxonomic level possible with the material present (i.e., vegetative, flowers, fruits) and at minimum to the level to determine rarity. Lists of all observed species were compiled for each of the study plots. Revisits were made to plots containing habitat for rare plants species that were not identifiable at the time of the survey. The upland inventory was done between May 2 and June 22, 2006. All upland sites were initially visited during early May, during which the entire plots were surveyed.

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Table 1. Species with potential to occur in remediation site study plots.

Scientific Name	Common Name	State/ Federal Status ³	Known On Central Hanford?	Annual/ Perennial	Potential habitat within study area
<i>Ammannia robusta</i>	Grand Redstem	T	Y	A	Riparian emergent wetland.
<i>Areneria franklinii</i> var. <i>thompsonii</i>	Thompson's sandwort	R2	Y	P	Open sand.
<i>Artemisia campestris</i> ssp. <i>borealis</i> var. <i>wormskioldii</i>	Northern Wormwood	E/C	N	P	Riparian gravel and cobble.
<i>Astragalus columbianus</i>	Columbia Milk-vetch	S/SC	Y	P	Sedimentary interbeds associated with basalt.
<i>Astragalus geyeri</i>	Geyer's Milk-vetch	T	Y	A	Depressions in mobile or stabilized dunes, sandy flats, valley floors.
<i>Calyptridium roseum</i>	Rosy Pussypaws	T	Y	A	Low swales in sandy soils.
<i>Camissonia minor</i>	Small-flower Evening-primrose	S	Y	A	Open sites in gravelly or sandy soil.
<i>Camissonia pygmaea</i>	Dwarf Evening-primrose	S	Y	A	Open sites in variety of unstable substrates.
<i>Camissonia scapoidea</i>	Naked-stemmed evening primrose	S	N	A	Sandy soil.
<i>Centunculus minimus</i>	Chaffweed	R1	Y	A	Emergent wetlands.
<i>Corispermum pallidum</i>	Pale Bugseed	X	N	A	Sagebrush plains with drifting sand.
<i>Cryptantha gracilis</i>	Narrow-stem Cryptantha	S	N	A	Pockets of silt in talus, open areas.
<i>Cryptantha leucophaea</i>	Gray Cryptantha	S/SC	Y	A	Sandy soil.
<i>Cryptantha spiculifera</i>	Snake River Cryptantha	S	Y		Open sites in stable, compacted, substrates.
<i>Cuscuta denticulata</i>	Desert Dodder	T	Y	P	On various shrubs within sagebrush dessert.
<i>Eatonella nivea</i>	White Eatonella	T	Y	A	Variety of open substrates including sand and basalt gravel.
<i>Erigeron piperianus</i>	Piper's Daisy	S	Y	P	Dry, open areas on fine-textured sediments.
<i>Gilia leptomeria</i>	Great Basin Gilia	T	Y	A	Gravelly bluffs, sandy swales, caliche
<i>Hierochloe odorata</i>	Common Northern Sweet	R1	N	P	Streambanks

³ SC: Federal Species of Concern, unofficial status, species appears in jeopardy, but insufficient information to support listing.

E=Endangered in Washington; in danger of becoming extinct in Washington

T= Threatened in Washington; likely to become endangered in state, ,

S=Sensitive in Washington, vulnerable or declining, could become threatened or endangered in state.

R=Species status in review.

	Grass				
<i>Hypericum majus</i>	Canadian St. John's-wort	S	Y	P	Seasonally submerged riparian sites.
<i>Juncus uncialis</i>	Inch-high Rush	S	N	A	Moist areas, vernal pools.
<i>Lesquerella tupleschensis</i>	Whitebluffs bladderpod	E/SC	Y	P	Caliche, Ringold Formation.
<i>Lipocarpus aristulata</i>	Awned Halfchaff Sedge	T	Y	A	Riparian emergent wetland
<i>Loeflingia squarrosa</i> var. <i>squarrosa</i>	Loeflingia	T	Y	A	Sand
<i>Mimulus suksdorfii</i>	Suksdorf's Monkey-flower	S	Y	A	Variable substrate with seasonal moisture.
<i>Minuartia pusilla</i> var. <i>pusilla</i>	Annual Sandwort	R1	N	A	"Plains" and other habitats, with rigid sage.
<i>Monolepis pusilla</i>	Red Poverty-weed	T	N	A	Primarily alkaline or saline soil.
<i>Nicotiana attenuata</i>	Coyote Tobacco	S	N	A	
<i>Oenothera caespitosa</i> ssp. <i>caespitosa</i>	Cespitose Evening-primrose	S	Y	P	Varied: talus, banks of Columbia River.
<i>Oenothera caespitosa</i> ssp. <i>caespitosa</i>	Cespitose Evening-primrose	S	Y	P	Varied: talus, banks of Columbia River.
<i>Opuntia fragilis</i>	Brittle Prickly-pear	R1	N	P	Sandy slopes, rock outcrops, talus.
<i>Polycnemum fremontii</i> var. <i>fremontii</i>	Fremont's Combleaf	T	N		Gravelly clay, damp or wet sites, sagebrush desert
<i>Polygonum austinae</i>	Austin's Knotweed T	T	N	A	Dry to moist flats or banks.
<i>Rorippa columbiana</i>	Persistentsepal Yellowcress	E/SC	Y	P	Wet sites; along the Columbia River in gravel and cobble.
<i>Rotala ramosior</i>	Lowland Toothcup	T	Y	A	Riparian emergent wetland.
<i>Spartina pectinata</i>	Prairie Cordgrass	S	N	P	Riparian

Rare plant site locations were recorded with Garmin E-trek GPS units (UTM projection, Zone 11 North, NADS 1983 datum, WAAS enabled), and population and site information were recorded on sighting forms of the Washington Natural Heritage Program (Department of Natural Resources). Within the upland sample sites where potential habitat for known rare plant species was relatively extensive within the plot, GPS points were taken to depict the portion of the plot in which it occurred and cartoon maps were made.

RESULTS

Upland

No rare plants were observed in the upland plots during the 2006 survey. Maps depicting portions of those plots in which potential rare plant habitat (open, sand-dominated substrate) occurred are presented in Appendix B. A list of plant species observed within the upland plots are presented in Appendix C. Short descriptions of the sites are presented in "Site Descriptions", below.

Riparian

Rare plant species were found at the following sites:

Sites 7, 8 and 9: *Rorippa columbiae*

Cobble in the mid to lower cobble riparian profile, located in sites receiving surge from river flow (i.e., point bars with increased flow velocity)

Site 9: *Lipocarpa aristulata*

Fine-grained mud and sand deposited in backwater areas supporting non-persistent emergent wetlands.

Occurrence information forms (Washington Natural Heritage Program Occurrence Forms) are attached as Appendix D. A list of all species found in the riparian sites is presented in Appendix E.

In addition, there is a known occurrence of *Rorippa columbiae* near Site 10. Although we were there during relatively low water, the species was not seen at the site. This site should be resurveyed during a different year to determine whether the species shows up at the site during different conditions present during different years. The species is known to be present at different concentrations during different years and has apparently suffered a steep decline in stems during the early 2000s (Caplow 2003).

SITE DESCRIPTIONS

Upland

600-23: The site is within a gravel pit that was cut into the massive bed of deposits from the Missoula floods. The site has a sandy pebble to cobble gravel substrate. Some success of restoration planting, especially using *Purshia tridentata*, was observed. This site had a relatively low percentage of vegetative cover. The slope on the north side of the site had various species of *Astragalus*. *Camissonia pygmaea* (WNHP Occurrence Record 012, reported by Sackschewsky in 1992) and *Cryptantha leucophaea* (referred to in *C. pygmaea* Occurrence Record but not in WNHP Information System). These species did not occur in the study plot.

600-208: The site is located within the Hanford Townsite and appears to have been disturbed historically by agriculture and/or homesteading (non-native tree near center). The site may also

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have been within the footprint of short-term housing during the Camp Hanford period. The site is flat with high overall plant cover, although with little variability and is dominated by *Bromus tectorum*, with occasional *Stipa comata* and *Sporobolus cryptandrus* plants.

600-181: This site has a small blowout dune that was created by a down cut (or possible road) through the area with otherwise stabilized substrate. It is unclear how open the area was before the down cut was established. The down cut was probably a remnant of old Hanford Site activity (within the past 60 years), and the blowout may now be relatively stable as open sand. The blowout had good cover of native annual species and is potentially relatively good habitat for the rare annual species (although those species are more often found in more contiguous habitat). The portion of the site with much of the exposed fine and/or sandy substrates with higher rare plant potential is depicted in Figure X. The site is located within the second terrace of the ancient (Holocene) Columbia River (Fecht et al. 2004). A lizard and nesting bird were observed during the field visit (neither species was identified).

600-171: This site has areas of sandy openings along its north edge, where there is moderate potential for rare plants; that portion of the site is depicted in Figure X. The remaining area within the study polygon has a sand/gravel substrate with a relatively low potential for rare plants. The site is dominated by Sandberg's bluegrass and cheatgrass. It has mature, non-native trees, which, together with its nearness to the historic White Bluffs Townsite, suggest that it may have been farmed in the past. The site is located within the second terrace of the ancient (Holocene) Columbia River (Fecht et al. 2004).

600-139: This site has a mostly sandy pebble to cobble substrate with cover from sagebrush, grey rabbit brush, Sandberg's bluegrass and cheatgrass, except in a dip near the southwest corner (near the road) that had a sand substrate. The latter area, which has the most likely rare plant habitat, is depicted in Figure X. The site is located within the second terrace of the ancient (Holocene) Columbia River (Fecht et al. 2004).

600-131;

600-132/190;

628-1: These areas have a sandy pebble to cobble gravel substrate, with abundant evidence of human activity (roads, telephone pole stumps, building footprints, pavement, grading, dozer piles), apparently associated with both historic homesteading and Hanford Site activities. No obvious rare plant habitat was observed. Much of the areas had high cover of vegetation, primarily with sagebrush, Sandberg's bluegrass and cheatgrass. The site is located within the second terrace of the ancient (Holocene) Columbia River (Fecht et al. 2004).

116-F-1: This site had a substrate with a high percentage of large cobbles. It is located in a topographically low point, which may represent a channel of the ancient Columbia River, especially given the apparent armoring by cobble-gravel lag. The site is located within the third terrace of the ancient (Holocene) Columbia River and areas with silty, fine sand may represent the silt plug that was deposited when the ancient river channel was abandoned (Fecht et al. 2004). No rare plant habitat was observed at the site, which was dominated by invasive annual species, mostly cheatgrass and tumble-mustard. However, "fairy rings", a clear pattern of *Bromus tectorum* die-off that may represent an emerging fungal pathogen that suppresses *B. tectorum* (see Salstrom and Easterly 1997), were observed on the site.

100-F-2: This site has high cover of *Poa bulbosa* and *Bromus tectorum*, which together with trees along the site's southern edge, suggest that is within a former homestead and possibly agricultural

field. No rare plant habitat was observed, although a few fairy rings were present (see 116-F-1, above). The site is located within the third terrace of the ancient (Holocene) Columbia River in an area that appeared to be capped by a silty, fine sand plug that was deposited when the ancient (Holocene) river channel became abandoned (Fecht et al. 2004).

