UPPER COLUMBIA RIVER

Final
Quality Assurance Project Plan for the Phase 2 Sediment Study

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SECTION A: PROJECT MANAGEMENT

A1 TITLE AND APPROVAL SHEET

QUALITY ASSURANCE PROJECT PLAN FOR THE PHASE 2 SEDIMENT STUDY

EPA Project Coordinator	Laura Buelow	Date	4/15/13
EPA Project Coordinator	Matt Wilkening	Date	4/10/13
TAI Project Coordinator	Marko Adzic	Date	04/08/13
EPA Quality Assurance Manager	Ginna Grepo-Grove	Date	4/12/13
TAI Technical Coordinator	Anne Fairbrother	Date	3/28/13
Co-Principal Investigator	Robert Santore	Date	March 25, 2013
Co-Principal Investigator	Paul Paquin	Date	3/22/13
Senior Technical Advisor	Rick Cardwell	Date	4/3/13
Senior Technical Advisor	Scott Becker	Date	3/25/13
Task QA Manager	Rock Vitale	Date	3/26/13
Analytical Chemistry Laboratory Coordinator	Kris McCaig	Date	4/9/13
Bioassay Laboratory Coordinator	Ashley Kaiser	Date	3/28/13
Chemistry Laboratory Project Manager	Lynda Huckestein	Date	3/26/13
Chemistry Laboratory QA Manager	Suzanne LeMay	Date	3/26/13
Bioassay Laboratory Project Manager	Jeffrey Cotsifas	Date	3/29/13
Bioassay Laboratory QA Manager	Stephen L. Clark	Date	3/29/13
Database Administrator	Randy O'Boyle	Date	3/28/13

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ACRONYMS AND ABBREVIATIONS

Agreement	June 2, 2006, Settlement Agreement
ACG	analytical concentration goal
AFDW	ash-free dry weight
AIC	Akaike's information criterion
ASTM	American Society for Testing and Materials
AVS	acid volatile sulfide
BERA	Baseline Ecological Risk Assessment
BLM	biotic ligand model
CAS	Columbia Analytical Services
COC	chain-of-custody
COPC	chemical of potential concern
CSM	conceptual site model
DOC	dissolved organic carbon
DQI	data quality indicator
DQO	data quality objective
DMP	data management plan
Ecology	Washington State Department of Ecology
EDD	electronic data deliverable
EPA	U.S. Environmental Protection Agency
ESB	equilibrium-partitioning sediment benchmark
ESI	Environmental Services, Inc.
Exponent	Exponent, Inc.
f_{OC}	fraction of organic carbon
FSP	field sampling plan
GIS	geographic information system
IWTU	interstitial water toxicity unit
LCS	laboratory control sample
LCSD	LCS duplicate
MDL	method detection limit
mPECQ	mean probable effects concentration quotient
MQO	measurement quality objective
MRL	method reporting limit

MS	matrix spike
MSD	matrix spike duplicate
NAWQC	National ambient water quality criteria
NELAC	National Environmental Laboratory Accreditation Conference
NIST	National Institute of Standards and Technology
PARCC	precision, accuracy or bias, representativeness, completeness and comparability
pwBLM	BLM calculation based on sediment porewater composition
QA	quality assurance
QA/QC	quality assurance and quality control
QAPP	quality assurance project plan
QC	quality control
RI/FS	remedial investigation and feasibility study
RM	river mile
RPD	relative percent difference
RSD	relative standard deviation
SEM – AVS	simultaneously extracted metals minus acid volatile sulfide (which is defined as 'excess SEM'. See also "SEMx".)
SEM	simultaneously extracted metals
SEM_X	excess SEM; the difference of SEM minus AVS
$SEM_{X,OC}$	carbon normalized excess SEM
SHSP	Site Health and Safety Plan
Site	Upper Columbia River site
SLERA	Screening Level Ecological Risk Assessment
SOP	standard operating procedure
TAI	Teck American Incorporated
TAL	target analyte list
TIE	Toxicity Identification Evaluation
TOC	total organic carbon
UCR	Upper Columbia River
Zn/V	zinc-to-vanadium ratio

UNITS OF MEASURE

°C	degree(s) Celsius
cm	centimeter(s)
d	day
dw	dry weight
in.	inch(es)
h	hour(s)
km	kilometer(s)
lux	unit of illumination
L:D	light to dark ratio (photoperiod)
m	meter(s)
m^2	square meter(s)
mg/L	milligram(s) per liter
mL	milliliter(s)
mm	millimeter(s)
µm	micrometer(s)
µS/cm	microSiemens/centimeter
µg/L	microgram(s) per liter
µmol/g	micromoles per gram
µmol/g_d	micromoles per gram (dry weight)
µmol/g_{OC}	micromoles per gram organic carbon
v/v	volume to volume
wwt/wwt	wet weight to wet weight

A3 DISTRIBUTION LIST

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Chemistry Laboratory Project Manager	Lynda Huckestein
Chemistry Laboratory QA Manager	Suzanne LeMay
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Bioassay Laboratory QA Manager	Stephen L. Clark

A4 INTRODUCTION AND TASK ORGANIZATION

A4.1 Introduction

This document presents the quality assurance project plan (QAPP) for the Phase 2 sediment study (herein the 'study') of the Upper Columbia River (UCR) (herein the 'Site'), which extends from the U.S.-Canada border (river mile [RM] 745) to Grand Coulee Dam (RM 596). This study is one of many tasks being completed as part of the Site remedial investigation and feasibility study (RI/FS) by Teck American Incorporated (TAI) under U.S. Environmental Protection Agency (EPA) oversight. The objective of the RI/FS is to investigate the nature and extent of unacceptable risk at the Site to people and the environment.

This QAPP describes the organization, data quality objectives (DQOs), study design, analytical procedures, and quality assurance and quality control (QA/QC) procedures upon which the study will be based. The field sampling plan (FSP) describes field procedures and protocols that will be followed and is presented in Appendix A.

The primary objective of this study is to evaluate if there are unacceptable risks to benthic invertebrates (herein 'benthos') associated with exposure to metals and other chemicals in UCR sediments. To achieve this, site-specific relationships between chemical of potential concern (COPC) concentrations (including factors affecting bioavailability) and toxicity will be evaluated. Data collection efforts will focus on obtaining information that will inform our understanding of potential relationships between sediment chemistry and toxicity. In addition, data collected during this study will be used to inform other components of the ecological risk assessment (e.g., evaluation of risk to aquatic plants, sediment-probing birds, and other receptors).

EPA's DQO process (USEPA 2006a) was used to guide the development of the requirements and design rationale for data collection activities presented in this QAPP.

A4.2 Task Organization

This section presents the organizational structure for activities associated with the work, including task management and oversight, fieldwork, sample analysis, and data management. Contact information for team task members is provided in Table A4-1.

A4.2.1 EPA Organization and Responsibilities

EPA will oversee TAI activities associated with the study and will coordinate U.S. Department of the Interior, Washington State Department of Ecology (Ecology), and

tribal (i.e., the Confederated Tribes of the Colville Reservation and the Spokane Tribe of Indians) input with respect to review of technical documents submitted by TAI. In addition EPA, under Section 106 of the National Historic Preservation Act, has the primary responsibility for consulting with interested parties. EPA's project coordinators, Dr. Laura Buelow and Matt Wilkening, will be responsible for ensuring that the work performed is consistent with all applicable EPA guidance. The EPA quality assurance (QA) manager is Ginna Grepo-Grove, or designee.

A4.2.2 TAI Organization and Responsibilities

Marko Adzic will serve as TAI's project coordinator and will have the primary responsibility for ensuring that TAI meets all the requirements and associated deliverables specified within the June 2, 2006, Settlement Agreement (Agreement) (USEPA 2006b). Dr. Anne Fairbrother will be responsible for overseeing technical aspects of this task.

A4.2.3 Key Task Personnel

TAI technical team members for the study and their respective responsibilities are identified below.

Technical Team Coordinator—Dr. Fairbrother (Exponent, Inc. [Exponent]) will oversee task activities, review QA reports, and ensure that required activities are completed in sequence. Dr. Fairbrother will work closely with the co-principal investigator(s) and task QA coordinator to ensure that all requirements are met and study objectives achieved.

Co-principal Investigator(s)—Robert Santore and Paul Paquin (both of HDR│HydroQual Inc.)—will serve as co-principal investigators and will oversee and approve all project activities, review QA reports, approve final project QA needs, and authorize necessary actions and adjustments needed to accomplish program QA objectives. They will provide on-site supervision as needed and ensure that proper sample collection, preservation, storage, transport, and chain-of-custody (COC) procedures are followed. They will inform the technical team coordinator when problems occur and will communicate and document corrective actions taken.

Senior Technical Advisor(s)—Drs. Rick Cardwell (Cardwell Consulting, LLC) and Scott Becker (Integral Consulting Inc.) will serve as senior technical advisors for the study, and are responsible for providing technical oversight in the design, implementation, and data interpretation.

Task QA Coordinator—Rock Vitale (Environmental Services, Inc. [ESI]) is the task QA coordinator and is responsible for providing overall QA support for the study. Mr. Vitale will coordinate the validation of laboratory data; communicate data quality issues; and work with the database administrator to address potential data limitations. Mr. Vitale will report directly to the analytical chemistry laboratory coordinator, and will work closely with the bioassay laboratory coordinator, the database administrator, and the laboratories to ensure that the data are of the highest quality.

Bioassay Laboratory Coordinator—Ashley Kaiser (Exponent) is the bioassay laboratory coordinator and is responsible for ensuring that bioassay method development is completed satisfactorily; coordinating receipt of samples by the test laboratory and tracking the laboratory's progress; addressing QA issues related to the bioassays; and addressing any scheduling issues. Ms. Kaiser will report to the technical team coordinator, and will work closely with the task QA coordinator and the database administrator.

Analytical Chemistry Laboratory Coordinator—Kris McCaig (TAI) is the analytical chemistry laboratory coordinator and is responsible for ensuring that laboratory method selection and/or development is satisfactorily completed prior to the analysis of samples; coordinating with the testing laboratory and tracking the laboratory's progress; verifying that the laboratory has implemented the requirements of this QAPP; addressing QA issues related to the laboratory analyses; ensuring that laboratory capacity is sufficient to undertake the required analyses in a timely manner; and addressing scheduling issues related to laboratory analyses. Ms. McCaig will report directly to the TAI project coordinator and will work closely with the technical team coordinator.

Database Administrator—Mr. Randy O'Boyle (Exponent) is the database administrator and will have primary responsibility for data management and database maintenance and development. Mr. O'Boyle will be responsible for overseeing and/or conducting the following activities: establishing storage formats and procedures appropriate for data collected; ensuring all data packages are complete and delivered in the correct format; maintaining the integrity and completeness of the database; and providing data summaries to data users for interpretation and reporting. Mr. O'Boyle will report directly to the technical team coordinator and will work closely with the task QA coordinator and laboratories.

A4.2.4 Laboratories

The following responsibilities apply to respective project and QA managers at the analytical and bioassay laboratories. The analytical laboratory will be Columbia Analytical Services (CAS) while the bioassay laboratory will be Pacific EcoRisk (pending approval by EPA). Each will have the following staff available for this project.

Analytical Chemistry Laboratory Project Manager—Lynda Huckestein (CAS) is responsible for the successful and timely completion of sample analyses, as well as the following:

- Ensuring that samples are received and logged correctly, that the correct methods and modifications are used, and that data are reported within specified turnaround times
- Reviewing analytical data to ensure that procedures were followed as required in this QAPP, the cited methods, and laboratory standard operating procedures (SOPs)
- Apprising the laboratory coordinator of the schedule and status of sample analyses and data package preparation
- Notifying the laboratory coordinator if problems occur in sample receiving, analysis, or scheduling, or if control limits cannot be met
- Taking appropriate corrective action as necessary
- Reporting data and supporting QA information as specified in this QAPP
- Providing electronic data deliverables (EDDs) in a format consistent and compatible with the database.

Analytical Chemistry Laboratory QA Manager—Suzanne LeMay (CAS) is responsible for overseeing QA activities in the laboratory and ensuring the quality of the data for this task. Specific responsibilities include the following:

- Oversee and implement the laboratory's QA program
- Maintain QA records for each laboratory production unit
- Ensure that QA/QC procedures are implemented as required for each method and provide oversight of QA/QC practices and procedures
- Review and address or approve non-conformity and corrective action reports
- Coordinate responses to any quality control (QC) issues that affect this task with the analytical chemistry laboratory project manager.

Roles and responsibilities outlined above for CAS will also apply to Pacific EcoRisk, where Jeffrey Cotsifas and Stephen Clark will serve as the project manager and QA manager, respectively.

A5 PROBLEM DEFINITION AND BACKGROUND

The Baseline Ecological Risk Assessment (BERA) work plan (TAI 2011) identified several historical studies that collected and evaluated sediment chemistry and toxicity data from the Site. Detailed summaries and an integration of these data are presented within Appendices D (sediment chemistry) and E (sediment toxicity) of the BERA work plan. Similarly, the Screening Level Ecological Risk Assessment (SLERA; TAI 2010) identified a number of COPCs within sediments and associated porewater for which data collected to date are either 1) insufficient to assess the potential for adverse ecological effects, or 2) indicate a potential for adverse ecological effects. As a result, additional data collection and analyses are needed to evaluate potential risks to benthos associated with these COPCs. A summary of sediment/porewater COPCs requiring additional evaluation as determined by the SLERA are presented in Table A5-1. At the direction of EPA, COPCs to be evaluated for this study are limited to target analyte list metals[1].

Further evaluation of potential risks to benthos using multiple lines of evidence such as sediment and porewater chemistry, as well as whole-sediment toxicity tests, is required. To guide these efforts and ensure that representative areas spanning a range of potential exposures are evaluated, site-specific data were used to examine spatial gradients and define characteristic ranges (i.e., "bins") for representative sediment bed properties. Specifically, sediment bed properties identified in consultation with EPA were selected to represent a spectrum of site conditions and exposure gradients. These bed properties include zinc-to-vanadium ratio (Zn/V), total organic carbon (TOC), mean probable effects concentration quotient (mPECQ), and sediment texture.

Using geostatistical methods, the aforementioned sediment bed properties were mapped on a continuous basis over the Site. Joint variations of bed properties were used to define groups of sediment that, in turn, were categorized into high, medium, and low

[1] At the time of writing, a Site-wide COPC refinement document is being prepared and will be submitted under separate cover. This refinement will include and evaluate any and all EPA-approved data as collected for the RI/FS (e.g., beach sediments, surface water, fish tissue etc…); and will refine the assumptions and methods used in the 2010 Screening Level Ecological Risk Assessment. It is not anticipated that results of the aforementioned refinement will adversely affect data collection efforts for this Study as it has been developed to incorporate a tiered-approach (e.g., Toxicity Identification and Evaluation).

exposure gradient bins. A summary of the results (i.e., spatial distribution of sediment groups) is detailed in Appendix B[2].

A6 DATA NEEDS

Independent studies conducted to date at the Site have identified a number of sediment COPCs that may adversely affect benthos. These studies do not, however, sufficiently establish potential concentration-response relationships, nor do they fully integrate measures of bioavailability (USEPA 2007). As a result, the primary purpose of this study is to evaluate potential risks to benthos associated with exposure to sediment/porewater COPCs[3]. To do this, additional sediment/porewater chemistry data and synoptic benthic toxicity tests are needed. In addition, sediment and porewater data collected during this study can and will be used to inform other components of the BERA. For example, these data can and will be used, as appropriate and applicable, in the evaluation of unacceptable risks to other ecological receptors such as aquatic plants and sediment-probing birds, see Figure A6-1. Furthermore and if required by EPA, invertebrate tissue chemistry from *Hyalella azteca* collected after Toxicity Identification Evaluation (TIE) testing will be considered as a secondary line of evidence.

A7 DATA QUALITY OBJECTIVES, CRITERIA, AND DESIGN RATIONALE

EPA's seven-step DQO process (USEPA 2006a) was used to guide the design rationale for the Phase 2 sediment study. Each step is described below.

A7.1 Step 1—State the Problem

As noted in Section A6, studies conducted to date have identified a number of sediment COPCs that may adversely affect benthos within the UCR. These studies do not

[2] As documented on July 3, 2012, on the basis that sampling can proceed (see Section A7.1.2 herein), TAI while reserving its right to raise technical concerns associated with EPA's alternate locations (refer to June 11, 2012 correspondence), will undertake sediment sampling activities and analyses at EPA's alternate locations (refer to April 27, 2012 letter to TAI). TAI, also under protest, has incorporated the site reconnaissance recommendations outlined by EPA's contractor (CH2M Hill, Inc.; June 27, 2012 technical memorandum). As a result, although the methods presented herein (including the Appendix) may not have fully been considered for EPA's program, they remain appropriate. In addition and as requested by EPA, materials presented within Appendix B, may be updated following data collection and the analyses outlined herein.

[3] The primary purpose is consistent with EPA's February 2010 level-of-effort paper, which states "the goal of this sediment sampling component of the baseline ecological risk assessment (BERA) is to evaluate risks to benthic invertebrates associated with exposure to metals and other chemicals in the UCR [as identified by the screening-level ecological risk assessment (SLERA) for the site]."

sufficiently establish potential concentration-response relationships, nor do they fully integrate measures of bioavailability (USEPA 2007). Accordingly, this study will characterize factors that influence bioavailability of COPCs in sediment and assess if unacceptable risks to benthos exist. Application of concentration-response relationships to benthic bioassay data and associated chemistry (sediment/laboratory and field porewater) will provide a basis for evaluating potential risks to benthos throughout the UCR. Sediment and field porewater data collected during this study can and will also be used to inform other components of the BERA (e.g., in the evaluation of risk to aquatic plants, sediment-probing birds, and other receptors). Furthermore, sediment/field porewater data collected during this study will be used to refine spatial gradients; sediment bed properties such as slag content (e.g., Zn/V ratio[4]), TOC, mPECQ, and sediment texture (refine the nature and extent of unacceptable risk at the Site[5]).

A7.1.1 Team Members and Roles

Team members and their roles are described in Section A4.2 of this QAPP.

A7.1.2 Schedule

It is anticipated that this work will be completed in early to mid-fall (September to October). For planning purposes, it is anticipated that preliminary results will be available by late winter (December). These preliminary data will be used to help guide, inform, and refine which samples will undergo additional long-term toxicity tests and specialized analyses such as backscatter electron microscopy. It is acknowledged that prior to initiating the aforementioned additional tests and specialized analyses, technical memoranda, or amendment(s) to this QAPP will be required. As a result, the above-mentioned schedule is for planning purposes only and is subject to change.

Following Phase 2 sediment/toxicity data collection, analyses, and evaluation, if the EPA determines that there is insufficient information to support an informed risk-based management decision using existing site data; additional sediment/toxicity sample collection may be needed. The need for future sampling will be data driven and directed by EPA, if determined to be necessary.

[4] The basis and rationale of using a Zn/V ratio was detailed within Appendix D of the BERA work plan (TAI 2011). Other chemical ratios and/or methods (i.e., backscatter electron microscopy) may also be used to refine sediment bed properties and facilitate data interpretation.

[5] The sampling design is not intended to provide an assessment of spatial distribution of contaminants in the Site.

A7.2 Step 2—Identify the Goal of the Study

Consistent with EPA's February 2010 level-of-effort, this study was "designed to evaluate the risks to benthic invertebrate communities." As a result, the primary goal of this study is to evaluate risks to benthos associated with exposure to COPCs in UCR sediments. Specific DQOs to be addressed are as follows:

- Are sediment COPCs bioavailable at levels indicative of potential unacceptable risks to benthos?
- Are there significant differences in survival, growth, or reproduction of benthos (i.e., amphipods and midge) exposed to Site and reference sediments? If significant differences occur
  - What is the magnitude of these effects?
  - Are these effects due to COPCs as measured in sediments and/or porewater?
  - What concentration-response relationships can be established between measured COPC concentrations and observed effects?

In addition to the above-mentioned primary goal and associated DQOs, other questions to be addressed by this study include

- Are sediment COPCs bioavailable at levels indicative of potential unacceptable risks to other ecological receptors (e.g., aquatic plants, sediment-probing birds)?
- Can the nature and extent of unacceptable risk at the Site via spatial gradients and sediment bed properties such as slag content (e.g., Zn/V ratio[6]), TOC, mPECQ, and sediment texture be further refined?[7]

A7.3 Step 3—Identify Information Inputs

The third step of the DQO process (USEPA 2006a) requires consideration of the following:

- Types and potential sources of information (e.g., site characteristics or variables) that should be measured to provide estimates or resolve decisions
- Information to provide a basis for specifying performance or acceptance criteria
- Information on the performance of appropriate sampling and analyses methods.

[6] The basis and rationale of using a Zn/V ratio was detailed within Appendix D of the BERA work plan (TAI 2011). Other chemical ratios and/or methods (i.e., backscatter electron microscopy) may also be used to refine sediment bed properties and facilitate data interpretation.

[7] The sampling design is not intended to provide an assessment of spatial distribution of contaminants in the Site.

Determination or estimation of unacceptable risks to benthos and other ecological receptors (refer to Figure A6-1) requires representative data on bioavailability for COPCs in Site sediments as collected over a range of exposure gradients. Samples collected along anticipated exposure gradients will facilitate the collection of representative Site sediments, and the evaluation of potential concentration-response relationships and unacceptable risks. The sampling design is not intended to provide an assessment of spatial distribution of contaminants in the Site.

The degree of COPC bioavailability will be measured and evaluated using a range of methods. These include, but are not limited to, mPECQ, excess simultaneously extracted metals (SEM_X) (simultaneously extracted metals minus acid volatile sulfide [SEM – AVS]), carbon-normalized excess SEM ($SEM_{X,OC}$ = SEM_X/fraction organic carbon), pH, and the biotic ligand model (BLM). Significant differences in the survival, growth, or reproduction of benthos will be evaluated using synoptic whole-sediment bioassays with standard test organisms (i.e., amphipods and midge) and sediments collected at the Site and in one or more reference areas.

The adequacy of multiple metal ratio methods for describing sediment bed properties such as slag content will be evaluated by using field observations (e.g., presence/ absence and percent of visible black silica glass particles) in conjunction with sediment chemistry. Sediment samples will be archived and no fewer than 35 samples will undergo backscatter electron microscopy following a review of the preliminary data. Samples will be selected for this specialized work following a review of the preliminary chemistry data; and will be documented in a technical memorandum, or QAPP addendum, for EPA's review and approval.

Information from both field and laboratory chemistry (sediment/porewater) and bioassay endpoints will be used to identify areas of unacceptable risk to benthos and evaluate concentration-response relationships.

A7.3.1 Sediment and Field Porewater Chemistry

Whole sediment and field porewater chemistry will be collected from 140 sampling stations. This total includes 124 Site samples (10 of which are intended to be internal references), and 16 external reference samples (Table A7-1). External reference samples include 6 tributary reference, and 10 upstream reference samples. Samples will be collected and analyzed from the top 6 in. (15 cm) of the sediment (i.e., the depth commonly associated with the biologically active zone). To evaluate the degree to which sediment COPCs may be bioavailable and indicative of potential unacceptable risks, the following analytical measurements will be conducted on all samples.

Whole-Sediment Chemistry

Sediment samples will be analyzed for grain size, pH, AVS (acid volatile sulfide), SEM, TOC, and target analyte list (TAL) metals[8]. EPA methods for analyses of bulk sediment chemistry are listed in Table A7-2.

Field Porewater Chemistry

Field porewater samples will be collected *ex situ* via suction (i.e., airstones). In short, this will involve the careful insertion (horizontally) of an airstone within the sediment as it remains in the sampling equipment (i.e., Van Veen sampler) at the time of sample collection (prior to any compositing that may be performed). Upon insertion, the top of the airstone will sit approximately 3 in. (7 cm) below the sediment surface. The airstone will be connected to a large (≤140 mL) syringe via decontaminated polyethylene tubing through which field porewater will be extracted.

If sufficient volume is available, field porewater samples will be analyzed for TAL metals (the dissolved fraction) and other water quality parameters needed to assess metal bioavailability using the BLM. Therefore, the volume-dependent priority order of porewater analytes includes 1) aluminum, cadmium, calcium, copper, iron, lead, magnesium, manganese, nickel, potassium, sodium, and zinc; 2) pH, dissolved organic carbon [DOC], hardness (to be calculated), and alkalinity; and 3) chloride and sulfate. Chemical analyses will be performed according to EPA methods (Table A7-2).

A7.3.2 Whole-Sediment Bioassays

Of the 140 sampling stations identified and discussed in Section A7.3.1, whole-sediment bioassays using the amphipod *Hyalella azteca* and the midge *Chironomus dilutus* will be synoptically performed on 74 (53 percent) of the samples, in accordance with EPA[9]; refer to Maps A7-1 through A7-9. Specifically, bioassays to be performed on all 74 samples include the following:

- 28-day whole-sediment toxicity tests with the amphipod, *H. azteca* (endpoints of survival, weight, and biomass [USEPA 2000; ASTM 2012])
- 10-day whole-sediment toxicity tests with the midge, *C. dilutus* (endpoint of survival, weight, and biomass [USEPA 2000; ASTM 2012]).

[8] TAL metals include aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, vanadium, and zinc.

[9] The sampling design is not intended to provide an assessment of spatial distribution of contaminants in the Site.

In addition to the above-listed standard bioassays, reproductive endpoints will be also assessed on 18 split-samples. Consistent with EPA's direction, preference for these 18 split-samples will be given to those stations located within high and medium exposure gradient bins, but will be finalized following review of preliminary data. Results of the above-listed 10- and 28-day survival and growth tests, in conjunction with preliminary chemistry data will be used to refine and identify which samples will undergo further evaluation; and will be documented in a technical memorandum, or QAPP addendum, for EPA's review and approval. Specific bioassays to be performed on these 18 samples include the following:

- 42-day whole-sediment toxicity tests with the amphipod, *H. azteca* (endpoints of survival, weight, biomass, and neonates/surviving female [USEPA 2000; ASTM 2012])
- 50- to 65-day whole-sediment toxicity tests with the midge, *C. dilutus* (endpoints of survival, weight, biomass, emergence, eggs/surviving female, egg hatching, and viability of young using <24 hour old larvae [USEPA 2000; ASTM 2012]).

To meet Study DQOs and minimize the potential for confounding inter-batch variability with other variables (e.g., due to a chemical gradient), short-term bioassay testing will be initiated only after completing all field sampling. Short-term bioassays will be conducted in multiple batches, with each batch consisting of up to approximately 15 samples plus controls. Samples will be assigned to batches using a stratified random approach. The strata will be based on river reaches to ensure that each batch will contain samples from across all geographic areas of the river (including external reference locations), to the maximum extent possible. Within strata, samples will be randomly selected for each batch. Upon identifying and assigning bioassay samples in respective batches, the stratified random bioassay batching scheme will be reviewed and approved by EPA prior to bioassay testing.

Bioassay results will be used to evaluate if the survival, growth, or reproduction of benthos in Site sediments differ significantly from those in reference sediments. One approach that will be used to conduct this analysis is application of the "reference envelope" approach which examines whether responses from Site samples lie below the range of results from reference samples (Hunt et al. 2001). If significant differences are identified, these data will also aid to evaluate and address a) the magnitude of these effects; and b) a concentration-response relationship between COPCs and observed effects. These results will also be used to evaluate the relative value of respective bioassays for other potential sampling efforts.

Should equivocal or unexplained responses be identified in the bioassays, further evaluation (i.e., TIE) will be completed if required to discern the class of chemicals resulting in the observed effects, or if these responses are a consequence of non-chemical properties. TIEs would be conducted according to EPA guidance and studies reported in the scientific literature (e.g., Ho et al. 2007; Hockett and Mount 1996); see Section B4.2.2 of this QAPP for further details. Associated with TIE testing and if required by EPA, invertebrate tissue chemistry from *H. azteca* collected after TIE testing will be considered as a secondary line of evidence.

In addition to the aforementioned bioassays, no fewer than 35 sediment samples will be selected for backscatter electron microscopy. Preliminary results (e.g., chemistry data, field observations etc.) will be used to refine and identify which samples will undergo this evaluation. Samples to be tested, the detailed approach, and associated QA/QC requirements will be documented in a technical memorandum for EPA's review and agreement.

A7.4 Step 4—Define the Boundaries of the Study

This step specifies the population of interest for the study, the geographical boundaries of the Site, and any temporal considerations that may be required.

A7.4.1 Target Populations for Risk Evaluation

Target populations of primary interest are benthos that live in or on UCR sediment; and other ecological receptors (e.g., sediment-probing birds) as identified within the conceptual site model, refer to Figure A6-1. *H. azteca* and *C. dilutus* consistently have demonstrated to be sensitive indicator organisms for sediment contamination, particularly for metals (Milani et al. 2003); therefore, they are protective of target populations of interest. Consistent with Guidance (USEPA 1997), should EPA determine that there is insufficient information to support an informed risk-based management decision using existing site data (includes data from this study), additional sediment/toxicity data may be needed. Such studies may include the use of other test organisms (e.g., freshwater mussels) should information within the scientific community indicate they are better suited to evaluate sediment contamination, and if standard test methods approved by American Society for Testing and Materials (ASTM) or EPA are available.

A7.4.2 Geographic Boundaries of the Site

The Site, as stated in Section A4.1 of this document, encompasses the UCR from the U.S.-Canada border (RM 745) to the Grand Coulee Dam (approximately RM 596).

Sediments will be collected and analyzed (chemically and toxicologically) from representative locations throughout the UCR. Reference sediments will be collected from locations upstream (north) of the Site and those identified by EPA (April 27, 2012 correspondence), see Maps A7-7 through A7-9.

A7.4.3 Temporal Considerations

Samples will be collected in the fall of 2013 from representative areas throughout the UCR and will be used to refine exposure gradients, identify areas of potential unacceptable risk to benthos, and evaluate relative responsiveness of bioassay endpoints. Preliminary data will be used to guide, inform, and select samples which will be analyzed for reproductive endpoints, backscatter electron microcopy, and TIE investigations (if necessary). Consistent with EPA Guidance (USEPA 1997), should EPA determine that there is insufficient information to support an informed risk-based management decision using the above-mentioned data in association with other existing site data (e.g., Phase 1 sediment/toxicity data; [USEPA 2006c]); additional sediment/toxicity data may be needed. Furthermore and per the terms and conditions of the Agreement, should TAI identify the need for additional data; this would be documented in a technical memorandum.

A7.5 Step 5—Define the Statistics and Types of Inferences

Step 5 of the DQO process provides data analysis approaches that will be used to evaluate the data and draw conclusions on risks to benthic receptors and other ecological receptors. It is necessary to have a general understanding of the types of data analyses that will be conducted to ensure that the required parameters are measured, and that a sufficiently large data set is developed to provide the desired level of confidence in the statistics. This approach will ensure the generation of a data set that will be adequate for use in conducting the baseline ecological risk assessment.

This section briefly describes how bioavailability parameters will be incorporated into the analysis to determine toxicity of sediments. Statistical methods for determining which bioassays are toxic are described as well as how concentration-response relationships between bioavailable concentrations of COPCs in sediment or porewater and toxic effects on benthos will be derived.

A7.5.1 Estimation of Bioavailability

Consistent with EPA's suggestion[10], the lines of evidence and the refinement of sediment bed properties (refer to Appendix B) may be updated and refined using sediment and

[10] Refer to specific comment number four from EPA's June 21, 2012 correspondence to TAI.

porewater data collected from this and other site-specific data (i.e., beach sediment and white sturgeon sediment toxicity data). Such analyses may aid in evaluating the nature and extent of unacceptable risk within the Site[11]. Because environmental factors can alter the bioavailability of contaminants these bioavailability effects can confound relationships between organism response and the total (bulk) concentration in sediments. Therefore, it is likely that a stronger relationship (e.g., correlation) between sediment characteristics and bioassay responses will be evident once data are adjusted to account for site-specific bioavailability. Preparation of samples for laboratory bioassays necessarily results in changes to sediment characteristics that affect bioavailability, such as amount of AVS present (dependent upon degree of oxidation of the sediments), the chemistry of sediment porewaters, and particle size. Therefore, the analyses described in Section A7-3 will be performed not only with synoptic chemistry and bioassay data, but also with chemistry-only samples (sediment and porewater measurements).

Observations and data identifying sediments where metals are most likely to pose unacceptable risks to benthos, will be supported by an analysis of the relationship of positive bioassay responses with concentrations of AVS, SEM, TOC, and other important constituents that affect bioavailability (i.e., other binding ligands and competing cations). If positive responses are seen when they are predicted to not occur (e.g., in sediment samples with high AVS and/or organic carbon), this will provide a line of evidence that metals are not causing the positive response seen in the bioassay. Other lines of evidence, such as the TIE or concentrations of organic chemicals, will then need to be examined to see if they are better at explaining the observed responses. When used in conjunction with bioassay data, excess SEM and carbon normalized excess SEM is expected to improve the statistical quality of the data, and lead to a more thorough understanding of the causes of observed toxicity.

Because excess SEM tends to be a conservative approach (it can identify sediments that are not toxic, but is not very good at identifying those with moderate toxicity; refer to USEPA [2007]), a second line of evidence using porewater chemistry will be employed. One such approach entails the application of interstitial water toxic units (USEPA 2007) for the SEM metals, another relatively conservative assessment method. In addition, we will consider the results of an application of the BLM to porewater collected in both the laboratory (bioassays) and the field to determine site-specific toxicity thresholds.

[11] The sampling design is not intended to provide an assessment of spatial distribution of contaminants in the Site.

A7.5.2 Analysis of Bioassay Data

EPA guidance will be followed concerning statistical analysis of sediment toxicity data when analyzing results from the whole-sediment bioassays (USEPA 2000). As such, a variety of methods will be used to evaluate these data. Samples that exhibit adverse responses relative to reference samples will be further evaluated to determine if the responses are related to COPCs. Additional detail regarding the consideration and selection of reference sites is discussed in Section B1.1 of this document. A reference envelope approach (e.g., Hunt et al. 2001) will also be applied to the data, where reference site responses will be used to develop a response distribution and select a lower tolerance limit (e.g., generally the 5th percentile) to evaluate Site responses. Site samples with responses (e.g., survival or biomass) below the tolerance limit would be considered a "positive" response.

Samples exhibiting positive bioassay responses could be further analyzed through a TIE (USEPA 2007; Ho et al. 2007; Hockett and Mount 1996) to determine the likely causative factor(s) of the toxic response. Simply, the TIE methodology involves the physical and chemical manipulation of the sample to methodically alter the potency of different chemical classes. Biological responses are then used to gauge the relative change in toxicity caused by these manipulations. Three types of manipulations of bulk sediment samples could be implemented 1) cation exchange resin or sulfide addition to sequester and reduce the toxicity of metals; 2) coconut charcoal or Ambersorb® addition to sequester and reduce the toxicity of organic compounds; and/or 3) Zeolite addition to reduce ammonia toxicity.

If any of the aforementioned manipulations are demonstrated to result in a significant reduction in toxicity versus that of non-manipulated sediments, this would suggest that the targeted chemical class is the primary driver of the positive response. Subsequent phases of the TIE process could be implemented to pinpoint specific COPCs as causative factors of the sample toxicity, if deemed necessary.

A7.5.3 Concentration-Response Relationships

Exploratory data analysis will be conducted to determine which, if any, measured parameters are most correlated with observed toxicity responses. Data generated in this study will be sufficient to support a variety of statistical analyses, including but not limited to regression analyses (e.g., stepwise linear regression) or the more parsimonious method used in information theoretic approaches (e.g., Akaike's information criterion [AIC]). Principal component analyses also might provide information about which group of analytes are most likely associated with positive bioassay responses, although these analyses will not provide a quantitative relationship. Note that these analyses will

be conducted based on bulk sediment and laboratory porewater data. This type of data analysis will provide one line of evidence, but because it is based on correlative parameters it is not a very good predictor of causality. For example, if an analyte that is not causing toxicity changes its concentration in the same relative amount as a physical stressor (e.g., particle size), then it may appear that the analyte is the cause of the response when in reality it is not. Nevertheless, such correlative relationships may be helpful in site management once causality is more definitively established.

The adequacy of multiple metal ratio methods for describing sediment bed properties such as slag content will be evaluated by using field observations (e.g., presence/ absence and percent of visible black silica glass particles) in conjunction with sediment chemistry (e.g., aluminum, calcium, copper, iron, vanadium, and zinc). This analysis will facilitate the identification and selection of select samples for backscatter electron microscopy. Sample selection for this specialized work will be documented in a QAPP addendum for EPA's review and approval.

A7.6 Step 6—Specify Performance or Acceptance Criteria

The goal of Step 6 is to define performance or acceptance criteria to minimize the possibility of either making erroneous conclusions or failing to keep uncertainty in estimates to within acceptable levels (USEPA 2006d). For this study, performance and acceptance criteria will apply to generating appropriate and acceptable data for use during risk assessment activities, as well as providing sufficient data to reduce uncertainty and the probability for false positive or false negative decision errors[12].

A7.6.1 Sampling Completeness

As demonstrated by previous sampling experience at the site (e.g., USEPA 2006e), the percentage of successful collection of sediment cannot be determined *a priori* because of the unforeseen challenges at some areas, such as sample refusal due to bedrock and/or large cobbles, (i.e., sediments generally having particle diameters greater than 2 mm). Because a large number of backup stations are available to mitigate such potential challenges, the overall goal is to collect 100 percent of the targeted samples representing each of the sample bins. To move to an alternative location the field sampling team will consult with EPA or their designee as to the benefit of continuing to attempt to collect a

[12] Because of variability in collected data, statistical analysis can lead to varying decision outcomes. A false negative decision error (Type II), for example, is when examination of the data leads to a conclusion of no risk, when there is a true potential risk, while a false positive decision error (Type I) indicates a potential risk, when the true risk is negligible (USEPA 2006c).

sample at a site where minimal or no appropriately sized sediment is available. Final determination of the study success will be evaluated against the DQOs.

A7.6.2 Data Quality

Techniques for sediment and field porewater sample collection must provide samples of sufficient volume that are collected from appropriate depths. Inferences about these attributes will be based on field observations and a limited number of analytical measurements of critical parameters (e.g., see recommendations for reference area sediments). Precision will be determined by repeatability of chemical measures in duplicate samples (see below).

DQOs are developed using EPA's DQO process (USEPA 2006a) to describe data and data quality needs. Data quality indicators (DQIs) such as the precision, accuracy or bias, representativeness, completeness, and comparability (PARCC) parameters and analytical sensitivity will be used to assess conformance of data with QC criteria (USEPA 2002a).

Field QC samples will include trip blanks, equipment rinsate blanks, field duplicate samples, and certified reference materials. These QC samples will be collected or prepared by sampling personnel in the field and submitted to the laboratory as natural samples.

Equipment rinsate blanks will be used to identify possible contamination from the sampling environment or from sampling equipment. These blanks will be collected by pouring deionized or distilled water over (or through) decontaminated sampling equipment and into a sample jar. One equipment rinsate blank will be collected for each type of sampling equipment used during the sampling event (at an interval of one per day) and will be analyzed for the previously listed metals.

Field split samples will be collected to assess the homogeneity of sediment samples collected in the field and the precision of the sampling process. Field splits will be prepared by collecting two aliquots of sample from the homogenized sediment and submitting them for analysis as separate samples. Field splits will be prepared from at least 10 percent of the sampling locations.

An experimental blank will be used to identify possible contamination from the laboratory and will be collected according to laboratory protocols. Experimental blanks will be collected once per sampling event.

A matrix spike/matrix spike duplicate (MS/MSD) will be performed in the laboratory to assess the accuracy of the analyses. The MS/MSD will be performed according to the laboratory protocols and will occur at a frequency of once every 20 samples.

Method detection limits (MDLs) and method reporting limits (MRLs) for sediment and porewater samples are summarized in Table A7-3, and were selected to ensure consistency with EPA's sediment detection limit evaluation process (USEPA 2008).

Test organism survival should be high prior to the start of the bioassays (e.g., ≥80 percent for 48 hours before the start of a test [USEPA 2000; ASTM 2012]) and survival should remain high (e.g., mean survival of 80 percent for *H. azteca* and 70 percent for *C. dilutus*) in test controls throughout the test duration. Additionally, minimum growth or size requirements may be set for control organisms to ensure that the test population is developing within an acceptable range.

Also, hardness, alkalinity, and ammonia measurements should vary by less than 50 percent over the duration of the exposure, and overlying water-dissolved oxygen concentrations should be maintained at greater than 2.5 mg/L (USEPA 2000).

A7.7 Step 7—Develop the Plan for Collecting Data

Detailed discussions of the various study components are presented in Section B1 of this QAPP. Because field sampling methods associated with this study involves sediment collection or penetration and disturbance, TAI and its technical team will work with potentially affected parties to assess the effects of the planned work and seek ways to avoid, minimize, or mitigate any adverse effects on historic properties. A cultural resources coordination plan (Appendix C) has been prepared to provide relevant background information about Site-related cultural resources, define measures for protecting resources, and define procedures for consulting with the appropriate state, federal, and tribal parties with interests in the cultural resources of the UCR.

A8 SPECIAL TRAINING/CERTIFICATES

TAI has assembled a technical team with the requisite experience and technical skills to successfully complete the study. Minimum training and certification requirements for laboratory personnel are provided in the laboratory QA plans (Appendices D and E).

The bioassay laboratory must demonstrate experience with the conduct of all four of the bioassays to be used in this study, as well as the TIE procedure. Accreditation from the National Environmental Laboratory Accreditation Conference (NELAC) is desirable, but not a requirement.

Sampling personnel will be familiar with the Site cultural resources coordination plan (Appendix C). Sampling personnel will report any materials that might be considered a cultural resource to cultural resource observers participating in the field sampling program.

A9 DOCUMENTATION AND RECORDS

This section identifies on-site and laboratory records to be maintained for this project, information to be included in project reports, data reporting format for data report packages, and document control procedures to be used. Critical records required for this study are identified below with descriptive or supporting information as appropriate. Records will include documents and electronic deliverables related to field sampling (field notebook, sample logs, COC, etc.), toxicity testing, and chemistry laboratory documentation (laboratory records, data packages, project reports, electronic deliverables, etc.), data validation, and data reports. Data reports will be made available through integration into the project web tool. Briefly, this will be an electronic data management system that is accessible via an external web site. The QAPP, FSP (Appendix A), Site Health and Safety Plan (SHSP) (TCAI 2007), and the general SHSP addendum (Attachment A1 to Appendix A) will be provided to each person listed in Section A3. Any revisions or amendments to any of the documents that comprise the FSP will also be provided to these individuals.

A9.1 Field Documentation

The TAI technical team field supervisor will ensure that the field team receives the final approved version of the QAPP prior to the initiation of field activities. Minimum field records that will be maintained include the following:

- Field logbooks
- Photo documentation
- Field data forms
- Sample tracking/COC forms.

Additional content, information, and use of the above-listed documents are further described in the FSP (Appendix A).

A9.2 Chemistry Laboratory

Full laboratory data reports will be provided in electronic format to the task QA coordinator, who will oversee data verification and validation, as well as archiving the final data and data quality reports in the project file. EDDs will be prepared in spreadsheet format and will be compatible with the TAI technical team's database.

Documentation requirements for the analytical laboratory (CAS) are detailed in the QA manual (Appendix D) and will, at a minimum, include the following:

- A cover letter discussing analytical procedures and any difficulties that were encountered
- Sample receipt and analysis dates
- Final analyte concentration including reporting limit, laboratory qualifiers, and reanalysis
- Percent recovery of each compound in the matrix spike sample
- Matrix spike recovery control limits
- Relative percent difference (RPD) for all MS/MSD and/or laboratory control sample (LCS)/LCS duplicate (LCSD) results
- RPD control limits for MS/MSD and/or LCS/LCSD reports
- LCS results when analyzed
- Recovery control limits for LCS or standard reference material recoveries and relative standard deviation
- Blank results for method blanks, experimental blanks, and equipment blanks
- Method blank summary indicating associated samples
- Case narrative.

A9.3 Bioassay Laboratory

The bioassay laboratory will provide a data package for each sample delivery group or analysis batch that will contain all information required for a complete QA review, including the following:

- A cover letter discussing bioassay procedures and any difficulties encountered
- A case narrative referencing or describing procedures used and any analytical problems and deviations from SOPs and this QAPP
- COC and cooler receipt forms

- A summary of the bioassay results
- Results for all QA/QC checks, including serial dilutions, LCS and reference toxicant tests, and any other QC procedures required by applicable method protocols and laboratory SOPs
- The laboratory toxicity report will document the source of control sediment and associated measurements
- The laboratory toxicity report will document how organisms of known age were obtained for testing
- The weight of a representative subsample of organisms at the start of sediment exposures will be documented
- The laboratory toxicity report will document the measured light intensity during testing
- Original data reports and laboratory worksheets as applicable.

A9.4 Data Quality Documentation

Data verification (i.e., confirming the accuracy and completeness of field and laboratory data) will be performed by the TAI technical team for data generated in the field, and by each laboratory for the analytical data that it generates. Data validation and data quality assessment for this task will be completed and provided to the task QA coordinator.

Accuracy of the laboratory EDDs will be verified by, or under the direction of, the database administrator. All changes to data stored in the database will be recorded in the database change log. Any data tables prepared from the database for data users will include all qualifiers that were applied by the laboratories and during data validation.

Data validation reports will be prepared and provided to the laboratory QA manager. Any limitation to the usability of the data will be discussed in this report. Completed data validation checklists will also be provided to the task QA coordinator by the data validator.

SECTION B: DATA GENERATION AND ACQUISITION

B1 SAMPLING PROCESS DESIGN AND RATIONALE

This section presents the detailed design and rationale for the sediment study that will result in a data set that supports assessing risk to benthos and other ecological receptors (e.g., sediment-probing birds). The sampling approach was developed based on information from previous investigations and information on sediment COPCs and their potential toxicity[13].

B1.1 Sampling Locations and Rationale

Determination or estimation of unacceptable risks to benthos requires representative data on bioavailability of COPCs in sediments as collected over a range of exposure gradients. A summary of the sampling locations, associated rationale, and site reconnaissance is provided in Appendix F.

In addition, to account for uncertainties such as culturally sensitive areas, and/or sediments that cannot be tested due to large grain sizes (e.g., gravels and cobbles) alternative sampling locations have been identified. Refer to Maps A7-1 through A7-6 and Table B1-1 for a summary of proposed and reserve sampling locations and their associated coordinates.

Evaluating sediment toxicity through the use of bioassays requires collection and use of reference sediment samples. EPA (USEPA 1994) has identified a number of desirable characteristics for bioassay reference locations for use in a RI/FS, and for bioassessments of non-wadeable streams (USEPA 2006a). They include the following:

- Upgradient in the same watershed as the study site
- Comparable physical setting as the study site
- Similar water depth and flow as the study site

[13] As documented on July 3, 2012, on the basis that sampling can proceed (refer to Section A7.1.2 herein), TAI while reserving its right to raise technical concerns associated with EPA's alternate locations (refer to June 11, 2012 correspondence), will undertake sediment sampling activities and analyses at EPA's alternate locations (refer to April 27, 2012 letter to TAI). TAI, also under protest, has incorporated the site reconnaissance recommendations outlined by EPA's contractor (CH2M Hill, Inc.; June 27, 2012 technical memorandum). As a result, although the methods presented herein (including Appendices) may not have not fully been considered for EPA's program, they remain appropriate for this document. In addition and as requested by EPA, materials presented within Appendix B, may be updated following data collection and the analyses outlined herein.

- Similar sediment grain size distribution, sediment TOC content, and water quality as the study site
- Relatively uncontaminated or minimally impaired.

Considering these approaches, the following desirable characteristics and/or performance standards will be considered as part of identifying internal references as well:

- Similar sediment grain size distribution
- Uncontaminated (e.g., $mPECQ_{metals}$ <0.2; [USEPA 2010])
- Survival and growth will meet the test acceptability criteria for control sediment (USEPA 2000; ASTM 2012).

Given the above-listed desirable characteristics, a preferred reference area is located upstream from the Site (in the same watershed), is relatively uncontaminated, and has similar grain size distribution and TOC content. Therefore, this study will target the acquisition of about 16 external reference locations, of which a minimum of 10 will be located in Canada (i.e., Columbia River at Genelle and Lower Arrow Lake). In addition, and per EPA's letter listing alternate locations[14], reference areas sampled in 2005 will be resampled for this study.

B1.2 Bioavailability Measurements

It is important to recognize that the bioavailability of sediment or porewater COPCs is not necessarily a constant fraction of total COPC concentrations but is dependent on the nature of the sediment matrix and concentrations of other constituents (e.g., calcium, magnesium, potassium, sodium, and chloride) affecting chemical speciation and/or biological responses. Sediment conditions or chemical properties that have been integrated into the design to assess COPC bioavailability include the following:

- **AVS and SEM.** EPA (USEPA 2007) recognizes the utility of AVS and SEM for assessing the absence of toxicity of sediments contaminated with selected metals (i.e., silver, cadmium, chromium, copper, lead, nickel, mercury, and zinc) as part of the equilibrium sediment partitioning benchmark (ESB) approach (USEPA 2005). These chemical characteristics are used to define excess SEM (SEM_X; the difference SEM – AVS) and have utility for identifying locations

[14] As documented on July 3, 2012, on the basis that sampling can proceed (refer to Section A7.1.2 herein), TAI while reserving its right to raise technical concerns associated with EPA's alternate locations (refer to June 11, 2012 correspondence), will undertake sediment sampling activities and analyses at EPA's alternate locations (refer to April 27, 2012 letter to TAI) which includes the tributary reference locations.

where toxicity to benthos due to SEM metals is not expected. Specifically, when AVS ≥ 0.1 μmol/g, benthos should be adequately protected if SEM does not exceed AVS by more than 1.7 μmol/g_d (i.e., SEM_X = SEM – AVS ≤ 1.7). While this approach is predictive of sediments that are not toxic, it can only identify relative risk for sediments when SEM_X > 0, at which point additional information (e.g., further characterization) is generally, recommended (Ankley et al. 1996; USEPA 2005). This is due to the fact that some sediment with SEM_X > 0 may not result in toxicity, because factors other than AVS are modifying the bioavailability of sediment metals (e.g., association of metals with other binding phases such as sediment organic matter or metal oxides). On the basis of SEM_X, it has been shown that sediments with SEM_X < 1.7 μmol/g_d pose low risk of adverse biological effects, whereas sediments with SEM_X >120 μmol/g_d may be expected to cause adverse biological effects. For SEM_X between 1.7 and 120 μmol/g_d, the potential for toxicity is uncertain. Because of this uncertainty, if the threshold for no effects is exceeded, then EPA recommends that additional information be considered (USEPA 2005).

SEM_X is useful because metal sulfides are among the most insoluble and tightly bound forms of metals in sediments, and consideration of AVS in the determination of SEM_X accounts for that portion of the sediment metals that are expected to be bound to sulfide minerals. Other important binding phases in sediments containing SEM_X may be associated with organic matter.

- **TOC.** Some metals (e.g., copper) and many organic chemicals bind strongly to organic materials in the sediment, thereby altering their potential toxicity. Measurement of TOC can be used to carbon normalize excess SEM ($SEM_{X,OC} = SEM_X / f_{OC}$; where f_{OC} is the fraction of sediment organic carbon ≡ TOC (Ankley et al. 1996; USEPA 2005). A refined predictor of toxicity can be achieved when the organic carbon content of the sediment is also considered in the determination of $SEM_{X,OC}$.

  Sediment with low carbon-normalized SEM_X < 130 μmol/g_{OC} should pose a low risk of adverse biological effects due to SEM metals. For sediments with high carbon-normalized SEM_X > 3,000 μmol/g_{OC}, adverse biological effects due to SEMs may be expected. For sediments with carbon-normalized SEM_X > 130 μmol/g_{OC}, there is uncertainty about whether effects are expected and additional study (e.g., toxicity tests) is recommended (USEPA 2005).

- **Other ions.** Cationic metals compete with calcium for binding sites, and also will readily bind with the oxides of magnesium and iron, thus altering their

bioavailability. Measurements of the concentrations of these ions in bulk samples will also be helpful in interpreting the potential for toxicity of these metals.

The application of AVS, SEM, and f_{OC} are practical steps in evaluating metal bioavailability based on bulk sediment characteristics that are relatively easy and routine to obtain. Additional information regarding relative COPC bioavailability will be gained by concomitant porewater characterization.

B1.2.1 Field Porewater Measurements

Field porewater will be collected for analysis at the same time and location where sediments are collected. Field porewater data will help reduce uncertainty about potential risks associated with sediments and will be another line of evidence. Primary field porewater measurements to be conducted include the following:

- **Dissolved COPCs**. The dissolved concentration represents that fraction which passes through a 0.45 μm filter. For metals, the dissolved concentration provides a relevant measure of exposure because 1) national ambient water quality criteria (NAWQC) for metals are based on the dissolved concentration; 2) interstitial water toxicity unit (IWTU) methods are calculated by normalization of porewater concentrations by the NAWQC (USEPA 2005); and 3) dissolved concentrations may be interpreted in the context of the BLM as a way to account for the effects of water quality on metal bioavailability.
- **General chemical properties.** Standard measures necessary to help interpret COPC bioavailability include DOC, pH, and major cations/anions.

A BLM calculation based on sediment porewater composition (pwBLM) can explicitly account for the effects of DOC, pH, and cation concentrations on the bioavailability of porewater metals. The mechanistic basis of the pwBLM allows for an explicit consideration of mixtures based upon metals accumulated at biotic ligands as the basis for predicting biological effects.

B1.3 Whole-sediment Bioassays

An additional measure of COPC bioavailability will include sediment bioassays synoptically performed on 53 percent of the samples (48 site samples and 26 internal, tributary, or upstream reference samples). These tests will provide direct measures that refine and reduce uncertainties regarding COPC toxicity and bioavailability. In addition, these tests will ascertain if Site sediments adversely affect the survival, growth, or reproduction of benthos. If significant differences are identified, these data will also

help to address 1) the magnitude of these effects; and 2) a concentration-response relationship between COPCs and observed effects. The collection of toxicity data will be coordinated with the collection of laboratory porewater chemistry data from test chambers to support test interpretation.

B1.3.1 Biological Endpoints (Measurements)

Seventy-four sediment samples will be used to conduct acute and chronic bioassays with *H. azteca* and *C. dilutus*. Four standard sediment toxicity tests will be conducted. Specifically, the following two bioassays will be performed on all 74 samples:

- 28-day whole-sediment toxicity tests with the amphipod, *H. azteca*
- 10-day whole-sediment toxicity tests with the midge, *C. dilutus.*

As noted within Section A7.3.2, to meet Study DQOs and minimize the potential for confounding inter-batch variability with other variables (e.g., due to a chemical gradient), short-term bioassay testing will be initiated only after completing all field sampling. Short-term bioassays will be conducted in multiple batches, with each batch consisting of up to approximately 15 samples plus controls. Samples will be assigned to batches using a stratified random approach. The strata will be based on river reaches to ensure that each batch will contain samples from across all geographic areas of the river (including external reference locations), to the maximum extent possible. Within strata, samples will be randomly selected for each batch. Upon identifying and assigning bioassay samples in respective batches, the stratified random bioassay batching scheme will be reviewed and approved by EPA prior to bioassay testing.

In addition, reproductive endpoints will be evaluated on 18 split-samples. Preference for these 18 split-samples will be given to sampling stations located within high-medium exposure gradients. Sample selection will be evaluated using results of the above-listed 10- and 28-day survival and growth tests in conjunction with preliminary chemistry data; and presented in a technical memorandum for EPA's review and concurrence. It is anticipated that sample selection will target sediment with 1) low to moderate toxicity response in short-term studies; 2) high metal concentrations in porewater or bulk sediment; and/or 3) a range of sediment and porewater characteristics. Specific bioassays to be performed on these 18 split-samples include the following:

- 42-day whole-sediment toxicity tests with the amphipod, *H. azteca*.
- 50- to 65-day whole-sediment toxicity tests with the midge, *C. dilutus.*

Standard responses (endpoints) of test organisms to be measured are summarized in Table B1-2 and include the following:

- Survival (number of surviving organisms divided by the initial number of organisms).
- Weight
  - *H. azteca*–dry weight [DW] of surviving organisms divided by the number of surviving organisms
  - *C. dilutus*–ash-free dry weight [AFDW] of surviving organisms divided by the number of surviving organisms.
- Biomass
  - *H. azteca*–DW of surviving organisms divided by the initial number of organisms
  - *C. dilutus*–AFDW of surviving organisms divided by the initial number of organisms
- Reproduction (measures of reproduction vary by bioassay and may include number of young divided by the number of females surviving bioassay; number of eggs oviposited divided by the number of females surviving; number of eggs produced divided by the number of females surviving, etc.).
- Emergence (applicable only to the long-term *C. dilutus* bioassay tests, measures of emergence include number of organisms that reach the terrestrial adult [imago] stage divided by the initial number of organisms; and the time until emergence).

Standard bioassay test conditions for the above-referenced four tests are in Tables B1-3 through B1-6 (USEPA 2000). Required performance criteria are in Tables B1-7 through B1-10 (USEPA 2000). Standard bioassay endpoints will be reported in accordance with applicable guidance (USEPA 2000; ASTM 2012) including those endpoints specific to long-term *C. dilutus* bioassays noted on Table 15.4 of USEPA (2000).

Sediments with a low $mPECQ_{metals}$ (e.g., <0.2), may be re-assigned *a posteriori* as "internal" reference sites, in consultation with EPA. Designated internal and external references sites will be integrated into a reference envelope approach that will define a range, or lower tolerance limit, of acceptable reference conditions against which toxic sediment can be compared (Hunt et al. 2001).

B1.3.2 Physico-chemical Data in Overlying Water

A variety of physico-chemical properties will be measured in the test chamber water column (overlying water) to document water quality during bioassay tests as specified by USEPA (2000); see Tables B1-3 to B1-6.

The following water quality properties will be documented in each of the test chambers:

- Hardness (mg/L as calcium carbonate)
- Alkalinity (mg/L as calcium carbonate)
- Conductivity (µS/cm)
- pH (standard units)
- Ammonia (mg/L)
- Temperature (°C)
- Dissolved oxygen (mg/L).

B1.3.3 Laboratory Porewater Measurements

Laboratory porewater will be collected at the beginning and end of the bioassay tests for the short-term tests and at the beginning, midpoint, and end of the tests for the long-term tests. Laboratory porewater data will be used in concert with the biological endpoint data to evaluate concentration-response relationships. Primary laboratory porewater measurements (volume permitting) will include the following:

- **Dissolved COPCs**. For metals, the dissolved concentration provides a relevant measure of exposure because 1) NAWQC for metals are based on the dissolved concentration; 2) IWTU methods are calculated by normalization of porewater concentrations by the NAWQC (USEPA 2005); and 3) dissolved concentrations may be interpreted in the context of the BLM as a way to account for the effects of water quality on metal bioavailability.
- **General chemical properties.** Standard measures necessary to help interpret COPC bioavailability include DOC, pH, and major cations/anions.

A pwBLM can explicitly account for the effects of DOC, pH, and cation concentrations on the bioavailability of porewater metals. The mechanistic basis of the pwBLM allows for an explicit consideration of mixtures based upon metals accumulated at biotic ligands as the basis for predicting biological effects.

B1.4 Toxicity Identification Evaluation

Should equivocal or unexplained differences be identified during the whole-sediment bioassays, further evaluation using TIE could be completed on select samples to address if the effects are due to classes of COPCs. Samples selected for TIEs would be identified in a technical memorandum; see Section B4.2.2 for decision rules regarding sample selection. TIEs would be performed in accordance with EPA guidance and studies reported in the scientific literature (e.g., Ho et al. 2007; Hockett and Mount 1996).

B2 SAMPLING METHODS

Field sampling methods for collection of bulk chemistry and porewater samples are described in the FSP (Appendix A). The FSP includes the following topics:

- Station positioning (Section 2.2.2)
- Field equipment and supplies (Section 2.2.3)
- Sampling methods (Section 2.2.3.1)
- Sample containers and labels (sample labels, sample identifier custody seals, sample custody/tracking procedures) (Section 2.5)
- Field documentation and procedures (field logbooks, photo documentation, COC forms) (Section 3).

SOPs for each sampling method are provided in Attachment 2 of the FSP.

The FSP also describes the collection of field split samples that will be provided to EPA for analysis as part of their QA/QC program. These will contain not less than 200 grams of sediment and will comprise approximately 15 percent of the samples collected for chemical analysis. In addition, up to seven split samples from bioassay stations located upstream from the confluence of Onion Creek (RM 730) will also be evaluated as part of EPA's QA/QC program. Pending approval and agreement from the Canadian Government, EPA would also collect up to three split-samples for bioassay testing in upstream reference locations. Field QC samples are described in Section 2.2.3.4 of the FSP.

In the event that unanticipated or changed circumstances occur in the field, the field supervisor will institute the necessary corrective actions, complete a corrective action record, and ensure that the appropriate procedures are followed. If corrective actions require a departure from the FSP, these changes will be documented on a field change request form (refer to Appendix A for examples of these and other forms) and submitted to EPA. In any other circumstances where sampling conditions are unexpected, the appropriate sampling actions consistent with this task's objectives will be conducted. This change will be noted by the field supervisor in the field log, and a change request form will be completed for the project files and submitted to EPA. Any problems that cannot be easily resolved or that affect the final quality of the work product will be brought to the attention of the TAI technical team coordinator, TAI project coordinator, and EPA. EPA will be notified of any problems that may affect the final outcome of this task. Additional information regarding corrective actions and related documentation is provided in Section C1.

B3 SAMPLE HANDLING AND CUSTODY

Principal documents used to identify samples and to document possession will be field logbooks and COC records. Custody will be documented for all samples at all stages of the analytical or transfer process. COC procedures for sample handling prior to delivery to the laboratories are outlined in the FSP (Appendix A).

Upon receipt of samples, the laboratory will check the physical integrity of the containers and custody seals, and samples will be inventoried by comparing sample labels to those on the COC forms. The laboratory will include the COC and shipping container receipt forms in the data package. Any breaks in the COC or non-conformances will be noted and reported in writing to the laboratory coordinator within 24 hours of receipt of the samples. Specific laboratory QA plans are provided in Appendix D (analytical laboratory) and Appendix E (bioassay laboratory). Laboratory project managers will ensure that a sample-tracking record is maintained that follows each sample through all stages of sample processing at the laboratory.

Sediment samples will be stored in accordance with specifications detailed in Table B3-1; storage specifications for porewater samples are in Table B3-2. Laboratories will maintain COC documentation and documentation of proper storage conditions for the entire time that the samples are in their possession. The laboratory will not dispose of the samples for this task until authorized to do so by the task QA coordinator.

B4 SAMPLE PROCESSING AND ANALYTICAL METHODS

Samples collected for this study will be analyzed for chemical parameters shown in Table A7-2 as summarized below.

B4.1 Chemical Analyses

COPC concentrations in whole-surface sediments will be measured and samples will be characterized for grain size, organic carbon content, AVS, SEM, TAL metals, and other parameters as appropriate (e.g., pH). Field porewater will be collected using airstones (refer to Section A7.3.1 and Appendix A for method) and preserved for the following analyses (volume permitting): dissolved TAL metals, pH, DOC, hardness, alkalinity, and major cations/ions (calcium, magnesium, sodium, chloride, potassium, and sulfate). Table B3-2 includes order of priority for these analyses. AVS and SEM will be measured in at least one chemistry-only replicate per sample during sediment toxicity tests (including repeat measurements during long-term reproduction toxicity tests). Bulk sediment chemistry, porewater metals (from peepers), and BLM parameters (from

centrifuged sediment) will be analyzed anew prior to longer-term reproduction toxicity tests.

B4.2 Bioassays

Bioassay methodologies and protocols to be employed will be similar for the test species (*H. azteca* and *C. dilutus*) following the standard protocols outlined below. Details are described in EPA (USEPA 2000) and ASTM (2012).

Bioassay endpoints will be evaluated using a minimum of 8 replicates for biological endpoints per sediment sample for each short-term bioassay (Figure B4-1), and a minimum of 12 (42-day *H. azteca*) or 16 (long-term *C. dilutus*) replicates for biological endpoints for each long-term bioassay (Figure B4-2). Additional replicate bioassay chambers will be run on each sediment sample exclusively to assess porewater. Chemistry replicates will not be used to evaluate biological endpoints (i.e., survival, growth, or reproduction). Thus, the 28-day *H. azteca* bioassays will have a total of 14 replicates (8 for biological endpoints and 3 each for porewater chemistry analysis at day 7 and during the week prior to day 28). The 10-day *C. dilutus* assays will have 11 replicates for the 10-day test (8 for biological endpoints and 3 for porewater chemistry analysis at day 7). The 42-d *H. azteca* bioassay will have a total of 18 replicates (12 for biological endpoints and 3 each for porewater chemistry analysis at day 7 and sometime between days 21 and 27). The long-term *C. dilutus* bioassays will have a total of 25 replicates (16 for biological endpoints and 3 each for chemistry analysis at day 7, sometime between days 21 and 27, and again between days 42 and 49). The 16 biological replicates specified for the long-term *C. dilutus* bioassay includes four test chambers that will be run solely to produce auxiliary males for possible use in the bioassay test. These chambers are not true test replicates and will not be assessed for biological endpoints. Schematics illustrating the above-mentioned anticipated number of bioassay and chemistry-only replicates are presented in Figures B4-1 and B4-2, and the total number of replicate chambers is shown in tabulated form in Table B4-1.

Prior to bioassay testing, sediment samples will be homogenized, and 100 mL of the sediment will be distributed into each replicate and covered with laboratory water. Test chambers will be allowed to stabilize for one day prior to the introduction of test organisms. From the laboratory culture population, 10 test organisms (except for long-term *C. dilutus* tests which have 12 test organisms) will be randomly distributed to each replicate and allowed to burrow into the sediment.

Water quality will be measured in the overlying water of representative replicate chambers for each sample according to EPA guidance. Lighting, room temperature, and

other environmental operations of the exposure system will be monitored daily. As required in USEPA (2000) and ASTM (2012) (and listed in Tables B1-3 to B1-10), conductivity, hardness, pH, alkalinity, and ammonia will be measured in the overlying water of test chambers at the initiation and termination of the bioassays. Conductivity will also be measured weekly, and DO and ammonia on a daily basis. Dissolved oxygen will be maintained above 2.5 mg/L; water temperature will be measured daily in at least one test replicate per treatment to ensure that the daily average temperature is within ±1°C of 23°C.

At test termination, survival, weight, biomass, and any other required endpoints will be assessed and recorded. Endpoints for each bioassay are listed in Table B1-2.

B4.2.1 Laboratory Porewater Analysis

The additional chambers set-up for chemistry analysis of each sediment sample will contain test organisms, but will only be used for porewater chemistry measurements. Porewater will be sampled from each sediment sample selected for short-term toxicity tests at the start of exposures using centrifugation. These porewater samples will be analyzed for DOC, pH, alkalinity, sulfide, major cations, and major anions to inform the BLM for interpreting toxicity data. Porewater will also be collected using Brumbaugh type peepers; refer to SOP-9 of Appendix A. Porewater collected from the Brumbaugh type peeper will be analyzed for TAL metals except for mercury.

B4.2.2 Toxicity Identification and Evaluation (TIE)

Should equivocal or unexplained differences be identified during the whole-sediment bioassays or if the calculated concentration-response curve is not robust, further evaluation using TIE will be completed on selected samples to address if the effects are due to a class of COPCs. It is not possible to determine *a priori* which samples might need to undergo TIE testing. In addition to the equivocal samples, it will be desirable to analyze a few toxic and non-toxic samples where the toxicity results correlate well with contaminant concentrations to ensure the TIE tests are performing as expected. A technical memorandum will be prepared detailing which samples will be tested, why those samples were selected, and the TIE test procedures to be used. The following factors will be considered in determining whether to run TIE tests:

- The robustness of the correlation supporting a stressor-response gradient. If an extremely robust gradient of correlated exposure and response is observed, the TIE will not be conducted as it may not be that important to identify the specific cause of toxicity. However, if the gradient is weak or if correlations are less definitive, then a TIE would help reduce uncertainty and will be performed.

- If there are significant outliers from the general correlations between exposure variables and effects. There may be more than one exposure variable across the UCR that can induce sediment toxicity, and these may or may not correlate with one another. In addition, it is always possible that some sediment characteristic could cause effects in sediment toxicity tests, but that characteristics would not be readily captured by the sediment characteristics that are being measured.
- Strength of the toxicity response in the bioassays. Less toxicity will mean it is less likely a TIE will be successful in identifying the toxicant, so samples with marginal toxicity will not be analyzed.

The following Phase I methodologies could be implemented:

- **Zeolite addition to evaluate ammonia toxicity**. Based on available guidance (Ho et al. 2007; Hockett and Mount 1996), a 20 percent (v/v or wwt/wwt) Zeolite sediment addition is adequate to evaluate the ammonia-caused toxicity. The appropriate amount of Zeolite would be mixed thoroughly into the sediment and allowed to equilibrate for 1 to 4 days prior to organism addition and bioassay initiation, as detailed in Ho et al. (2007).
- **Cation exchange resin or sulfide addition to reduce soluble metals.** Available guidance literature suggest the use of a SIR-300 resin, which exhibits a high affinity for copper, cadmium, zinc, nickel, and lead; once prepared, a 20 percent addition of resin to sediment is recommended, followed by a minimum 24-hour equilibrium period. Alternatively, sulfide addition is accomplished by spiking sediments with a sodium sulfide (hydrate form) solution (Ho et al. 2007).
- **Coconut charcoal/carbonaceous resin addition to reduce toxicity of organic chemicals**. Available guidance literature recommends that the rate of charcoal addition depends on the physical properties of sediment (2 percent to 5 percent for fine and medium sediments); alternatively, a 20 percent addition of Ambersorb (wwt/wwt) resin can also be used (Ho et al. 2007).

B5 QUALITY CONTROL

Laboratory QC procedures are described below.

B5.1 Analytical Laboratory Quality Control

Extensive and detailed requirements for laboratory QC procedures are provided in the EPA methods that will be used for this study (Table A7-2). Every method protocol includes descriptions of QC procedures, and many incorporate additional QC

requirements by reference to separate QC sections. QC requirements include control limits and requirements for corrective action in many cases. QC procedures will be completed by the laboratories, as required in each protocol and their internal SOPs, and as indicated in this QAPP.

The frequency of analysis for LCSs, MS/MSD samples or laboratory duplicates, and method blanks will be one for every 20 samples or one per extraction or analysis batch, whichever is more frequent. Calibration procedures will be completed at the frequency specified in each method description. Equipment blanks will be subjected to the same processes as the sediment preparation.

As required for EPA SW-846 methods (USEPA 2008), performance-based control limits have been established by the laboratory. These and all other control limits specified in the method descriptions will be used by the laboratory to establish the acceptability of the data or the need for reanalysis of the samples. Laboratory control limits for recovery of internal standards (including certified reference material), matrix spikes, and LCSs, and for relative percent difference of laboratory duplicates, are provided in the analytical laboratory's QA manual (Appendix D).

B5.2 Data Quality Indicators

The overall quality objective for this task is to develop and implement procedures that will ensure the collection of representative data of known and acceptable quality. QA procedures and measurements that will be used for this task are based on EPA guidance. Data quality indicators such as the PARCC parameters and analytical sensitivity will be used to assess conformance of data with QC criteria (USEPA 2002b). Measurement quality objectives (MQOs) for the quantitative PARCC parameters are provided in Tables B5-1 and B5-2. Data quality indicators and QC objectives are described in this section.

Precision reflects the reproducibility between individual measurements of the same property. Precision will be evaluated using the results of laboratory duplicates and field splits. Precision is expressed in terms of the RPD for two measurements. The following equation is used to calculate the RPD between measurements:

$$RPD = \frac{|C_1 - C_2|}{(C_1 + C_2)/2} \times 100$$

Where: RPD = relative percent difference
C_1 = first measurement
C_2 = second measurement

For three or more measurements, the relative standard deviation (RSD) is used to evaluate precision. The RSD is calculated as the ratio of the standard deviation of three or more measurements to the average of the measurements, expressed as a percentage.

Accuracy and bias represent the degree to which a measured concentration conforms to a reference value. Results for matrix spikes, LCSs, field blanks, and method blanks will be reviewed to evaluate accuracy and bias of the data. The following calculation is used to determine percent recovery for a matrix spike sample:

$$\%R = \frac{M - U}{C} \times 100$$

Where: %R = percent recovery
M = measured concentration in spiked sample
U = measured concentration in unspiked sample
C = concentration of added spike

Percent recovery for a LCS or reference material is calculated as follows:

$$\%R = \frac{M}{C} \times 100$$

Where: %R = percent recovery
M = measured concentration in reference sample
C = established reference concentration

Results for field and method blanks can reflect systematic bias that results from contamination of samples during collection or analysis. Detection of any target analytes in field or method blanks will be evaluated as potential indicators of bias.

QC samples and procedures are specified in each method protocol (analytical methods are presented in Table A7-2). All QC requirements will be completed by the analytical laboratories as described in the protocols, including the following (as applicable to each analysis):

- Initial calibration
- Initial calibration verification
- Continuing calibration
- Calibration or instrument blanks
- Method blanks
- Laboratory control samples
- Internal standards (including certified reference material)

- Serial dilutions
- Matrix spikes
- Laboratory duplicates.

To alert data users of possible bias or imprecision, data qualifiers will be applied to reported analyte concentrations when associated QC samples or procedures do not meet laboratory internal control limits (Appendix D).

Analytical concentration goals (ACGs) provide the target concentration required for the chemical analysis. Methods selected for this study are expected to provide sufficient sensitivity to yield ACGs that are below the lowest reference value for this study (Table A7-3).

