UPPER COLUMBIA RIVER

FINAL
Assessment of Sediment Toxicity to White Sturgeon
Data Summary Report

Prepared for

Teck American Incorporated

P.O. Box 3087
Spokane, Washington 99220

Prepared by

Cardno ENTRIX
Shaping the Future

Saskatoon, SK S7N 3B5

HDR| HydroQual

6700 Kirkville Road
East Syracuse, NY 13057

In cooperation with

University of Saskatchewan, Aquatic Toxicity Research Facility

Exponent, Inc.

Parametrix, Inc.

Windward Environmental LLC

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ACRONYMS AND ABBREVIATIONS

ANCOVA	analysis of covariance
ANOVA	analysis of variance
ATRF	Aquatic Toxicity Research Facility
ASTM	American Society for Testing and Materials
AVS	acid volatile sulfide
BBE	Birchbank Eddy
BDL	below detection limit
BERA	Baseline Ecological Risk Assessment
BL	biotic ligand
BLM	biotic ligand model
Ca^{2+}	calcium ion
CAS	Columbia Analytical Services
CB	China Bend
CERC	Columbia Environmental Research Center
Cl^-	chloride ion
COPC	chemical of potential concern
CRF	change request form
CTRL	artificial substrate control
D/C	deviation / corrective action report
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DE	substrates as collected above the water line from the gravel bar at DME
DGT	diffusive gradient thin-film
DME	Deadman's Eddy
DO	dissolved oxygen
DOD	U.S. Department of Defense
DOC	dissolved organic carbon
DQO	data quality objective
ELS	early life stages
EOT	end-of-test
EPA	U.S. Environmental Protection Agency

ESI	Environmental Services, Inc.
F^-	fluoride ion
f_{OC}	fraction of organic carbon
GE	Genelle Eddy
H2O	water-only control
HDPE	high density polyethylene
HNO_3	nitric acid
ICP	inductively-coupled plasma
IQR	inter-quartile range
K^+	potassium ion
LALL	Lower Arrow Lakes
LC50	lethal copper concentration where 50 percent mortality is observed
LD	Little Dalles
LMF	Lower Marcus Flats
LOD	limit of detection
LOQ	limit of quantitation
Mg^{2+}	magnesium ion
MDL	method detection limit
MLE	maximum likelihood estimate
mPECQ	mean probable effects concentration quotient
MRL	method reporting limit
Na^+	sodium ion
NELAC	National Environmental Laboratory Accreditation Conference
NP	Northport
ORD	Office of Research and Development
OW	overlying water
PAHs	polycyclic aromatic hydrocarbons
pH	hydrogen ion activity
PCBs	polychlorinated biphenyls
PW	porewater
QA	quality assurance
QA/QC	quality assurance and quality control
QC	quality control
QAPP	quality assurance project plan

RI/FS	remedial investigation and feasibility study
RL	reporting limit
RM	river mile
SO_4^{2-}	sulfate ion
SDG	sample delivery group
ΣSEM – AVS	simultaneously extracted metals minus acid volatile sulfide (which is defined as "excess SEM"; see also "SEMx")
SEM	simultaneously extracted metals
ΣSEM_X	excess SEM; the difference of SEM minus AVS
$\Sigma SEM_{X,OC}$	carbon normalized excess SEM
Site	Upper Columbia River site
SWI	Sediment-water interface
TAI	Teck American Incorporated
TAL	target analyte list
TDS	total dissolved solids
TOC	total organic carbon
TU	toxic unit
UCR	Upper Columbia River
U of S	University of Saskatchewan
UMF	Upper Marcus Flats
US	United States
USGS	U.S. Geological Survey