600-204: This site is relatively flat except along one edge, which has had a down cut dug through it, likely a result of Hanford Site activities. Some plant diversity is present along the slope of the down cut (*Balsamorhiza careyana* and *Sporobolus cryptandrus*), although the remainder of the site is dominated by sagebrush, Sandburg's bluegrass and cheatgrass. The site is located within the second terrace of the ancient (Holocene) Columbia River (Fecht et al. 2004).

JA JONES: This site is located in a quarry dug into the unsorted sandy pebble to cobble gravels from Missoula Flood depositional material. Restoration planting has occurred, but survival is irregular, with the best survival along the northern margin (and upper edge) of the quarry. The site was mulched with straw. The substrate is not typical rare plant habitat (which is more sorted), and the potential for those species to occur on the site is low.

300-49: This site, located along the river, has a combination of sand and sandy pebble to cobble gravel. There is some potential for rare plants, but the cover of vegetation was high even in some of the sandy sites, which reduces the habitat suitability for many rare plants within this type of habitat. The site was drill-seeded, planted with shrubs and mulched with straw.

618-4: This site is flat with a mixture of sand and sandy-gravel substrate. The northeast quadrant is sandy and is potential rare plant habitat, although no rare plants were observed. The site was drill-seeded and planted with shrubs; the *Artemisia tridentata* plugs were mostly lying down with exposed roots. This site has good potential for native plant restoration, especially using *Purshia tridentata*. The portion of the site with the highest potential for rare plant habitat is depicted in Figure X

1607-H-2: This site is planer with a slight north slope and a large cobble substrate, suggesting a cobble lag established by the Columbia River. It is located at the lower edge of the third terrace of the ancient (Holocene) Columbia River (Fecht et al. 2004). It had high cover of *Bromus tectorum* and a cohort of old shrubs (primarily sagebrush). A known site for *Erigeron piperianus* is nearby (WNHP occurrence records; reported by M. Sackschewsky in 1984) on a fine-textured substrate that is part of the overbank deposition associated with the ancient Columbia River terrace Fecht et al. (2004). This habitat was not apparent within the plot, and the likelihood of rare plants at the site appeared to be low.

116-N-3: This site has a substrate of sandy pebble to cobble gravels with an apparently high percentage of large cobble. It is located at the upstream toe of a Pleistocene cataclysmic flood bar with giant ripples. The site has been very disturbed, and the landscape has apparently been downgraded or removed by historic Hanford Site activities.

100D-48.2: The substrate of this site is dominated by sandy pebbles to cobble gravels. It is at the downstream end of a large Pleistocene cataclysmic flood bar (somewhat above the first or upper terrace of the ancient Columbia River (Fecht et al. 2004). The site was drill-seeded, planted with shrubs and mulched with straw. The site is relatively close to 100D and has been directly impacted by Hanford Site activities there. There is no obvious rare plant habitat within the site.

100D-49-2: The substrate of this site is dominated by sandy pebbles to cobble gravels. It is at the downstream end of a large Pleistocene cataclysmic flood bar (somewhat above the first or upper terrace of the ancient Columbia River; Fecht et al. 2004). The site was drill-seeded, planted with shrubs and mulched with straw. The site is relatively close to 100D and has been directly impacted by Hanford Site activities there. There is no obvious rare plant habitat within the site.

116-DR-1&2: The substrate of this site is primarily sandy gravel to cobble gravel, except a small area of mostly silt and sand in the southern portion of the site. It is located at the downstream end of a large Pleistocene cataclysmic flood bar (near the margin of the first or upper terrace of the ancient Columbia River (Fecht et al. 2004). The site was drill-seeded, planted with shrubs and mulched with straw (several unused bales nearby). *Elymus caput-medusa* was observed associated with the old straw litter within and between this site and the nearby study site 1607-D2:1. The portion of the site with the most likely rare plant habitat is depicted in Figure X.

1607-D2:1: The substrate of this site was mostly sandy pebble to cobble gravel, except for a small area near its edge with an area of silt and sand. The latter substrate has some potential for rare plants, which is depicted in Figure X. The site is located at the downstream end of a large Pleistocene cataclysmic flood bar (near the margin of the first or upper terrace of the ancient Columbia River (Fecht et al. 2004). The site has a slight slope to the north, which decreases the dominance of *Bromus tectorum*, and there is a relatively good diversity of native species. The site was drill-seeded, planted with shrubs and mulched with straw.

Riparian

Slope is presented in three general classes: low (<5 degrees), medium (between 3-8 degrees) and steep (>8 degrees).

Site 1: The site is located on a relatively steep gradient above the cobble riparian zone. The upper zone has overbank deposition, which supports the horsetail (*Equisetum* spp.) and reed canarygrass (*Phalaris arundinacea*) habitat types. In addition, within the cobble zone, sand and mud are deposited over and between the rocks, forming small, shallow pockets of mud in small leeward areas that appear to be only marginally stabilized. This was observed primarily in this upriver portion of the site (where shining flatsedge—*Cyperus bipartitus*—a state ‘watch’ species). This upriver portion is flatter than the rest of the area and is in the slight lee of the undulating shoreline.

Site 2: The site has a steep riparian zone. The substrate is large cobble, and there is little sedimentation at the site due to exposure to water flow. Immediately above the riparian zone is a flat terrace, where there are signs of historic disturbance (road building, etc.). The site is located north of 100D, upstream from D Island.

Site 3: Site has steep slope (up to 15-20 degrees) with large cobble and compressed riparian vegetation zones. Above the riparian study zone, there is sign of past bulldozer activity to create a river access road and bench 5-15 feet above high waterline.

Between stakes A and B, sand and mud were recently deposited in the lee backwater. There, the sediment was in the form of ‘flakes’ that were repositioned from mud encrusted on river cobble by daily flooding action. This site was not currently vegetated. However, it is likely habitat for the development of a non-persistent emergent wetland, and this site should be reexamined for rare plant species in the future. If the mud deposit persists but emergent wetland vegetation does not develop, toxicological and other impacts to the site should be examined.

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Site 4: This site, near 100N, has a low slope of 3-5 degrees within the zone of daily inundation and a slightly steeper slope above that, creating a relatively broad riparian zone. The substrate is cobble and large cobble lag along the shoreline, with a patina of mud, and a few pockets of mud. The site has an interesting assemblage of plant species (see plant list), although none were rare.

Site 5: The slope of the shore and upland transition zone is low, creating a relatively broad riparian zone. The site is located downstream from Coyote Rapids, and the substrate consists of large rock and cobble lag. Some coyote willow is located at one at one end of the site.

Site 6: The site is a lateral shoreline with relatively steep (5-15 degrees) slope in the zone with daily inundation, with a steeper slope to the terrace bench above. The riparian vegetation zones are relatively compressed, with the relatively unvegetated cobble substrate quickly transitioning to a strip of mulberry, with mature trees. Lots of Russian thistle carcasses upslope. Some beaver signs (chewed tree stems) at the site.

Site 7: Site includes a steep lateral shoreline between stakes C and B, and the very low slope shoreline at the top of the F slough "bank-attached island-bar complex" between stakes B and A. Along the lateral shoreline, the slope of the riparian zone approaches 10 degrees, and steeper above the immediate riparian area. There, the riparian vegetation is compressed into a narrow band, with a strip of thick reed canarygrass (*Phalaris arundinacea*). This area is located below remediation activity at 100F area, and siltation fences are in place. Stake B is at the top of a point bar and the area downstream has a broad area of cobble. The riffle zone created by the top of the point bar is ideal habitat for persistentsepal yellow cress (*Rorippa columbiae*), patches of which were found there (this was a previously known site). The chute behind the point bar was weedy.

Site 8: Cobble shoreline with small projections into the water flow, creating an undulating shoreline with low to moderate slope. Above the regularly flooded zone, the slope levels out onto a large point bar and chute system. Small patches of persistentsepal yellow cress occurred in microsites on the small point bars in settings with river surge, in sites with low to medium slope. To the south of Site 8, the small point bars decrease in size and prominence, soon becoming one long, continuous cobble slope for at least 0.5 miles. The area south along the cobble shore was surveyed for 300(+/-) m, with only one additional group of persistentsepal yellow cress found.

All persistentsepal yellow cress located was just below or within lower margin of riparian vegetation. Similar to other persistentsepal yellow cress sites found during this survey, none was found lower in the cobble zone, presumably due to high levels of daily consistent dam releases. At this site, persistentsepal yellow cress appears to have regrown from stem nodes after water levels receded (the main stem tips often have yellowed leaves, with regrowth from node as big and robust as we remember observing—with visits during three seasons since 1991).

Site 9: The riparian areas at this site have low to medium slopes. There is cobble substrate in the active riparian zone with areas of sedimentation in backwater and some overbank sites. The upper edge of daily inundation has reed canarygrass, behind which is a steep slope. Persistentsepal yellow cress occurs in cobble with low slope between stakes B and C. At this site, the position of persistentsepal yellow cress relative to water flow is not typical of most other occurrence sites, and also has unusually diverse other species in the occurrence. Rebar in cobble approximately 3m south of Stake A (beyond site boundary); no persistentsepal yellow cress observed there (or within 75m). At this rebar, there was also evidence of cobble having been repositioned (eroded); i.e., less mud on stones, smaller cobbles and gravel.

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Emergent wetland zones appear to be accumulating as repositioned 'flakes' from mud patinas upstream are washed then deposited in downstream leeward areas, forming patches 0.5-5m². One large patch of mud and sand supporting non-persistent emergent wetland vegetation is located on a concrete apron associated with the outfall from 100H. Plants found at that site included awned halfchaff sedge (*Lipocarpa aristulata*), a species considered to be threatened in Washington (WNHP 2006). Other species included the Washington Natural Heritage Program "watch" species shining flatsedge (*Cyperus bipartitus*) and mat mudwort (*Limosella acaulis*). Sign of deer browsing on vegetation in mud in non-persistent emergent wetland.

Site 10. The site has a low slope near the top of a point bar with a broad cobble zone and little to no mud and sand backwaters. There is some diversity of cobble size. The site is located downstream from top of D Island and appears to have had some historic physical disturbance.

DISCUSSION

The rare annuals found on the upland portion of the Hanford Site occur in open sands and/or in sites that appear to receive seasonal concentrations of moisture. Although specific germination requirements are unknown for the rare annual species, yearly variability in weather conditions likely influences annual population sizes. For example, one *Mimulus suksdorfii* occurrence on Central Hanford had five plants during this summer (2006, personal observation), while hundreds of plants were present at the site in 1997 (WNHP occurrence records), indicating that population sizes can fluctuate widely. *Loeflingia squarrosa*, also recorded for that site during the 1997 survey, was not relocated during 2006. Likewise, a *Nicotiana attenuata* occurrence first seen during 1995 on the Yakima Training Center (personal observation) was not relocated during 2006 visit (personal observation).

The last year in which rare plant surveys on the Hanford Site and/or the Yakima Training Center coincided with years in which large numbers *Mimulus suksdorfii* were recorded was 1995 and 1996, which together with 1997 were years in which that species was also found in relative abundance on the Hanford Site. Weather records from the Richland Station, Western Regional Climate Center Cooperative Network 1994-1997 and 2004-present (Table 2) indicate that high precipitation, together with temperatures that were not above normal, likely accounted for the relatively large number and size of occurrences that were found those years. Those several years of high precipitation likely increased the seed bank for those species, inflating the population to sizes observed during the later portion of that period.