The laboratory will determine a MDL for each analyte, as required by EPA (USEPA 2004). MDLs are statistically derived and reflect the concentration at which an analyte can be detected in a clean matrix with 99 percent confidence that a false positive result has not been reported. The analytical laboratory will have established MRLs at levels above the MDLs for the task analytes. These values are based on the laboratory's experience analyzing environmental samples and reflect the typical sensitivity obtained by the analytical system; they represent the level of analyte above which concentrations are accurately quantified.

The laboratory will quantify analytes at concentrations above the MRL. Analytes detected at concentrations between the MDL and MRL will be flagged with a "J" qualifier to indicate that the value is an estimate (i.e., the analyte concentration is greater than or equal to the MDL and less than the MRL). Analytes that are not detected will be reported as the MDL and will be flagged with a "U" qualifier. MDLs will be adjusted by the laboratory as necessary to reflect sample dilution or matrix interference.

Representativeness is the degree to which data represent a characteristic of an environmental condition. In the field, representativeness will be addressed primarily in the sampling design by the selection of sampling sites and sample collection procedures. In the laboratory, representativeness will be ensured by the proper handling and storage of samples, the use of standard performance-based methods, and initiation of analyses within holding times.

Comparability is the qualitative similarity of one data set to another (i.e., the extent to which different data sets can be combined for use). Comparability will be addressed through the use of field and laboratory methods that are consistent with methods and procedures recommended by EPA.

Completeness is a measure of the amount of valid data obtained from the analytical measurement system and the complete implementation of defined field procedures. The target completeness objective will be 90 percent; the actual completeness may vary depending on the intrinsic nature of the samples. Completeness of the data will be assessed during QC reviews.

Completeness is defined as follows for all measurements:

$$\%C = \frac{V}{T} \times 100$$

Where: %C = percent completeness
V = number of measurements judged valid
T = total number of measurements

B6 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

Analytical instrument testing, inspection, maintenance, setup, and calibration will be conducted by the laboratories in accordance with requirements identified in laboratory SOPs and manufacturer instructions. In addition, each of the specified analytical methods provides protocols for proper instrument setup, tuning, and critical operating parameters. Instrument maintenance and repair will be documented in the laboratory's maintenance logs or record books.

B7 INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

Before beginning each analysis, laboratory instruments will be properly calibrated, and the calibration will be verified with appropriate check standards and calibration blanks for each parameter. Instrument calibration procedures and schedules will conform to analytical protocol requirements and descriptions provided in the laboratories' QA plans.

Calibration standards will be obtained from either the EPA repository or a commercial vendor, and the laboratories will maintain traceability back to the National Institute of Standards and Technology (NIST). Stock standards will be used to establish intermediate standards and calibration standards. Special attention will be given to expiration dating, proper labeling, proper refrigeration, and prevention of contamination. Documentation relating to the receipt, mixing, and use of standards will be recorded in a laboratory logbook. All calibration and spiking standards will be

checked against standards from another source, as specified in the methods and the laboratory QA manual.

B8 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

The quality of supplies and consumables used during sample collection and laboratory analysis can affect the quality of the data. All equipment that comes into contact with the samples and extracts must be sufficiently clean to prevent detectable contamination, and the analyte concentrations must be accurate in all standards used for calibration and quality control purposes.

The quality of laboratory water used will be documented at the laboratory. All containers will be visually inspected prior to use, and any suspect containers will be discarded.

Reagents of appropriate purity and suitably cleaned laboratory equipment will also be used for all stages of laboratory analyses. Details for acceptance requirements for supplies and consumables at the laboratories are provided in laboratory SOPs and QA plans. All supplies will be obtained from reputable suppliers with appropriate documentation or certification. Supplies will be inspected to confirm that they meet use requirements, and certification records will be retained by the field supervisor (i.e., for supplies used in the field) or the laboratory QA manager (i.e., for supplies used in the laboratory).

B9 DATA MANAGEMENT

Data for this study will be generated both in the field and at the analytical and bioassay laboratories. The final repository for sample information will be the relational database housed at http://teck-ucr.exponent.com. Procedures used to transfer data from the point of generation to the database are described in this section.

The data management plan (DMP) and its amendment establishes standard procedures for the management of all documents and environmental data (field and laboratory) generated during the RI/FS. The DMP describes data management procedures relating to the creation, acquisition, handling, storage, and distribution of task-related data. Data management systems and procedures described below are intended to establish and maintain an efficient organization of large volumes of complex environmental information for a diverse combination of data types. To accomplish this task, the following four management systems will be used to provide organized and efficient data management and retrieval:

- **Project database**. Stores environmental sampling and analysis data, information pertaining to geographic information system (GIS) files, and citations of documents related to collection, analysis, or interpretation of environmental data stored in the database. Both current and historical data are stored in the project database.
- **Geographic information system (GIS)**. Stores spatial data and enables the cartographic presentation of data trends and patterns.
- **Hard copy files**. Maintains a record and archive of documents from field studies and resulting reports.
- **Web site** (http://www.ucr-rifs.com). Makes available draft documents and other project information via the secure domain. Users with appropriate privileges are able to download documents.

Study activities will use spatial data sets and analyses for planning, data interpretation, decision support, and data presentation. Links between data in the project database and GIS files will be established via common identifiers for sampling locations and other geographic features.

B9.1 Field Data

Data that are generated during sediment collection and sample preparation will be manually entered into the field logbook, field data forms, and COC forms. Data from these sources will be entered into the project database directly from the field logbook and field data forms. These data include sample collection coordinates, station names, sampling dates, sample identifiers and numbers, and additional station and sample information. All entries will be reviewed for accuracy and completeness by a second individual, and any errors will be corrected before the data are approved for release to data users.

B9.2 Analytical Laboratory Data

A variety of manually entered and electronic instrument data will be generated at the laboratories. Data will be manually entered into the following:

- Standard logbooks
- Storage temperature logs
- Balance calibration logs
- Instrument logs

- Sample preparation and analysis worksheets
- Maintenance logs
- Individual laboratory notebooks.

All manual data entry into the laboratory information management system will be proofed at the analytical laboratories. Data collected from each laboratory instrument, either manually or electronically, will be reviewed and confirmed by analysts before reporting. A detailed description of procedures for laboratory data management and data review and verification is provided in the laboratory QA plans (Appendices D and E).

SECTION C: ASSESSMENT AND OVERSIGHT

This task will rely on the knowledge and expertise of the TAI technical team. The field team and laboratories will stay in close verbal contact with the co-principal investigator and the task QA coordinator during all phases of this task. This level of communication will serve to keep the management team apprised of activities and events, and will allow for informal but continuous task oversight.

C1 ASSESSMENTS AND RESPONSE ACTIONS

Assessment activities will include readiness reviews prior to sampling and prior to release of the final data to the data users, as well as internal review while work is in progress. An informal technical systems audit may be conducted if problems are encountered during any phase of this task.

Readiness reviews are typically conducted to ensure that all necessary preparations have been made for efficient and effective completion of each critical phase of work. The first readiness review will be conducted prior to field sampling. The field supervisor will verify that all field equipment is ready for transfer to the site. The field supervisor will also verify that the field team and subcontractor(s), as required, have been scheduled and briefed, and that the contract for the subcontractor has been signed by both parties. Any deficiencies noted during this readiness review will be corrected prior to initiation of sampling activities.

The second readiness review will be completed before final data are released for use. The database administrator will verify that all results have been received from the laboratories, data validation and data quality assessment have been completed for all of the data, and data qualifiers have been entered into the database and verified. Any deficiencies noted during this review will be corrected by the database administrator, the task QA coordinator, or their designee. Data will not be released for final use until all data have been verified and validated and approved by EPA. No report will be prepared in conjunction with the readiness reviews.

Technical review of intermediate and final work products generated for this task will be completed throughout the course of all sampling and laboratory activities, data validation, data management, and data interpretation to ensure that every phase of work is accurate and complete and follows the QA procedures outlined in this QAPP. Any problems that are encountered will be resolved between the reviewer and the person completing the work. Any problems that cannot be easily resolved or that affect the final quality of the work product will be brought to the attention of the TAI technical

team coordinator and TAI project coordinator. EPA will be notified of any problems that may affect the final outcome of this task, according to the Agreement.

The laboratories will be required to have implemented a review system that serves as a formal surveillance mechanism for all laboratory activities. Each phase of work will be reviewed by a supervisor before it is approved for release. Details are provided in the laboratory QA plans (Appendices D and E).

Technical system audits may be conducted if serious problems are encountered during sampling or analysis operations. Any task team member who discovers or suspects a non-conformance is responsible for reporting the non-conformance to the co-principal investigator, the task QA coordinator, or the laboratory project or QA manager, as applicable. The task QA coordinator will ensure that no additional work dependent on the non-conforming activity is performed until a confirmed non-conformance is corrected. Any confirmed non-conformance issues will be relayed to the TAI technical team coordinator. In addition, during corrective actions, communication between the field personnel and the laboratory relative to the accuracy and completeness of the COC documents will follow corrective-action procedures.

C2 REPORTS TO MANAGEMENT

The laboratories will keep the appropriate technical team laboratory coordinator(s) and QA manager(s) apprised of their progress on a regular basis. The laboratories will provide the following information:

- Inventory and status of samples held at the laboratory in spreadsheet format by sample delivery group
- Summaries of out-of-control laboratory QC data that resulted in a requirement for corrective action and a description of the corrective actions implemented
- Descriptions and justification for any significant changes in methodology or QA/QC procedures.

The technical team laboratory coordinator and QA manager will provide this information to the task QA coordinator who, in turn, will provide this information to the TAI technical team coordinator.

The laboratory will be required to have implemented routine systems of reporting non-conformance issues and their resolution. These procedures are described in the laboratory QA manuals. Laboratory non-conformance issues will also be described in the field sampling report if they affect the quality of the data.

Data packages and EDDs will be prepared by the laboratory upon completion of analyses for each sample delivery group. The case narrative will include a description of any problems encountered, control limit exceedances (if applicable), and a description and rationale for any deviations from protocol. Copies of corrective action reports generated at the laboratory will also be included with the data package.

Validated data will be provided electronically to EPA. These data will also be provided with the data summary report containing an overview of the field event, a sampling location map, sample collection methods, and rationale for any deviations from the FSPs and QAPP according to the Agreement.

SECTION D: DATA VALIDATION AND USABILITY

Data generated in the field and at the laboratories will be verified and validated according to criteria and procedures described in this section. Data quality and usability will be evaluated, and a discussion will be included in the data validation report. In the following sections, the term "laboratory" refers to both the analytical and bioassay laboratories.

D1 DATA REVIEW, VERIFICATION, AND VALIDATION

Field and laboratory data for this task will undergo a formal verification and validation process. All entries into the database will be verified. All errors found during the verification of field data, laboratory data, and the database will be corrected and documented prior to release of the final data.

Data verification and validation will be completed according to methods described in the following EPA guidance documents for data validation:

- Guidance on Environmental Data Verification and Validation (USEPA 2002b)
- EPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review (USEPA 2004).

Data will be qualified as estimated as necessary if results for surrogates, LCSs, MS/MSD samples, or laboratory duplicates do not meet method-specified control limits, including performance-based control limits. Results for other QC procedures will be qualified if they do not meet control limits outlined in EPA's functional guidelines and SOPs for data validation (USEPA 1995, 1996, 1999, 2004). Data will be qualified as undetected based on concentrations of target analytes detected in laboratory or field blanks, according to EPA's functional guidelines and SOPs for data validation.

Performance-based control limits are established periodically by the laboratories as required for the selected methods. Current values will be provided in the laboratory QA plans, as applicable.

No guidelines are available for validation of data for AVS, TOC, and DOC. These data will be validated using procedures described in the functional guidelines for inorganic data review (USEPA 2004), as applicable. Data will be qualified as estimated, as necessary, if results for QC samples do not meet performance-based control limits.

Results for field split-samples will be evaluated using control limits of 35 percent. Data will not be qualified as estimated if the MQOs are exceeded, but RPD results will be tabulated and any exceedances will be discussed in the data summary report.

Equipment rinse blanks will be evaluated and data qualifiers applied in the same manner as method blanks, described in the functional guidelines for data review (USEPA 1995, 1996, 1999, 2004). Data will be rejected if control limits for acceptance of data are not met, as described in USEPA (1995, 1996, 1999, 2004).

D2 VERIFICATION AND VALIDATION METHODS

Field data will be verified during preparation of samples and COC forms. Field data and COC forms will be reviewed daily by the field supervisor. After field data are entered into the project database, 100 percent verification of the entries will be completed to ensure the accuracy and completeness of the database. Any discrepancies will be resolved before the final database is released for use.

Approximately 10 percent of the chemistry data will be fully validated, including the first two data packages generated for each chemical analysis type. Validation for the remaining data will be based on review of the summary forms for sample and QC data. If problems or questions are encountered during validation, the laboratory will be contacted for resolution. An additional full validation will be completed, if required, to fully assess the quality of the data or to verify that laboratory errors have been addressed.

Procedures for verification and validation of laboratory data and field QC samples will be completed as described in the functional guidelines and SOPs for data validation (USEPA 1995, 1996, 1999, 2004) and summarized in Section D1 above. Accuracy and completeness of each data set will be verified at the laboratory when EDDs are prepared and again as part of data validation. Ten percent of entries to the database from the laboratory EDDs will be checked against the hard-copy data packages. Data validation will be completed by ESI.

In addition to verification of field and laboratory data and information, data qualifier entries into the database will be verified. Any discrepancies will be resolved before the final database is released for use.

MRL goals for this task are provided in Table A7-3. Reporting limits for non-detects will be compared to the MRL goals to evaluate method sensitivity for each sample. Any exceedance of actual MRLs over the target MRLs will be discussed in the data validation report.

D3 RECONCILIATION WITH USER REQUIREMENTS

The goal of data validation is to determine the quality of each data result and to identify those that do not meet the task MQOs. Non-conforming data may be qualified as estimated (i.e., a "J" qualifier will be applied to the result) or rejected as unusable (i.e., an "R" qualifier will be applied to the result) during data validation if criteria for data quality are not met. Data may also be qualified as undetected during validation based on laboratory and field blank results. Rejected data will not be used for any purpose. A summary of the qualified data and the reasons for qualification will be included in the data validation report.

Data qualified as estimated will be used for all intended purposes and will be appropriately qualified in the final project database. However, these data are less precise or less accurate than unqualified data. Data users are responsible for assessing the effect of the inaccuracy or imprecision of the qualified data on statistical procedures and other data uses. The data quality discussion in the data validation report will include information regarding the direction or magnitude of bias or the degree of imprecision for qualified data to facilitate the assessment of data usability. Data validation reports will also include a discussion of data limitations and their effect on data interpretation activities.

SECTION E: REFERENCES

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FIGURES

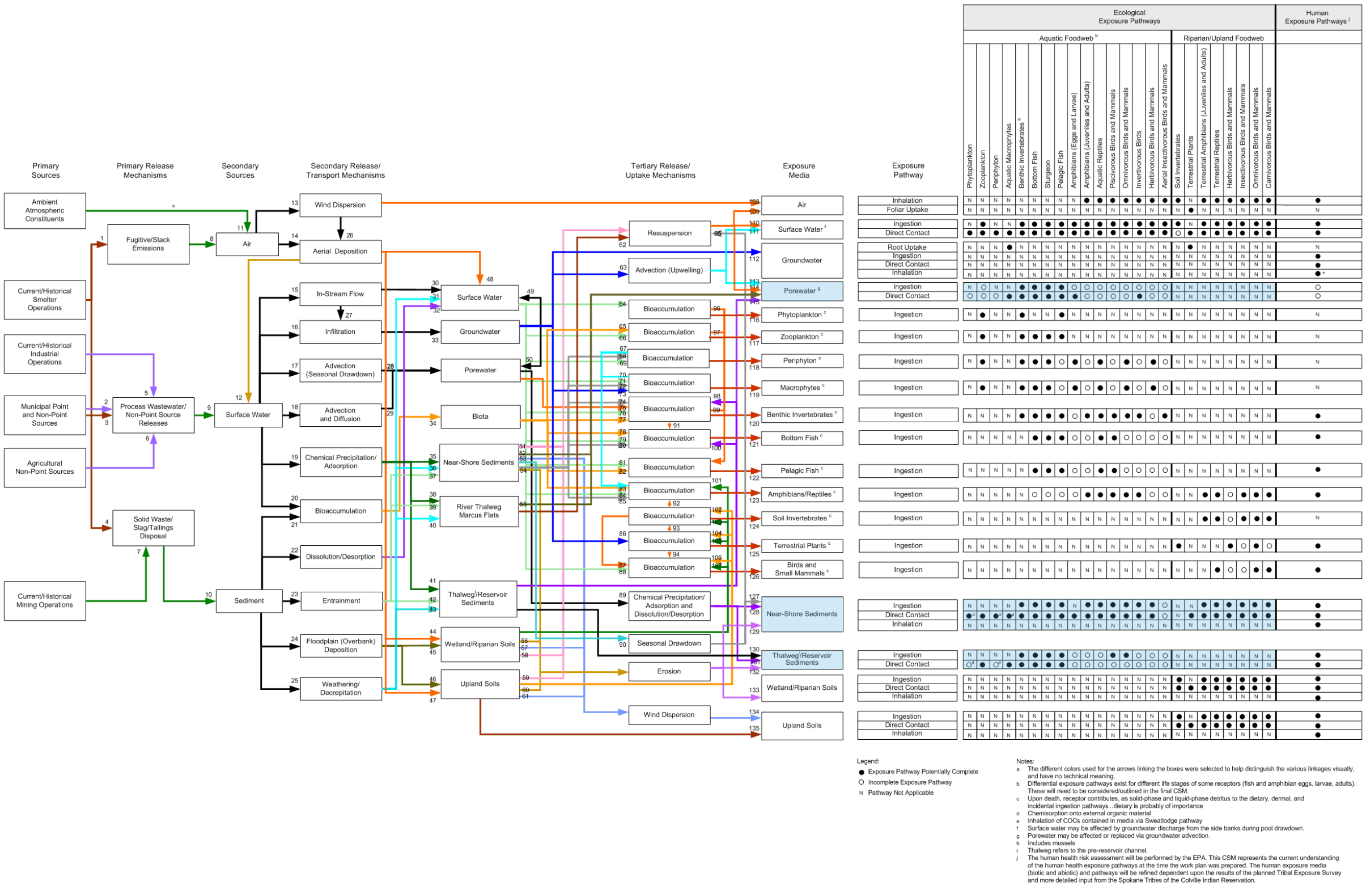
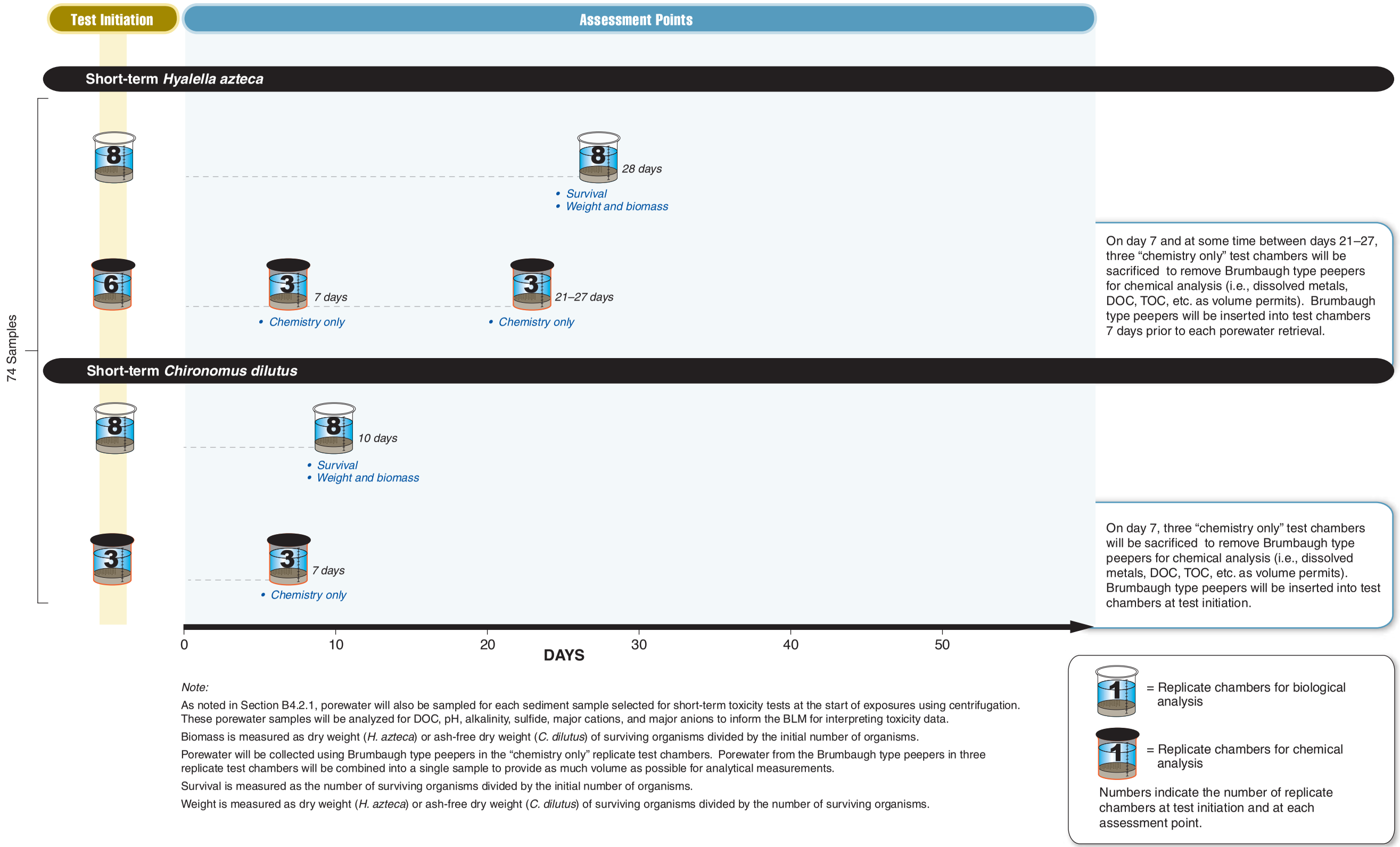


Figure A6-1. Sitewide Conceptual Site Model

Note: Exposure media and ecological receptors that Phase 2 Sediment Study data will address are shaded in blue.



Note:

As noted in Section B4.2.1, porewater will also be sampled for each sediment sample selected for short-term toxicity tests at the start of exposures using centrifugation. These porewater samples will be analyzed for DOC, pH, alkalinity, sulfide, major cations, and major anions to inform the BLM for interpreting toxicity data.

Biomass is measured as dry weight (*H. azteca*) or ash-free dry weight (*C. dilutus*) of surviving organisms divided by the initial number of organisms.

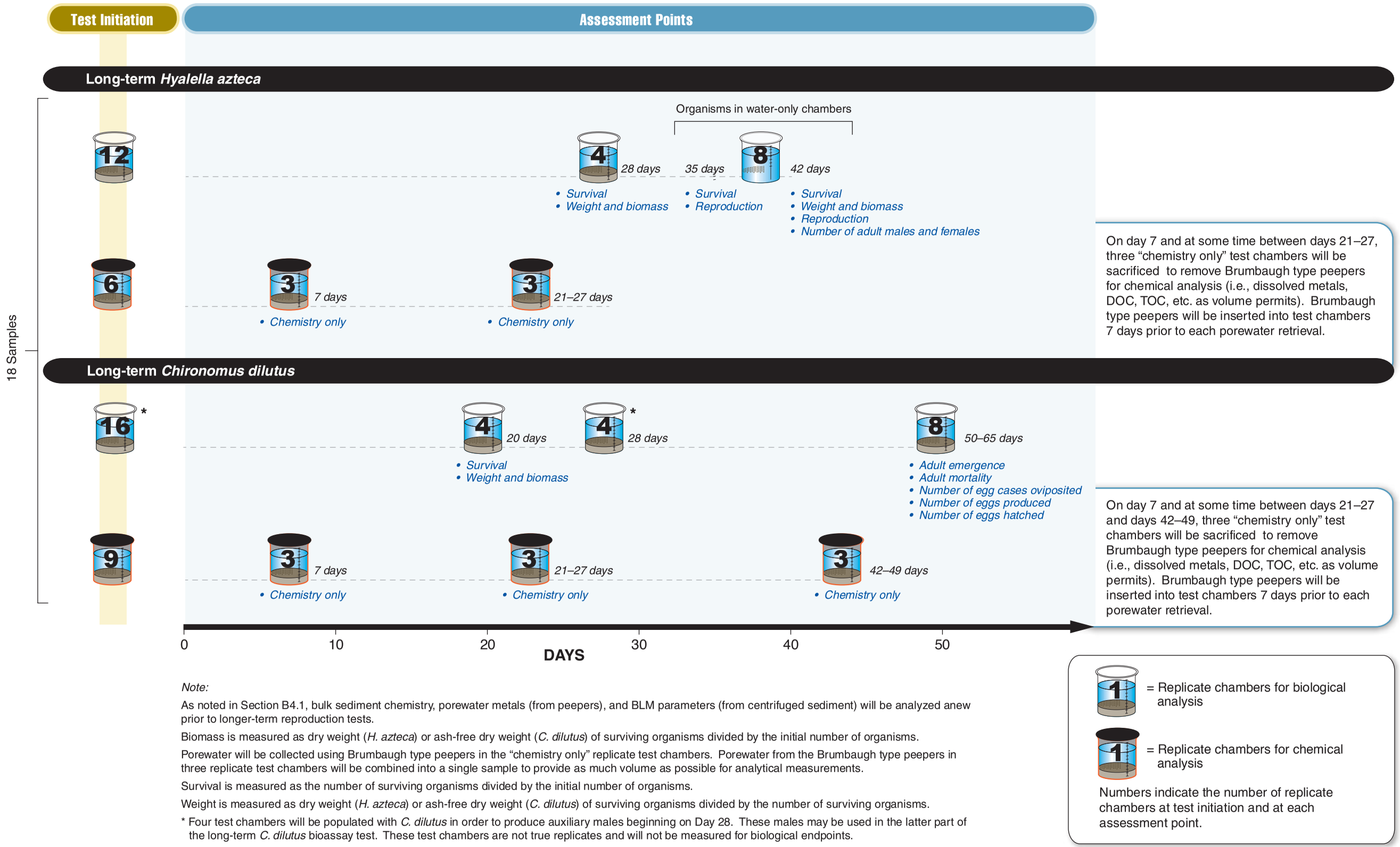
Porewater will be collected using Brumbaugh type peepers in the "chemistry only" replicate test chambers. Porewater from the Brumbaugh type peepers in three replicate test chambers will be combined into a single sample to provide as much volume as possible for analytical measurements.

Survival is measured as the number of surviving organisms divided by the initial number of organisms.

Weight is measured as dry weight (*H. azteca*) or ash-free dry weight (*C. dilutus*) of surviving organisms divided by the number of surviving organisms.

0900083.031 0101 09/13/12 WA

Figure B4-1. Short-term Bioassay Timeline for Each Sediment Sample



Note:

As noted in Section B4.1, bulk sediment chemistry, porewater metals (from peepers), and BLM parameters (from centrifuged sediment) will be analyzed anew prior to longer-term reproduction tests.

Biomass is measured as dry weight (*H. azteca*) or ash-free dry weight (*C. dilutus*) of surviving organisms divided by the initial number of organisms.

Porewater will be collected using Brumbaugh type peepers in the "chemistry only" replicate test chambers. Porewater from the Brumbaugh type peepers in three replicate test chambers will be combined into a single sample to provide as much volume as possible for analytical measurements.

Survival is measured as the number of surviving organisms divided by the initial number of organisms.

Weight is measured as dry weight (*H. azteca*) or ash-free dry weight (*C. dilutus*) of surviving organisms divided by the number of surviving organisms.

* Four test chambers will be populated with *C. dilutus* in order to produce auxiliary males beginning on Day 28. These males may be used in the latter part of the long-term *C. dilutus* bioassay test. These test chambers are not true replicates and will not be measured for biological endpoints.

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Figure B4-2. Long-term Bioassay Timeline for Each Sediment Sample

Maps

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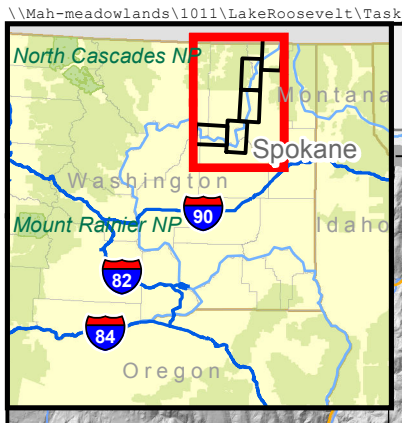


U.S. - Canada Border

Grand Forks

Danville

Laurier

Toroda

Kettle River

Curlew

Goldstake

Orient

Dulwich

Bodie

Toroda Creek

Old Toroda

Malo

Karamin

Barstow

Bossburg

Wauconda

Old Wauconda

Pollard

Boyds

Bear

Evans

Powell

Torboy

Marcus

Republic

Harter

Ward

Kettle Falls

Greenwood

Aeneas Valley

Aeneas

Okanogan

Pinkney City

Park Rapids

Orin

Lyman Lake Moses Mountain

Big Road 64

Gold Creek

West Fork

Ferry

Arden

Arzina

Rice

Stevens

Waterloo

Daisy

Maud

Addy

Fairview

Bingville

Bluecreek

Cozy Nook

Gifford

Addy Gifford

Impach

Meteor

Chewelah

Bissel

Covada

Kewa

Nespelem

Colville Indian Reservation

Cedonia Addy

Cedonia

Carrs Corner

Waits

Valley

Kulzer

Sanpoil River

Hunters

Grays

Keller

Fruitland

Springdale Hunters

Belvedere

Turk

Cline

Springdale

Koontzville

Seatons Grove

Deer Trail

Camas

Enterprise

Lone Pine

Elmer City

Mason City

Spokane Indian Reservation

Williams Valley

Electric City

Osborne

Miles

Fort Spokane

Ford

Bagdad Junction

Hesseltine

Wellpinit

Seven Bays

Sherman

Lincoln

Long Lake

Little Falls

Wilbur

Creston

Farwell

Crescent

Hanson

Govan

Almira

Telford

Mondovi

Davenport

Reardan

Rocklyn

Gravelles

Omans

Elanor

Grant

Lincoln

Tile 1

Tile 2

Tile 3

Tile 4

Tile 5

Legend

- Populated Places
- County Lines
- Reservations
- 24 Meter Water Depth Contour
- Sediment > 2mm (CCT)
- Sediment > 2mm (Interpolated)

EPA Alternate Location

- Bioassay
- Chemistry-Only
- Internal Reference
- Reserve

HDR | HydroQual

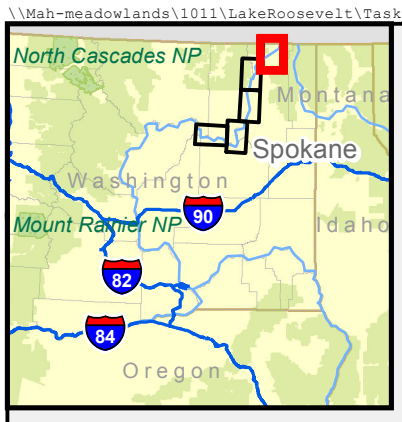
Km 0 5 10

Miles 0 5 10

N

Map A7-1. **Overview of Proposed Sediment Sampling Locations**
Upper Columbia River, WA

\\Mah-meadowlands\1011\LakeRoosevelt\Task D81_Project_Support\Sediment_QAPP_Revisions\Sampling_Maps\UCRTemplate-Toxicity_Tests.mxd @ 08-10-2012



U.S. - Canada Border

Frontier

Velvet

Sample 1-R5 at RM 744
Sample 1-R1 at RM 744
Sample 1-R3 at RM 744
Sample 1-R2 at RM 742
Sample 1-B1 at RM 744
Sample 1-C4 at RM 743
Sample 1-R4 at RM 743
251
Deep Lake Boundary
Sample 1-B3 at RM 740
Sample 1-B2 at RM 742
Sample 1-R6 at RM 741
Sample 1-R8 at RM 737
Sample 1-R7 at RM 739
Sample 1-C3 at RM 739
25
Sample 1-C2 at RM 739
Sample 1-B4 at RM 737
Sample 1-B5 at RM 737
Sample 1-B6 at RM 738
Sample 1B-R4 at RM 735
Sample 1B-C3 at RM 735
Sample 1-C1 at RM 738
Sample 1B-C2 at RM 734
Sample 1B-C4 at RM 733
Sample 1-R9 at RM 737
Sample 1-R10 at RM 737
Sample 1B-R3 at RM 735
Sample 1B-R1 at RM 735
Sample 1B-R2 at RM 734
Sample 2-B1 at RM 733
Sample 2-B2 at RM 732
8th Fir Sou
Sample 1B-C1 at RM 734
Leadpoint
Sample 2-R2 at RM 732
Sample 2-R1 at RM 732
Sample 2-R3 at RM 732
Sample 2-C1 at RM 731
Sample 2-C2 at RM 731
Sample 2-R4 at RM 731
Sample 2-R5 at RM 731
Sample 2-R6 at RM 731
Sample 2B-R2 at RM 728
Sample 2-B3 at RM 731
Sample 2-R7 at RM 730
Sample 2B-R1 at RM 728
Sample 2-B4 at RM 730
Sample 2-C4 at RM 730
Sample 2-R10 at RM 729
Sample 2-B5 at RM 729
Sample 2-B6 at RM 729
Sample 2B-C4 at RM 728
Sample 2-R8 at RM 730
Sample 2-C3 at RM 730
Sample 2-R9 at RM 729
Sample 2B-C1 at RM 727
Sample 2B-R3 at RM 727
Sample 2B-C2 at RM 727
Johnson Grade
Sample 2B-R4 at RM 726
Sample 3-R1 at RM 726
Marble
Sample 3-B1 at RM 725
Sample 2B-C3 at RM 726
Deep Lake Boundary
Sample 3-B3 at RM 724
Sample 3-R2 at RM 725
Sample 3-C1 at RM 724
Sample 3-R3 at RM 725
Sample 3-B6 at RM 722
Sample 3-R8 at RM 722
Sample 3-B2 at RM 724
Spirit
Sample 3-R4 at RM 724
Aladdin
Sample 3-C2 at RM 724
Sample 3-R5 at RM 723
Sample 3-R6 at RM 723
Sample 3-B5 at RM 723
Sample 3-B4 at RM 723
Sample 3-C3 at RM 723
Onion Creek
Goldfield Mill
Clugston Creek
Onion Creek
Aladdin

Legend

- Populated Places
- County Lines
- 24 Meter Water Depth Contour
- Sediment > 2mm (CCT)
- Sediment > 2mm (Interpolated)

EPA Alternate Location

- Bioassay
- Chemistry-Only
- Internal Reference
- Reserve

HDR | HydroQual

Km
0 1.25 2.5

Miles
0 1.25 2.5

N

Map A7-2. **Tile 1 - Proposed Sediment Sampling Locations**
Upper Columbia River, WA

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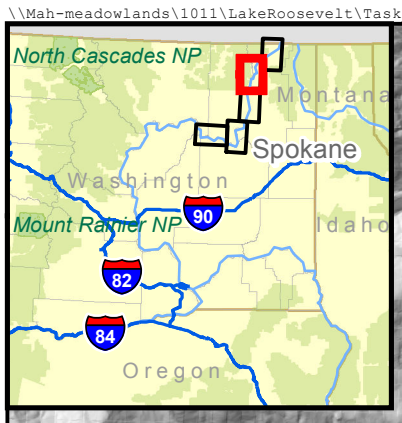

Sample 3-R10 at RM 721
Sample 3-R9 at RM 721
Sample 3B-C1 at RM 720
Sample 3-R6 at RM 723
Sample 3-B5 at RM 723
Sample 3B-R1 at RM 720
Ryan
Sample 3-R7 at RM 722
Sample 3-C3 at RM 723
Sample 3-C4 at RM 721
Sample 3-B6 at RM 722
Sample 3-R8 at RM 722
Sample 3B-C2 at RM 719
Barstow
Sample 3B-R2 at RM 718
Sample 3B-R3 at RM 717
Sample 3B-R4 at RM 715
Kettle River
Bossburg
Sample 3B-C3 at RM 715
395
Sample 3B-C4 at RM 714
Boyds
Evans
Bear
Sample 4-R11 at RM 712
Powell
25
Sample 4-R12 at RM 707
Sample 4-R1 at RM 711
Sample 4-C2 at RM 707
Sample 4-B1 at RM 710
Sample 4-R3 at RM 708
Sample 4-B2 at RM 708
Sample 4-C1 at RM 710
Sample 4-R5 at RM 707
Sample 4-B6 at RM 709
Sample 4-B3 at RM 707
East Marcus
Sample 4-B4 at RM 706
Marcus
Sample 4-C3 at RM 706
Sample 4-R4 at RM 707
Sample 4-R6 at RM 705
Sample 4-R7 at RM 705
Sample 4-R9 at RM 705
Sample 4-B5 at RM 705
Sample 4-C4 at RM 705
Echo
Sample 4-C5 at RM 704
Harter
Sample 4B-R1 at RM 702
Kettle Falls
Sample Ref-1b at RM 701
Sample 4-C6 at RM 703
Sample 4B-C1 at RM 701
Sample 4-R10 at RM 703
Ward
Williams Lake
20
Inchelium Kettle Falls
Greenwood
Sample Ref-1 at RM 699
Sample 4B-R2 at RM 698
Lygaard
Sample Ref-2b at RM 697
Sample 4B-C2 at RM 698
Inchelium Kettle Falls
Sample Ref-2 at RM 696
Sample Ref-3b at RM 693
Sample 4B-R3 at RM 693
Sample 4B-C3 at RM 692
Sample 4B-R4 at RM 691
Sample Ref-3 at RM 689
Colville Indian Reservation

Legend

- Populated Places
- County Lines
- Reservations
- 24 Meter Water Depth Contour
- Sediment > 2mm (CCT)
- Sediment > 2mm (Interpolated)

EPA Alternate Location

- Bioassay
- Chemistry-Only
- Internal Reference
- Reserve

HDR | HydroQual

0 1.25 2.5 Km

0 1.25 2.5 Miles

N

Map A7-3. **Tile 2 - Proposed Sediment Sampling Locations**
Upper Columbia River, WA

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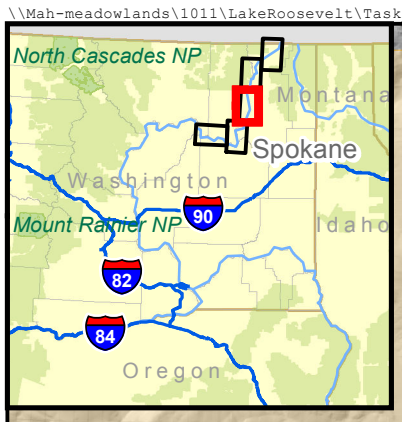

Sample Ref-3 at RM 689
Sample 4B-C4 at RM 688
Sample 5-R2 at RM 686
Arzina
Rice
Sample 5-R1 at RM 685
Inchelium Kettle Falls
Sample 5-R3 at RM 683
Sample 5-R4 at RM 680
Sample Ref-4b at RM 681
Waterloo
Sample 5-C1 at RM 680
Daisy
Sample Ref-4 at RM 679
Sample 5-B1 at RM 678
Sample 5-R5 at RM 679
Sample 5-R8 at RM 677
Sample Ref-5b at RM 678
Sample 5-B2 at RM 678
Sample 5-C2 at RM 678
Maud
Sample 5-R7 at RM 678
Sample 5-R6 at RM 677
Sample 5-B6 at RM 676
Sample 5-B3 at RM 678
Sample 5-C3 at RM 677
Sample Ref-5 at RM 676
Sample 5-B4 at RM 677
Sample 5-B5 at RM 676
Addy, Gifford
Colville Indian Reservation
Sample 5-R9 at RM 676
Gifford
Sample 5-C4 at RM 675
Inchelium
Inchelium-Covada Ferry Crossing Landing
Sample 5-R10 at RM 675
Impach
25
Meteor
Sample 5B-C1 at RM 674
Sample 5B-R1 at RM 673
Sample 5B-C3 at RM 671
Sample 5B-C2 at RM 671
Sample 5B-R2 at RM 672
Bissel
Covada
Cedonia Addy
Sample 5B-R4 at RM 668
Sample 5B-R3 at RM 670
Kewa
Sample 5B-C4 at RM 668
Sample 6-R2 at RM 667
Sample 6-R1 at RM 667
Sample 6-R3 at RM 666
Sample 6-R4 at RM 666
Sample 6-C1 at RM 666
Sample 6-C2 at RM 666
Sample 6-B2 at RM 665
Sample 6-B3 at RM 666
Sample 6-B1 at RM 665
Sample 6-R5 at RM 665
Sample 6-R6 at RM 665
Sample 6-R8 at RM 665
Sample 6-R7 at RM 665
Cedonia
Sample 6-B4 at RM 665
Sample 6-C3 at RM 664
Sample 6-B5 at RM 664
Sample 6-C4 at RM 664
Sample 6-B6 at RM 664
Sample 6-R10 at RM 664
Sample 6B-R1 at RM 661
Sample 6-R9 at RM 664
Springdale Hunters
Sample 6B-C1 at RM 663

Legend

- Populated Places
- County Lines
- Reservations
- 24 Meter Water Depth Contour
- Sediment > 2mm (CCT)
- Sediment > 2mm (Interpolated)

EPA Alternate Location

- Bioassay
- Chemistry-Only
- Internal Reference
- Reserve

HDR | HydroQual

Km
0 1.25 2.5

Miles
0 1.25 2.5

N

Map A7-4. **Tile 3 - Proposed Sediment Sampling Locations**
Upper Columbia River, WA

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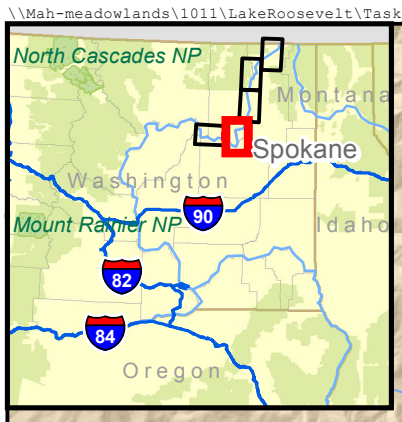


Sample 6B-C2 at RM 659
Sample 6B-R2 at RM 658
Sample Ref-6b at RM 658
Sample 6B-C3 at RM 657
Sample Ref-6 at RM 652
Sample 6B-R4 at RM 651
Sample 6B-C4 at RM 652
Sample 6B-R3 at RM 654
Sample 7-C2 at RM 649
Sample 7-R2 at RM 649
Sample 7-C1 at RM 648
Sample 7-R3 at RM 647
Sample 7-R1 at RM 648
Sample 7-R9 at RM 647
Sample Ref-7 at RM 646
Sample 7-B2 at RM 646
Sample 7-B3 at RM 645
Sample 7-B1 at RM 646
Sample 7-R4 at RM 645
Sample 7-R6 at RM 645
Sample 7-R10 at RM 644
Sample Ref-7b at RM 643
Sample 7-B4 at RM 643
Sample 7-B6 at RM 643
Sample 7-B5 at RM 643
Sample 7-R5 at RM 642
Sample 7-R8 at RM 642
Sample 7-R7 at RM 640
Sample 7-C4 at RM 641
Sample 7-C3 at RM 640
Sample 7B-C3 at RM 626
Sample 7B-R1 at RM 630
Sample 7B-C2 at RM 632
Sample 7B-C1 at RM 637
Sample Ref-8 at RM 632
Sample Ref-8b at RM 633
Sample 7B-C4 at RM 634

Hunters
Springdale
Hunters
Fruitland
Enterprise
Miles
Fort Spokane
Seven Bays
Lincoln
25

Spokane Indian Reservation

Colville Indian Reservation

Legend

- Populated Places
- County Lines
- Reservations
- 24 Meter Water Depth Contour
- Sediment > 2mm (CCT)
- Sediment > 2mm (Interpolated)

EPA Alternate Location

- Bioassay
- Chemistry-Only
- Internal Reference
- Reserve

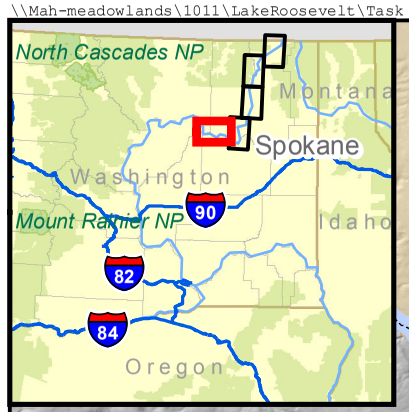
HDR | HydroQual

0 1.25 2.5 Km

0 1.25 2.5 Miles

N

Map A7-5. **Tile 4 - Proposed Sediment Sampling Locations**
Upper Columbia River, WA



Note: River miles for sample locations rounded to the nearest whole river mile

Legend

- Grand Coulee Dam
- Populated Places
- Reservations
- County Lines
- 24 Meter Water Depth Contour
- Sediment > 2mm (CCT)
- Sediment > 2mm (Interpolated)

EPA Alternate Location

- Bioassay
- Chemistry-Only
- Internal Reference
- Reserve

Colville Indian Reservation

Keller
Sanpoil River
Belvedere
Seatons Grove
Koontzville
155
Elmer City
Lone Pine
Crown Point Vista
174
Mason City
Coulee Dam
Grand Coulee
North Dam
Delano Heights
Heights (subdivision)
Sprague
Electric City
Osborne
Spring Coulee
West
Bagdad Junction
Hesseltine
21
Sample Ref-9 at RM 604
Sample 8B-R2 at RM 602
Sample 8B-R1 at RM 603
Sample 8-B4 at RM 605
Sample Ref-10 at RM 601
Sample 8-R10 at RM 604
Sample 8-R8 at RM 605
Sample 8B-C4 at RM 598
Grand Coulee Dam
Sample 8-C2 at RM 605
Sample 8B-C2 at RM 600
Sample 8-R4 at RM 605
Sample 8-C3 at RM 603
Sample 7B-R3 at RM 615
Sample 7B-R4 at RM 617
Sample 8-C4 at RM 604
Sample 8-R2 at RM 606
Sample 8-R3 at RM 604
Sample 8-R5 at RM 606
Sample 8-B3 at RM 605
Sample 8B-C1 at RM 602
Sample 8-B1 at RM 606
Sample 8-B2 at RM 605
Sample 8B-R4 at RM 598
Sample 8B-C3 at RM 599
Sample 8B-R3 at RM 599
Sample 8-B6 at RM 607
Sample 8-R1 at RM 606
Sample Ref-10b at RM 601
Sample 8-R6 at RM 606
Sample 8-C1 at RM 609
Sample Ref-9b at RM 607
Sample 8-R9 at RM 607
Sample 8-B5 at RM 608
Sample 7B-R2 at RM 622
Sample 8-R7 at RM 609
Sample 7B-C3 at RM 626

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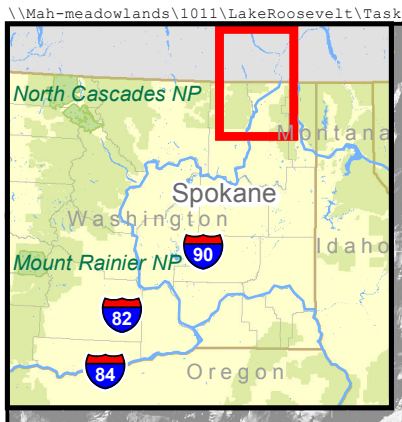
Km: 0 1.25 2.5
Miles: 0 1.25 2.5
N

Map A7-6. **Tile 5 - Proposed Sediment Sampling Locations**

Upper Columbia River, WA

\\Mah-meadowlands\1011\LakeRoosevelt\Task D84 Sediment QAPP Revisions\Sampling Maps\UCRTemplate-SedQAPP EXTERNAL OVERVIEW.mxd @ 07-10-2012



LAL-2
LAL-3
LAL-1
LAL-6
LAL-4
Lower Arrow Lake
LAL-5
Kootenay River
Castlegar
G-2
G-3
G-4
G-1
Trail
Columbia River
Grand Forks
Pend d'Oreille River
U.S. - Canada Border
Danville
Laurier
Frontier
Velvet
Goldstake
Northport
251
Trib-5
Trib-6
Trib-4
Leadpoint
Kettle River
Curlew
Orient
Dulwich
Marble
Deep Lake Boundary
Spirit
21
Malo
Karamin
Barstow
Ryan
Onion Creek
Goldfield Mill
Bossburg
Clugston Creek
Onion Creek
Pollard
Boyds
Evans
Powell
Bear
Aladdin
Ione
Torboy
395
Trib-2
Marcus
East Marcus
Douglas Falls
Echo
Joe Creek
Harter
Kettle Falls
Williams Lake
Ward
25
Greenwood
Aladdin
Pinkney City
Colville
20
Park Rapids
Orin
Trib-1
Trib-3
Colville Indian Reservation
Arzina
Rice
Arden
Colville River
Stevens

Legend

- Major Cities
- Populated Places
- Reservations
- County Lines
- External Reference Location

HDR | HydroQual

Km: 0 4 8

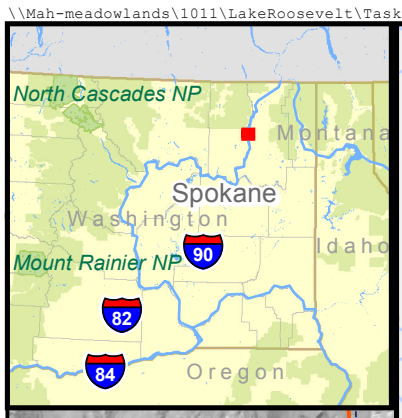
Miles: 0 4 8

N

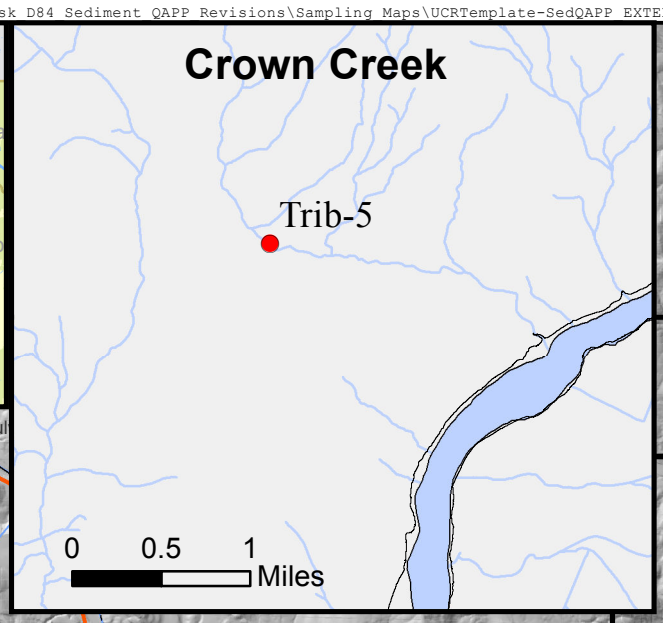
Map A7-7. **Overview of External Reference Locations for Phase 2 Sediment Study**

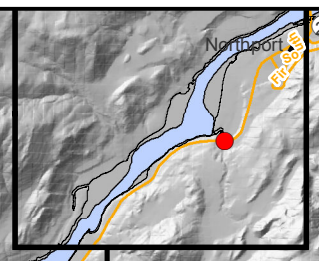
Upper Columbia River, WA / Columbia River, BC

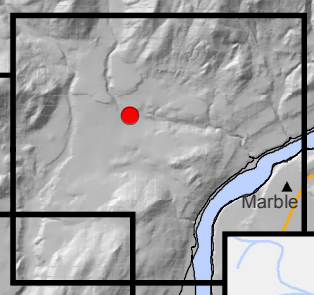
\\Mah-meadowlands\1011\LakeRoosevelt\Task D84 Sediment QAPP Revisions\Sampling Maps\UCRTemplate-SedQAPP EXTERNAL OVERVIEW.mxd @ 07-10-2012



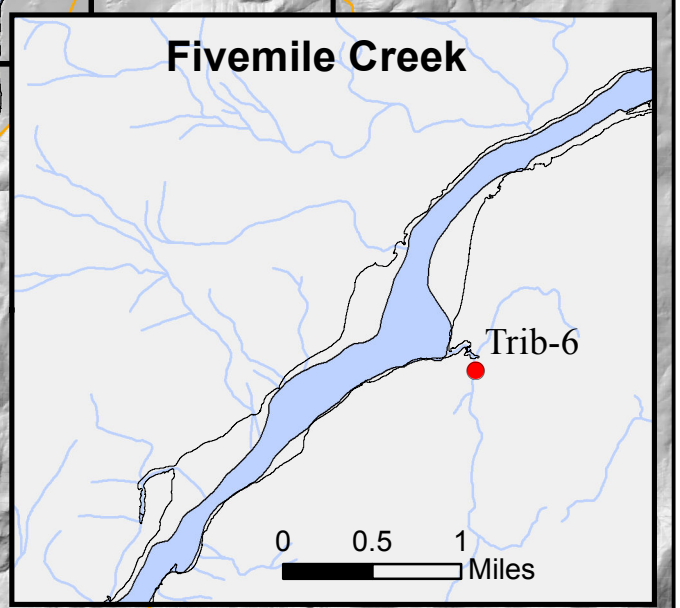
Crown Creek



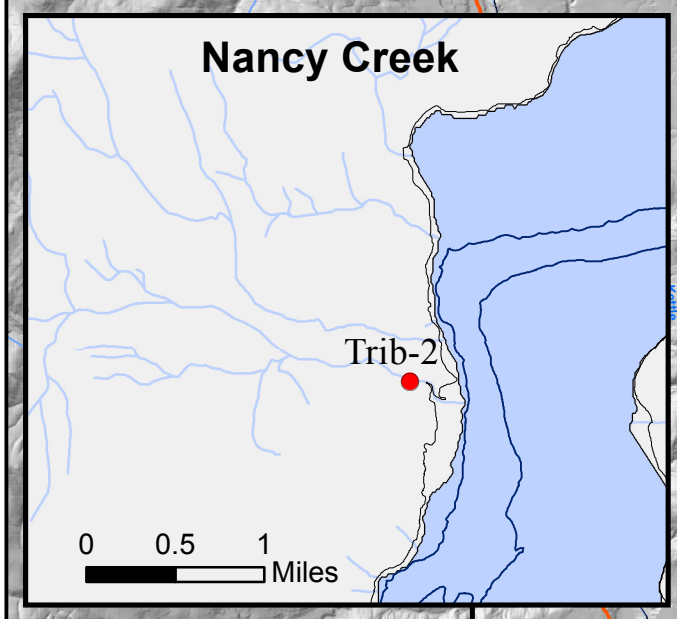


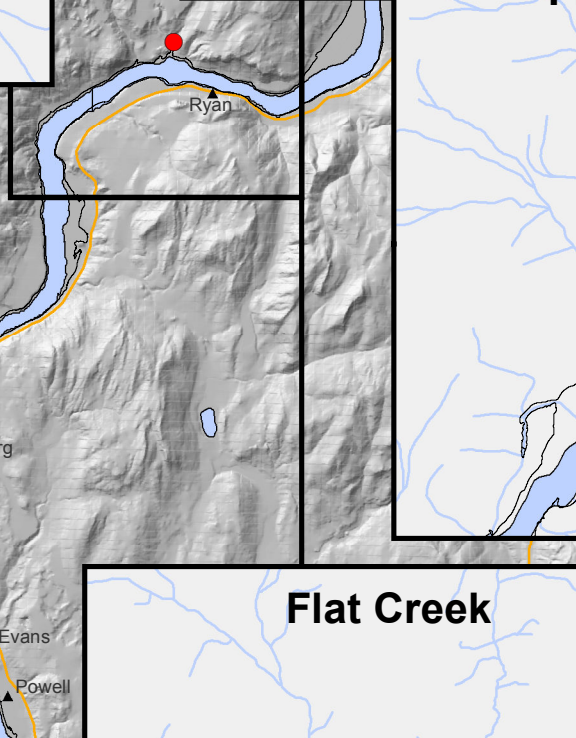


Fivemile Creek

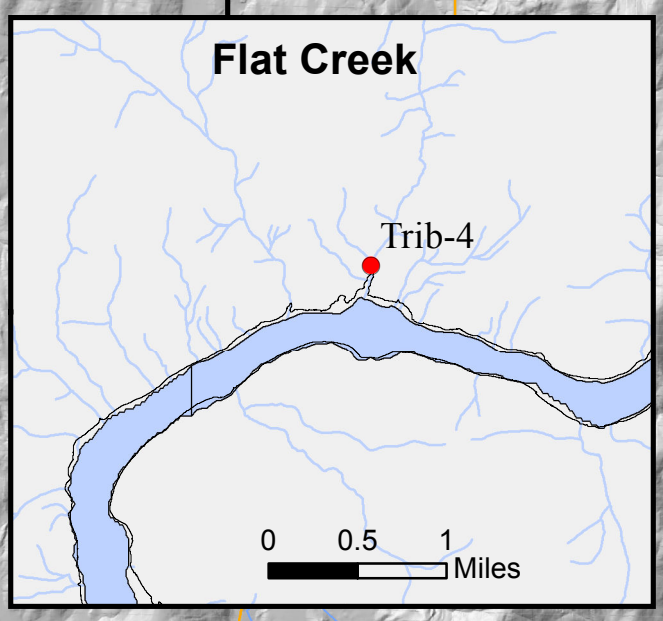


Nancy Creek

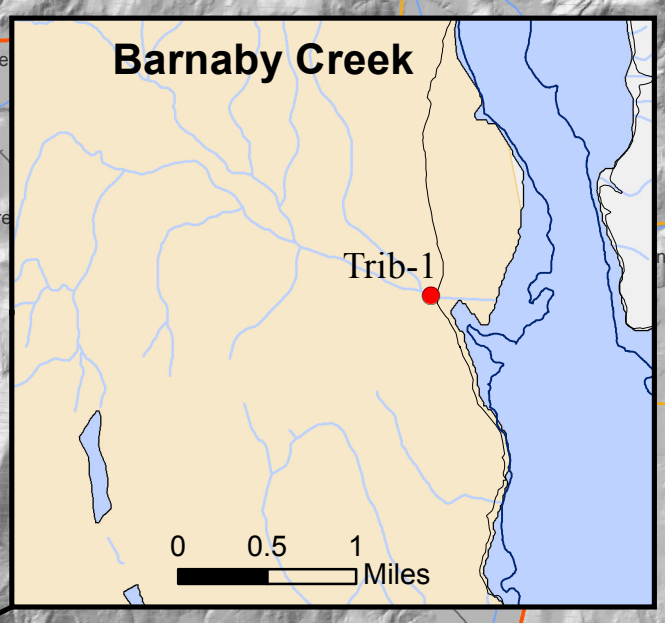




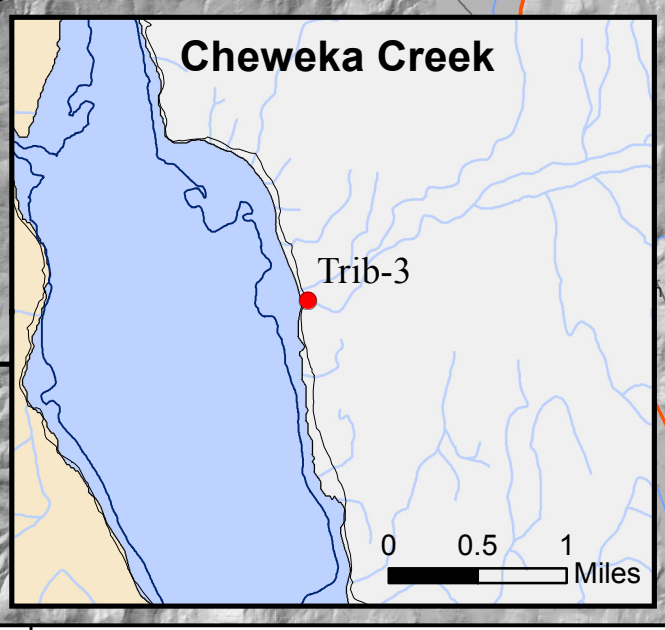
Flat Creek



Barnaby Creek



Cheweka Creek



Legend

- Populated Places
- County Lines
- 24 Meter Water Depth Contour
- Reservations
- EPA Alternate Location

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0 1.25 2.5 Km

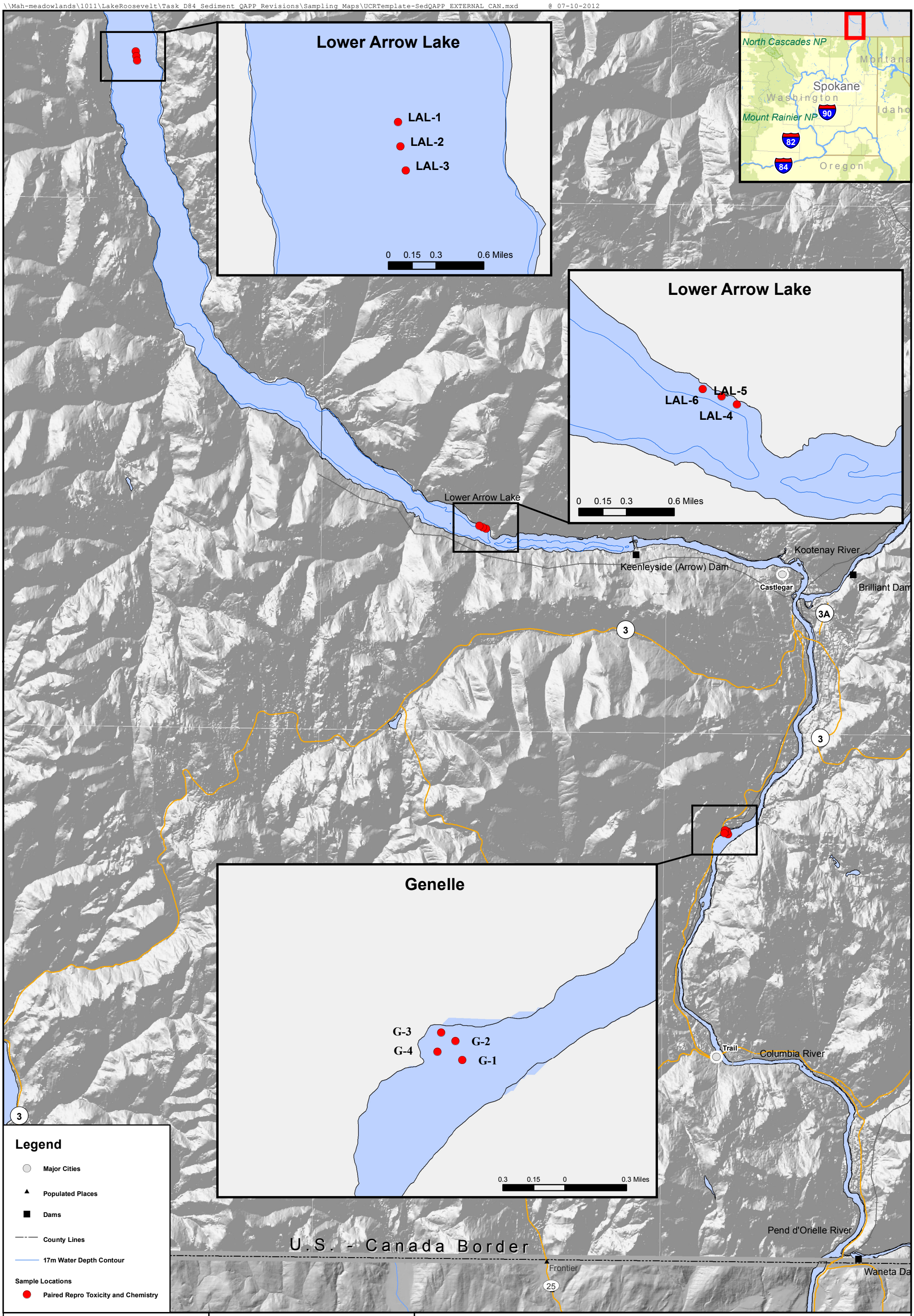
0 0.5 1 Miles

N

Map A7-8. **External Reference Locations in U.S. for Phase 2 Sediment Study**

Upper Columbia River, WA

\\Mah-meadowlands\1011\LakeRoosevelt\Task D84 Sediment QAPP Revisions\Sampling Maps\UCRTemplate-SedQAPP_EXTERNAL_CAN.mxd @ 07-10-2012



HDR | HydroQual

Map A7-9. **External Reference Locations in Canada for Phase 2 Sediment Study**

Columbia River, BC

3 !+$S

Table A4-1. Technical Team Task Member Information

Name	Task Role	Phone	Email
Teck American Incorporated			
Marko Adzic	TAI Project Coordinator	(509) 623-4585	Marko.Adzic@teck.com
U.S. Environmental Protection Agency			
Laura Buelow	EPA Project Coordinator	(509) 376-5466	buelow.laura@epa.gov
Matt Wilkening	EPA Project Coordinator	(208) 378-5760	Wilkening.Matt@epamail.epa.gov
Ginna Grepo-Grove	EPA QA Manager	(206) 553-1632	grepo-grove.gina@epa.gov
Consultant Team			
Anne Fairbrother	TAI Techincal Team Coordinator	(425) 519-8716	afairbrother@exponent.com
Robert Santore	Co-principal Investigator	(315) 484-6220	rsantore@hdrinc.com
Paul Paquin	Co-principal Investigator	(201) 529-5151	ppaquin@hdrinc.com
Rick Cardwell	Senior Technical Advisor	(541) 207-2002	cardwellconsultingllc@comcast.net
Scott Becker	Senior Technical Advisor	(206) 957-0349	sbecker@integral-corp.com
Dave Enos	Field Supervisor	(509) 944-3807	David.Enos@urs.com
Ashley Kaiser	Bioassay Laboratory Coordinator	(425) 519-8720	akaiser@exponent.com
Kris McCaig	Analytical Chemistry Laboratory Coordinator	(509) 623-4501	Kris.McCaig@teck.com
Rock Vitale	Task QA Manager	(610) 935-5577	rvitale@envstd.com
Laboratories			
Lynda Huckestein	Chemistry Laboratory Project Manager	(360) 501-3358	Lynda.Huckestein@alsglobal.com
Suzanne LeMay	Chemistry Laboratory QA Manager	(360) 577-7222	Suzanne.LeMay@alsglobal
Jeffrey Cotsifas	Bioassay Laboratory Project Manager	(707) 207-7761	cotsifas@pacificecorisk.com
Stephen L. Clark	Bioassay Laboratory QA Manager	(707) 207-7766	slclark@pacificecorisk.com

Table A5-1. Sediment/Porewater COPCs Requiring Additional Evaluation as Determined by the SLERA

Analyte	Basis for Decision
Nutrients	
Ammonia	Gaps in spatial coverage
Cyanide	Gaps in spatial coverage
Nitrite-Nitrate	Gaps in spatial coverage
Phosphorous	No SEV
Metals/Metalloids	
Aluminum	No SEV
Antimony	Maximum Measured Concentration > SEV
Arsenic	Maximum Measured Concentration > SEV
Barium	No SEV
Beryllium	Maximum Measured Concentration > SEV
Bismuth	No SEV
Boron	No SEV
Cadmium	Maximum Measured Concentration > SEV
Calcium	No SEV
Cerium	No SEV
Cesium	No SEV
Chloride	No SEV
Chromium	Maximum Measured Concentration > SEV
Cobalt	No SEV
Copper	Maximum Measured Concentration > SEV
Dysprosium	No SEV
Erbium	No SEV
Europium	No SEV
Fluoride	No SEV
Gadolinium	No SEV
Gallium	No SEV
Germanium	No SEV
Gold	Not measured
Holmium	No SEV
Indium	Not measured
Iron	No SEV
Lanthanum	No SEV
Lead	Maximum Measured Concentration > SEV
Lithium	No SEV
Lutetium	No SEV
Magnesium	No SEV
Manganese	No SEV
Mercury	Maximum Measured Concentration > SEV
Molybdenum	No SEV
Neodymium	No SEV
Nickel	Maximum Measured Concentration > SEV
Niobium	No SEV
Potassium	No SEV
Praseodymium	No SEV
Rubidium	No SEV
Samarium	No SEV
Scandium	No SEV
Selenium	No SEV
Silicon (Silica)	No SEV
Silver	Maximum Measured Concentration > SEV
Sodium	No SEV
Strontium	No SEV
Sulfur (Sulfate)	No SEV

Table A5-1. Sediment/Porewater COPCs Requiring Additional Evaluation as Determined by the SLERA

Analyte	Basis for Decision
Metals/Metalloids (continued)	
Tantalum	No SEV
Tellurium	Not measured
Terbium	No SEV
Thallium	No SEV
Thorium	No SEV
Thulium	No SEV
Tin	Not measured
Titanium	No SEV
Tungsten	No SEV
Uranium	No SEV
Vanadium	No SEV
Ytterbium	No SEV
Yttrium	No SEV
Zinc	Maximum Measured Concentration > SEV
Zirconium	No SEV
Dioxins/Furans	
1,2,3,4,6,7,8-HpCDD	No SEV
1,2,3,4,6,7,8-HpCDF	No SEV
1,2,3,4,7,8,9-HpCDF	No SEV
1,2,3,4,7,8-HxCDD	No SEV
1,2,3,4,7,8-HxCDF	No SEV
1,2,3,6,7,8-HxCDD	No SEV
1,2,3,6,7,8-HCDF	No SEV
1,2,3,7,8,9-HxCDD	No SEV
1,2,3,7,8,9-HxCDF	No SEV
1,2,3,7,8-PCDF	No SEV
1,2,3,7,8-PCDD	No SEV
2,3,4,6,7,8-HxCDF	No SEV
2,3,4,7,8-PCDF	No SEV
2,3,7,8-TCDD	No SEV
2,3,7,8-TCDF	No SEV
Octachlorodibenzodioxin	No SEV
Octachlorodibenzofuran	No SEV
TCDD TEQ	Maximum Measured Concentration > SEV
PBDEs	
Total PBDEs	Not measured
Pesticides	
2,4'-DDD	Total DDT and Metabolites $\geq$ SEV
4,4'-DDD	Total DDT and Metabolites $\geq$ SEV
Total DDD	Total DDT and Metabolites $\geq$ SEV
2,4'-DDE	Total DDT and Metabolites $\geq$ SEV
4,4'-DDE	Total DDT and Metabolites $\geq$ SEV
Total DDE	Total DDT and Metabolites $\geq$ SEV
2,4'-DDT	Total DDT and Metabolites $\geq$ SEV
4,4'-DDT	Total DDT and Metabolites $\geq$ SEV
Total DDT	Total DDT and Metabolites $\geq$ SEV
Total DDx	Total DDT and Metabolites $\geq$ SEV
Atrazine	No SEV
alpha-BHC	No SEV
beta-BHC	No SEV
Endrin aldehyde	No SEV
Hexachlorobenzene	No SEV
Methoxychlor	Maximum Measured Concentration > SEV

Table A5-1. Sediment/Porewater COPCs Requiring Additional Evaluation as Determined by the SLERA

Analyte	Basis for Decision
SVOCs	
2,2'-oxybis(1-Chloropropane)	No SEV
2,4,5-Trichlorophenol	No SEV
2,4,6-Trichlorophenol	No SEV
2,4-Dichlorophenol	No SEV
2,4-Dimethylphenol	No SEV
2,4-Dinitrophenol	No SEV
2,4-Dinitrotoluene	No SEV
2,6-Dinitrotoluene	No SEV
2-Chloronaphthalene	No SEV
2-Chlorophenol	No SEV
2-Methylphenol (o-cresol)	No SEV
2-Nitroaniline	No SEV
2-Nitrophenol	No SEV
3,3'-Dichlorobenzidine	No SEV
3-Nitroaniline	No SEV
4,6-Dinitro-2-methylphenol	No SEV
4-Chloro-3-methylphenol	No SEV
4-Chloroaniline	No SEV
4-Chlorophenyl-phenyl ether	No SEV
4-Nitroaniline	No SEV
4-Nitrophenol	No SEV
Acetophenone	No SEV
Benzaldehyde	No SEV
Benzyl alcohol	No SEV
bis(2-Chloroethoxy)methane	No SEV
Bis(2-chloroethyl)ether	No SEV
Caprolactam	No SEV
Dimethyl phthalate	All Detection Limit > SEV
Di-n-octylphthalate	All Detection Limit > SEV
Hexachlorocyclopentadiene	No SEV
Isophorone	No SEV
Nitrobenzene	No SEV
N-Nitrosodi-n-propylamine	No SEV
N-Nitrosodiphenylamine	No SEV
Pentachlorophenol	No SEV
Phenol	No SEV

Notes:

SEV = screening ecological value

Table A7-1. Number of Sample Locations

Sample Type		Analyses	EPA Alternative Sampling Locations	
			Primary	Reserve
Site		Chemistry & Bioassay	48	114
		Chemistry Only	66	
	Internal Reference	Chemistry & Bioassay	10	10
Reference	Tributary	Chemistry & Bioassay	6	0
	Upstream	Chemistry & Bioassay	10	0
		Total	*140*	*124*

Table A7-2. Analytes and Methods

Analytes	Sample Preparation Protocol	Sample Preparation Procedure	Quantitative Analysis Protocol	Quantitative Analysis Procedure	MDL/MRL Detection Limit
Porewater Samples					
Dissolved TAL metals: aluminum (Al), antimony (Sb), arsenic (As), barium (Ba), beryllium (Be), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), lead (Pb), manganese (Mn), nickel (Ni), selenium (Se), silver (Ag), thallium (Tl), vanadium (V), and zinc (Zn)	EPA CLP	Acid Digestion	EPA 6020A	ICP/MS	See Footnote B1
Dissolved TAL metals: calcium (Ca), iron (Fe), magnesium (Mg), potassium (K), and sodium (Na)	EPA CLP	Acid Digestion	EPA 6010C	ICP/AES	See Footnote B2
TOC and DOC	--	--	EPA 9060A	--	(0.07/0.5) mg/L
pH	--	--	SM 4500 H+ B	Electrometric	0.1 unit
Alkalinity as $CaCO_3$	--	--	SM 2320 B	Titration	(3/9) mg/L as $CaCO_3$
Hardness as $CaCO_3$	--	--	SM 2340C	Calculated	(0.07/0.4) mg/L as $CaCO_3$
Chloride, sulfate	--	--	EPA 300	Ion Chromatography	See Footnote A
Sediment Samples					
TAL metals: aluminum (Al), antimony (Sb), arsenic (As), barium (Ba), beryllium (Be), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), lead (Pb), manganese (Mn), nickel (Ni), selenium (Se), silver (Ag), thallium (Tl), vanadium (V), and zinc (Zn)	EPA 3050B	Acid Digestion	EPA 6020A	ICP/MS	See Footnote B1
TAL metals: calcium (Ca), iron (Fe), magnesium (Mg), potassium (K), and sodium (Na)	EPA 3050B	Acid Digestion	EPA 6010C	ICP/AES	See Footnote B2
Mercury (total)	EPA 7471B	Acid Digestion	EPA 7471B	Cold Vapor AA	(0.002/0.02) mg/kg
AVS/SEM	USEPA (1991)	NA	EPA 6010C/AVS-SEM	ICP/AES	See Footnote C
TOC	NA	NA	ASTM D4129-05	Coulometric	(0.02/0.05)%
pH	NA	NA	EPA 9045D	Electrometric	0.1 unit
Grain Size	NA	NA	ASTM D422	Gravimetric	NA

Notes:

AA = atomic absorption
AES = atomic emission spectrometry
ASTM = American Society for Testing and Materials
AVS = acid volatile sulfides
AVS/SEM = acid volatile sulfides/simultaneously extractable metals
$CaCO_3$ = calcium carbonate
CLP = Contract Laboratory Program
DOC = dissolved organic carbon
EPA = U.S. Environmental Protection Agency
ICP = inductively coupled plasma
MDL = method detection limit
MRL = method reporting limit
MS = mass spectrometry
NA = not applicable
SEM = simultaneously extractable metals
SM = Standard Methods for the Examination of Water and Wastewater
TAL = target analyte list
TOC = total organic carbon

A. Detection Limits for EPA Method 300

Chloride MDL = 0.03 mg/L MRL = 0.2 mg/L
Sulfate MDL = 0.02 mg/L MRL = 0.2 mg/L

B2. Reporting Limits for EPA Method 6010C

(MDL | MRL)

Porewater	Sediment
Ca = 9 | 50 µg/L	Ca = 2 | 10 mg/kg dw
Fe = 3 | 20 µg/L	Fe = 0.7 | 4 mg/kg dw
K = 40 | 400 µg/L	K = 20 | 80 mg/kg dw
Na = 20 | 200 µg/L	Na = 4 | 40 mg/kg dw
Mg = 0.4 | 20 µg/L	Mg = 0.04 | 2 mg/kg dw

C. Method Reporting Limits for AVS/SEM

AVS MRL= 0.016 µmol/g dw
SEM-Sb = 0.004 µmol/g dw
SEM-As = 0.02 µmol/g dw
SEM-Cd = 0.0004 µmol/g dw
SEM-Cr = 0.001 µmol/g dw
SEM-Cu = 0.002 µmol/g dw
SEM-Pb = 0.002 µmol/g dw
SEM-Ni = 0.003 µmol/g dw
SEM-Zn = 0.002 µmol/g dw

B1. Reporting Limits for EPA Method 6020A (MDL | MRL)

Porewater	Sediment
Al = 0.3 | 2 µg/L	Al = 0.4 | 2 mg/kg dw
Sb = 0.02 | 0.05 µg/L	Sb = 0.02 | 0.05 mg/kg dw
As = 0.1 | 0.5 µg/L	As = 0.06 | 0.5 mg/kg dw
Ba = 0.02 | 0.05 µg/L	Ba = 0.005 | 0.05 mg/kg dw
Be = 0.006 | 0.02 µg/L	Be = 0.003 | 0.02 mg/kg dw
Cd = 0.005 | 0.02 µg/L	Cd = 0.004 | 0.02 mg/kg dw
Cr =0.04 | 0.2 µg/L	Cr = 0.03 | 0.2 mg/kg dw
Co = 0.006 | 0.02 µg/L	Co = 0.003 | 0.02 mg/kg dw
Cu = 0.02 | 0.1 µg/L	Cu = 0.08 | 0.1 mg/kg dw
Pb = 0.005 | 0.02 µg/L	Pb = 0.009 | 0.05 mg/kg dw
Mn = 0.006 | 0.05 µg/L	Mn = 0.03 | 0.05 mg/kg dw
Ni = 0.03 | 0.2 µg/L	Ni = 0.03 | 0.2 mg/kg dw
Se = 0.3 | 1 µg/L	Se = 0.2 | 1 mg/kg dw
Ag = 0.004 | 0.02 µg/L	Ag = 0.008 | 0.02 mg/kg dw
Tl = 0.005 | 0.02 µg/L	Tl = 0.003 | 0.02 mg/kg dw
V = 0.03 | 0.2 µg/L	V = 0.02 | 0.2 mg/kg dw
Zn = 0.2 | 0.5 µg/L	Zn = 0.2 | 0.5 mg/kg dw

Table A7-3. Derivation of Analytical Concentration Goals and Proposed Laboratory Reporting and Detection Limits Based on Ecological Screening Criteria and Available Data for the Site

	Ecological Screening Criteria				Porewater		Sediment	
Analyte/Parameter	Chronic EPA NAWQC (µg/L)	Ecology Chronic WQS (µg/L)	CCT Aquatic Life Chronic Criteria (µg/L)	STI Aquatic Life Chronic Criteria (µg/L)	MDL (µg/L)	MRL (µg/L)[a]	Toxicity Benchmark Values (mg/kg dw)[b]	MRL (mg/kg dw)[a]
Conventional Parameters								
Alkalinity	NA	NA	NA	NA	3,000	9,000	NA	NA
DOC	NA	NA	NA	NA	NA	NA	NA	NA
TOC	NA	NA	NA	NA	NA	NA	NA	0.05 %
Hardness	NA	NA	NA	NA	800	2,000	NA	NA
pH	NA	NA	NA	NA	NA	NA	NA	0.5 (unitless)
Cations/Anions								
Calcium	NA	NA	NA	NA	9	50	NA	10
Chloride	230,000	230,000	230,000	230,000	30	200	NA	NA
Magnesium	NA	NA	NA	NA	0.4	20	NA	4
Potassium	NA	NA	NA	NA	40	400	NA	80
Sodium	NA	NA	NA	NA	20	200	NA	40
Sulfate	NA	NA	NA	NA	10	200	NA	NA
Metals and Metalloids[c]								
Aluminum	87	NA	87	87	0.3	2	NA	2
Antimony	NA	NA	NA	NA	0.02	0.05	NA	0.05
Arsenic	150	190	150	150	0.1	0.5	9.79	0.5
Barium	NA	NA	NA	NA	0.02	0.05	NA	0.05
Beryllium	NA	NA	NA	NA	0.006	0.02	NA	0.02
Cadmium	0.25	0.77 [d]	0.19 [d]	0.77 [d]	0.005	0.02	0.99	0.02
Chromium	74	128 [d]	53 [d]	53	0.04	0.2	43.4	0.2
Cobalt	NA	NA	NA	NA	0.006	0.02	NA	0.02
Copper	9.0	8.1 [d]	6.4 [d]	6.4	0.02	0.1	31.6	0.1
Iron	1,000	NA	1,000	1,000	3	20	NA	4
Lead	2.5	1.6 [d]	1.6 [d]	1.6	0.005	0.02	35.8	0.05
Manganese	NA	NA	NA	NA	0.006	0.05	NA	0.05

Table A7-3. Derivation of Analytical Concentration Goals and Proposed Laboratory Reporting and Detection Limits Based on Ecological Screening Criteria and Available Data for the Site

	Ecological Screening Criteria				Porewater		Sediment	
Analyte/Parameter	Chronic EPA NAWQC (µg/L)	Ecology Chronic WQS (µg/L)	CCT Aquatic Life Chronic Criteria (µg/L)	STI Aquatic Life Chronic Criteria (µg/L)	MDL (µg/L)	MRL (µg/L)[a]	Toxicity Benchmark Values (mg/kg dw)[b]	MRL (mg/kg dw)[a]
Metals and Metalloids[c] (continued)								
Mercury	0.80	0.012	0.80	0.012	NA	NA	0.18	0.02
Nickel	52 [d]	112 [d]	37 [d]	37 [d]	0.03	0.2	22.7	0.2
Selenium	5.0	20	5.0	5.0	0.3	1	NA	1
Silver	1.6 [d]	1.7 [d]	1.6 [d]	1.7 [d]	0.004	0.02	NA	0.02
Thallium	NA	NA	NA	NA	0.005	0.02	NA	0.02
Vanadium	NA	NA	NA	NA	0.03	0.2	NA	2
Zinc	120	74	84	74	0.2	0.5	121	0.5

Notes:

[a] Non-detects will be reported to the MDL. Values between the MDL and the MRL will be estimated (i.e., "J" qualified).