UNITS OF MEASURE

%	percent
µg Cu/L	micrograms of copper per liter
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
µm	micrometer(s)
µmol/g	micromoles per gram
µmol/gd	micromoles per gram dry weight
µmol/goc	micromoles per gram of organic carbon
µS/cm	microSiemens per centimeter
cm	centimeter(s)
cm^2	square centimeter(s)
dph	days post hatch
dw	dry weight
g	gram(s)
g/L	grams per liter
gal	gallon(s)
hr(s)	hour(s)
in.	inch(es)
L	liter(s)
L/day	liters per day
L/min	liters per minute
lb(s)	pound(s)
M	molarity
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mg/L as $CaCO_3$	milligrams per liter as calcium carbonate
mm	millimeter(s)
mol/L	moles per liter
nmol/g_W	nanomoles per gram wet weight
ppm	parts per million
su	standard units

1 INTRODUCTION

This report presents a summary of work completed and associated data (biological and analytical) collected under the Quality Assurance Project Plan (QAPP) and its amendments for the Assessment of Sediment Toxicity to White Sturgeon (*Acipenser transmontanus*) (TAI 2010a,b,c; included herein as Appendix A). This work was conducted as part of the Upper Columbia River (UCR) Remedial Investigation and Feasibility Study (RI/FS). Primary objectives of the RI/FS are to investigate the nature and extent of unacceptable risk at the Site[1], to provide information in support of baseline risk assessments for human health (to be completed by the U.S. Environmental Protection Agency [EPA]), and the environment (to be completed by Teck American Incorporated [TAI]); and to develop and evaluate potential remedial alternatives. Data generated in the sturgeon sediment toxicity study are intended to supplement information for the baseline ecological risk assessment (BERA). The use of these data in support of risk evaluations will be determined during the baseline ecological risk assessment process.

1.1 PURPOSE AND DATA QUALITY OBJECTIVES

Given the epibenthic nature of white sturgeon, there is the potential for increased exposure to chemicals associated with sediments within the UCR. Specifically, there is a concern that contaminants of potential concern (COPCs) in sediments may present an unacceptable risk to early life stages (ELS) of white sturgeon (i.e., the hiding stage where fry are in proximity to sediments). To identify specific data needs in addressing the aforementioned concern and to establish decision rules for the collection of data, the EPA data quality objective (DQO) process (USEPA 2006) was used for this study.

As an outcome of the DQO process, the purpose of this study and primary DQO was (under laboratory controlled conditions) to assess toxicity of COPCs associated with sediments from the UCR to ELS (including the hiding stage) of white sturgeon (*A. transmontanus*). Specific DQOs addressed included:

- Is the survival and growth of white sturgeon adversely affected when exposed to Site sediments in comparison to reference sediments?, and
- If so, can these adverse effects be attributed to exposure to metal concentrations in sediments, sediment porewater, or overlying water?

[1] The UCR site as defined within the June 2, 2006 Settlement Agreement is the areal extent of hazardous substances contamination within the United States in or adjacent to the Upper Columbia River, including the Franklin D. Roosevelt Lake, from the U.S.–Canada border to the Grand Coulee Dam, and those areas in proximity to the contamination which are suitable and necessary for implementation of response actions.

This report summarizes the data collected and identifies whether DQOs of the QAPP for the white sturgeon studies conducted using UCR sediments have been met. This report is not intended to evaluate risk, nor does it consider other relevant Site data (e.g., surface water data). Such evaluations will be performed and detailed as part of the BERA. During the BERA, and consistent with EPA guidance (USEPA 1997), should EPA determine that there is insufficient information to support an informed risk-based management decision, additional data may be needed.

In addition to the above-mentioned DQOs, a limited number of water-borne acute 96-hr toxicity tests using copper were completed as part of this study (described independently in Appendix B and summarized below). These acute tests were intended to supplement parallel acute toxicity tests being performed by the U.S. Geological Survey, Columbia Environmental Research Center (USGS, CERC) on behalf of the EPA; and help evaluate the relative sensitivity of white sturgeon (USGS 2010). The acute tests are also considered to represent reference toxicant tests.