Thus, it seems that 2006 was not a particularly good year to detect the presence of at least some species of rare annuals in the Columbia Basin. Portions of the upland sites with potential habitat (see maps in Appendix C) should be resurveyed during years with different weather patterns.

In addition, fluctuating patterns of river water levels in the affects the riparian vegetation. For example, some species that occur in emergent wetlands were still not flowering when surveyed during late October 2005, and were submerged for at least parts of days during most of the growing season. Frequent and/or prolonged submergence of *Rorippa columbiae* is thought to have contributed to a precipitous decline in the abundance of that species in monitoring plots along the Hanford Reach during the past decade (Caplow 2004). That species only infrequently sets seed successfully in this area. In addition, a *R. columbiae* site is known from immediately upstream of Site 10 (WNHP Occurrence Map); it was not relocated during this 2006 survey. This site should be resurveyed to determine whether the occurrence stretched into the plot and if it would be detectable during years with different flow regimes.

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Table 2. Monthly Total Precipitation (inches; adapted from Western Regional Climate Center, 2006). Monthly climate data for selected years including 1995 and 1996, during which plant surveys found relatively large and/or numerous occurrences of rare annuals on the Hanford Site and the nearby Yakima Training Center (including *Mimulus suksdorfii*, *Cryptantha rostellata*, *Collomia macrocalyx*, *Camissonia pygmaea*, *Eatonella nivea*, and *Nicotiana attenuata*). Values that are more than one standard deviation from the mean are shaded.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1994	0.00	0.16	0.03	0.66	1.44	0.64	0.54	0.00	0.00	1.25	0.65	0.95	6.32
1995	2.00	0.39	0.00	0.00	0.41	0.00	0.60	0.00	0.00	0.00	1.04	2.03	2.39
1996	0.96	1.49	1.27	0.76	0.98	0.20	0.26	0.00	0.14	1.05	1.97	2.29	9.88
1997	1.67	0.37	0.86	0.73	0.26	0.53	0.26	0.17	0.38	0.82	0.86	0.47	7.38
2004	1.17	1.21	0.25	0.23	1.56	1.33	0.00	0.53	0.17	0.38	0.32	0.74	7.89
2005	0.67	0.06	0.44	0.43	0.72	0.33	0.19	0.09	0.60	0.55	0.89	2.33	7.30
2006	1.67	0.27	0.38	1.03	0.73	0.71	0.05	0.00	0.00	0.00	0.00	0.00	
MEAN	1.02	0.70	0.60	0.50	0.57	0.50	0.21	0.25	0.27	0.51	0.94	1.06	6.91
S.D.	0.67	0.49	0.44	0.37	0.44	0.47	0.30	0.34	0.30	0.49	0.63	0.66	1.65
NO YRS	57	57	57	57	57	58	57	56	54	57	56	57	51

LITERATURE CITED

- Bjornstad, B.N., C.J. Murray and C.I. Steefel. 1994. Physical and chemical heterogeneity within cataclysmic flood deposits, south-central Washington. Geological Society of America. Abstracts with Programs V.26(7): A-68.
- Caplow, F. 2003. Studies of the Hanford Rare Plants. Unpublished report prepared for the Washington Office of The Nature Conservancy by Washington Natural Heritage Program, Department of Natural Resources, Olympia.
- Easterly, R.T. and D.L. Salstrom. 1997. Central Hanford 1998 Plant Community Inventory. Unpublished report to The Nature Conservancy of Washington, Seattle.
- Fecht, K.R., T.E. Marceau, B.N. Bjornstad, D.G. Horton, G.V. Last, R.E. Peterson, S.P. Reidel and M.M. Valenta. 2004. Late Pleistocene- and Holocene-Age Columbia River Sediments and Bedforms: Hanford Reach Area, Washington, Part 1. Geologic Atlas Series. BHI-01648. Rev.0.
- Salstrom, D.L. and R.T. Easterly. 1995. Riparian plant communities: south shore and islands of the Columbia River on the Hanford Site, Washington. Unpublished report to The Nature Conservancy of Washington, Seattle.
- Stetler, L.D. and D.R. Gaylord. 1996. Evaluating eolian-climatic interactions using a regional climate model from Hanford, Washington (USA). Geomorphology 17:99-113.
- Washington Natural Heritage Program. Website accessed October 15, 2006. <http://www.dnr.wa.gov/nhp/index.html>.
- Western Regional Climate Center. Climate Records for Richland Station (Yakima Airport). Website accessed August 10, 2006. Precipitation: <http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?wa7015>.

APPENDIX C. Plants observed in upland remediation sites, 2006.

Species	116-N-3	600-171	600-23	600-139	600-208	JA JONES	300-49	618-4	116-F-2	116F-1; 5/08
<i>Achillea millefolium</i>	1	1	1	1		1				1
<i>Achnatherum hymenoides</i>		1	1			1	1	1		1
<i>Agoseris heterophylla</i>	1									
<i>Agropyron cristatum</i>							1	1		
<i>Ambrosia acanthicarpa</i>			1			1	1	1		
<i>Amsinckia lycopsoides</i>										1
<i>Amsinckia menziesii</i>		1								
<i>Amsinckia</i> spp.	1		1		1	1	1	1		
<i>Amsinckia tessellata</i>	1									
<i>Artemisia tridentata</i>			1			1		1		
<i>Asparagus officianalis</i>					1					
<i>Astragalus caricinus</i>		1	1							
<i>Astragalus purshii</i>			1							
<i>Astragalus sclerocarpus</i>			1	1						
<i>Astragalus succumbens</i>			1							
<i>Balsamorhiza carreyana</i>										
<i>Bromus tectorum</i>	1	1	1	1	1	1	1	1	1	1
<i>Cardaria pubescens</i>									1	
<i>Centaurea diffusa</i>	1					1	1			
<i>Ceratocephala testiculata</i>										
<i>Chaenactis douglasii</i>		1								
<i>Chondrilla juncea</i>			1	1				1		
<i>Chrysothamnus viscidiflorus</i>			1					1		
<i>Convolvulus</i> (cf)								1		
<i>Cryptantha circumscissa</i>		1	1	1		1				
<i>Cryptantha pterocarya</i>				1						
<i>Descurainia incana</i>										

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Species	116-N-3	600-171	600-23	600-139	600-208	JA JONES	300-49	618-4	116-F-2	116F-1; 5/08
<i>Descurainia sophia</i>									1	1
<i>Descurainia</i> sp.										
<i>Draba verna</i>	1	1								1
<i>Elymus elymoides</i>	1									
<i>Elymus lanceolatus</i> ssp. <i>lanceolatus</i>					1?		1	1		
<i>Epilobium brachycarpum</i>										
<i>Eriastrum sparsiflorum</i>										
<i>Ericameria nauseosus</i> ssp. <i>nauseosus</i>	1	1	1	1		1	1	1		1
<i>Erigeron poliospermus</i>										
<i>Erigeron pumilus</i>	1									
<i>Erigeron</i> sp.						1				
<i>Eriogonum niveum</i>			1			1		1		
<i>Eriogonum vimineum</i>										
<i>Erodium cicutarium</i>	1	1		1		1	1	1	1	1
<i>Erysimum asperum</i>						1				
<i>Gilia sinuata</i>		1				1				
<i>Gilia</i> spp.	1									
<i>Grindelia columbiana</i>										
<i>Hesperostipa comata</i>		1			1		1	1		
<i>Holosteum umbellatum</i>	1	1		1					1	1
<i>Hymenopappus filifolius</i>							1	1		
<i>Lactuca serriola</i>	1					1				1
<i>Lagophylla ramosissima</i>	1									
<i>Lepidium perfoliatum</i>				1						
<i>Lomatium macrocarpum</i>		1								
<i>Lupinus</i> sp. (annual)		1								
<i>Machaeranthera canescens</i>	1	1	1	1			1			
<i>Medicago sativa</i>			1							

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Species	116-N-3	600-171	600-23	600-139	600-208	JA JONES	300-49	618-4	116-F-2	116F-1; 5/08
<i>Mentzelia laevicaulis</i>			1							
<i>Morus alba</i>		1			1					
<i>Oenothera pallida</i>		1				1	1	1		
<i>Penstemon acuminatus</i>						1				
<i>Phacelia hastata</i>							1	1		
<i>Phacelia linearis</i>			1	1		1				
<i>Phlox longifolia</i>										
<i>Plantago patagonica</i>	1	1		1			1	1		
<i>Phlox gracilis</i> ssp. <i>humilus</i>		1		1		1				
<i>Poa bulbosa</i>		1	1	1	1			1	1	1
<i>Poa secunda</i>	1			1	1	1	1	1		1
<i>Polemonium micranthum</i>									1	
<i>Pseudoroegneria spicata</i>	1		1		1	1	1	1		
<i>Psoralidium lanceolatum</i>							1			
<i>Pteryxia terebinthina</i>										
<i>Purshia tridentata</i>			1			1				
<i>Rumex venosus</i>										
<i>Salsola kali</i> (tragus?)	1	1		1	1					1
<i>Senecio vulgaris</i>								1		1
<i>Sisymbrium altissimum</i>	1		1	1	1	1	1	1	1	
<i>Sphaeralcea munroana</i>	1	1								
<i>Sporobolus cryptandrus</i>		1	1	1	1				1	1
<i>Tiquilia nuttallii</i>										
<i>Tragopogon dubium</i>					1		1		1	1
<i>Triteleia grandiflora</i> var. <i>grandiflora</i>		1	1							
<i>Vulpia cf bromoides</i>		1								
<i>Vulpia microstachys</i>		1	1	1						
<i>Vulpia</i> sp.									1	

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Species	1607-H-2	100D-48.2	100D-49-2	116-DR-1&2	1607-D2:1	628-1	600-131	600-132/190	600-181	600-204
<i>Achillea millefolium</i>	1	1	1	1	1	1		1	1	
<i>Achnatherum hymenoides</i>		1		1	1				1	1
<i>Agoseris heterophylla</i>									1	1
<i>Agropyron cristatum</i>					1					
<i>Ambrosia acanthicarpa</i>									1	
<i>Amsinckia lycopoides</i>			1							
<i>Amsinckia menziesii</i>									1	
<i>Amsinckia</i> spp.		1		1	1	1				
<i>Amsinckia tessellata</i>										
<i>Artemisia tridentata</i>			1	1	1				1	1
<i>Asparagus officianalis</i>										
<i>Astragalus caricinus</i>				1				1		
<i>Astragalus purshii</i>										1
<i>Astragalus sclerocarpus</i>							1	1		
<i>Astragalus succumbens</i>										
<i>Balsamorhiza carreyana</i>										1
<i>Bromus tectorum</i>	1	1	1	1	1		1	1	1	1
<i>Cardaria pubescens</i>										
<i>Centaurea diffusa</i>	1	1	1	1	1					
<i>Ceratocephala testiculata</i>				1						
<i>Chaenactis douglasii</i>		1		1						
<i>Chondrilla juncea</i>										
<i>Chrysothamnus viscidiflorus</i>										
<i>Convolvulus</i> (cf)										
<i>Cryptantha circumscissa</i>								1	1	1
<i>Cryptantha pterocarya</i>										
<i>Descurainia incana</i>									1	
<i>Descurainia sophia</i>										