[b] Based on consensus-based threshold effect concentrations (TECs.) Source: MacDonald et al. (2000).

[c] Water samples are analyzed for dissolved metals and sediment samples are analyzed for total metals.

[d] Criteria are hardness or pH dependent and are calculated using the means of those parameters from the Ecology (2006) surface water data. Mean hardness = 66.89 mg/L (range 58.3 to 77.3 mg/L), Mean pH = 8.11 standard units, Mean temperature = 9.5°C.

NAWQC = national ambient water quality criteria
CCT = Colville Confederated Tribes
DOC = dissolved organic carbon
dw = dry weight
MDL = method detection limit
MRL = method reporting limit
NA = not applicable
STI = Spokane Tribe of Indians
TEC = threshold exposure concentrations
TOC = total organic carbon
WQS = water quality standard

Table B1-1. Sampling Locations

River Mile	CSM Unit	X_UTM_11N	Y_UTM_11N	Latitude	Longitude
744	CSM Unit 1	453509.4201	5427422.5025	48.9980	-117.6356
743	CSM Unit 1	453049.2160	5425706.7652	48.9825	-117.6417
742	CSM Unit 1	451648.4545	5424098.8892	48.9679	-117.6606
740	CSM Unit 1	449383.7152	5422536.5077	48.9537	-117.6914
739	CSM Unit 1	447418.4558	5421563.1309	48.9448	-117.7181
739	CSM Unit 1	447786.7914	5421919.1414	48.9480	-117.7131
738	CSM Unit 1	446702.4589	5420858.9288	48.9384	-117.7278
738	CSM Unit 1	446805.9822	5420459.5044	48.9348	-117.7263
737	CSM Unit 1	445699.4516	5420996.5968	48.9395	-117.7415
737	CSM Unit 1	446362.5845	5421153.1449	48.9410	-117.7325
735	CSM Unit 1	443177.8505	5418969.8971	48.9211	-117.7756
734	CSM Unit 1	442907.6141	5418852.1021	48.9200	-117.7793
734	CSM Unit 1	442467.0883	5418819.2320	48.9196	-117.7853
733	CSM Unit 1	441090.2453	5417255.8861	48.9054	-117.8039
733	CSM Unit 1	441604.8343	5418331.8254	48.9152	-117.7970
732	CSM Unit 1	440379.5707	5416787.8301	48.9012	-117.8135
731	CSM Unit 1	438638.5012	5415121.2071	48.8860	-117.8370
731	CSM Unit 1	439803.8784	5415827.6896	48.8925	-117.8212
731	CSM Unit 1	439332.2297	5416009.6655	48.8941	-117.8277
730	CSM Unit 1	438161.3082	5414310.6777	48.8787	-117.8434
730	CSM Unit 1	438059.8053	5414097.9036	48.8767	-117.8448
730	CSM Unit 1	437662.4861	5414117.1880	48.8769	-117.8502
729	CSM Unit 1	436880.8238	5413705.7781	48.8731	-117.8608
729	CSM Unit 1	436540.9523	5413587.1195	48.8720	-117.8654
728	CSM Unit 1	435609.5237	5413195.8161	48.8684	-117.8780
727	CSM Unit 1	434669.4030	5412226.0305	48.8596	-117.8907
727	CSM Unit 1	434190.3665	5411916.3190	48.8567	-117.8972
726	CSM Unit 1	433680.1512	5411584.2567	48.8537	-117.9041
725	CSM Unit 1	432384.0675	5410533.4624	48.8441	-117.9216
724	CSM Unit 1	432191.0169	5408515.6151	48.8259	-117.9239
724	CSM Unit 1	431675.6534	5408577.7051	48.8264	-117.9309
724	CSM Unit 1	431407.7056	5407978.5225	48.8210	-117.9345
724	CSM Unit 1	431999.6766	5407758.1616	48.8191	-117.9264
723	CSM Unit 1	431061.2423	5407494.7208	48.8166	-117.9391
723	CSM Unit 1	430516.6068	5407063.5406	48.8127	-117.9464
723	CSM Unit 1	430251.0952	5406968.7694	48.8118	-117.9500
722	CSM Unit 1	429259.6594	5407490.5539	48.8164	-117.9636
721	CSM Unit 1	428055.4950	5407623.6644	48.8174	-117.9801
720	CSM Unit 1	426962.7318	5407475.5179	48.8160	-117.9949
719	CSM Unit 1	426117.5261	5404740.7728	48.7913	-118.0059
715	CSM Unit 1	422930.3481	5401213.9989	48.7592	-118.0487
714	CSM Unit 1	422143.2689	5398707.5541	48.7365	-118.0589
710	CSM Unit 2	424498.5577	5393545.3791	48.6904	-118.0259
710	CSM Unit 2	424141.7407	5392332.5779	48.6794	-118.0305
708	CSM Unit 2	422307.5206	5391562.8467	48.6723	-118.0553
707	CSM Unit 2	420548.2110	5391412.7358	48.6707	-118.0792
707	CSM Unit 2	418339.8305	5392015.8116	48.6758	-118.1093
706	CSM Unit 2	418971.9838	5390738.2203	48.6644	-118.1004
706	CSM Unit 2	419432.7220	5390220.0593	48.6598	-118.0941
705	CSM Unit 2	418628.2125	5388994.1163	48.6487	-118.1048
705	CSM Unit 2	419070.5788	5388803.6176	48.6470	-118.0987
704	CSM Unit 2	418880.1322	5387654.2160	48.6367	-118.1011
704	CSM Unit 2	420010.3993	5387622.5715	48.6365	-118.0857
703	CSM Unit 2	419944.9095	5386148.0589	48.6233	-118.0863
701	CSM Unit 2	416956.7457	5384334.9785	48.6066	-118.1265
699	CSM Unit 2	416050.4669	5380836.1877	48.5750	-118.1381

Table B1-1. Sampling Locations

River Mile	CSM Unit	X_UTM_11N	Y_UTM_11N	Latitude	Longitude
698	CSM Unit 3	416735.0144	5379566.6837	48.5637	-118.1286
696	CSM Unit 3	414919.3797	5376770.9835	48.5383	-118.1526
692	CSM Unit 3	413016.4130	5373254.3451	48.5064	-118.1777
689	CSM Unit 3	412113.9581	5370135.7474	48.4782	-118.1892
688	CSM Unit 3	410840.2606	5368231.4983	48.4609	-118.2060
680	CSM Unit 3	412646.8818	5357580.3021	48.3653	-118.1794
679	CSM Unit 3	411884.2490	5356534.9157	48.3558	-118.1895
678	CSM Unit 3	413961.7518	5354583.3221	48.3386	-118.1610
678	CSM Unit 3	413349.6141	5354533.6893	48.3380	-118.1693
678	CSM Unit 3	412683.5026	5354463.5628	48.3373	-118.1782
678	CSM Unit 3	412129.8358	5354418.5881	48.3368	-118.1857
677	CSM Unit 3	413398.2903	5352205.2719	48.3171	-118.1681
677	CSM Unit 3	412726.9162	5352643.6036	48.3210	-118.1773
676	CSM Unit 3	413948.6113	5351681.2164	48.3125	-118.1606
676	CSM Unit 3	414422.9844	5351520.9095	48.3111	-118.1542
676	CSM Unit 3	414649.1196	5352332.8588	48.3184	-118.1513
675	CSM Unit 3	413784.3845	5350035.8974	48.2976	-118.1625
674	CSM Unit 3	414765.0562	5347924.3964	48.2788	-118.1488
671	CSM Unit 3	413628.0184	5343195.2220	48.2361	-118.1632
671	CSM Unit 3	414124.0527	5343215.7328	48.2363	-118.1565
668	CSM Unit 3	410901.1046	5339274.8928	48.2005	-118.1991
666	CSM Unit 3	411556.0854	5335806.6497	48.1693	-118.1896
666	CSM Unit 3	411018.7702	5336033.4157	48.1713	-118.1968
666	CSM Unit 3	411227.3782	5336335.0334	48.1741	-118.1941
665	CSM Unit 3	410854.7068	5335454.2515	48.1661	-118.1989
665	CSM Unit 3	410705.3603	5334113.1373	48.1540	-118.2006
665	CSM Unit 3	411268.5670	5335730.8443	48.1686	-118.1934
664	CSM Unit 3	411008.6049	5333713.5271	48.1504	-118.1965
664	CSM Unit 3	411317.0992	5333324.1709	48.1470	-118.1923
664	CSM Unit 3	410720.0991	5333756.5288	48.1508	-118.2004
664	CSM Unit 3	410970.5675	5333359.2566	48.1472	-118.1969
663	CSM Unit 3	409919.5526	5332421.6511	48.1387	-118.2108
659	CSM Unit 3	407026.5480	5328246.9336	48.1007	-118.2488
657	CSM Unit 3	407578.6532	5324298.4494	48.0653	-118.2405
652	CSM Unit 3	400540.3906	5322333.7476	48.0465	-118.3345
652	CSM Unit 3	400847.7260	5322829.8370	48.0510	-118.3305
649	CSM Unit 3	397295.6854	5320051.8665	48.0255	-118.3775
648	CSM Unit 3	396304.1652	5319441.8134	48.0198	-118.3907
646	CSM Unit 3	397434.7901	5315605.9057	47.9855	-118.3746
646	CSM Unit 3	398099.5200	5315221.9882	47.9822	-118.3656
646	CSM Unit 3	396847.3055	5316334.6183	47.9920	-118.3826
645	CSM Unit 3	398713.0791	5315131.1322	47.9815	-118.3573
643	CSM Unit 3	398618.1482	5312027.9462	47.9535	-118.3579
643	CSM Unit 3	398839.9041	5310727.6951	47.9419	-118.3546
643	CSM Unit 3	398714.8503	5311566.1192	47.9494	-118.3565
641	CSM Unit 3	399383.8076	5307273.0598	47.9109	-118.3465
640	CSM Unit 3	399053.1499	5306933.8442	47.9078	-118.3509
637	CSM Unit 3	398667.3963	5301315.6713	47.8572	-118.3547
634	CSM Unit 3	397025.1674	5297988.6596	47.8270	-118.3759
632	CSM Unit 3	392537.3457	5299898.6690	47.8434	-118.4363
632	CSM Unit 3	391906.6828	5299446.3188	47.8393	-118.4446
626	CSM Unit 3	386089.6203	5303883.2933	47.8782	-118.5235
609	CSM Unit 3	366204.1236	5308848.2973	47.9190	-118.7908
608	CSM Unit 3	364224.4362	5309115.9473	47.9210	-118.8174
607	CSM Unit 3	364223.8196	5309575.7299	47.9251	-118.8176
606	CSM Unit 3	363009.4477	5310489.9501	47.9331	-118.8341

Table B1-1. Sampling Locations

River Mile	CSM Unit	X_UTM_11N	Y_UTM_11N	Latitude	Longitude
605	CSM Unit 3	362219.5509	5311913.6540	47.9457	-118.8451
605	CSM Unit 3	362335.6817	5312464.3123	47.9507	-118.8438
605	CSM Unit 3	362427.0537	5313415.7405	47.9593	-118.8428
605	CSM Unit 3	363836.2186	5313271.5550	47.9583	-118.8239
604	CSM Unit 3	361825.4727	5313132.1417	47.9566	-118.8508
604	CSM Unit 3	360887.9216	5313945.7006	47.9637	-118.8636
603	CSM Unit 3	360370.7016	5313754.7389	47.9619	-118.8705
602	CSM Unit 3	359207.2189	5312342.1436	47.9489	-118.8856
601	CSM Unit 3	356060.9582	5312511.8486	47.9497	-118.9278
600	CSM Unit 3	355217.8178	5311280.4868	47.9385	-118.9386
599	CSM Unit 3	353792.3763	5311819.0023	47.9430	-118.9579
598	CSM Unit 3	352173.8334	5312027.8193	47.9445	-118.9796
External Reference Locations					
Trib-1	Barnaby Creek	409599.0882	5365221.8770	48.4337	-118.2222
Trib-2	Nancy Creek	417960.0043	5389749.2880	48.6554	-118.1140
Trib-3	Cheweka Creek	412656.5780	5363476.2147	48.4184	-118.1805
Trib-4	Flat Creek	428210.3396	5408246.6044	48.8231	-117.9781
Trib-5	Crown Creek	430719.1785	5412475.2448	48.8614	-117.9446
Trib-6	Fivemile Creek	441398.6667	5416524.0973	48.8989	-117.7996
Lower Arrow Lake		417590.4138	5491377.5174	49.5694	-118.1398
Lower Arrow Lake		417614.5377	5491131.9909	49.5672	-118.1394
Lower Arrow Lake		417669.4369	5490887.5742	49.5650	-118.1386
Lower Arrow Lake		435667.1209	5466414.5085	49.3471	-117.8857
Lower Arrow Lake		435858.3129	5466340.1099	49.3464	-117.8831
Lower Arrow Lake		436014.4621	5466259.1383	49.3457	-117.8809
Genelle		448590.9184	5450405.5787	49.2043	-117.7058
Genelle		448699.7059	5450340.7110	49.2037	-117.7043
Genelle		448560.9976	5450257.5264	49.2030	-117.7061
Genelle		448752.8572	5450192.3689	49.2024	-117.7035
Reserve Locations					
744	CSM Unit 1	453467.0850	5427258.8783	48.9965	-117.6362
744	CSM Unit 1	453182.7745	5426533.4896	48.9899	-117.6400
744	CSM Unit 1	453588.2571	5427558.5769	48.9992	-117.6345
743	CSM Unit 1	453044.9424	5425055.4056	48.9766	-117.6417
742	CSM Unit 1	452591.6512	5424701.4318	48.9734	-117.6478
741	CSM Unit 1	451031.6871	5423758.5958	48.9648	-117.6690
739	CSM Unit 1	448355.4421	5422309.9013	48.9516	-117.7054
737	CSM Unit 1	363791.7652	5311551.4066	47.9428	-118.8240
737	CSM Unit 1	445899.6744	5421131.3897	48.9407	-117.7388
737	CSM Unit 1	446122.3203	5420985.1424	48.9394	-117.7357
735	CSM Unit 1	442963.6188	5419186.2676	48.9230	-117.7786
735	CSM Unit 1	443093.4939	5418969.8631	48.9210	-117.7768
735	CSM Unit 1	443543.8270	5419245.9786	48.9236	-117.7707
734	CSM Unit 1	442815.2564	5418839.6755	48.9199	-117.7806
732	CSM Unit 1	441061.5339	5417081.8569	48.9039	-117.8043
732	CSM Unit 1	440549.5791	5417293.9410	48.9057	-117.8113
732	CSM Unit 1	440012.8552	5416681.7387	48.9002	-117.8185
731	CSM Unit 1	439370.7699	5415630.5437	48.8907	-117.8271
731	CSM Unit 1	438796.5388	5415696.0756	48.8912	-117.8350
731	CSM Unit 1	438903.3279	5415215.3541	48.8869	-117.8334
730	CSM Unit 1	438384.6746	5414794.8399	48.8830	-117.8404
730	CSM Unit 1	438147.4244	5414464.0447	48.8800	-117.8436
729	CSM Unit 1	437139.6506	5413801.3798	48.8740	-117.8573
729	CSM Unit 1	436564.8183	5413686.5724	48.8729	-117.8651
728	CSM Unit 1	435504.0364	5412975.9687	48.8664	-117.8794
728	CSM Unit 1	435831.0622	5413561.7065	48.8717	-117.8751

Table B1-1. Sampling Locations

River Mile	CSM Unit	X_UTM_11N	Y_UTM_11N	Latitude	Longitude
Reserve Locations (continued)					
727	CSM Unit 1	433879.2918	5411733.6064	48.8550	-117.9014
726	CSM Unit 1	432851.5242	5411157.8576	48.8498	-117.9153
726	CSM Unit 1	433366.8018	5411453.6148	48.8525	-117.9083
725	CSM Unit 1	432015.0278	5409798.1401	48.8374	-117.9265
725	CSM Unit 1	432291.9754	5409134.4831	48.8315	-117.9226
724	CSM Unit 1	431500.1156	5408365.3311	48.8245	-117.9333
723	CSM Unit 1	431574.9290	5407627.9344	48.8179	-117.9321
723	CSM Unit 1	430826.6285	5407387.8550	48.8156	-117.9423
722	CSM Unit 1	430277.8522	5407169.9098	48.8136	-117.9497
722	CSM Unit 1	429445.7016	5407239.6105	48.8141	-117.9610
721	CSM Unit 1	428466.8141	5407797.1528	48.8190	-117.9745
721	CSM Unit 1	427574.4198	5407796.8690	48.8189	-117.9866
720	CSM Unit 1	426267.6107	5406857.8863	48.8103	-118.0043
718	CSM Unit 1	425881.6760	5403961.6779	48.7842	-118.0090
717	CSM Unit 1	424926.1779	5402793.9814	48.7736	-118.0218
715	CSM Unit 1	422213.0046	5400342.1397	48.7512	-118.0582
712	CSM Unit 1	423883.4961	5395557.8842	48.7084	-118.0346
711	CSM Unit 1	424342.0331	5394268.8047	48.6969	-118.0282
709	CSM Unit 2	423074.9214	5391768.8503	48.6742	-118.0449
708	CSM Unit 2	421223.0965	5391914.9176	48.6753	-118.0701
707	CSM Unit 2	419942.0117	5391598.5128	48.6723	-118.0874
707	CSM Unit 2	419261.0478	5391742.5653	48.6735	-118.0967
707	CSM Unit 2	420001.0260	5392779.1715	48.6829	-118.0869
705	CSM Unit 2	418993.5109	5389358.0759	48.6520	-118.0999
705	CSM Unit 2	419822.6609	5389209.6489	48.6508	-118.0886
705	CSM Unit 2	418517.0001	5390073.1658	48.6584	-118.1065
704	CSM Unit 2	419061.7584	5387607.3498	48.6363	-118.0986
703	CSM Unit 2	420521.5816	5385568.7634	48.6181	-118.0784
702	CSM Unit 2	416976.9193	5384847.9590	48.6112	-118.1264
701	CSM Unit 2	416708.7224	5384856.6594	48.6112	-118.1300
698	CSM Unit 3	416289.2542	5379288.1317	48.5611	-118.1346
697	CSM Unit 3	415116.9224	5378552.6767	48.5543	-118.1503
693	CSM Unit 3	413755.1486	5374478.6852	48.5175	-118.1679
693	CSM Unit 3	412745.7854	5374990.0535	48.5220	-118.1817
691	CSM Unit 3	413570.1954	5372295.3335	48.4978	-118.1700
686	CSM Unit 3	411920.5609	5364655.0886	48.4289	-118.1907
685	CSM Unit 3	411741.7980	5363158.6333	48.4154	-118.1928
683	CSM Unit 3	412187.3026	5360437.4712	48.3910	-118.1862
681	CSM Unit 3	411681.5116	5358429.8534	48.3729	-118.1926
680	CSM Unit 3	413586.0810	5357643.6493	48.3660	-118.1667
679	CSM Unit 3	412794.8433	5355906.5887	48.3503	-118.1770
678	CSM Unit 3	412420.6447	5353611.4682	48.3296	-118.1816
678	CSM Unit 3	411844.1665	5354906.8003	48.3412	-118.1897
677	CSM Unit 3	413310.8246	5353490.8058	48.3287	-118.1696
677	CSM Unit 3	414130.0949	5353398.1086	48.3279	-118.1585
676	CSM Unit 3	413414.0224	5350894.0804	48.3053	-118.1677
675	CSM Unit 3	414715.6921	5349616.9854	48.2940	-118.1498
673	CSM Unit 3	415561.3346	5346467.4193	48.2658	-118.1378
672	CSM Unit 3	415045.5045	5344167.9850	48.2450	-118.1443
670	CSM Unit 3	412780.9335	5341626.0134	48.2219	-118.1743
668	CSM Unit 3	411236.8950	5340403.7388	48.2107	-118.1948
667	CSM Unit 3	410799.9953	5337610.3087	48.1855	-118.2001
667	CSM Unit 3	411375.8938	5338732.3050	48.1956	-118.1926
666	CSM Unit 3	410888.9402	5336566.4881	48.1761	-118.1987
666	CSM Unit 3	411054.1045	5336613.0865	48.1765	-118.1965

Table B1-1. Sampling Locations

River Mile	CSM Unit	X_UTM_11N	Y_UTM_11N	Latitude	Longitude
Reserve Locations (continued)					
665	CSM Unit 3	410772.7857	5335024.3225	48.1622	-118.1999
665	CSM Unit 3	411095.7067	5335058.6293	48.1626	-118.1956
665	CSM Unit 3	411713.3021	5334577.0184	48.1583	-118.1872
665	CSM Unit 3	411402.9060	5334503.1453	48.1576	-118.1913
664	CSM Unit 3	410510.2992	5333386.1065	48.1474	-118.2031
664	CSM Unit 3	411036.2171	5332925.5305	48.1434	-118.1959
661	CSM Unit 3	406892.3536	5332357.5447	48.1377	-118.2515
658	CSM Unit 3	407143.2772	5326143.9382	48.0818	-118.2468
658	CSM Unit 3	406881.7821	5324463.8014	48.0667	-118.2499
654	CSM Unit 3	404117.6052	5321860.1674	48.0428	-118.2864
651	CSM Unit 3	398017.9043	5321965.2712	48.0428	-118.3683
649	CSM Unit 3	395521.8959	5319939.5152	48.0242	-118.4013
648	CSM Unit 3	395851.5591	5318623.1128	48.0124	-118.3965
647	CSM Unit 3	397086.0290	5318241.1340	48.0092	-118.3799
647	CSM Unit 3	396985.9692	5317216.6610	47.9999	-118.3810
645	CSM Unit 3	399113.4720	5314048.0094	47.9718	-118.3517
645	CSM Unit 3	398469.3868	5314615.9455	47.9768	-118.3605
644	CSM Unit 3	399080.6682	5313509.3701	47.9669	-118.3520
643	CSM Unit 3	399407.0937	5312138.6304	47.9547	-118.3473
642	CSM Unit 3	399075.2655	5308876.3601	47.9253	-118.3510
642	CSM Unit 3	398488.3346	5310388.8622	47.9388	-118.3592
640	CSM Unit 3	399543.1256	5306527.2679	47.9042	-118.3442
633	CSM Unit 3	394888.1888	5298252.7991	47.8290	-118.4045
630	CSM Unit 3	391064.1153	5301561.2741	47.8582	-118.4564
622	CSM Unit 3	383720.7709	5309442.3438	47.9277	-118.5566
617	CSM Unit 3	376117.8436	5310454.1125	47.9354	-118.6587
615	CSM Unit 3	372773.0327	5310180.1736	47.9323	-118.7034
609	CSM Unit 3	365474.6107	5308243.7408	47.9134	-118.8004
607	CSM Unit 3	363277.3454	5309964.2159	47.9284	-118.8304
607	CSM Unit 3	363029.3212	5310369.0399	47.9320	-118.8338
606	CSM Unit 3	363791.7652	5311551.4066	47.9428	-118.8240
606	CSM Unit 3	362853.6428	5311396.1753	47.9412	-118.8365
606	CSM Unit 3	363565.6871	5310783.2682	47.9358	-118.8268
606	CSM Unit 3	362719.5815	5310811.8786	47.9359	-118.8381
605	CSM Unit 3	361977.7758	5312566.5373	47.9515	-118.8486
605	CSM Unit 3	362738.2816	5312556.8751	47.9516	-118.8384
604	CSM Unit 3	360767.7616	5312910.7008	47.9544	-118.8649
604	CSM Unit 3	361535.2357	5312529.4221	47.9511	-118.8545
603	CSM Unit 3	359502.9597	5312933.1314	47.9543	-118.8818
602	CSM Unit 3	357524.0949	5312862.1105	47.9532	-118.9083
601	CSM Unit 3	356539.8783	5311225.6969	47.9383	-118.9209
599	CSM Unit 3	354493.9201	5311585.8752	47.9411	-118.9484
598	CSM Unit 3	352811.0635	5312741.3546	47.9511	-118.9713

Notes:

CSM = Conceptual Site Model

A Cultural Resources Working Group review of the proposed sample locations convened on August 7, 2012 and approved sediment sampling within 150 feet (Area = 70,686 ft^2 = 1.6 acres) of each of the above-listed sediment sampling positions (Letter from Dr. Laura Buelow of the U.S. Environmental Protection Agency dated August 24, 2012).

Table B1-2. Summary of Bioassay Endpoints

28-d *Hyalella azteca*	10-d *Chironomus dilutus*	42-d *Hyalella azteca*	Long-term *Chironomus dilutus*
• Survival • Weight & biomass	• Survival • Weight & biomass	• Survival (at Days 28, 35, and 42) • Weight & biomass (at Days 28 and 42) • Reproduction (at Days 35 and 42) • Number of adult males (at Days 42) • Number of adult females (at Days 42)	• Survival (at Day 20) • Weight and biomass (at Day 20) • Male and female emergence • Adult mortality • Number of egg cases oviposited • Number of eggs produced • Number of hatched eggs

Note:
Survival is measured as the number of surviving organisms divided by the initial number of organisms.
Weight is measured as the dry weight (*H. azteca*) or ash-free dry weight (*C. dilutus*) of surviving organisms divided by the number of surviving organisms.
Biomass is measured as the dry weight (*H. azteca*) or ash-free dry weight (*C. dilutus*) of surviving organisms divided by the initial number of organisms.
Reproduction is measured as the number of young divided by the number of females.

Table B1-3. Test Conditions for Conducting a 28-d Sediment Toxicity Test with *Hyalella azteca*

Parameter	Conditions
Test type	Whole-sediment toxicity test with renewal of overlying water
Temperature	23 ± 1°C
Light quality	Wide-spectrum fluorescent lights
Illuminance	About 500 lux
Photoperiod	16L:8D
Test chamber	300-mL high-form lipless beaker
Sediment volume	100 mL
Overlying water volume	175 mL
Renewal of overlying water	2 volume additions/d; continuous or intermittent (e.g., 1 volume addition every 12 h)
Age of organisms [a]	7- to 8-d old at the start of the test with a goal of achieving starting weights in the range of 0.02 to 0.035 mg/organism. The weight of a representative sample of organisms at the start of sediment exposures will be documented.
Number of organisms/chamber	10
Number of replicate chambers/treatment [a]	14 replicates: 8 for biological endpoints and 6 for chemistry only
Feeding [a]	YCT food: fed 1.0 mg YCT/day to each test chamber during Days 0 to 13, and 2 mg YCT/day to each test chamber during the remaining exposure (Days 14 to 27).
Aeration	None, unless DO in overlying water drops below 2.5 mg/L.
Overlying water [a]	Test water will consist of reconstituted water created using the methods specified in Borgmann (1996) but modified to contain 0.4 mg/L bromide.
Test chamber cleaning	If screens become clogged during a test, gently brush the *outside* of the screen.
Overlying water quality	Hardness, alkalinity, conductivity, pH, and ammonia at the beginning and end of a test. Temperature daily. Conductivity weekly. DO and pH three times/week. Concentrations of DO should be measured more often if DO drops more than 1 mg/L since the previous measurement.
Test duration [a]	28 d
Endpoints	Survival, weight, and biomass
Test acceptability	Minimum mean control survival of 80% on Day 28.

Source: USEPA (2000)

Notes:

[a] Modified from EPA standard method as directed by EPA (letters from Shawn D. Blocker on June 21, 2012 and Dr. Laura Buelow on August 24, 2012)

DO = dissolved oxygen

Table B1-4. Recommended Test Conditions for Conducting a 10-d Sediment Toxicity Test with *Chironomus dilutus*

Parameter	Conditions
Test type	Whole-sediment toxicity test with renewal of overlying water
Temperature	23 ± 1°C
Light quality	Wide-spectrum fluorescent lights
Illuminance	About 500 lux
Photoperiod	16L:8D
Test chamber	300-mL high-form lipless beaker
Sediment volume	100 mL
Overlying water volume	175 mL
Renewal of overlying water	2 volume additions/d; continuous or intermittent (e.g., 1 volume addition every 12 h)
Age of organisms [a]	Second- to third-instar larvae (about 10-d-old larvae; all organisms must be third instar or younger with approximately 50% of the organisms at second instar and approximately 50% of the organisms at third instar; goal to achieve a starting average weight of 0.12 mg/organism). The weight of a representative sample of organisms at the start of sediment exposures will be documented.
Number of organisms/chamber	10
Number of replicate chambers/treatment [a]	11 replicates: 8 for biological endpoints and 3 for chemistry only
Feeding [a]	TetraMin® goldfish food, 6 mg of particles fed daily to each test chamber.
Aeration	None, unless DO in overlying water drops below 2.5 mg/L.
Overlying water [a]	Reformulated moderately hard reconstituted water (as specified in USEPA [2000] page 25)
Test chamber cleaning	If screens become clogged during a test, gently brush the *outside* of the screen.
Overlying water quality	Hardness, alkalinity, conductivity, pH, and ammonia at the beginning and end of a test. Temperature and DO daily.
Test duration	10 d
Endpoints	Survival, weight, and biomass (AFDW)
Test acceptability	Minimum mean control survival must be 70%, with minimum mean weight/surviving control organism of 0.48 mg AFDW.

Source: USEPA (2000)

Notes:

[a] Modified from EPA standard method as directed by EPA (letters from Shawn D. Blocker on June 21, 2012 and Dr. Laura Buelow on August 24, 2012)

AFDW = ash-free dry weight

DO = dissolved oxygen

Table B1-5. Test Conditions for Conducting a 42-d Sediment Toxicity Test with *Hyalella azteca*

Parameter	Conditions
Test type	Whole-sediment toxicity test with renewal of overlying water
Temperature	23 ± 1°C
Light quality	Wide-spectrum fluorescent lights
Illuminance	About 500 lux
Photoperiod	16L:8D
Test chamber	300-mL high-form lipless beaker
Sediment volume	100 mL
Overlying water volume	175 mL in the sediment exposure from Day 0 to Day 28 (175 to 275 mL in the water-only exposure from Day 28 to Day 42)
Renewal of overlying water	2 volume additions/d; continuous or intermittent (e.g., 1 volume addition every 12 h)
Age of organisms [a]	7- to 8-d-old at the start of the test with a goal of achieving starting weights in the range of 0.02 to 0.035 mg/organism. The weight of a representative sample of organisms at the start of sediment exposures will be documented.
Number of organisms/chamber	10
Number of replicate chambers/treatment [a]	18 replicates: 12 for biological endpoints and 6 for chemistry only. Of the 12 replicates for biological endpoints, 4 replicates are for 28-d survival and growth and 8 replicates are for 35- and 42-d survival, growth, and reproduction.
Feeding [a]	YCT food: fed 1.0 mg YCT/day to each test chamber during Days 0 to 13, and 2 mg YCT/day to each test chamber during the remaining exposure (Days 14 to 42).
Aeration	None, unless DO in overlying water drops below 2.5 mg/L.
Overlying water [a]	Test water will consist of reconstituted water created using the methods specified in Borgmann (1996) but modified to contain 0.4 mg/L bromide.
Test chamber cleaning	If screens become clogged during a test, gently brush the *outside* of the screen.
Overlying water quality	Hardness, alkalinity, conductivity, and ammonia at the beginning and end of a sediment exposure (Day 0 and 28). Temperature daily. Conductivity weekly. DO and pH three times/week. Concentrations of DO should be measured more often if DO drops more than 1 mg/L since the previous measurement.
Test duration	42 d
Endpoints	28-d survival, weight, and biomass; 35-d survival and reproduction; and 42-d survival, weight, biomass reproduction, and number of adult males and females on Day 42.
Test acceptability	Minimum mean control survival of 80% on Day 28.

Source: USEPA (2000)

Notes:

[a] Modified from EPA standard method as directed by EPA (letters from Shawn D. Blocker on June 21, 2012 and Dr. Laura Buelow on August 24, 2012)

DO = dissolved oxygen

Table B1-6. Test Conditions for Conducting a Long-term Sediment Toxicity Test with *Chironomus dilutus*

Parameter	Conditions
Test type	Whole-sediment toxicity test with renewal of overlying water
Temperature	23 ± 1°C
Light quality	Wide-spectrum fluorescent lights
Illuminance	About 500 lux
Photoperiod	16L:8D
Test chamber	300-mL high-form lipless beaker
Sediment volume	100 mL
Overlying water volume	175 mL
Renewal of overlying water	2 volume additions/d; continuous or intermittent (e.g., 1 volume addition every 12 h)
Age of organisms	< 24-h-old larvae. The weight of a representative sample of organisms at the start of sediment exposures will be documented.
Number of organisms/chamber	12
Number of replicate chambers/treatment [a]	25 replicates: 16 for biological endpoints and 9 for chemistry only. Of the 16 replicates for biological endpoints, 4 replicates are created only to produce auxiliary males.
Feeding [a]	TetraMin® goldfish food, 6 mg of particles fed daily to each test chamber starting Day 1
Aeration	None, unless DO in overlying water drops below 2.5 mg/L.
Overlying water [a]	Reformulated moderately hard reconstituted water (as specified in USEPA 2000 page 25)
Test chamber cleaning	If screens become clogged during a test, gently brush the *outside* of the screen.
Overlying water quality	Hardness, alkalinity, conductivity, and ammonia at the beginning, on Day 20, and at the end of a test. Temperature daily (ideally continuously). DO and pH three times/week. Conductivity weekly. Concentrations of DO should be measured more often if DO has declined by more than 1 mg/L since the previous measurement.
Test duration	About 50 to 65 d; each treatment is ended separately when no additional emergence has been recorded for seven consecutive days. When no emergence is recorded from a treatment, termination of that treatment should be based on the control sediment using this 7-d criterion.
Endpoints	20-d survival, weight, and biomass; female and male emergence, adult mortality, the number of egg cases oviposited, the number of eggs produced, and the number of hatched eggs.
Test acceptability	Average size of *C. dilutus* in the control sediment at 20 d must be at least 0.6 mg/surviving organism as dry weight or 0.48 mg/surviving organism as AFDW. Emergence should be greater than or equal to 50%. Experience has shown that pupae survival is typically >83% and adult survival is >96%. Time to death after emergence is <6.5 d for males and <5.1 d for females. The mean number of eggs/egg case should be greater than or equal to 800 and the percent hatch should be greater than or equal to 80%.

Source: USEPA (2000)

Notes:

[a] Modified from EPA standard method as directed by EPA (letters from Shawn D. Blocker on June 21, 2012 and Dr. Laura Buelow on August 24, 2012)

AFDW = ash-free dry weight

DO = dissolved oxygen

Table B1-7. Test Acceptability Requirements for a 28-d Sediment Toxicity Test with *Hyalella azteca*

A.	It is recommended for conducting a 28-d test with *Hyalella azteca* that the following performance criteria be met	
	1.	Age of *H. azteca* at the start of the test should be 7- to 8-d old with a goal of achieving starting weights in the range of 0.02 to 0.035 mg/organism[a]. Starting a test with substantially younger or older organisms may compromise the reproductive endpoint.
	2.	Average survival of *H. azteca* in the control sediment on Day 28 should be greater than or equal to 80%. Mean weight of *H. azteca* in the control sediment on Day 28 should be greater than or equal to 0.4 mg dry/individual.[a]
	3.	Hardness, alkalinity, and ammonia in the overlying water typically should not vary by more than 50% during the sediment exposure, and DO should be maintained above 2.5 mg/L in the overlying water.
B.	Performance-based criteria for culturing *H. azteca* include the following	
	1.	It may be desirable for laboratories to periodically perform 96-h water-only reference-toxicity tests to assess the sensitivity of culture organisms. Data from these reference-toxicity tests could be used to assess genetic strain or life-stage sensitivity of test organisms to select chemicals.
	2.	Laboratories should track parental survival in the cultures and record this information using control charts if known-age cultures are maintained. Records should also be kept on the frequency of restarting cultures and the age of brood organisms.
	3.	Laboratories should record the following water quality characteristics of the cultures at least quarterly: pH, hardness, alkalinity, and ammonia. Dissolved oxygen in the cultures should be measured weekly. Temperature of the cultures should be recorded daily. If static cultures are used, it may be desirable to measure water quality more frequently.
	4.	Laboratories should characterize and monitor background contamination and nutrient quality of food if problems are observed in culturing or testing organisms.
	5.	Physiological measurements such as lipid content might provide useful information regarding the health of the cultures.
C.	Additional requirements	
	1.	All organisms in a test must be from the same source. If organisms are purchased, vendor information must be reported.
	2.	All test chambers (and compartments) should be identical and should contain the same amount of sediment and overlying water.
	3.	Standard negative-control sediment, quartz sand negative control sediment[a], and appropriate solvent controls must be included in a test. The concentration of solvent used must not adversely affect test organisms.
	4.	Test organisms must be cultured and tested at 23°C (±1°C).
	5.	The daily mean test temperature must be within ±1°C of 23°C. The instantaneous temperature must always be within ±3°C of 23°C.
	6.	Natural physio-chemical characteristics of test sediment collected from the field should be within the tolerance limits of the test organisms (see USEPA [2000] for standard tolerance limits).
	7.	Source of overlying water and control sediments must be documented and reported.

Source: USEPA (2000)

Notes:

[a] Modified from EPA standard method as directed by EPA (letter from Shawn D. Blocker on June 21, 2012 and Dr. Laura Buelow on August 24, 2012)

DO = dissolved oxygen

Table B1-8. Test Acceptability Requirements for a 10-d Sediment Toxicity Test with *Chironomus dilutus*

A.	It is recommended for conducting a 10-d test with *C. dilutus* that the following performance criteria be met	
	1.	Tests must be started with second- to third-instar larvae (about 10-d-old larvae) with a goal of achieving a starting average weight of 0.12 mg/organism[a].
	2.	Average survival of *C. dilutus* in the control sediment must be greater than or equal to 70% at the end of the test.
	3.	Average size of *C. dilutus* in the control sediment must be at least 0.48 mg AFDW at the end of the test.
	4.	Hardness, alkalinity, and ammonia in the overlying water typically should not vary by more than 50% during the test, and DO should be maintained above 2.5 mg/L in the overlying water.
B.	Performance-based criteria for culturing *C. dilutus* include the following	
	1.	It may be desirable for laboratories to periodically perform 96-h water-only reference-toxicity tests to assess the sensitivity of culture organisms. Data from these reference-toxicity tests could be used to assess genetic strain or life-stage sensitivity of test organisms to select chemicals.
	2.	Laboratories should keep a record of time to first emergence for each culture and record this information using control charts. Records should also be kept on the frequency of restarting cultures.
	3.	Laboratories should record the following water quality characteristics of the cultures at least quarterly: pH, hardness, alkalinity, and ammonia. DO in the cultures should be measured weekly. Temperature of the cultures should be recorded daily. If static cultures are used, it may be desirable to measure water quality more frequently.
	4.	Laboratories should characterize and monitor background contamination and nutrient quality of food if problems are observed in culturing or testing organisms.
	5.	Physiological measurements such as lipid content might provide useful information regarding the health of the cultures.
C.	Additional requirements	
	1.	All organisms in a test must be from the same source. If organisms are purchased, vendor information must be reported.
	2.	All test chambers (and compartments) should be identical and should contain the same amount of sediment and overlying water.
	3.	Standard negative-control sediment, quartz sand negative control sediment[a], and appropriate solvent controls must be included in a test. The concentration of solvent used must not adversely affect test organisms.
	4.	Test organisms must be cultured and tested at 23°C (±1°C).
	5.	The daily mean test temperature must be within ±1°C of 23°C. The instantaneous temperature must always be within ±3°C of 23°C.
	6.	Natural physio-chemical characteristics of test sediment collected from the field should be within the tolerance limits of the test organisms. (see USEPA [2000] for standard tolerance limits).
	7.	Source of overlying water and control sediments must be documented and reported.

Source: USEPA (2000)

Notes:

[a] Modified from EPA standard method as directed by EPA (letters from Shawn D. Blocker on June 21, 2012 and Dr. Laura Buelow on August 24, 2012)

AFDW = ash-free dry weight

DO = dissolved oxygen

Table B1-9. Test Acceptability Requirements for a 42-d Sediment Toxicity Test with *Hyalella azteca*

A.	It is recommended for conducting a 42-d test with *H. azteca* that the following performance criteria be met	
	1.	Age of *H. azteca* at the start of the test should be 7- to 8-d-old with a goal of achieving starting weights in the range of 0.02 to 0.035 mg/organism[a]. Starting a test with substantially younger or older organisms may compromise the reproductive endpoint.
	2.	Average survival of *H. azteca* in the control sediment on Day 28 should be greater than or equal to 80%. Mean weight of *H. azteca* in the control sediment should be greater than or equal to 0.4 mg dry/individual on Day 28, and greater than or equal to 0.5 mg dry/individual on Day 42.[a]
	3.	Laboratories participating in round-robin testing reported after 28-d sediment exposures in a control sediment, survival >80% for >88% of the laboratories; length >3.2 mm/individual for >71% of the laboratories; and dry weight >0.15 mg/individual for >66% of the laboratories. Reproduction from Day 28 to Day 42 was >2 young/female for >71% of the laboratories participating in the round-robin testing. Reproduction was more variable within and among laboratories; hence, more replicates might be needed to establish statistical differences among treatments with this endpoint.
	4.	Hardness, alkalinity, and ammonia in the overlying water typically should not vary by more than 50% during the sediment exposure, and DO should be maintained above 2.5 mg/L in the overlying water.
B.	Performance-based criteria for culturing *H. azteca* include the following	
	1.	It may be desirable for laboratories to periodically perform 96-h water-only reference-toxicity tests to assess the sensitivity of culture organisms. Data from these reference-toxicity tests could be used to assess genetic strain or life-stage sensitivity of test organisms to select chemicals.
	2.	Laboratories should track parental survival in the cultures and record this information using control charts if known-age cultures are maintained. Records should also be kept on the frequency of restarting cultures and the age of brood organisms.
	3.	Laboratories should record the following water quality characteristics of the cultures at least quarterly: pH, hardness, alkalinity, and ammonia. DO in the cultures should be measured weekly. Temperature of the cultures should be recorded daily. If static cultures are used, it may be desirable to measure water quality more frequently.
	4.	Laboratories should characterize and monitor background contamination and nutrient quality of food if problems are observed in culturing or testing organisms.
	5.	Physiological measurements such as lipid content might provide useful information regarding the health of the cultures.
C.	Additional requirements	
	1.	All organisms in a test must be from the same source. If organisms are purchased, vendor information must be reported.
	2.	All test chambers (and compartments) should be identical and should contain the same amount of sediment and overlying water.
	3.	Standard negative-control sediment, quartz sand negative control sediment[a], and appropriate solvent controls must be included in a test. The concentration of solvent used must not adversely affect test organisms.
	4.	Test organisms must be cultured and tested at 23°C (±1°C).
	5.	The daily mean test temperature must be within ±1°C of 23°C. The instantaneous temperature must always be within ±3°C of 23°C.
	6.	Natural physio-chemical characteristics of test sediment collected from the field should be within the tolerance limits of the test organisms. (See USEPA [2000] for standard tolerance limits).
	7.	Source of overlying water and control sediments must be documented and reported.

Source: USEPA (2000)

Notes:

[a] Modified from EPA standard method as directed by EPA (letters from Shawn D. Blocker on June 21, 2012 and Dr. Laura Buelow on August 24, 2012)

DO = dissolved oxygen

Table B1-10. Test Acceptability Requirements for a Long-term Sediment Toxicity Test with *Chironomus dilutus*

A.	It is recommended for conducting a long-term test with *C. dilutus* that the following performance criteria be met	
	1.	Tests must be started with less than 1-d- (<24-h) old larvae. Starting a test with substantially older organisms may compromise the emergence and reproductive endpoint.
	2.	Average survival of *C. dilutus* in the control sediment must be greater than or equal to 70% on Day 20 and greater than 65% at the end of the test.
	3.	Average size of *C. dilutus* in the control sediment at 20 d must be at least 0.6 mg/surviving organism as dry weight or 0.48 mg/surviving organism as AFDW. Emergence should be greater than or equal to 50%. Experience has shown that pupae survival is typically >83% and adult survival is >96%. Time to death after emergence is <6.5 d for males and <5.1 d for females. The mean number of eggs/egg case should be greater than or equal to 800 and the percent hatch should be greater than or equal to 80%.
	4.	Hardness, alkalinity, and ammonia in the overlying water typically should not vary by more than 50% during the test, and DO should be maintained above 2.5 mg/L in the overlying water.
B.	Performance-based criteria for culturing *C. dilutus* include the following	
	1.	It may be desirable for laboratories to periodically perform 96-h water-only reference-toxicity tests to assess the sensitivity of culture organisms. Data from these reference-toxicity tests could be used to assess genetic strain or life-stage sensitivity of test organisms to select chemicals.
	2.	Laboratories should keep a record of time to first emergence for each culture and record this information using control charts. Records should also be kept on the frequency of restarting cultures.
	3.	Laboratories should record the following water quality characteristics of the cultures at least quarterly: pH, hardness, alkalinity, and ammonia. DO in the cultures should be measured weekly. Temperature of the cultures should be recorded daily. If static cultures are used, it may be desirable to measure water quality more frequently.
	4.	Laboratories should characterize and monitor background contamination and nutrient quality of food if problems are observed in culturing or testing organisms.
	5.	Physiological measurements such as lipid content might provide useful information regarding the health of the cultures.
C.	Additional requirements	
	1.	All organisms in a test must be from the same source. If organisms are purchased, the vendor information must be reported.
	2.	All test chambers (and compartments) should be identical and should contain the same amount of sediment and overlying water.
	3.	Standard negative-control sediment, quartz sand negative control sediment[a], and appropriate solvent controls must be included in a test. The concentration of solvent used must not adversely affect test organisms.
	4.	Test organisms must be cultured and tested at 23°C (±1°C).
	5.	The daily mean test temperature must be within ±1°C of 23°C. The instantaneous temperature must always be within ±3°C of 23°C.
	6.	Natural physio-chemical characteristics of test sediment collected from the field should be within the tolerance limits of the test organisms. (See USEPA [2000] for standard tolerance limits).
	7.	Source of overlying water and control sediments must be documented and reported.

Source: USEPA (2000)

Notes:

[a] Modified from EPA standard method as directed by EPA (letters from Shawn D. Blocker on June 21, 2012 and Dr. Laura Buelow on August 24, 2012)

AFDW = ash-free dry weight
DO = dissolved oxygen

Table B3-1. Sampling Containers, Preservation, and Holding Time Requirements for Sediment Chemistry

Priority	Analysis	Container Type	Container Size	Filtered	Preservation	Holding Time	Proposed Laboratory Sample Size	Total Minimum Sample Size Needed [a, b]
1	TAL metals, percent moisture	WMG	8 oz	NA	4±2ºC			337 g
	EPA 6020A metals					6 months	10 g	
	EPA 6010C metals					6 months	10 g	
2	Mercury					28 days	5 g	
2	pH					7 days	20 g	
2	Total organic carbon					28 days	1 g	
2	AVS/SEM	WMG	8 oz	NA	No headspace, 4±2ºC	14 days	25 g	
3	Grain size	WMG	4 oz	NA	4±2ºC	6 months	100 g	
3	Backscatter electron microscopy	WMG	16 oz	NA	4±2ºC	NA	5 g	
3	Archival						161 g	
1	Bioassay	Plastic	15 gal	NA	4±2ºC	ASAP	12 gal	12 gal

Notes:

[a] Total sample size does not include additional sample volumes needed for laboratory quality control or field duplicate samples. If sufficient sample volume is available, attempt to fill all sample containers provided. If insufficient sample volume is available, fill containers to laboratory minimiums in order of priority and then fill the priority containers with any remaining sample.

[b] Project field duplicate samples should be collected for 10 percent of all analytical samples and submitted blind to the analytical laboratory. In addition, EPA split samples (containing at least 200 g) will be collected for 15 percent of all analytical samples by EPA.

ASAP = as soon as possible
AVS/SEM = acid volatile sulfide/simultaneously extracted metals
TAL = target analyte list
NA = not applicable
WMG = wide-mouth glass

Table B3-2. Sample Containers, Preservation, and Holding Time Requirements for Porewater

Priority Rating		Container Type	Container Size (mL)	Filtered	Preservation	Holding Time	Proposed Minimum Laboratory Sample Size (mL) [a]
1	**Dissolved TAL Metals**						
	Aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, manganese, nickel, selenium, silver, thallium, vanadium, and zinc	HDPE	50	Filtered	1 mL of 20% HNO_3, pH<2; 4±2ºC	6 months	20
	Calcium, iron, magnesium, potassium, and sodium						20
2	**Organic Carbon**						
	DOC [b]	HDPE	50	Not filtered	4 ± 2ºC	28 days	25
	TOC					28 days	20
3	**Conventional Parameters [c]**						
3.1	pH	HDPE	50	Not filtered	4 ± 2ºC	ASAP	15
3.2	Alkalinity as $CaCO_3$					14 days	25
3.3	Hardness [d]					6 months	
3.4	Chloride, sulfate					28 days	10
						Total (mL) ≥	135
				Syringe volume = maximum porewater volume available (mL) =			140

Notes:

[a] If sufficient sample volume is available, attempt to fill all sample containers provided. If insufficient sample volume is available, fill containers to laboratory minimiums in order of priority and then fill the priority containers with any remaining sample.

[b] The chain-of-custody for DOC must be marked "lab filter needed"

[c] Minimum sample volumes for the hierarchy of listed conventional analytes to be analyzed by the laboratory are as follows: pH = 15 mL; alkalinity/hardness = 25 mL; and chloride & sulfate = 10 mL.

[d] Hardness will be calculated per: equivalent $CaCO_3$ = 2.5 (mg Ca^{2+}/L) + 4.1(mg Mg^{2+}/L).

ASAP = as soon as possible

$CaCO_3$ = calcium carbonate

DOC = dissolved organic carbon

HDPE = high density polyethylene bottle

HNO_3 = nitric acid

TAL = target analyte list

TOC = total organic carbon

Table B4-1. Number of Samples for Analytical Chemistry and Bioassay Measurements

Sample Analysis [a]	Media	Number of Sediment Sampling Locations	Number of Replicate Chambers per Location	Number of Assessments per Chamber	Number of Analyses from all Locations
Analytical Chemistry					
Sediment	Sediment	140	NA	NA	140
Field porewater	Porewater	140	NA	NA	140
Bioassay					
28-d *H. azteca*	Biota	74	8	1	592
Lab porewater	Porewater (peeper)[b]	74	6	0.3	148
	Porewater (centrifuge)[c]	74	NA	NA	74
10-d *C. dilutus*	Biota	74	8	1	592
Lab porewater	Porewater (peeper)[b]	74	3	0.3	74
	Porewater (centrifuge)[c]	74	NA	NA	74
42-d *H. azteca* [d]	Biota	18	12	1	216
Lab porewater	Porewater (peeper)[b]	18	6	0.3	36
	Porewater (centrifuge)	18	NA	NA	18
Long-term *C. dilutus* [d]	Biota	18	16 [e]	1	288 [e]
Lab porewater	Porewater (peeper)[b]	18	9	0.3	54
	Porewater (centrifuge)	18	NA	NA	18
				Sediment total	140
				Biota total	1,688
				Porewater total	636

Notes:

[a] Does not include routine water quality monitoring (e.g., for temperature, dissolved oxygen, pH, conductivity) that will be conducted to ensure that the tests are conducted under standard conditions.

[b] Lab porewater will be collected using Brumbaugh type peepers in the "chemistry only" replicate test chambers. Porewater from the Brumbaugh type peepers in three replicate test chambers will be combined into a single sample to provide as much volume as possible for analytical measurements.

[c] Lab porewater will be sampled from each sediment sample selected for short-term toxicity tests at the start of exposures using centrifugation. These porewater samples will be analyzed for DOC, pH, alkalinity, sulfide, major cations, and major anions to inform the BLM for interpreting toxicity data.

[d] Bulk sediment chemistry, porewater metals (from peepers), and BLM parameters (from centrifuged sediment) will be analyzed anew prior to longer-term reproduction toxicity tests.

[e] Four test chambers will be populated with *C. dilutus* for each sediment location in order to produce auxiliary males for possible use in the latter steps of the long-term *C. dilutus* bioassay tests. These chambers are not true replicates and will not be measured for biological endpoints.

NA = not applicable

Table B5-1. Measurement Quality Objectives for Sediment Samples

Parameter	Analytical Accuracy (% recovery)	Analytical Precision (relative % deviation)	Overall Completeness (percent)
Metals	75-125	20	90
Mercury	75-125	20	90
TOC	70-125	20	90
AVS	55-145	45	90
SEM	75-125	30	90
Grain Size	NA	NA	NA

Notes:
AVS = acid volatile sulfide
SEM = simultaneously extracted metals
TOC = total organic carbon
NA = not applicable

Table B5-2. Measurement Quality Objectives for Porewater Samples

Analysis	Analytical Accuracy (% recovery)	Analytical Precision (relative % deviation)	Overall Completeness (percent)
TOC and DOC	80-120	17	90
Alkalinity as $CaCO_3$	NA	20	90
Hardness as $CaCO_3$	90-120	20	90
Cations/anions	90-110	20	90
Metals and metalloids	75-125	20	90

Notes:

$CaCO_3$ = calcium carbonate

TOC = total organic carbon

DOC = dissolved organic carbon

NA = not applicable

APPENDIX B

TECHNICAL MEMORANDUM
UPPER COLUMBIA RIVER
GEOGRAPHICAL INFORMATION
SYSTEM-BASED SURFACE
SEDIMENT BED MAPPING

CONTENTS

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ACRONYMS AND ABBREVIATIONS

BERA	Baseline Ecological Risk Assessment
CSM	conceptual site model
EPA	U.S. Environmental Protection Agency
GIS	Geographic Information System
mPECQ	mean probable effect concentration quotient
PEC	probable effect concentration
PECQ	probable effect concentration quotient
QAPP	quality assurance project plan
RMS	root-mean-square
RMSE	root-mean-square error
s-n	streamwise-normal
TOC	total organic carbon
UCR	Upper Columbia River
Zn/V	zinc-to-vanadium

UNITS OF MEASURE

cm	centimeter
ft	feet
in.	inches
m	meter
mg/kg	milligrams per kilogram
mm	millimeter

1 INTRODUCTION

Measurements from prior sediment investigations, including U.S. Environmental Protection Agency (EPA) Phase 1 efforts, were used to examine Upper Columbia River (UCR) surface sediment gradients (i.e., how different sediment constituents change with location) and define characteristic ranges (i.e., "bins") for representative bed properties. Site measurements were used to examine gradients in terms of spatial relationships for metals identified as having the primary potential to be risk drivers–zinc; copper; lead; and cadmium. To account for differences in cross-channel conditions, gradients were also examined for shallow (<24 m; <80 ft)[1] and deep (>24 m; >80 ft) water areas of the site. As determined in consultation with EPA, site measurements were used to define composite sediment bed properties that may be relevant indicators of factors that influence exposure potential, including zinc-to-vanadium (Zn/V) ratio; total organic carbon (TOC); and mean probable effects concentration quotient (mPECQ). Site measurements were also used to define sediment texture.

Categorical bins (i.e., high, medium, and low) for each composite bed property were developed and then used to develop Geographical Information System (GIS)-based bed property maps to visually define and illustrate distinct groupings of sediment properties. Composite properties were spatially interpolated. Joint variations of interpolated composite bed properties were used to define distinct sediment groups that represent a spectrum of site conditions and gradients. Using the composite bed properties presented herein (i.e., mPECQ, TOC, and Zn/V ratio), EPA re-evaluated the binning process and proposed an alternative, as detailed within Appendix F of the Phase 2 Sediment Study quality assurance project plan (QAPP). EPA's alternative categorical binning process (see Appendix F) was used to guide and select sediment sampling locations for Phase 2 sediment sampling activities. Further to EPA's August 24, 2012 correspondence, EPA does not consider the analyses presented in this Appendix as final, but rather as a point of departure resulting in Appendix F. EPA's approval of the QAPP does not include approval of Appendix B.

[1] These depth zones were operationally defined in the Baseline Ecological Risk Assessment (BERA) Work Plan (TAI 2011).

2 SURFACE SEDIMENT GRADIENT ANALYSIS

Surface sediment gradients were examined using measurements collected as part of prior site investigations (Table B2-1). Data from prior investigations are compiled into a site-specific database. Site gradients were defined by examining spatial patterns for four metals that are anticipated to be primary risk drivers in UCR sediment. Those metals are zinc, copper, lead, and cadmium. Measurements for those four metals were also used in combination with measurements for TOC, sediment grain size, and vanadium to examine gradients in terms of composite sediment bed properties. Composite bed properties selected for purposes of identifying site gradients and proposed sample collection locations were 1) Zn/V ratio; 2) TOC; 3) mPECQ; and 4) sediment texture. Composite bed properties were spatially interpolated using geostatistical methods (i.e., cokriging). Joint variations of composite bed properties were used to define distinct sediment groups that represent a spectrum of site conditions and anticipated gradients for future sampling.

2.1 SEDIMENT MEASUREMENTS

Data from prior investigations are compiled into a database using Microsoft Access software (hereafter called the database) and are accessible at http://teck-ucr.exponent.com/. Database contents and organization are described in the Data Management Plan: Amendment No. 1 (TAI 2010). The dataset for gradient analysis was derived from 20 studies. Descriptions of these 20 studies are presented in Table B2-1. A map of the site with sediment sample locations by study is presented in Map B2-1.

Surface sediment measurements for all samples with a starting depth at the sediment-water interface were retrieved from the database. These samples typically represent conditions in the top 6 in. (15 cm) of the sediment column.[2] The data retrieved include all sediment data uploaded through August 25, 2010. As an initial step in the analysis process, data were filtered using the GIS selection tool to include all sediment samples collected from locations within 100 m (330 ft) of the river shoreline elevation at high pool. This filtering step retains sediment samples collected from locations within the UCR as well as those near tributary mouths while removing samples from more distant tributary locations. Additional filtering was performed using the GIS selection tool. For zinc, copper, lead, cadmium, vanadium, and TOC, total chemical measurements for whole sediment samples were selected. Whole sediment samples are designated as "Sediment", "Sediment <2 mm", and "Sediment -2 mm" in the database.

[2] Sample types include surface grabs and cores. Sample thickness can vary with collection technique.

Table B2-1. Summary of Upper Columbia River Sediment Studies

Reference Tag [a]	Citation [b]	Study ID	Cd	Cu	Pb	Zn	V	TOC	GS [c]
Besser et al. (2007)	Besser, John M.; Brumbaugh, William G.; Ivey, Chris D.; Ingersoll, Christopher G.; Moran, Patrick W. 2007. Biological and Chemical Characterization of Metal Bioavailability in Sediments from Lake Roosevelt, Columbia River, Washington, USA. Archives of Environmental Contamination Toxicology	USGS_04_LR	√	√	√	√			√
Bortleson et al. (2001)	Compliments Bortleson study presents as 'Bortleson et al., 2001' , and as a subset of 'USGS, 2005'	SRC_Bortleson	√	√	√	√	√	√	
Cox et al. (2005)	Cox, S.E., P.R. Bell, J.S. Lowther, and P.C. VanMetre. 2005. Vertical Distribution of Trace-Element Concentrations and Occurrence of Metallurgical Slag Particles in Accumulated Bed Sediments of Lake Roosevelt, Washington, September 2002. Scientific Investigations Report 2004-5090. USGS	USGS_Cox2005	√	√	√	√	√	√	
Dowling (2007)	Brendan Dowling. 2007. Field Reconnaissance and Sediment Sampling Report - Upper Columbia River Site Washington. WA DOE, Toxics Cleanup Program.	WADOE_2007	√	√	√	√			
Johnson et al. (1989)	Johnson, A., D. Norton, and B. Yake. 1989. An Assessment of Metal Contamination in Lake Roosevelt. WA DOE.	Johnson et al. 1989							√
Paulson et al. (2006)	Anthony J. Paulson, Richard J. Wagner, Richard F. Sanzolone, and Steven E. Cox. 2006. Data tables for: Concentrations of Elements in Sediments and Selective Fractions of Sediments, and in Natural Waters in Contact with Sediments from Lake Roosevelt, Washington, September 2004. Open-File Report 2006-1350. USGS prepared in cooperation with the National Park Service. 2006/12/27.	USGS_04_LR	√	√	√	√	√		√
SRC (2008a)	SRC. 2008. SRC Database - July 2008 mdb. SRC.	Ecology1990-1993	√	√	√	√		√	
SRC (2008b)	SRC. 2008. SRC Database - July 2008 mdb. SRC.	Ecology1990Sed/Fish						√	
SRC (2008c)	SRC. 2008. SRC Database - July 2008 mdb. SRC.	Ecology1994						√	
SRC (2008d)	SRC. 2008. SRC Database - July 2008 mdb. SRC.	SCCD1996	√	√	√	√			
Teck (2010a)	Teck American. 2010. 2010 Beach Sediment Study for the Teck American Incorporated RI/FS.	Teck_2010_BeachSD	√	√	√	√	√		√
Teck (2010b)	Teck American. 2010. 2010 White Sturgeon Sediment Toxicity Testing for the Teck American Incorporated RI/FS.	Teck_2010_Sturgeon_SedTox							
Teck (2009)	Integral Consulting. 2009. 2009 Beach Sediment Study for the Teck American Incorporated RI/FS. Integral Consulting.	Teck_2009_BeachSD	√	√	√	√	√	√	√
USEPA (2002)	USEPA. 2002. Preliminary Assessments and Site Inspections Report Upper Columbia River Mines and Mills, Stevens County, Washington TDD: 01-02-0028	USEPA2002Mines/Mills	√	√	√	√	√		
USEPA (2003)	E&E Inc. and R. F. Weston. 2003. Upper Columbia River Expanded Site Inspection Report, Northeast Washington (Region 10, START-2). U.S. EPA / Weston. 2003/03/01.	USEPA_2001_ESI	√	√	√	√	√	√	√

Table B2-1. Summary of Upper Columbia River Sediment Studies (continued)

Reference Tag [a]	Citation [b]	Study ID	Cd	Cu	Pb	Zn	V	TOC	GS [c]
USEPA (2005) [d]	CH2M-Hill. 2006. CH2MHILL ftp site 7_2_06 UCR. (U.S. EPA Phase I Sediment Study, 2005')	USEPA 2005 Sediment	√	√	√	√	√	√	√
USGS (1984)	USGS. 1984. Water Quality Samples for the Nation USGS 12400520 COLUMBIA RIVER AT NORTHPORT, WA. U.S. Geological Survey - Water Resources Discipline. Historical surface water and suspended sediment data ranging from 11/15/1951 to 9/27/2000.	USGS_Northp	√	√	√	√			
USGS (2003a)	USGS. 2003. 2003. USGS_Northport.xls (from CH2M-Hill database, via Parametrix).	USGS. 2003	√	√	√	√			
USGS (2005)	USGS. 2005. USGS_Data1a: USGS_Data2a: SevenB.xls (from CH2M-Hill database via Parametrix).	USGS. 2005	√	√	√	√			
Ecology (2003)	Ecology 2003b. 2003. WRIA42.XLS (from CH2M-Hill database, via Parametrix).	Ecology 2001	√	√	√	√	√	√	√

Notes:

[a] Reference Tags used as labels for legends on maps and graphics.

[b] Citations correspond to UCR database.

[c] GS = Grain size.

[d] Publication for USEPA 2005 Phase I Sediment Study is USEPA (2006).

Total chemical measurements include all analytical methods except sequential extraction (i.e., all data except "ICP_MS_SSE" were included). Data filtering procedures to select total chemical measurements for whole sediment samples are presented in Table B2-2. For sediment grain size, all data designated as sediment size fractions (e.g. "Sediment") were selected. Sediment grain size classes (e.g. very coarse, coarse, medium, fine, and very fine) were categorized into four sediment categorical classes–gravel, sand, silt, and clay. Sediment texture grain size classes are presented in Table B2-3.