The purpose of water-borne acute toxicity tests and primary DQO was to assess acute toxicity of water-borne copper to white sturgeon (*Acipenser transmontanus*) at 16 and 45 days post hatch (dph). Acute toxicity tests were also conducted using the standard test species rainbow trout (*Oncorhynchus mykiss*) at comparable ELS to assess relative sensitivity. The specific DQOs included:

- Determine what concentrations of copper are acutely toxic to ELS white sturgeon and rainbow trout using standard 96-hr toxicity tests
- Determine the relative sensitivity of white sturgeon and rainbow trout to copper at the tested life stages.

Biotic ligand model (BLM)-normalized acute copper toxicities (i.e., LC50s) for white sturgeon were determined at 16 and 45 dph to be 15.8 µg Cu/L and 29.5 µg Cu/L, respectively. Rainbow trout LC50s at 17 and 48 dph were determined to be 30.3 µg Cu/L and 39.7 µg Cu/L, respectively.

1.2 REPORT ORGANIZATION

This report is organized into the following sections:

- Section 1 – Introduction. This section describes the purpose and objectives of the evaluation of the toxicity of COPCs in sediment to ELS of white sturgeon.
- Section 2 – Study Design and Sampling Methods. This section provides an overview of the study, including sediment target sample locations, laboratory exposure design, hatchery collection, and laboratory analyses.

- Section 3 – Quality Assurance Project Plan, Deviations and Modifications. This section discusses any modifications and deviations from the QAPP; and potential uncertainties associated with the study.
- Section 4 – Validation Assessment. This section provides an overview of the validation assessment conducted on analytical data.
- Section 5 – Results. This section presents a summary of data, integrating and interpreting results relative to the primary study question(s).
- Section 6 – Discussion and Recommendations. This section presents a summary of the results in terms of data gaps and provides recommendations.
- Section 7 – References. This section presents bibliographic information for documents cited herein.

Consistent with the format of the QAPP (TAI 2010a,b,c), results and discussions associated with the limited number of acute water exposure toxicity tests are independently presented in Appendix B of this data report.

2 STUDY DESIGN AND SAMPLING METHODS

A summary of study design, sampling methods, and analytical procedures used to assess exposure of ELS, including the hiding stage, of white sturgeon (*A. transmontanus*) to UCR sediments is presented below. Details of study design and test acceptability criteria are in the QAPP (Table B-9) and in Section 5. Test acceptability criteria are summarized in Table 2-1. The QAPP is included with this report as Appendix A for ease of reference.

2.1 STUDY DESIGN – SEDIMENTS

Site sediment sampling locations were specifically selected in areas known to encompass confirmed white sturgeon spawning- and/or nursing-grounds (Howell and McLellan 2006; Weakland et al. 2011). As such, Site sampling efforts were focused from Kettle Falls (river mile [RM] 703) to the U.S.–Canada border (i.e., RM 745); and were intended to represent a gradient of COPC sediment concentrations associated with granulated slag. Specifically, and as outlined in the QAPP (TAI 2010a), these COPCs included cadmium, copper, lead, and zinc. Primary sampling areas targeted included Deadman's Eddy (DME; RM 737), China Bend (CB; RM 723), Upper Marcus Flats (UMF; RM 706), and Lower Marcus Flats (LMF; RM 704). Alternate sampling areas (i.e., Northport [NP; RM 735] and Little Dalles [LD; RM 729]) were also identified in the event that sediments could not be retrieved from the above-mentioned primary areas. Primary and alternate Site sampling areas are illustrated in Figure 2-1. As illustrated in Figure 2-1, each sampling area contained three distinct sampling locations (e.g., -01, -02, and -03). A summary of primary and alternate sampling location coordinates per sampling area is presented in Table 2-2.

With the permission of the Canadian government, target reference sediments were sampled in three areas located upstream of Trail, British Columbia. These included Birchbank Eddy (BBE; RM 764), Genelle (GE; RM 766), and Lower Arrow Lakes (LALL; RM 788), refer to Figure 2-2 and Table 2-2.