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Species	1607-H- 2	100D- 48.2	100D- 49-2	116-DR- 1&2	1607- D2:1	628-1	600-131	600- 132/190	600-181	600-204
<i>Descurainia</i> sp.										1
<i>Draba verna</i>			1	1		1		1	1	1
<i>Elymus elymoides</i>			1	1	1					
<i>Elymus lanceolatus</i> ssp. <i>lanceolatus</i>										
<i>Epilobium brachycarpum</i>									1	
<i>Eriastrum sparsiflorum</i>				1						
<i>Ericameria nauseosus</i> ssp. <i>nauseosus</i>	1	1	1	1	1	1	1	1	1	1
<i>Erigeron poliospermus</i>		1	1							
<i>Erigeron pumilus</i>		1								
<i>Erigeron</i> sp.										
<i>Eriogonum niveum</i>		1								
<i>Eriogonum vimineum</i>										1
<i>Erodium cicutarium</i>	1	1	1	1	1		1		1	1
<i>Erysimum asperum</i>										
<i>Gilia sinuata</i>									1	1
<i>Gilia</i> spp.										
<i>Grindelia columbiana</i>					1					
<i>Hesperostipa comata</i>								1		1
<i>Holosteum umbellatum</i>			1	1		1	1	1	1	1
<i>Hymenopappus filifolius</i>										
<i>Lactuca serriola</i>		1			1	1	1	1		
<i>Lagophylla ramosissima</i>										
<i>Lepidium perfoliatum</i>	1			1						
<i>Lomatium macrocarpum</i>										1
<i>Lupinus</i> sp. (annual)										
<i>Machaeranthera canescens</i>	1	1	1	1	1					
<i>Medicago sativa</i>		1		1	1					1
<i>Mentzelia laevicaulis</i>										

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Species	1607-H- 2	100D- 48.2	100D- 49-2	116-DR- 1&2	1607- D2:1	628-1	600-131	600- 132/190	600-181	600-204
<i>Morus alba</i>										
<i>Oenothera pallida</i>								1	1	
<i>Penstemon acuminatus</i>		1	1		1					
<i>Phacelia hastata</i>										
<i>Phacelia linearis</i>			1	1					1	
<i>Phlox longifolia</i>									1	
<i>Plantago patagonica</i>						1	1	1	1	
<i>Phlox gracilis</i> ssp. <i>humilis</i>							1	1	1	1
<i>Poa bulbosa</i>	1		1	1				1		
<i>Poa secunda</i>			1	1	1	1	1	1	1	1
<i>Polemonium micranthum</i>										
<i>Pseudoroegneria spicata</i>	1	1	1	1	1					
<i>Psoraleidum lanceolatum</i>										
<i>Pteryxia terebinthina</i>									1	1
<i>Purshia tridentata</i>										
<i>Rumex venosus</i>									1	
<i>Salsola kali</i> (tragus?)	1	1	1	1	1					
<i>Senecio vulgaris</i>										
<i>Sisymbrium altissimum</i>	1	1	1	1	1	1		1	1	1
<i>Sphaeralcea munroana</i>	1	1	1	1	1	1	1	1		
<i>Sporobolus cryptandrus</i>	1						1	1		
<i>Tiquilia nuttallii</i>										1
<i>Tragopogon dubium</i>										
<i>Triteleia grandiflora</i> var. <i>grandiflora</i>									1	
<i>Vulpia cf bromoides</i>	1							1		
<i>Vulpia microstachys</i>				1				1		
<i>Vulpia</i> sp.							1			

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APPENDIX C. Potential plant habitat within upland plot sites.

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APPENDIX D. Species observed in riparian study sites, 2005.

Species	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10
	11/1/2005	10/26/2005	10/26/2005	10/27/2005	10/27/2005	10/24/2005	10/27/2005	10/31/2005	10/25/2005, 10/31	10/26/2005
<i>Achillea millifolium</i>	1		1			1				
<i>Acroptilon repens</i>	1					1				
<i>Agrostis exarta</i>								1		1
<i>Agrostis gigantea/A. stolonifera</i>										
<i>Agrostis spp.</i>	1	1		1	1	1		1	1	1
<i>Allium schoenoprasum</i>	1		1	1	1	1	1	1	1	1
<i>Apocynum cannabinum</i>	1	1	1	1	1	1	1	1	1	1
<i>Artemisia campestris ssp. borealis var. scouleriana</i>			1					1		
<i>Artemisia dracunculus</i>						1				
<i>Artemisia lindleyana</i>	1			1		1	1	1	1	
<i>Artemisia ludoviciana</i>	1	1	1	1	1	1	1	1	1	1
<i>Asclepias speciosa</i>	1					1	1		1	
<i>Asparagus officinalis</i>						1		1		
<i>Aster spp.</i>	1	1	1	1	1	1	1	1		1
<i>Bidens frondosa</i>				1			1			1
<i>Carex arthrostachya</i>				1						
<i>Carex microptera</i>				1						
<i>Carex sp.</i>				1					1	
<i>Centaurea diffusa</i>	1		1			1		1	1	
<i>Centaureum umbellatum</i>				1						
<i>Chamaesyce serpyllifolia</i>										
<i>Cichorium intybus</i>		1	1		1	1	1	1	1	
<i>Cirsium arvense</i>	1	1	1		1	1	1	1	1	
<i>Clematis ligusticifolia</i>						1				
<i>Convolvulus arvense</i>	1	1	1				1	1	1	1

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Species	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10
<i>Conzys canadensis</i>						1		1	1	
<i>Coreopsis tinctoria</i> var. <i>atkinsoniana</i>	1	1	1	1	1	1		1	1	1
<i>Cuscuta pentagona</i> var. <i>pentagona</i>				1						
<i>Cyperus bipartitus</i>	1								1	
<i>Cyperus</i> sp.	1									
<i>Cyperus squarrosus</i>									1	
<i>Cyperus strigosus</i>	1			1			1			
<i>Dianthus armeria</i>	1	1	1	1	1		1	1	1	
<i>Dichanthelium acuminatum</i> var. <i>fasciculatum</i>		1	1							
<i>Echinochloa crus-gali</i>							1			
<i>Eleocharis ovata</i>									1	
<i>Eleocharis</i> spp.	1		1	1			1	1	1	
<i>Elymus lanceolatus</i> ssp. <i>lanceolatus</i>						1		1		
<i>Elymus</i> sp. *						1				
<i>Epilobium brachycarpum</i>									1	
<i>Equisetum arvense</i>				1						
<i>Equisetum laevigatum</i>										1
<i>Equisetum</i> spp.	1			1	1	1			1	1
<i>Equisetum variagatum</i>									1	1
<i>Eragrostis pectinacea</i>							1		1	
<i>Euthamia graminifolia</i> var. <i>graminifolia</i>			1	1						
<i>Euthamia occidentalis</i>	1	1		1	1	1				1
<i>Gaillardia aristata</i>			1					1		
<i>Gnaphalium palustre</i>									1	
<i>Gratiola neglecta</i>	1								1	
<i>Grindelia columbiana</i>		1	1					1		

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Species	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10
<i>Helenium autumnale</i>	1	1	1	1	1	1	1	1	1	
<i>Heterotheca villosa</i>								1		
<i>Hypericum perforatum</i>	1	1	1	1	1	1		1	1	
<i>Juncus</i> spp.	1						1		1	
<i>Lactuca serriola</i>						1				
<i>Lathyrus</i> sp.						1				
<i>Liliopsis occidentalis</i>				1			1	1	1	
<i>Lipocarpa aristulata</i>									1	
<i>Lolium perenne</i> spp. <i>multiflorum</i>		1					1			
<i>Lotus unifoliolatus</i>					1					
<i>Ludwigia palustris</i>									1	
<i>Lupinus</i> sp.		1				1				
<i>Lycopus americanus</i>					1					1
<i>Lycopus asper</i>	1		1	1		1	1		1	1
<i>Lycopus</i> sp.										1
<i>Lythrum salicaria</i>						1			1	
<i>Melilotus alba</i>		1	1	1	1			1	1	
<i>Mentha arvensis</i>	1			1		1		1	1	1
<i>Mollugo verticillata</i>	1			1						1
<i>Morus alba</i>		1	1	1	1	1	1	1		1
<i>Myosotis laxa</i>	1			1					1	
<i>Myriophyllum spicatum</i>							1			
<i>Oxalis</i> sp.										1
<i>Panicum capillare</i>								1		
<i>Panicum</i> sp.									1	
<i>Pascopyron smithii</i>			1							
<i>Pennisetum glaucum</i>							1	1	1	
<i>Phalaris arundinacea</i>	1	1	1	1	1	1	1	1	1	
<i>Plantago lanceolata</i>	1	1	1	1	1	1	1	1		1

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Rare Plant Inventory
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Species	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10
<i>Plantago major</i>	1	1	1	1	1		1	1	1	
<i>Poa annua</i>									1	
<i>Poa compressa</i>	1	1	1	1	1	1	1	1	1	1
<i>Poa palustris</i>	1									
<i>Poa</i> spp.	1					1			1	
<i>Polygonum</i> spp.	1	1	1	1			1	1	1	1
<i>Polypogon monospiensis</i>									1	
<i>Potentilla</i> spp.			1					1	1	
<i>Rorippa columbiana</i>							1	1	1	
<i>Rorippa palustris</i>							1			1
<i>Rorippa</i> spp.	1		1	1		1		1	1	
<i>Rumex crispus</i>	1					1		1		
<i>Rumex salicifolius</i>									1	
<i>Salix exigua</i>				1	1	1				
<i>Salix</i> sp.					1					
<i>Scirpus</i> spp.				1			1			
<i>Solanum</i> sp.						1				
<i>Solidago</i> sp.									1	
<i>Sporobolus asper</i>								1	1	1
<i>Sporobolus cryptandrus</i>						1	1			
<i>Stellaria</i> sp.								1		
<i>Symphyotrichum campestre</i> var. <i>campestre</i>		1	1	1			1	1		1
<i>Symphyotrichum frondosum</i>		1		1	1	1	1			
<i>Symphyotrichum lanceolatum</i> ssp. <i>hesperium</i>	1		1	1	1		1	1	1	1
<i>Symphyotrichum spathulatum</i> var. <i>intermedium</i>								1	1	1
<i>Taraxacum officinale</i>								1		
<i>Tragopogon dubius</i>						1				

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Species	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10
<i>Trifolium</i> sp.			1	1			1	1	1	1
<i>Verbascum thapsis</i>	1		1			1		1	1	
<i>Verbena bracteata</i>									1	
<i>Verbena hastata</i> var. <i>scabra</i>	1	1					1	1	1	
<i>Veronica americana</i>									1	
<i>Veronica anagallis-aquatica</i>									1	
<i>Veronica peregrina</i>							1			
<i>Veronica</i> sp.		1								
<i>Viola</i> sp.				1				1		1
<i>Xanthium strumarium</i>				1				1	1	
Graminoid (vegetative)	1	1		1					1	
Forb 1 (seedling)			1					1	1	
Forb 2 (vegetative, coarsely pubescent, petiolate, raised veins on underside of leaf)								1		
Forb 3 (rosette of compound leaves)	1									
cf. <i>Iris</i> (vegetative; cf. <i>I. pseudocorus</i>)	1							1		
Tree - 2nd sp.						1				