Table B2-2. Data Filtering Procedures to Select Total Chemical Measurements

Analyte	GIS selection query code
Zn, Cu, Pb, Cd, and V	("method_code" <> 'ICP_MS_SSE') AND ("material_analyzed" = 'Sediment' OR "material_analyzed" = 'Sediment-2mm' OR "material_analyzed" = 'Sediment<2mm')
TOC	("method_code" <> 'ICP_MS_SSE') AND ("material_analyzed" = 'Sediment' OR "material_analyzed" = 'Sediment-2mm' OR "material_analyzed" = 'Sediment<2mm') AND ("LAB_REP"<> '2')

Table B2-3. Sediment Texture Grain Size Classes

Reference Tag	Measurement	Assigned Class
Besser et al. (2007)	Sand	Sand
	Silt	Silt
	Clay	Clay
Johnson et al. (1989)	Gravel	Gravel
	Sand	Sand
	Silt	Silt
	Clay	Clay
Paulson et al. (2006)	Sand	Sand
	Silt	Silt
	Clay	Clay
Teck (2010a)	Cobbles + VCoarseGravel + CoarseGravel + Med_ Gravel + Fine_Gravel + VFine_Gravel	Gravel
	VCoarseSand + CoarseSand + Med. Sand + Fine_Sand + VeryFineSand	Sand
	Silt	Silt
	Clay	Clay
Teck (2009)[a]	Cobbles + VCoarseGravel + CoarseGravel + Med_ Gravel + Fine_Gravel + VFine_Gravel	Gravel
	VCoarseSand + CoarseSand + Med. Sand + Fine_Sand + VeryFineSand	Sand
	Silt	Silt
	Clay	Clay
USEPA (2003)	Gravel	Gravel
	Sand	Sand
	Silt	Silt
	Clay	Clay

Table B2-3. Sediment Texture Grain Size Classes (continued)

Reference Tag	Measurement	Assigned Class
USEPA (2005)[a]	Gravel	Gravel
	CoarseSand + Med. Sand + Fine_Sand	Sand
	Silt	Silt
	Clay + Colloids	Clay
WADOE (2003)	Gravel	Gravel
	Sand	Sand
	Silt	Silt
	Clay	Clay
Bortleson et al. (2001)	Percent fines only	Not Used
Johnson (1991)	Percent fines only	Not Used
USGS (2003a)	Percent fines only	Not Used
USGS (2005)	Percent fines only	Not Used

[a] Citation corresponds to UCR database listed in Table B2-1.

2.2 GRADIENTS FOR PRIMARY RISK DRIVERS IN SEDIMENT

Gradients represent patterns of how concentrations change with distance downstream as well as with water depth. Zinc, copper, lead, and cadmium concentrations in UCR surface sediments at sampling locations from prior investigations are presented as functions of river mile and water depth in Figure B2-1. Shallow water includes areas where water depths are 24 m (~80 ft) or less. Deep water includes areas where water depths exceed 24 m. Using this approach, gradients can be visualized on a point-wise basis.

Different metals exhibit different gradients. Zinc and copper have gradients that decrease rapidly in Reaches 1 and 2 (conceptual site model [CSM] Unit 1), are intermediate in Reach 3 (CSM Unit 2), and lowest in Reaches 4 through 6 (CSM Unit 3). Lead shows a pattern of more gradually decreasing concentrations across all reaches. In contrast, cadmium concentrations are highly variable and do not appear to exhibit strong gradients. However, all metals tend to exhibit lower concentrations in sediments from shallow water locations than from deep water locations.

2.3 GRADIENTS FOR COMPOSITE SEDIMENT BED PROPERTIES

Surface sediment measurements were also used to examine gradients in terms of composite bed properties assumed to be indicators of factors that influence exposure potential. Composite properties used for this analysis are 1) Zn/V ratio; 2) TOC; 3) mPECQ; and 4) sediment texture. Descriptions and characteristic ranges (i.e., "bins") for these properties are presented in Table B2-4.

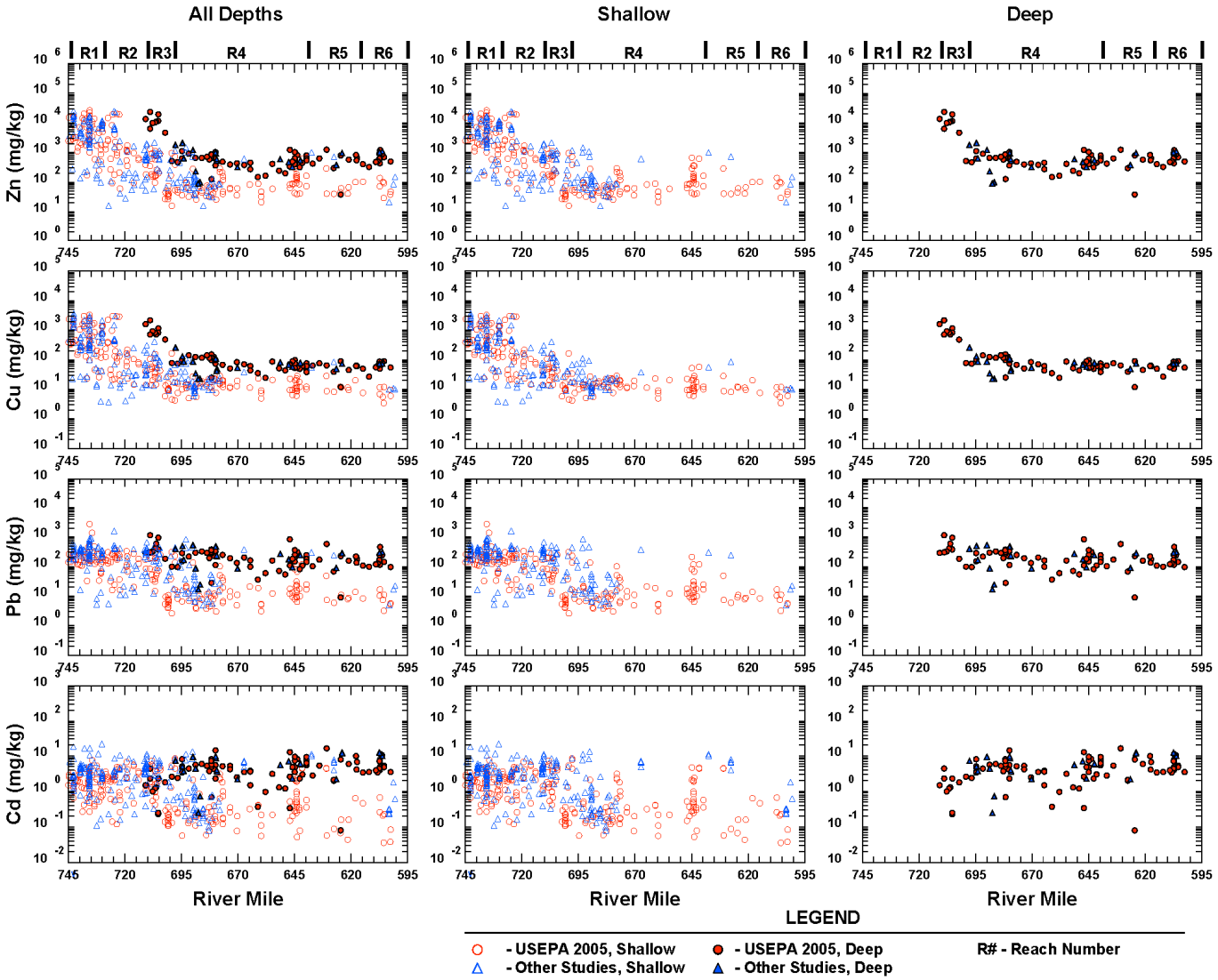

Figure B2-1. Upper Columbia River Sediment Zn, Cu, Pb, and Cd Gradients

Table B2-4. Summary of Zn/V, TOC, mPECQ and Texture Bins Used to Categorize Sediments

	Characteristic Bin			
Bed Property	High	Medium		Low
Zn/V	> 50	10 – 50		< 10
TOC	> 10,000 mg/kg	5,000 – 10,000 mg/kg		< 5,000 mg/kg
mPECQ	> 2	0.2 – 2		< 0.2
Texture	Gravelly	Mixed	Sandy	Muddy
Gravel	> 20%	< 20%	< 40%	< 40%
Sand	< 40%	> 40%	> 40%	< 40%
Mud (Silt and Clay)	< 40%	40 – 60%	< 40%	> 40%

Bins for Zn/V ratios were employed as described in Appendix D of the Baseline Ecological Risk Assessment (BERA) work plan (TAI 2011). TOC was used as an indicator of potential bioavailability. Bins for TOC values were identified based on the 75th and 50th percentiles of the probability distribution for all site sediment TOC measurements. Estimated mPECQ values, as determined from concentrations of four metals expected to be primary risk drivers (zinc, copper, lead, and cadmium), were used as an indicator of potential effects.[3] Procedures used to calculate mPECQ values are presented in Attachment B1. Bins for mPECQ values were developed based on discussions between the EPA-led Government team and TAI during the January 20 through 21, 2010 meeting in Seattle, Washington. Sediment texture was used as a general index of sediment type. Bins for sediment texture were based on percentages of gravel, sand, and "mud" in each sample as presented in the texture diagram shown in Figure B2-2. Mud was subjectively defined as the sum of silt and clay.

Zn/V, TOC, mPECQ, and sediment texture values for UCR surface sediments at sampling locations from prior investigations are presented as functions of river mile and water depth in Figure B2-3. Different bed properties exhibit different gradients. Zn/V ratios and mPECQ values are very similar and have gradients that are highest in Reaches 1 and 2 (CSM Unit 1), are intermediate in Reach 3 (CSM Unit 2), and are low to intermediate in

[3] As described by MacDonald et al. (2000), mPECQ values are defined based on eight metals–arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc. For UCR sediment gradient analyses, mPECQ values were approximated using measurements for the four primary metal risk drivers–zinc, copper, lead, and cadmium. The remaining metals are not expected to be significant components of overall mPECQ values and are not expected to be contributors to site risks for sediments. PECQ values for arsenic, chromium, mercury, and nickel are usually lower than for zinc, copper, lead, and cadmium. Also, mPECQ values approximated using the four primary metals are typically greater than values calculated for all eight metals because the sums of PECQ values are divided by four rather than eight. For example, mPECQ values for the four primary metals average 2.04 and a have a maximum of 22.44 while values for eight metals average 1.14 and have a maximum of 11.63.

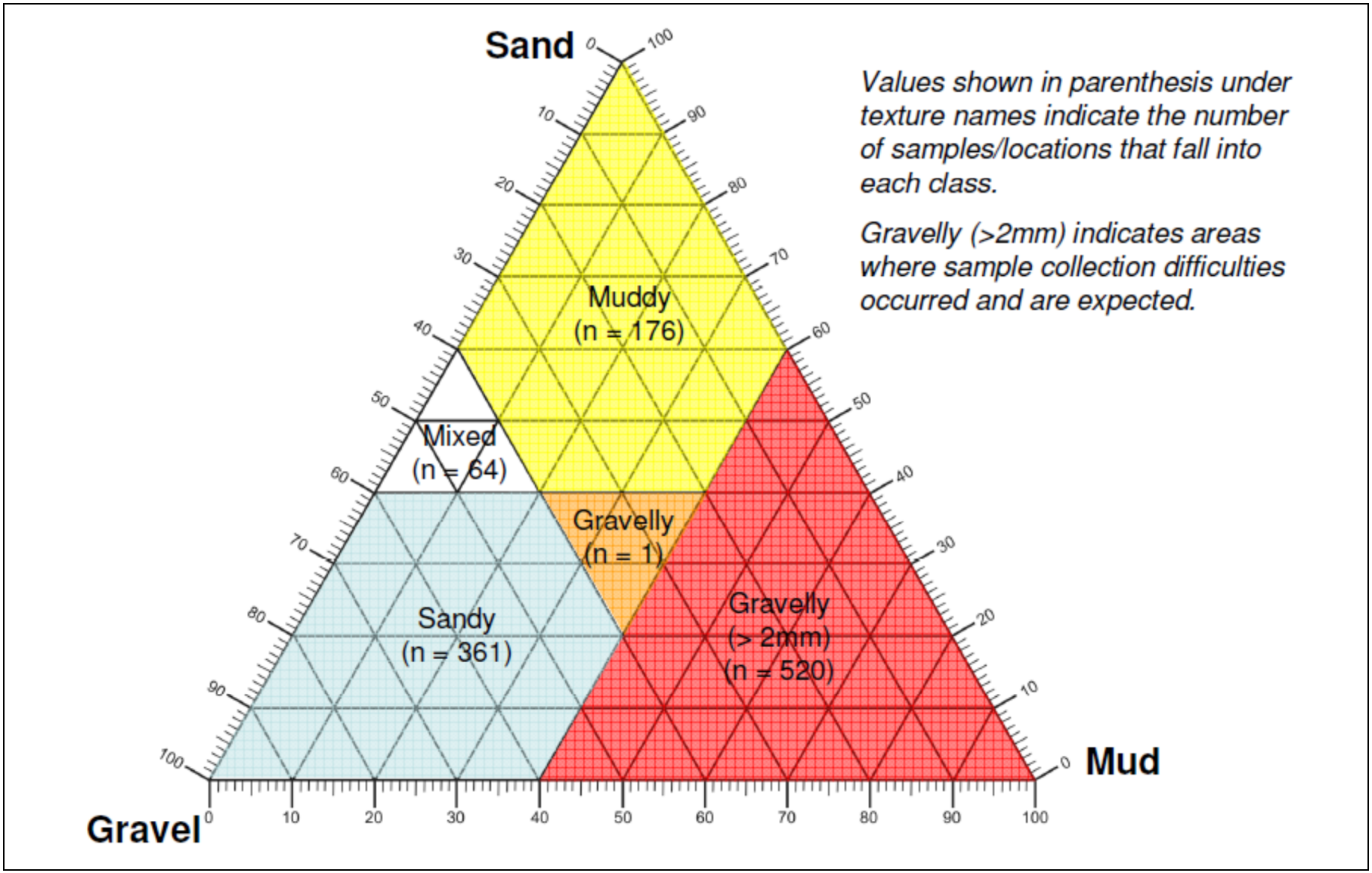

Figure B2-2. Upper Columbia River Sediment Texture Class Diagram

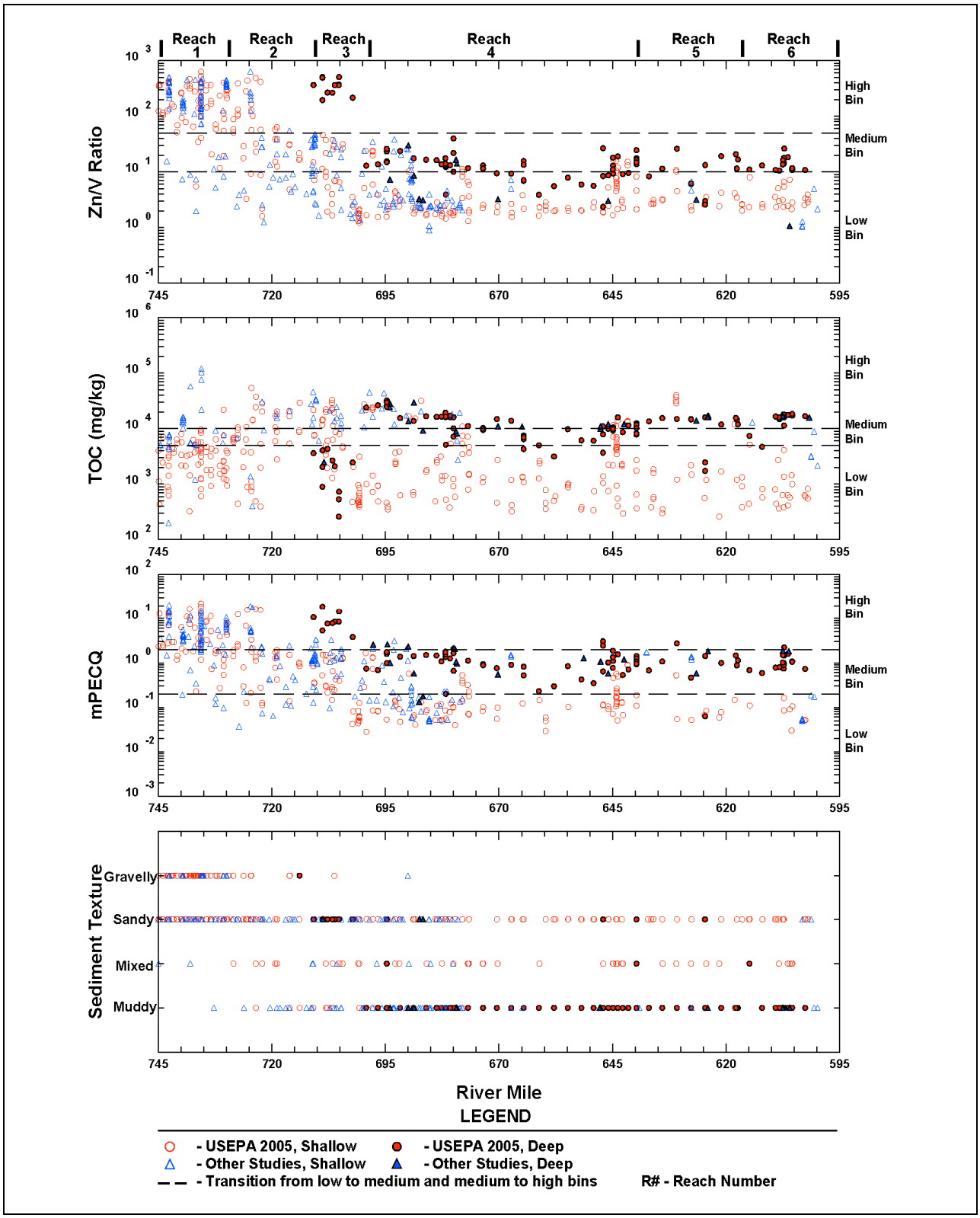

Figure B2-3. Upper Columbia River Sediment Zn/V, TOC, mPECQ, and Texture Gradients

Reaches 4 through 6 (CSM Unit 3). Zn/V ratios and mPECQ values for sediments in deep water tend to be somewhat higher than values for sediments in shallow water. Patterns for TOC are more variable. However, TOC values for sediments in deep water tend to be higher than values for sediments in shallow water. Sediment texture tends to be gravelly to sandy in Reaches 1 and 2, transitions to sandy and muddy textures in Reaches 3 through 6, and is predominantly muddy in sediments from deep water areas of Reaches 4 through 6.

Upstream, higher Zn/V ratios and mPECQ values tend to occur in gravelly to sandy areas (Reaches 1 and 2). Downstream, low Zn/V and mPECQ values tend to occur in sandy, shallow water areas with low to intermediate values occurring in muddy, deep water areas (Reaches 4 through 6). Trends between Zn/V, mPECQ, and texture in Reach 3 are variable. It is worth noting that strong correlation (r^2=0.914) exists between mPECQ values and Zn/V ratios as presented in Figure B2-4.

2.4 GEOSTATISTICAL SPATIAL INTERPOLATION OF COMPOSITE SEDIMENT BED PROPERTIES

Sediment bed properties were spatially interpolated using geostatistical methods. This interpolation step was performed to estimate bed properties on a continuous basis over the study area (i.e., over the entire area of the river bed). Zn/V ratio, TOC, mPECQ, and grain size (gravel, sand, silt, and clay percentages[4]) were interpolated by cokriging using sediment bed elevation data[5] (USCGS 1950) as a covariate. Bed elevations were used as a covariate because they have a much higher spatial density than any other data source (consisting of more than 120,000 individual values) and also because the data reflect predominant trends in cross-channel (i.e., shallow versus deep) and axial (i.e., upstream versus downstream) directions.

All interpolations were performed in channel-fitted coordinates. Data were transformed from Cartesian (x,y) to streamwise-normal (s-n) coordinates using a modified version of the approach described by Legleiter and Kyriakidis (2006). This transformation re-maps the river from a meandering system in Cartesian space to a linear system in channel-fitted coordinate space. Use of channel-fitted coordinates helps better represent flow distances between points along the river and is important for areas such as river bends and other locations where river orientation changes.

[4] Silt and clay were interpolated separately and then summed to provide estimates for mud.

[5] Water depth soundings were converted to sediment bed elevations by subtracting measured water depths from the reference elevation datum for the measurements.

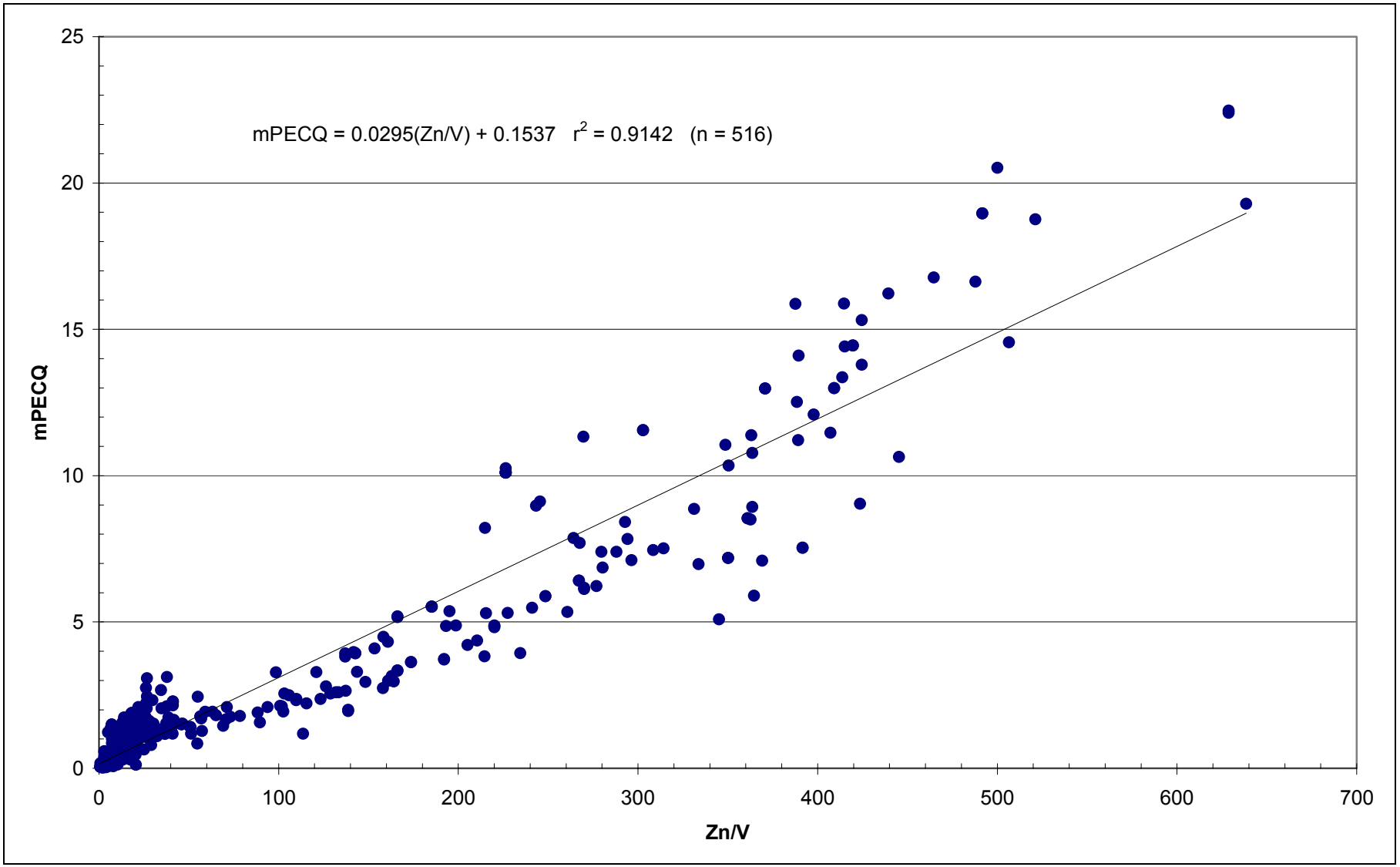

Figure B2-4. Relationship Between Sediment mPECQ Values and Zn/V Ratios

Cokriging was performed using ESRI ArcGIS 9.3 software with the Geostatistical Analyst extension. Cokriging (and kriging in general) depends on differences between measurements at distant locations and how those differences change with location. Distances between locations are divided into regular blocks (lags). The relationship between differences in measurements over blocked distances defines the empirical semivariogram. A modeled semivariogram is used to approximate the relationship expressed by the empirical semivariogram as part of cokriging. Modeled semivariogram form depends on several parameters, including model function, lag size, number of lags, nugget, partial sill, and major and minor ranges. Semivariogram parameter values were obtained by experimentation (i.e., trail and error) in combination with values estimated by the software. A summary of semivariogram parameter values is presented in Table B2-5. Semivariogram parameter exploration results are presented in Table B2-6. Efforts were made to optimize parameters by systematically varying lag size, number of lags, nugget, and major and minor range values to reduce errors and bias in cross-validation statistics reported by the software (e.g., lowest root-mean-square error with

Table B2-5. Summary of Cokriging-semivariogram Parameters and Cross-validation Statistics

Statistics	Zn/V Ratio	TOC	mPECQ	Gravel	Sand	Silt	Clay	Probability of Percent Gravel Exceeding 40%
Cokriging Semivariogram Parameters								
Model Function	Spherical	Spherical	Spherical	Spherical	Spherical	Spherical	Spherical	Exponential
Lag Size	75	75	75	75	75	75	75	30
# Lags	40	40	40	40	40	40	40	20
Nugget	0.40631	0.74982	0.45229	0	0	0	0	0
Partial Sill	1.5197	1.0237	1.5576	4379.6	1814.9	210.4	69.032	0.25211
Major Range	3000	3000	3000	3000	3000	3000	3000	1200
Minor Range	1500	800	1500	800	200	200	1500	200
Cross-Validation								
RMS Error	94.71	10450	3.272	29.73	32.18	17.25	13.2	0.2944
Regression Slope	0.887	0.268	0.752	0.903	0.548	0.634	0.343	-

Notes:

Parameters were obtained by experimentation in combination with values estimated by Geostatistical Analyst software extension in order to minimize cross-validation root-mean-square (RMS) errors and obtain a regression slope between interpolated and measured values that was as close to unity (i.e., the 1:1 line of perfect agreement) as could be achieved. The threshold parameter for probability cokriging was set to 40% gravel. In all cases, sediment bed elevation was used as the secondary variable (covariate) for cokriging.

Table B2-6. Summary of Semivariogram Parameter Range Explorations

ZnV

Variations in Lag Size

No Anisotropy; Major range = (lag size)*(# of lags)

Lag Size	# of Lags	RMSE[a]	Slope
75	20	96.98	0.906
75	40	92.82	0.846
75	80	88.32	0.787
75	100	87.56	0.784
150	50	87.56	0.784
150	80	86.77	0.747
150	100	86.69	0.731

Variations in Major Range

Lag Size = 75; Number of Lags = 40

Major Range	Minor Range	RMSE	Slope
500	3000	91.46	0.876
1000	3000	96.03	0.862
1500	3000	96.39	0.872
2000	3000	94.76	0.883
2500	3000	93.97	0.869

Variations in Minor Range

Lag Size = 75; Number of Lags = 40

Major Range	Minor Range	RMSE	Slope
3000	500	97.32	0.927
3000	1000	100.60	0.856
3000	1500	94.71	0.887
3000	2000	94.93	0.865
3000	2500	94.51	0.884

TOC

No Anisotropy; Major range = (lag size)*(# of lags)

Lag Size	# of Lags	RMSE	Slope
75	20	10680	0.223
75	40	10640	0.183
75	80	10510	0.148
75	100	10360	0.133
150	50	10360	0.133
150	80	10110	0.141
150	100	10030	0.113

Lag Size = 75; Number of Lags = 40

Major Range	Minor Range	RMSE	Slope
500	3000	10700	0.230
800	3000	10710	0.242
1000	3000	10720	0.217
1500	3000	10760	0.217
2000	3000	10750	0.210
2500	3000	10680	0.205

Lag Size = 75; Number of Lags = 40

Major Range	Minor Range	RMSE	Slope
3000	500	10320	0.274
3000	800	10450	0.268
3000	1000	10500	0.251
3000	1500	10580	0.221
3000	2000	10600	0.195
3000	2500	10620	0.229

mPECQ

No Anisotropy; Major range = (lag size)*(# of lags)

Lag Size	# of Lags	RMSE	Slope
75	20	3.395	0.734
75	40	3.159	0.696
75	80	2.961	0.714
75	100	2.925	0.701
150	50	2.925	0.701
150	80	2.882	0.658
150	100	2.874	0.642

Lag Size = 75; Number of Lags = 40

Major Range	Minor Range	RMSE	Slope
500	3000	3.217	0.767
1000	3000	3.323	0.735
1500	3000	3.263	0.713
2000	3000	3.238	0.705
2500	3000	3.198	0.701

Lag Size = 75; Number of Lags = 40

Major Range	Minor Range	RMSE	Slope
3000	500	3.244	0.769
3000	1000	3.316	0.778
3000	1500	3.272	0.752
3000	2000	3.226	0.757
3000	2500	3.188	0.736

Table B2-6. Summary of Semivariogram Parameter Range Explorations (continued)

Gravel

Variations in Lag Size				*Variations in Major Range*				*Variations in Minor Range*			
No Anisotropy; Major range = (lag size)*(# of lags)				Lag Size = 75; Number of Lags = 40				Lag Size = 75; Number of Lags = 40			
Major Range	Minor Range	RMSE	Slope	Major Range	Minor Range	RMSE	Slope	Major Range	Minor Range	RMSE	Slope
75	20	30.88	0.894	200	3000	30.15	0.899	3000	200	27.92	0.897
75	40	30.91	0.887	800	3000	31.44	0.890	3000	800	29.73	0.903
75	80	30.88	0.886	1000	3000	31.62	0.885	3000	1000	29.9	0.900
150	50	30.87	0.886	1500	3000	31.55	0.885	3000	1500	30.22	0.895
150	80	30.86	0.886	2000	3000	31.3	0.884	3000	2000	30.48	0.890
150	100	30.85	0.886	2500	3000	31.1	0.887	3000	2500	30.72	0.886

Sand

No Anisotropy; Major range = (lag size)*(# of lags)				Lag Size = 75; Number of Lags = 40				Lag Size = 75; Number of Lags = 40			
Major Range	Minor Range	RMSE	Slope	Major Range	Minor Range	RMSE	Slope	Major Range	Minor Range	RMSE	Slope
75	20	34.62	0.518	200	3000	34.84	0.494	3000	200	32.18	0.548
75	40	35.32	0.527	500	3000	35.33	0.490	3000	500	32.78	0.560
75	80	35.6	0.518	1000	3000	35.46	0.497	3000	1000	33.75	0.540
150	50	35.7	0.516	1500	3000	35.6	0.587	3000	1500	34.36	0.540
150	80	35.68	0.518	2000	3000	35.6	0.507	3000	2000	34.78	0.532
150	100	35.63	0.519	2500	3000	35.47	0.517	3000	2500	35.09	0.524

Silt

No Anisotropy; Major range = (lag size)*(# of lags)				Lag Size = 75; Number of Lags = 40				Lag Size = 75; Number of Lags = 40			
Major Range	Minor Range	RMSE	Slope	Major Range	Minor Range	RMSE	Slope	Major Range	Minor Range	RMSE	Slope
75	20	19.25	0.559	200	3000	18.87	0.582	3000	200	17.25	0.634
75	40	20	0.561	500	3000	19.22	0.588	3000	500	18.2	0.623
75	80	20.25	0.571	1000	3000	19.63	0.574	3000	1000	18.93	0.577
150	50	20.32	0.571	1500	3000	19.87	0.565	3000	1500	19.36	0.571
150	80	20.24	0.578	2000	3000	19.98	0.565	3000	2000	19.65	0.564
150	100	20.21	0.574	2500	3000	20.03	0.565	3000	2500	19.85	0.566

Table B2-6. Summary of Semivariogram Parameter Range Explorations (continued)

	Variations in Lag Size				*Variations in Major Range*				*Variations in Minor Range*			
	No Anisotropy; Major range = (lag size)*(# of lags)				Lag Size = 75; Number of Lags = 40				Lag Size = 75; Number of Lags = 40			
	Major Range	Minor Range	RMSE	Slope	Major Range	Minor Range	RMSE	Slope	Major Range	Minor Range	RMSE	Slope
Clay	75	20	13.21	0.347	200	3000	12.48	0.332	3000	200	12.48	0.334
	75	40	13.55	0.356	500	3000	13.08	0.354	3000	500	12.82	0.308
	75	80	13.69	0.328	1000	3000	13.42	0.349	3000	1000	13.07	0.328
	150	50	13.69	0.326	1500	3000	13.58	0.351	3000	1500	13.20	0.343
	150	80	13.66	0.326	2000	3000	13.57	0.353	3000	2000	13.38	0.339
	150	100	13.65	0.326	2500	3000	13.55	0.351	3000	2500	13.48	0.346
	No Anisotropy; Major range = (lag size)*(# of lags)				Lag Size = 75; Number of Lags = 40				Lag Size = 75; Number of Lags = 40			
	Major Range	Minor Range	RMSE		Major Range	Minor Range	RMSE		Major Range	Minor Range	RMSE	
Probability Gravel > 40%	30	20	0.2957		200	1200	0.2992		1200	200	0.2944	
	30	40	0.3034		400	1200	0.3001		1200	400	0.2963	
	30	80	0.3082		800	1200	0.3028		1200	800	0.3003	
	75	20	0.3051		200	600	0.2926		600	200	0.2880	
	75	40	0.3093		300	600	0.2944		600	400	0.2918	
	75	80	0.3118									

[a] RMSE = root-mean-square error

regression slopes closest to unity). Semivariograms for sediment bed elevation and other interpolated bed properties are presented in Attachment B2. Interpolation results were mapped on a 30 m by 30 m raster grid scale. At this scale, the river bed area is represented as 336,670 grid cells.

Zn/V ratios were cokriged using logarithms of the data and included all samples where both zinc and vanadium were measured. There were 586 locations where concurrent zinc and vanadium measurements existed. An overview of Zn/V ratio interpolation results is shown in Map B2-2. TOC was cokriged using logarithms of the data and included 464 locations where measurements existed. An overview of TOC interpolation results is shown in Map B2-3. Estimated mPECQ values were cokriged using logarithms of the data and included all samples where zinc, copper, lead, and cadmium were measured. There were 565 locations where concurrent measurements of the four metals existed. An overview of mPECQ value interpolation results is shown in Map B2-4.

Grain size components were cokriged using data for which percentages of gravel, sand, silt, and clay were measured. There were 938 locations where grain size was measured. As part of data processing prior to cokriging, data were combined into regular grain size classes. For example, if a dataset reported measurements for three sand-sized particle types (e.g., coarse sand, medium sand, and fine sand), data for those particle types were summed to yield the total percentage of sand in a sample. Locations where gravel was not reported were assumed to have zero percent gravel content. Locations where samples could not be collected were assumed to have one hundred percent gravel content, representative of the presence of gravel-sized or larger bed materials. As part of data processing following cokriging, interpolated values were normalized (i.e., divided by the sum of all grain size components) to ensure that grain size percentages summed to exactly one hundred percent. Sediment texture was determined from normalized interpolation results using sediment texture classes depicted in Figure B2-2. An overview of interpolated sediment texture results is shown in Map B2-5.

Locations where the sediments are expected to be predominantly comprised of gravel-sized or larger (>2 mm) particles were estimated by probability cokriging gravel percentage with bed elevation. The primary threshold parameter was set to an exceedence probability of 40 percent gravel. This threshold value was selected because none of the sediment samples collected as part of EPA Phase I efforts had a gravel content that exceeded 40 percent. Sediments with a predominant texture >2 mm were mapped as areas where gravel content was estimated to exceed 40 percent at a probability of 0.5 (50 percent) or greater. Gravelly sediment (> 2mm) areas estimated by probability cokriging are expected to be a lower bound for the extent of all gravelly textured sediment.

More detailed ("zoom-in") maps displaying interpolation results for Zn/V ratio, TOC, mPECQ, and sediment texture are presented in Attachment B3.

2.5 CHARACTERISTIC SEDIMENT GROUPS

Sediments were categorized into characteristic groups based on joint variation of interpolated Zn/V, TOC, and mPECQ results ("primary bed properties"). Each primary bed property was categorized into their respective high, medium, and low bins. Combinations of the three primary properties in their three bins results in 3^3 or 27 possible combinations (categories). Within the GIS software, a unique category was assigned to each 30-m raster cell used to represent the sediment bed as determined by the interpolated Zn/V, TOC, and mPECQ bins that occurred in each cell. The 27 categories were further combined into 10 sediment groups with distinct characteristics. A summary of sediment categories and groups and their respective characteristics is presented in Table B2-7.

The sediment bed surface area and percentage of total river area assigned to each sediment category and group was determined from interpolation results. Zn/V ratio and TOC values for each group represent individual bins for these properties while mPECQ values represent a predominant mPECQ value. As inferred from interpolated Zn/V ratios and mPECQ values, Groups 1 through 3 represent sediments that may have the greatest potential for metal exposure. Other groups are expected to have lower exposure. Potential internal reference areas represent sediments that have characteristically low mPECQ values (<0.2), low Zn/V ratio (<10), and a range of TOC values. An overview map showing spatial distributions of sediment groups is presented in Map B2-6. More detailed ("zoom-in") maps displaying sediment groups are presented in Attachment B4.

Table B2-7. Summary of Sediment Category and Group Characteristics

Sediment Category Characteristics						Sediment Group Characteristics					
Category	ZnV	TOC	mPECQ	Area (m^2)	Area (%)	Group	Zn/V	TOC	Predominant mPECQ	Area (m^2)	Area (%)
1	High	High	High	5,707,800	1.88						
2	High	High	Medium	540,900	0.18	1	High	High	High	6,248,700	2.06
3	High	High	Low	0	0.00						
4	High	Medium	High	11,713,500	3.87						
5	High	Medium	Medium	1,049,400	0.35	2	High	Medium	High	12,762,900	4.21
6	High	Medium	Low	0	0.00						
7	High	Low	High	5,030,100	1.66						
8	High	Low	Medium	367,200	0.12	3	High	Low	High	5,397,300	1.78
9	High	Low	Low	0	0.00						
10	Medium	High	High	11,547,000	3.81						
11	Medium	High	Medium	76,212,000	25.15	4	Medium	High	Medium	88,003,800	29.04
12	Medium	High	Low	244,800	0.08						
13	Medium	Medium	High	3,328,200	1.10						
14	Medium	Medium	Medium	33,845,400	11.17	5	Medium	Medium	Medium	37,323,900	12.32
15	Medium	Medium	Low	150,300	0.05						
16	Medium	Low	High	1,320,300	0.44						
17	Medium	Low	Medium	9,600,300	3.17	6	Medium	Low	Medium	11,841,300	3.91
18	Medium	Low	Low	920,700	0.30						
19	Low	High	High	304,200	0.10	7	Medium	High	Medium	27,838,800	9.19
20	Low	High	Medium	27,534,600	9.09						
21	Low	High	Low	2,880,900	0.95	IR	Low	High	Low		
22	Low	Medium	High	287,100	0.09	8	Medium	Medium	Medium	38,987,100	12.87
23	Low	Medium	Medium	38,700,000	12.77						
24	Low	Medium	Low	2,785,500	0.92	IR	Low	Medium	Low		
25	Low	Low	High	961,200	0.32	9	Medium	Low	Medium	63,567,000	20.98
26	Low	Low	Medium	62,605,800	20.66						
27	Low	Low	Low	5,365,800	1.77	IR	Low	Low	Low	11,032,200	3.64

Notes:

Categories were determined based on joint variation (i.e., intersection) of Zn/V, TOC, and mPECQ bins.
Groups were defined by combining categories and assigning a predominant mPECQ bin.
Predominant mPECQ bins were determined by the mPECQ bin associated with the category that has the largest surface area in the group.
IR = potential internal reference area.

3 REFERENCES

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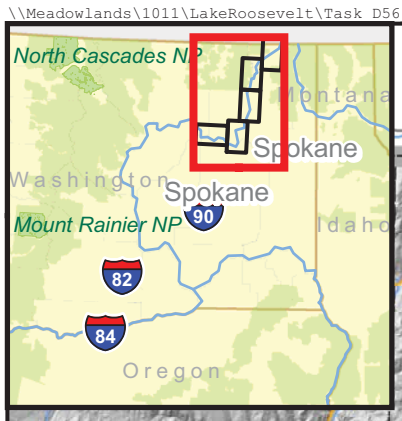
Maps

\\Meadowlands\1011\LakeRoosevelt\Task D56 Sediment QAPP Memo\Map Docs\Sediment Mapping\UCRTemplate-Study Samples.mxd @ 10-29-2010



U.S.- Canada Border

Grand Forks

Danville

Laurier

Velvet

Northport

Toroda

Kettle River

Curlew

Goldstake

Orient

Bodie

Toroda Creek

Old Toroda

Malo

Karamin

Wauconda

Old Wauconda

Pollard

Torboy

Republic

Barstow

Boyds

Marble

Ryan

Onion Creek

Spirit

Deep Lake Boundary

Aladdin

Chewelah

Reach 1

Reach 2

Reach 3

Reach 4

Reach 5

Reach 6

CSM Unit 1

CSM Unit 2

CSM Unit 3

Harter

Echo

Clugston Creek

Onion Creek

Ward

Greenwood

Pinkney City

Park Rapids

Orin

Arden

Colville River

Aeneas Valley

Aeneas

Okanogan

Lyman Lake Moses Mountain

Bia Road 64

Gold Creek

West Fork

Ferry

Arzina

Rice

Stevens

Waterloo

Daisy

Addy

Fairview

Bingville

Maud

Gifford

Addy Gifford

Bluecreek

Cozy Nook

Colville Indian Reservation

Covada

Bissel

Kewa

Cedonia Addy

Carrs Corner

Waits

Cedonia

Kulzer

Nespelem

Hunters

Fruitland

Springdale Hunters

Turk

Deer Trail

Camas

Enterprise

Belvedere

Douglas

Koontzville

Lone Pine

Mason City

Loot Agents (subdivision)

Spokane Indian Reservation

Osborne

Bagdad Junction

Miles

Wellpinit

Seven Bays

Lincoln

Sherman

Little Falls

Long Lake

Wilbur

Creston

Govan

Hanson

Telford

Mondovi

Reardan

Davenport

Rocklyn

Omans

Gravelles

Elanor

Farwell

Crescent

Grant

Lincoln

Kiner

Legend

- Populated Places
- Reservations
- County Lines
- 24 Meter Water Depth Contour
- Reach Boundary

Study Locations

- USGS (1984)
- USGS (2003a)
- USGS (2005)
- Besser et al. (2007)
- Cox et al. (2005)
- Teck (2009)
- Teck (2010a)
- Dowling (2007)
- Ecology (2003)
- SRC (2008a)
- SRC (2008b)
- SRC (2008c)
- Bortleson et al. (2001)
- Johnson et al. (1989)
- SRC (2008d)
- USEPA (2002)
- USEPA (2003)
- USEPA (2005)

HydroQual Inc.

0 5 10 Km

0 5 10 Miles

N

Map B2-1. **Sediment Mapping Study Locations**

Upper Columbia River, WA

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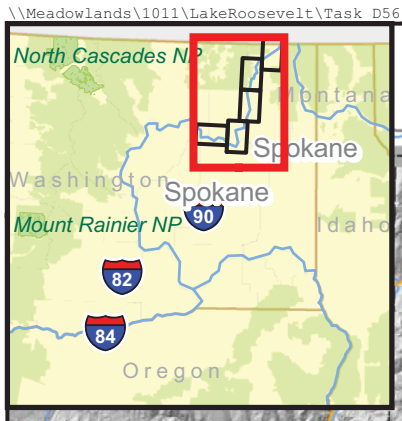

U.S.- Canada Border

Tile 1

Tile 2

Tile 3

Tile 4

Tile 5

Colville Indian Reservation

Spokane Indian Reservation

Grand Forks
Danville
Laurier
Velvet
Leadpoint
Toroda
Kettle River
Curlew
Goldstake
Orient
Marble
Spirit
Deep Lake Boundary
Bodie
Toroda Creek
Old Toroda
Malo
Karamin
Ryan
Barstow
Bossburg
Onion Creek
Wauconda
Old Wauconda
Pollard
Boyds
Evans
Aladdin
Torboy
Republic
Marcus
Harter
Echo
Chiliqua Creek
Onion Creek
Kettle Falls
Ward
Greenwood
Pinkney City
Park Rapids
Aeneas Valley
Aeneas
Okanogan
Lyman Lake Moses Mountain
Big Road 64
Gold Creek
West Fork
Ferry
Arzina
Rice
Stevens
Arden
Colville River
Waterloo
Daisy
Addy
Fairview
Bingville
Maud
Bluecreek
Cozy Nook
Impach
Gifford
Addy Gifford
Meteor
Chewelah
Covada
Bissel
Kewa
Cedonia Addy
Carrs Corner
Waits
Nespelem
Sanpoil River
Cedonia
Kulzer
Hunters
Grays
Springdale Hunters
Keller
Belvedere
Fruitland
Cline
Douglas
Seatons Grove
Turk
Camas
Elmer City
Deer Trail
Enterprise
Lone Pine
Osborne
Bagdad Junction
Hesseltine
Miles
Wellpinit
Seven Bays
Lincoln
Sherman
Little Falls
Wilbur
Creston
Hanson
Govan
Telford
Mondovi
Reardan
Davenport
Grant
Rocklyn
Lincoln
Omans
Gravelles
Elanor
Kiner
Farwell
Crescent

Legend

- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Field Sample)
- Sediment > 2mm (Interpolated)

Zinc to Vanadium Ratio Samples
- < 10
- 10 - 50
- > 50

Zinc to Vanadium Ratio Interpolation
- < 10
- 10 - 50
- > 50

HydroQual Inc.

Km 0 5 10

Miles 0 5 10

N

Map B2-2. **Overview of Interpolated Sediment Zn/V Ratios**

Upper Columbia River, WA

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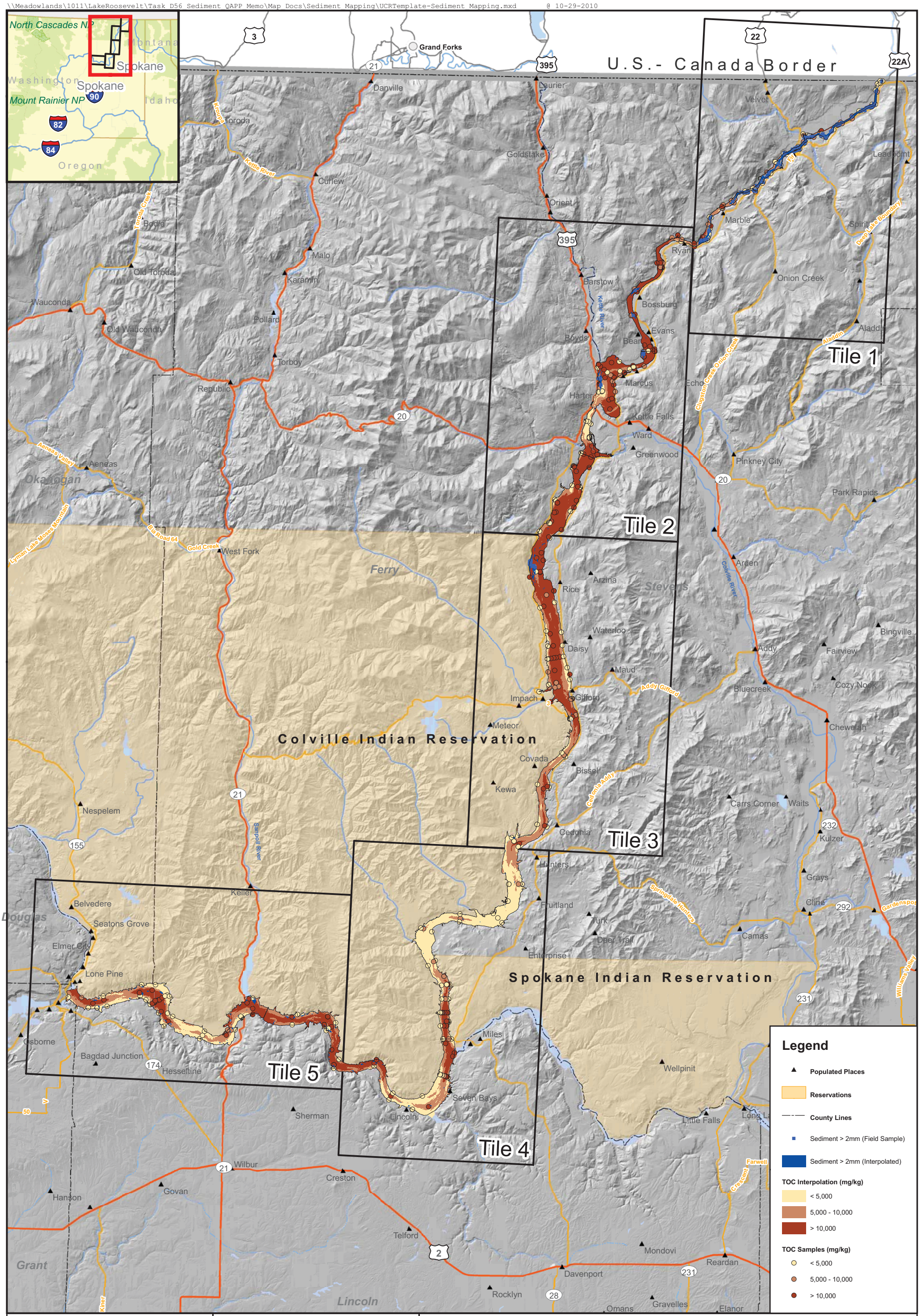


HydroQual Inc.

0 5 10 Km

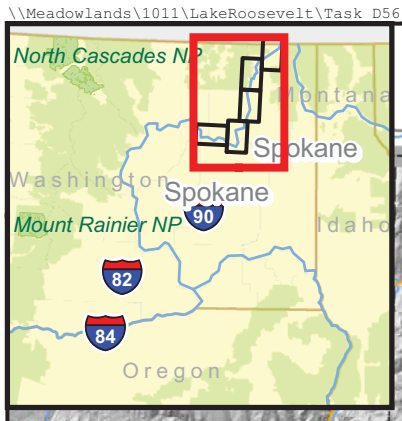
0 5 10 Miles

N

Map B2-3. **Overview of Interpolated Sediment TOC Values**

Upper Columbia River, WA

\\Meadowlands\1011\LakeRoosevelt\Task D56 Sediment QAPP Memo\Map Docs\Sediment Mapping\UCRTemplate-Sediment Mapping.mxd @ 10-29-2010



U.S.- Canada Border

Tile 1

Tile 2

Tile 3

Tile 4

Tile 5

Colville Indian Reservation

Spokane Indian Reservation

Grand Forks
Danville
Laurier
Velvet
Leadpoint
Goldstake
Orient
Marble
Spirit
Onion Creek
Ryan
Barstow
Bossburg
Evans
Boyds
Bear
Marcus
Harter
Kettle Falls
Ward
Greenwood
Pinkney City
Park Rapids
Arden
Arzina
Rice
Waterloo
Daisy
Maud
Impach
Gifford
Meteor
Covada
Bissel
Kewa
Cedonia
Addy
Bluecreek
Fairview
Cozy Nook
Chewelah
Bingville
Carrs Corner
Waits
Kulzer
Grays
Cline
Camas
Hunters
Fruitland
Turk
Deer Trail
Enterprise
Miles
Seven Bays
Lincoln
Wellpinit
Little Falls
Sherman
Wilbur
Creston
Govan
Hanson
Telford
Mondovi
Reardan
Davenport
Rocklyn
Omans
Gravelles
Elanor
Toroda
Bodie
Old Toroda
Malo
Karamin
Pollard
Torboy
Wauconda
Old Wauconda
Republic
Aeneas
Aeneas Valley
Okanogan
Lyman Lake Moses Mountain
Bia Road 64
Gold Creek
West Fork
Ferry
Nespelem
Keller
Belvedere
Seatons Grove
Elmer City
Lone Pine
Douglas
Osborne
Bagdad Junction
Hesseltine
Curlew
Kettle River
Toroda Creek
Kruger
Sanpoil River
Deep Lake Boundary
Aladdin
Onion Creek
Chugstan Creek
Colville River
Addy Gifford
Cedonia Addy
Springdale Hunters
Williams Valley
Farwell
Crescent
Grant
Lincoln
Kiner
3
21
22
22A
395
20
155
174
50
2
231
292
28

Km 0 5 10

Miles 0 5 10

N

Legend

- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Field Sample)
- Sediment > 2mm (Interpolated)

mPECQ Interpolation
- < 0.2
- 0.2 - 2.0
- > 2.0

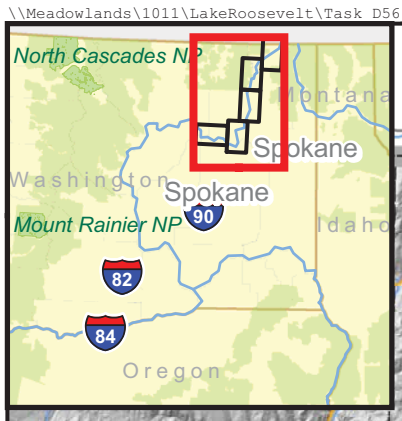
mPECQ Samples
- < 0.2
- 0.2 - 2.0
- > 2.0

HydroQual Inc.

Map B2-4. **Overview of Interpolated Sediment mPECQ Values**

Upper Columbia River, WA

\\Meadowlands\1011\LakeRoosevelt\Task D56 Sediment QAPP Memo\Map Docs\Sediment Mapping\UCRTemplate-Sediment Mapping.mxd @ 10-29-2010



U.S.- Canada Border

Grand Forks

Danville

Laurier

Velvet

Leadpoint

Goldstake

Orient

Marble

Spirit

Deep Lake Boundary

Ryan

Onion Creek

Barstow

Bossburg

Aladdin

Aladdin

Tile 1

Kettle River

Curlew

Toroda

Kettle River

Toroda Creek

Bodie

Old Toroda

Malo

Karamin

Wauconda

Old Wauconda

Pollard

Torboy

Republic

Boyds

Evans

Beare

Marcus

Harter

Kettle Falls

Ward

Greenwood

Onion Creek

Chiqueton Creek

Echo

Pinkney City

Park Rapids

Tile 2

Aeneas Valley

Aeneas

Okanogan

Lyman Lake Moses Mountain

Bia Road 64

Gold Creek

West Fork

Ferry

Arzina

Rice

Stevens

Colville River

Arden

Waterloo

Daisy

Addy

Fairview

Bingville

Maud

Bluecreek

Cozy Nook

Addy Gifford

Impach

Gifford

Meteor

Colville Indian Reservation

Chewelah

Covada

Bissel

Kewa

Cedonia Addy

Carrs Corner

Waits

Nespelem

Sanpoil River

Cedonia

Tile 3

Kulzer

Hunters

Grays

Springdale Hunters

Fruitland

Cline

Gardenspor

Turk

Deer Trail

Camas

Enterprise

Douglas

Belvedere

Seatons Grove

Elmer City

Keller

Lone Pine

Spokane Indian Reservation

Williams Valley

Osborne

Bagdad Junction

Hesseltine

Tile 5

Miles

Wellpinit

Seven Bays

Lincoln

Sherman

Tile 4

Little Falls

Long La

Farwell

Crescent

Wilbur

Creston

Govan

Hanson

Telford

Mondovi

Reardan

Davenport

Grant

Rocklyn

Lincoln

Omans

Gravelles

Elanor

Kiner

Legend

- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Field Sample)
- Sediment > 2mm (Interpolated)

Sediment Texture Interpolation

- Gravelly
- Mixed
- Muddy
- Sandy

Sediment Texture Samples

- Gravelly
- Mixed
- Muddy
- Sandy

HydroQual Inc.

0 5 10 Km

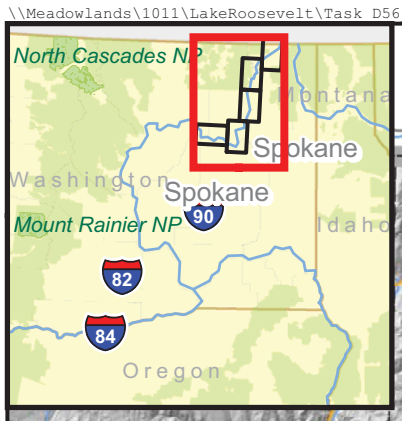
0 5 10 Miles

N

Map B2-5. **Overview of Interpolated Sediment Texture**

Upper Columbia River, WA

\\Meadowlands\1011\LakeRoosevelt\Task D56 Sediment QAPP Memo\Map Docs\Sediment Mapping\UCRTemplate-Sediment Mapping.mxd @ 10-29-2010



U.S.- Canada Border

Tile 1

Tile 2

Tile 3

Tile 4

Tile 5

Colville Indian Reservation

Spokane Indian Reservation

Ferry

Stevens

Okanogan

Douglas

Grant

Lincoln

Grand Forks

Danville

Laurier

Velvet

Leadpoint

Toroda

Kettle River

Curlew

Goldstake

Orient

Marble

Spirit

Deep Lake Boundary

Toroda Creek

Bodie

Old Toroda

Malo

Karamin

Ryan

Barstow

Onion Creek

Wauconda

Old Wauconda

Pollard

Bossburg

Boyds

Evans

Aladdin

Torboy

Republic

Marcus

Harter

Echo

Chiqaton Creek

Onion Creek

Kettle Falls

Ward

Greenwood

Pinkney City

Park Rapids

Aeneas Valley

Aeneas

Lyman Lake Moses Mountain

Bia Road 64

Gold Creek

West Fork

Arden

Colville River

Arzina

Rice

Waterloo

Bingville

Daisy

Addy

Fairview

Maud

Cozy Nook

Bluecreek

Addy Gifford

Impach

Gifford

Chewelah

Meteor

Covada

Bissel

Kewa

Cedonia Addy

Carrs Corner

Waits

Nespelem

Sanpoil River

Cedonia

Kulzer

Hunters

Grays

Springdale Hunters

Belvedere

Keller

Fruitland

Cline

Seatons Grove

Turk

Camas

Elmer City

Deer Trail

Enterprise

Lone Pine

Williams Valley

Osborne

Bagdad Junction

Hesseltine

Miles

Wellpinit

Seven Bays

Sherman

Lincoln

Little Falls

Long La

Wilbur

Creston

Farwell

Crescent

Hanson

Govan

Telford

Mondovi

Reardan

Davenport

Rocklyn

Omans

Gravelles

Elanor

Kiner

3 21 395 22 22A 20 155 174 50 2 28 231 292

Legend

- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Interpolated)

Sediment Group

- Group 1
- Group 2
- Group 3
- Group 4
- Group 5
- Group 6
- Group 7
- Group 8
- Group 9
- Internal Reference

HydroQual Inc.

0 5 10 Km

0 5 10 Miles

N

Map B2-6. **Overview of Interpolated Sediment Groups**

Upper Columbia River, WA

ATTACHMENT B1

MPECQ CALCULATION PROCEDURES

mPECQ CALCULATION PROCEDURES

Probable effect concentration (PEC) values have been used to assess potential for effects based on dry-weight normalized metal concentrations in bulk sediment (Long et al. 1998; MacDonald et al. 2000). The quotient of a metal and its PEC is the probable effect concentration quotient (PECQ). The mean probable effect concentration quotient (mPECQ) has been used to express potential for effects for mixtures of metals in sediments (MacDonald et al. 2000). In freshwater, mPECQ are defined based on conditions for eight (8) metals—arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), nickel (Ni), and zinc (Zn) (MacDonald et al. 2000).

Only four metals are anticipated to be primary risk drivers in Upper Columbia River (UCR) sediment. Those are zinc, copper, lead, and cadmium. For UCR surface sediment gradient analyses, mPECQ values were approximated based only on zinc, copper, lead, and cadmium measurements:

$$mPECQ = \frac{\frac{[Zn]}{[PEC]_{Zn}} + \frac{[Cu]}{[PEC]_{Cu}} + \frac{[Pb]}{[PEC]_{Pb}} + \frac{[Cd]}{[PEC]_{Cd}}}{4} \quad (1)$$

where: [Zn], [Cu], [Pb], [Cd] = bulk sediment concentration of Zn, Cu, Pb, and Cd, respectively (mg/kg, dry weight); and $[PEC]_{Zn}$, $[PEC]_{Cu}$, $[PEC]_{Pb}$, $[PEC]_{Cd}$, = probable effect concentration for Zn, Cu, Pb, and Cd, respectively (mg/kg, dry weight). PEC values for Zn, Pb, Cu, and Cd are summarized in Table B1-1.

Table B1-1. Probable Effects Concentrations for Zinc, Lead, Copper, and Cadmium

Metal	PEC (mg/kg dry weight)
Zinc	459
Copper	149
Lead	128
Cadmium	4.98

Source: MacDonald et al. (2000)

REFERENCES

Long, E.R, D.D. MacDonald, J.C. Cubbage, and C.G. Ingersoll. 1998. Predicting the toxicity of sediment-associated trace metals with simultaneously extracted trace metal:acid-volatile sulfide concentrations and dry weight-normalized concentrations: A critical comparison. *Environmental Toxicology and Chemistry*, 17(5):972-974.

MacDonald, D.D., C.G. Ingersoll, and T.A. Berger. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. *Archives of Environmental Contamination and Toxicology*, 39:20–31.

ATTACHMENT B2

EMPIRICAL AND MODELED SEMIVARIOGRAMS

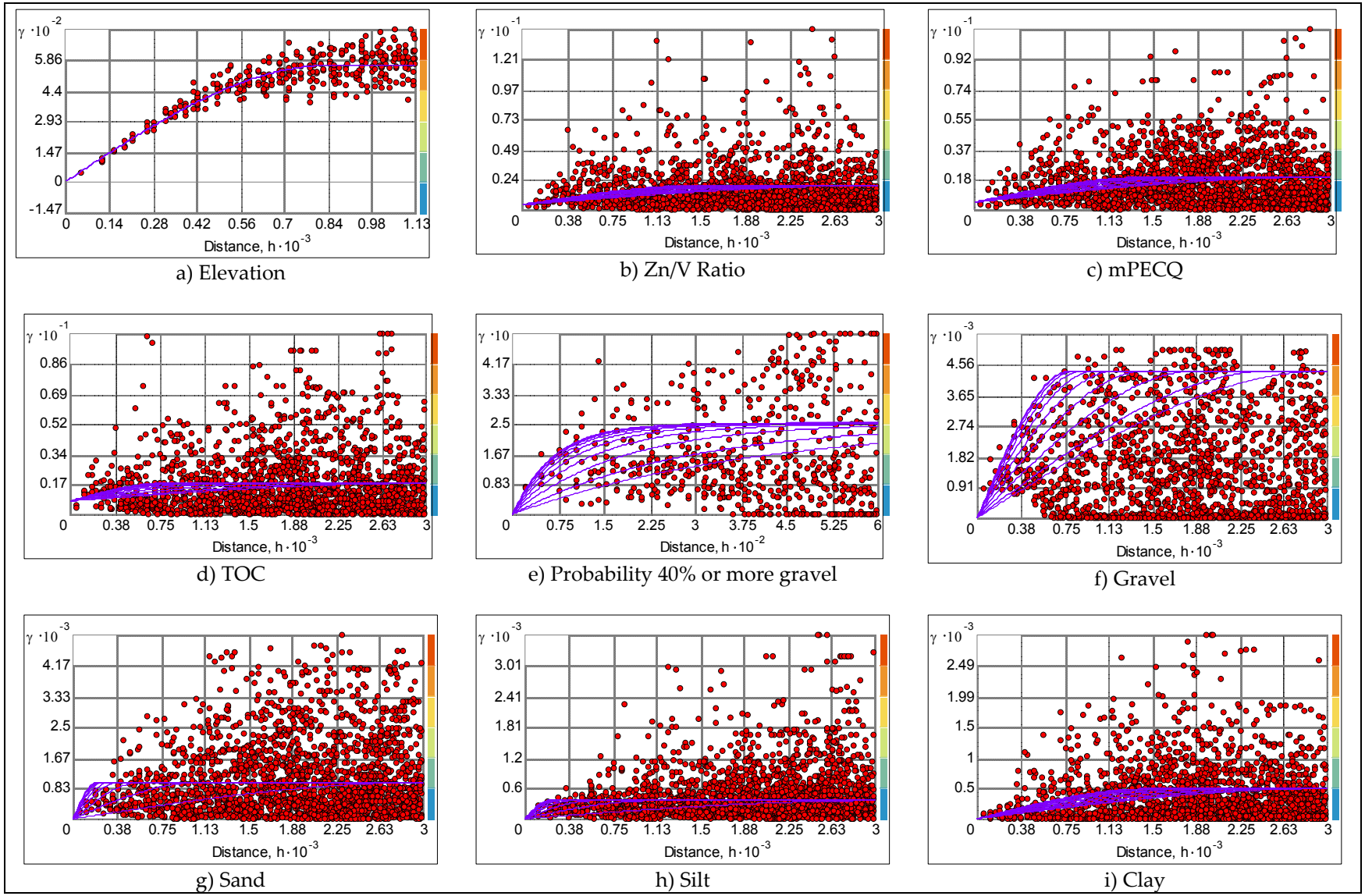
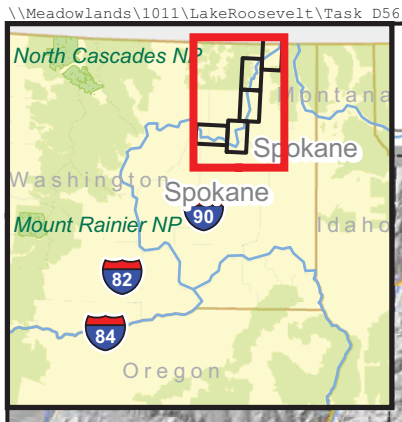


Figure B2-1. Cokriging Semivariograms
Notes: Empirical semivariograms represented by red circles. Modeled semivariograms (anisotropic) represented by blue lines. Semivariogram for bed elevation is shown to illustrate the underlying behavior of the secondary variable used for cokriging.

ATTACHMENT B3 (1 OF 3)

DETAILED MAPS OF INTERPOLATED SEDIMENT BED PROPERTIES

\\Meadowlands\1011\LakeRoosevelt\Task D56 Sediment QAPP Memo\Map Docs\Sediment Mapping\UCRTemplate-Sediment Mapping.mxd @ 10-29-2010



U.S.- Canada Border

Grand Forks

Danville

Laurier

Velvet

Leadpoint

Toroda

Kettle River

Curlew

Goldstake

Orient

Marble

Spirit

Deep Lake Boundary

Bodie

Toroda Creek

Malo

Old Toroda

Karamin

Ryan

Barstow

Onion Creek

Wauconda

Old Wauconda

Pollard

Bossburg

Boyds

Evans

Aladdin

Tile 1

Torboy

Republic

Marcus

Harter

Kettle Falls

Ward

Greenwood

Chugatan Creek

Onion Creek

Aeneas Valley

Aeneas

Okanogan

Pinkney City

Park Rapids

Tile 2

Lyman Lake Moses Mountain

Bia Road 64

Gold Creek

West Fork

Ferry

Arden

Colville River

Arzina

Rice

Stevens

Waterloo

Bingville

Daisy

Addy

Fairview

Maud

Addy Gifford

Bluecreek

Cozy Nook

Impach

Gifford

Meteor

Chewelah

Colville Indian Reservation

Covada

Bissel

Kewa

Cedonia Addy

Carrs Corner

Waits

Nespelem

Sanpoil River

Cedonia

Kulzer

Tile 3

Hunters

Grays

Springdale Hunters

Keller

Belvedere

Fruitland

Cline

Douglas

Seatons Grove

Turk

Camas

Elmer City

Deer Trail

Enterprise

Lone Pine

Spokane Indian Reservation

Williams Valley

Osborne

Miles

Bagdad Junction

Hesseltine

Wellpinit

Tile 5

Seven Bays

Tile 4

Sherman

Lincoln

Little Falls

Wilbur

Creston

Farwell

Crescent

Hanson

Govan

Telford

Mondovi

Reardan

Grant

Davenport

Rocklyn

Lincoln

Omans

Gravelles

Elanor

Legend

- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Field Sample)
- Sediment > 2mm (Interpolated)

Zinc to Vanadium Ratio Samples
- < 10
- 10 - 50
- > 50

Zinc to Vanadium Ratio Interpolation
- < 10
- 10 - 50
- > 50

HydroQual Inc.

0 5 10 Km

0 5 10 Miles

N

Map B3-1. **Overview of Interpolated Sediment Zn/V Ratios**

Upper Columbia River, WA

\\Meadowlands\1011\LakeRoosevelt\Task D56 Sediment QAPP Memo\Map Docs\Sediment Mapping\UCRTemplate-Sediment Mapping.mxd @ 10-29-2010

U.S.- Canada Border

Frontier

Velvet

251

Fir

Leadpoint

Deep Lake Boundary

25

Spirit

Ryan

Onion Creek

Goldfield Mill

Clugston Creek Onion Creek

Aladdin

Aladdin

Legend

- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Field Sample)
- Sediment > 2mm (Interpolated)

Zinc to Vanadium Ratio Samples

- < 10
- 10 - 50
- > 50

Zinc to Vanadium Ratio Interpolation

- < 10
- 10 - 50
- > 50

HydroQual Inc.

0 1.25 2.5 Km

0 1.25 2.5 Miles

N

Map B3-2. **Tile 1 - Interpolated Sediment Zn/V Ratios**

Upper Columbia River, WA

\\Meadowlands\1011\LakeRoosevelt\Task D56 Sediment QAPP Memo\Map Docs\Sediment Mapping\UCRTemplate-Sediment Mapping.mxd @ 10-29-2010

Barstow
Kettle River
395
Ryan
25
Boyds
Bear
East Marcus
Marcus
Echo
Harter
Williams Lake
Kettle Falls
Ward
Inchelium Kettle Falls
20
Greenwood
Inchelium Kettle Falls

Legend

- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Field Sample)
- Sediment > 2mm (Interpolated)

Zinc to Vanadium Ratio Samples

- < 10
- 10 - 50
- > 50

Zinc to Vanadium Ratio Interpolation

- < 10
- 10 - 50
- > 50

HydroQual Inc.

Km: 0 1.25 2.5

Miles: 0 1.25 2.5

N

Map B3-3. **Tile 2 - Interpolated Sediment Zn/V Ratios**

Upper Columbia River, WA

\\Meadowlands\1011\LakeRoosevelt\Task D56 Sediment QAPP Memo\Map Docs\Sediment Mapping\UCRTemplate-Sediment Mapping.mxd @ 10-29-2010

Arzina
Rice
Waterloo
Daisy
Maud
Addy Gifford
Gifford
Colville Indian Reservation
Inchelium
Ferry Crossing Landing
Impach
Meteor
Covada
Bissel
Cedonia Addy
Kewa
Cedonia
Springdale Hunters

Legend

- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Field Sample)
- Sediment > 2mm (Interpolated)

Zinc to Vanadium Ratio Samples

- < 10
- 10 - 50
- > 50

Zinc to Vanadium Ratio Interpolation

- < 10
- 10 - 50
- > 50

HydroQual Inc.

0 1.25 2.5 Km

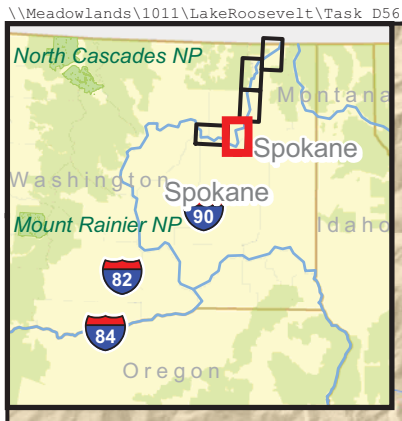
0 1.25 2.5 Miles

N

Map B3-4. **Tile 3 - Interpolated Sediment Zn/V Ratios**

Upper Columbia River, WA

\\Meadowlands\1011\LakeRoosevelt\Task D56 Sediment QAPP Memo\Map Docs\Sediment Mapping\UCRTemplate-Sediment Mapping.mxd @ 10-29-2010



Springdale Hunters
Hunters
Fruitland
25
Enterprise
Colville Indian Reservation
Spokane Indian Reservation
Miles
Fort Spokane
Seven Bays
Lincoln

Legend

- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Field Sample)
- Sediment > 2mm (Interpolated)

Zinc to Vanadium Ratio Samples

- < 10
- 10 - 50
- > 50

Zinc to Vanadium Ratio Interpolation

- < 10
- 10 - 50
- > 50

HydroQual Inc.

0 1.25 2.5 Km

0 1.25 2.5 Miles

N

Map B3-5. **Tile 4 - Interpolated Sediment Zn/V Ratios**

Upper Columbia River, WA

Belvedere
155
Seatons Grove
Koontzville
Elmer City
Lone Pine
Crown Point Vista
Mason City
Grand Coulee Dam
Colville Indian Reservation
Keller
21
Grand Coulee
Electric City
Osborne
Grand Coulee Hill
174
Bagdad Junction
Hesseltine
West
52

Legend

- Grand Coulee Dam
- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Field Sample)
- Sediment > 2mm (Interpolated)

Zinc to Vanadium Ratio Samples

- < 10
- 10 - 50
- > 50

Zinc to Vanadium Ratio Interpolation

- < 10
- 10 - 50
- > 50

HydroQual Inc.