As outlined within the QAPP (TAI 2010a), a large volume of sediment was targeted at each of the above-mentioned sampling areas (i.e., 50 gal per location times 3 locations per area = 150 gal per area). To help achieve this goal, the Cultural Resources Working Group approved sampling efforts to occur within an area of approximately 0.3 acres from the center of each sampling location (TAI 2010a,b). Despite this relatively large sampling area, the presence of coarse-grained substrates (e.g., gravels, cobbles, and boulders), and an armored river bed made collecting sufficiently large volumes difficult. Of the nine targeted sampling areas, sediments of sufficient volume for subsequent exposure testing were successfully collected within six areas (i.e., LMF, UMF, NP, LD, GE, and LALL). A summary of retrieved sediments is presented in Table 2-3.

As indicated in Table 2-3, with the exception of UMF, GE, and LALL; the average volume of sediment collected per area was less than the targeted 150 gal; while insufficient volumes were retrieved from CB, DME, and BBE. Given the difficulty in collecting sufficient volumes of Site sediments, substrates collected above the water line from the gravel bar at DME for methods development work (TAI 2010d,e,f) were incorporated into this study as directed by EPA (TAI 2010c). Detailed descriptions of field sampling activities (including methods development work) are presented in Appendix C of this report.

Upon completion of field sampling activities, all sediments were transported in a refrigerated truck to the University of Saskatchewan (U of S), Aquatic Toxicity Research Facility (ATRF) where they were homogenized, sampled for laboratory analysis, and incorporated into respective fluvial exposure chambers per the QAPP (TAI 2010c; see Appendix A).

2.2 STUDY DESIGN – LABORATORY EXPOSURE

Homogenized sediments were evenly layered at the bottom of dedicated continuous flow-through exposure chambers at a thickness of approximately 2 in., (TAI 2010a,b,c). Replicate exposure chambers were established based on available sediment volume. A maximum of six replicates was established using sediments collected from sampling locations UMF-01, LD-01, and LALL. A floor plan of exposure chambers as established and monitored at the U of S, ATRF is presented in Figure 2-3. Chambers illustrated with the same color are replicate treatments.

As illustrated in Figure 2-3, in addition to exposure chambers containing Site-specific and reference sediments, two types of negative controls were also established and monitored throughout the duration of the study. One was a water-only (H2O) control, the other an artificial substrate control (CTRL). As detailed in the QAPP (TAI 2010a,b,c) and evaluated during methods development work (TAI 2010d,e,f), the artificial substrate selected for this study was the Rolf C. Hagen, Inc. Aquarium Substrate Item No. 12648. To enrich the habitat within all exposure chambers (including H2O controls), Rolf C. Hagen, Inc. Aquarium Substrate Item No. 12422 (i.e., large gravel) was systematically placed in each exposure chamber per the QAPP (TAI 2010a,b,c).

Prior to placing sediments/substrates into test chambers, up to eight RENA Micro Bubbler 6-in. ceramic air-stones were distributed along the bottom of each exposure chamber for non-intrusive porewater (PW) sampling. In short, exposure chambers were continuous flow-through systems designed and operated at a water flow-rate of approximately 0.2 L/min; at an illumination cycle of 16-light:8-dark (16:8) hrs., and at a target water temperature of 16 ± 1°C. Total water replacement rate (i.e., flow-through) was approximately 250 L/day, and estimated total volume of water in each exposure system was 230 L. On August 31, 2010, flow-through rate was increased to 375 L/day to mitigate

increasing levels of inorganic nitrogen. On the following day, flow-through rate was decreased to 300 L/day, and on September 7, 2010, flow-through rate was returned to 250 L/day. Details associated with exposure chamber design and operation are provided in Appendix A (TAI 2010a,b,c). In addition, Figure 2-4 and photographs in Appendix D provide further detail regarding the final exposure chamber design.