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Species	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10
<i>Plantago major</i>	1	1	1	1	1		1	1	1	
<i>Poa annua</i>									1	
<i>Poa compressa</i>	1	1	1	1	1	1	1	1	1	1
<i>Poa palustris</i>	1									
<i>Poa</i> spp.	1					1			1	
<i>Polygonum</i> spp.	1	1	1	1			1	1	1	1
<i>Polypogon monospiensis</i>									1	
<i>Potentilla</i> spp.			1					1	1	
<i>Rorippa columbiana</i>							1	1	1	
<i>Rorippa palustris</i>							1			1
<i>Rorippa</i> spp.	1		1	1		1		1	1	
<i>Rumex crispus</i>	1					1		1		
<i>Rumex salicifolius</i>									1	
<i>Salix exigua</i>				1	1	1				
<i>Salix</i> sp.					1					
<i>Scirpus</i> spp.				1			1			
<i>Solanum</i> sp.						1				
<i>Solidago</i> sp.									1	
<i>Sporobolus asper</i>								1	1	1
<i>Sporobolus cryptandrus</i>						1	1			
<i>Stellaria</i> sp.								1		
<i>Symphyotrichum campestre</i> var. <i>campestre</i>		1	1	1			1	1		1
<i>Symphyotrichum frondosum</i>		1		1	1	1	1			
<i>Symphyotrichum lanceolatum</i> ssp. <i>hesperium</i>	1		1	1	1		1	1	1	1
<i>Symphyotrichum spathulatum</i> var. <i>intermedium</i>								1	1	1
<i>Taraxacum officinale</i>								1		
<i>Tragopogon dubius</i>						1				

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Species	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10
<i>Trifolium</i> sp.			1	1			1	1	1	1
<i>Verbascum thapsis</i>	1		1			1		1	1	
<i>Verbena bracteata</i>									1	
<i>Verbena hastata</i> var. <i>scabra</i>	1	1					1	1	1	
<i>Veronica americana</i>									1	
<i>Veronica anagallis-aquatica</i>									1	
<i>Veronica peregrina</i>							1			
<i>Veronica</i> sp.		1								
<i>Viola</i> sp.				1				1		1
<i>Xanthium strumarium</i>				1				1	1	
Graminoid (vegetative)	1	1		1					1	
Forb 1 (seedling)			1					1	1	
Forb 2 (vegetative, coarsely pubescent, petiolate, raised veins on underside of leaf)								1		
Forb 3 (rosette of compound leaves)	1									
cf. <i>Iris</i> (vegetative; cf. <i>I. pseudocorus</i>)	1							1		
Tree - 2nd sp.						1				

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APPENDIX D

PERFORMANCE ASSESSMENT

Multi-increment Sampling (MIS) Performance Assessment

Technical Support for 100/300 Area River Corridor Baseline Risk Assessment (RCBRA)

The fall sampling event, which assessed soil at 20% of the investigation areas, representing all nine environment and site type combinations, was conducted as a performance assessment. The purpose of the performance assessment was to provide information on the 'between-sample' and 'between investigation-area' variability in contaminant concentrations. The multi-increment sampling (MIS) methodology uses ~50 increments of soil, one from each section of the grid established over the study area. Each soil increment is collected from the 0 to 15 cm (0 to 6 in) depth. The soil is sieved to remove any particles and organic materials larger than 2 mm. The results of the performance assessment are used to evaluate the adequacy of the number of samples and increments per investigation area.

Data analysis followed Figure 1 (same as DOE/RL-2005-42 Figure 2-2). The first step in the assessment was to determine if the indicator contaminants in Table 1 (compiled from DOE/RL-2005-42 Tables 1-1 and 1-2) were detected. Detected indicator contaminants were then evaluated to determine if they were present at levels greater than practical quantitation limits (PQLs) or Hanford Site background. If they were detected above these levels then the concentrations were reviewed relative to human health cleanup levels from DOE/RL-2005-42 Table 2-2 (unrestricted soil cleanup levels). Table 1 lists the practical quantitation limits, background concentrations, and cleanup levels for the indicator contaminants. Contaminants that were not detected, and contaminants with concentrations less than quantitation limits or Hanford Site background, do not warrant further consideration in the statistical design. Contaminants that exceeded these criteria were retained for evaluation against cleanup levels. Exclusion criteria are depicted in Figure 1, and noted in the final column of Table 2.

Summary statistics for the indicator contaminants are provided in Table 2; there are two columns provided in Table 2 so that the reader can determine if the contaminant was detected at concentrations greater than the practical quantitation limit or background. Four indicator contaminants (C-14, H-3, TPH-DRO, TPH-GRO) will only be measured in sediment or water and thus were not measured in the performance assessment soil samples.

Concentrations of detected indicator contaminants are presented in Figures 2 through 47. The plots include, as applicable, reference lines at background levels, practical quantitation limits, and cleanup or action levels. The plots show both detected (filled circles) and non-detected (open circles) sample results. One can readily review the magnitude of the sample results relative to the reference lines. Contaminants with concentrations less than background/quantitation limits or much less than the cleanup level do not warrant further consideration in the statistical design. Reviewing these plots led to identifying five indicator contaminants that had concentrations either greater than or approaching cleanup levels and thus warrant further sampling design analyses. These five indicator contaminants are:

- Arsenic
- Hexavalent chromium
- Lead
- Benzo(a)pyrene
- Uranium-233/234

It is noted that radium-226 and radium-228 are measured in two and one results respectively above background; the cleanup levels for these radionuclides are basically at background concentrations. Given the similarity of the measurements to background levels, radium-226 and radium-228 were not evaluated further.

Visual Sampling Plan (VSP) Version 4.0a was used to evaluate the statistical performance of sampling design options. Statistical design parameters were the same as used in the DOE/RL-2005-42 Appendix

B except that measured standard deviations were used and the delta¹ term was set to 50% of the action level. Tables 3 through 7 provide a summary of the standard deviation for each of the five contaminants by site type. We have provided calculations of the standard deviation with non-detects replaced by 0 and non-detects replaced by half of the PQL as points of comparison. Table 8 provides a summary of the number of samples calculated with the VSP 4.0a software, and the standard deviation of the data as reported was used in these calculations. For most cases the number of recommended MIS samples is either 2 (the minimum number for this VSP design option²) or 3. However, there are three contaminant and site type combinations where the number of MIS samples is greater than 3. These cases are discussed below.

Hexavalent chromium: The concentrations of hexavalent chromium exceeded the cleanup level at the riparian reference site. This led to VSP calculating a very large number of samples. However, consider that any combination of 1 to 5 samples would have come to the same risk conclusion – all hexavalent chromium sample results at the riparian reference site exceeded the cleanup level. This suggests that a large sample size is not needed because even though the concentration is high, variability is not extreme (coefficient of variation [CV] at the riparian reference site was about 63%). The number of samples calculated using VSP was also large at another site (100-F-2) because two sample results were large non-detect values (about 5-10 times larger than the other three sample results).

Lead: One site was noted during MIS collection to have surface and subsurface debris. This site, 600-131, had high and variable levels of lead. Using the lead standard deviation, VSP 4.0a calculated more than two samples at this heterogeneous site.

Confidence levels of the data were evaluated for the two contaminant and site combinations where one or more MIS results were greater than the cleanup level. These contaminant and site combinations are hexavalent chromium at the riparian reference site and lead at site 600-131. The mean and upper confidence level (UCL) of the mean (using the data as reported) for the combinations of 2, 3, 4, and 5 samples are presented in Table 9. The UCLs are less than the overall maximum detect for the hexavalent chromium data in only two cases; the lead UCLs are less than the overall maximum concentration in five cases (about 10x less than the maximum in two of these five cases).

Recommendations based on VSP results, relative standard deviations, confidence levels of the data, and the values in the data relative to cleanup levels:

1. Collect three MIS samples at all riparian sites.
 - a. Riparian sites have no other soil sample data for human health exposure analysis
 - b. Riparian sites, in particular the reference site, have the highest levels of many indicator contaminants.
2. Collect two MIS samples at upland sites with no evidence of debris
 - a. Upland sites generally had low levels of indicator contaminants
 - b. Two is the minimum number of samples recommended by VSP.
3. Collect five MIS samples at upland sites with evidence of lead-containing debris (e.g., batteries, paint chips) in the top 15 cm (6 in.)
 - a. These sites appear to have the greatest heterogeneity of contaminants, including at least one contaminant of significance to human health
 - b. Consider collecting additional increments (i.e. 100 increments per investigation area) at these plots

¹ Delta defines the width of the gray region, which is the concentration range (in this case the difference of true means) that is considered small enough to accept.

² Two samples would be the minimum number of samples that could reject the null hypothesis

Table 1. Summary of Indicator Contaminants.