0 1.25 2.5 Km

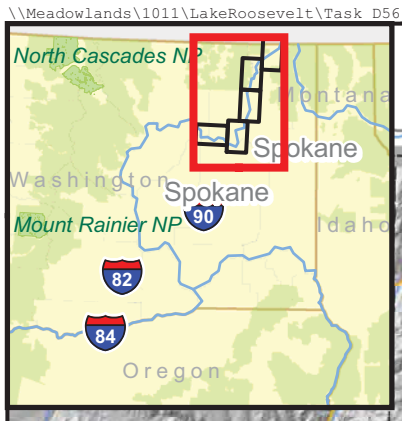
0 1.25 2.5 Miles

N

Map B3-6. **Tile 5 - Interpolated Sediment Zn/V Ratios**

Upper Columbia River, WA

\\Meadowlands\1011\LakeRoosevelt\Task D56 Sediment QAPP Memo\Map Docs\Sediment Mapping\UCRTemplate-Sediment Mapping.mxd @ 10-29-2010



U.S.- Canada Border

Tile 1

Tile 2

Tile 3

Tile 4

Tile 5

Colville Indian Reservation

Spokane Indian Reservation

Okanogan

Ferry

Stevens

Douglas

Grant

Lincoln

Grand Forks

Danville

Laurier

Velvet

Leadpoint

Toroda

Kettle River

Curlew

Goldstake

Orient

Marble

Spirit

Deep Lake Boundary

Toroda Creek

Bodie

Old Toroda

Malo

Karamin

Ryan

Barstow

Onion Creek

Wauconda

Old Wauconda

Pollard

Bossburg

Evans

Aladdin

Boyds

Beard

Torboy

Marcus

Republic

Harter

Chewelah

Kettle Falls

Ward

Greenwood

Aeneas Valley

Aeneas

Pinkney City

Park Rapids

Lyman Lake Moses Mountain

Bia Road 64

Gold Creek

West Fork

Arden

Arzina

Rice

Waterloo

Bingville

Daisy

Addy

Fairview

Maud

Bluecreek

Cozy Nook

Impach

Gifford

Addy Gifford

Meteor

Covada

Bissel

Kewa

Cedonia Addy

Carrs Corner

Waits

Nespelem

Sanpoil River

Cedonia

Kulzer

Keller

Hunters

Grays

Belvedere

Seatons Grove

Fruitland

Springdale Hunters

Cline

Turk

Elmer City

Deer Trail

Camas

Lone Pine

Enterprise

Osborne

Bagdad Junction

Hesseltine

Miles

Wellpinit

Seven Bays

Sherman

Lincoln

Little Falls

Wilbur

Creston

Hanson

Govan

Telford

Mondovi

Reardan

Davenport

Rocklyn

Omans

Gravelles

Elanor

Farwell

Crescent

Kiner

Chugaton Creek Onion Creek

Aladdin

Corville River

Williams Valley

Gardenspot

Tum Tum

Km 0 5 10

Miles 0 5 10

N

Legend

- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Field Sample)
- Sediment > 2mm (Interpolated)

TOC Interpolation (mg/kg)
- < 5,000
- 5,000 - 10,000
- > 10,000

TOC Samples (mg/kg)
- < 5,000
- 5,000 - 10,000
- > 10,000

HydroQual Inc.

Map B3-7. **Overview of Interpolated Sediment TOC Values**

Upper Columbia River, WA

\\Meadowlands\1011\LakeRoosevelt\Task D56 Sediment QAPP Memo\Map Docs\Sediment Mapping\UCRTemplate-Sediment Mapping.mxd @ 10-29-2010

U.S.- Canada Border

Frontier

Velvet

251

Fir

Leadpoint

Deep Lake Boundary

Spirit

25

Ryan

Onion Creek

Clugston Creek Onion Creek

Goldfield Mill

Aladdin

Aladdin

Legend

- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Field Sample)
- Sediment > 2mm (Interpolated)

TOC Interpolation (mg/kg)

- < 5,000
- 5,000 - 10,000
- > 10,000

TOC Samples (mg/kg)

- < 5,000
- 5,000 - 10,000
- > 10,000

HydroQual Inc.

Km
0 1.25 2.5

Miles
0 1.25 2.5

N

Map B3-8. **Tile 1 - Interpolated Sediment TOC Values**

Upper Columbia River, WA

ATTACHMENT B3 (2 OF 3)

DETAILED MAPS OF INTERPOLATED SEDIMENT BED PROPERTIES

\\Meadowlands\1011\LakeRoosevelt\Task D56 Sediment QAPP Memo\Map Docs\Sediment Mapping\UCRTemplate-Sediment Mapping.mxd @ 10-29-2010

Barstow
Kettle River
395
Ryan
25
Boyds
Bear
East Marcus
Marcus
Harter
Echo
Williams Lake
Kettle Falls
Ward
Inchelium Kettle Falls
20
Greenwood
Inchelium Kettle Falls

Legend

- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Field Sample)
- Sediment > 2mm (Interpolated)

TOC Interpolation (mg/kg)

- < 5,000
- 5,000 - 10,000
- > 10,000

TOC Samples (mg/kg)

- < 5,000
- 5,000 - 10,000
- > 10,000

HydroQual Inc.

0 1.25 2.5 Km

0 1.25 2.5 Miles

N

Map B3-9. **Tile 2 - Interpolated Sediment TOC Values**

Upper Columbia River, WA

\\Meadowlands\1011\LakeRoosevelt\Task D56 Sediment QAPP Memo\Map Docs\Sediment Mapping\UCRTemplate-Sediment Mapping.mxd @ 10-29-2010

Arzina
Rice
Waterloo
Daisy
Maud
Addy Gifford
Gifford
Colville Indian Reservation
Inchelium
Impach
Ferry Crossing Landing
Meteor
Covada
Bissel
Cedonia Addy
Kewa
Cedonia
Springdale Hunters

Legend

- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Field Sample)
- Sediment > 2mm (Interpolated)

TOC Interpolation (mg/kg)
- < 5,000
- 5,000 - 10,000
- > 10,000

TOC Samples (mg/kg)
- < 5,000
- 5,000 - 10,000
- > 10,000

HydroQual Inc.

0 1.25 2.5 Km

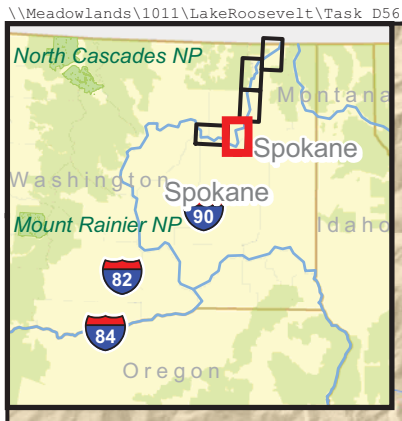
0 1.25 2.5 Miles

N

Map B3-10. **Tile 3 - Interpolated Sediment TOC Values**

Upper Columbia River, WA

\\Meadowlands\1011\LakeRoosevelt\Task D56 Sediment QAPP Memo\Map Docs\Sediment Mapping\UCRTemplate-Sediment Mapping.mxd @ 10-29-2010



Colville Indian Reservation

Spokane Indian Reservation

Springdale
Hunters
Hunters
Fruitland
25
Enterprise
Miles
Fort Spokane
Seven Bays
Lincoln

Legend

- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Field Sample)
- Sediment > 2mm (Interpolated)

TOC Interpolation (mg/kg)
- < 5,000
- 5,000 - 10,000
- > 10,000

TOC Samples (mg/kg)
- < 5,000
- 5,000 - 10,000
- > 10,000

HydroQual Inc.

0 1.25 2.5 Km

0 1.25 2.5 Miles

N

Map B3-11. **Tile 4 - Interpolated Sediment TOC Values**

Upper Columbia River, WA

Belvedere
155
Seatons Grove
Koontzville
Elmer City
Lone Pine
Crown Point Vista
Mason City
Grand Coulee Dam
Grand Coulee
Electric City
Osborne
Grand Coulee Hill
West
52
174
Bagdad Junction
Hesseltine
Colville Indian Reservation
Keller
21

Legend

- Grand Coulee Dam
- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Field Sample)
- Sediment > 2mm (Interpolated)

TOC Samples (mg/kg)

- < 5,000
- 5,000 - 10,000
- > 10,000

TOC Interpolation (mg/kg)

- < 5,000
- 5,000 - 10,000
- > 10,000

HydroQual Inc.

0 1.25 2.5 Km

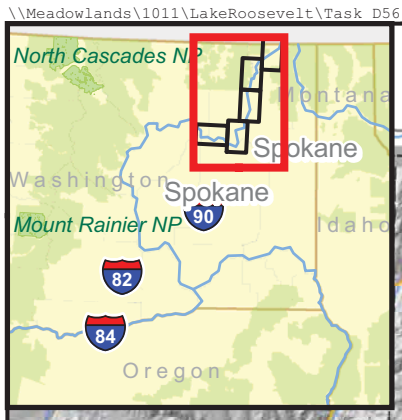
0 1.25 2.5 Miles

N

Map B3-12. **Tile 5 - Interpolated Sediment TOC Values**

Upper Columbia River, WA

\\Meadowlands\1011\LakeRoosevelt\Task D56 Sediment QAPP Memo\Map Docs\Sediment Mapping\UCRTemplate-Sediment Mapping.mxd @ 10-29-2010



U.S.- Canada Border

Grand Forks

Danville

Laurier

Velvet

Leadpoint

Goldstake

Orient

Marble

Spirit

Deep Lake Boundary

Onion Creek

Ryan

Barstow

Bossburg

Evans

Boyds

Beard

Aladdin

Tile 1

Marcus

Harter

Kettle Falls

Ward

Greenwood

Pinkney City

Park Rapids

Tile 2

Arden

Colville River

Arzina

Rice

Waterloo

Daisy

Maud

Addy

Fairview

Bingville

Cozy Nook

Bluecreek

Addy Gifford

Impach

Gifford

Meteor

Chewelah

Colville Indian Reservation

Covada

Bissel

Kewa

Cedonia Addy

Carrs Corner

Waits

Cedonia

Tile 3

Kulzer

Hunters

Grays

Springdale Hunters

Fruitland

Cline

Turk

Deer Trail

Camas

Enterprise

Spokane Indian Reservation

Williams Valley

Miles

Wellpinit

Seven Bays

Lincoln

Tile 4

Tile 5

Sherman

Little Falls

Wilbur

Creston

Govan

Hanson

Telford

Mondovi

Reardan

Davenport

Rocklyn

Omans

Gravelles

Elanor

Osborne

Bagdad Junction

Hesseltine

Lone Pine

Belvedere

Seatons Grove

Elmer City

Keller

Nespelem

Republic

West Fork

Aeneas

Aeneas Valley

Lyman Lake Moses Mountain

Bear Road 64

Gold Creek

Ferry

Okanogan

Douglas

Grant

Lincoln

Kettle River

Curlew

Malo

Karamin

Pollard

Torboy

Toroda

Toroda Creek

Bodie

Old Toroda

Wauconda

Old Wauconda

Kruppa

Sanpoil River

Kiner

Chuguton Creek

Onion Creek

Echo

Aladdin

Farwell

Crescent

Long La

Pinkney City

Park Rapids

Gardenspor

Williams Valley

3

21

395

22

22A

20

232

292

231

155

174

50

2

28

Legend

- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Field Sample)
- Sediment > 2mm (Interpolated)

mPECQ Interpolation
- < 0.2
- 0.2 - 2.0
- > 2.0

mPECQ Samples
- < 0.2
- 0.2 - 2.0
- > 2.0

HydroQual Inc.

0 5 10 Km

0 5 10 Miles

N

Map B3-13. **Overview of Interpolated Sediment mPECQ Values**

Upper Columbia River, WA

\\Meadowlands\1011\LakeRoosevelt\Task D56 Sediment QAPP Memo\Map Docs\Sediment Mapping\UCRTemplate-Sediment Mapping.mxd @ 10-29-2010

U.S.- Canada Border

Frontier

Velvet

251

Fir

Leadpoint

Deep Lake Boundary

25

Spirit

Ryan

Onion Creek

Goldfield Mill

Clugston Creek Onion Creek

Aladdin

Aladdin

Legend

- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Field Sample)
- Sediment > 2mm (Interpolated)

mPECQ Interpolation
- < 0.2
- 0.2 - 2.0
- > 2.0

mPECQ Samples
- < 0.2
- 0.2 - 2.0
- > 2.0

HydroQual Inc.

0 1.25 2.5 Km

0 1.25 2.5 Miles

N

Map B3-14. **Tile 1 - Interpolated Sediment mPECQ Values**

Upper Columbia River, WA

\\Meadowlands\1011\LakeRoosevelt\Task D56 Sediment QAPP Memo\Map Docs\Sediment Mapping\UCRTemplate-Sediment Mapping.mxd @ 10-29-2010

Barstow
Kettle River
395
Ryan
25
Boyds
Bear
East Marcus
Marcus
Harter
Echo
Williams Lake
Kettle Falls
Ward
20
Inchelium Kettle Falls
Greenwood
Inchelium Kettle Falls

Legend

- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Field Sample)
- Sediment > 2mm (Interpolated)

mPECQ Interpolation

- < 0.2
- 0.2 - 2.0
- > 2.0

mPECQ Samples

- < 0.2
- 0.2 - 2.0
- > 2.0

HydroQual Inc.

0 1.25 2.5 Km

0 1.25 2.5 Miles

N

Map B3-15. **Tile 2 - Interpolated Sediment mPECQ Values**

Upper Columbia River, WA

\\Meadowlands\1011\LakeRoosevelt\Task D56 Sediment QAPP Memo\Map Docs\Sediment Mapping\UCRTemplate-Sediment Mapping.mxd @ 10-29-2010

Arzina
Rice
Waterloo
Daisy
Maud
Addy Gifford
Gifford
Colville Indian Reservation
Inchelium
Impach
Ferry Crossing Landing
Meteor
Covada
Bissel
Cedonia Addy
Kewa
Cedonia
Springdale Hunters

Legend

- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Field Sample)
- Sediment > 2mm (Interpolated)

mPECQ Interpolation
- < 0.2
- 0.2 - 2.0
- > 2.0

mPECQ Samples
- < 0.2
- 0.2 - 2.0
- > 2.0

HydroQual Inc.

0 1.25 2.5 Km

0 1.25 2.5 Miles

N

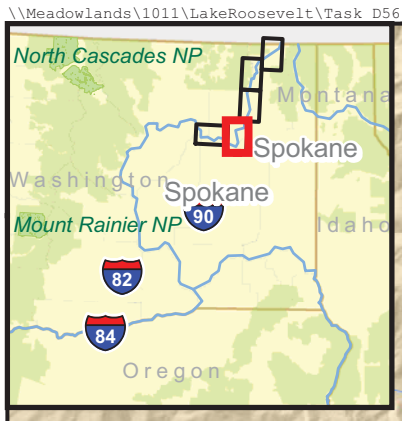
Map B3-16. **Tile 3 - Interpolated Sediment mPECQ Values**

Upper Columbia River, WA

ATTACHMENT B3 (3 OF 3)

DETAILED MAPS OF INTERPOLATED SEDIMENT BED PROPERTIES

\\Meadowlands\1011\LakeRoosevelt\Task D56 Sediment QAPP Memo\Map Docs\Sediment Mapping\UCRTemplate-Sediment Mapping.mxd @ 10-29-2010



Colville Indian Reservation

Spokane Indian Reservation

Springdale
Hunters
Hunters
Fruitland
25
Enterprise
Miles
Fort Spokane
Seven Bays
Lincoln

Legend

- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Field Sample)
- Sediment > 2mm (Interpolated)

mPECQ Interpolation

- < 0.2
- 0.2 - 2.0
- > 2.0

mPECQ Samples

- < 0.2
- 0.2 - 2.0
- > 2.0

HydroQual Inc.

0 1.25 2.5 Km

0 1.25 2.5 Miles

N

Map B3-17. **Tile 4 - Interpolated Sediment mPECQ Values**

Upper Columbia River, WA

Belvedere
155
Seatons Grove
Koontzville
Elmer City
Lone Pine
Crown Point Vista
Mason City
Grand Coulee Dam
Grand Coulee
Electric City
Osborne
Grand Coulee Hill
West
52
174
Bagdad Junction
Hesseltine
Keller
21
Colville Indian Reservation

Legend

- Grand Coulee Dam
- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Field Sample)
- Sediment > 2mm (Interpolated)

mPECQ Samples

- < 0.2
- 0.2 - 2.0
- > 2.0

mPECQ Interpolation

- < 0.2
- 0.2 - 2.0
- > 2.0

HydroQual Inc.

0 1.25 2.5 Km

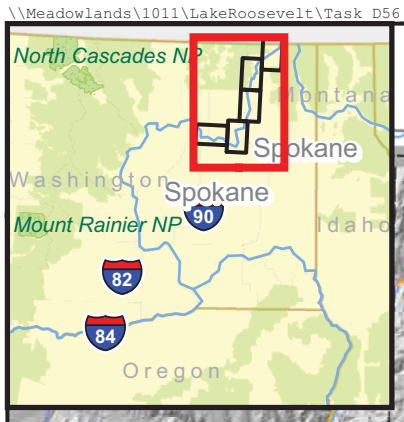
0 1.25 2.5 Miles

N

Map B3-18. **Tile 5 - Interpolated Sediment mPECQ Values**

Upper Columbia River, WA

\\Meadowlands\1011\LakeRoosevelt\Task D56 Sediment QAPP Memo\Map Docs\Sediment Mapping\UCRTemplate-Sediment Mapping.mxd @ 10-29-2010



U.S.- Canada Border

Tile 1

Tile 2

Tile 3

Tile 4

Tile 5

Colville Indian Reservation

Spokane Indian Reservation

Ferry

Stevens

Lincoln

Grant

Okanogan

Douglas

Grand Forks

Danville

Laurier

Velvet

Leadpoint

Toroda

Kettle River

Curlew

Goldstake

Orient

Marble

Spirit

Deep Lake Boundary

Toroda Creek

Bodie

Old Toroda

Malo

Karamin

Ryan

Barstow

Bossburg

Onion Creek

Aladdin

Wauconda

Old Wauconda

Pollard

Boyds

Evans

Bear

Torboy

Marcus

Republic

Harter

Kettle Falls

Chiliqua Creek

Onion Creek

Ward

Greenwood

Pinkney City

Aeneas Valley

Aeneas

Park Rapids

Lyman Lake Moses Mountain

Bia Road 64

Gold Creek

West Fork

Arden

Colville River

Arzina

Rice

Waterloo

Bingville

Daisy

Addy

Fairview

Maud

Bluecreek

Cozy Nook

Addy Gifford

Impach

Gifford

Meteor

Chewelah

Covada

Bissel

Kewa

Cedonia Addy

Carrs Corner

Waits

Nespelem

Sanpoil River

Cedonia

Kulzer

Keller

Hunters

Grays

Springdale Hunters

Belvedere

Seatons Grove

Fruitland

Cline

Gardens

Turk

Elmer City

Deer Trail

Camas

Enterprise

Lone Pine

Osborne

Bagdad Junction

Hesseltine

Miles

Wellpinit

Seven Bays

Sherman

Lincoln

Little Falls

Long La

Farwell

Crescent

Wilbur

Creston

Hanson

Govan

Telford

Mondovi

Reardan

Davenport

Rocklyn

Omans

Gravelles

Elanor

3 21 395 22 22A 20 155 174 50 2 231 28 232 292

Legend

- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Field Sample)
- Sediment > 2mm (Interpolated)

Sediment Texture Interpolation

- Gravelly
- Mixed
- Muddy
- Sandy

Sediment Texture Samples

- Gravelly
- Mixed
- Muddy
- Sandy

HydroQual Inc.

0 5 10 Km

0 5 10 Miles

N

Map B3-19. **Overview of Interpolated Sediment Texture**

Upper Columbia River, WA

\\Meadowlands\1011\LakeRoosevelt\Task D56 Sediment QAPP Memo\Map Docs\Sediment Mapping\UCRTemplate-Sediment Mapping.mxd @ 10-29-2010

U.S.- Canada Border

Frontier

Velvet

251

Fir

Leadpoint

Deep Lake Boundary

Spirit

25

Ryan

Onion Creek

Clugston Creek Onion Creek

Goldfield Mill

Aladdin

Aladdin

Legend

- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Field Sample)
- Sediment > 2mm (Interpolated)

Sediment Texture Interpolation

- Gravelly
- Mixed
- Muddy
- Sandy

Sediment Texture Samples

- Gravelly
- Mixed
- Muddy
- Sandy

HydroQual Inc.

0 1.25 2.5 Km

0 1.25 2.5 Miles

N

Map B3-20. **Tile 1 - Interpolated Sediment Texture**

Upper Columbia River, WA

\\Meadowlands\1011\LakeRoosevelt\Task D56 Sediment QAPP Memo\Map Docs\Sediment Mapping\UCRTemplate-Sediment Mapping.mxd @ 10-29-2010

Barstow
Kettle River
395
Ryan
25
Boyds
Bear
East Marcus
Marcus
Echo
Harter
Williams Lake
Kettle Falls
Ward
20
Inchelium Kettle Falls
Greenwood
Inchelium Kettle Falls

Legend

- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Field Sample)
- Sediment > 2mm (Interpolated)

Sediment Texture Interpolation

- Gravelly
- Mixed
- Muddy
- Sandy

Sediment Texture Samples

- Gravelly
- Mixed
- Muddy
- Sandy

HydroQual Inc.

0 1.25 2.5 Km

0 1.25 2.5 Miles

N

Map B3-21. **Tile 2 - Interpolated Sediment Texture**

Upper Columbia River, WA

\\Meadowlands\1011\LakeRoosevelt\Task D56 Sediment QAPP Memo\Map Docs\Sediment Mapping\UCRTemplate-Sediment Mapping.mxd @ 10-29-2010

Arzina
Rice
Waterloo
Daisy
Maud
Addy Gifford
Gifford
Colville Indian Reservation
Inchelium
Impach
Ferry Crossing Landing
Meteor
Covada
Bissel
Cedonia Addy
Kewa
Cedonia
Springdale Hunters
Inchelium Kettle Falls

Legend

- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Field Sample)
- Sediment > 2mm (Interpolated)

Sediment Texture Interpolation

- Gravelly
- Mixed
- Muddy
- Sandy

Sediment Texture Samples

- Gravelly
- Mixed
- Muddy
- Sandy

HydroQual Inc.

Km: 0 1.25 2.5

Miles: 0 1.25 2.5

N

Map B3-22. **Tile 3 - Interpolated Sediment Texture**

Upper Columbia River, WA

\\Meadowlands\1011\LakeRoosevelt\Task D56 Sediment QAPP Memo\Map Docs\Sediment Mapping\UCRTemplate-Sediment Mapping.mxd @ 10-29-2010

Colville Indian Reservation

Spokane Indian Reservation

Springdale
Hunters
Hunters
Fruitland
25
Enterprise
Miles
Fort Spokane
Seven Bays
Lincoln

Legend

- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Field Sample)
- Sediment > 2mm (Interpolated)

Sediment Texture Interpolation

- Gravelly
- Mixed
- Muddy
- Sandy

Sediment Texture Samples

- Gravelly
- Mixed
- Muddy
- Sandy

HydroQual Inc.

0 1.25 2.5 Km

0 1.25 2.5 Miles

N

Map B3-23. **Tile 4 - Interpolated Sediment Texture**

Upper Columbia River, WA

Belvedere
155
Scotons Grove
Koontzville
Elmer City
Lone Pine
Crown Point Vista
Mason City
Grand Coulee Dam
Grand Coulee
Electric City
Osborne
Grand Coulee Hill
West
52
Bagdad Junction
174
Hesseltine
Colville Indian Reservation
Keller
21

Legend

- Grand Coulee Dam
- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Field Sample)
- Sediment > 2mm (Interpolated)

Sediment Texture Samples

- Gravelly
- Mixed
- Muddy
- Sandy

Sediment Texture Interpolation

- Gravelly
- Mixed
- Muddy
- Sandy

HydroQual Inc.

0 1.25 2.5 Km

0 1.25 2.5 Miles

N

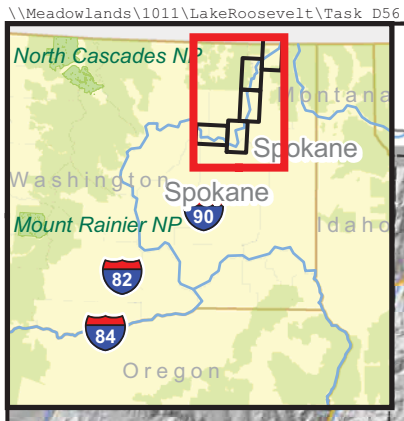
Map B3-24. **Tile 5 - Interpolated Sediment Texture**

Upper Columbia River, WA

ATTACHMENT B4

DETAILED MAPS OF INTERPOLATED SEDIMENT GROUPS

\\Meadowlands\1011\LakeRoosevelt\Task D56 Sediment QAPP Memo\Map Docs\Sediment Mapping\UCRTemplate-Sediment Mapping.mxd @ 10-29-2010



U.S. - Canada Border

Tile 1

Tile 2

Tile 3

Tile 4

Tile 5

Colville Indian Reservation

Spokane Indian Reservation

Okanogan

Ferry

Stevens

Douglas

Grant

Lincoln

Grand Forks

Danville

Laurier

Velvet

Leadpoint

Toroda

Kettle River

Curlew

Goldstake

Orient

Marble

Spirit

Deep Lake Boundary

Toroda Creek

Bodie

Old Toroda

Malo

Karamin

Ryan

Barstow

Onion Creek

Wauconda

Old Wauconda

Pollard

Bossburg

Evans

Aladdin

Boyds

Bear

Torboy

Marcus

Republic

Harter

Kettle Falls

Chewelah

Ward

Greenwood

Aeneas Valley

Aeneas

Pinkney City

Park Rapids

Lyman Lake Moses Mountain

Bia Road 64

Gold Creek

West Fork

Arden

Arzina

Rice

Waterloo

Daisy

Addy

Fairview

Bingville

Maud

Cozy Nook

Addy Gifford

Bluecreek

Impach

Gifford

Meteor

Covada

Bissel

Kewa

Cedonia Addy

Carrs Corner

Waits

Nespelem

Cedonia

Kulzer

Sanpoil River

Hunters

Grays

Springdale Hunters

Keller

Belvedere

Fruitland

Cline

Seatons Grove

Turk

Elmer City

Deer Trail

Camas

Enterprise

Lone Pine

Osborne

Bagdad Junction

Hesseltine

Miles

Wellpinit

Seven Bays

Sherman

Lincoln

Little Falls

Wilbur

Creston

Govan

Hanson

Telford

Mondovi

Reardan

Davenport

Rocklyn

Omans

Gravelles

Elanor

Km 0 5 10

Miles 0 5 10

N

Legend

- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Interpolated)

Sediment Group

- Group 1
- Group 2
- Group 3
- Group 4
- Group 5
- Group 6
- Group 7
- Group 8
- Group 9
- Internal Reference

HydroQual Inc.

Map B4-1. **Overview of Interpolated Sediment Groups**

Upper Columbia River, WA

\\Meadowlands\1011\LakeRoosevelt\Task D56 Sediment QAPP Memo\Map Docs\Sediment Mapping\UCRTemplate-Sediment Mapping.mxd @ 10-29-2010

U.S.- Canada Border

Frontier

Velvet

251

Fir

Leadpoint

25

Deep Lake Boundary

Spirit

Ryan

Onion Creek

Goldfield Mill

Clugston Creek Onion Creek

Aladdin

Aladdin

Legend

- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Interpolated)

Sediment Group

- Group 1
- Group 2
- Group 3
- Group 4
- Group 5
- Group 6
- Group 7
- Group 8
- Group 9
- Internal Reference

HydroQual Inc.

0 1.25 2.5 Km

0 1.25 2.5 Miles

N

Map B4-2. **Tile 1 - Interpolated Sediment Groups**

Upper Columbia River, WA

\\Meadowlands\1011\LakeRoosevelt\Task D56 Sediment QAPP Memo\Map Docs\Sediment Mapping\UCRTemplate-Sediment Mapping.mxd @ 10-29-2010

Barstow
Kettle River
395
Ryan
25
Boyds
Bear
East Marcus
Marcus
Echo
Harter
Williams Lake
Kettle Falls
Ward
20
Inchelium Kettle Falls
Greenwood
Inchelium Kettle Falls

Legend

- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Interpolated)

Sediment Group

- Group 1
- Group 2
- Group 3
- Group 4
- Group 5
- Group 6
- Group 7
- Group 8
- Group 9
- Internal Reference

HydroQual Inc.

0 1.25 2.5 Km

0 1.25 2.5 Miles

N

Map B4-3. **Tile 2 - Interpolated Sediment Groups**

Upper Columbia River, WA

\\Meadowlands\1011\LakeRoosevelt\Task D56 Sediment QAPP Memo\Map Docs\Sediment Mapping\UCRTemplate-Sediment Mapping.mxd @ 10-29-2010

Arzina
Rice
Waterloo
Daisy
Maud
Addy Gifford
Gifford
Colville Indian Reservation
Inchelium
Impach
Ferry Crossing Landing
Meteor
Covada
Bissel
Cedonia Addy
Kewa
Cedonia
Springdale Hunters

Legend

- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Interpolated)

Sediment Group

- Group 1
- Group 2
- Group 3
- Group 4
- Group 5
- Group 6
- Group 7
- Group 8
- Group 9
- Internal Reference

HydroQual Inc.

Km
0 1.25 2.5

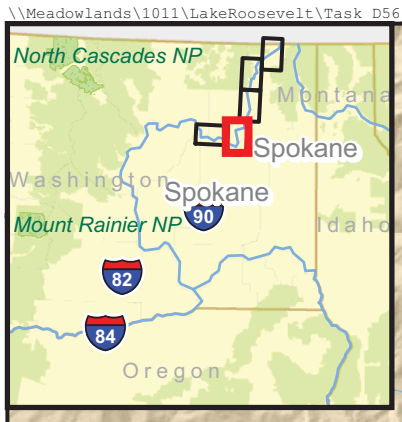
Miles
0 1.25 2.5

N

Map B4-4. **Tile 3 - Interpolated Sediment Groups**

Upper Columbia River, WA

\\Meadowlands\1011\LakeRoosevelt\Task D56 Sediment QAPP Memo\Map Docs\Sediment Mapping\UCRTemplate-Sediment Mapping.mxd @ 10-29-2010



Colville Indian Reservation

Spokane Indian Reservation

Springdale
Hunters
Hunters
Fruitland
25
Enterprise
Miles
Fort Spokane
Seven Bays
Lincoln

Legend

- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Interpolated)

Sediment Group

- Group 1
- Group 2
- Group 3
- Group 4
- Group 5
- Group 6
- Group 7
- Group 8
- Group 9
- Internal Reference

HydroQual Inc.

0 1.25 2.5 Km

0 1.25 2.5 Miles

N

Map B4-5. **Tile 4 - Interpolated Sediment Groups**

Upper Columbia River, WA

Belvedere
155
Seatons Grove
Koontzville
Elmer City
Lone Pine
Crown Point Vista
Mason City
Grand Coulee Dam
Grand Coulee
Electric City
Osborne
Grand Coulee Hill
West
52
174
Bagdad Junction
Hesseltine
Keller
21
Colville Indian Reservation

Legend

- Grand Coulee Dam
- Populated Places
- Reservations
- County Lines
- Sediment > 2mm (Interpolated)

Sediment Group

- Group 1
- Group 2
- Group 3
- Group 4
- Group 5
- Group 6
- Group 7
- Group 8
- Group 9
- Internal Reference

HydroQual Inc.

0 1.25 2.5 Km

0 1.25 2.5 Miles

N

Map B4-6. **Tile 5 - Interpolated Sediment Groups**

Upper Columbia River, WA

APPENDIX A

FIELD SAMPLING PLAN FOR THE PHASE 2 SEDIMENT STUDY

CONTENTS

LIST OF FIGURES

LIST OF MAPS

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

AVS/SEM	acid volatile sulfide/simultaneously extracted metals
COC	chain of custody
COPCs	chemicals of potential concern
DGPS	differential global positioning system
EPA	U.S. Environmental Protection Agency
FSP	field sampling plan
GPS	global positioning system
ID	identification number
LG	licensed geologist
NAD83	North American Datum of 1983
QA/QC	quality assurance and quality control
QC	quality control
RI/FS	remedial investigation and feasibility study
RM	river mile
SHSP	site health and safety plan
Site	Upper Columbia River site
SOP	standard operating procedure
TAI	Teck American Incorporated
UCR	Upper Columbia River
UTM	universal transverse mercator

UNITS OF MEASURE

cm	centimeter(s)
cm/sec	centimeter(s) per second
° C	degree(s) Celsius
ft	foot/feet
ft/sec	foot/feet per second
G	gram(s)
in.	inch(es)
gal	gallon(s)
L	liter(s)
lbs	pound(s)
mL	milliliter(s)
mm	millimeter(s)

1 INTRODUCTION

This document presents the field sampling plan (FSP) for the Phase 2 sediment study (herein the 'study') for the Upper Columbia River (UCR), which extends from river mile (RM) 745 to RM 596 near the Grand Coulee Dam (herein the 'Site'). Information collected in this study will be used to support the remedial investigation and feasibility study (RI/FS) and baseline ecological risk assessment.

The primary objective of the study is to evaluate if there are unacceptable risks to benthic invertebrates (herein 'benthos') associated with exposure to metals and other chemicals, collectively referred to as chemicals of potential concern (COPCs) in UCR sediments. To achieve this, site-specific relationships between COPC concentrations (including factors affecting bioavailability) and toxicity will be evaluated. In addition, data collected during this study will be used to inform other components of the ecological risk assessment (e.g., evaluation of risk to aquatic plants, sediment-probing birds, and other receptors). This FSP describes how and where sediments will be collected for chemical and biological analyses.

1.1 OVERVIEW

Sediment data collected to date have identified a number of sediment COPCs that may adversely affect benthos within the UCR (TAI 2010, 2011). These data do not sufficiently establish potential concentration-response relationships, nor do they fully integrate measures of bioavailability (USEPA 2007). Accordingly, this study will characterize factors that influence bioavailability of COPCs in sediment to help assess if unacceptable risks to benthos exist. Specific questions to be addressed with this work include

- Are sediment COPCs bioavailable at levels indicative of potential unacceptable risks to benthos?
- Are there significant differences in the survival, growth, or reproduction of benthos (i.e., amphipods and midge) exposed to Site and reference sediments? If significant differences occur
  - What is the magnitude of these effects?
  - Are these effects due to COPCs as measured in sediments and/or porewater concentrations?
  - What concentration-response relationships can be established between COPCs and observed effects?

In addition to the above-mentioned primary goal and associated data quality objectives, other questions to be addressed by this study include

- Are sediment COPCs bioavailable at levels indicative of potential unacceptable risks to other ecological receptors (e.g., aquatic plants, sediment-probing birds)?
- Can the nature and extent of unacceptable risk at the Site via spatial gradients and sediment bed properties such as slag content (e.g., zinc/vanadium ratio[1]), total organic carbon, mean probable effects concentration quotient, and sediment texture be further refined?[2]

This FSP describes field methods that will be used to collect sediments for the study. Section 2 of this FSP describes field procedures that will be followed. Section 3 describes procedures for field documentation. References cited in this document are listed in Section 4.

Attachments to this FSP include

- **Attachment A1 - General Site Health and Safety Plan (SHSP), Addendum.** Describes site-specific requirements and procedures to minimize the safety risk to personnel who carry out the field study program.
- **Attachment A2 - Standard Operating Procedures (SOPs).** Detailed field procedures to be used include
  - SOP-1 – Positioning at Below-Water Stations
  - SOP-2 – Sample Labeling
  - SOP-3 –Sediment and Porewater Sample Collection
  - SOP-4 – Decontamination of Sediment Sampling Equipment
  - SOP-5 – Field Documentation
  - SOP-6 – Sample Packing and Shipping
  - SOP-7 – Sample Custody
  - SOP-8 – Boat Inspection and Cleaning for Aquatic Invasive Species

[1] The basis and rationale of using a zinc:vanadium ratio was detailed within Appendix D of the Baseline Ecological Risk Assessment work plan (TAI 2011). Other chemical ratios and/or methods (i.e., backscatter electron microscopy) may also be used to refine sediment bed properties and facilitate data interpretation.
[2] The sampling design is not intended to provide an assessment of spatial distribution of contaminants in the Site.

- **Attachment A3 - Examples of Various Field Forms.** Contains examples of various forms that will be used during field sampling–sediment collection, processing, and external examination forms; a chain-of-custody (COC) form; and sample labeling forms.
- **Attachment A4 - Archaeological Monitoring Protocol.** Provides study-specific procedures to be followed if any archaeological objects or resources are discovered during sampling activities.

2 SAMPLE COLLECTION AND PROCESSING

The following section describes procedures and methods that will be used during the study, including sampling procedures, record keeping, sample handling, storage, and field quality control procedures. Sample collection and processing will be conducted in accordance with the SOPs, provided in Attachment A2. Depending on field conditions, procedures specified in the referenced SOPs may be modified if necessary.

2.1 SAMPLING STATIONS

Consistent with input from the U.S. Environmental Protection Agency (EPA), field personnel will attempt to collect whole sediment and field porewater at 140 target sampling stations from the top 6 in. (15 cm) of the sediment for the analysis of analytical chemistry. These 140 target stations include 124 Site stations (includes 10 internal reference stations), 6 tributary reference stations (sampled in 2005 too), and 10 upstream reference stations in Canada. In addition to chemical analysis, standard short-term bioassays (with survival and growth endpoints) using *Hyalella azteca* and *Chironomus dilutus* will be synoptically performed on whole sediment samples from 74[3] of the 140 locations. Reproductive endpoints will be assessed using long-term bioassays on archived sediment from 18 of the 74 bioassay locations[4].

To account for uncertainties such as the presence of culturally sensitive areas or sediments with unacceptably large grain sizes (e.g., gravels and cobbles), reserve sampling locations have been identified to substitute for Site sampling locations if necessary. A list of Site, reference, and reserve sampling locations identified for this study is provided in Table A1, and station locations are illustrated on Maps A1 through A9. As designated within Table A1, sampling locations have been assigned a station-specific identification number (ID), geographic coordinates (northing/easting and latitude/longitude), and analytical (chemical and/or biological) tests to be performed. One or more reserve stations have been assigned to each Site station (Table A1).

[3] The 74 samples that will be assessed using bioassays include 48 Site samples, 10 internal reference samples, 6 tributary reference samples, and 10 upstream reference samples.

[4] Selection of these 18 samples will be finalized following field sampling activities and will be based on preliminary results from short-term bioassays in conjunction with chemistry data. The data will be used to refine and identify which samples will undergo further evaluation; and will be documented in a technical memorandum, or quality assurance project plan addendum, for EPA's review and approval.

2.2 FIELD SURVEY AND SAMPLING METHODS

It is anticipated that at least two sampling teams and one shore-based team (for sample transport and logistics support) will be used to complete field sampling activities. Sampling vessels will have a deck large enough to accommodate a minimum of three crew members in addition to the vessel's captain and one EPA oversight individual. In addition, it will have enough deck space to accommodate sampling gear (e.g., Van Veen samplers, Lexan tub, hand tools, decontamination materials), coolers, and multiple sampling boxes containing ancillary equipment. Vessels will include navigational lights, anchors, and basic sonar (e.g., fathometer). Vessel operators will be familiar with the area and will have the capability to make headway and maneuver in the potentially turbulent, high-velocity waters of the UCR.

2.2.1 Task Schedule

Subject to EPA approval, field sampling is expected to begin in early to mid-fall (September to October) 2013 and take approximately 4 to 6 weeks. Thirty days prior to field sampling activities, a detailed schedule will be prepared by the field sampling crew to facilitate planning and scheduling of EPA technical and cultural oversight.

2.2.2 Sampling Location Positioning

A differential global positioning system (DGPS)[5] and associated navigation system (e.g., Nobeltec™ marine navigation software) will be used to locate and navigate to sampling locations listed in Table A1. The procedure for locating each sediment sample location by universal transverse mercator (UTM) coordinates is detailed in SOP-1 (Attachment A2). The standard projection method to be used during field activities will be the horizontal datum of North American datum of 1983 (NAD83) and UTM Zone 11.

The field team leader will assess the potential for successful sampling at the designated coordinates. It is important to note that the Cultural Resources Working Group in association with EPA has approved sediment sampling activities within a 150-ft radius of the designated coordinates. The first 'anchor point' (i.e., boat position) in which a sediment grab will be attempted, will be at the designated coordinates unless the field team leader, in consultation with EPA oversight personnel, determines through best

[5] If a signal for the DGPS cannot be received, a handheld global positioning system (GPS) unit will be used to locate sampling station coordinates.

professional judgment that sampling is not likely to be successful (e.g., bedrock or large woody debris observed) at the designated coordinates.

If sampling at the designated coordinates is not likely to be successful, or if an initial collection attempt is unsuccessful, the boat may be repositioned at any other 'anchor point' within 150 ft of the designated coordinates, where the field team leader, in consultation with EPA oversight personnel, determines that sampling success will be improved. Three attempts from three 'anchor points' within the 150 ft approved radius of a sample location will be made. After the nine attempts (i.e., three grabs per 'anchor point'), the field team leader will consult with EPA to determine whether moving to a reserve location is necessary.

A schematic illustrating the aforementioned sequence of sampling activities is illustrated within Figure A1 below. 'Anchor points' within the 150-ft approved radius of the designated sample location (coordinates), are represented by the large diameter red dots, while individual grab attempts are represented by the small diameter block dots.

2.2.3 Field Equipment and Supplies

Minimum field equipment and supplies anticipated for this study include sampling equipment (e.g., Van Veen grab sampler), hand tools (e.g., mechanical stainless paddle wheel mixer, scoops, shovel), decontamination supplies, sample containers, coolers, shipping containers, cameras, field logs and forms (or electronic tablet), personal protection equipment, and personal gear. Protective wear (e.g., gloves) is required to minimize the possibility of cross-contamination between sampling locations.

Sample containers, preservatives, distilled/deionized water, coolers, and packaging material for samples will be supplied by the analytical laboratory. Details on required sample volumes for sediment and field porewater are provided in Table A2.

Sample containers will be clearly labeled at or prior to the time of sampling. Completing as much labeling as possible prior to the field work (especially electronic labeling) is advantageous because it reduces errors stemming from inconsistent naming, handwriting legibility, and label adhesion that may occur when labeling in field conditions. Labels will include the task name, sample location and number, samplers' initials, analyses to be performed, and sample date and time. Sample labeling procedures are detailed in SOP-2 (Attachment A2) and an example sample label is provided in Attachment A3.

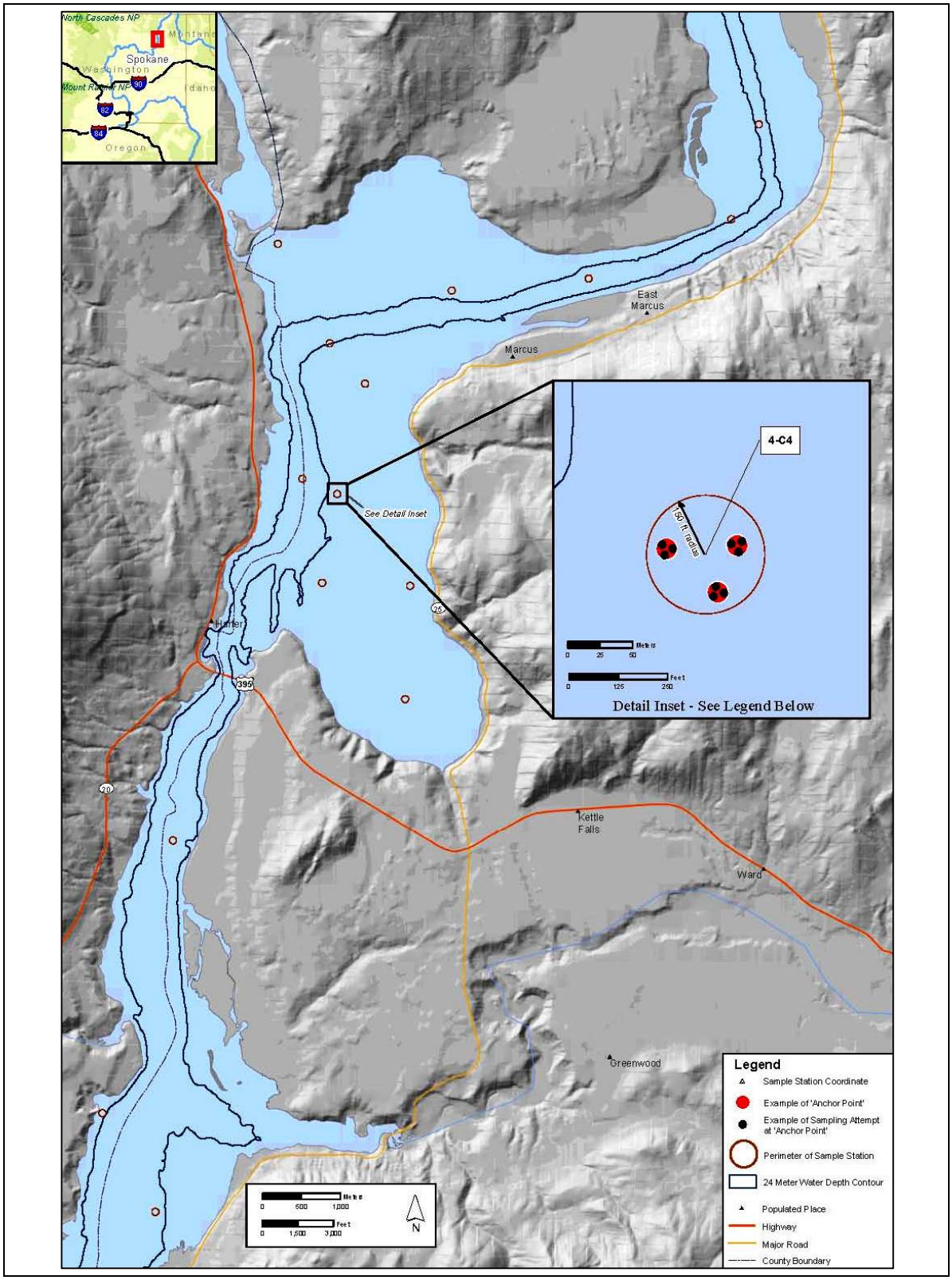


Figure A1. Schematic of 'Anchor Point' Sampling Design per Designated Sampling Location.

2.2.4 Sampling Methods

This section describes the sediment and porewater sampling methods that will be implemented in the field. These methods are supported by SOPs and summarized in Section 2.2.5.

Grab Sampler Deployment

Below-water surface sediment samples will be collected using a decontaminated Van Veen power grab sampler[6] (herein 'grab sampler'), see SOP-3 (Attachment A2). A standard Van Veen grab sampler will also be available as a back-up in the event that the primary grab sampler is damaged, malfunctions, or is lost. The grab sampler will be deployed using a hydraulic winch and an overhead davit or boom at a controlled rate of speed. The position of the grab sampler relative to the riverbed will be shown on the vessel's depth sounder, or alternatively will be determined by rigging the hydrowire to a meter wheel or using pre-marked meter lengths on the cable itself. After the grab sampler collects the sediment sample, it will be lifted slowly off the bottom and then steadily raised to the surface at a speed of about 30 cm/sec (1 ft/sec). Each grab sample will be retrieved aboard the vessel and evaluated for the following acceptance criteria:

- Complete closure of the grab sampler
- Overlying water is present
- Adequate penetration depth is achieved
- No sediment contact with top access doors (the sampler is not overfilled)
- Minimal signs of winnowing from the sampler.

Grab samples not meeting the above-listed acceptance criteria will be "rejected," but will be temporarily held onboard while subsequent sampling drops attempt to obtain an "accepted" sample (i.e., a sample meeting all the acceptance criteria). Rejected sample materials will be temporarily placed in a decontaminated, transparent Lexan tub for cultural inspection; and the sampling steps repeated until an accepted sample has been obtained or until a minimum of nine attempts per sampling station have failed. Should subsequent sampling attempts also fail to meet the above-listed acceptance criteria, additional rejected sediments will be placed in the same or separate Lexan tubs. Field personnel will use their experience and professional judgment applying the acceptance criteria to identify accepted and rejected samples.

[6] The Van Veen power grab sampler is a custom built sampler designed specifically for operating in hard bottom materials and in higher water flow areas. It consists of a 400 lbs base frame and a Van Veen style bucket that is operated by a pneumatic cylinder with 900 lbs of closing force, using an on-board air compressor and top-side controller. It is built completely from Stainless Steel 304.

Upon obtaining and retrieving a grab sample, overlying water will be siphoned off near one corner of the sampler prior to porewater collection (see section below).

Material in the grab sampler will be photographed. The photograph ID will be documented in the field so that the photograph can be subsequently labeled with station location, date, and time of sample. Field personnel will don clean gloves prior to porewater collection (see section below) and /or handling the sediment sample.

As acknowledged within Section 2.1 and illustrated within Maps A1 through A9, uncertainties such as the presence of unacceptably large grain sizes (>2 mm), may adversely affect meeting the above-listed sample acceptance criterion. In the event that all nine sampling attempts fail to meet the acceptance criteria, prior to discarding all rejected sediments from this location, field personal will (following inspection for cultural resources) assess the overall grain-size distribution of rejected materials temporarily stored in the Lexan tub(s) and photograph the collected materials. Field personnel will use their experience and professional judgment to evaluate the relative volume of fine-grained sediments (i.e., ≤2 mm). A 5-mm sieve will be used to sieve any sediment samples that, based on the guidance provided by EPA, require sieving to achieve the desired grain size distribution. If there is sufficient volume to perform sediment chemistry and biological analyses per Table A2, sediment samples should be evaluated and homogenized as laid out in the steps below, and collected for future laboratory analyses. The collection of these rejected sediments will allow some evaluation of the area, in the event that similar sampling difficulties are encountered at reserve locations.

Porewater Collection

Field porewater samples will be collected directly from the grab sampler via suction (i.e., using a ceramic airstone). An airstone will be carefully inserted horizontally into the sediment sample as it remains in the grab sampler through a specially constructed side-port (Figure A2). In the event of an obstruction near the sampling port, such that the airstone cannot be inserted horizontally, field personnel will

1) Attempt insertion of the airstone by pushing the airstone into the sediment at an angle
2) Attempt insertion of the airstone into the second port, located on the opposite side of the grab sampler
3) Attempt insertion of the airstone through the surface of the sample, or
4) Collect another grab sample.[7]

[7] The lack of successful field porewater collection with an airstone is not justification for rejecting a sediment sample for chemical and/or toxicity testing.

Figure A2. Illustration of Custom-designed Sampling Side Port on the Van Veen Power Grab Sampler

Upon insertion, the top of the airstone will sit approximately 3 in. (7 cm) below the sediment surface. The airstone will be connected to a ≤140 mL syringe via pre-cleaned decontaminated Tygon® or similar polyethylene tubing as provided by the analytical laboratory, through which porewater can be extracted directly into the pre-cleaned syringe. Extracted porewater will be discharged directly from the syringe into sampling containers provided by the analytical laboratory. For porewater samples requiring filtration, a decontaminated 0.45 μm polyethylene syringe filter provided by the analytical laboratory will be attached to the syringe so that the extracted field porewater can be pressed through the filter directly into the appropriate sampling containers (see SOP-3 in Attachment A2).

If available, porewater will be collected from both accepted and rejected sediments in separate syringes. If any amount of porewater is collected from an accepted sample, that volume of porewater will be analyzed (using the analysis prioritization indicated in Table A2) and the syringe of rejected porewater will be discarded. Porewater from multiple rejected or accepted samples may be combined (as described in the next paragraph) so long as the porewater from the accepted and rejected sediments is not mixed. The lack of successful field porewater collection with an airstone is not justification for rejecting a sediment sample for chemical and/or toxicity testing.

If insufficient porewater volume is collected from the first accepted or rejected sediment grab samples, additional porewater may be collected from subsequent grab samples. Additional porewater can be collected using the same syringe containing the porewater from the first grab sample so that porewater collected from multiple samples becomes composited in the syringe (waters from accepted and rejected sediments will not be mixed). Additional sediment grabs will not be attempted solely to increase the porewater volume for porewater samples. If the sediment volume recovered during the first

accepted grab sample is adequate for the sediment sample needs, any porewater recovered from this sediment will be analyzed in accordance with the prioritization indicated in Table A2.

Porewater will be expelled from the syringe into labeled, laboratory-provided sample containers (Table A2). This water will be distributed unfiltered or filtered as specified by the analytical method. Porewater samples will be stored in a cooler with ice until they are transferred from the sampling vessel[8].

Cultural Resources Examination

Following porewater extraction, the recovered sediment will be emptied from the grab sampler into a decontaminated, transparent Lexan tub for on-site cultural resource examination. The onboard cultural resource monitor will examine the sediment to determine if cultural resources are present. If cultural resources are present, the field crew will follow instructions from the cultural resources monitor regarding what to do with the recovered sediment and cultural artifacts, as well as whether to abandon the sampling station.

Geological Examination and Press-Sieving

Following cultural clearance, using appropriate decontaminated tools (e.g., mechanical stainless paddle wheel mixer, gloved hands, scoops) the sample will be homogenized in the Lexan tub until the texture and color of the sediment appears to be uniform.

A qualified person[9] will characterize the sediment and visually estimate the percentage of the homogenized material that is ≤2 mm in size. All observations will be documented. Sediments that are composed entirely of fine grained material (≤2 mm) will be retained with no additional processing. Sediments that are composed mostly of fine grained materials but also include some larger pieces of gravel or debris will have the larger pieces of gravel or debris removed by hand. Samples with large proportions of materials that are >2 mm will be coarsely sieved using a 5 mm sieve. Sieving will be performed by shaking or pressing (e.g., using gloved hands to break apart clumps) the sediment

[8] As outlined in Section B4.2.1 of the quality assurance project plan, additional chambers will be set-up for porewater chemistry measurements. From these additional chambers, porewater will also be collected using Brumbaugh type peepers, see SOP-9.

[9] A qualified person is either a Washington State Licensed Geologist (LG) or an engineer/scientist who has received site-specific training in the following: 1) identification of sedimentary deposits of the UCR basin, 2) recognition of amorphous silica-rich glass, 3) particle size and percentage estimation, 4) soil/sediment classification systems, and 5) recording of observations.

through the sieve. Unacceptable sieving techniques include drying the sediment or washing it through the sieve using water. A final determination will be made whether the press-sieved sample meets the requirement for >25 percent of the sample to be fine grained (i.e., <2 mm).

A qualified person will also visually examine the sediment for the presence or absence of black silica glass particles. Results of this examination will be recorded in the field logbook and datasheets, including the approximate percent of the sample that is represented by these particles. Presence or absence of black silica glass particles will be assessed based on the presence of vitreous, conchoidal fracture(s), and a translucent appearance.

The homogenized sediment will be photographed. The photograph ID will be documented in the field so that the photograph can be subsequently labeled with station location, date, and time of sample.

Sample Collection

Once the geological evaluation is complete, the homogenized sediment may be placed into labeled (SOP-2), laboratory-provided, sample containers (Table A2). Sample containers for a field duplicate sample (if needed) will be filled from the same homogenized sediment as the primary sample. The container for the acid volatile sulfide / simultaneously extracted metals (AVS/SEM) analysis should be filled first, as the results of this analysis are affected by excess oxygen exposure. The AVS/SEM container should be filled with sediment leaving no headspace, and the preservative should be distributed through the sample by inverting the container or by mixing. All remaining sediment samples for the analytical chemistry should be filled. Sediment samples for the analytical laboratory will be stored in a cooler with ice until they are transferred from the sampling vessel.

As outlined within Table A2, up to 12 gal (44.5L) of sediment will be collected from stations where bioassay analyses will be conducted. These sediments can be stored in appropriate, decontaminated containers (e.g., three 5-gal buckets). A thin layer of river water should be added to the sediment to prevent excess oxygenation during transport to the bioassay laboratory. As previously noted, it is acknowledged that at designated bioassay sampling stations, field sampling personal will strive to collect the 44.5 L of sediment necessary to complete all planned analyses. However, the potential lack of attaining the desired 44.5 L of sediment will not be cause to reject or dismiss the sediment sampling location. Rather, the retained sediment volume will be evaluated relative to the

analytical priorities outlined within Table A2 (i.e., 1.2 L for chemical analysis; 3.7 L for chemical analysis and short-term bioassays; 8.0-L for chemical analysis, short- and long-term bioassays; and 44.5 L for chemical analysis, short- and long-term bioassays, and Toxicity Identification Evaluation). Bioassay samples may be stored at ambient temperature until they are transferred from the sampling vessel. After being transferred from the sampling vessel, all samples (chemical and bioassay) will be stored in a refrigerated area while awaiting shipping.

Decontamination

The grab sampler and associated equipment (e.g., Lexan tubs and scoops) will be decontaminated between station locations in accordance with decontamination procedures, see SOP-4 (Attachment A2). The airstone, tubing, and syringe are dedicated to each sampling station (and to accepted and rejected sediments at each station) and will be discarded following use.

2.2.5 Sampling Method Summary

The field sampling method described in Section 2.2.4 can be summarized into the following steps:

1. Deploy decontaminated grab sampler at sampling station. Record GPS location.
2. Retrieve grab sampler and check grab sampler for sample acceptability (e.g., closed sampler, not overfilled, minimal winnowing). Photograph sediment in the sampler.
3. If acceptance criteria are not met, classify this sediment as rejected. Rejected sediment should be processed as described below and temporarily stored during attempts to collect accepted sediment.
4. Siphon water from sampler.
5. Extract porewater from the grab sampler into a syringe using an airstone (label syringe as containing porewater from rejected or accepted sediments).
6. Deposit sediment into Lexan tub.
7. Examine sediment for the presence of cultural resources. If the recovered sediment contains cultural resources, follow instructions from the cultural resource monitor regarding what to do with the recovered sediment and cultural artifacts as well as whether to abandon the sampling station.

8. Samples rejected due to incorrect grabs as defined in Step 2 will not be processed for chemical analysis or toxicity testing.
9. Evaluate and document sediment particle size[10]
    a. Remove large rocks and debris from sediments by hand containing mostly fine particles.
    b. Press sediment through a 5 mm sieve if sediments contain large fractions of particles >2 mm. Do not use river water to wash sediments through sieve.
    c. Assess the sediment grain size (at least 25 percent must be ≤2 mm).
10. Evaluate and document the presence of black silica particles in sediment.
11. Photograph homogenized sediments
12. Fill all porewater and sediment sample containers, beginning with the AVS/SEM container for sediments.
    a. Fill the AVS/SEM container completely, leaving no headspace. Distribute the AVS/SEM preservative by storing the container inverted or by mixing.
    b. Fill all remaining sediment containers for analytical chemistry, minimizing headspace
    c. Fill appropriate decontaminated bioassay containers (e.g., 5-gallon buckets with lids) with sediment.
    d. Add river water to bioassay sediment samples to create a thin water layer. This layer will minimize oxygenation during transit.
    e. Fill porewater sample containers with filtered or unfiltered water as appropriate for the analytical method.
13. Store all analytical chemistry samples in a cooler with ice. Bioassay samples may be stored on the sampling vessel at ambient temperature.
14. Return any excess sediment and/or porewater to the river, decontaminate equipment (e.g., grab sampler, Lexan tub, mechanical stainless paddle wheel mixer), and move to next sample station.

[10] As detailed in SOP-3, if there is sufficient volume to perform analyses per Table A2, sediment samples should be evaluated and homogenized as laid out in the steps below, and retained for future analyses. The collection of these rejected sediments will allow some evaluation of the area, in the event that similar sampling difficulties are encountered at reserve locations.

15. Upon arriving at the dock, transfer all sample containers into a refrigerated area where they can be stored until shipped.

2.2.6 Sampling Contingencies

During the course of sampling, field conditions or circumstances may adversely affect sampling success. Such conditions or circumstances may include, but are not necessarily limited to, the presence of cultural resources (refer to Cultural Resources Coordination Plan, Appendix C of the quality assurance project plan), the presence of coarse substrates (e.g., gravels, cobbles, boulders, bedrock), and/or above-average river flow conditions. To accommodate such circumstances, reserve sampling stations have been identified for the 124 Site stations (Table A1). In the event that samples cannot be collected from a Site sampling station, the field sampling crew will attempt to collect a sample from one of the reserve stations designated as applicable to the target station (reserve stations designated for each target station are listed in Table A1). If attempts to collect sediment from both the target and all designated reserve stations are unsuccessful, no sample will be collected for this location (i.e., no additional locations will be substituted or attempted).

2.2.7 Sample Acceptability and Quality Assurance

To ensure that a minimum sample quality is achieved, acceptance criteria will be applied to each sediment sample as described in Section 2.2.4. These criteria include specifications for the integrity of the sample in the grab sampler (e.g., complete closure of the grab sampler, sample not overfilling the sampler, minimal winnowing) and specifications for the sediment composition (i.e., at least 25 percent fine particles ≤2 mm). Field personnel will apply these criteria using their experience and professional judgment.

2.2.8 Field Quality Control Samples

Field quality control (QC) samples will be used to assess sample variability and evaluate potential sources of contamination. Types of QC samples that will be collected for this study are described below. Detailed information on quality assurance/quality control (QA/QC) procedures, limits, and reporting are provided in the quality assurance project plan.

Field QC samples will include field duplicate samples (both internal and those collected by EPA in support of their QA/QC program) and equipment rinsate blanks. The

following QC samples will be collected in the field and analyzed by the analytical laboratory:

- **Field Duplicate Samples (Internal).** Field duplicate samples will be collected and analyzed to assess variability associated with sample processing and laboratory variability at the analytical laboratory. Field duplicates will be collected from no less than 10 percent of the sediment samples (i.e., 14 samples if sediment is successfully collected from all 140 target [or reserve] locations). These duplicates will be collected at approximately even intervals throughout the sampling period. No field duplicate samples will be collected for the bioassays.
- **Field Split Samples (EPA).** EPA field split samples will be collected by EPA representatives from no less than 15 percent of the sediment samples (i.e., 21 samples if sediment is successfully collected from all 140 target [or reserve] locations) for chemical analysis as part of EPA's QA/QC program. Each EPA field split sample will contain not less than 200 grams and will be collected as splits of homogenized sediments. Up to seven split samples from bioassay stations located upstream from the confluence of Onion Creek (RM 730) will also be evaluated as part of EPA's QA/QC program. Pending approval and agreement from the Canadian Government, EPA would also collect up to three split-samples for bioassay testing in upstream reference locations. In addition, laboratory negative control substrates employed by Pacific EcoRisk will also be provided for EPA's QA/QC testing program.
- **Equipment Rinsate Blanks.** Equipment rinsate blanks will be collected to identify possible contamination from the sampling environment or from the sampling equipment (e.g., mechanical stainless paddle wheel mixer, scoops, bowls). Equipment rinsate blanks will be generated once a day per sampling crew. Equipment rinsate blanks will consist of running distilled/deionized water over the sampling equipment after decontamination. Equipment rinsate blanks will be collected a minimum of one time for each kind of sampling equipment used during the field event (i.e., at least one blank for the sampler, one for the bowl, and one for the scoop).
- **Field Blanks.** In addition, one field blank will be collected for the airstone, tubing, filter, and syringe combination during the field effort. Since these components are decontaminated in the laboratory and are single-use in the field, the airstone/tubing/filter/syringe combination will not be decontaminated in the field prior to sample collection. Field blanks will be analyzed for the presence of target

analyte list metals by collecting deionized water passed through the syringe, tubing, airstone, and filter.

2.2.9 Individual Sample Numbering

Each distinct sediment and porewater sample will be assigned a unique identifier. The sample ID will be numbered sequentially with project/client, study name, medium, station ID, sample type as shown below.

SE or PW or R or FB = medium (SE for sediment, PW for porewater, R for rinsate, FB for field blank)

= Station ID number (see Table A1)

B or C = Analyses to be conducted (bioassay plus chemistry or chemistry only).

Examples

SE-1-B2 = Sediment sample taken at station 1-B2

PW-2B-C3 = Porewater sample taken at station 2B-C3

R-3-B3 = Equipment rinsate taken at station 3-B3.

Field duplicate samples will be assigned unique identifiers in the field using fictitious station ID numbers that will be clearly documented in the field notes. These samples will not be identified as field duplicates to the laboratory.

2.2.10 Equipment Decontamination Procedures

All sampling equipment coming into direct contact with samples will be decontaminated prior to beginning field work, between sampling stations, and at the conclusion of the field effort as outlined with SOP-4 (Attachment A2). Clean room 100 certified nitrile gloves will be used for handling samples and will be discarded in between sampling stations. Clean gloves will be worn at each sampling station to avoid transfer of potential contaminants.

Syringes, syringe filters, and associated tubing used for porewater sample collection will be pre-cleaned by the analytical laboratory. Porewater will be filtered directly into sampling containers provided by Columbia Analytical Services.

2.3 SAMPLE HANDLING

Records will be maintained to document all activities and data associated with field sampling, with chemical analyses, and bioassays. Results of data verification and

validation activities will also be documented. Procedures for documenting field activities are described herein (see SOP-5; Attachment A2); laboratory procedures are presented within Appendices D (analytical laboratory) and E (bioassay laboratory) of the quality assurance project plan.

Planning and documentation of all activities are emphasized to ensure that sample identity and integrity are preserved during all stages of the field operation. The following documentation will be provided with samples:

- A field record form that contains information about each sampling station
- Photo documentation
- A sample identification label that accompanies and identifies each individual sample
- A COC form that provides continuous tracking information for all samples.

The following information will be handwritten on the sample label at the time of collection with an indelible marker (or preprinted sample labels may be used):

- Sediment sample number
- Date
- Time.

If necessary, corrections will be made on the sample labels by drawing a single line through the error and entering the correct information with an indelible marker. All corrections will be initialed and dated by the person performing the correction. If possible, the individual who made the error will correct it.

Sample labels will be placed either on the sample container or with the sample container inside resealable plastic bags. When individual samples are prepared for shipment, this sample label will remain with the packaging.

Sediment samples should also be characterized according to the following parameters, and recorded in field logs (SOP-5; Attachment A2):

- Sediment type (e.g., silt, sand)
- Texture (e.g., fine-grain, coarse, poorly sorted sand)
- Color
- Presence/absence of black silica glass particles (based on vitreous, conchoidal fracture(s), and a translucent appearance); if present estimate relative percent composition
- Visual presence of biological structures (e.g., amphipods, macrophytes)
- Presence of shells

- Presence of debris (e.g., twigs, leaves), especially organic debris
- Stratification, if any
- Presence of a sheen, if any
- Odor (e.g., hydrogen sulfide), if any.

2.4 CULTURAL RESOURCES

In accordance with the protocols outlined in Attachment A4, Archeological Monitoring Protocol, a cultural resources monitor will be present on each sampling vessel throughout the duration of the sampling effort. The monitoring archaeologist(s) will visually examine each sediment sample after the grab sampler deposits it in the Lexan tub.

2.5 SAMPLE PACKAGING AND TRANSPORT

After completing each day of sampling, the sampling vessel will return to the boat launch and the field crew will deliver the samples, held in coolers with ice, to the onshore sample processing team. The onshore processing team will have at their disposal a secure area for processing and preparing samples for shipment to the processing laboratory (SOP-6; Attachment A2). At the onshore sample processing facility, the following procedures will be employed:

1. Review field logs regarding sample characteristics
2. Leave the original sample label with the sediment sample
3. Ensure that appropriate SOPs have been followed regarding sample identification
4. Further prepare sample for shipment to the analytical laboratory and complete the COC forms.

All samples will be stored in an onshore refrigerated area while they are awaiting shipping. Prior to shipping to the analytical laboratory, analytical samples will be packed on ice (in sufficient quantity to keep the samples at 4° C for up to 48 hours), and shipped via priority overnight delivery service or courier service, so that they arrive at the processing laboratory within 48 hours from the time of sample shipment. Bioassay samples will be shipped in a manner that ensures that the samples remain cool and arrive at the bioassay laboratory within 48 hours from the time of sample shipment.

Sturdy plastic coolers will be used as shipping containers. Sufficient samples will be placed in each cooler to occupy 60 to 70 percent of the cooler volume, and the remaining space in the cooler will be filled with ice. Completed COC forms will be placed in

resealable plastic bags and included in each cooler. After each cooler is packed with samples and ice, it will be secured at both ends with nylon strapping tape and the following items will be attached:

- Address label for processing laboratory
- Two custody seals
- Overnight shipping airbill
- Perishable goods label.

2.6 STUDY-DERIVED WASTE

All study-derived wastes will be disposed of at appropriate facilities (USEPA 2008). All disposable materials and supplies used for sample collection and processing (e.g., paper towels, gloves, tubing, needle-less syringes from porewater collection) will be placed in heavyweight garbage bags or other appropriate containers. This waste will be placed in a normal refuse container for disposal at a solid waste landfill. Solvent wastes will be stored in containers and disposed at an appropriate offsite facility. Acid waste will be neutralized and disposed locally.

2.7 VESSEL PROCEDURES FOR AQUATIC INVASIVE SPECIES CONTROL

Aquatic invasive species are a serious ecological and economic threat, and sediment sampling with research vessels and equipment has the potential to spread non-native noxious weeds, pathogens, and exotic flora and fauna among water bodies. The sampler vessel captain and crew will be familiar with the risks of invasive species and trained on inspection and decontamination procedures. The sampler vessel(s) will be thoroughly inspected and cleaned before the field effort to prevent transport of exotic species (e.g., New Zealand mudsnail, quagga and zebra mussels, and milfoil) in accordance with SOP-8 (Attachment A2). Because the UCR is not an Area of Extreme or Moderate Concern, the sampling vessels do not need to be decontaminated between sampling stations within the UCR or after the sampling effort is complete.

3 FIELD DOCUMENTATION

The integrity of each sample from the time of collection to the point of data reporting must be maintained. Proper record-keeping and COC procedures will be implemented to allow samples to be traced from collection to final disposition. Representative photographs will be taken of each type of sampling activity performed during the study. Site photographs from various angles and views of the sampling locations will be collected.

3.1 FIELD LOG

All field activities and observations will be noted in a field log. The field log will be either a bound document containing individual field and sample log forms or an electronic tablet containing the same documentation. Information will include personnel, date, time, station designation, sampler, types of sample(s) collected, and general observations. Any changes that occur during sampling (e.g., personnel, responsibilities, deviations from the FSP) and the reasons for these changes will be documented in the field log. The log will identify onsite visitors (if any) and the number of photographs taken at each sampling station. The field supervisor is responsible for ensuring that the field log and all field data forms are correct; if electronic records are kept, the field supervisor will upload those to the secure project website on a daily basis, or as often as practical. Requirements for logbook keeping include the following:

- If paper logbooks are used
  - They will be bound, with consecutively numbered pages.
  - Removal of any pages, even if illegible, will be prohibited.
  - Entries will be made legibly with black (or dark) waterproof ink.
  - Corrections will be made by drawing a single line through the original entry, with the corrected entry written alongside the original. Corrections will be initialed and dated and may require a footnote for explanation
- Each day's first entry will be made on a new, blank page
- Easy to understand, descriptive language will be used
- Entries will be made while activities are in progress or as soon afterward as possible (the date and time that the notation is made should be noted, as well as the time of the observation itself)

- Blank lines on a page or blank pages in the file book will be lined out to indicate that they were intentionally left blank
- The date and time, based on a 24-hour clock (e.g., 0900 for 9:00 am and 2100 for 9:00 pm), will appear on each page.

In addition to the preceding requirements, if a paper logbook is used, the person recording the information must initial and date each page of the field logbook. If more than one individual makes entries on the same page, each recorder must initial and date each entry. The bottom of the page must be signed and dated by the individual who makes the last entry. The field supervisor, after reading the day's entries, also must sign and date the last page of each daily entry in the field logbook.

The type of information that may be included in the field log and/or field data forms includes the following:

- Task name, task location, and task number
- Task start date and end date
- Weather conditions
- Name of person making entries and other field staff
- Onsite visitors, if any
- Sampling vessel, if any
- Date and collection time of each sample
- The sampling station name
- Water depth, and sampling location coordinates derived from GPS for each drop of the grab sampler.
- Specific information on each type of sampling activity
- Observations made during sample collection
- Number of photographs taken at each sampling location
- A record of site health and safety meetings, updates, and related monitoring
- Any deviation from the sampling plan and reasons for deviation.

In addition, a sampling location map will be updated during sampling and will be maintained throughout the sampling event. All logs must be completed at the time any observations are made. Copies of all logs and forms will be retained by Teck American Incorporated (TAI) and its technical team. It is advisable to photocopy each day's entries to provide a backup copy that can be kept at a secure location (field lab, hotel room, or the like).

3.2 CHAIN-OF-CUSTODY PROCEDURES

Samples are in custody if they are in the custodian's view, stored in a secure place with restricted access, or placed in a container secured with custody seals. A COC record will be signed by each person who has custody of the samples and will accompany the samples at all times. Copies of the COC will be included in laboratory and QA/QC reports. Attachment A3 contains an example of the COC form that will be used during the study, with directions for how to fill out the form in SOP-7 (Attachment A2).

The COC form will be either paper or electronic and, at a minimum, will include the following information:

- Site name
- Field supervisor's name and team members responsible for collection of the listed samples
- Collection date and time for each sample
- Sample type (i.e., sediment, porewater, or rinsate)
- Number of sample containers (i.e., coolers) shipped
- Requested analyses for each sample (as per Table A2)
- Sample preservation information (if any)
- Name of the carrier relinquishing the samples to the transporter, noting date and time of transfer, and the designated sample custodian at the receiving facility.

The field supervisor, as the designated field sample custodian, will be responsible for all sample tracking and COC procedures for samples in the field. The field sample custodian will be responsible for final sample inventory and will maintain sample custody documentation. The field sample custodian will complete COC forms prior to removing samples from the field. Upon transferring samples to the laboratory sample custodian or shipping courier, the field supervisor will sign, date, and note the time of transfer on the COC form. The original COC form will be transported with the samples to the laboratories. All samples will be shipped to the testing laboratories in either coolers or shipping containers sealed with custody seals.

Each laboratory will designate a sample custodian who will be responsible for receiving samples and documenting their progress through the laboratory analytical process. The sample custodian for each laboratory will confirm the integrity of the custody seals upon sample arrival at the laboratory. The laboratory sample custodian will also ensure that the COC and sample tracking forms are properly completed, signed, dated, and initialed upon receipt of the samples.