During the course of the study a total of 41 exposure chambers were established and monitored. Six replicates were established for sediments collected from UMF-01, LD-01, and LALL; four replicates from LMF-02 and GE; two replicates from substrates as collected above the water line from the gravel bar at Deadman's Eddy (hereafter referred to as "DE"), and two replicates from NP-03; see Table 2-4. In addition to the 41 exposure chambers, 12 chambers were designated as "chemistry-only", in which other passive sampling devices (i.e., peepers and diffusive gradient thin-film [DGT] probes) were installed and used to obtain additional water quality information within the top ±1 cm of the sediment-water interface. Diffusive gradient thin-film probes and peepers were sampled on days 8, 27, and 57 during the course of the study; following a 2-day (DGT) and a 7-day (peeper) equilibration period. A summary of replicates per sampling location (including chemistry-only chambers) is presented in Table 2-4.

2.3 STUDY DESIGN – TEST SPECIES AND DURATION

Fertilized white sturgeon eggs were obtained from the Kootenay Trout Hatchery located in Fort Steele, British Columbia on July 7, 2010. During the July 7, 2010, fertilization event, hatchery staff collected eggs from three females and sperm from four male adult white sturgeon captured in the Columbia River near the U.S.-Canada border (Ron Ek 2010, pers. comm.; FFSBC 2011). Fertilization of eggs was harmonized in the hatchery by injecting the mature sturgeon with a gonadotropin analog on two subsequent days. Embryos were transported in oxygenated bags and received at the U of S, ATRF within 12 hrs of fertilization.

Upon receipt at the U of S, ATRF embryos were acclimated to test waters[2] for 1 hr before being incubated in McDonald-type hatching jars for 72 hrs until neurulation occurred. After 72 hrs, flow conditions were increased to gently agitate the embryos and mitigate the potential for fungus development. Hatching jars were inspected daily, and infertile, damaged or fungus-infected embryos removed. Hatching began and ended on the 18th and 24th of July, respectively. During this time, sturgeon larvae were transferred from hatching

[2] Test water used during the study was intended to have a target water hardness of 65 to 70 mg/L as $CaCO_3$, and consisted of a 1:1 mixture of dechlorinated City of Saskatoon water and ATRF reverse osmosis water.

jars to culturing tanks until hatching was complete. For the purposes of this study, Day-0 of exposure testing and evaluation is defined as 2 dph and occurred on July 24, 2010.

Neurulation rate, which is taken as a direct measure of hatching success, was >85 percent for the fish provided to the U of S for this study. Neurulation was estimated at >79 percent for the same fertilization event (i.e., July 7, 2010) at the Kootenay Trout Hatchery (FFSBC 2011), thus meeting one of the primary test acceptance criteria (Table 2-1). Hatching success was as high or higher than that in previous years at the hatchery, and very few deformed fish were produced (FFSBC 2011). In comparison with other recent laboratory studies with white sturgeon, hatchability of eggs used in the current study was relatively high. In a study investigating the effect of substrate type on white sturgeon hatching success, Parsley and Kofoot (2013) reported hatching rates that ranged from 2.7 to 60.7 percent, with very low hatching rates observed in tanks with periphyton- and algae-covered rocks, and the highest hatching rates observed in tanks with clean glass-plate bottoms. Ingersoll and Mebane (2014) reported less than 50 percent hatch of white sturgeon eggs used in their experiments, indicating that a large proportion of eggs was unfertilized.