Group	Indicator contaminant	Units	PQL	Hanford Site Background			HH Direct Exposure CUL
				Mean	90th percentile	Source	
Inorganic	Aluminum	ug/kg	NA	8080000	11800000	DOE/RL-92-24	NA
	Antimony	ug/kg	600	15700	NA	DOE/RL-92-24	32000
	Arsenic	ug/kg	1000	4200	6470	DOE/RL-92-24	20000
	Barium	ug/kg	500	92700	132000	DOE/RL-92-24	16000000
	Beryllium	ug/kg	NA	670	810	Ecology 94-115	10400
	Cadmium	ug/kg	200	450	810	Ecology 94-115	80000
	Chromium	ug/kg	200	10900	18500	DOE/RL-92-24	120000000
	Copper	ug/kg	1000	15500	22000	DOE/RL-92-24	2960000
	Hexavalent Chromium	ug/kg	500	NA	NA	NA	2100
	Iron	ug/kg	NA	24500000	32600000	DOE/RL-92-24	NA
	Lead	ug/kg	500	6300	10200	DOE/RL-92-24	250000
	Lithium	ug/kg	5000	34100	33500	DOE/RL-92-24	1600000
	Manganese	ug/kg	NA	384000	512000	DOE/RL-92-24	NA
	Mercury	ug/kg	200	260	330	DOE/RL-92-24	24000
	Nickel	ug/kg	NA	13000	19100	DOE/RL-92-24	1600000 &
	Nitrate	ug/kg	2500	30100	52000	DOE/RL-92-24	12800000
	Silver	ug/kg	200	1600	730	DOE/RL-92-24	400000
	Tin	ug/kg	NA	NA	NA	NA	NA
	Uranium	ug/kg	5000	2300	3200	calculated	240000
	Vanadium	ug/kg	NA	57600	85100	DOE/RL-92-24	NA
	Zinc	ug/kg	1000	53000	67800	DOE/RL-92-24	24000000
Organics	Acenaphthene	ug/kg	100	NA	NA	NA	4800000
	Acenaphthylene	ug/kg	100	NA	NA	NA	4800000
	Anthracene	ug/kg	50	NA	NA	NA	24000000
	Benzo(a)pyrene	ug/kg	15	NA	NA	NA	137
	Benzo(ghi)perylene	ug/kg	30	NA	NA	NA	2400000
	Benzo(k)fluoranthene	ug/kg	15	NA	NA	NA	1400
	Chrysene	ug/kg	100	NA	NA	NA	14000
	Dibenz[a,h]anthracene	ug/kg	30	NA	NA	NA	340
	Fluoranthene	ug/kg	50	NA	NA	NA	3200000
	Fluorene	ug/kg	30	NA	NA	NA	3200000
	Indeno(1,2,3-cd)pyrene	ug/kg	30	NA	NA	NA	1370
	Naphthalene	ug/kg	100	NA	NA	NA	1600000
	Phenanthrene	ug/kg	50	NA	NA	NA	24000000
	Pyrene	ug/kg	50	NA	NA	NA	2400000
	Methoxychlor +	ug/kg	NA	NA	NA	NA	NA
	1,2,4-trichlorobenzene	ug/kg	330	NA	NA	NA	800000
	1,2-dichlorobenzene	ug/kg	330	NA	NA	NA	7200000
	2,4,5-trichlorophenol	ug/kg	330	NA	NA	NA	8000000
	2,4,6-trichlorophenol	ug/kg	330	NA	NA	NA	91000
	Dibenzofuran	ug/kg	330	NA	NA	NA	160000
	Pentachlorophenol	ug/kg	330	NA	NA	NA	8300
	TPH-DRO **	NA	NA	NA	NA	NA	NA
	TPH-GRO **	NA	NA	NA	NA	NA	NA
	Carbon-14 **	NA	NA	NA	NA	NA	NA
Radio-nuclides	Cobalt-60	pCi/g	0.05	NA	NA	NA	1.4
	Cesium-137	pCi/g	0.1	0.417	1.05	DOE/RL-96-12	6.2
	Europium-152	pCi/g	0.1	NA	NA	NA	3.3
	Europium-154	pCi/g	0.1	NA	NA	NA	3
	Plutonium-238	pCi/g	1	0.00158	0.00378	DOE/RL-96-12	37.4
	Radium-226	pCi/g	0.1	0.561	0.815	DOE/RL-96-12	1.04
	Radium-228	pCi/g	0.2	0.945	1.32	DOE/RL-96-12 ***	1.69
	Strontium-90	pCi/g	1	0.0806	0.178	DOE/RL-96-12	4.5
	Thorium-228	pCi/g	1	0.945	1.32	DOE/RL-96-12 ***	2.26
	Thorium-232	pCi/g	1	0.945	1.32	DOE/RL-96-12	1.3
	Tritium **	NA	NA	NA	NA	NA	NA
	Uranium-233/234	pCi/g	1	0.793	1.1	DOE/RL-96-12	1.1
	Uranium-235	pCi/g	1	0.0515	0.109	DOE/RL-96-12	0.84
	Uranium-238	pCi/g	1	0.763	1.06	DOE/RL-96-12	1.1

** Not a soil contaminant - thus no soil sample results

*** Th-232 daughter

+ not a soil contaminant but included in the soil suite although not detected in soil samples & cleanup level is from the 100 Area RDR/RAWP

Table 2. Summary Statistics for Indicator Contaminants.

Analyt e Type	Indicator Contaminant	Number of samples	Number of detects	Frequency of detection	Units	Detect > PQL?	Max detect > back- ground?	Detects						Non-detects			Eliminatio n Criterio n **
								Average conc- entration	Standard deviation	Min.	Median	Max.	relative standard deviation	Min	Median	Max	
Inorganic	Aluminum	45	45	1.00	ug/kg	NA	no	5820000	1410000	3960000	5230000	9300000	24%	NA	NA	NA	C
	Antimony	45	9	0.20	ug/kg	yes	NA	497	194	190	606	806	39%	190	607	626	Retained
	Arsenic	45	45	1.00	ug/kg	yes	yes	3680	2150	1800	2700	9500	58%	NA	NA	NA	Retained
	Barium	45	45	1.00	ug/kg	yes	no	74000	16500	48600	71000	114000	22%	NA	NA	NA	C
	Beryllium	45	37	0.82	ug/kg	NA	no	389	227	5	410	810	58%	5	5	15	C
	Cadmium	45	25	0.56	ug/kg	yes	yes	625	546	43	655	1600	87%	30	107	110	Retained
	Chromium	45	45	1.00	ug/kg	yes	yes	13400	7490	4500	9900	31300	56%	NA	NA	NA	Retained
	Copper	45	45	1.00	ug/kg	yes	yes	17900	7050	10300	15400	38300	39%	NA	NA	NA	Retained
	Hexavalent Chromium	45	29	0.64	ug/kg	yes	NA	1350	2550	213	407	10400	189%	181	202.5	207	Retained
	Iron	45	45	1.00	ug/kg	NA	no	19600000	2630000	12000000	20000000	24500000	13%	NA	NA	NA	C
	Lead	45	45	1.00	ug/kg	yes	yes	28200	55100	4000	11400	327000	195%	NA	NA	NA	Retained
	Lithium	45	45	1.00	ug/kg	yes	no	6540	1900	4100	5800	10900	29%	NA	NA	NA	C
	Manganese	45	45	1.00	ug/kg	NA	yes	336000	72800	238000	322000	525000	22%	NA	NA	NA	Retained
	Mercury	45	18	0.40	ug/kg	no	no	43.7	27.2	21	41.5	139	62%	19	21	22	B
	Nickel	45	45	1.00	ug/kg	NA	yes	12600	3890	7400	10900	21300	31%	NA	NA	NA	Retained
	Nitrate	15	15	1.00	ug/kg	yes	yes	49700	35600	12100	38300	121000	72%	NA	NA	NA	Retained
	Silver	45	0	0.00	ug/kg	no	NA	NA	NA	NA	NA	NA	NA	70	212	219	A
	Tin	45	33	0.73	ug/kg	NA	NA	2170	1990	530	1400	8400	92%	766	808	814	Retained
	Uranium	45	3	0.07	ug/kg	no	yes	3250	220	3110	3130	3500	7%	970	3120	3230	B
Organic	Vanadium	45	45	1.00	ug/kg	NA	no	45000	7890	24100	44200	63500	18%	NA	NA	NA	C
	Zinc	45	45	1.00	ug/kg	yes	yes	92100	76800	31800	43400	252000	83%	NA	NA	NA	Retained
	1,2,4-Trichlorobenzene	45	0	0.00	ug/kg	no	NA	NA	NA	NA	NA	NA	NA	320	330	670	A
	1,2-Dichlorobenzene	45	0	0.00	ug/kg	no	NA	NA	NA	NA	NA	NA	NA	320	330	670	A
	2,4,5-Trichlorophenol	45	0	0.00	ug/kg	no	NA	NA	NA	NA	NA	NA	NA	810	830	1700	A
	2,4,6-Trichlorophenol	45	0	0.00	ug/kg	no	NA	NA	NA	NA	NA	NA	NA	320	330	670	A
	Acenaphthene*	75	0	0.00	ug/kg	no	NA	NA	NA	NA	NA	NA	NA	32.7	330	670	A
	Acenaphthylene*	75	0	0.00	ug/kg	no	NA	NA	NA	NA	NA	NA	NA	32.7	330	670	A
	Anthracene*	75	5	0.07	ug/kg	no	NA	11.5	9.5	3.60	7.10	24	82%	3.27	330	670	B
	Benzo(a)pyrene*	75	20	0.27	ug/kg	yes	NA	19.4	27.2	3.45	8.55	120	140%	3.27	330	670	Retained
	Benzo(ghi)perylene*	75	17	0.23	ug/kg	yes	NA	15.7	17.1	3.41	10.40	69	109%	3.27	330	670	Retained
	Benzo(k)fluoranthene*	75	18	0.24	ug/kg	yes	NA	18.3	32.9	0.00	5.00	140	179%	3.27	330	670	Retained
	Chrysene*	75	18	0.24	ug/kg	no	NA	34.5	58.5	3.85	15.38	260	170%	3.27	330	670	B
	Dibenz[a,h]anthracene*	75	3	0.04	ug/kg	no	NA	19.9	24.5	3.80	7.77	48	123%	3.27	330	670	B
	Dibenzofuran*	45	0	0.00	ug/kg	no	NA	NA	NA	NA	NA	NA	NA	320	330	670	A
	Fluoranthene*	75	24	0.32	ug/kg	yes	NA	45.2	87.7	7.70	16.75	430	194%	6.53	330	670	Retained
	Fluorene*	75	1	0.01	ug/kg	no	NA	10.3	NA	10.3	10.26	10.258	NA	3.27	330	670	B
	Indeno(1,2,3-cd)pyrene*	75	13	0.17	ug/kg	yes	NA	25.1	25.7	3.15	13.91	79.18	102%	3.27	330	670	Retained
	Methoxychlor	45	0	0.00	ug/kg	no	NA	NA	NA	NA	NA	NA	NA	0.004	1.3	1.4	A
	Naphthalene*	75	2	0.03	ug/kg	no	NA	15.7	0.4	15.39	15.70	16	3%	32.7	330	670	B
Radionuclides	Pentachlorophenol	45	0	0.00	ug/kg	no	NA	NA	NA	NA	NA	NA	NA	810	830	1700	A
	Phenanthrene*	75	20	0.27	ug/kg	yes	NA	19.4	34.4	3.50	5.92	130	177%	3.27	330	670	Retained
	Pyrene*	75	21	0.28	ug/kg	yes	NA	51.4	92.7	7.49	22.35	430	180%	6.53	330	670	Retained
	Cesium-137	45	16	0.36	pCi/g	yes	no	0.154	0.062	0.05	0.16	0.24	40%	0.065	0.115	0.24	Retained
	Cobalt-60	45	1	0.02	pCi/g	yes	NA	0.092	NA	0.09	0.09	0.092	NA	0.059	0.099	0.25	Retained
	Europium-152	45	3	0.07	pCi/g	yes	NA	0.431	0.288	0.22	0.32	0.758	67%	0.11	0.235	0.5	Retained
	Europium-154	45	0	0.00	pCi/g	no	NA	NA	NA	NA	NA	NA	NA	0.17	0.3	0.52	A
	Plutonium-238	35	0	0.00	pCi/g	no	no	NA	NA	NA	NA	NA	NA	-0.059	0	0.22	A
	Radium-226	45	40	0.89	pCi/g	yes	yes	0.451	0.146	0.23	0.44	0.885	32%	0.24	0.27	0.86	Retained
	Radium-228	45	31	0.69	pCi/g	yes	yes	0.716	0.240	0.47	0.64	1.6	33%	0.35	0.62	1.3	Retained
	Thorium-228	45	34	0.76	pCi/g	no	no	0.508	0.118	0.28	0.50	0.777	23%	0.088	0.271	0.395	B
	Thorium-228 GEA	45	42	0.93	pCi/g	yes	yes	0.647	0.208	0.29	0.64	1.1	32%	0.15	0.21	0.28	Retained
	Thorium-232	45	32	0.71	pCi/g	no	no	0.478	0.122	0.30	0.47	0.735	26%	0.079	0.281	0.518	B

Analyt e Type	Indicator Contaminant	Number of samples	Number of detects	Frequency of detection	Units	Detect > PQL?	Max detect > back- ground?	Detects						Non-detects			Eliminatio n Criterion **
								Average conc- entration	Standard deviation	Min.	Median	Max.	relative standard deviation	Min	Median	Max	
	Thorium-232 GEA	45	31	0.69	pCi/g	yes	yes	0.716	0.240	0.47	0.64	1.6	33%	0.35	0.58	1.3	Retained
	Total beta radiostrontium	45	0	0.00	pCi/g	no	no	NA	NA	NA	NA	NA	NA	0.1	0.25	0.4	A
	Uranium-233/234	45	28	0.62	pCi/g	yes	yes	0.543	0.366	0.16	0.50	1.41	68%	0.077	0.12	0.297	Retained
	Uranium-235	45	0	0.00	pCi/g	no	no	NA	NA	NA	NA	NA	NA	0.14	0.29	0.5	A
	Uranium-235 GEA	45	0	0.00	pCi/g	no	no	NA	NA	NA	NA	NA	NA	0.17	0.31	0.54	A
	Uranium-238	45	23	0.51	pCi/g	no	no	0.518	0.263	0.16	0.53	0.967	51%	0.042	0.152	0.288	B
	Uranium-238 GEA	45	0	0.00	pCi/g	no	no	NA	NA	NA	NA	NA	NA	5.5	10	19	A

* PAHs were measured with two methods; 8270 at all investigation areas (45 samples); 8310 at upland investigation areas only (30 samples); thus, 75 samples total

** Elimination Criteria Code: A = Analyte never detected
B = Max detect < PQL
C = Max detect < Hanford Site Background
Retained = Analyte retained

Table 3. Arsenic Concentrations from MIS Soil Samples.