Upon receipt of the samples by the laboratory, the laboratory sample custodian will inventory the samples by comparing sample labels (numbers and tags) to those on the COC document. If sample temperatures fall outside the acceptable range, the field supervisor should be alerted immediately. The custodian will enter sample numbers into a laboratory tracking system by task code and sample designation. The custodian will assign a unique laboratory sample identifier to each sample number and will be responsible for distributing the samples to the appropriate analyst or for storing samples at the correct temperature in an appropriate and secure area.

4 REFERENCES

TAI. 2010. Upper Columbia River screening-level ecological risk assessment (SLERA). Prepared by Parametrix, Inc., Exponent, and Integral Consulting, Inc. for Teck American Incorporated, Spokane, WA.

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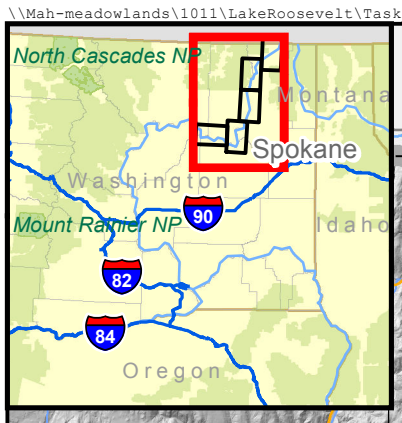
Maps

\\Mah-meadowlands\1011\LakeRoosevelt\Task D81_Project_Support\Sediment_QAPP_Revisions\Sampling_Maps\UCRTemplate-Toxicity_Tests.mxd @ 08-20-2012



U.S. - Canada Border

Grand Forks

Tile 1

Tile 2

Tile 3

Tile 4

Tile 5

Colville Indian Reservation

Spokane Indian Reservation

Okanogan

Ferry

Stevens

Lincoln

Grant

Legend

- Populated Places
- County Lines
- Reservations
- 24 Meter Water Depth Contour
- Sediment > 2mm (CCT)
- Sediment > 2mm (Interpolated)

EPA Alternate Location

- Bioassay
- Chemistry-Only
- Internal Reference
- Reserve

HDR | HydroQual

0 5 10 Km

0 5 10 Miles

N

Map A1. **Overview of Proposed Sediment Sampling Locations**
Upper Columbia River, WA

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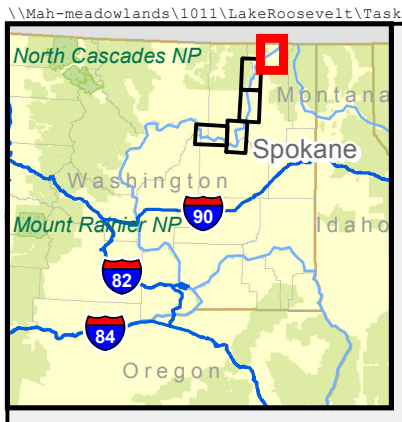

U.S. - Canada Border

Frontier

Velvet

Sample 1-R5 at RM 744
Sample 1-R1 at RM 744
Sample 1-R3 at RM 744
Sample 1-R2 at RM 742
Sample 1-B1 at RM 744
Sample 1-C4 at RM 743
Sample 1-R4 at RM 743
251
Deep Lake Boundary
Sample 1-B3 at RM 740
Sample 1-B2 at RM 742
Sample 1-R6 at RM 741
Sample 1-R8 at RM 737
Sample 1-R7 at RM 739
Sample 1-C3 at RM 739
25
Sample 1-C2 at RM 739
Sample 1-B4 at RM 737
Sample 1-B5 at RM 737
Sample 1-B6 at RM 738
Sample 1B-R4 at RM 735
Sample 1B-C3 at RM 735
Sample 1-C1 at RM 738
Sample 1B-C2 at RM 734
Sample 1B-C4 at RM 733
Sample 1-R9 at RM 737
Sample 1-R10 at RM 737
Sample 1B-R3 at RM 735
Sample 1B-R1 at RM 735
Sample 1B-R2 at RM 734
Sample 2-B1 at RM 733
Sample 2-B2 at RM 732
8th Fir Sou
Sample 1B-C1 at RM 734
Leadpoint
Sample 2-R2 at RM 732
Sample 2-R1 at RM 732
Sample 2-R3 at RM 732
Sample 2-C1 at RM 731
Sample 2-C2 at RM 731
Sample 2-R4 at RM 731
Sample 2-R5 at RM 731
Sample 2-R6 at RM 731
Sample 2B-R2 at RM 728
Sample 2-B3 at RM 731
Sample 2-R7 at RM 730
Sample 2B-R1 at RM 728
Sample 2-B4 at RM 730
Sample 2-C4 at RM 730
Sample 2-R10 at RM 729
Sample 2-B5 at RM 729
Sample 2-B6 at RM 729
Sample 2B-C4 at RM 728
Sample 2-R8 at RM 730
Sample 2-C3 at RM 730
Sample 2-R9 at RM 729
Sample 2B-C1 at RM 727
Sample 2B-R3 at RM 727
Sample 2B-C2 at RM 727
Johnson Graze
Sample 2B-R4 at RM 726
Sample 3-R1 at RM 726
Marble
Sample 3-B1 at RM 725
Sample 2B-C3 at RM 726
Sample 3-B3 at RM 724
Sample 3-R2 at RM 725
Sample 3-C1 at RM 724
Sample 3-R3 at RM 725
Sample 3-B6 at RM 722
Sample 3-R8 at RM 722
Sample 3-B2 at RM 724
Sample 3-R4 at RM 724
Sample 3-C2 at RM 724
Sample 3-R5 at RM 723
Sample 3-R6 at RM 723
Sample 3-B5 at RM 723
Sample 3-B4 at RM 723
Sample 3-C3 at RM 723
Deep Lake Boundary
Spirit
Aladdin
Onion Creek
Goldfield Mill
Clugston Creek
Onion Creek
Aladdin

Legend

- Populated Places
- County Lines
- 24 Meter Water Depth Contour
- Sediment > 2mm (CCT)
- Sediment > 2mm (Interpolated)

EPA Alternate Location

- Bioassay
- Chemistry-Only
- Internal Reference
- Reserve

HDR | HydroQual

0 1.25 2.5 Km

0 1.25 2.5 Miles

N

Map A2. **Tile 1 - Proposed Sediment Sampling Locations**
Upper Columbia River, WA

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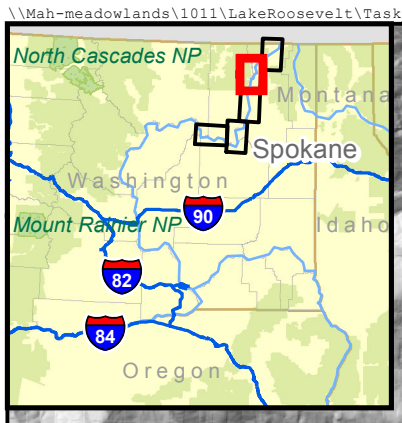


Sample 3-R10 at RM 721
Sample 3-R9 at RM 721
Sample 3B-C1 at RM 720
Sample 3-R6 at RM 723
Sample 3-B5 at RM 723
Sample 3B-R1 at RM 720
Ryan
Sample 3-R7 at RM 722
Sample 3-C3 at RM 723
Sample 3-C4 at RM 721
Sample 3-B6 at RM 722
Sample 3-R8 at RM 722
Sample 3B-C2 at RM 719
Barstow
Sample 3B-R2 at RM 718
Sample 3B-R3 at RM 717
Sample 3B-R4 at RM 715
Kettle River
Bossburg
Sample 3B-C3 at RM 715
395
Sample 3B-C4 at RM 714
Boyds
Evans
Bear
Sample 4-R11 at RM 712
Powell
25
Sample 4-R12 at RM 707
Sample 4-R1 at RM 711
Sample 4-C2 at RM 707
Sample 4-B1 at RM 710
Sample 4-R3 at RM 708
Sample 4-B2 at RM 708
Sample 4-C1 at RM 710
Sample 4-R5 at RM 707
Sample 4-B6 at RM 709
Sample 4-B3 at RM 707
East Marcus
Sample 4-B4 at RM 706
Marcus
Sample 4-C3 at RM 706
Sample 4-R4 at RM 707
Sample 4-R6 at RM 705
Sample 4-R7 at RM 705
Sample 4-R9 at RM 705
Sample 4-B5 at RM 705
Sample 4-C4 at RM 705
Echo
Sample 4-C5 at RM 704
Harter
Sample 4B-R1 at RM 702
Kettle Falls
Sample Ref-1b at RM 701
Sample 4-C6 at RM 703
Sample 4B-C1 at RM 701
Sample 4-R10 at RM 703
Ward
Williams Lake
20
Inchelium Kettle Falls
Greenwood
Sample Ref-1 at RM 699
Sample 4B-R2 at RM 698
Lygaard
Sample Ref-2b at RM 697
Sample 4B-C2 at RM 698
Inchelium Kettle Falls
Sample Ref-2 at RM 696
Sample Ref-3b at RM 693
Sample 4B-R3 at RM 693
Sample 4B-C3 at RM 692
Sample 4B-R4 at RM 691
Sample Ref-3 at RM 689
Colville Indian Reservation

Legend

- Populated Places
- County Lines
- Reservations
- 24 Meter Water Depth Contour
- Sediment > 2mm (CCT)
- Sediment > 2mm (Interpolated)

EPA Alternate Location

- Bioassay
- Chemistry-Only
- Internal Reference
- Reserve

HDR | HydroQual

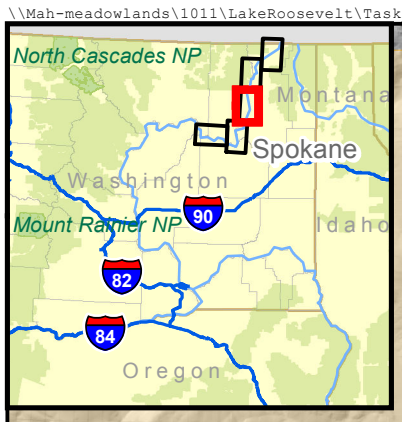
0 1.25 2.5 Km

0 1.25 2.5 Miles

N

Map A3. **Tile 2 - Proposed Sediment Sampling Locations**
Upper Columbia River, WA

\\Mah-meadowlands\1011\LakeRoosevelt\Task D81 Project Support\Sediment QAPP Revisions\Sampling Maps\UCRTemplate-Toxicity Tests.mxd @ 08-10-2012



Sample Ref-3 at RM 689
Sample 4B-C4 at RM 688
Sample 5-R2 at RM 686
Arzina
Rice
Sample 5-R1 at RM 685
Inchelium Kettle Falls
Sample 5-R3 at RM 683
Sample 5-R4 at RM 680
Sample Ref-4b at RM 681
Waterloo
Sample 5-C1 at RM 680
Daisy
Sample Ref-4 at RM 679
Sample 5-B1 at RM 678
Sample 5-R5 at RM 679
Sample 5-R8 at RM 677
Sample Ref-5b at RM 678
Sample 5-B2 at RM 678
Sample 5-C2 at RM 678
Maud
Sample 5-R7 at RM 678
Sample 5-R6 at RM 677
Sample 5-B6 at RM 676
Sample 5-B3 at RM 678
Sample 5-C3 at RM 677
Sample Ref-5 at RM 676
Sample 5-B4 at RM 677
Sample 5-B5 at RM 676
Addy, Gifford
Colville Indian Reservation
Sample 5-R9 at RM 676
Gifford
Sample 5-C4 at RM 675
Inchelium
Inchelium-Covada Ferry Crossing Landing
Sample 5-R10 at RM 675
Impach
25
Meteor
Sample 5B-C1 at RM 674
Sample 5B-R1 at RM 673
Sample 5B-C3 at RM 671
Sample 5B-C2 at RM 671
Sample 5B-R2 at RM 672
Bissel
Covada
Cedonia Addy
Sample 5B-R4 at RM 668
Sample 5B-R3 at RM 670
Kewa
Sample 5B-C4 at RM 668
Sample 6-R2 at RM 667
Sample 6-R1 at RM 667
Sample 6-R3 at RM 666
Sample 6-R4 at RM 666
Sample 6-C1 at RM 666
Sample 6-C2 at RM 666
Sample 6-B2 at RM 665
Sample 6-B3 at RM 666
Sample 6-B1 at RM 665
Sample 6-R5 at RM 665
Sample 6-R6 at RM 665
Sample 6-R8 at RM 665
Sample 6-R7 at RM 665
Cedonia
Sample 6-B4 at RM 665
Sample 6-C3 at RM 664
Sample 6-B5 at RM 664
Sample 6-C4 at RM 664
Sample 6-B6 at RM 664
Sample 6-R10 at RM 664
Sample 6B-R1 at RM 661
Sample 6-R9 at RM 664
Springdale Hunters
Sample 6B-C1 at RM 663

Legend

- Populated Places
- County Lines
- Reservations
- 24 Meter Water Depth Contour
- Sediment > 2mm (CCT)
- Sediment > 2mm (Interpolated)

EPA Alternate Location

- Bioassay
- Chemistry-Only
- Internal Reference
- Reserve

HDR | HydroQual

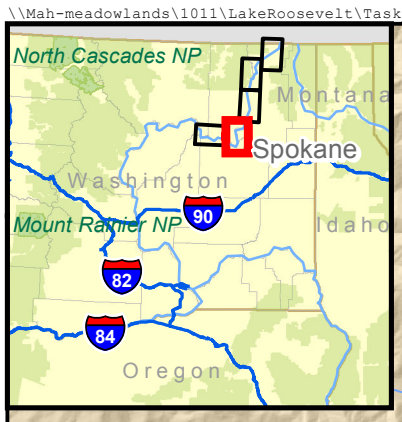
Km
0 1.25 2.5

Miles
0 1.25 2.5

N

Map A4. **Tile 3 - Proposed Sediment Sampling Locations**
Upper Columbia River, WA

\\Mah-meadowlands\1011\LakeRoosevelt\Task D81 Project Support\Sediment QAPP Revisions\Sampling Maps\UCRTemplate-Toxicity Tests.mxd @ 08-10-2012



Sample 6B-C2 at RM 659
Sample 6B-R2 at RM 658
Sample Ref-6b at RM 658
Sample 6B-C3 at RM 657
Sample Ref-6 at RM 652
Sample 6B-R4 at RM 651
Sample 6B-C4 at RM 652
Sample 6B-R3 at RM 654
Sample 7-C2 at RM 649
Sample 7-R2 at RM 649
Sample 7-C1 at RM 648
Sample 7-R1 at RM 648
Sample 7-R3 at RM 647
Sample 7-R9 at RM 647
Sample Ref-7 at RM 646
Sample 7-B2 at RM 646
Sample 7-B3 at RM 645
Sample 7-B1 at RM 646
Sample 7-R4 at RM 645
Sample 7-R6 at RM 645
Sample 7-R10 at RM 644
Sample Ref-7b at RM 643
Sample 7-B4 at RM 643
Sample 7-B6 at RM 643
Sample 7-B5 at RM 643
Sample 7-R5 at RM 642
Sample 7-R8 at RM 642
Sample 7-R7 at RM 640
Sample 7-C4 at RM 641
Sample 7-C3 at RM 640
Sample 7B-C3 at RM 626
Sample 7B-R1 at RM 630
Sample 7B-C2 at RM 632
Sample 7B-C1 at RM 637
Sample Ref-8 at RM 632
Sample Ref-8b at RM 633
Sample 7B-C4 at RM 634

Hunters
Springdale
Hunters
Fruitland
Enterprise
Miles
Fort Spokane
Seven Bays
Lincoln
25

Spokane Indian Reservation

Colville Indian Reservation

Legend

- Populated Places
- County Lines
- Reservations
- 24 Meter Water Depth Contour
- Sediment > 2mm (CCT)
- Sediment > 2mm (Interpolated)

EPA Alternate Location

- Bioassay
- Chemistry-Only
- Internal Reference
- Reserve

HDR | HydroQual

0 1.25 2.5 Km

0 1.25 2.5 Miles

N

Map A5. **Tile 4 - Proposed Sediment Sampling Locations**
Upper Columbia River, WA

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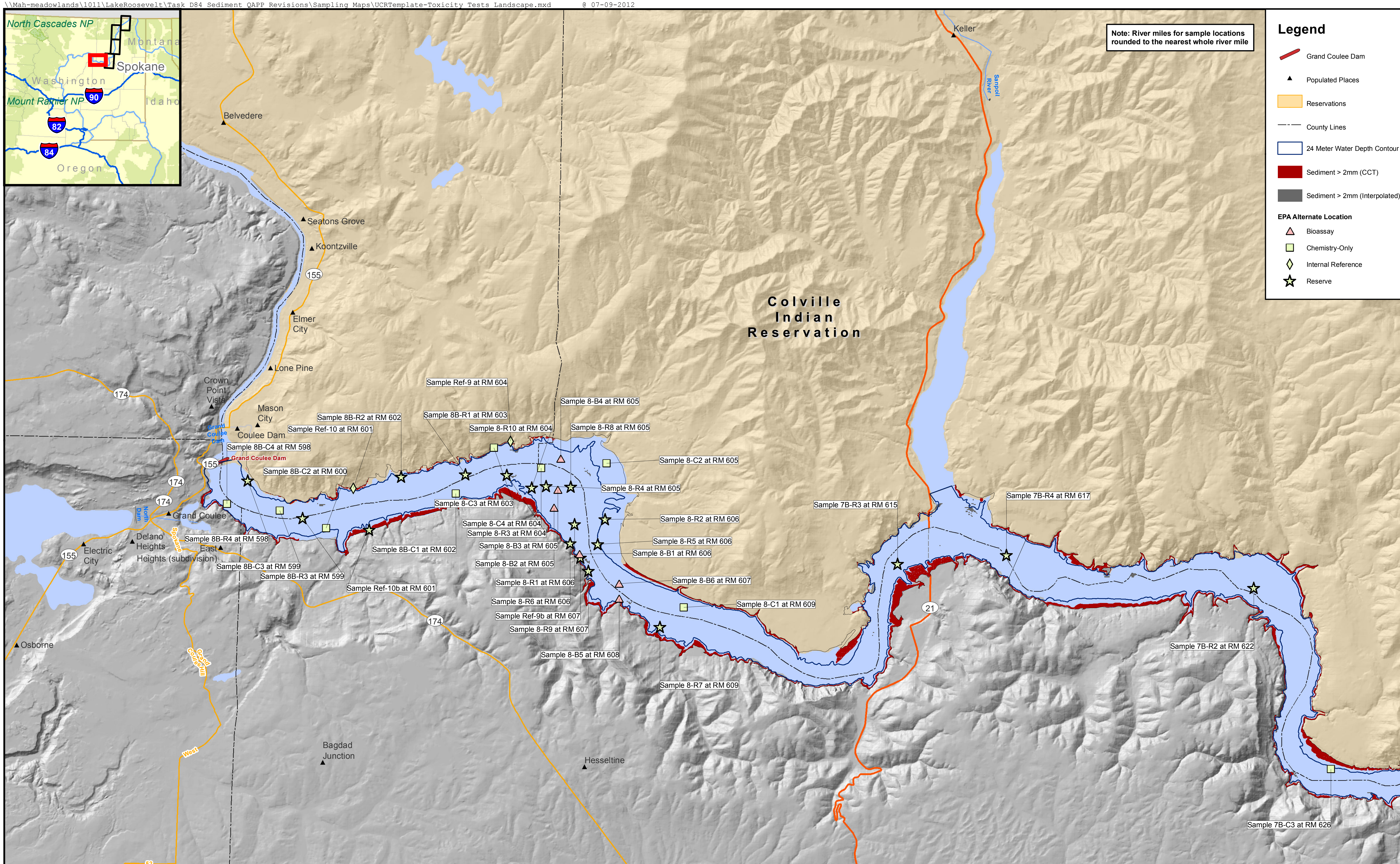


Legend
Grand Coulee Dam
Populated Places
Reservations
County Lines
24 Meter Water Depth Contour
Sediment > 2mm (CCT)
Sediment > 2mm (Interpolated)
EPA Alternate Location
Bioassay
Chemistry-Only
Internal Reference
Reserve
Note: River miles for sample locations rounded to the nearest whole river mile
North Cascades NP
Montana
Spokane
Washington
Mount Rainier NP
Idaho
Oregon
Colville Indian Reservation
Keller
Belvedere
Seatons Grove
Koontzville
Elmer City
Lone Pine
Crown Point Vista
Mason City
Coulee Dam
Grand Coulee Dam
Grand Coulee
Delano Heights
East Heights (subdivision)
Electric City
Osborne
Bagdad Junction
Hesseltine
Sample Ref-9 at RM 604
Sample 8-B4 at RM 605
Sample 8B-R2 at RM 602
Sample 8B-R1 at RM 603
Sample Ref-10 at RM 601
Sample 8-R10 at RM 604
Sample 8-R8 at RM 605
Sample 8B-C4 at RM 598
Sample 8-C2 at RM 605
Sample 8B-C2 at RM 600
Sample 8-R4 at RM 605
Sample 8-C3 at RM 603
Sample 7B-R3 at RM 615
Sample 7B-R4 at RM 617
Sample 8-R2 at RM 606
Sample 8-C4 at RM 604
Sample 8-R3 at RM 604
Sample 8-R5 at RM 606
Sample 8B-R4 at RM 598
Sample 8-B3 at RM 605
Sample 8-B1 at RM 606
Sample 8B-C1 at RM 602
Sample 8-B2 at RM 605
Sample 8B-C3 at RM 599
Sample 8B-R3 at RM 599
Sample 8-R1 at RM 606
Sample 8-B6 at RM 607
Sample Ref-10b at RM 601
Sample 8-R6 at RM 606
Sample 8-C1 at RM 609
Sample Ref-9b at RM 607
Sample 8-R9 at RM 607
Sample 8-B5 at RM 608
Sample 7B-R2 at RM 622
Sample 8-R7 at RM 609
Sample 7B-C3 at RM 626

HDR | HydroQual

0 1.25 2.5 Km
0 1.25 2.5 Miles
N

Map A6. **Tile 5 - Proposed Sediment Sampling Locations**

Upper Columbia River, WA

\\Mah-meadowlands\1011\LakeRoosevelt\Task_D84_Sediment_QAPP_Revisions\Sampling_Maps\UCRTemplate-SedQAPP_EXTERNAL_OVERVIEW.mxd @ 07-10-2012

LAL-2
LAL-3
LAL-1
LAL-6
LAL-4
LAL-5
Lower Arrow Lake
Kootenay River
Castlegar
G-2
G-3
G-4
G-1
Trail
Columbia River
Grand Forks
U.S. - Canada Border
Pend d'Oreille River
Danville
Laurier
Frontier
Velvet
Goldstake
Northport
251
Trib-5
Trib-6
Trib-4
Leadpoint
Kettle River
Curlew
Orient
Dulwich
Marble
Spirit
Deep Lake Boundary
21
Malo
Karamin
Ryan
Onion Creek
Bossburg
Goldfield Mill
Barstow
Kettle River
Pollard
Boyds
Evans
Powell
Bear
Aladdin
Ione
Torboy
395
Trib-2
Marcus
East Marcus
Douglas Falls
Echo
Joe Creek
Harter
Kettle Falls
Williams Lake
Ward
25
Greenwood
Aladdin
Pinkney City
Colville
20
Park Rapids
Orin
Arden
Trib-1
Trib-3
Colville Indian Reservation
Arzina
Rice
Colville River
Stevens

Legend

- Major Cities
- Populated Places
- Reservations
- County Lines
- External Reference Location

HDR | HydroQual

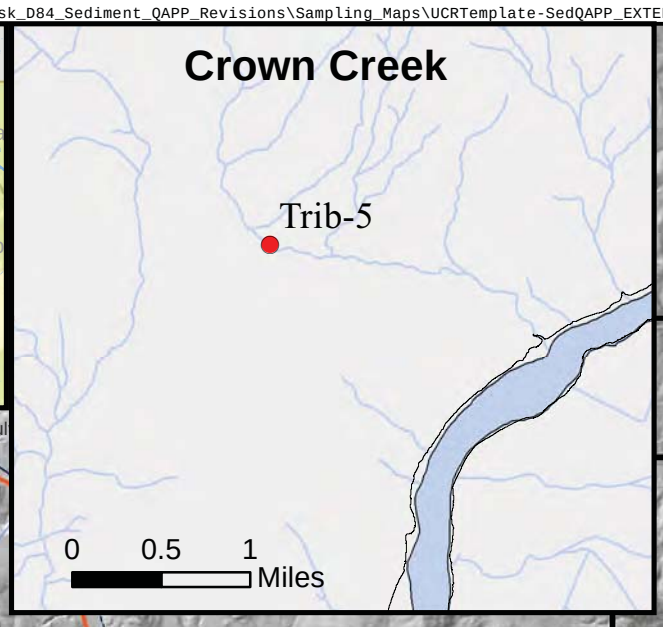
Km: 0 4 8
Miles: 0 4 8
N

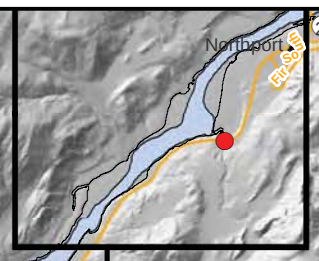
Map A7. **Overview of External Reference Locations for Phase 2 Sediment Study**

Upper Columbia River, WA / Columbia River, BC

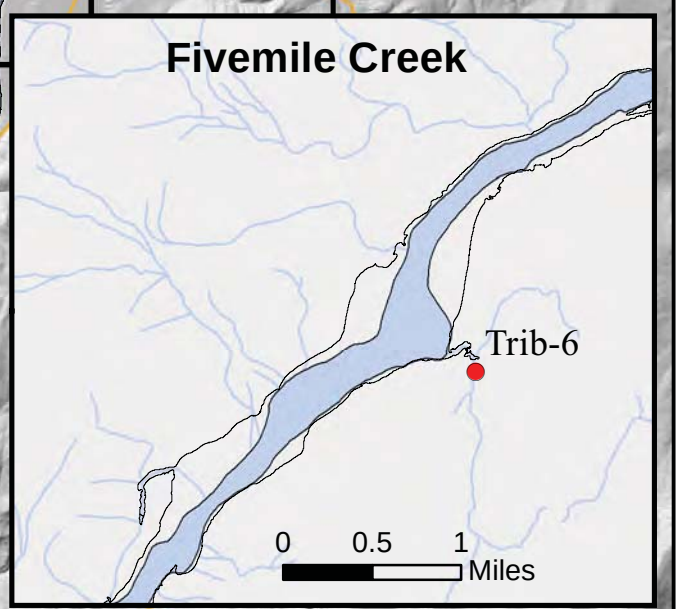
\\Mah-meadowlands\1011\LakeRoosevelt\Task_D84_Sediment_QAPP_Revisions\Sampling_Maps\UCRTemplate-SedQAPP_EXTERNAL_OVERVIEW.mxd @ 07-10-2012

Crown Creek

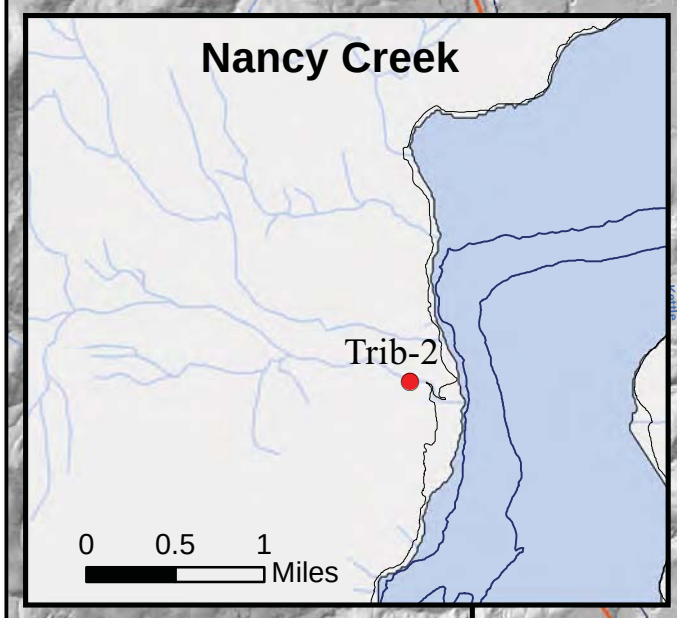




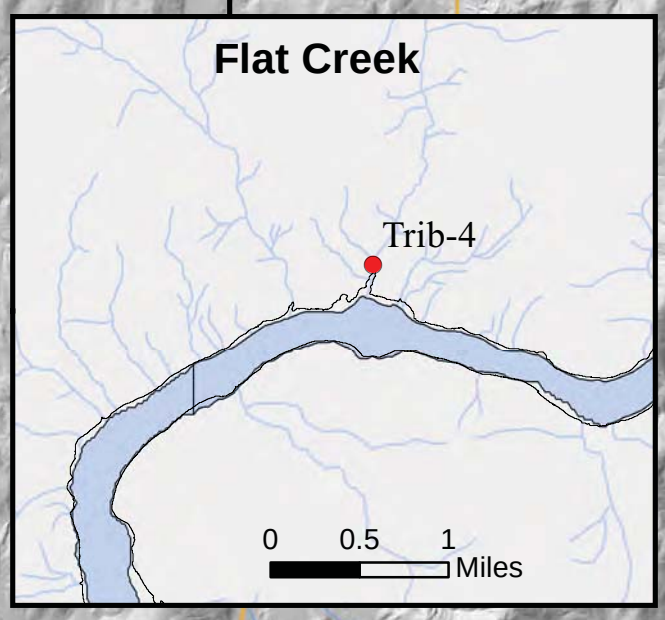
Fivemile Creek



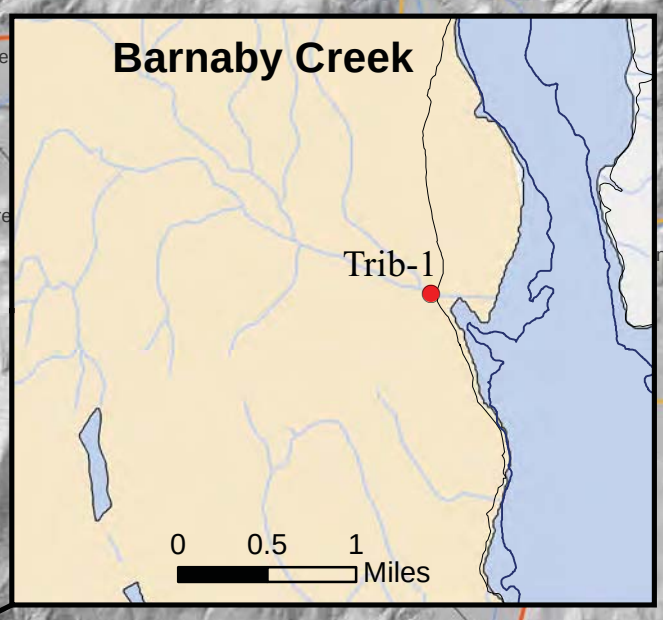
Nancy Creek



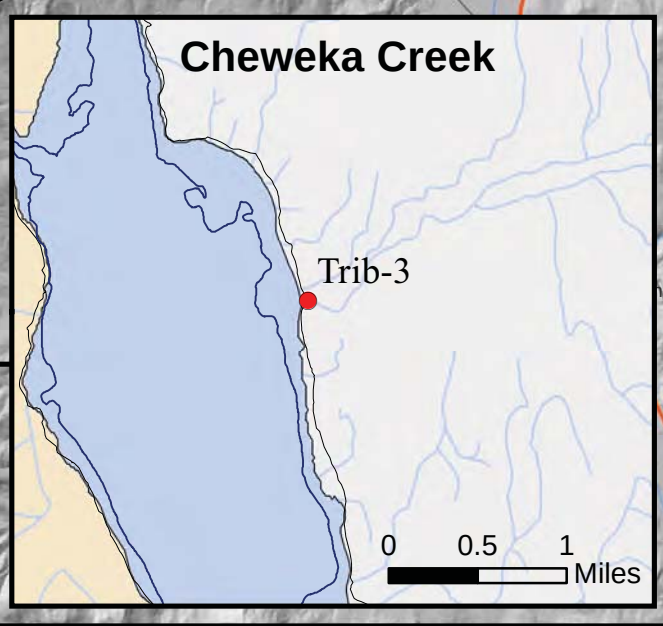
Flat Creek



Barnaby Creek



Cheweka Creek



Dul
Marble
Ryan
Bossburg
Evans
Bear
Powell
395
Marcus
East Marcus
Harter
Kettle Falls
25
20
Inchelium
Kettle Falls
Nygaard
Aladdin
Arzina
Rice
Johnson Grade
Jumpoff Joe Creek

Legend

- Populated Places
- County Lines
- 24 Meter Water Depth Contour
- Reservations
- EPA Alternate Location

HDR | HydroQual

0 1.25 2.5 Km

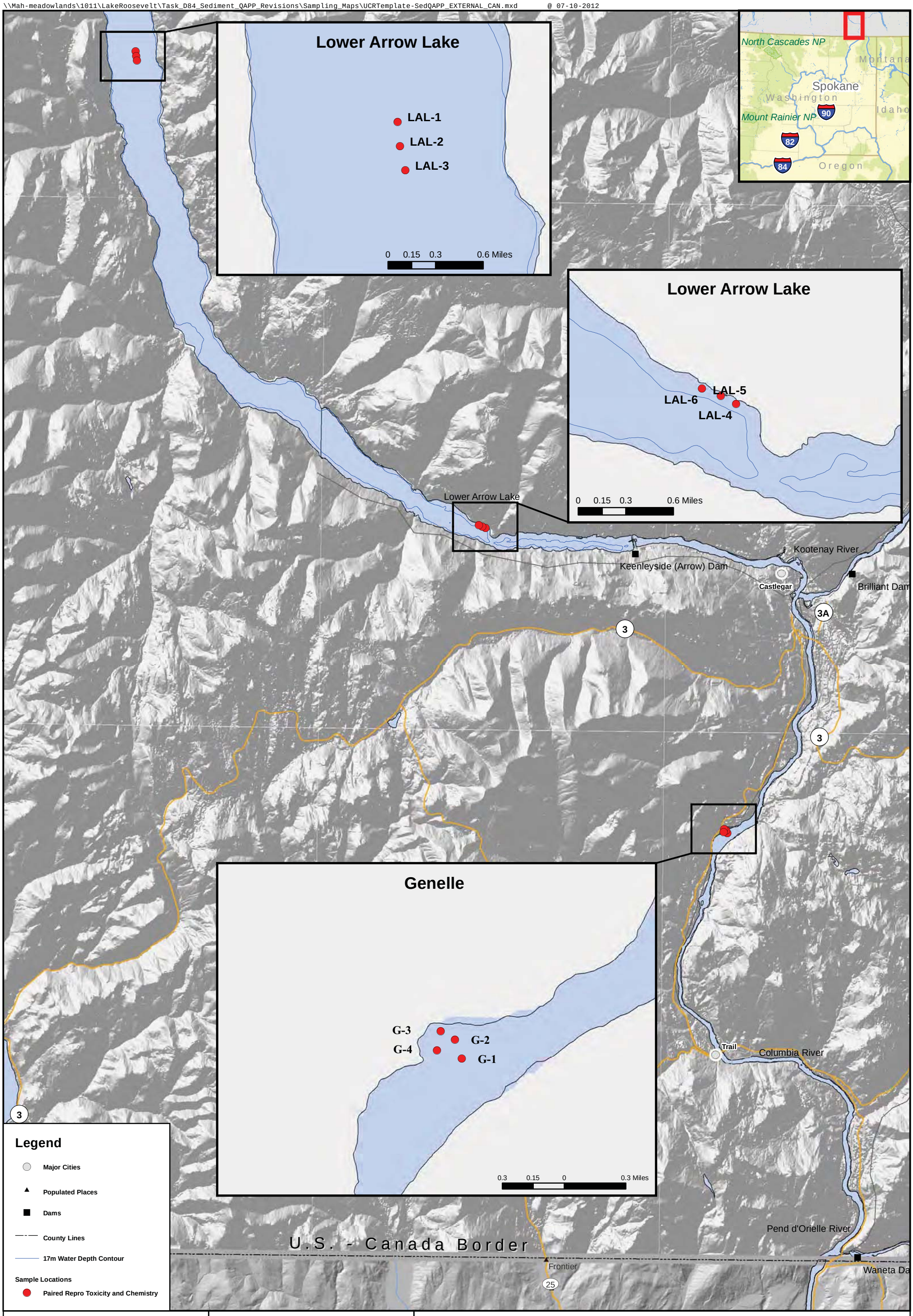
0 0.5 1 Miles

N

Map A8. **External Reference Locations in U.S. for Phase 2 Sediment Study**

Upper Columbia River, WA

\\Mah-meadowlands\1011\LakeRoosevelt\Task_D84_Sediment_QAPP_Revisions\Sampling_Maps\UCRTemplate-SedQAPP_EXTERNAL_CAN.mxd @ 07-10-2012



HDR | HydroQual

Km 0 2 4

Miles 0 2 4

N

Map A9. **External Reference Locations in Canada for Phase 2 Sediment Study**

Columbia River, BC

3 !+$S

Table A1. Proposed Station Locations for Phase 2 Sediment Collection

Station ID	River Mile	Depth	X UTM 11N	Y UTM 11N	Latitude	Longitude	Sample Type	Reserve Stations
1-B1	744	Shallow	453509.4201	5427422.5025	48.9980	-117.6356	Bioassay	1-R1, 1-R5, 1-R2, 1-R10, 1-C1, 1-R9, 2-R9, 2-R10
1-C4	743	Shallow	453049.2160	5425706.7652	48.9825	-117.6417	Chemistry-Only	1-R3, 1-R4, 3-R3, 1-R6, 2-R2, 2-R3, 2-R4, 2-R5, 2-R6, 2-R7
1-B2	742	Shallow	451648.4545	5424098.8892	48.9679	-117.6606	Bioassay	1-R9, 1-C2, 1B-R1, 1B-R2, 1B-R3, 1B-R4, 2-R1, 2B-R2, 1-R1, 1-R2, 1-R5, 1-R7, 1-R8, 1-R10
1-B3	740	Shallow	449383.7152	5422536.5077	48.9537	-117.6914	Bioassay	3-R10, 1-R3, 1-R6, 2-R2, 2-R4, 2-R7
1-C2	739	Shallow	447418.4558	5421563.1309	48.9448	-117.7181	Chemistry-Only	1-R9, 1B-C2, 1B-C3, 1B-C4, 2-R1, 2B-R2, 1B-R1, 1B-R2, 1B-R3, 1B-R4, 3-R10, 1-R1, 1-R2, 1-R5, 1-R7, 1-R8, 1-R10
1-C3	739	Shallow	447786.7914	5421919.1414	48.9480	-117.7131	Chemistry-Only	1-R7, 1-R8, 1B-C1, 3-R4, 1-R9
1-B6	738	Shallow	446702.4589	5420858.9288	48.9384	-117.7278	Bioassay	1-R10, 1-R2, 1-R1, 1-R5, 1-C1, 1-R9, 2-R9, 2-R10
1-C1	738	Shallow	446805.9822	5420459.5044	48.9348	-117.7263	Chemistry-Only	1-R1, 1-R5, 1-R2, 1-R10, 2-R9, 2-R10, 1-R9, 1B-R1, 1B-R2, 1B-R3, 1B-R4
1-B4	737	Shallow	445699.4516	5420996.5968	48.9395	-117.7415	Bioassay	1-R9, 1-C2, 1B-R1, 1B-R2, 1B-R3, 1B-R4, 2-R1, 2B-R2, 1-R1, 1-R2, 1-R5, 1-R7, 1-R8, 1-R10
1-B5	737	Shallow	446362.5845	5421153.1449	48.9410	-117.7325	Bioassay	1-R7, 1-R8, 1B-C1, 1-C3, 3-R4, 1-R9
1B-C3	735	Shallow	443177.8505	5418969.8971	48.9211	-117.7756	Chemistry-Only	1B-R1, 1B-R2, 1B-R3, 1B-R4, 1-R9, 2-R1, 2B-R2, 3-R1, 3-R6, 1-R1, 1-R2, 1-R5, 1-R10, 1-R7, 1-R8
1B-C1	734	Shallow	442907.6141	5418852.1021	48.9200	-117.7793	Chemistry-Only	1-R7, 1-R8, 3-R4, 1B-R1, 1B-R2, 1B-R3, 1B-R4
1B-C2	734	Shallow	442467.0883	5418819.2320	48.9196	-117.7853	Chemistry-Only	1B-R1, 1B-R2, 1B-R3, 1B-R4, 1-R9, 2-R1, 2B-R2, 3-R1, 3-R6, 1-R1, 1-R2, 1-R5, 1-R10, 1-R7, 1-R8
1B-C4	733	Shallow	441604.8343	5418331.8254	48.9152	-117.7970	Chemistry-Only	1B-R1, 1B-R2, 1B-R3, 1B-R4, 1-R9, 2-R1, 2B-R2, 3-R1, 3-R6, 1-R1, 1-R2, 1-R5, 1-R10, 1-R7, 1-R8
2-B1	733	Shallow	441090.2453	5417255.8861	48.9054	-117.8039	Bioassay	2-R1, 2B-R2, 1B-R1, 1B-R2, 1B-R3, 1B-R4, 3-R2, 3-R6, 4-R7, 2-R9, 2-R10
2-B2	732	Shallow	440379.5707	5416787.8301	48.9012	-117.8135	Bioassay	2-R2, 2-R4, 2-R5, 2-R6, 2-R7, 2-R3 2-C1, 2-C3, 2-C2, 1-R6, 3-R1, 3-R7, 3-R8, 3-R9
2-B3	731	Shallow	438638.5012	5415121.2071	48.8860	-117.8370	Bioassay	2-R2, 2-R4, 2-R5, 2-R6, 2-R7, 2-R3 2-C1, 2-C3, 2-C2, 1-R6, 3-R1, 3-R7, 3-R8, 3-R9
2-C1	731	Shallow	439803.8784	5415827.6896	48.8925	-117.8212	Chemistry-Only	2-R2, 2-R4, 2-R5, 2-R6, 2-R7, 2-R3, 2B-R1, 2B-R3, 2B-R4,1-R6
2-C2	731	Shallow	439332.2297	5416009.6655	48.8941	-117.8277	Chemistry-Only	2-R3, 2-R2, 2-R4, 2-R5, 2-R6, 2-R7, 2B-R1, 2B-R3, 2B-R4, 1-R6
2-B4	730	Shallow	438161.3082	5414310.6777	48.8787	-117.8434	Bioassay	2-R2, 2-R4, 2-R5, 2-R6, 2-R7, 2-R3 2-C1, 2-C3, 2-C2, 1-R6, 3-R1, 3-R7, 3-R8, 3-R9
2-C3	730	Shallow	438059.8053	5414097.9036	48.8767	-117.8448	Chemistry-Only	2-R2, 2-R4, 2-R5, 2-R6, 2-R7, 2-R3, 2B-R1, 2B-R3, 2B-R4,1-R6
2-C4	730	Shallow	437662.4861	5414117.1880	48.8769	-117.8502	Chemistry-Only	2B-R3, 2B-R4, 1-R3, 1-R4, 3-R3
2-B5	729	Shallow	436880.8238	5413705.7781	48.8731	-117.8608	Bioassay	2-R10, 2-R9, 1-R10, 1-R5, 1-R1, 1-R2, 3-R5, 2-R1, 2B-R2
2-B6	729	Shallow	436540.9523	5413587.1195	48.8720	-117.8654	Bioassay	2-R10, 2-R9, 1-R10, 1-R5, 1-R1, 1-R2, 3-R5, 2-R1, 2B-R2
2B-C4	728	Shallow	435609.5237	5413195.8161	48.8684	-117.8780	Chemistry-Only	2B-R1, 2-R2, 2-R4, 2-R5, 2-R6, 2-R7
2B-C1	727	Shallow	434669.4030	5412226.0305	48.8596	-117.8907	Chemistry-Only	2B-R1, 2-R2, 2-R4, 2-R5, 2-R6, 2-R7
2B-C2	727	Shallow	434190.3665	5411916.3190	48.8567	-117.8972	Chemistry-Only	2B-R1, 2-R2, 2-R4, 2-R5, 2-R6, 2-R7
2B-C3	726	Shallow	433680.1512	5411584.2567	48.8537	-117.9041	Chemistry-Only	2B-R3, 2B-R4, 1-R3, 1-R4, 3-R3
3-B1	725	Shallow	432384.0675	5410533.4624	48.8441	-117.9216	Bioassay	3-R1, 3-R7, 3-R8, 3-R9, 3-C1, 2-R3, 2B-R1, 4-R6, 2-R2, 2-R4, 2-R5, 2-R6, 2-R7, 2-R8
3-B2	724	Shallow	432191.0169	5408515.6151	48.8259	-117.9239	Bioassay	3-R5, 2-R9, 2-R10, 3-R6, 3-R2, 3-R10
3-B3	724	Shallow	431675.6534	5408577.7051	48.8264	-117.9309	Bioassay	3-R4, 3-R2, 3-R6, 2-R1, 2B-R2, 1B-R1, 1B-R2, 1B-R3, 1B-R4, 4-R7
3-C1	724	Shallow	431407.7056	5407978.5225	48.8210	-117.9345	Chemistry-Only	3-R7, 3-R8, 3-R9, 3-R1, 2B-R1, 4-R6, 2-R2, 2-R4, 2-R5, 2-R6, 2-R7, 2-R3
3-C2	724	Shallow	431999.6766	5407758.1616	48.8191	-117.9264	Chemistry-Only	3-R3, 2B-R3, 2B-R4, 4-R1
3-B4	723	Shallow	431061.2423	5407494.7208	48.8166	-117.9391	Bioassay	3-R5, 2-R9, 2-R10, 3-R6, 3-R2, 3-R10
3-B5	723	Shallow	430516.6068	5407063.5406	48.8127	-117.9464	Bioassay	3-R2, 3-R6, 2-R1, 2B-R2, 4-R7, 3-R4, 3-R5
3-C3	723	Shallow	430251.0952	5406968.7694	48.8118	-117.9500	Chemistry-Only	3-R3, 2B-R3, 2B-R4, 4-R1
3-B6	722	Shallow	429259.6594	5407490.5539	48.8164	-117.9636	Bioassay	3-R7, 3-R8, 3-R9, 3-R1, 3-C1, 2B-R1, 4-R6, 2-R2, 2-R4, 2-R5, 2-R6, 2-R7, 2-R3
3-C4	721	Shallow	428055.4950	5407623.6644	48.8174	-117.9801	Chemistry-Only	3-R3, 2B-R3, 2B-R4, 4-R1
3B-C1	720	Shallow	426962.7318	5407475.5179	48.8160	-117.9949	Chemistry-Only	3B-R1, 3B-R2, 3B-R3, 3B-R4, 3-R1
3B-C2	719	Shallow	426117.5261	5404740.7728	48.7913	-118.0059	Chemistry-Only	3B-R1, 3B-R2, 3B-R3, 3B-R4, 3-R1
3B-C3	715	Shallow	422930.3481	5401213.9989	48.7592	-118.0487	Chemistry-Only	3B-R1, 3B-R2, 3B-R3, 3B-R4, 3-R1
3B-C4	714	Shallow	422143.2689	5398707.5541	48.7365	-118.0589	Chemistry-Only	3B-R1, 3B-R2, 3B-R3, 3B-R4, 3-R1
4-B1	710	Deep	424498.5577	5393545.3791	48.6904	-118.0259	Bioassay	3-R4, 4-R7, 4-C4, 2-R1, 2B-R2,3-R2, 3-R6
4-C1	710	Shallow	424141.7407	5392332.5779	48.6794	-118.0305	Chemistry-Only	4-R5, 4-R9, 4-R11, 4-R3, 4-R4, 4-R10, 4-R12, 4-R1, 5-R5, 5-R6
4-R2	709	Deep	423074.9214	5391768.8503	48.6742	-118.0449	Bioassay	4-R6, 3-R7, 3-R8, 3-R9
4-B2	708	Deep	422307.5206	5391562.8467	48.6723	-118.0553	Bioassay	4-R7, 4-C4, 3-R2, 3-R6, 2-R1, 2B-R2, 1B-R1, 1B-R2, 1B-R3, 1B-R4
4-B3	707	Shallow	420548.2110	5391412.7358	48.6707	-118.0792	Bioassay	4-R7, 4-C4, 3-R2, 3-R6, 2-R1, 2B-R2, 1B-R1, 1B-R2, 1B-R3, 1B-R4
4-C2	707	Shallow	418339.8305	5392015.8116	48.6758	-118.1093	Chemistry-Only	4-R12, 4-R10, 4-R5, 4-R9, 4-R11, 4-R4, 4-R3, 4-R1, 5-R1, 5-R7, 3-R10
4-B4	706	Deep	418971.9838	5390738.2203	48.6644	-118.1004	Bioassay	4-R1, 4-R3, 4-R4, 4-R5, 4-R9, 4-R11, 4-R10, 4-R12, 5-R5, 5-R6
4-C3	706	Shallow	419432.7220	5390220.0593	48.6598	-118.0941	Chemistry-Only	4-R4, 4-R3, 4-R1, 4-R9, 4-R5, 4-R10, 4-R12, 4-R11, 5-R5, 5-R6
4-B5	705	Deep	418628.2125	5388994.1163	48.6487	-118.1048	Bioassay	3-R5, 2-R9, 2-R10, 4-R7, 4-C4, 4-R1, 4-R11, 4-R3, 4-R4, 4-R5, 4-R9, 4-R10, 4-R12
4-C4	705	Shallow	419070.5788	5388803.6176	48.6470	-118.0987	Chemistry-Only	4-R7, 3-R2, 3-R6, 3-R4, 3-R5, 3-R10, 4-R1, 4-R3, 4-R4, 4R-5
4-C5	704	Shallow	420010.3993	5387622.5715	48.6365	-118.0857	Chemistry-Only	4-R5, 4-R9, 4-R11, 4-R3, 4-R4, 4-R10, 4-R12, 4-R1, 3-R10, 5-R9, 5-R5
4-C6	703	Shallow	419944.9095	5386148.0589	48.6233	-118.0863	Chemistry-Only	4-R6, 3-R1, 3-R7, 3-R8, 3-R9, 4-R1, 4-R3, 4-R4, 4-R5
4B-C1	701	Deep	416956.7457	5384334.9785	48.6066	-118.1265	Chemistry-Only	4B-R1, 5-R8, 3-R3
Ref-1	699	Shallow	416050.4669	5380836.1877	48.5750	-118.1381	Bioassay	Ref-1b
4B-C2	698	Deep	416735.0144	5379566.6837	48.5637	-118.1286	Chemistry-Only	4B-R2, 4B-R3, 4B-R4, 4R-11, 4R-5, 4R-9
Ref-2	696	Shallow	414919.3797	5376770.9835	48.5383	-118.1526	Bioassay	Ref-2b
4B-C3	692	Deep	413016.4130	5373254.3451	48.5064	-118.1777	Chemistry-Only	4B-R2, 4B-R3, 4B-R4, 4R-11, 4R-5, 4R-9
Ref-3	689	Shallow	412113.9581	5370135.7474	48.4782	-118.1892	Bioassay	Ref-3b
4B-C4	688	Shallow	410840.2606	5368231.4983	48.4609	-118.2060	Chemistry-Only	4B-R4, 4B-R2, 4B-R3, 4R-5, 4R-9, 4R-11
5-C1	680	Deep	412646.8818	5357580.3021	48.3653	-118.1794	Chemistry-Only	5-R5, 5-R6, 5-R7, 5-R9, 5-R1, 4-R9, 4-R11
Ref-4	679	Shallow	411884.2490	5356534.9157	48.3558	-118.1895	Bioassay	Ref-4b

Table A1. Proposed Station Locations for Phase 2 Sediment Collection

Station ID	River Mile	Depth	X UTM 11N	Y UTM 11N	Latitude	Longitude	Sample Type	Reserve Stations
5-B1	678	Shallow	413961.7518	5354583.3221	48.3386	-118.1610	Bioassay	5-R8, 4B-R1, 6-R4, 6-R5, 6-R9
5-B2	678	Deep	413349.6141	5354533.6893	48.3380	-118.1693	Bioassay	5-R5, 5-R6, 5-R7, 5-R9, 5-R1, 4-R1, 4-R9
5-B3	678	Deep	412683.5026	5354463.5628	48.3373	-118.1782	Bioassay	5-R5, 5-R6, 5-R7, 5-R9, 5-R1, 4-R1, 4-R9
5-C2	678	Deep	412129.8358	5354418.5881	48.3368	-118.1857	Chemistry-Only	5-R3, 5-R10, 5B-R2, 5B-R3, 5B-R4, 4-R6, 5-R1, 5-R5, 5-R6, 5-R7, 5-R9, 5-R8
5-B4	677	Deep	413398.2903	5352205.2719	48.3171	-118.1681	Bioassay	5-R5, 5-R6, 5-R7, 5-R9, 5-R1, 4-R1, 4-R9
5-C3	677	Deep	412726.9162	5352643.6036	48.3210	-118.1773	Chemistry-Only	5-R5, 5-R6, 5-R7, 5-R9, 5-R1, 4-R9, 4-R11
5-B5	676	Deep	413948.6113	5351681.2164	48.3125	-118.1606	Bioassay	5-R3, 5-R10, 5-C2, 5B-R1, 5-R1, 5-R5, 5-R6, 5-R7, 5-R8, 5-R9
5-B6	676	Deep	414422.9844	5351520.9095	48.3111	-118.1542	Bioassay	5-R3, 5-R10, 5-C2, 5B-R2, 5B-R3, 5B-R4, 4-R6, 5-R1, 5-R5, 5-R6, 5-R7, 5-R9, 5-R8
Ref-5	676	Shallow	414649.1196	5352332.8588	48.3184	-118.1513	Bioassay	Ref-5b
5-C4	675	Deep	413784.3845	5350035.8974	48.2976	-118.1625	Chemistry-Only	5-R5, 5-R6, 5-R7, 5-R9, 5-R1, 4-R9, 4-R11
5B-C1	674	Deep	414765.0562	5347924.3964	48.2788	-118.1488	Chemistry-Only	5B-R2, 5B-R3, 5B-R4, 5B-R1, 6-R1, 6-R3, 6-R6, 6-R7, 6-R10, 5-R3, 5-R10
5B-C2	671	Deep	414124.0527	5343215.7328	48.2363	-118.1565	Chemistry-Only	5B-R2, 5B-R3, 5B-R4, 5B-R1, 6-R1, 6-R3, 6-R6, 6-R7, 6-R10, 5-R3, 5-R10
5B-C3	671	Shallow	413628.0184	5343195.2220	48.2361	-118.1632	Chemistry-Only	5-R8, 6-R5, 6-R9, 6-C1, 6-C3, 3-R3
5B-C4	668	Deep	410901.1046	5339274.8928	48.2005	-118.1991	Chemistry-Only	5B-R2, 5B-R3, 5B-R4, 5B-R1, 6-R1, 6-R3, 6-R6, 6-R7, 6-R10, 5-R3, 5-R10
6-B3	666	Shallow	411556.0854	5335806.6497	48.1693	-118.1896	Bioassay	6-R3, 6-R6, 6-R7, 6-R10, 6-R1, 5B-R1, 7-R4, 7-R5, 7-R10, 5B-R2, 5B-R3, 5B-R4
6-C1	666	Deep	411018.7702	5336033.4157	48.1713	-118.1968	Chemistry-Only	6-R4, 6-R5, 6-R9, 6B-R1, 6B-R2, 6B-R3, 6B-R4
6-C2	666	Deep	411227.3782	5336335.0334	48.1741	-118.1941	Chemistry-Only	6-R8, 6-R2, 5-R7, 7-R8
6-B1	665	Shallow	410854.7068	5335454.2515	48.1661	-118.1989	Bioassay	6-R3, 6-R6, 6-R7, 6-R10, 6-R1, 5B-R1, 7-R4, 7-R5, 7-R10, 5B-R2, 5B-R3, 5B-R4
6-B2	665	Deep	411268.5670	5335730.8443	48.1686	-118.1934	Bioassay	6-R8, 6-R2, 5-R7, 7-R8
6-B4	665	Shallow	410705.3603	5334113.1373	48.1540	-118.2006	Bioassay	6-R4, 6-R5, 6-R9, 6-C1, 6-C3, 6B-R1, 6B-R2, 6B-R3, 6B-R4
6-B5	664	Shallow	411008.6049	5333713.5271	48.1504	-118.1965	Bioassay	6-R3, 6-R6, 6-R7, 6-R10, 6-R1, 5B-R1, 7-R4, 7-R5, 7-R10, 5B-R2, 5B-R3, 5B-R4
6-B6	664	Deep	411317.0992	5333324.1709	48.1470	-118.1923	Bioassay	6-R3, 6-R6, 6-R7, 6-R10, 6-R1, 5B-R1, 7-R4, 7-R5, 7-R10, 5B-R2, 5B-R3, 5B-R4
6-C3	664	Shallow	410720.0991	5333756.5288	48.1508	-118.2004	Chemistry-Only	6-R4, 6-R5, 6-R9, 6B-R1, 6B-R2, 6B-R3, 6B-R4
6-C4	664	Deep	410970.5675	5333359.2566	48.1472	-118.1969	Chemistry-Only	6-R8, 6-R2, 5-R7, 7-R8
6B-C1	663	Deep	409919.5526	5332421.6511	48.1387	-118.2108	Chemistry-Only	6-R3, 6-R6, 6-R7, 6-R10, 6-R1
6B-C2	659	Deep	407026.5480	5328246.9336	48.1007	-118.2488	Chemistry-Only	6B-R1, 6B-R3, 6B-R4, 6B-R2, 7-R1, 7-R2, 6-R4, 6-R5, 6-R9
6B-C3	657	Deep	407578.6532	5324298.4494	48.0653	-118.2405	Chemistry-Only	6B-R1, 6B-R3, 6B-R4, 6B-R2, 7-R1, 7-R2, 6-R4, 6-R5, 6-R9
6B-C4	652	Deep	400540.3906	5322333.7476	48.0465	-118.3345	Chemistry-Only	6-R1, 6-R3, 6-R6, 6-R7, 6-R10
Ref-6	652	Shallow	400847.7260	5322829.8370	48.0510	-118.3305	Bioassay	Ref-6b
7-C2	649	Shallow	397295.6854	5320051.8665	48.0255	-118.3775	Chemistry-Only	7-R1, 7-R2, 7-R3, 7-R9, 7B-R1, 7B-R2, 6-R4, 6-R5
7-C1	648	Deep	396304.1652	5319441.8134	48.0198	-118.3907	Chemistry-Only	7-R1, 7-R2, 7-R3, 7-R9, 7B-R1, 7B-R2, 6-R4, 6-R5
7-B1	646	Deep	397434.7901	5315605.9057	47.9855	-118.3746	Bioassay	7-R1, 7-R2, 7-R3, 7-R9, 7-C1, 7B-R1, 7B-R2, 6B-R1, 6B-R3, 6B-R4
7-B2	646	Deep	398099.5200	5315221.9882	47.9822	-118.3656	Bioassay	7-R6, 7-R7, 7-R4, 7-R5, 7-R10, 6-R1, 6-R3, 6-R6, 6-R7, 6-R10, 7B-R4
Ref-7	646	Shallow	396847.3055	5316334.6183	47.9920	-118.3826	Bioassay	Ref-7b
7-B3	645	Deep	398713.0791	5315131.1322	47.9815	-118.3573	Bioassay	7-R4, 7-R5, 7-R10, 7-R6, 7-R7 , 7B-R4, 6-R3, 6-R6, 6-R7, 6-R10
7-B4	643	Shallow	398618.1482	5312027.9462	47.9535	-118.3579	Bioassay	7-R1, 7-R2, 7-R3, 7-R9, 7-C2, 6B-R2, 7B-R1, 7B-R2
7-B5	643	Deep	398839.9041	5310727.6951	47.9419	-118.3546	Bioassay	7-R8, 6-R8, 8-R1, 8-R3
7-B6	643	Deep	398714.8503	5311566.1192	47.9494	-118.3565	Bioassay	7-R4, 7-R5, 7-R10, 7-R6, 7-R7, 7B-R4, 6-R3, 6-R6, 6-R7, 6-R10
7-C4	641	Deep	399383.8076	5307273.0598	47.9109	-118.3465	Chemistry-Only	7-R8, 6-R2, 6;R8, 8-R3
7-C3	640	Deep	399053.1499	5306933.8442	47.9078	-118.3509	Chemistry-Only	7-R8, 6-R2, 6;R8, 8-R3
7B-C1	637	Deep	398667.3963	5301315.6713	47.8572	-118.3547	Chemistry-Only	7B-R4, 7-R4, 7-R5, 7-R6, 7-R7, 7-R10
7B-C4	634	Deep	397025.1674	5297988.6596	47.8270	-118.3759	Chemistry-Only	7B-R3, 8B-R1, 8R-2, 8R-3, 8R-4
7B-C2	632	Deep	392537.3457	5299898.6690	47.8434	-118.4363	Chemistry-Only	7B-R4, 7-R4, 7-R5, 7-R6, 7-R7, 7-R10
Ref-8	632	Shallow	391906.6828	5299446.3188	47.8393	-118.4446	Bioassay	Ref-8b
7B-C3	626	Deep	386089.6203	5303883.2933	47.8782	-118.5235	Chemistry-Only	7B-R3, 8B-R1, 8R-2, 8R-3, 8R-4
8-C1	609	Deep	366204.1236	5308848.2973	47.9190	-118.7908	Chemistry-Only	8-R7, 7B-R2, 7B-R1, 7-R1, 7-R2
8-B5	608	Deep	364224.4362	5309115.9473	47.9210	-118.8174	Bioassay	8-R6, 8-R9, 8-R10, 8-R2, 8B-R1, 7-R4, 7-R5, 7-R6, 7-R7, 7-R10, 8-R1, 8R-3, 8-R4, 8-R5, 8-R7
8-B6	607	Deep	364223.8196	5309575.7299	47.9251	-118.8176	Bioassay	8-R8, 8-R1, 8-R5, 8-R3, 8-R4, 8B-R3, 8B-R4, 7-R8, 8-R2, 8-R6, 8-R9, 8-R10
8-B1	606	Deep	363009.4477	5310489.9501	47.9331	-118.8341	Bioassay	8-R2, 8-R10, 8-R6, 8-R9, 8B-R1, 7-R4, 7-R5, 7-R6, 7-R7, 7-R10, 8-R1, 8R-3, 8-R4, 8-R5, 8-R7
8-B2	605	Deep	362219.5509	5311913.6540	47.9457	-118.8451	Bioassay	8-R6, 8-R9, 8-R10, 8-R2, 8B-R1, 7-R4, 7-R5, 7-R6, 7-R7, 7-R10, 8-R1, 8R-3, 8-R4, 8-R5, 8-R7
8-B3	605	Deep	362335.6817	5312464.3123	47.9507	-118.8438	Bioassay	8-R8, 8-R1, 8-R5, 8-R3, 8-R4, 8B-R3, 8B-R4, 7-R8, 8-R2, 8-R6, 8-R9, 8-R10
8-B4	605	Deep	362427.0537	5313415.7405	47.9593	-118.8428	Bioassay	8-R6, 8-R9, 8-R10, 8-R2, 8B-R1, 7-R4, 7-R5, 7-R6, 7-R7, 7-R10, 8-R1, 8R-3, 8-R4, 8-R5, 8-R7
8-C2	605	Shallow	363836.2186	5313271.5550	47.9583	-118.8239	Chemistry-Only	8-R7, 7B-R2, 7B-R1, 7-R1, 7-R2
8-C4	604	Deep	361825.4727	5313132.1417	47.9566	-118.8508	Chemistry-Only	8-R8, 8-R1, 8-R5, 8-R3, 8-R4, 7-R8, 7B-R3
Ref-9	604	Shallow	360887.9216	5313945.7006	47.9637	-118.8636	Bioassay	Ref-9b
8-C3	603	Deep	360370.7016	5313754.7389	47.9619	-118.8705	Chemistry-Only	5-R2, 5-R4, 8-R3
8B-C1	602	Deep	359207.2189	5312342.1436	47.9489	-118.8856	Chemistry-Only	8B-R1, 8-R6, 8R-9, 8R-10
Ref-10	601	Shallow	356060.9582	5312511.8486	47.9497	-118.9278	Bioassay	Ref-10b
8B-C2	600	Deep	355217.8178	5311280.4868	47.9385	-118.9386	Chemistry-Only	8B-R2, 8-R7, 7B-R1, 7B-R2, 8-R2, 8-R6, 8-R9, 8-R10
8B-C3	599	Deep	353792.3763	5311819.0023	47.9430	-118.9579	Chemistry-Only	8B-R3, 8B-R4, 8-R1, 8-R3, 8-R4, 8-R5, 8-R8
8B-C4	598	Deep	352173.8334	5312027.8193	47.9445	-118.9796	Chemistry-Only	8B-R2, 8-R7, 7B-R1, 7B-R2, 8-R2, 8-R6, 8-R9, 8-R10

Table A1. Proposed Station Locations for Phase 2 Sediment Collection

Station ID	River Mile	Depth	X UTM 11N	Y UTM 11N	Latitude	Longitude	Sample Type	Reserve Stations
External Reference Locations								
Trib-1	Barnaby Creek	-	409599.0882	5365221.8770	48.4337	-118.2222	Bioassay	-
Trib-2	Nancy Creek	-	417960.0043	5389749.2880	48.6554	-118.1140	Bioassay	-
Trib-3	Cheweka Creek	-	412656.5780	5363476.2147	48.4184	-118.1805	Bioassay	-
Trib-4	Flat Creek	-	428210.3396	5408246.6044	48.8231	-117.9781	Bioassay	-
Trib-5	Crown Creek	-	430719.1785	5412475.2448	48.8614	-117.9446	Bioassay	-
Trib-6	Fivemile Creek	-	441398.6667	5416524.0973	48.8989	-117.7996	Bioassay	-
LAL-1	Lower Arrow Lake	Deep	417590.4138	5491377.5174	49.5694	-118.1398	Bioassay	-
LAL-2	Lower Arrow Lake	Deep	417614.5377	5491131.9909	49.5672	-118.1394	Bioassay	-
LAL-3	Lower Arrow Lake	Deep	417669.4369	5490887.5742	49.5650	-118.1386	Bioassay	-
LAL-4	Lower Arrow Lake	Shallow	435667.1209	5466414.5085	49.3471	-117.8857	Bioassay	-
LAL-5	Lower Arrow Lake	Shallow	435858.3129	5466340.1099	49.3464	-117.8831	Bioassay	-
LAL-6	Lower Arrow Lake	Shallow	436014.4621	5466259.1383	49.3457	-117.8809	Bioassay	-
G-1	Genelle	Shallow	448590.9184	5450405.5787	49.2043	-117.7058	Bioassay	-
G-2	Genelle	Shallow	448699.7059	5450340.7110	49.2037	-117.7043	Bioassay	-
G-3	Genelle	Shallow	448560.9976	5450257.5264	49.2030	-117.7061	Bioassay	-
G-4	Genelle	Shallow	448752.8572	5450192.3689	49.2024	-117.7035	Bioassay	-
Reserve Locations								
1-R1	744	Shallow	453467.0850	5427258.8783	48.9965	-117.6362		
1-R3	744	Shallow	453182.7745	5426533.4896	48.9899	-117.6400		
1-R5	744	Shallow	453588.2571	5427558.5769	48.9992	-117.6345		
1-R4	743	Shallow	453044.9424	5425055.4056	48.9766	-117.6417		
1-R2	742	Shallow	452591.6512	5424701.4318	48.9734	-117.6478		
1-R6	741	Shallow	451031.6871	5423758.5958	48.9648	-117.6690		
1-R7	739	Shallow	448355.4421	5422309.9013	48.9516	-117.7054		
1-R8	737	Shallow	446258.7842	5421198.4632	48.9414	-117.7339		
1-R9	737	Shallow	445899.6744	5421131.3897	48.9407	-117.7388		
1-R10	737	Shallow	446122.3203	5420985.1424	48.9394	-117.7357		
1B-R1	735	Shallow	442963.6188	5419186.2676	48.9230	-117.7786		
1B-R3	735	Shallow	443093.4939	5418969.8631	48.9210	-117.7768		
1B-R4	735	Shallow	443543.8270	5419245.9786	48.9236	-117.7707		
1B-R2	734	Shallow	442815.2564	5418839.6755	48.9199	-117.7806		
2-R1	732	Shallow	441061.5339	5417081.8569	48.9039	-117.8043		
2-R2	732	Shallow	440549.5791	5417293.9410	48.9057	-117.8113		
2-R3	732	Shallow	440012.8552	5416681.7387	48.9002	-117.8185		
2-R4	731	Shallow	439370.7699	5415630.5437	48.8907	-117.8271		
2-R5	731	Shallow	438796.5388	5415696.0756	48.8912	-117.8350		
2-R6	731	Shallow	438903.3279	5415215.3541	48.8869	-117.8334		
2-R7	730	Shallow	438384.6746	5414794.8399	48.8830	-117.8404		
2-R8	730	Shallow	438147.4244	5414464.0447	48.8800	-117.8436		
2-R9	729	Shallow	437139.6506	5413801.3798	48.8740	-117.8573		
2-R10	729	Shallow	436564.8183	5413686.5724	48.8729	-117.8651		
2B-R1	728	Shallow	435504.0364	5412975.9687	48.8664	-117.8794		
2B-R2	728	Shallow	435831.0622	5413561.7065	48.8717	-117.8751		
2B-R3	727	Shallow	433879.2918	5411733.6064	48.8550	-117.9014		
3-R1	726	Shallow	432851.5242	5411157.8576	48.8498	-117.9153		
2B-R4	726	Shallow	433366.8018	5411453.6148	48.8525	-117.9083		
3-R2	725	Shallow	432015.0278	5409798.1401	48.8374	-117.9265		
3-R3	725	Shallow	432291.9754	5409134.4831	48.8315	-117.9226		
3-R4	724	Shallow	431500.1156	5408365.3311	48.8245	-117.9333		
3-R5	723	Shallow	431574.9290	5407627.9344	48.8179	-117.9321		
3-R6	723	Shallow	430826.6285	5407387.8550	48.8156	-117.9423		
3-R7	722	Shallow	430277.8522	5407169.9098	48.8136	-117.9497		
3-R8	722	Shallow	429445.7016	5407239.6105	48.8141	-117.9610		
3-R9	721	Shallow	428466.8141	5407797.1528	48.8190	-117.9745		
3-R10	721	Shallow	427574.4198	5407796.8690	48.8189	-117.9866		
3B-R1	720	Shallow	426267.6107	5406857.8863	48.8103	-118.0043		
3B-R2	718	Shallow	425881.6760	5403961.6779	48.7842	-118.0090		
3B-R3	717	Shallow	424926.1779	5402793.9814	48.7736	-118.0218		

Table A1. Proposed Station Locations for Phase 2 Sediment Collection

Station ID	River Mile	Depth	X UTM 11N	Y UTM 11N	Latitude	Longitude	Sample Type	Reserve Stations
Reserve Locations (continued)								
3B-R4	715	Shallow	422213.0046	5400342.1397	48.7512	-118.0582		
4-R11	712	Deep	423883.4961	5395557.8842	48.7084	-118.0346		
4-R1	711	Deep	424342.0331	5394268.8047	48.6969	-118.0282		
4-R2	709	Deep	423074.9214	5391768.8503	48.6742	-118.0449	Reassigned as a Primary Station following Cultural Resources Review.	
4-R3	708	Shallow	421223.0965	5391914.9176	48.6753	-118.0701		
4-R4	707	Shallow	419942.0117	5391598.5128	48.6723	-118.0874		
4-R5	707	Shallow	419261.0478	5391742.5653	48.6735	-118.0967		
4-R12	707	Shallow	420001.0260	5392779.1715	48.6829	-118.0869		
4-R7	705	Shallow	418993.5109	5389358.0759	48.6520	-118.0999		
4-R9	705	Shallow	419822.6609	5389209.6489	48.6508	-118.0886		
4-R6	705	Deep	418517.0001	5390073.1658	48.6584	-118.1065		
4-R10	703	Shallow	420521.5816	5385568.7634	48.6181	-118.0784		
4B-R1	702	Deep	416976.9193	5384847.9590	48.6112	-118.1264		
Ref-1b	701	Shallow	416708.7224	5384856.6594	48.6112	-118.1300		
4B-R2	698	Deep	416289.2542	5379288.1317	48.5611	-118.1346		
Ref-2b	697	Shallow	415116.9224	5378552.6767	48.5543	-118.1503		
4B-R3	693	Deep	413755.1486	5374478.6852	48.5175	-118.1679		
Ref-3b	693	Shallow	412745.7854	5374990.0535	48.5220	-118.1817		
4B-R4	691	Shallow	413570.1954	5372295.3335	48.4978	-118.1700		
5-R2	686	Shallow	411920.5609	5364655.0886	48.4289	-118.1907		
5-R1	685	Deep	411741.7980	5363158.6333	48.4154	-118.1928		
5-R3	683	Deep	412187.3026	5360437.4712	48.3910	-118.1862		
Ref-4b	681	Shallow	411681.5116	5358429.8534	48.3729	-118.1926		
5-R4	680	Shallow	413586.0810	5357643.6493	48.3660	-118.1667		
5-R5	679	Deep	412794.8433	5355906.5887	48.3503	-118.1770		
5-R7	678	Deep	412420.6447	5353611.4682	48.3296	-118.1816		
Ref-5b	678	Shallow	411844.1665	5354906.8003	48.3412	-118.1897		
5-R6	677	Deep	413310.8246	5353490.8058	48.3287	-118.1696		
5-R8	677	Deep	414130.0949	5353398.1086	48.3279	-118.1585		
5-R9	676	Deep	413414.0224	5350894.0804	48.3053	-118.1677		
5-R10	675	Shallow	414715.6921	5349616.9854	48.2940	-118.1498		
5B-R1	673	Shallow	415561.3346	5346467.4193	48.2658	-118.1378		
5B-R2	672	Shallow	415045.5045	5344167.9850	48.2450	-118.1443		
5B-R3	670	Shallow	412780.9335	5341626.0134	48.2219	-118.1743		
5B-R4	668	Deep	411236.8950	5340403.7388	48.2107	-118.1948		
6-R1	667	Deep	410799.9953	5337610.3087	48.1855	-118.2001		
6-R2	667	Deep	411375.8938	5338732.3050	48.1956	-118.1926		
6-R3	666	Deep	410888.9402	5336566.4881	48.1761	-118.1987		
6-R4	666	Deep	411054.1045	5336613.0865	48.1765	-118.1965		
6-R5	665	Shallow	410772.7857	5335024.3225	48.1622	-118.1999		
6-R6	665	Deep	411095.7067	5335058.6293	48.1626	-118.1956		
6-R7	665	Deep	411713.3021	5334577.0184	48.1583	-118.1872		
6-R8	665	Deep	411402.9060	5334503.1453	48.1576	-118.1913		
6-R9	664	Shallow	410510.2992	5333386.1065	48.1474	-118.2031		
6-R10	664	Deep	411036.2171	5332925.5305	48.1434	-118.1959		
6B-R1	661	Deep	406892.3536	5332357.5447	48.1377	-118.2515		
6B-R2	658	Shallow	407143.2772	5326143.9382	48.0818	-118.2468		
Ref-6b	658	Shallow	406881.7821	5324463.8014	48.0667	-118.2499		
6B-R3	654	Deep	404117.6052	5321860.1674	48.0428	-118.2864		
6B-R4	651	Deep	398017.9043	5321965.2712	48.0428	-118.3683		
7-R2	649	Deep	395521.8959	5319939.5152	48.0242	-118.4013		
7-R1	648	Deep	395851.5591	5318623.1128	48.0124	-118.3965		
7-R3	647	Deep	397086.0290	5318241.1340	48.0092	-118.3799		
7-R9	647	Deep	396985.9692	5317216.6610	47.9999	-118.3810		
7-R4	645	Deep	399113.4720	5314048.0094	47.9718	-118.3517		
7-R6	645	Deep	398469.3868	5314615.9455	47.9768	-118.3605		
7-R10	644	Deep	399080.6682	5313509.3701	47.9669	-118.3520		
Ref-7b	643	Shallow	399407.0937	5312138.6304	47.9547	-118.3473		
7-R8	642	Shallow	399075.2655	5308876.3601	47.9253	-118.3510		
7-R5	642	Deep	398488.3346	5310388.8622	47.9388	-118.3592		
7-R7	640	Deep	399543.1256	5306527.2679	47.9042	-118.3442		

Table A1. Proposed Station Locations for Phase 2 Sediment Collection

Station ID	River Mile	Depth	X UTM 11N	Y UTM 11N	Latitude	Longitude	Sample Type	Reserve Stations
Reserve Locations (continued)								
Ref-8b	633	Shallow	394888.1888	5298252.7991	47.8290	-118.4045		
7B-R1	630	Deep	391064.1153	5301561.2741	47.8582	-118.4564		
7B-R2	622	Deep	383720.7709	5309442.3438	47.9277	-118.5566		
7B-R4	617	Deep	376117.8436	5310454.1125	47.9354	-118.6587		
7B-R3	615	Deep	372773.0327	5310180.1736	47.9323	-118.7034		
8-R7	609	Deep	365474.6107	5308243.7408	47.9134	-118.8004		
8-R9	607	Deep	363277.3454	5309964.2159	47.9284	-118.8304		
Ref-9b	607	Shallow	363029.3212	5310369.0399	47.9320	-118.8338		
8-R2	606	Shallow	363791.7652	5311551.4066	47.9428	-118.8240		
8-R1	606	Deep	362853.6428	5311396.1753	47.9412	-118.8365		
8-R5	606	Deep	363565.6871	5310783.2682	47.9358	-118.8268		
8-R6	606	Deep	362719.5815	5310811.8786	47.9359	-118.8381		
8-R4	605	Deep	361977.7758	5312566.5373	47.9515	-118.8486		
8-R8	605	Deep	362738.2816	5312556.8751	47.9516	-118.8384		
8-R3	604	Deep	360767.7616	5312910.7008	47.9544	-118.8649		
8-R10	604	Deep	361535.2357	5312529.4221	47.9511	-118.8545		
8B-R1	603	Deep	359502.9597	5312933.1314	47.9543	-118.8818		
8B-R2	602	Deep	357524.0949	5312862.1105	47.9532	-118.9083		
Ref-10b	601	Shallow	356539.8783	5311225.6969	47.9383	-118.9209		
8B-R3	599	Deep	354493.9201	5311585.8752	47.9411	-118.9484		
8B-R4	598	Shallow	352811.0635	5312741.3546	47.9511	-118.9713		

Table A2. Sample Collection Specifications for Field-Collected Sediment and Porewater

Priority	Analysis	Container Type	Container Size	Filtered	Preservation	Holding Time	Minimum Laboratory Sample Size	Total Minimum Sample Size Needed [a, b, c]
Sediments								
Chemistry								
1	TAL metals, percent moisture	WMG	8 oz	NA	4±2ºC			337 g
	EPA 6020A metals					6 months	10 g	
	EPA 6010C metals					6 months	10 g	
2	Mercury					28 days	5 g	
2	pH					7 days	20 g	
2	Total organic carbon					28 days	1 g	
2	AVS/SEM	WMG	8 oz	NA	No headspace, ZnAc; 4±2ºC	14 days	25 g	
3	Grain size	WMG	8 oz	NA	4±2ºC	6 months	100 g	
3	Backscatter electron microscopy	WMG	16 oz	NA	4±2ºC	NA	5 g	
3	Archival						161 g	
	Sediment Volume for Chemistry Analyses (A) = 40 oz. (1.2 L)							
	Sediment Volume for EPA QA/QC (B) = 24 oz. (0.7 L)							
	Summation A + B = 64 oz. (1.9 L)							
Bioassays								
1	Short-term Toxicity Tests	Plastic	5 gal	NA	4±2ºC	ASAP	2.5 L (0.7 gal)	
2	Long-term Toxicity Tests						4.3 L (1.1 gal)	
3	TIE						36.6 L (9.7 gal)	
						Sediment Volume for Complete Bioassay Analyses =	**44.5 L (~12 gal)**	
Porewater								
1	Dissolved TAL Metals							135 mL
	EPA 6020A metals	HDPE	50 mL	FILTERED	1 mL of 20% HNO_3, pH<2; 4±2ºC	6 months	20 mL	
	EPA 6010C metals						20 mL	
2	Organic Carbon							
	DOC [d]	HDPE	50 mL	Not Filtered	4±2ºC	28 days	25 mL	
	TOC						20 mL	
3	Conventional Parameters							
	pH	HDPE	50 mL	Not Filtered	4±2ºC	28 days	15 mL	
	Alkalinity as $CaCO_3$						25 mL	
	Hardness							
	Chloride, sulfate						10 mL	

Notes:

[a] Total sample size does not include additional sample volumes needed for laboratory quality control or field duplicate samples. If sufficient sample volume is available, attempt to fill all sample containers provided. If insufficient sample volume is available, fill containers to laboratory minimiums in order of priority and then fill the priority containers with any remaining sample.