On Day-0, sturgeon fry were manually transferred (10 at a time) from culturing tanks into respective exposure chambers until the target seeding density of approximately 100 sturgeon fry per exposure chamber was attained. As detailed within the QAPP (TAI 2010a), this approach was adopted to ensure that sturgeon fry were randomly distributed within exposure chambers (treatments). A summary of seeding densities[3] per exposure chamber is presented in Table 2-5. A target seeding density of 100 sturgeon fry per exposure chamber was based on analyses presented in Vardy et al. (2011) and Tompsett et al. (2014). Recommendations from Tompsett et al. (2014) were based on observations from that study, as well as from data collected by Vardy et al. (2011). Those recommendations were meant to provide culturing conditions that minimized mortality to white sturgeon during the transition to exogenous feeding stage. On a mass-per-unit volume of water basis, the recommendation was 0.11 g/L, and on the basis of surface area, the recommendation was 58 cm^2/fish. These recommendations were based on a fish density of 86 fish per 40-L chamber and were meant to minimize density-dependent mortality. Exposure chambers in the current study were 3-fold larger (i.e., 120 L), and habitat was enriched (i.e., gravel was added) consistent with the QAPP (TAI 2010a,b,c). At the target seeding density of 100 fish per chamber, the fish loading rate was expected to be approximately 0.04 g/L (during the transition to exogenous feeding stage), which is well below the stocking density above which density-dependent effects may be anticipated.

[3] Seeding densities were calculated by summing 1) the number of mortalities recorded for the duration of the study, 2) the estimated number of lost/escaping fish, and 3) the number of surviving fish at the end of the study.

As indicated in Table 2-5, although the target seeding density was 100 sturgeon fry per exposure chamber, there was variability in actual seeding densities. This variability was largely attributable to errors in tracking the number of fish additions performed for each tank. As specified above, fish were taken from the stock tank and added to the exposure tanks in 10-fish increments. Fish were added to exposure chambers in a random manner, and because of the number of technicians involved, it was difficult to accurately keep track of the number of fish additions to each tank. In addition, during this initial period of time, sturgeon fry were observed to escape through small spaces in seals located near the bottom of the posterior screens of exposure chambers. This occurred in the H2O treatments, where there was no sediment covering the bottom seals of the posterior screen, providing a route for fish to escape to the posterior chamber or to the water reservoir. Within 48 hrs of test initiation, the seals were fixed and lost/escaping sturgeon were relocated (if in the posterior part of the exposure chambers or in good health in the reservoir) or replaced in-kind, if dead.

Replacement of fish occurred within the first 24 hrs for any chamber that contained dead fish or within the first 48 hrs in the H2O tanks, where fish were observed getting stuck in porewater sampling tubes. The total number of sturgeon fry that were replaced within the first 48 hrs was 28 fish. There is some uncertainty associated with the potential for sturgeon fry to be completely flushed from exposure chambers (i.e., beyond the posterior chamber; refer to Appendix A), but as mentioned above, fish escapes were generally an issue with the H2O exposures, and there was no observation of fish leaving the system.

While achieving the nominal target seeding density for all chambers was the desired outcome, it was also important to seed all tanks as quickly as possible to closely align the initiation of exposures across the various treatments. Variability in seeding density was not anticipated to affect the study outcome because of the conservatively low target stocking density used in this study, which was well below the stocking density described by Tompsett et al. (2014) for maximizing number of fish per tank while minimizing density-dependent mortality. In addition, a complete accounting of fish mortality, loss, and survival after 48 hrs provided a mechanism to determine the number of fish seeded in each exposure system.

During exposures, daily activities included:

1. Conduct morning exposure system checks
2. Feed
3. Conduct morning observations
4. Fill head tanks
5. Maintain food cultures

6. Evaluate morning mortalities
7. Change filters
8. Take water quality measurements
9. Evaluate noon mortalities
10. Clean systems
11. Evaluate evening mortalities
12. Set up automatic feeders
13. Conduct evening exposure system check.

Timing of these activities is clearly described in Appendix I-2. Food was introduced to exposure chambers on July 30, 2010, and continued through the duration of the exposures. Frequency of feeding was at least as often as described in the QAPP, but the timing of feeding and type of food items provided at each feeding varied during the exposures because of the level of effort associated with all other daily activities. Fish were fed *ad libitum*, but mass or volume of food provided at each feeding event was not recorded.