Sample location	HEIS Number	Conc. (ug/kg)	Qual	PQL (ug/kg)	Mean as reported (ug/kg)	St. dev. as reported (ug/kg)	St. dev. ND as 0 (ug/kg)	St. dev. ND = 0.5 PQL (ug/kg)
600-131	J10DM5	2400		200	2140	167	NA	NA
	J10DM6	2100		200				
	J10DM7	2200		200				
	J10DM8	2000		200				
	J10DM9	2000		200				
Pit 23	J10DN0	2300		200	2200	100	NA	NA
	J10DN1	2300	J	200				
	J10DN2	2100	J	200				
	J10DN3	2200	J	200				
	J10DN4	2100	J	200				
Upland Native Reference Central Plateau	J10DR5	2700		500	2780	476	NA	NA
	J10DR6	3000		500				
	J10DR7	2100		500				
	J10DR8	2700		500				
	J10DR9	3400		500				
Upland Backfill Elevated 100-F-2	J10DP0	3800		200	3740	391	NA	NA
	J10DP1	3500		200				
	J10DP2	4100		200				
	J10DP3	4100		200				
	J10DP4	3200		200				
Upland Backfill Low 116-DR-1&2	J10DR0	2000		500	2320	311	NA	NA
	J10DR1	2300		500				
	J10DR2	2100		500				
	J10DR3	2400		500				
	J10DR4	2800		500				
Upland Native Elevated JA Jones	J10DT0	2800		500	2200	430	NA	NA
	J10DT1	2500		500				
	J10DT2	1900		500				
	J10DT3	2000		500				
	J10DT4	1800		500				
Riparian Elevated #3	J10DP5	3100		500	2960	297	NA	NA
	J10DP6	2600		500				
	J10DP7	3300		500				
	J10DP8	2700		500				
	J10DP9	3100		500				
Riparian Low #10 Downriver 100-D	J10LJ0	6800		500	6460	207	NA	NA
	J10LJ1	6300	C	500				
	J10LJ2	6300		500				
	J10LJ3	6500		500				
	J10LJ4	6400		500				
Riparian Reference #13 Vernita Bridge	J10DN5	8200		500	8360	658	NA	NA
	J10DN6	7800		500				
	J10DN7	8200		500				
	J10DN8	8100		500				
	J10DN9	9500		500				

J = The reported value is an estimate.

C = The analyte was detected in the associated QC blank above the IDL/MDL.

NA = Not applicable.

Table 4. Hexavalent Chromium Concentrations from MIS Soil Samples.

Sample location	HEIS Number	Conc. (ug/kg)	Qual	PQL (ug/kg)	Mean as reported (ug/kg)	St. dev. as reported (ug/kg)	St. dev. ND as 0 (ug/kg)	St. dev. ND = 0.5 PQL (ug/kg)
600-131	J10DM5	199	U	200	342	188	274	228
	J10DM6	447		200				
	J10DM7	246		200				
	J10DM8	195	U	200				
	J10DM9	622		200				
Pit 23	J10DN0	256	J	200	222	35	134	80
	J10DN1	200	UJ	200				
	J10DN2	213	J	200				
	J10DN3	259	J	200				
	J10DN4	181	UJ	200				
Upland Native Reference Central Plateau	J10DR5	489		200	287	118	208	161
	J10DR6	205	U	200				
	J10DR7	204	U	200				
	J10DR8	286		200				
	J10DR9	250		200				
Upland Backfill Elevated 100-F-2	J10DP0	437	D	400	994	914	218	405
	J10DP1	200	U	200				
	J10DP2	351		200				
	J10DP3	1990	UD	2000				
	J10DP4	1990	UD	2000				
Upland Backfill Low 116-DR-1&2	J10DR0	400	UD	400	326	83	174	93
	J10DR1	399	UD	400				
	J10DR2	322		200				
	J10DR3	196	U	200				
	J10DR4	315		200				
Upland Native Elevated JA Jones	J10DT0	204	U	200	315	103	214	146
	J10DT1	398		200				
	J10DT2	399		200				
	J10DT3	201	U	200				
	J10DT4	372		200				
Riparian Elevated #3	J10DP5	252		200	344	110	185	146
	J10DP6	407		200				
	J10DP7	440		200				
	J10DP8	200	U	200				
	J10DP9	419		200				
Riparian Low #10 Downriver 100-D	J10LJ0	244		200	557	234	344	310
	J10LJ1	595		200				
	J10LJ2	745		200				
	J10LJ3	398	U	200				
	J10LJ4	801		200				
Riparian Reference #13 Vernita Bridge	J10DN5	10400	D		5940	3700	4310	No PQL reported
	J10DN6	8970	D					
	J10DN7	5600	D					
	J10DN8	2070	UD					
	J10DN9	2670	D					

J = The reported value is an estimate.

U = Analyzed for but not detected above limiting criteria (≤ PQL)

D = Sample was analyzed using a secondary dilution factor (i.e., dilution factor different than 1.0).

Table 5. Lead Concentrations from MIS Soil Samples.

Sample location	HEIS Number	Conc. (ug/ kg)	Qual	PQL (ug/k g)	Mean as reported (ug/kg)	St. dev. as reported (ug/kg)	St. dev. ND as 0 (ug/kg)	St. dev. ND = 0.5 PQL (ug/kg)
600-131	J10DM5	327000		200	116000	142000	NA	NA
	J10DM6	198000		200				
	J10DM7	12400		200				
	J10DM8	29400		200				
	J10DM9	12300		200				
Pit 23	J10DN0	4300		200	4360	483	NA	NA
	J10DN1	4000	J	200				
	J10DN2	4100	J	200				
	J10DN3	5200	J	200				
	J10DN4	4200	J	200				
Upland Native Reference Central Plateau	J10DR5	6300	C	500	6300	561	NA	NA
	J10DR6	6100	C	500				
	J10DR7	5500	C	500				
	J10DR8	7000		500				
	J10DR9	6600		500				
Upland Backfill Elevated 100-F-2	J10DP0	10200		200	11200	1390	NA	NA
	J10DP1	10100		200				
	J10DP2	12700		200				
	J10DP3	10200		200				
	J10DP4	12700		200				
Upland Backfill Low 116-DR-1&2	J10DR0	5500		500	5020	630	NA	NA
	J10DR1	4800		500				
	J10DR2	5000		500				
	J10DR3	4100		500				
	J10DR4	5700		500				
Upland Native Elevated JA Jones	J10DT0	7900		500	7880	2080	NA	NA
	J10DT1	7300		500				
	J10DT2	6700		500				
	J10DT3	6100		500				
	J10DT4	11400		500				
Riparian Elevated #3	J10DP5	17800		500	16700	1940	NA	NA
	J10DP6	19500		500				
	J10DP7	15600		500				
	J10DP8	14600		500				
	J10DP9	16100	C	500				
Riparian Low #10 Downriver 100-D	J10LJ0	37200	C	500	36800	3920	NA	NA
	J10LJ1	36400		500				
	J10LJ2	39200		500				
	J10LJ3	40600		500				
	J10LJ4	30400		500				
Riparian Reference #13 Vernita Bridge	J10DN5	49900		500	49700	3640	NA	NA
	J10DN6	47100		500				
	J10DN7	45900	C	500				
	J10DN8	50400		500				
	J10DN9	55300	C	500				

J = The reported value is an estimate.

C = The analyte was detected in the associated QC blank above the IDL/MDL.

NA = Not applicable.

Table 6. Benzo(a)pyrene concentrations from MIS soil samples.

Sample location	HEIS Number	Conc. (ug/kg)	Qual	PQL (ug/kg)	Mean as reported (ug/kg)	St. dev. as reported (ug/kg)	St. dev. ND as 0 (ug/kg)	St. dev. ND = 0.5 PQL (ug/kg)
600-131	J10DM5	8.8		3.27	12.6	11.0	NA	NA
	J10DM6	8.1		3.33				
	J10DM7	8.6		3.33				
	J10DM8	32		3.31				
	J10DM9	5.3		3.28				
Pit 23	J10DN0	3.27	UJ	3.27	3.3	0.0	0.0	0.015
	J10DN1	3.31	UJ	3.31				
	J10DN2	3.33	UJ	3.33				
	J10DN3	3.34	UJ	3.34				
	J10DN4	3.34	UJ	3.34				
Upland Native Reference Central Plateau	J10DR5	3.35	U	3.35	3.3	0.0	0.0	0.005
	J10DR6	3.35	U	3.35				
	J10DR7	3.33	U	3.33				
	J10DR8	3.34	U	3.34				
	J10DR9	3.33	U	3.33				
Upland Backfill Elevated 100-F-2	J10DP0	3.37	U	3.37	8.0	7.4	8.6	8.0
	J10DP1	9.425		3.37				
	J10DP2	3.379		3.36				
	J10DP3	3.37	U	3.37				
	J10DP4	20.376		3.37				
Upland Backfill Low 116-DR-1&2	J10DR0	8.816		3.35	6.0	1.8	NA	NA
	J10DR1	6.633		3.35				
	J10DR2	4.643		3.35				
	J10DR3	4.525		3.35				
	J10DR4	5.625		3.36				
Upland Native Elevated JA Jones	J10DT0	9.235		3.35	26.7	30.2	NA	NA
	J10DT1	10.585		3.33				
	J10DT2	80.197		3.34				
	J10DT3	20.54		3.35				
	J10DT4	13.091		3.35				

J = The reported value is an estimate.

U = Analyzed for but not detected above limiting criteria (<= PQL)

NA = Not applicable.

Table 7. Uranium-233/234 concentrations from MIS soil samples.