[b] Project field duplicate samples should be collected for 10 percent of all analytical sediment samples and submitted blind to the analytical laboratory. In addition, EPA split sediment samples (containing at least 200 g) will be collected for 15 percent of all analytical samples.

[c] Up to seven split samples from bioassay stations located upstream from the confluence of Onion Creek (RM 730) will also be evaluated as part of EPA's QA/QC program. Pending approval and agreement from the Canadian Government, EPA would also collect up to three split-samples for bioassay testing in upstream reference locations.

[d] The chain-of-custody for DOC must be marked "lab filter needed"

ASAP = as soon as possible
AVS/SEM = acid volatile sulfide/simultaneously extracted metals
$CaCO_3$ = calcium carbonate
DOC = dissolved organic carbon
HDPE = high density polyethylene
HNO_3 = nitric acid
NA = not applicable
TAL = target analyte list
TIE = Toxicity Identification Evaluation
TOC = total organic carbon
WMG = wide-mouth glass
ZnAc = zinc acetate

ATTACHMENT A1

GENERAL SITE HEALTH AND SAFETY PLAN ADDENDUM
PHASE 2 SEDIMENT STUDY

CONTENTS

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

CFR	Code of Federal Regulations
COPC	chemical of potential concern
GPS	global positioning system
HAZWOPER	hazardous waste operations and emergency response
OSHA	Occupational Safety and Health Administration
PFD	personal flotation device
PPE	personal protective equipment
RI/FS	remedial investigation and feasibility study
SHSP	site health and safety plan
Site	Upper Columbia River site
TAI	Teck American Incorporated
UCR	Upper Columbia River
WISHA	Washington Industrial Safety and Health Act

SITE HEALTH AND SAFETY PLAN ADDENDUM APPROVAL

This Addendum to the general site health and safety plan (SHSP) has been reviewed and approved by Teck American Incorporated's (TAI) lead technical consultant (Exponent Inc.) for the Phase 2 Sediment Study at the Upper Columbia River (UCR) site (Site) in support of the remedial investigation and feasibility study (RI/FS) for the Site.

Anne Fairbrother Digitally signed by Anne Fairbrother
DN: cn=Anne Fairbrother, o=Exponent, ou=Ecosciences, email=afairbrother@exponent.com, c=US
Date: 2013.04.02 17:57:08 -06'00' April 2, 2013

Exponent Task Manager Date

Joseph M. Sorokach 2013.04.02 15:42:53 -07'00' April 2, 2013

Exponent Corporate Health and Safety Officer Date

SITE HEALTH AND SAFETY PLAN ADDENDUM ACKNOWLEDGEMENT

This Addendum to the general SHSP (TCAI 2009) is approved by for use at the Site. The general SHSP and Addendum are the minimum health and safety standard for the Site and will be strictly enforced for all personnel conducting sediment sampling activities at the Site. Subcontracted personnel may request to adopt a subcontractor-specific plan in lieu of this Addendum to the general SHSP, but must obtain prior written approval from Exponent and provide written concurrence from the subcontractor that the subcontractor will assume direct responsibility and liability for administering the plan to its employees.

I have reviewed this Addendum, to the general SHSP for the study. I have had an opportunity to ask any questions I may have and have been provided with satisfactory responses. I understand the purpose of the plan, and I consent to adhere to its policies, procedures, and guidelines.

Employee signature	Company	Date
Employee signature	Company	Date
Employee signature	Company	Date
Employee signature	Company	Date
Employee signature	Company	Date
Employee signature	Company	Date
Employee signature	Company	Date

1 INTRODUCTION

This Addendum to the UCR RI/FS general SHSP provides specific Site information and health and safety provisions to protect workers from potential hazards during sediment sampling at locations along the UCR.

Site background information and general health and safety provisions to protect workers from potential hazards during work at the Site are presented in the general SHSP (TCAI 2009).

Subcontractors that are contracted to perform field work associated with the RI/FS may adopt this SHSP or develop and follow their own SHSPs. However, subcontractor SHSPs must be consistent with the provisions outlined in the Addendum and the general SHSP, and any discrepancies will follow the most protective practices.

It is Exponent's policy to provide a safe and healthful work environment. No aspect of the work is more important than protecting the health and safety of all workers.

Exponent cannot guarantee the health or safety of any person entering the Site. Because of the potentially hazardous nature of the Site and the activity occurring thereon, it is not possible to regulate personal diligence or to discover, evaluate, and provide protection for all possible hazards that may be encountered. Strict adherence to the health and safety guidelines set forth herein will reduce, but not eliminate, the potential for injury and illness at the Site. The health and safety guidelines in this plan were prepared specifically for the Site and should not be used on any other site without prior evaluation by trained health and safety personnel.

A copy of this Addendum and the general SHSP must be in the custody of the field crew during field activities. All individuals performing field work must read, understand, and comply with this plan before undertaking field activities. Once the information has been read and understood, the individual must sign the Site Health and Safety Acknowledgment Form provided with this Addendum to the general plan. Any changes to the plan will be written in the plan and initialed by all potentially affected field personnel. The signed form and any initialed changes will become part of Exponent's project file. A copy of the form will be provided to TAI.

This Addendum may be modified at any time based on the judgment of the site safety officer in consultation with the corporate health and safety officer and project manager or designee. Any modification will be presented to the onsite team during a safety briefing and will be recorded in the field notebook.

1.1 ORGANIZATION

Task-specific safety procedures associated with sediment sampling are presented in this Addendum to the general SHSP. In addition, this Addendum provides detailed field site and hospital location maps, air monitoring requirements, specific requirements for personal protective equipment (PPE), work zone definitions, and key emergency contact information.

The general SHSP (TCAI 2009) provides background site information and general health and safety provisions to protect workers from potential hazards during field activities. The information includes general safety guidelines for physical hazards, a chemical hazard evaluation, health and safety training requirements, general PPE requirements, emergency planning, general decontamination procedures, vehicle safety, and spill containment.

1.2 SCOPE OF WORK

Sediment samples will be collected at stations throughout the length of the UCR (see Site map, Attachment A1-1). Each sediment sample will be collected using a Van Veen dredge. Access to all of the sediment collection areas will require the use of a boat. The coordinates of each sediment sample station location will be surveyed using a global positioning system (GPS) unit.

1.3 DEFINITIONS

Contamination reduction zone:	Area between the exclusion and support zones that provides a transition between contaminated and clean zones
Exclusion zone:	Any area of the Site where hazardous substances are present, or are reasonably suspected to be present, and pose an exposure hazard to personnel
HAZWOPER:	Hazardous Waste Operations and Emergency Response standard, as described in 29 Code of Federal Regulations (CFR) Part 1910.120
OSHA:	Occupational Safety and Health Administration
Support zone:	Any area of the Site, so designated, that is outside the exclusion and contamination reduction zones
WISHA:	Washington Industrial Safety and Health Act, as described in Chapter 49.17 Revised Code of Washington

2 SAFETY GUIDELINES FOR PHYSICAL HAZARDS

All work will be done using the buddy system. Depending upon the time of year and the location of work, biting insects may be an issue when accessing any of the sampling locations during the sampling event. Table 2-1 summarizes potential physical hazards posed by proposed Site activities. Table 2-2 presents potential physical hazards that are expected to be present during sediment sampling activities.

Table 2-1. Summary of Activities and Potential Hazards

Activity	Potential Hazard
Sediment Sampling	Boating and water hazards, slippery walking surfaces, cold/hypothermia (depending on sampling event), heat stress (depending on sampling event), material handling, adverse weather, work in remote areas

Table 2-2. Potential Physical Hazards and Proposed Safety Procedures

Potential Hazard	Yes	No	Proposed Safety Procedure
Slippery surfaces	X		Use caution; wear properly fitting shoes or boots with good gripping capacity; keep work area orderly
Cold/hypothermia	X		Keep warm and dry, bring changes of clothes; do not work in extreme conditions without proper equipment and training; follow cold stress information (Attachment A1-2); potential for cold/hypothermia will depend on season
Heat stress	X		Drink water frequently in hot weather; take work breaks; follow the heat-related illness policy (Attachment A1-3); potential for heat stress will depend on season
Material handling	X		Lift properly; seek assistance if necessary; do not overfill coolers or boxes
Adverse weather	X		Seek shelter during storms; work in adverse weather conditions only with proper training, clothing, and equipment
Drowning		X	Wear personal flotation devices (PFDs) at all times when working over water. Inspect the PFDs prior to use and do not use defective PFDs. Keep sampling equipment on boats organized at all times. Boats are required to be equipped with a throwable life ring, fire extinguisher, and warning horn, and each field member will be briefed on their storage location.
Work in remote areas	X		Use buddy system; carry radio and/or cellular phone; bring sufficient equipment in case of accident or injury (first aid kit, shelter if appropriate)
Biting insects	X		Use repellents, as needed.

3 CHEMICAL HAZARD EVALUATION

A chemical hazard evaluation is presented in the general SHSP (TCAI 2009) and incorporated herein by reference.

4 PERSONAL PROTECTIVE EQUIPMENT AND SAFETY EQUIPMENT

The following sections address PPE and safety equipment required for completing the sediment sampling activities.

4.1 PERSONAL PROTECTIVE EQUIPMENT

Based on chemical and physical hazards associated with the sediment sampling activities, Tables 4-1 and 4-2 identify the PPE required for sampling.

Table 4-1. Level of Protection Required for Site Activities

Site Activity	Level of Protection	
	Initial[a]	Contingency[b]
Sediment sampling	MD	Leave Site, reassess situation
Sample handling	D	Leave Site, reassess situation

[a] See Table 4-2 for definitions

[b] Based on unexpected change in Site conditions

Table 4-2. Levels of Protection and Personal Protective Equipment

Protection Level	Required	Personal Protection Equipment
Level D	X	Long pants and shirt or work coveralls, safety glasses or goggles (as appropriate), and nitrile, neoprene, or Barrier® 5 layer laminate gloves (as appropriate). Hard hat and hearing protection as needed.
Level MD	X	Same as Level D with modification (M) of addition of rain gear and PFD, as needed.

Is there potential for a respirator to be donned during field work? Yes _____ No X

4.2 SAFETY EQUIPMENT

The following safety equipment will be onsite during the proposed field activities.

Air Monitoring (Check the items required for this project.)

☐ Photoionization Detector	☐ Air sampling pumps
☐ Lower Explosive Limit/Oxygen meter	☐ Miniram
☐ Hydrogen sulfide meter	☐ Radiation meter
☐ Detector pump and tubes	☐ Other _____

First Aid Kit (mandatory, including adhesive band-aids, gauze, tape, gloves, cardiopulmonary resuscitation shield, triangle bandage)

[X]	Emergency blanket	[X]	Sunscreen
[X]	Insect repellent	[ ]	Other _____

Other (Check the items required for this project.)

[X]	Eyewash	[ ]	Fit test supplies
[X]	Drinking water	[X]	Fire extinguisher (boat)
[ ]	Stop watch for monitoring heart rate	[ ]	Windsock
[ ]	Thermoscan® thermometer (or equivalent) for heat stress monitoring	[X]	Cellular phone
		[ ]	Radio sets
[X]	Survival kit	[X]	Global positioning system
[X]	Personal flotation device	[X]	Other Satellite phone
[ ]	Cool vests		

5 AIR MONITORING

The principal chemicals of potential concern (COPCs) at the Site are not volatile (i.e., metals). There is a small chance for the COPCs to become airborne in dust form if the sediment is dry, although the sediments are unlikely to contain a significant amount of fine particles. In addition, the chemical hazard evaluation presented in the general SHSP (TCAI 2009) concluded that, based on previous evaluations, none of the sediment chemicals is expected to pose a threat to field personnel during sediment sampling activities. If windblown dust becomes problematic to the field crew, operations may be suspended. Tables 5-1 and 5-2 provide air monitoring requirements and action levels to be used during sampling activities.

Table 5-1. Site-specific Air Monitoring Requirements

Monitoring Instrument	Calibration Frequency	Parameters of Interest	Monitoring Frequency
Visual	N/A	Dust	Continuous

Table 5-2. Action Levels Established to Determine the Appropriate Level of Personal Protection

Instrument	Reading	Action [a]	Comments
Visual	Visual Dust	Leave Site, if necessary	

6 EMERGENCY PLANNING

In case of any emergency affecting the Site, all affected personnel must immediately evacuate the work area and report to the Site safety officer at the following predetermined location.

DESIGNATED ASSEMBLY LOCATION: Field vehicle

In case of injury, field personnel should take precautions to protect the victim from further harm and notify local or facility emergency services. In remote areas, it will be necessary to have first aid-trained personnel on the field team. The victim may require decontamination prior to treatment—requirements will vary based on Site conditions.

Emergency medical care will be provided by

- [X] Local emergency medical provider (i.e., fire department; see Table 6-1 for local contact information)
- [X] Facility emergency medical provider
- [X] First aid-trained field staff (for remote areas only)

Table 6-1. Local Emergency Telephone Numbers

Local Resources	Name	Telephone	Notified Prior to Work (Yes/No)?
Fire	Varies by location	911	Yes. Notify the E911 coordinator for Stevens County (Debby McCanna; 509-684-2555) of the schedule and location of work.
Police	Varies by location	911	Yes (see above)
Ambulance	Varies by location	911	Yes (see above)
Main Hospital	Mount Carmel Hospital, Colville, WA	(509) 684-2561	No
Alternative Hospitals	Coulee Community Hospital, Grand Coulee, WA	(509) 633-1753	No
	Ferry County Memorial Hospital, Republic, WA	(509) 775-3333	No
	Lincoln Hospital, Davenport, WA	(509) 725-7101	No
	St Joseph's Hospital, Cheweleh, WA	(509) 935-8211	No
	Deer Park Hospital, Deer Park, WA	(509) 276-5061	No
	Deaconess Medical Center-Spokane, Spokane, WA	(509) 473-7178	No
	Holy Family Hospital, Spokane, WA	(509) 482-0111	No
	Sacred Heart Medical Center, Spokane, WA	(509) 474-3131	No
	Veterans Affairs Medical Center, Spokane, WA	(509) 434-7032	No

Table 6-1. Local Emergency Telephone Numbers (continued)

Local Resources	Name	Telephone	Notified Prior to Work (Yes/No)?
Site phone	Field cellular phone. Cellular phone coverage is spotty in the vicinity of the sampling areas. If cellular phone coverage is lost due to a mountain/ hill, drive a little further to get coverage. If cellular phone coverage is available, the 911 system will work. A satellite phone may be necessary for areas with limited cellular phone coverage.	TBD	NA
Directions to Mount Carmel Hospital (from Highway 395)	Begin traveling SE on Highway 395. Highway 395 becomes Main Street in Colville. Turn LEFT on E. Columbia Ave. Go 0.6 mile. Arrive at 982 E. Columbia Ave. Hospital is on right. (See detailed hospital location maps in Attachment A1- 1)		

In case of serious injuries, death, or other emergency, the TAI and Exponent task managers must be notified immediately. Contact numbers are listed in Table 6-2.

Table 6-2. Corporate Emergency Telephone Numbers

Corporate Resources	Name	Work/Cellular Telephone
TAI Task Manager	Marko Adzic	Work: (509) 623-4585 Cellular: (509) 991-0842
Exponent Task Manager	Anne Fairbrother	Work: (425) 519-8716 Cellular: (425) 213-7699

Table 6-3 provides local hospital contact and location information. See Attachment A1-1 for a detailed hospital location map.

Table 6-3. Project Area Hospital Information

Facility Name	Hours of Operation	Phone Number	Address	City
Coulee Community Hospital	24 hour emergency	509-633-1753	411 Fortuyn Road	Grand Coulee
Ferry County Memorial Hospital	24 hour emergency	509-775-3333	36 Klondike Road	Republic
Lincoln Hospital	24 hour emergency	509-725-7101	10 Nichols Street	Davenport
St Joseph's Hospital	24 hour emergency	509-935-8211	500 East Webster Street	Chewelah
Mount Carmel Hospital	24 hour emergency	509-684-2561	982 East Columbia Street	Colville
Deer Park Hospital	24 hour emergency	509-276-5061	East 1015 'D' Street	Deer Park

Table 6-3. Project Area Hospital Information (continued)

Facility Name	Hours of Operation	Phone Number	Address	City
Deaconess Medical Center-Spokane	24 hour emergency	509-473-7178	West Fifth Avenue	Spokane
Holy Family Hospital	Dependent on case	509-482-0111	North 5633 Lidgerwood Avenue	Spokane
Sacred Heart Medical Center	24 hour emergency	509-474-3131	West 101 Eighth Avenue	Spokane
Veterans Affairs Medical Center	7:30am-4:00pm	509-434-7032	North 4815 Assembly Street	Spokane

In the event any health or safety issue arises, after the victim(s) receive appropriate medical treatment, the relevant field crew member(s) will be interviewed to formally document the incident by, at a minimum, the field supervisor and task manager. All incidents will be documented in the field logbook. If applicable, a corrective action form will be filled out (see Field Sampling Plan Attachment A1) to ensure future health and safety issues are addressed.

7 WORK ZONES

The following work zones are defined for the sediment sampling activities.

Exclusion zone. The area immediately around the sampling activities will be designated as the exclusion zone. Because the majority of sampling will be on the water, and in remote locations, no designation (e.g., traffic cones or caution tape) will be utilized.

Contamination reduction zone. Not applicable. All sampling activities will occur within the exclusion zone.

Support zone. Not applicable. All sampling activities will occur within the exclusion zone.

Controls to be used to prevent entry by unauthorized persons. Sampling staff will remain cognizant of people approaching the exclusion zone. All unauthorized persons will be instructed to remain outside of the sampling area.

8 DECONTAMINATION

The field team will decontaminate all sampling equipment that comes into contact with sediment prior to the commencement of sampling at each location and upon completion of the study. This will include equipment such as trowels, mixing bowls, and utensils. The decontamination will consist of thoroughly rinsing all of the equipment with potable water, then with soap (i.e., Alconox®) and rinsed with potable water after each use.

Clean gloves will be worn at each sampling location to avoid transfer of potential contaminants among samples. Otherwise decontamination procedures will follow those presented in the general SHSP (TCAI 2009) and are incorporated herein.

9 VEHICLE SAFETY, SPILL CONTAINMENT, AND SHIPPING INSTRUCTIONS

Vehicle safety, spill containment, and shipping instructions are presented in the general SHSP (TCAI 2009) and are incorporated herein.

10 TASK-SPECIFIC SAFETY PROCEDURES

Slips, trips, and falls are anticipated to be the greatest hazards to field personnel during the sediment sampling event, as well as unexpected contact with the sampling equipment. Always move about the boat with caution. Wear properly fitting shoes or boots with non-slip soles and good ankle support. Be aware of the location and movement of the grab sampler at all times.

The Site is located in a remote region with limited cellular phone coverage. All field crews will have two-way radios or a satellite phone to maintain communication with the field supervisor. The field crews will coordinate departure and expected return times for all field activities with the field supervisor. Field crews will provide the field supervisor with status updates at least every four hours while performing field collection activities.

When working onboard a boat or near/over water, wear a PFD at all times. Inspect the PFDs daily prior to use and do not use if defective. Information on boating safety is presented in the general SHSP (TCAI 2009 Section 9.2).

Some of the areas that will be sampled are accessible to the public. Always be aware of your surroundings. Use the buddy system and keep in line-of-sight contact with other sampling personnel at all times. Do not leave samples or sampling equipment unattended. If you feel threatened, or if the situation feels unpredictable, leave the area immediately.

Always wear nitrile gloves and safety glasses or goggles when handling sampling equipment, samples, or preservative chemicals (if required). Keep a 1-liter eye wash bottle accessible during all field work. Avoid getting preservatives on your skin or clothes. If any preservatives are spilled or splashed on your skin or clothes, immediately rinse the affected area with potable water and get medical attention, if warranted. If any preservative is splashed in the eye, flush the eye with the eye wash solution and get immediate medical attention.

11 REFERENCE

TCAI. 2009. Upper Columbia River general site health and safety plan for the remedial investigation and feasibility study. Prepared for Teck American Incorporated. Integral Consulting Inc., Mercer Island, Washington, and Parametrix, Bellevue, WA.

ATTACHMENT A1-1

SITE MAP AND HOSPITAL LOCATION MAPS

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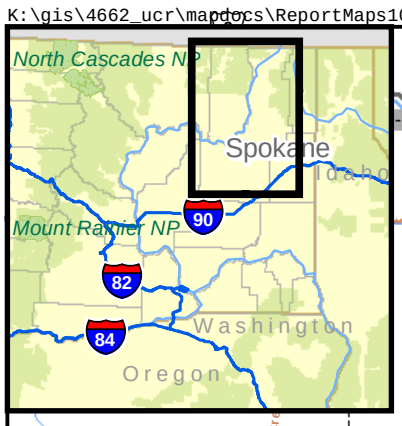


U.S.- Canada Border

Grand Forks

Ferry County Memorial Hospital

Marcus Flats

RM 712

RM 745

RM 730

RM 700

RM 676

RM 617

RM 640

RM 597

Coulee Community Hospital

Grand Coulee Dam

Mount Carmel Hospital

St Joseph's Hospital

Deer Park Hospital

Seven Bays

Long Lake Dam

Lincoln Hospital

Holy Family Hospital

Veterans Affairs Med Center

Sacred Heart Medical Center

Deaconess Medical Ctr-Spokane

Eastern State Hospital

Colville Indian Reservation

Spokane Indian Reservation

Okanogan

Ferry

Stevens

Pend Oreille

Douglas

Lincoln

Spokane

Kettle River

Colville River

Sanpoil River

Spokane River

Aeneas Valley

Addy-Gifford

Cedonia Addy

Springdale-Hunters

Bluestem

Coffeepot

Williams Valley

Swenson

Malloy Prairie

Salnave

Cheney-Spangle

Crescent

Farwell

Coulee Hite

Mohler

Snider

Gardenspot

Deer Park-Milan

Staley

Jennings

Wells

Old

Windblown Sediment/Dust Study Locations
Relict Flood Sampling Area
Upland Soil Study Area
Hospitals (AHA) (ESRI dataset, 2005)
River Reach Delineations (USGS)
Grand Coulee Dam
Populated Places
County Lines
Reservations
Urban Areas

Parametrix Exponent

Integral Hydroqual

Km 0 5 10

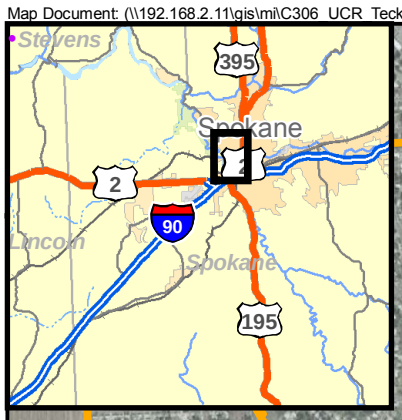
Miles 0 5 10

N

Sediment QAPP Study Locations and Hospitals

Upper Columbia River, WA

Map Document: (\\192.168.2.11\gis\mi\C306_UCR_Teck-Cominco\t0800_0802\UCR_SWQAPP_HospitalAllSpokane_05152008.mxd) JP-- 02/23/2009



Holy Family Hospital
North 5633 Lidgerwood Avenue
Spokane, WA
509-482-0111

Veterans Affairs Medical Center
North 4815 Assembly Street
Spokane WA
509-434-7032

St. Luke's Rehab
711 South Cowley Street
Spokane WA

Deaconess Medical Center-Spokane
800 West Fifth Avenue
Spokane WA
509-473-7178

Sacred Heart Medical Center
101 West Eighth Avenue
Spokane WA
509-474-3131

Indian Trail
Five Mile
Wall
Francis
291
Belt
A
Ash
Monroe
Driscoll
Wellesley
Maple
Empire
Garland
Courtland
Cochran
Euclid
Aubrey L White
Downriver Park
Northwest
North Foothills
Pettet
Indiana
Pettit
Mission
Maxwell
Summit
Broadway
Ohio
Spokane Falls
290
Riverside
Sprague
Browne
3rd
S
Stevens
Walnut
9th
Sumner
10th
Grand
14th
Bernard
Cedar
Sunset
195
2
90

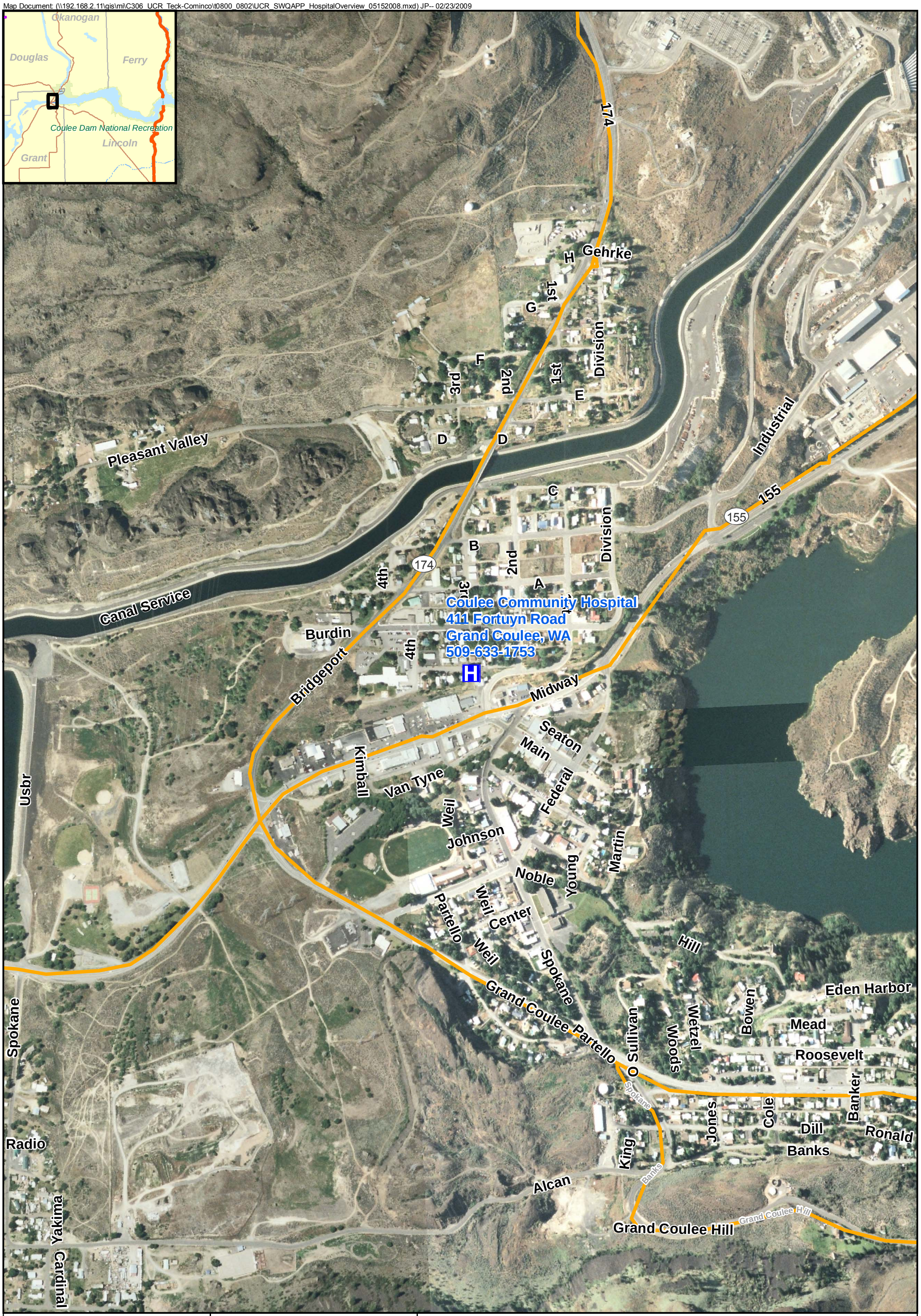
Integral Parametrix

Kilometers
0 0.25 0.5
Miles
0 0.25 0.5
N

Spokane Area Hospital Locations

Upper Columbia River, WA

Map Document: (\\192.168.2.11\gis\mi\C306_UCR_Teck-Cominco\t0800_0802\UCR_SWQAPP_HospitalOverview_05152008.mxd) JP-- 02/23/2009



Integral Parametrix

Meters
0 50 100

Feet
0 250 500

N

Coulee Community Hospital Location

Upper Columbia River, WA

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Dalton
5th
Reiper
4th
4th
Christensen
3rd
Forest
Margaret
3rd
Arcadia
2nd
2nd
Stevens
1st
Reiper
Crawford
Crawford
Crawford
Washington
Jefferson
High
A
Margaret
Mission
B
Arcadia
Washington
Evergreen
C
Orchard
Reiper
D
Deer Park Hospital
East 1015 D Street
Deer Park, WA
509-276-5061
Stevens
D
E
E
Parker
F
Forest
Colville
Arcadia
H
H
Dalton
I

Integral Parametrix

Meters
0 50 100
Feet
0 250 500
N

Deer Park Hospital Location

Upper Columbia River, WA

Map Document: (\\192.168.2.11\gis\mi\C306_UCR_Teck-Cominco\t0800_0802\UCR_SWQAPP_HospitalFerryCoMem_05152008.mxd) JP-- 02/23/2009

Integral Parametrix

Meters
0 50 100
Feet
0 250 500
N

Ferry County Memorial Hospital Location

Upper Columbia River, WA

Map Document: (\\192.168.2.11\gis\mi\C306_UCR_Teck-Cominco\t0800_0802\UCR_SWQAPP_HospitalLincoln_05152008.mxd) JP-- 02/23/2009

Integral Parametrix

Meters
0 50 100

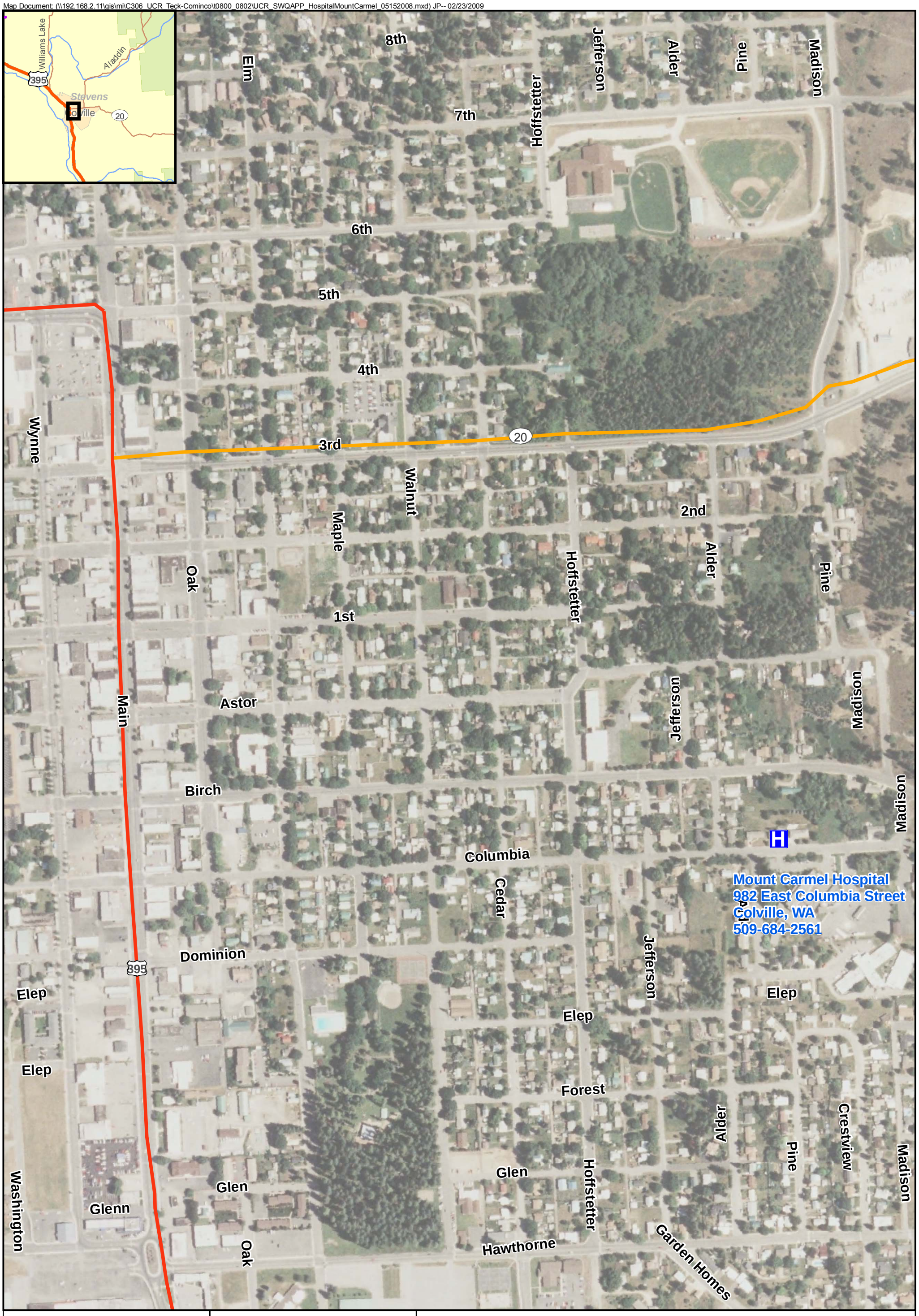
Feet
0 250 500

N

Lincoln Hospital Location

Upper Columbia River, WA

Map Document: (\\192.168.2.11\gis\mi\C306_UCR_Teck-Cominco\t0800_0802\UCR_SWQAPP_HospitalMountCarmel_05152008.mxd) JP-- 02/23/2009



Integral Parametrix

Meters
0 50 100

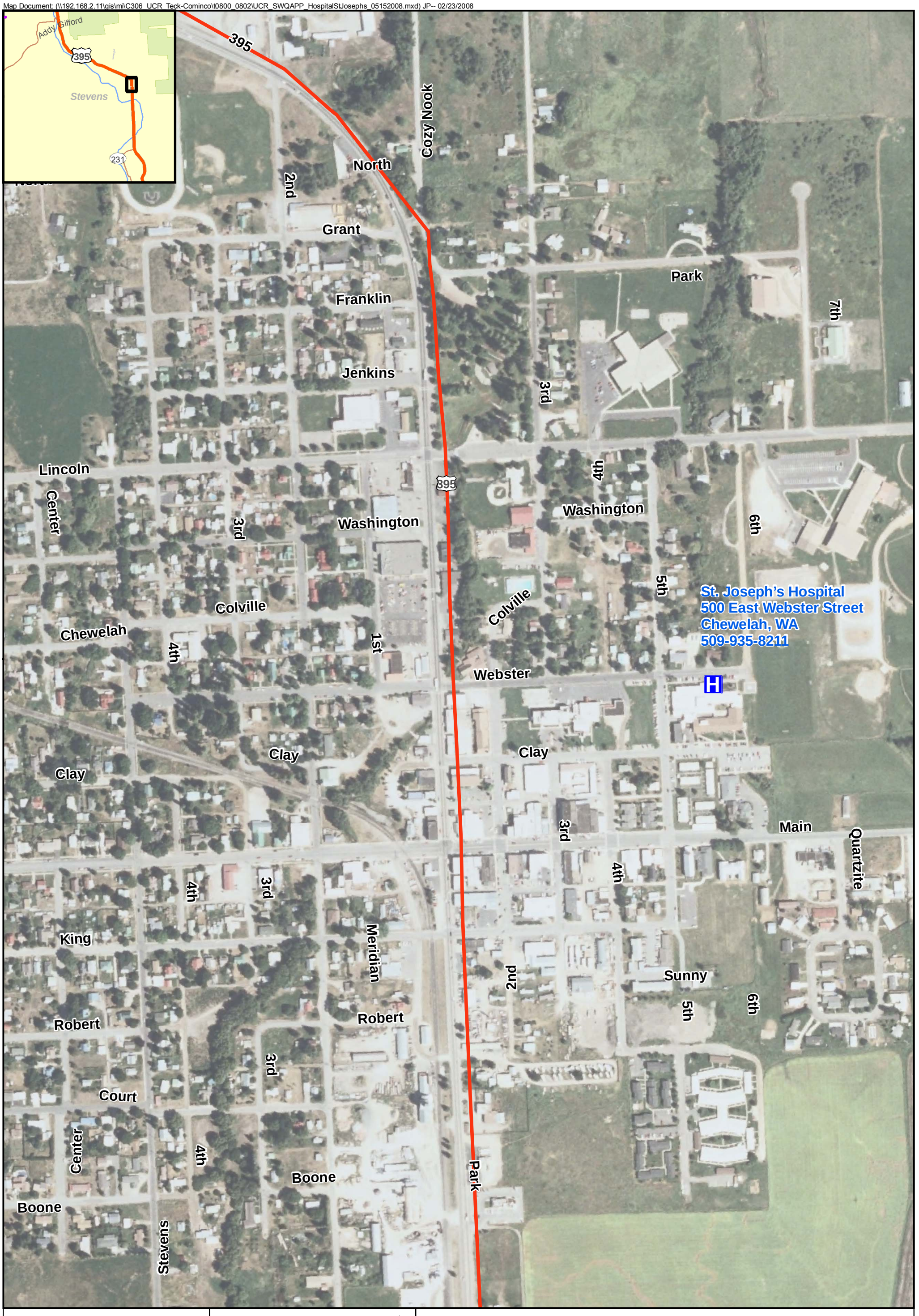
Feet
0 250 500

N

Mount Carmel Hospital Location

Upper Columbia River, WA

Map Document: (\\192.168.2.11\gis\mi\C306_UCR_Teck-Cominco\t0800_0802\UCR_SWQAPP_HospitalStJosephs_05152008.mxd) JP-- 02/23/2008



Integral Parametrix

Meters
0 50 100
Feet
0 250 500
N

St. Joseph's Hospital Location

Upper Columbia River, WA

ATTACHMENT A1-2

COLD-STRESS FACT SHEET

FROSTBITE

What happens to the body:

Freezing in deep layers of skin and tissue; pale, waxy-white skin color; skin becomes hard and numb; usually affects fingers, hands, toes, feet, ears, and nose.

What to do: (land temperatures)

- Move the person to a warm, dry area. Don't leave the person alone.
- Remove wet or tight clothing that may cut off blood flow to the affected area.
- **Do not** rub the affected area because rubbing damaged the skin and tissue.
- Gently place the affected area in a warm water bath (105°) and monitor the water temperature to **slowly** warm the tissue. Don't pour warm water directly on the affected area because it will warm the tissue too fast, causing tissue damage. Warming takes 25-40 minutes.
- After the affected area has been warmed, it may become puffy and blister. The affected area may have a burning feeling or numbness. When normal feeling, movement, and skin color have returned, the affected area should be dried and wrapped to keep it warm. **Note:** If there is a chance the affected area may get cold again, do not warm the skin. If the skin is warmed and then becomes cold again, it will cause severe tissue damage.
- Seek medical attention as soon as possible.

How to Protect Workers

- Recognize the environmental and workplace conditions that lead to potential cold-induced illnesses and injuries.
- Learn the signs and symptoms of cold-induced illnesses/injuries and what to do to help the worker.
- Train workers about cold-induced illnesses and injuries.
- Select proper clothing for cold, wet, and windy conditions. Layer clothing to adjust to changing environmental temperatures. Wear a hat and gloves, in addition to underwear that will keep water away from the skin (polypropylene.)
- Take frequent short breaks in warm, dry shelters to allow the body to warm up.
- Perform work during the warmest part of the day.
- Avoid exhaustion or fatigue because energy is needed to keep muscles warm.
- Use the buddy system (work in pairs.)
- Drink warm, sweet beverages (sugar water, sports-type drinks.) **Avoid drinks with caffeine** (coffee, tea, or hot chocolate) **or alcohol**.
- Eat warm, high-calorie foods like hot pasta dishes.

Workers are at increased risk when…

- They have predisposing health conditions such as cardiovascular disease, diabetes, and hypertension.
- They take certain medications. Check with your doctor, nurse, or pharmacy and ask if medicines you take affect you while working in cold environments.
- They are in poor physical condition, have a poor diet, or are older.

HYPOTHERMIA - (Medical Emergency)

What happens to the body:

Normal body temperature (98.6°F/37°C) drops to or below 95°F/35°C; fatigue or drowsiness; uncontrolled shivering; cool, bluish skin; slurred speech; clumsy movements; irritable, irrational, or confused behavior.

What to do: (land temperatures)

- Call for emergency help (i.e., ambulance or 911).
- Move the person to a warm, dry area. Don't leave the person alone.
- Remove wet clothing and replace with warm, dry clothing or wrap the person in blankets.
- Have the person drink warm, sweet drinks (sugar water or sports-type drinks) if he is alert. **Avoid drinks with caffeine** (coffee, tea, or hot chocolate) **or alcohol**.
- Have the person move his arms and legs to create muscle heat. If he is unable to do this, place warm bottles or hot packs in the armpits, groin, neck, and head areas. **Do not** rub the person's body or place him in a warm water bath. This may stop his heart.

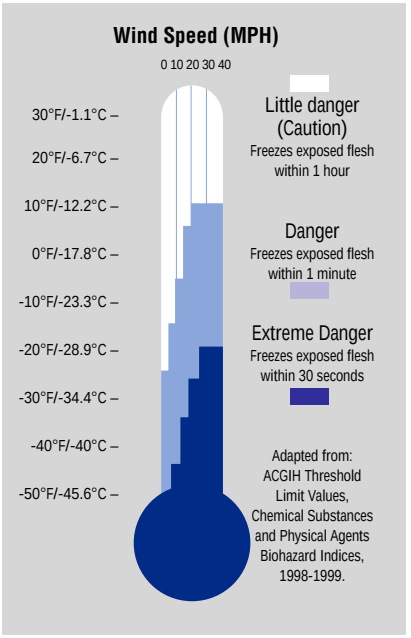
What to do: (water temperatures)

- Call for emergency help (i.e., ambulance or 911). Body heat is lost up to 25 times faster in water.
- **Do not** remove any clothing. Button, buckle, zip, and tighten any collars, cuffs, shoes, and hoods because the layer of trapped water closest to the body provides a layer of insulation that slows the loss of heat. Keep the head out of the water and put on a hat or hood.
- Get out of the water as quickly as possible or climb on anything floating. **Do not** attempt to swim unless a floating object or another person can be reached because swimming or other physical activity uses body heat and reduces survival time by about 50 percent.
- If getting out of the water is not possible, wait quietly and conserve body heat by folding arms across the chest, keeping thighs together, bending knees, and crossing ankles. If another person is in the water, huddle together with chests held closely.

THE COLD STRESS EQUATION

LOW TEMPERATURE + WIND SPEED + WETNESS = INJURIES & ILLNESS

When the body is unable to warm itself, serious cold-related illnesses and injuries may occur, and permanent tissue damage and death may result. **Hypothermia** can occur when *land temperatures* are **above** freezing or *water temperatures* are below 98.6°F/37°C. Cold-related illnesses can slowly overcome a person who has been chilled by low temperatures, brisk winds, or wet clothing.



Oregon Occupational Safety & Health Division
440-3336E-S (9/03)

ATTACHMENT A1-3

HEAT-RELATED ILLNESS PREVENTION POLICY

Instructions:

The following document has been provided to assist your company in developing a written Heat Related Illness (HRI) Prevention Policy for Outdoor Work activities per WAC 296-62-095 through WAC 296-62-09570, Heat Related Illnesses in the Outdoor Environment.

The program outline follows the recommendations found in DOSH Directive (WRD) 18.50, Heat Related Illness in the Outdoor Environment.

You must tailor these procedures to meet your specific work site conditions. Simply printing off the procedures would not comply with the provisions of the HRI Rule.

The underlined areas and tables must be filled in to tailor this program to meet your needs.

To assist you in tailoring these sample procedures to your work site conditions the following documents are available for reference:

Appendix A: Heat and Humidity Chart
Appendix B: Examples of Workload Activities
Appendix C: Sample HRI First Aid and Emergency Response Procedures

"Protecting Employees Working Outdoors from Heat-Related Illnesses"

"Training Guide for Heat-Related Illnesses"

DOSH Directive (WRD) 18.50: Heat Related Illness in the Outdoor Environment (June 5, 2007)

You can find these documents and other helpful tools by visiting the Department of Labor and Industries website at:

http://www.lni.wa.gov/safety/topics/atoz/heatstress/default.asp

Heat-Related Illness (HRI) Prevention
Outdoor Work Policy

⇨ _____is committed to preventing Heat Related Illnesses—HRI that can occur to employees working in the outdoor environment.

⇨ _____recognizes that exposure to extreme temperature, humidity and other environmental factors can lead to serious illnesses including heat fatigue, heat rash, fainting, heat cramps, heat exhaustion, and heat stroke. The following formal policy has been developed to protect employees from the hazards posed by working in the outdoor environment and to comply with the written procedures as required by WAC 296-62-095 through WAC 296-62-09570, Heat Related Illnesses in the Outdoor Environment. Outdoor work includes any employee assigned to work in the outdoor environment on a regular basis.

I. HRI Training Plan

Prior to assignment of any outdoor work activities, employees and supervisors of

⇨ _____ will be trained on our HRI procedures and the elements outlined below.
(See "Training Guide for Heat-Related Illness"-Found on DOSH website)

A. Employee Training

- Recognizing the environmental causes of HRI and personal factors that can increase the risk
- How our company identifies, evaluates, and controls HRI exposure
- Removal of Personal Protective Equipment during all breaks
- Frequently consuming water when HRI hazards are present
- Importance of acclimatization (Getting used to hot weather)
- Different types of HRI and the common signs and symptoms
- Importance of immediately reporting HRI symptoms of themselves or co-workers
- How our company will respond to HRI symptoms and emergencies
- The purpose and requirements of the HRI rules

B. Supervisor Training

- How to implement the provisions of the HRI rule
- What to do when an employee exhibits signs or symptoms of HRI, including emergency response
- How to safely move employees to a place that is easily reached by emergency medical providers
- How to provide clear directions to emergency medical providers so they can find the work site

II. Evaluation of HRI Hazards

⇨ _____ will evaluate HRI hazards based on a combination of factors including temperature, humidity, and other environmental conditions in all workplaces where outdoor work is performed. ⇨ _____ will routinely evaluate potential HRI hazards by checking one or more of the following:

(See Appendix A: Heat Index Chart as an evaluation option)

Air Temperature and Humidity *(list your source of information)*

- o Local weather report predictions from:

  _____

- o On-site temperature and humidity measuring equipment (and location):

  _____

- o Historical area weather data to approximate work site conditions from:

  _____

Other Environmental Factors *(list what may be present and increase HRI risk)*

- o **Radiant Heat** *(Example: Reflection of heat from asphalt, rocks, or composite roofing material; or work in direct sunlight)*

  _____

  _____

- o **Air Movement** *(Example: Wind blowing and temperature above 95 degrees F)*

  _____

  _____

- o **Conductive Heat Sources** *(Example: Operating orchard tractor for mowing)*

  _____

  _____

- o **Workload Activity and Duration** *(Example: Hand sawing wood, carrying masonry blocks, digging with a shovel)*

  _____

  _____

- o **Personal Protective Equipment/Clothing** *(Example: Wearing respirator, chemical resistant suit, and gloves for pesticide application or HAZMAT clean-up; or leathers and gloves for welding)*

  _____

  _____

III. Procedures for Controlling Environmental Factors

⇨ _____ will control HRI environmental factors at the worksite to reduce HRI risks. Depending on the environmental factors present, we will use one or more of the following methods for controlling HRI risks to protect employees:

List your control methods, when they will be used, and what the expected outcome is.

Control Method	When Used	Expected Outcome
Example 1: Use water hose to wet towels or clothing and place on the body; use cooling vest or cooling headbands	*When temperature is going to reach 95 degrees or more; or Heat Index reaches 90*	*Cool the body temperature*
Example 2: Take breaks in shaded area (house, garage, canopy, under trees)	*When working in direct sun light (e.g. roofers, asphalt pavers, berry pickers)*	*Cool the body temperature*
Example 3: Start work shift early (when daylight begins) and end shift early, or do not work during hottest parts of day	*When temperature expected to reach 90 degrees or more*	*Reduce time exposed to heat and keep body temperature cooler*
Example 4:Remove respirator, chemical suit and gloves, or welding leathers during breaks	*When temperature is going reach 80 degrees or more*	*Cool the body temperature and all reduce humidity close to body*

IV. Drinking Water

Sufficient potable drinking water will be provided and made accessible to employees.

⇨ _____ is responsible for ensuring sufficient water is available. At least **one quart of water per employee per hour** will be available when HRI hazards are present. **If you notice water is not present notify your supervisor immediately**. Water can be found in the following locations: *(List your water sources and locations)*

- _____
- _____
- _____

V. Adjusting Rest Breaks for Increased Work Load and Duration

⇨_____ will use an adjusted rest break schedule to minimize employees risk when there is an increased risk of HRI hazards due to work loads. Supervisors will adjust rest breaks as follows:

(See Appendix B: Examples of Work Load Activities)

Work Activity	Adjusted Rested Breaks and When Used
Example: Thinning apples 8-hours, roofing a residential house 6-hours, carrying masonry blocks 4-hours, shoveling hot asphalt for 8-hours	*Example: An additional break before and after lunch when. . .* *-temperature reaches 90 degrees and humidity is 50%* *-performing heavy work in direct sunlight or on hot surfaces*

VI. Procedures for Responding to Heat-Related Illnesses

⇨_____ will respond to HRI in a quick and safe manner. The table below outlines the potential types of heat-related illnesses, signs and symptoms, and specific First Aid and HRI Emergency procedures. The information will be present at all work sites where outdoor work activities are present.

- Emergency medical phone number:_____
- Specific work site address:_____
- Driving directions from a major roadway to the work site:_____

  .

  _____

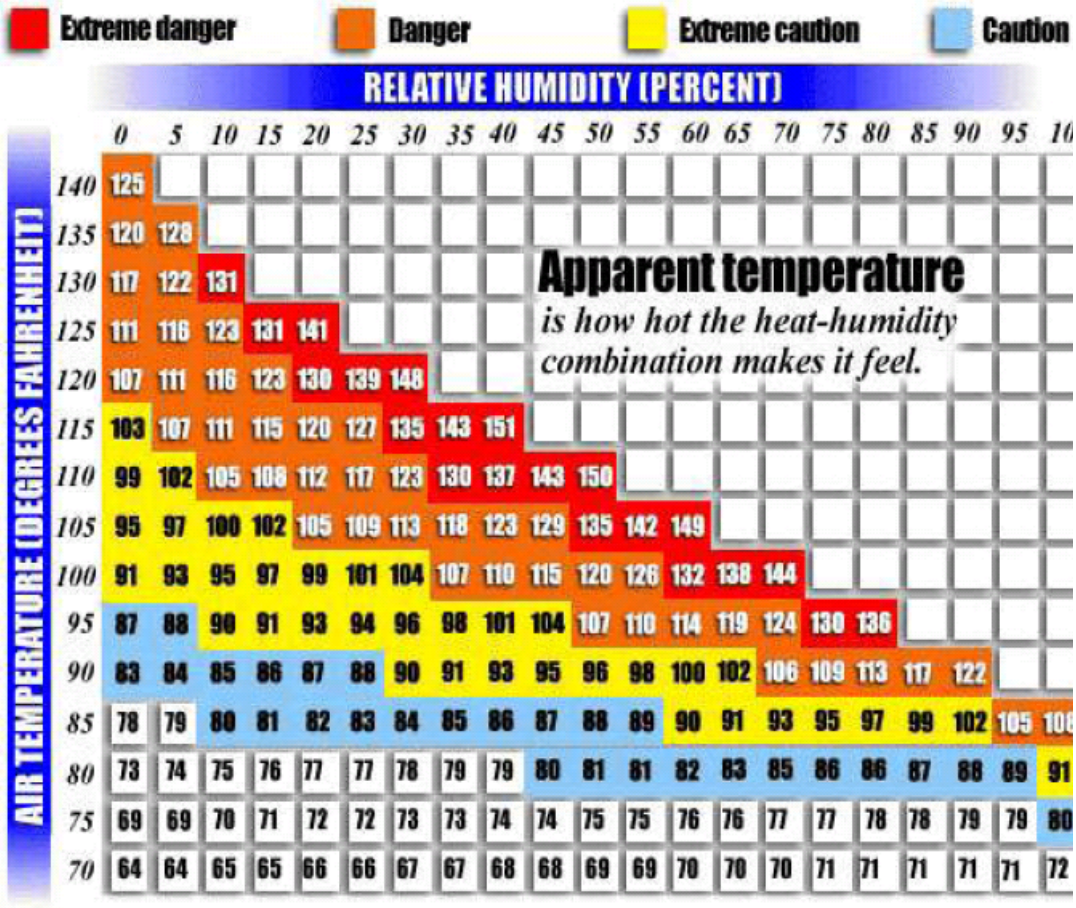
Procedures for Responding to Heat-Related Illnesses

(See Appendix C: Sample First Aid and Emergency Response Procedures)

Heat-Related Illness	Signs and Symptoms	First Aid and Emergency Response Procedures
Sunburn		
Heat Rash		
Heat Cramps		
Heat Exhaustion		
Heat Stroke		

APPENDIX A

Heat and Humidity Chart



http://www.crh.noaa.gov/dvn/tools/heatindex.pdf.

Heat Index	General Effect of Heat Index on People in Higher Risk Groups
80 - 89 *Caution*	Fatigue possible with prolonged exposure and physical activity.
90 - 104 *Extreme Caution*	Sunstroke, heat cramps, and heat exhaustion possible.
105 - 129 *Danger*	Sunstroke, heat cramps, and heat exhaustion likely, and heat stroke possible.
130 or higher *Extreme Danger*	Heat Stroke highly likely with continued exposure.

APPENDIX B

Examples of Workload Activities

Categories	Example Activities
Resting	Sitting quietly
	Sitting with moderate arm movements
Light	Sitting with moderate arm and leg movements
	Standing with light work at machine or bench while using mostly arms
	Using a table saw
	Standing with light or moderate work at machine or bench and some walking about
Moderate	Scrubbing in a standing position
	Walking about with moderate lifting or pushing
	Walking on level at 6 Km/hr while carrying 3 kg weight load
Heavy	Carpenter sawing by hand
	Shoveling dry sand
	Heavy assembly work on a non-continuous basis
	Intermittent heavy lifting with pushing or pulling (e.g. pick-and-shovel work)
Very Heavy	Shoveling wet sand

APPENDIX C:

Sample HRI First Aid and Emergency Response Procedures

Heat-Related Illness	Signs and Symptoms	First Aid and Emergency Response Procedures
Sunburn	• Red, hot skin • May blister	• Move to shade, loosen clothes to reduce temperature • Apply cool compress or water to cool burn • Get medical evaluation if severe
Heat Rash	• Red, itchy skin • Bumpy skin • Skin infection	• Apply cool water or compress to cool rash • Keep affected area dry to minimize infection • Control itching and infection with prescribed medication
Heat Cramps	• Muscle cramps or spasms • Grasping the affected area • Abnormal body posture	• Drink water or sports drinks to re-hydrate body • Rest, cool down in shaded area • Massage affected muscle to release body toxins • Get medical evaluation if cramps persist
Heat Exhaustion	• High pulse rate • Extreme sweating • Pale face • Insecure gait • Headache • Clammy and moist skin • Weakness • Fatigue • Dizziness	• Move to shade and loosen clothing to cool down • Initiate rapid cooling with fan, water mister, or ice packs • Lay flat and elevate feet to reduce heart rate and blood pressure • Monitor recovery (is body cooling?) • Drink small amounts of water to cool body and re-hydrate • Evaluate mental status (ask Who? Where? When? Q's) • **If no improvement call 911**
Heat Stroke	• Any of the above but more severe • Hot, dry skin (25-50% of cases) • Altered mental status with confusion and agitation • Can progress to loss of consciousness and seizures • Can be fatal	• **Call 911** • **Provide EMS with directions to work site** • Immediately remove from work activity to slow/stop body temp rise • Start rapid cooling with fan, water mister, or ice packs • Lay flat and elevate feet to reduce heart rate and blood pressure • If conscious give sips of water to cool body and re-hydrate • Monitor airway and breathing-administer CPR if needed

ATTACHMENT A2

STANDARD OPERATING PROCEDURES

STANDARD OPERATING PROCEDURE SOP-1

POSITIONING AT BELOW-WATER STATIONS

Purpose

The purpose of this standard operating procedure (SOP) is to describe procedures used for locating sampling stations below water.

Scope and Applicability

This SOP is applicable for determining the horizontal and vertical location of below-water stations. The SOP applies to all below-water surface sediment groups regardless of collection device or whether it is a grab or core sample.

Equipment and Materials

The horizontal positioning equipment will consist of a differential global positioning system (DGPS)[1] and associated navigation system (e.g., Nobeltec™ marine navigation software, Hypack or similar navigation software). The display will be capable of showing the present location of the vessel relative to the desired station location and will provide a bearing and distance to the station. The equipment will be capable of being pre-programmed with the National Oceanic and Atmospheric Administration (NOAA) nautical chart and sampling station locations. In the event normal GPS reception of four or more satellites is not available at a given location because of terrain blocking or other causes, alternative methods will be used to establish positions (see next section).

Vertical positioning will be measured with the vessel fathometer, or, in shallow water, a lead line and tape measure or a surveyor's rod.

Typical Procedures/Guidelines Horizontal Positioning

Horizontal positioning for below-water stations will be accomplished using DGPS based on the U.S. Coast Guard (USCG) Maritime Differential GPS Service signal or GPS if the USCG differential signal cannot be received. USCG operates a GPS remote broadcast site from Spokane that broadcasts corrected GPS signals on marine radio beacon frequencies. Position errors with this system typically are within 1 to 3 m (3.3 to 9.8 ft). The following

[1] If a signal for the DGPS cannot be received, a handheld GPS unit will be used to locate sampling station coordinates.

requirements apply to the GPS instrument and will be initially verified by the Field Team Leader during the course of the work:

- The GPS unit will be configured such that satellites less than 8 degrees above the horizon will not be used in position computations.
- A minimum of three satellites will be used for computing all positions.

The sampling vessel must locate and remain fixed on the general sampling location before sampling can begin. The vessel operator will be responsible for navigating the boat to each sample location. The Field Team Leader will verify that the sample location is within the allowable position circle and will assess the potential for successful sampling at the designated coordinates. It is important to note that the Cultural Resources Working Group in association with the U.S. Environmental Protection Agency has approved sediment sampling activities within a 150-ft radius of the designated coordinates. The first 'anchor point' (i.e., boat position) in which a sediment grab will be attempted, will be at the designated coordinates unless the Field Team Leader, in consultation with EPA oversight personnel, determines through best professional judgment that sampling is not likely to be successful (e.g., bedrock or large woody debris observed) at the designated coordinates.

If sampling at the designated coordinates is not likely to be successful, or if an initial collection attempt at the designated coordinates is unsuccessful, the boat may be repositioned at any other 'anchor point' within 150 ft of the designated coordinates, where the Field Team Leader, in consultation with EPA oversight personnel, determines that sampling success will be improved. Three attempts from each of the three 'anchor points' within the 150-ft approved radius of a sample location will be attempted. After nine attempts (three attempts per 'anchor point'), the Field Team Leader will consult with U.S. Environmental Protection Agency oversight personnel to determine whether moving to a reserve location is necessary. A schematic illustrating a potential sequence of sampling activities is depicted within Figure 1 below.

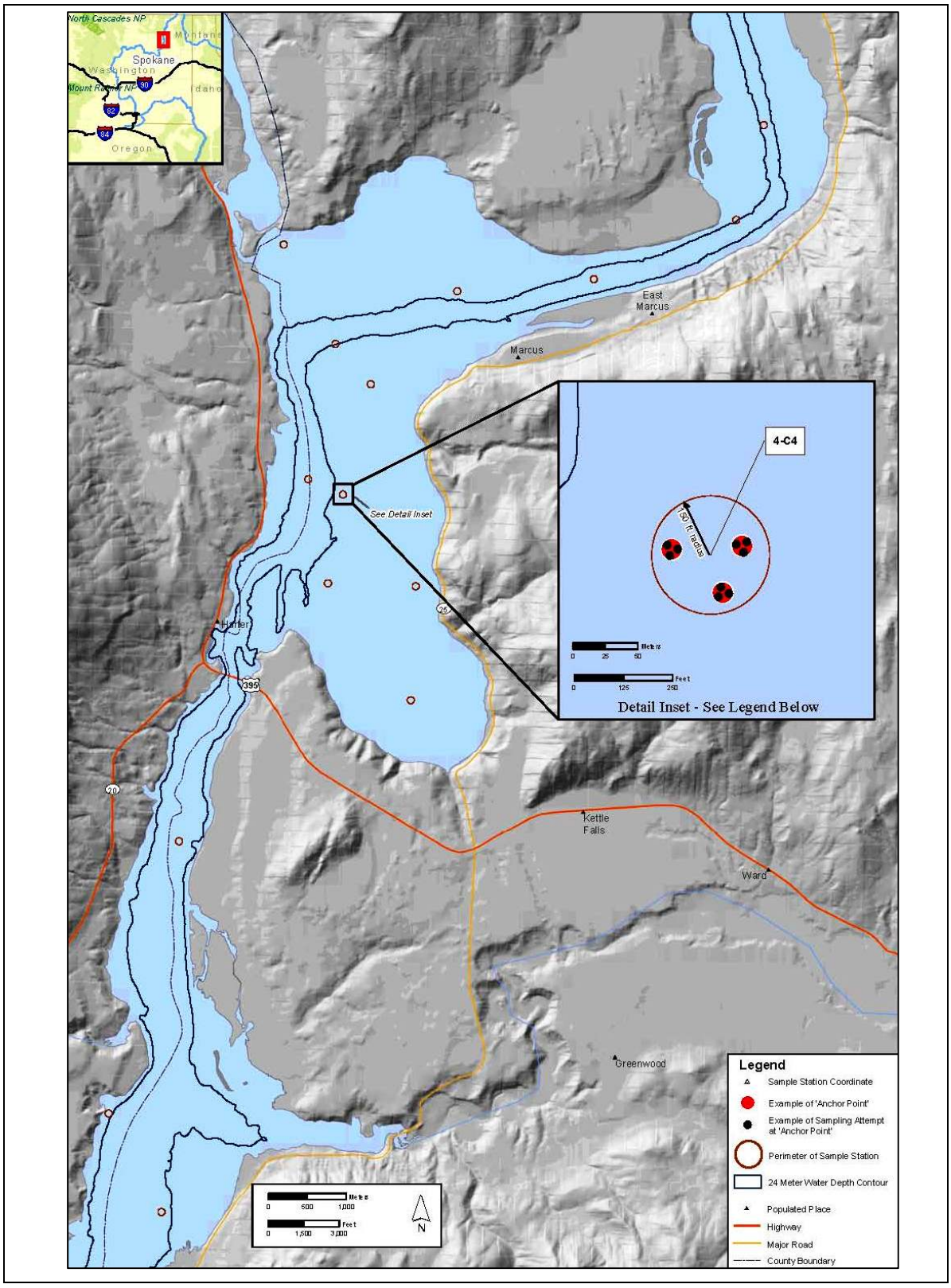


Figure 1. Schematic illustrating where sample success at the designated coordinates was not likely and the boat was repositioned and sediment samples collected (small diameter block dots) from three 'anchor points' (large diameter red dots) within the 150 foot approved radius of the designated sample location (coordinates).

If adequate GPS signals are not received, alternative methods for sample positioning will be used based on radar and/or laser rangefinder equipment. These methods will measure distances to at least two known points on the nautical chart or to two marker buoys equipped with radar reflectors and light reflective surfaces. These marker buoys will be deployed based on GPS positioning so that their locations can be plotted on a special navigation grid sheet along with the station locations to be sampled. These buoys will have short mooring line slopes of about 1.1 to 1 so as to minimize the lateral excursion of the buoys on the surface of the water. A radar and/or laser rangefinder fix will be taken at the time of the sampling.

When the vessel is not under power, it will typically swing perpendicular to the wind or current. If the sampling equipment is deployed over the side of the vessel instead of the stern, this will be done on the upwind or upcurrent side to prevent the vessel drifting onto the hydrowire (winch wire) once the sampler has contacted the bottom. In shallow water (less than about 10 m deep) with drift rates exceeding about 0.5 m/sec (1.6 ft/sec), the sampler may not perform correctly because of its lateral speed when it hits the bottom. Under high drift rates, it will be necessary to either anchor or hold the vessel in position using engine power. The adverse effects of drift rate decrease as the water depth increases because the vessel must drift a longer distance on the surface to pull the sampler out of alignment on the bottom.

The angle of the hydrowire to the vertical will be limited to approximately 5 degrees or less for all sampling activities, if possible. Once wire angles exceed 5 degrees, the offset error between the vessel and the sampler increases significantly. If this condition occurs, the vessel will be repositioned and another sample attempt made.

Vertical Positioning

The vertical position of below-water stations will be determined using a fathometer. In areas where the depth is too shallow, a survey rod or similar method will be used to measure the distance from the water surface to the riverbed. The depth to the station from the water surface will be converted to elevation based on the pool elevation established at the beginning of the day.

STANDARD OPERATING PROCEDURE SOP-2

SAMPLE LABELING

Scope and Applicability

This standard operating procedure (SOP) describes the general procedures for completing sample labels that will be used on the Phase 2 sediment sampling project. The project-specific field sampling plan (FSP) should be consulted regarding the rationale behind the sampling labeling protocol.

Equipment and Materials

- Sample labels
- Indelible marker
- Table A1 of the FSP.

Sample Identifier Labels

Field sample identifiers will be established before field sampling begins and applied to each sample as it is collected. Sample identifiers consist of codes designed to fulfill three purposes 1) to identify related samples (i.e., replicates) to ensure proper data analysis and interpretation; 2) to obscure the relationships between samples so that laboratory analysis will be unbiased by presumptive similarities between samples; and 3) to track individual sample containers to ensure that the laboratory receives all of the material associated with a single sample. The codes used are described below.

Each distinct sediment and porewater sample will be assigned a unique identifier. Sample identification (ID) will be numbered sequentially with project/client, study name, medium, station ID, sample type as shown.

SE or PW or R = sample medium (SE for sediment, PW for porewater, R for rinsate)

= Station ID number (see FSP Table A1).