Sample location	HEIS Number	Conc. (pCi/g)	Qual	MDA (pCi/g)	Mean as reported (pCi/g)	St. dev. as reported (pCi/g)	St. dev. ND as 0 (pCi/g)	St. dev. ND = 0.5 PQL (pCi/g)
600-131	J10DM5	0.189	U	0.24	0.155	0.072	0.000	0.032
	J10DM6	0.146	U	0.22				
	J10DM7	0.26	U	0.33				
	J10DM8	0.083	U	0.32				
	J10DM9	0.096	U	0.37				
Pit 23	J10DN0	0.12	U	0.31	0.155	0.080	0.000	0.013
	J10DN1	0.134	U	0.26				
	J10DN2	0.105	U	0.27				
	J10DN3	0.297	U	0.32				
	J10DN4	0.119	U	0.3				
Upland Native Reference Central Plateau	J10DR5	0.212	U	0.27	0.306	0.118	0.181	0.137
	J10DR6	0.294		0.28				
	J10DR7	0.505		0.28				
	J10DR8	0.294		0.28				
	J10DR9	0.224		0.21				
Upland Backfill Elevated 100-F-2	J10DP0	0.256		0.15	0.197	0.039	NA	NA
	J10DP1	0.192		0.15				
	J10DP2	0.161		0.15				
	J10DP3	0.212		0.12				
	J10DP4	0.163		0.14				
Upland Backfill Low 116-DR-1&2	J10DR0	0.194		0.14	0.171	0.080	0.126	0.081
	J10DR1	0.077	U	0.15				
	J10DR2	0.228		0.19				
	J10DR3	0.257		0.2				
	J10DR4	0.097	U	0.19				
Upland Native Elevated JA Jones	J10DT0	0.337		0.32	0.178	0.112	0.164	0.089
	J10DT1	0.252		0.21				
	J10DT2	0.085	U	0.22				
	J10DT3	0.088	U	0.34				
	J10DT4	0.13	U	0.33				
Riparian Elevated #3	J10DP5	0.501		0.27	0.516	0.159	0.267	0.183
	J10DP6	0.252	U	0.39				
	J10DP7	0.598		0.42				
	J10DP8	0.668		0.23				
	J10DP9	0.559		0.17				
Riparian Low #10 Downriver 100-D	J10LJ0	0.679		0.13	0.669	0.059	NA	NA
	J10LJ1	0.571		0.12				
	J10LJ2	0.679		0.14				
	J10LJ3	0.688		0.14				
	J10LJ4	0.729		0.15				
Riparian Reference #13 Vernita Bridge	J10DN5	0.879		0.34	1.190	0.198	NA	NA
	J10DN6	1.23		0.25				
	J10DN7	1.15		0.24				
	J10DN8	1.28		0.26				
	J10DN9	1.41		0.26				

U = Analyzed for but not detected above limiting criteria (<= MDA)

NA = Not applicable.

Table 8. Summary of VSP calculations

Indicator contaminant	Units	Action level	Delta	Site type	St. dev. (s)	Number of samples
Arsenic	ppb	20000	10000	Riparian reference	658	2
				Riparian low	207	2
Hexavalent chromium	ppb	2000	1000	Riparian reference	3700	150
				Riparian low	230	2
				Upland backfill high	914	11
Lead	ppb	250000	125000	Upland native low	142000	16
				Riparian low	3920	2
Benzo(a)pyrene	ppb	137	68	Upland native elevated	23	3
				Upland native low	10	3
				Upland backfill elevated	7	3
Uranium-233/234	pCi/g	1.1	0.55	Riparian reference	0.2	3

Table 9. Summary of confidence levels for combinations of data at two contaminant and site combinations

Contaminant	Site	Units	Number of samples	Mean	UCL
Hexavalent chromium	Riparian reference	ug/kg	2	9680	22500
		ug/kg		8000	51100
		ug/kg		6230	81100
		ug/kg		6530	76000
		ug/kg		7280	37600
		ug/kg		5520	67500
		ug/kg		5820	62400
		ug/kg		3830	35600
		ug/kg		4135	30500
		ug/kg		2370	7760
		ug/kg	3	8320	15800
		ug/kg		7150	20700
		ug/kg		7350	19900
		ug/kg		6020	18700
		ug/kg		6220	18100
		ug/kg		5050	19200
		ug/kg		5550	16000
		ug/kg		5750	15300
		ug/kg		4570	16200
		ug/kg		3450	9190
		ug/kg	4	6760	13600
		ug/kg		6910	13300
		ug/kg		6030	13900
		ug/kg		5180	12200
		ug/kg		4830	10620
		ug/kg	5	5940	11100
Lead	600-131	ug/kg	2	262000	1420000
		ug/kg		170000	3000000
		ug/kg		178000	2850000
		ug/kg		170000	3000000
		ug/kg		105000	1770000
		ug/kg		114000	1630000
		ug/kg		105000	1770000
		ug/kg		20900	174000
		ug/kg		12300	13200
		ug/kg		20850	174000
		ug/kg	3	179000	660000
		ug/kg		185000	639000
		ug/kg		179000	660000
		ug/kg		123000	661000
		ug/kg		117000	670000
		ug/kg		123000	661000
		ug/kg		79900	392000
		ug/kg		74200	400000
		ug/kg		79900	392000
		ug/kg		18000	48000
		ug/kg	4	142000	416000
		ug/kg		137000	420000
		ug/kg		142000	416000
		ug/kg		95300	380000
		ug/kg		63030	229000
		ug/kg	5	116000	312000

* All contaminant suites will be analyzed and evaluated in the risk assessment report.

** Use 90th percentile of Hanford background for inorganic chemicals and radionuclides.

Figure 1. Multi-increment soil sampling performance assessment flow chart.

Figure 2. Box plot of aluminum concentrations. Dotted line is 90th percentile of background (from DOE/RL-92-24).

Figure 3. Box plot of antimony concentrations. Open circles are non-detects. No 90th percentile background concentration is available for antimony.

Figure 4. Box plot of arsenic concentrations. Dashed line is the Washington State background level (Ecology 94-115).

Figure 5. Box plot of barium concentrations. Dotted line is 90th percentile of background (from DOE/RL-92-24).

Figure 6. Box plot of beryllium concentrations. Dotted line is 90th percentile of background (from DOE/RL-92-24). Open circles are non-detects.

Figure 7. Box plot of cadmium concentrations. Dotted line is 90th percentile of background (from DOE/RL-92-24). Open circles are non-detects.

Figure 8. Box plot of chromium concentrations. Dotted line is 90th percentile of background (from DOE/RL-92-24). Open circles are non-detects.

Figure 9. Box plot of hexavalent chromium concentrations. Open circles are non-detects.

Figure 10. Box plot of iron concentrations. Dotted line is 90th percentile of background (from DOE/RL-92-24).

Figure 11. Box plot of lead concentrations. Dotted line is 90th percentile of background (from DOE/RL-92-24).

Figure 12. Box plot of lithium concentrations. Dotted line is 90th percentile of background (from DOE/RL-92-24).

Figure 13. Box plot of manganese concentrations. Dotted line is 90th percentile of background (from DOE/RL-92-24).

Figure 14. Box plot of mercury concentrations. Dotted line is 90th percentile of background (from DOE/RL-92-24).

Figure 15. Box plot of nickel concentrations. Dotted line is 90th percentile of background (from DOE/RL-92-24).

Figure 16. Box plot of nitrate concentrations. Dotted line is 90th percentile of background (from DOE/RL-92-24).

Figure 17. Box plot of silver concentrations. Dotted line is 90th percentile of background (from DOE/RL-92-24). Open circles are non-detects.

Figure 18. Box plot of tin concentrations. There are no background or cleanup levels for tin. Open circles are non-detects.

Figure 19. Box plot of uranium concentrations. Dotted line is 90th percentile of background (calculated). Open circles are non-detects.

Figure 20. Box plot of vanadium concentrations. Dotted line is 90th percentile of background (from DOE/RL-92-24).

Figure 21. Box plot of zinc concentrations. Dotted line is 90th percentile of background (from DOE/RL-92-24).

Figure 22. Box plot of anthracene concentrations. Dotted line is the PQL. Open circles are non-detects.

Figure 23. Box plot of benzo(a)pyrene concentrations. Dotted line is the PQL. Open circles are non-detects.

Figure 24. Box plot of benzo(ghi)perylene concentrations. Dotted line is the PQL. Open circles are non-detects.

Figure 25. Box plot of benzo(k)fluoranthene concentrations. Dotted line is the PQL. Open circles are non-detects.

Figure 26. Box plot of chrysene concentrations. Dotted line is the PQL. Open circles are non-detects.

Figure 27. Box plot of dibenz(a,h)anthracene concentrations. Dotted line is the PQL. Open circles are non-detects.

Figure 28. Box plot of fluoranthene concentrations. Dotted line is the PQL. Open circles are non-detects.

Figure 29. Box plot of fluorene concentrations. Dotted line is the PQL. Open circles are non-detects.

Figure 30. Box plot of indeno(1,2,3-cd)pyrene concentrations. Dotted line is the PQL. Open circles are non-detects.

Figure 31. Box plot of naphthalene concentrations. Dotted line is the PQL. Open circles are non-detects.

Figure 32. Box plot of phenanthrene concentrations. Dotted line is the PQL. Open circles are non-detects.

Figure 33. Box plot of pyrene concentrations. Dotted line is the PQL. Open circles are non-detects.

Figure 34. Box plot of cesium-137 concentrations. Dotted line is 90th percentile of background (from DOE/RL-96-12). Open circles are non-detects.

Figure 35. Box plot of cobalt-60 concentrations. Open circles are non-detects.

Figure 36. Box plot of plutonium-238 concentrations. Dotted line is 90th percentile of background (from DOE/RL-96-12). Open circles are non-detects.

Figure 37. Box plot of radium-226 (by GEA) concentrations. Dotted line is 90th percentile of background (from DOE/RL-96-12). Open circles are non-detects.

Figure 38. Box plot of radium-228 (by GEA) concentrations. Dotted line is 90th percentile of background (from DOE/RL-96-12). Open circles are non-detects.

Figure 39. Box plot of total beta radiostrontium concentrations. Dotted line is 90th percentile of background (from DOE/RL-96-12). Open circles are non-detects.

Figure 40. Box plot of thorium-228 concentrations. Dotted line is 90th percentile of background (from DOE/RL-96-12). Open circles are non-detects.

Figure 41. Box plot of thorium-228 (by GEA) concentrations. Dotted line is 90th percentile of background (from DOE/RL-96-12).. Open circles are non-detects.

Figure 42. Box plot of thorium-232 concentrations. Dotted line is 90th percentile of background (from DOE/RL-96-12). Open circles are non-detects.

Figure 43. Box plot of thorium-232 (by GEA) concentrations. Dotted line is 90th percentile of background (from DOE/RL-96-12). Open circles are non-detects.

Figure 44. Box plot of uranium-233/234 concentrations. Open circles are non-detects.

Figure 45. Box plot of uranium-235 concentrations. Dotted line is 90th percentile of background (from DOE/RL-96-12). Open circles are non-detects.

Figure 46. Box plot of uranium-238 concentrations. Dotted line is 90th percentile of background (from DOE/RL-96-12). Open circles are non-detects.

Figure 47. Box plot of total uranium (calculated from the isotopes). Dotted line is 90th percentile of background (from DOE/RL-96-12). Open circles are non-detects.

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