Examples

SE-1-B2 = Sediment sample taken at station 1-B2

PW-2B-C3 = Porewater sample taken at station 2B-C3

R-3-B3 = Equipment rinsate taken at station 3-B3

This information will be entered onto the sample label with an indelible marker. Other information that will be entered onto the sample label includes:

- TAI_2013_SedTox (general study identifier)
- Samplers initials
- Date
- Time
- Preservative (if applicable).

If necessary, corrections will be made on the sample labels by drawing a single line through the error and entering the correct information with an indelible marker. All corrections will be initialed and dated by the person performing the correction.

The sample labels will be placed on each sample container. Sample packaging is discussed in SOP-6.

STANDARD OPERATING PROCEDURE SOP-3

SEDIMENT AND POREWATER SAMPLE COLLECTION

Scope and Applicability

The purpose of this standard operating procedure (SOP) is to describe the procedures used to collect surface sediment with a modified Van Veen power grab sampler[1]. For the purposes of this SOP, surface sediment is defined as the upper 10 to 15 cm (top 4 to 6 in.) of the sediment column, but may vary given the sampling interval specified in the study design. The specific sampling interval will be specified in the project-specific field sampling plan (FSP). Surface sediment is typically analyzed for various physical and chemical variables so the sampling equipment and sampling procedures must be compatible with all analyses.

The procedures listed below may be modified in the field by the field supervisor and field personnel, based on field and site conditions, after appropriate annotations have been made in the field logbook.

A modified stainless-steel Van Veen power grab sampler is capable of collecting acceptable samples from a variety of substrates, such as mud, sand, gravel, and pebbles (APHA 1989; USEPA 2001). The modified Van Veen power grab sampler incorporates several design improvements over the traditional Van Veen grab sampler, to improve the quality of the sediment samples. This custom built sampler is also designed specifically for operating in hard bottom materials and in higher water flow areas. It consists of a 400-lbs base frame and a Van Veen style bucket that is operated by a pneumatic cylinder with 900 lbs. of closing force, using an on-board air compressor and top-side controller. It is built completely from Stainless Steel 304, see Figure 1 below.

The grab sampler has two doors on top to allow easy access to the sample for visual characterization and subsampling of undisturbed surface sediments. The interiors of the doors are made of screens to minimize disturbance of the sediment surface when the grab sampler is lowered to the bottom. Rubber flaps cover each screen as the grab sampler is retrieved to prevent disturbing the sediment sample as it is raised through the water column. The arms of the sampler are lengthened and arced to provide a stronger seal

[1] The procedures described in this SOP include those that would apply to other grab samplers (e.g., Ekman or standard Van Veen), which would be available as a backup sampler for the proposed power grab.

when the grab sampler is closed, thereby minimizing sample leakage when the grab sample is retrieved. The procedures for collecting surface sediment samples using the modified Van Veen grab sampler are described below.

Figure 1. Illustration of Custom-designed Van Veen Power Grab Sampler

Equipment and Materials

Accurate, representative samples should be collected with this procedure, which requires vigilant care and precision by each sample team member.

Equipment required for sediment sampling using the Van Veen grab sampler includes the following:

- Stainless-steel Van Veen power grab sampler and spare parts
- Winch and hydrowire (with load capacities three times the weight of a full sampler)
- Sample collection table
- Teflon® or polyethylene siphon (inner diameter = 1.27 cm, length = 60 to 90 cm)
- Stainless-steel ruler
- Stainless-steel paddle wheel mixer/spoons/spatulas, or Lexan scoop
- Transparent Lexan tub
- Stainless-steel mixing bowl or pot
- Porewater suction sampler with ceramic airstone
- ≤ 140 mL porewater extraction syringe with pre-cleaned decontaminated Tygon® or similar polyethylene tubing
- Socket and crescent wrenches
- Water pump and hose (for rinsing the grab sampler, sampling utensils, and sample collection table).

Procedures for Sediment Sample Collection

1. Locate the sample station per SOP-1. Label sampling containers prior to filling in accordance with SOP-2.
2. Document sample location conditions in field notebook and take digital pictures of area, per SOP-5.
3. Attach the grab sampler to the hydrowire with a swivel. The swivel minimizes the twisting forces on the sampler during deployment and ensures that proper contact is made with the bottom. For safety, the hydrowire, swivel, and all shackles should have a load capacity at least three times the weight of a full sampler.
4. Place the decontaminated grab sampler on a clean surface (e.g., the sample collection table) and open it.

5. Ensure that the two release chains and the two retrieval chains are hanging free and are not wrapped around the arms of the sampler.
6. Ensure that all doors are firmly latched shut.
7. Attach the ring of the release chains to the release mechanism, and insert the safety pin to prevent the mechanism from being activated prematurely.
8. Start the winch, raise the release mechanism and the sampler, and swing it outboard.
9. Remove the safety pin from the trigger, and lower the sampler through the water column at a slow and steady speed (e.g., 30 cm/sec).
10. The depth of the sampler as it is lowered through the water column should be determined either by rigging the hydrowire to a meter wheel or using pre-marked meter lengths on the cable itself.
11. Allow the grab sampler to contact the bottom gently, with only its weight being used to force it into the sediments. The sampler should not be allowed to "free fall" to the bottom because this may result in premature triggering, an excessive bow wake, or improper orientation upon contact with the bottom. Allow approximately 60 cm of slack in the hydrowire after contact with the bottom is made to ensure that the release mechanism is activated.
12. When the cable is drawn taut, record DGPS coordinates. Note, in order to ensure that the position fix is representative of the actual location sampled, the antenna for the GPS unit must be located as close as practical to the sampler (e.g., within 1 to 2 meters).
13. After the grab sampler has rested on the bottom for approximately 5 seconds, the pneumatic-powered mechanism is activated to close the clam-shell sides and collect the sediment sample.
14. The grab sampler is then retrieved at a slow and steady rate (e.g., 30 cm/sec). Note that the amount of time that the grab sampler rests on the bottom is dependent upon the kind of substrate (e.g., sediment with a high moisture content will require less time on the bottom to avoid over-penetration).
15. Ensure that the sampling vessel is not headed into any waves before the sampler breaks the water surface to minimize vessel rolling and potential sample disturbance. Care must be taken to avoid loss of fine-grained sediments, mixing of sediment layers upon impact, and loss of sediment from tilting or washout upon ascent.

16. After the grab sampler breaks the water surface and is raised above the height of the sample collection table, swing the grab sampler inboard, keep the sampler in an upright position and gently lower it onto the table, maintaining tension on the hydrowire to prevent the grab sampler from rolling when it contacts the table. Avoid quick movements of the sampler, especially rotation, as this could disrupt the sediment surface interface.
17. When the grab sampler contacts the table, insert wedges under both jaws so that the grab sampler will be held in an upright position when tension on the hydrowire is relaxed.
18. Relax the tension on the hydrowire, and remove the release and retrieval chains from the surface of the grab sampler.
19. As soon as the grab sampler is secured, open the doors on the top of the grab sampler, and inspect the sample for acceptability. The following acceptability criteria should be satisfied:
    a. The sampler is not overfilled with the sample to the point that the sediment surface presses against the top of the sampler or is extruded through the top of the sampler
    b. Overlying water is present (indicating minimal leakage)
    c. The overlying water is not excessively turbid (indicating minimal disturbance of the interface or winnowing)
    d. The sediment surface is relatively undisturbed; the sediment-water interface is intact and relatively flat with no sign of channeling or sample washout
    e. The desired penetration depth is achieved
    f. There is no sign of sediment loss (incomplete closure of the sampler, penetration at an angle, or tilting upon retrieval).

Grab samples not meeting the above-listed acceptance criteria will be 'rejected,' but will be temporarily held onboard while subsequent sampling drops attempt to obtain an 'accepted' sample (i.e., a sample meeting all the acceptance criteria). Rejected sample materials will be temporarily placed in a decontaminated, transparent Lexan tub for cultural inspection; and the sampling steps repeated until an accepted sample has been obtained or until a minimum of nine attempts per sampling station have failed. Should subsequent sampling attempts also fail to meet the above-listed acceptance criteria, additional rejected samples will be placed in the same or separate Lexan tub(s). Field personnel, in consultation with EPA oversight personnel, will use their experience and

professional judgment applying the acceptance criteria to identify accepted and rejected samples.

Penetration depth should be determined with a decontaminated stainless-steel ruler by measuring the distance from the top of the sampler to the sediment interface and subtracting this from the inside depth of the sampler. If the sample is fairly level inside the sampler, this measurement can be made at one edge. If the sample is uneven but has an intact interface, then measurements should be made on opposite edges of the sample and the average value used. This observation (i.e., that the sediment surface is slanted) and subsequent calculation of the average penetration depth should be recorded in the field logbook. If penetration depth is inadequate, add auxiliary weights, and repeat the above steps.

Remove the overlying water by slowly siphoning it off near one or more sides of the grab sampler. Ensure that the siphon does not contact the sediments or that fine-grained suspended sediment is not siphoned off. If sediment is suspended in the overlying water, do not proceed with siphoning until the sediment is allowed sufficient time to settle.

Material in the grab sampler will be photographed. The photograph ID will be documented in the field so that the photograph can be subsequently labeled with station location, date, and time of sample. Field personnel will don clean gloves prior to handling the sediment sample.

In the event that all nine sampling attempts fail to meet the acceptance criteria, prior to discarding any rejected sediments from this location, field personal will (following inspection for cultural resources) assess the overall grain-size distribution of rejected materials temporarily stored in the Lexan tub(s) and photograph the collected materials. Field personnel will use their experience and professional judgment to evaluate the relative volume of fine-grained sediments (i.e., ≤2 mm). If there is sufficient volume to perform analyses per Table A2 of the FSP, sediment samples should be evaluated and homogenized as laid out in the steps below, and retained for future analyses. The collection of these rejected sediments will allow some evaluation of the area, in the event that similar sampling difficulties are encountered at reserve locations.

Sample Removal and Processing

1. For acceptable samples, porewater will be collected directly from the sampler via suction (i.e., ceramic airstone). A cylindrically shaped ceramic airstone (10 to 15 cm long and 1.5 cm in diameter) will be carefully inserted (horizontally) into the sediment sample as it remains in the grab sampler through a specially constructed side-port (see Figure 2).

Figure 2. Illustration of Porewater Collection via Airstone and Typical Ceramic Airstone

2. Upon insertion, the top of the airstone will sit approximately 3 in. (7 cm) below the sediment surface. The airstone will be connected to a ≥140 mL syringe via pre-cleaned decontaminated Tygon® or similar polyethylene tubing as provided by the analytical

laboratory, through which porewater can be extracted directly into the pre-cleaned syringe. Extracted porewater will be discharged directly from the syringe into sampling containers provided by the analytical laboratory. For porewater samples requiring filtration, a decontaminated 0.45 μm polyethylene syringe filter provided by the analytical laboratory will be attached to the syringe so that the extracted field porewater can be pressed through the filter directly into the appropriate sampling containers. From the syringe, extracted porewater will be discharged into respective sampling bottles as obtained from the analytical laboratory.

3. If available, porewater will be collected from both accepted and rejected sediments in separate syringes. If any amount of porewater is collected from an accepted sample, that volume of porewater will be analyzed (using the analysis prioritization indicated in Table A2 of the FSP), and the syringe of rejected porewater will be discarded. Porewater from multiple rejected or accepted samples may be combined (as described in the next paragraph) so long as the porewater from the accepted and rejected sediments is not mixed.

4. If insufficient porewater volume is collected from the first accepted or rejected sediment grab samples, additional porewater may be collected from subsequent grab samples. Additional porewater can be collected using the same syringe containing the porewater from the first grab sample so that porewater collected from multiple samples becomes composited in the syringe (waters from accepted and rejected sediments will not be mixed). Additional sediment grabs will not be attempted solely to increase the porewater volume for porewater samples. If the sediment volume recovered during the first accepted grab sample is adequate for the sediment sample needs, any porewater recovered from this sediment will be analyzed in accordance with the prioritization indicated in Table A2 of the FSP.

5. Porewater will be expelled from the syringe into labeled, laboratory-provided sample containers (Table A2 of the FSP). This water will be distributed unfiltered or filtered as specified by the analytical method. Porewater samples will be stored in a cooler with ice until they are transferred from the sampling vessel.

6. After porewater extraction, the bulk sediment sample will be placed into a decontaminated transparent Lexan tub, to facilitate on-site cultural resource observations. The onboard cultural resource monitor will examine the sediment to determine if cultural resources are present. If cultural resources are present, the field crew will follow instructions from the cultural resources monitor regarding what to do with the recovered sediment and cultural artifacts, as well as whether to abandon the sampling station.

7. Using appropriate, decontaminated tools (e.g., mechanical stainless paddle wheel mixer, spoons, gloved hands) the sample will be homogenized in the Lexan tub until the texture and color of the sediment appears to be uniform.
8. A qualified person[2] will characterize the sediment and visually estimate the percentage of the homogenized material that is ≤2 mm in size. All observations will be documented. Sediments that are composed entirely of fine grained material (≤2 mm) will be retained with no additional processing. Sediments that are composed mostly of fine grained materials but also include some larger pieces of gravel or debris will have the larger pieces of gravel or debris removed by hand. Samples with large proportions of materials that are >2 mm will be coarsely sieved using a 5 mm sieve. Sieving will be performed by shaking or pressing (e.g., using gloved hands to break apart clumps) the sediment through the sieve. The larger particles will be discarded and only the smaller fraction will be retained. Unacceptable sieving techniques include drying the sediment or washing it through the sieve using water.
9. The sediment will be characterized as specified in the study design. Characteristics that will be recorded in the field logbook and/or data form include:
    a. Sediment type (e.g., silt, sand)
    b. Texture (e.g., fine-grain, coarse, poorly sorted sand)
    c. Color
    d. Presence/absence of black silica glass particles (based on vitreous, conchoidal fracture(s), and a translucent appearance); if present estimate relative percent composition
    e. Presence/location/thickness of the redox potential boundaries (a visual indication of black is often adequate for documenting anoxia)
    f. Presence of biological structures (e.g., amphipods, tubes, macrophytes)
    g. Presence of debris (e.g., twigs, leaves)
    h. Presence of shells
    i. Stratification, if any
    j. Presence of a sheen

[2] A qualified person is either a Washington State Licensed Geologist (LG) or an engineer/scientist who has received site-specific training in the following: 1) identification of sedimentary deposits of the Upper Columbia River basin, 2) recognition of amorphous silica-rich glass, 3) particle size and percentage estimation, 4) soil/sediment classification systems, and 5) recording of observations.

k. Odor (e.g., hydrogen sulfide, oil, creosote).

10. The homogenized sediment will be photographed. The photograph ID will be documented in the field so that the photograph can be subsequently labeled with station location, date, and time of sample.

11. Once the geological evaluation is complete, the homogenized sediment may be placed into labeled, laboratory-provided, sample containers. Sample containers for a field duplicate sample (if needed) will be filled from the same homogenized sediment as the primary sample.

    a. The container for the acid volatile sulfides/simultaneously extracted metals (AVS/SEM) analysis should be filled first, as the results of this analysis are affected by excess oxygen exposure. The AVS/SEM container should be filled with sediment leaving no headspace, and the preservative should be distributed through the sample by inverting the container or by mixing.

    b. All remaining sediment samples for the analytical chemistry should be filled.

    c. Sediment samples for the analytical laboratory will be stored in a cooler with ice until they are transferred from the sampling vessel.

12. If any sample remains in the grab sampler after the surface sediment has been collected, move the sampling vessel away from the station, open the jaws of the grab sampler, attach the ring of the deployment chains to the release mechanism, insert the safety pin, start the winch, raise the grab sampler, and allow the remainder of the sediment sample to fall onto the sample collection table or into waste sediment collection buckets/tubs. Discard this material away from the station, and rinse away any sediment adhering to the inside of the grab sampler. The grab sampler is now ready for additional sampling at the same station or decontamination before sampling at a new station.

13. The grab sampler and associated equipment (e.g., Lexan tub and scoop) will be decontaminated between station locations in accordance with decontamination procedures (see SOP-4).

14. Rinse the boat deck clean after all grab samples are collected and secure the sampler before moving to the next station.

References

APHA. 1989. Standard methods for the examination of water and waste water. Seventeenth Edition. Prepared and published by American Public Health Association, the American Water Works Association, and the Water Pollutant Control Federation.

USEPA. 2001. Methods for collection, storage, and manipulation of sediments for chemical and toxicological analyses: Technical Manual. EPA-823-B-01-002. U.S. Environmental Protection Agency, Office of Water, Office of Science & Technology, Washington, DC.

STANDARD OPERATING PROCEDURE SOP-4

DECONTAMINATION OF SEDIMENT SAMPLING EQUIPMENT

This standard operating procedure (SOP) describes procedures for decontaminating sampling and processing equipment contaminated by inorganic materials. To prevent potential cross contamination of samples, all reusable sediment sampling and processing equipment will be decontaminated before each use. Reusable sampling equipment includes the grab sampler, Lexan tubs, spoons, trowels, etc. Decontaminated equipment will be stored away from areas that may cause recontamination and rinsate blanks will be collected. When handling decontamination chemicals, field personnel will follow all relevant procedures and will wear protective clothing as stipulated in the site-specific health and safety plan.

Equipment and Materials

Equipment required for decontamination includes the following:

- Polyethylene or polypropylene tub (to collect solvent rinsate)
- Plastic bucket(s) (e.g., 5-gallon bucket)
- Tap water or site water
- Properly labeled squirt bottles (or large spray bottles if needed)
- Funnels
- Alconox®, Liquinox®, or equivalent industrial detergent
- 10 percent (v/v) nitric acid (reagent grade) for inorganic contaminants
- Baking soda
- Long-handled, hard-bristle brushes
- Plastic sheeting, garbage bags, and aluminum foil
- Personal protective equipment as specified in the health and safety plan.

Decontamination Procedures

Reusable sampling equipment should be decontaminated before and after the sampling effort, between sampling stations, and at any other times specified by the field sampling

plan (FSP). The specific procedure for decontaminating reusable sampling equipment is as follows:

1. Rinse the equipment thoroughly with tap or site water to remove any visible sediment or debris.
2. Pour a small amount of concentrated laboratory detergent into a bucket (e.g., about 1/2 tablespoons per 5-gallon bucket) and fill it halfway with tap or site water. If the detergent is in crystal form, all crystals should be completely dissolved prior to use.
3. Scrub the equipment in the detergent solution using a long-handled brush with rigid bristles, using a back-and-forth motion. Be sure to clean the outside of samplers, bowls, and other tools that may be covered with sediment. Remove all particulate matter and surface films.
4. Double rinse the equipment with tap or site water and set right-side-up on a stable surface to drain.
5. Carefully rinse the equipment with 10 percent nitric acid (HNO_3) from a squirt bottle, and let the excess solvent drain into a waste container (which may need to be equipped with a funnel). This solvent acts primarily to remove metal contamination. Ensure that the stream of solvent contacts all of the surfaces of the sampling equipment.
6. Set the equipment in a clean location and allow it to air dry.
7. Rinse with tap or site water. Equipment does not need to be dried before use.
8. If the decontaminated sampling equipment is not to be used immediately, wrap small items in aluminum foil (dull side facing the cleaned area).
9. If the sample collection or processing equipment is cleaned at the field laboratory and transported to the site, then the decontaminated equipment will be wrapped in aluminum foil (dull side facing the cleaned area) and stored and transported in a clean plastic bag (e.g., a trash bag) until ready for use, unless the project-specific FSP lists special handling procedures.
10. Transfer decontamination fluids to a sealable container and properly dispose of them.

If the surface of the stainless steel equipment appears to be rusting (possibly due to prolonged contact with organic-rich sediment), it should be given an acid rinse, followed by a site water rinse at the end of each sampling day to minimize corrosion.

STANDARD OPERATING PROCEDURE SOP-5

FIELD DOCUMENTATION

Scope and Applicability

This standard operating procedure (SOP) presents the general information that should be documented for all sediment collection activities. Proper record keeping will be implemented in the field to allow samples to be traced from collection to final disposition. All information pertaining to field operations during sample collection must be properly documented to ensure transparency (and reproducibility) of methods and procedures. Several types of field documents will be used for this purpose by field personnel.

Equipment and Materials

- Field logbook
- Black waterproof ink pen
- Field forms
- Digital camera.

Field Logbooks

During field sampling events, field logbooks are used to record all daily field activities. The purpose of the field logbook is to thoroughly document the sampling event to ensure transparency and reproducibility. The field logbook will contain sediment sampling-related information supplemental to the field data sheets. Any deviations from the project-specific field sampling plan that occur during sampling (e.g., personnel, responsibilities, sample station locations) and the reasons for these changes will be documented in the field logbook. Other types of information that may be included in the field logbook include the following:

- Project sampling name/type
- Name of person making entries and other field staff
- On-site visitors, if any
- Observations made during sample collection, including collection complications, visible debris, and other details not entered onto the field form
- Any surface vegetation that may be removed from the sampling location prior to sampling

- A record of site health and safety meetings, updates, and related monitoring
- Presence of construction/maintenance activities or man-made features that may influence sediment composition or transport
- The locations of nearby surface water features (e.g., streams, wetlands, oxbows) or anthropogenic influences (e.g., roads, houses, campsite)
- Equipment calibration records (e.g., instrument type and serial number, calibration supplies used, calibration methods and calibration results, date, time, and personnel performing the calibration).

The field supervisor will maintain the field logbook and is responsible for ensuring that the field logbook and all field data forms are correct. Requirements for logbook entries will include the following:

- Entries will be made legibly with black (or dark) waterproof ink
- Unbiased, accurate language will be used
- Entries will be made while activities are in progress or as soon afterward as possible (the date and time that the notation is made should be noted, as well as the time of the observation itself)
- Each consecutive day's first entry will be made on a new, blank page
- The field supervisor must sign and date the last page of each daily entry in the field logbook
- When field activity is complete, the logbook will be entered into the TAI technical team project file.

All logbook entries must be completed at the time any observations are made. Logbook corrections will be made by drawing a single line through the original entry, allowing the original entry to be read. The corrected entry will be written alongside the original. Corrections will be initialed and dated and may require a footnote for explanation. When possible at the end of each day of sampling, backup copies of the pages having entries for the current day should be made. These copies should be stored at a secure location (e.g., the hotel room) and not returned to the field.

Upon completion of the field sampling event, the field supervisor will be responsible for submitting all field logbooks to be copied. A discussion of copy distribution is provided below.

Field Data Forms

Field data forms will be used during this field sampling event to record the relevant sample information collected during a sampling event. These forms will be filled out completely by the sampling team during each sediment collection and will include the following information:

- Project name and date
- Names of all members of the sampling team
- A brief description of the weather
- The time each station had sediment collected
- The station number
- Station location details from the GPS–latitude, longitude, positional accuracy, and elevation
- The sample ID and analysis to be performed
- The sediment pH measured in the field
- Presence/absence and percent of black silica glass particles
- A list of photograph numbers taken at the site
- Any additional collection comments.

Upon completion of the field sampling event, the field supervisor will be responsible for submitting all field data forms to be copied. A discussion of copy distribution is provided below.

Photographs

In certain instances, digital photographs of sampling stations may be taken using a camera-lens system with a perspective similar to the naked eye. Photographs should include a measured scale in the picture, when practical (e.g., ruler, pencil, coin, etc.). Photographs may also be taken of sample characteristics and routine sampling activities. Telephoto or wide-angle shots will not be used because they cannot be used in enforcement proceedings. The following items should be recorded in the field logbook for each photograph taken:

1. The photographer's name or initials, the date, the time of the photograph, and the general direction faced (orientation)
2. A brief description of the subject and the field work portrayed in the picture

3. For digital photographs, the sequential number of the photograph, the file name, the file location, and back-up compact disk (CD) number (if applicable).

Upon completion of the field sampling event, the field supervisor will be responsible for submitting all photographic materials to be copied to CDs. The CDs will be placed in the project files (at the task manager's location). Photo logs and any supporting documentation from the field logbooks will be photocopied and placed in the project files with the disks.

Distribution of Copies

Electronic scans of the field logbooks and field data forms will be made after completion of the field sampling event and stored electronically in the project files for use by project staff. The original field logbooks and forms will be placed in a locked file cabinet at the task manager's location.

Set-up of Locking File Cabinet

Each field event will have its own dedicated section in a locking file cabinet. The section label will include the project name and work order number. The following documents may be included in this folder for each field event:

- Original field logbook(s)
- Original field data forms
- Photograph CDs
- Original signed chain of custody forms.

STANDARD OPERATING PROCEDURE SOP-6

SAMPLE PACKAGING AND SHIPPING

Scope and Applicability

Specific requirements for sample packaging and shipping must be followed to ensure the proper transfer and documentation of environmental samples collected during field operations. Procedures for the careful and consistent transfer of samples from the field to the laboratory are outlined herein. This standard operating procedure (SOP) presents the method to be used when packing samples that will either be hand-delivered or shipped by commercial carrier to the laboratory.

Equipment and Materials

Specific equipment or supplies necessary to properly pack and ship environmental samples include the following:

- Field Sampling Plan for the Phase 2 Sediment Study
- Project-specific field logbook
- Resealable airtight bags (assorted sizes)
- Wet ice in doubled, sealable bags; frozen Blue Ice®; or dry ice
- Coolers
- Bubble wrap
- Fiber-reinforced packing tape and duct tape
- Clear plastic packing tape
- Scissors or knife
- Chain-of-custody (COC) forms–these may be produced in an electronic format using a database program (e.g., FORMS II Lite) - in which case a computer and printer would be needed as well
- COC seals
- Large plastic garbage bags (preferably 3 mil [0.003 in.] thick) for cooler lining
- Paper towels
- "Fragile," "This End Up," “Perishable,” and/or "Handle With Care" labels

- Mailing labels
- Airbills for overnight shipment.

Procedure

In some cases, samples may be transferred from the field to a local storage facility where they can be either frozen or refrigerated. Depending on the logistics of the operation, field personnel may transport samples to the laboratory themselves or utilize a commercial courier or shipping service. If a courier service is used, then field personnel should be aware of potentially limiting factors to timely shipping (e.g., availability of overnight service and weekend deliveries to specific areas of the country, shipping regulations "restricted articles" [e.g., dry ice]) prior to shipping the samples).

Sample Storage Prior to Shipment

Samples will be placed in secure storage (i.e., locked room or vehicle) or remain in the possession of sampling personnel before shipment. Sample storage areas will be locked and secured to maintain sample integrity and COC requirements. In the field, samples will be maintained in coolers with wet ice at 4°C until they are packaged for shipping to the offsite analytical laboratory.

Sample Preparation

The following steps should be followed to ensure the proper transfer of samples from the field to the laboratory:

At the sample collection site

1. Appropriately document all samples using the proper logbooks or field forms and required sample container identification (i.e., sample labels with unique IDs) using the sample labeling techniques described in SOP-2.
2. Clean the outside of all dirty sample containers to remove any residual material that may lead to cross-contamination.
3. Store each sample container in an individual sealable plastic bag that allows the sample label to be read.
4. As the samples have a required storage temperature, place a sufficient amount of wet ice in the sample cooler to maintain the temperature inside the cooler (e.g., 4°C) throughout the sampling day.
5. Store all sample containers in coolers on wet ice until ready for shipping.

To prepare samples and coolers for shipping

1. Choose the appropriate size cooler(s) and make sure that the outside and inside of the cooler is clean of gross contamination. If the cooler has an external drain, the drain should be capped and thoroughly taped shut with duct tape.
2. The cooler should be lined with bubble wrap and a large plastic bag (preferably a bag with a thickness of 3 millimeters) should be opened and placed inside the cooler.
3. Individually wrap each glass container (which at the sample collection site had already been placed in an individual sealable plastic bag) in bubble wrap using either tape or a rubber band to hold the bubble wrap in place. Place the wrapped samples into the large plastic bag in the cooler, leaving sufficient room for ice to keep the samples cold (i.e., 4°C).
4. Concurrently with placing samples in the shipping cooler(s), the field supervisor will fill out a COC form with sample IDs and laboratory analyses to be performed (see example blank and filled out COC forms in Attachment 3 to the FSP).
5. Make sure all applicable laboratory quality control sample designations have been made on the COC forms. Samples that will be archived for possible future analysis should be clearly identified on the COC form and should be also be labeled as "Do Not Analyze: Hold and archive for possible future analysis" as some laboratories interpret "archive" to mean continue holding the residual sample after analysis.
6. Check sample containers against the COC form to ensure all samples intended for shipment are included.
7. As the samples have a required storage temperature, add enough ice to keep the samples refrigerated during overnight shipping (i.e., 4°C). The amount of ice that may be required should always be overestimated. Ice should be enclosed in a re-sealable plastic bag and then placed in a second sealable plastic bag to prevent leakage. Avoid separating the samples from the ice with excess bubble wrap because it will insulate the containers from the ice. After all samples and ice have been added to the cooler, use bubble wrap (or other available clean packing material) to fill any empty space to keep the samples from shifting during transport.
8. The field supervisor will sign and date the completed COC form and retain a copy for project files. Place the signed COC form in a re-sealable bag and tape the bag

containing the form to the inside of the cooler lid. Each cooler should contain an individual (or multiple) COC form(s) for the samples contained in that particular cooler.

9. After the cooler is sufficiently packed to prevent shifting of the containers, close the lid and seal it shut with fiber-reinforced packing tape. The cooler should be taped shut around the opening between the lid and the bottom of the cooler and around the circumference of the cooler at both hinges.

10. As security against unauthorized handling of the samples, apply three COC seals across the opening of the cooler lid—one on the front of the cooler and one on each side. Be sure the seals are properly affixed to the cooler so they are not removed during shipment. Additional clear packing tape across the seal may be necessary if the outside of the cooler is wet.

11. Notify the laboratory contact and the project quality assurance/quality control (QA/QC) coordinator that samples will be shipped and the estimated arrival time. Upon completion of field activities, the field supervisor will provide copies of all COC forms to the task manager and task analytical chemistry QA/QC coordinator.

Sample Shipping

Hand Delivery to the Testing Laboratory

1. The field supervisor will notify the laboratory contact and the team project QA/QC coordinator that samples will be delivered to the laboratory and the estimated arrival time.

2. All environmental samples that are hand-delivered to the testing laboratory will be received by the laboratory on the same day that they were packed in the coolers.

3. Copies of all COC forms will be provided to the task manager.

Shipped by Commercial Carrier to the Laboratory

1. Use a mailing label and label the cooler with destination and return addresses, and add other appropriate stickers, such as "This End Up," "Fragile," "Perishable," and "Handle With Care." If the shipment contains multiple coolers, indicate on the mailing label the number of coolers that the testing laboratory should expect to receive (e.g., 1 of 2; 2 of 2). Place clear tape over the mailing label to firmly affix it to the outside of the cooler and to protect it from the weather. This is a secondary label in case the airbill is lost during shipment.

2. Fill out the airbill as required and fasten it to handle tags provided by the shipper (or the top of the cooler if handle tags are not available).

3. If samples need to be frozen (–20°C) during shipping, then dry ice will need to be placed in the sample cooler. Be aware of any additional shipping, handling, and special labeling requirements that may be required by the shipper for these samples.

4. The field supervisor will notify the laboratory contact and the task analytical chemistry QA/QC coordinator that samples will be shipped and the estimated arrival date and time. All environmental samples are shipped at 4°C or –20°C, and will be shipped overnight for next morning delivery. The field supervisor will provide copies of all COC forms to the task manager upon completion of the study.

STANDARD OPERATING PROCEDURE SOP-7

SAMPLE CUSTODY

Scope and Applicability

This standard operating procedure (SOP) describes procedures for custody management of environmental samples during the Phase 2 sediment sampling program. The procedure outlined herein will be used in conjunction with SOP-2, which covers sample labeling; SOP-5, which covers field documentation; and SOP-6, which covers sample packaging and shipping.

Chain-of-custody (COC) forms ensure that samples are traceable from the time of collection through processing and analysis until final disposition. A sample is considered to be in a person's custody if any of the following criteria are met:

1. The sample is in the person's possession
2. The sample is in the person's view after being in possession
3. The sample is in the person's possession and is being transferred to a designated secure area
4. The sample has been locked up to prevent tampering after it was in the person's possession.

At no time is it acceptable for samples to be outside the custody of a designated person unless the samples have been transferred to a secure area (i.e., locked up and custody sealed) or transferred to the laboratory. If the samples cannot be placed in a secure area, then a field team member must physically remain with the samples at all times (e.g., at meal times, etc.).

Materials and Methods

- COC forms may be produced in an electronic format using a database program (e.g., FORMS II Lite), in which case a computer and printer would be needed as well
- Custody seals
- Shipping air bills.

Chain-of-Custody Forms

The COC form is critical because it documents sample possession from the time of collection through the final disposition of the sample. The form also provides information to the laboratory regarding what analyses are to be performed on the samples that are shipped.

The COC form will be completed after each field collection activity and before the samples are shipped to the laboratory. Project-assigned sample IDs will be recorded on the COC form. The COC form will also identify the sample collection date and time, the type of sample, the project, and the sampling personnel. Two COC form copies will be sent to the laboratory along with the sample(s). Copies of the COC form will be placed into a plastic re-sealable bag and secured to the inside top of each cooler. Another copy will be retained by the field supervisor for filing in the project files by the task manager at the completion of the study.

Sampling personnel are responsible for the care and custody of the samples until they are shipped. When transferring possession of the samples, the individuals relinquishing and receiving the samples must sign the COC form(s), indicating the time and date that the transfer occurs.

Procedures

The following guidelines will be followed to ensure the integrity of the samples:

1. Prior to sample shipping or storage, COC entries will be made electronically for all samples on a secure computer. Information on the COCs will be checked against field logbook entries.
2. At the bottom of each COC form is a space for the signatures of the persons relinquishing and receiving the samples and the time and date that the transfer occurred. The time that the samples were relinquished should match exactly the time they were received by another party. Under no circumstances should there be any time when custody of the samples is undocumented.
3. The COC form should not be signed until the information has been checked for inaccuracies by the field supervisor. All changes should be made by drawing a single line through the incorrect entry and initialing and dating the revision. Revised entries should be made in the space below the entries. Any blank lines remaining on the COC form after corrections are made should be marked out with single lines that are initialed and dated. This procedure will preclude any unauthorized additions.

5. If samples are sent by a commercial carrier not affiliated with the laboratory, such as Federal Express (FedEx) or United Parcel Service (UPS), the name of the carrier should be recorded on the COC form. Any tracking numbers supplied by the carrier should be also entered on the COC form. The time of transfer should be as close to the actual drop-off time as possible. After two copies of the COC forms are signed, they should be sealed inside the transfer container. The other signed copy will be retained by the field supervisor.
6. If errors are found after the shipment has left the custody of sampling personnel, a corrected version of the forms must be made and sent to all relevant parties. Minor errors can be rectified by making the change on a copy of the original with a brief explanation and signature. Errors in the signature block may require a letter of explanation.
7. Upon completion of the field sampling event, the field supervisor will be responsible for submitting all COC forms to be copied.

Custody Seal

As security against unauthorized handling of the samples during shipping, three custody seals will be affixed to each sample cooler. The custody seals will be placed across the front and on each side of the cooler prior to shipping. Be sure the seals are properly affixed to the cooler so they cannot be removed during shipping. Additional tape across the seal may be prudent.

Shipped Air Bills

When samples are shipped from the field to the testing laboratory via a commercial carrier (e.g., FedEx, UPS), an air bill or receipt is provided by the shipper. Upon completion of the field sampling event, the field supervisor will be responsible for submitting the sender's copy of all shipping air bills to the task manager. The air bill number (or tracking number) should be noted on the applicable COC form before they are sealed inside the cooler.

Acknowledgement of Sample Receipt

In most cases, on the day samples are received by the testing laboratory, the laboratory will confirm receipt with the task analytical chemistry laboratory coordinator. This confirmation may be via e-mail or an official laboratory 'Acknowledgment of Sample Receipt' form that confirms the sample ID numbers and analysis to be performed. If an error is detected by the task analytical chemistry laboratory coordinator, the laboratory will be called immediately. Decisions made during any telephone conversation should be

documented in writing and archived in the project file by the task manager. If necessary, corrections should be made to the COC form and the corrected version of the COC form should be sent to the laboratory (either via e-mail or facsimile) by the task analytical chemistry laboratory coordinator.

STANDARD OPERATING PROCEDURE SOP-8

BOAT INSPECTION AND CLEANING FOR AQUATIC INVASIVE SPECIES

Purpose

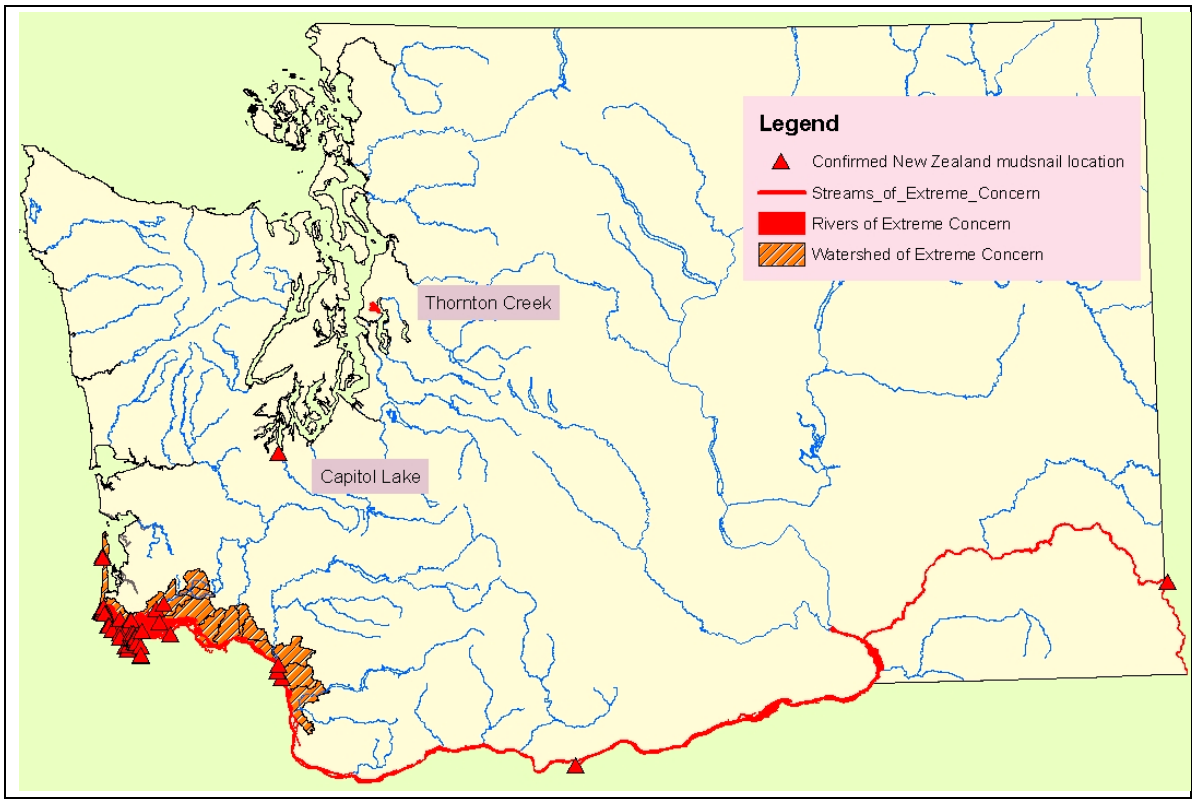
This standard operating procedure (SOP) covers field operations for the Upper Columbia River (UCR) Phase 2 sediment study. Aquatic invasive species (AIS) are a serious ecological and economic threat, and sediment sampling with research vessels and equipment has the potential to spread non-native noxious weeds, pathogens, and exotic flora and fauna among water bodies. Environmental ethics and Washington law prohibit the transportation of all aquatic plants, animals, and many noxious weeds. Specifically, it is a misdemeanor to transport aquatic plants on any state or public road, including forest roads or to knowingly import, move within the state, or export animals.

Scope and Applicability

SOP-8 is to minimize the risk of spreading any organisms, especially AIS, within or between water bodies as a result of fieldwork, reconnaissance activities, or other operations.

Research vessel captains and crew will be familiar with the risks of invasive species and trained on inspection and decontamination procedures. Watercraft will be thoroughly inspected and cleaned before the study to prevent transport of exotic species (e.g., New Zealand mudsnail, quagga and zebra mussels, and milfoil).

This SOP considers and incorporates prevention and control measures identified in the Washington Department of Ecology's Hazard Analysis and Critical Control Point (HACCP) Plans for conducting operations in Areas of Extreme Concern and Areas of Moderate Concern. The UCR is **NOT** included in an Area of Extreme or Moderate Concern, see below.



Statewide regions of extreme concern as published by:
http://www.ecy.wa.gov/programs/eap/InvasiveSpecies/AIS-PublicVersion.html.

Definitions

AIS (Aquatic Invasive Species)–Any freshwater or marine species that is not native to an ecosystem and whose introduction does or is likely to cause economic, human health, or environmental harm.

Areas of Extreme Concern–Areas of the state documented as having established AIS that are considered to be a particular environmental or economic threat and hard to remove from sampling equipment, such as areas with New Zealand mudsnail populations. Most equipment and sampling gear used in these areas must undergo rigorous inspection and decontamination procedures to prevent accidental introductions to other waters. Maps of these areas are available at http://www.ecy.wa.gov/programs/eap/InvasiveSpecies/AIS-PublicVersion.html.) The UCR is **NOT** included in an Area of Extreme Concern.

Areas of Moderate Concern–Areas of the state not documented as having established New Zealand mudsnail or other species of extreme concern. These areas may have other invasive species, including plants, animals, fish, invertebrates, and fish pathogens that should not be spread. The UCR is **NOT** included in an Area of Moderate Concern.

Decontamination–A method used to kill invasive species that may be lodged in or on equipment. These include drying, hot water wash, freezing, and chemical treatments.

HACCP (Hazard Analysis and Critical Control Point)–This is a systematic analysis tool used to identify the risks and the preventative procedures needed to significantly reduce the spread of aquatic species from sampling equipment and operations. HACCPs for areas of both Moderate and Extreme Concern are available at http://www.ecy.wa.gov/programs/eap/InvasiveSpecies/AIS-PublicVersion.html .

Noxious Weed–A plant included on the State Noxious Weed List. They are invasive, non-native plants that are a threat to the natural resources, ecology, and economy of Washington State. The list of noxious weeds and information about the State Noxious Weed Control Board is available at http://www.nwcb.wa.gov/.

Equipment–This means all equipment that contacts water, sediment, plants, or the ground during site access, reconnaissance, and sample collection. Such equipment includes, but is not limited to, ropes, boats, trailers, vehicles, anchors, chain, cables, personal floatation devices, and others.

General Procedures

Use equipment which can be easily inspected and cleaned to both avoid spreading invasive species and reduce impacts to planned field schedules. Where feasible, especially when working in areas of extreme concern, dedicate gear to be used only in that water body.

When a water body is known to be infected with mussels or milfoil

- Boats entering the water are not required to be inspected and cleaned.
- Boats leaving the water must be inspected and cleaned according to these procedures.

When a water body is known to NOT be infected with mussels or milfoil, such as the UCR

- Arriving boats need to be inspected according to these procedures before entering the water. If ANY milfoil, mussel adults, juveniles or larvae are discovered, a complete cleaning of all equipment according to these procedures is required.
- Boats leaving the water require no inspection and cleaning.

After field work inspect, clean, and if working in an area of extreme concern, decontaminate equipment. This step is divided into two parts.:

1) Thoroughly inspect the boat, trailer and all equipment for mud and AIS (plants and mussels). In addition to looking, inspect by gently running your hand along the entire surface of the equipment. Take time and carefully feel for juvenile mussels (it will feel like sandpaper). Remove any visible vertebrates, invertebrates, plants, algae, or sediment. If necessary, use a scrub brush and rinse with clean water either from the site or brought for that purpose. Drain all water in bilges or other equipment that could hold water from the site.
2) If working in an area of extreme concern, decontaminate equipment that contacted aquatic sediment, aquatic vegetation, or detritus. Wipe smooth surfaced sampling equipment that can be easily and fully wiped down until dry. The equipment must be smooth enough so there are no cracks or crevices that could harbor a sand-grain-sized juvenile mussel while being wiped dry.

Decontamination treatments should take place where the procedure can be carried out effectively and safely. Keep in mind that wash and rinse water must not drain to surface water, and all chemicals must be disposed of to a sanitary sewer.

Relaxing Requirements

Procedures laid out in this SOP must be followed prior to arriving at the UCR. Decontamination procedures as described in this SOP need not be followed when transiting to different sites within the UCR, or when leaving the UCR as it is NOT included in an Area of Extreme or Moderate Concern.

Equipment Storage

When moving between field sites, and upon returning from the field, store gear in a manner to facilitate drying. For example, boots should be stored on a drying rack until dry; open hatches and leave out drain plugs on boats.

Decontamination Treatment

Decontamination employs freezing, drying, or hot water. Treatment options listed below utilize temperature (heat) to ensure that AIS will be exterminated. At this time, hot water or drying are the recommended treatments for large equipment such as boats and boat trailers.

<u>Hot water sources</u>

- Hot water is preferred for decontaminating boating equipment

- A portable steam cleaner is recommended to maintain 60°C to ensure proper decontamination
- Car washes can be used for rinsing and cleaning, but are not an option for decontamination. The water is not hot enough to kill aquatic organisms.

Treating equipment with hot water

- Wear appropriate personal protection equipment to prevent burns to self and others
- Avoid or protect parts of equipment that might be damaged by hot water
- Ensure that the water is at least 60°C at the discharge side of whatever is being treated
- Flush all equipment for at least 10 seconds
- After treatment, ensure equipment drains and dries before re-stowing equipment.

Boat Trailers

1. Flush all interior and exterior surfaces of trailers, wheels, and tires until clean. Interior surfaces are the inside of the trailer's metal tube framing.

Boat Hulls–Exterior and Interior

1. Remove gear as needed (e.g. deck mat, dip nets, net anchors, boat anchor and line, ropes) to provide access to all areas of the boat to allow for effective cleaning.
2. Wash down the boat working from bow to stern, and top to bottom. Flush all nooks and crannies to get at all areas where aquatic species may have gotten into. Wash all boat-related gear.
3. Wash all bilge areas where accessible using hot water, working from bow to stern. However, do not flush the bilge of the jet sled with hot water because of the fuel tank located there.
4. Raise bow of boat for effective draining of water and muck that gets into bilge. Work all of the bilge water, sediment, and muck out of the drain on the transom.
5. Flush all interior and exterior through-hull pipes and screens. These may be located on the bottom of the hull, on the transom, or inside the hull (e.g., Skookum's strainers for wash down pumps and engine cooling system). Try back-flushing bilge pumps by introducing water into the bilge pump discharge port (on transom or hull exterior) and check to see if water flows through the bilge pump and into the bilge.

Boat Engines–Propeller and Jet Pump

Boat engines pump ambient water through them for cooling and can pick up and harbor unwanted material, which may be transported to another water body. While most boat engines have fine-mesh screens (~2 mm) that can prevent debris from getting into the engine, sand and mud particles may pass through. Jet-pump engines operating in shallow waters often move sediment and fine debris through the cooling passages, so more effort is needed to clean jet-pump engines. The external parts of engines can also collect weeds or other debris, especially propellers and other parts submerged in the water. Clean external parts of engines to remove all visible debris. Clean internal parts of engines by flushing with water as described below.

- Some engines have an adaptor that accepts garden hoses. Connect hose or adaptor and run water through the engine. Check to ensure that water is reaching and running from the cooling water pump intake areas.
- Some engines need the "ear muff" type flushing adaptor (many smaller engines): Connect hose to adaptor and attach adaptor to the engine. Turn on water. Start engine and let run at idle speed.
- Some engines have no flushing adaptor (some smaller engines). Mount the engine so that the lower unit can be submerged in a large container (e.g., 18-gallon tote) filled with water. Start engine and let run at idle speed.

Please note that all engines can be run while being flushed with cold water. However, running some engines while flushing with hot water could damage the engine, so do not run engines while flushing with hot water. Many engines can be flushed with hot water as long as the engine is not run at the same time.

STANDARD OPERATING PROCEDURE SOP-9

U.S. GEOLOGICAL SURVEY - COLUMBIA ENVIRONMENTAL RESEARCH CENTER PEEPER METHOD FOR IN-SITU SAMPLING OF SEDIMENT POREWATER

Purpose

Peepers (equilibrium diffusion samplers) are used for in-situ sampling of sediment porewater for dissolved metals and other ions. They are constructed from a plastic snap-cap vial that is filled with de-ionized (DI) water and fitted with a micro-porous membrane. The peeper volume is kept small relative to that of the surrounding sediment so as to minimize disturbance to the sediment/porewater equilibrium and depletion of dissolved metals in the surrounding porewater. For laboratory sediment toxicity tests, "mini" peepers are prepared from a 2.9-mL (2.5 mL nominal), low-density polyethylene snap-cap vial (Fisher Scientific catalog number 03-338-1B) and a 0.45 μm pore-size, 25 mm diameter polyether-sulfone (PES) filter membrane (VWR Scientific catalog number 28147-617), see Photo 1.

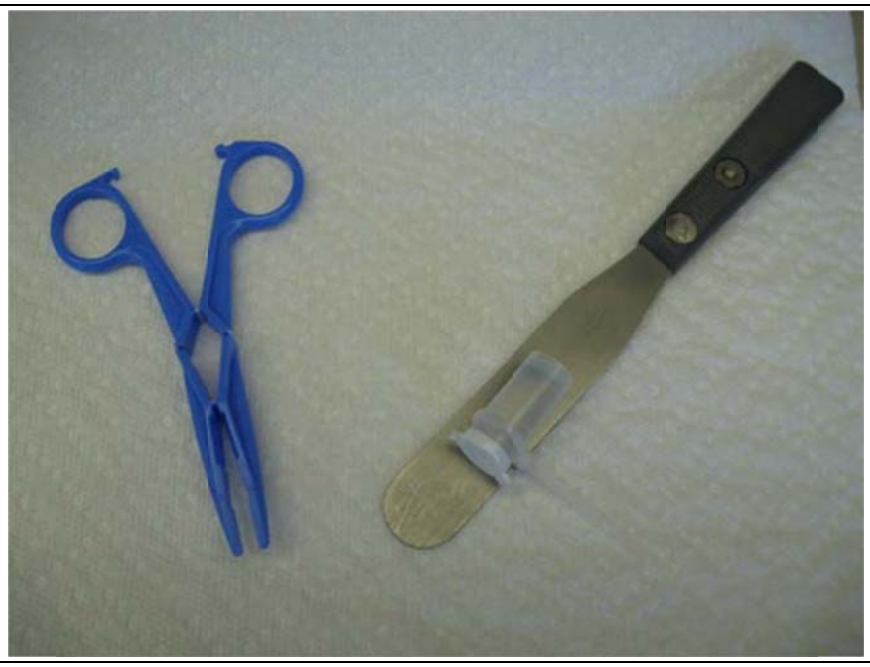


Photo 1. Typical tools for deployment of mini-peeper in laboratory test chamber

Preparation

Using a hole-punch tool (e.g., Roper-Whitney hand punch model 5JR), punch out a single 6-mm diameter hole in the center of each vial cap (with the cap still attached to the vial). A suitable number of punched vials are cleaned by soaking overnight (with occasional agitation to wet all vial surfaces) in a suitable plastic bottle containing 4M nitric acid (HNO_3), 2M hydrochloric acid (HCl). The vials are triple rinsed with DI water then stored in DI water until further preparation. To prepare the peepers, a small acid-cleaned plastic tub is half-filled with freshly de-oxygenated, DI water (DODI water) and up to 20 cleaned and punched vials (caps in the open position) are submerged in it (use a fresh batch of DODI water for each 20 vials). Wearing suitably clean waterproof gloves, a submerged vial is grasped with the cap open and held with its top edge just at the water surface. A PES filter membrane is then placed over it (aligned with minimal overlap near the hinged area of the vial) and the perforated cap is carefully closed to seal the membrane. Excess membrane material on the outside is torn away and discarded, but a small portion opposite the hinge is left to facilitate grasping both the membrane and cap when opening. Once seated, the membrane is inspected for rupture and the peeper is inverted above the water to check for leaks. The peeper should be inverted only momentarily, otherwise water droplets may begin to seep through the membrane. A correctly filled and sealed peeper will have no air bubbles inside. A small nylon cable tie (10-cm long for the mini-peeper) is strapped around the vial for aid in gauging depth when inserting in the sediment and to facilitate retrieval. The finished peeper is transferred to a wide-mouth 1-L or 2-L acid-cleaned high density polyethylene (HDPE) or polypropylene (PP) bottle containing DODI water and a few hundred mg of metal-chelating resin (e.g., Chelex-100™). After 20 vials are prepared the storage bottle is "topped off" with DODI water, then capped tightly and placed in a refrigerator. Peepers can be stored in this manner for several weeks before use, but the surrounding water must be de-oxygenated once again at least 24 hours in advance if they are to be stored for more than 48 hours before use (note that this is somewhat of an arbitrary guideline for minimizing DO inside the peeper). Typical materials associated with the preparation of mini-peepers for a laboratory toxicity test are illustrated within Photo 2.

Blanks

Prepare three peepers for each 20 samples to serve as blanks. After deployment, store the bottle containing these extra peepers in the DODI water and Chelex-100™ resin in a refrigerator. Process the blank peepers at the same time as those that were deployed.

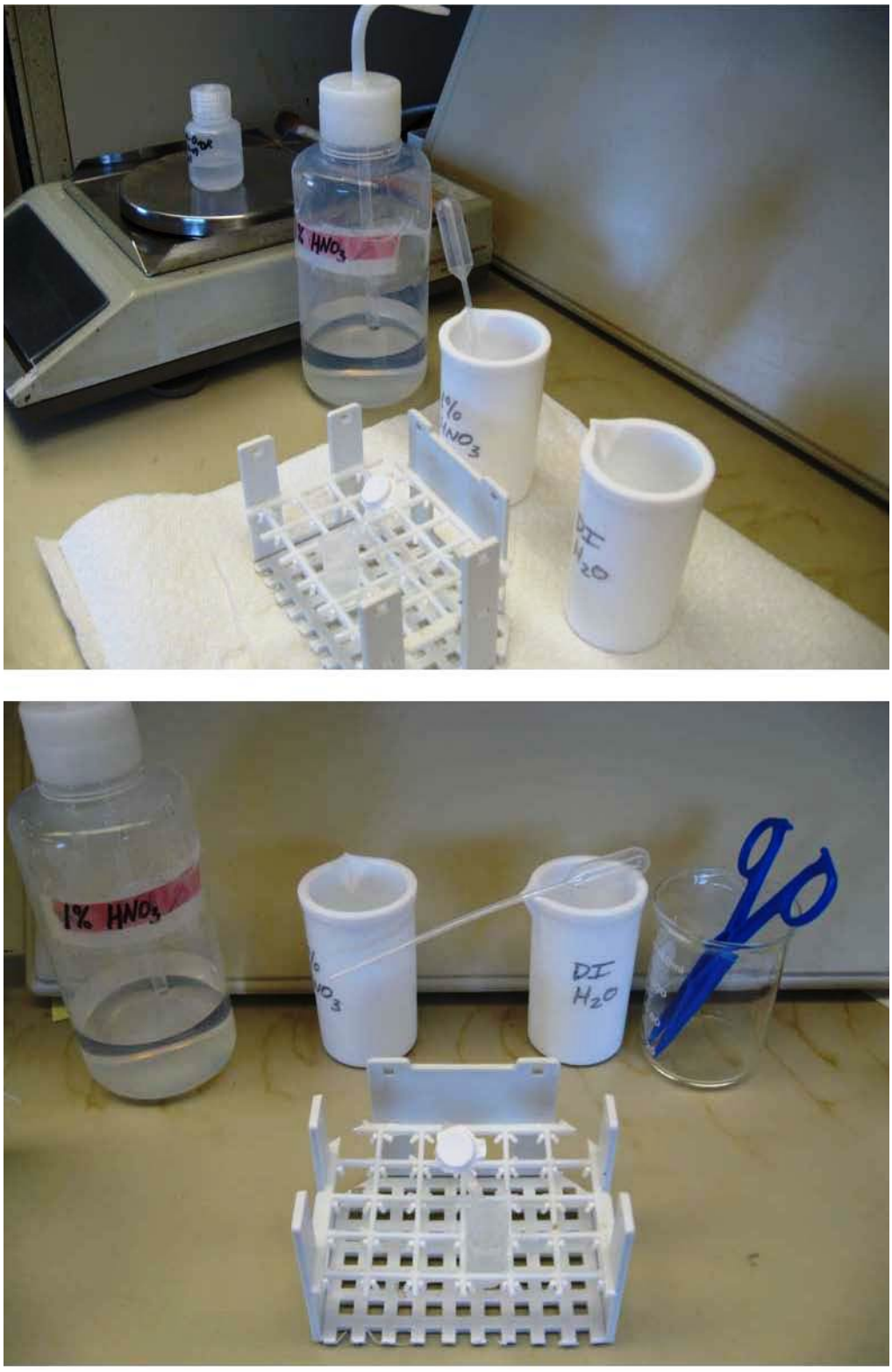


Photo 2. Typical materials associated with the preparation of mini-peepers in laboratory toxicity testing

Deployment/Retrieval

Deployment is performed in one of three ways depending on the sediment density and grain size. For most sediment the peeper can be pressed into the sediment using a spatula while grasping the cable tie with plastic (hemostat type) forceps, then "back-filled" with a small amount of sediment. If difficulty is encountered with that approach, (e.g., for dense or granulated sediments), a partial trench is first dug into the sediment using the spatula. Alternately, the peeper and the sediment can be loaded into the sediment toxicity test chamber simultaneously. For all burial methods, the bottom (closed end) of the peeper is situated next to the wall of the test chamber and the membrane end near the center so as to maximize the sediment volume "seen" by the membrane face. An example of a deployed peeper is illustrated within Photo 3.

Photo 3. Mini-peeper in sediment test chamber

At or following 7 days in the sediment, the peeper is pulled from the sediment by grasping the tag end of the wire tie with the plastic forceps and is carefully agitated in the overlying test water to remove loosely adhering sediment particles. It is then rinsed with a stream of DI water directed tangentially to the lid and membrane until all visible particles are displaced, then blotted dry using a laboratory tissue. The membrane and cap assembly is carefully opened with a DI-rinsed, gloved hand by grasping the protruding edge of membrane in conjunction with the edge of the cap. It is opened carefully to

prevent the membrane from falling into the liquid inside the vial. Liquid is transferred to an acid-cleaned 30-mL low density polyethylene (LDPE) bottle using a disposable polyethylene mini-pipette. Just before use, each mini-pipette is rinsed by drawing a small volume of high-purity 1 percent HNO_3, inverting, and then expelling to waste. The same sequence is then repeated with high purity water. Using the cleaned mini-pipette, the liquid from the peeper is transferred to an acid cleaned 30-mL bottle. About 2.5 mL of high purity 1.1 percent (v/v) HNO_3 is added to the peeper vial using a squirt bottle and with the mini-pipette this liquid is transferred to the receiving bottle in the same manner. The partially diluted sample is diluted to a final volume of 29 mL (29.2 g) with 1.1 percent (v/v) HNO_3 for analysis by ICP-MS (1 percent HNO_3 matrix, 10-fold dilution factor).

ATTACHMENT A3

EXAMPLES OF VARIOUS FIELD FORMS

CHAIN OF CUSTODY FORM

Page ____ of ____

Project: _____

Samplers: _____

Example

Project Contact:

Office _____

Phone _____

Ship to: Lab Name _____

Address _____

_____

_____

Contact _____

Phone _____

Soil Sample No.	Date	Time	Matrix	Preservative (if any)	ANALYSES REQUESTED					Extra Container	Archive	Comments

Analysis Turn Time: Normal Rush Rush Results Needed By:

Shipped by: Shipping Tracking No.:

Condition of Samples Upon Receipt: Custody Seal Intact?

Matrix Code:

SO - Soil

Other:

Relinquished by: _____ **Date/Time:** _____ **Received by:** _____ **Date/Time:** _____

(signature) *(signature)*

Relinquished by: _____ **Date/Time:** _____ **Received by:** _____ **Date/Time:** _____

(signature) *(signature)*

Special Intructions:

CHAIN OF CUSTODY FORM

Page ____ of ____

Example

Project: TAI UCR Soil Sampling

Samplers: Field S. Ampler, Helper S. Amplers

Project Contact: Project Manager

Office: Bellevue, Wa

Phone: 555-555-5555

Ship to:

Lab Name: Analytical Laboratory

Address: 111 Laboratory Lane

Seattle, WA 55555

Contact: Lab Mananger

Phone: 555-555-5555

Soil Sample No.	Date	Time	Matrix	Preservative (if any)	ANALYSES REQUESTED: Conventional Parameters	EPA TAL Metals	All Metal COIs	All Organic COIs		Extra Container	Archive	Comments
RF1-001	2010-06-01	1300	SO	None	x	x				N	N	None
RF1-002					x	x				N	N	None
RF1-003					x	x				N	N	None
RF1-004					x	x				N	N	None
RF1-005					x	x				N	N	None
RF1-006					x		x	x		N	N	None
RF1-007					x		x	x		N	N	None
RF1-008					x		x	x		N	N	None
RF1-009					x		x	x		N	N	None
RF1-010					x		x	x		N	N	None

Analysis Turn Time: (Normal) Rush Rush Results Needed By:

Shipped by: F. Sampler Shipping Tracking No.: 123456787463

Condition of Samples Upon Receipt: Custody Seal Intact?

Matrix Code:
SO - Soil
Other:

Relinquished by: Field S. Ampler *(signature)* **Date/Time:** 2010-06-01 1644 **Received by:** UPS *(signature)* **Date/Time:** 2010-06-01 1644

Relinquished by: *(signature)* **Date/Time:** **Received by:** *(signature)* **Date/Time:**

Special Intructions:

Custody Seal

CUSTODY SEAL

Example

Date: 2010-06-01 Time: 1630

Sampler Signature: *Field S. Ampler*

Sample Label

Example

Soil

Sample No: RF1-005 Date: 2010-06-01

Sampler: FSA Time: 0912

Preservative: None

	Field Change Request	

Field Change No.:_____
Page _____ to _____

Project number:
Project name:

CHANGE REQUEST
Applicable Reference:
Description of Change:

Reason for Change:

Impact on Present and Completed Work:

Requested by:
Date: ____/____/____
(Field Scientist)

Acknowledged by:
Date: ____/____/____
(Field Coordinator)

FIELD COORDINATOR RECOMMENDATION

Recommended Disposition:

Recommended by:
Date: ____/____/____

PROJECT MANAGER APPROVAL

Final Disposition:

Approved/Disapproved by:
Date: ____/____/____

CORRECTIVE ACTION RECORD

Page ___ of ___

Audit Report No. : _____ Date: _____

Report Originator:

Person Responsible for Response:

DESCRIPTION OF THE PROBLEM:

Date and Time Problem Recognized: _____ By: _____

Date of Actual Occurrence: _____ By: _____

Analyte: _____ Analytical Method:

Cause of Problem:

CORRECTIVE ACTION PLANNED:

Person Responsible for Corrective Action:

Date of Corrective Action:

Corrective Action Plan Approval: _____ Date:

DESCRIPTION OF FOLLOW-UP ACTIVITIES:

Person Responsible for Follow-up Activities:

Date of Follow-up Activity:

Final Corrective Action Approval: _____ Date:

SEDIMENT COLLECTION FIELD FORM

Project Name:______________________________ Project No.:___________________________ Page: ____________

Date:______________ Sampling Crew: ____

Weather: ____

Time:___________ Station No.:_____________ Elevation: ___________________

Latitude:________________ Longitude: ___________________ Accuracy: ___________________

Sample ID: ____ Soil pH: ___________

Sample analysis: ____ No. sample containers:____

Vegetation: ____

____

Photograph numbers: ____

____

Comments: ____

____

Time:___________ Station No.:_____________ Elevation: ___________________

Latitude:________________ Longitude: ___________________ Accuracy: ___________________

Sample ID: ____ Soil pH: ___________

Sample analysis: ____ No. sample containers:____

Vegetation: ____

____

Photograph numbers: ____

____

Comments: ____

____

Time:___________ Station No.:_____________ Elevation: ___________________

Latitude:________________ Longitude: ___________________ Accuracy: ___________________

Sample ID: ____ Soil pH: ___________

Sample analysis: ____ No. sample containers:____

Vegetation: ____

____

Photograph numbers: ____

____

Comments: ____

____

SEDIMENT/POREWATER SAMPLING FIELD FORM

2013 Phase 2 Sediment Study, Upper Columbia River

Date: _____ **Sampling Vessel & Team:** _____

Station ID: _____ **Weather:** _____

Drop # (Angle): _____ **Time:** _____ **Depth:** _____ **Accepted/Rejected:** _____

Latitude: _____ **Longitude:** _____ **Vessel Elev.:** _____

Photo IDs: _____ **Sampler penetration:** _____

% Fines (≤ 2 mm): _____ **% Silica glass particles:** _____ **Sed. pH:** _____

Sed. Characteristics (e.g., type, texture, color, redox indic., sheen, odor): _____

_____

Veg./Biota: _____

Sample ID(s): _____ **# Cont. Filled:** _____

Sample analyses: _____

Comments: _____

_____

Drop # (Angle): _____ **Time:** _____ **Depth:** _____ **Accepted/Rejected:** _____

Latitude: _____ **Longitude:** _____ **Vessel Elev.:** _____

Photo IDs: _____ **Sampler penetration:** _____

% Fines (≤ 2 mm): _____ **% Silica glass particles:** _____ **Sed. pH:** _____

Sed. Characteristics (e.g., type, texture, color, redox indic., sheen, odor): _____

_____

Veg./Biota: _____

Sample ID(s): _____ **# Cont. Filled:** _____

Sample analyses: _____

Comments: _____

_____

SEDIMENT/POREWATER SAMPLING FIELD FORM

2013 Phase 2 Sediment Study, Upper Columbia River

Date: 10/1/2013 **Sampling Vessel & Team:** Lucky Lass: CBS, TVS, & LOL

Station ID: 1-B1 **Weather:** Overcast, 50°F, drizzle

Drop # (Angle): 1 (<5°) **Time:** 10:02 **Depth:** 31 ft **Accepted/Rejected:** Rejected

Latitude: 48.99795 **Longitude:** -117.635592 **Vessel Elev.:** 334 MSL

Photo IDs: 117, 118 **Sampler penetration:** 10"

% Fines (≤ 2 mm): ~ 30% **% Silica glass particles:** 0% **Sed. pH:** 6.5

Sed. Characteristics (e.g., type, texture, color, redox indic., sheen, odor): Sandy with some silt. medium brown (10 YR 3/4), no redox/sheen/odor

Veg./Biota: Some visible organic materials (leaves)

Sample ID(s): NA **# Cont. Filled:** NA

Sample analyses: NA

Comments: Sampler overfilled with sediment, 140 mL porewater collected

---

Drop # (Angle): 2 (<5°) **Time:** 10:35 **Depth:** 30.5 ft **Accepted/Rejected:** Accepted

Latitude: 48.99795 **Longitude:** -117.635592 **Vessel Elev.:** 334 MSL

Photo IDs: 119, 120, 121, 122 **Sampler penetration:** 6"

% Fines (≤ 2 mm): ~ 30% **% Silica glass particles:** 0% **Sed. pH:** 6.5

Sed. Characteristics (e.g., type, texture, color, redox indic., sheen, odor): Sandy with some silt. medium brown (10 YR 3/4), no redox/sheen/odor

Veg./Biota: Some visible organic materials (leaves), a mussel

Sample ID(s): SE-1-B1, PW-1-B1 **# Cont. Filled:** 8

Sample analyses: All SE (metals/Hg/pH/TOC, AVS/SEM, GS, BSE/arch., bioassay). All PW (metals, TOC, conv.).

Comments: 130 mL of porewater collected

ATTACHMENT A4

ARCHAEOLOGICAL MONITORING PROTOCOL

CONTENTS

ACRONYMS AND ABBREVIATIONS

CCT	Confederated Tribes of the Colville Reservation
CRCP	cultural resources coordination plan
EPA	U.S. Environmental Protection Agency
NAGPRA	Native American Graves Protection and Repatriation Act
NPS	National Park Service
RI/FS	remedial investigation and feasibility study
STI	Spokane Tribe of Indians
TAI	Teck American Incorporated
UCR	Upper Columbia River
USBR	U.S. Bureau of Reclamation

INTRODUCTION

This protocol provides a summary of procedures to be followed by all Teck American Incorporated (TAI) technical team field personnel, including subcontractors, should potential discoveries, of cultural materials and deposits, and/or Indian burials and human remains occur during execution of field sampling programs and other activities associated with the Upper Columbia River (UCR) Site remedial investigation and feasibility study (RI/FS). Cultural materials and deposits (including sacred objects, funerary objects, and objects of cultural patrimony) as well as Indian burials and human remains are defined in the Native American Graves Protection and Repatriation Act (NAGPRA).

The procedures detailed below were developed to ensure compliance with the National Historic Preservation Act and the applicable requirements, procedures, and standards of the National Park Service (NPS), U.S. Bureau of Reclamation (USBR), Confederated Tribes of the Colville Reservation (CCT), and the Spokane Tribe of Indians (STI). Detailed information regarding existing discovery protocols for these entities, as well as implementing regulations, notification requirements, archaeological monitoring requirements, and other cultural resource coordination activities for the RI/FS are provided in the draft cultural resources coordination plan (CRCP).

DISCOVERIES WHEN AN ARCHAEOLOGICAL MONITOR IS PRESENT

At the discretion of the archaeological monitor or Tribal representative, ground-disturbing sampling or associated activity may be slowed or halted at any time that a suspected archaeological object or archaeological resource is encountered. The objective of this slowing or halting of ground-disturbing cleanup activity is to allow the archaeological monitor/Tribal representative to confirm and/or make a preliminary assessment of the discovery. At the discretion of the archaeological monitor or Tribal representative, a specific sample may be relocated from the location of the discovery but still be within the sampling location. Such relocation will be coordinated with the field supervisor.

At the request of the archaeological monitor or Tribal representative, the sampling personnel will either

- Assist in securing access to the location of the discovery and take appropriate measures to protect the location of the discovery from rain, stormwater, and other possible disturbances, or

- Assist in moving the artifacts to a protected and secure area of the Site away from the immediate sampling area. Removal of artifacts from the discovery location will be undertaken only if leaving the artifacts in place would jeopardize their integrity due to erosion or collection by unauthorized individuals.

The archaeological monitor, Tribal representative, or a member of the TAI technical team will remain onsite to ensure the security of the find until more extensive efforts can be made to secure the Site from further disturbance or a more extensive evaluation and documentation of the discovery can be made.

Notification of any cultural resources that have the potential to delay or halt sampling activities (i.e., human remains or those items covered under NAGPRA) must be provided as soon as possible to the U.S. Environmental Protection Agency (EPA) for further coordination with the consulting parties.

DISCOVERY OF HUMAN REMAINS

Native peoples in the study area consider the graves of their ancestors to be important in both their cultural identity and in defining their relationship with the land. These graves are therefore considered sacred and should be left undisturbed. Should inadvertent disturbance occur, the remains and associated materials ("funerary objects") must be treated with respect and honor. All appropriate federal, Tribal, and state laws, regulations, and procedures regarding burials should be rigorously enforced.

In the event that likely or confirmed human remains are encountered, all further sampling or other ground-disturbing activity will cease immediately. The protocol and notification procedures to be followed for any potential discoveries of human remains are provided in protocols of the NPS, USBR, CCT, and STI (Attachment 1 to the CRCP). Any discoveries within the boundaries of the Colville or the Spokane reservations must also be reported immediately to the respective Tribe.

The TAI technical team will assist the archaeological monitor and Tribal representative in securing the location of the discovery.

Other conditions for responses to discoveries of archaeological materials may be defined in the Archeological Resources Protection Act permit(s) issued for the sampling program. As detailed in the CRCP, responses to any discoveries of burials must also comply with provisions of NAGPRA and its implementing regulations, as well as the existing protocols of the NPS, USBR, CCT, and STI (Attachment 1 to the CRCP).

DISCOVERIES WHEN AN ARCHAEOLOGICAL MONITOR IS NOT PRESENT

As previously stated, an archaeological monitor and/or Tribal representative(s) will be present during all sampling activities. In the event, however, that suspected or evident artifacts or other archaeological deposits are encountered when an archaeological monitor or Tribal representative is not present, the immediate vicinity of the discovery will be secured. The discovery will be mapped and photographed in place but will be otherwise left as found (other than appropriate measures to secure the find and maintain security). In consultation with the land-managing agency or appropriate Tribe, as well as other interested parties, TAI will arrange for the location of the discovery to be examined by a professional archaeologist and Tribal representative in a timely manner. If the archaeologist confirms the presence of artifacts or other archaeological deposits, the procedures defined above for discoveries made during ground-disturbing activity monitored by an archaeologist will be implemented. The archaeologist will prepare appropriate State of Washington archaeological forms to document the find.

To ensure proper recognition of artifacts and other cultural items or deposits, all TAI field personnel will be provided with training in recognizing these materials by a professional archaeologist prior to the initiation of any sediment and soil sampling.

CONFIDENTIALITY

In accordance with state and federal law, all field personnel are required to keep the discovery of any found or suspected human remains, other cultural items, and potential historic properties confidential. Personnel are instructed that they are prohibited from contacting the media or any third party or otherwise sharing information regarding the discovery with any member of the public, and that they should immediately notify the field supervisor of any inquiry from the media or public. The field supervisor will then notify TAI of any such inquiries. To the extent permitted by law prior to any release of information, TAI, in coordination with EPA and other consulting parties, shall concur on the amount of information, if any, to be released to the public, any third party, and the media and the procedures for such a release.