Total test duration extended for 60 days and was concluded on September 22, 2010. All surviving sturgeon fry were euthanized, measured, weighed, visually assessed for external gross morphology, and preserved in 10 percent buffered formalin. Although test duration extended for 60 days, there were some cases in which individual fish were in the exposure chambers for a duration ranging from 58 to 60 days. This was due to the replacement of dead fish during the first 24 hrs (in any chamber that had dead fish) or 48 hrs (H2O-only exposures, in cases where fish were stuck in sampling equipment), and the necessary staggering of test termination over 2 days (i.e., September 21 and 22, 2010). It is also important to note that during the staggered test termination events, termination was initiated in all exposure chambers on September 21, 2010, and completed on September 22, 2010. Therefore, all exposure chambers contained fish until September 22, 2010, and removal of fish on September 21, 2010, was accounted for through use of the Kaplan-Meier survival analysis.

2.4 SAMPLING METHODS AND ANALYSES – SEDIMENT

With the exception of substrates collected above the water line from the gravel bar at Deadman's Eddy, surface sediments[4] were collected using a custom-built stainless steel

[4] Surface sediments for this study are defined as the upper 4 to 6 in. (10 to 15 cm) of the sediment column.

power VanVeen grab sampler[5] specifically designed to operate in hard bottom substrates. A detailed summary of field sediment sampling activities and methodologies (including those for DE substrates as collected above the water line) are presented in Appendix C. Immediately after collection, sediments were transferred into 5-gal decontaminated polyethylene buckets[6], sealed, and transported at 4°C to the U of S, ATRF where they were homogenized and then sampled prior to exposure testing.

Following homogenization, samples were collected and submitted to Columbia Analytical Services (CAS) for chemical analyses. Specifically, and as outlined within the QAPP (TAI 2010a; see Appendix A), samples were analyzed for target analyte list (TAL[7]) total metal concentrations, acid volatile sulfide and simultaneously extracted metals (AVS and SEM), total organic carbon (TOC), polychlorinated biphenyls (PCBs), organochlorine pesticides[8], polycyclic aromatic hydrocarbons (PAHs), pH, and grain size. At the end of the study, sediment samples were also collected from the exposure chambers and submitted for further analytical testing (i.e., TOC and total TAL metals). Therefore, for the five site-specific and two reference locations evaluated, a total of 50 sediment samples were collected and analyzed for this study. In addition, confirmatory analytical testing of control substrates was also completed prior to study initiation. A summary of analytical methods and associated detection limits for sediment/substrate samples is presented in Table 2-6.

2.5 SAMPLING METHODS AND ANALYSES – WATER

As noted in Section 2.2, RENA Micro Bubbler 6-in. ceramic air-stones distributed along the length of exposure chambers were used to extract PW samples at a depth of approximately 1 in. (2.5 cm) below the sediment surface. Water samples were also collected at the sediment-water interface (SWI[9]) and overlying water (OW[10]) using high density polyethylene (HDPE) syringes (TAI 2010a,c). Additional PW and SWI samples were also

[5] The power VanVeen grab sampler is capable of exerting approximately 900 lbs of closing force.

[6] Depending on sampling success, up to ten 5-gal polyethylene buckets per sampling location (30 buckets per sampling area) were filled to attain the target sediment volume of 50 gal per location.

[7] TAL metals include: aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, thallium, vanadium, and zinc.

[8] Specifically, samples were analyzed for dichlorodiphenyltrichloroethane (DDT), dichlorodiphenyldichloroethylene (DDE), and dichlorodiphenyldichloroethane (DDD).

[9] For the purpose of this study, SWI water is defined as that water located 1 cm above the surface of the sediment within respective exposure chambers.

[10] Overlying water samples within exposure chambers were collected within the top 6 in. (15 cm) of the water column.

collected using alternative passive[11] sampling devices from dedicated "chemistry-only" chambers. These samples were collected to provide comparative data at the SWI; and to collect PW data within the top 0.4 in. (1 cm) of the sediment profile. Given that both DGT probes and peepers require a distinct period of equilibration (2 and 7 days, respectively); and necessitate disturbing the sediment during deployment and retrieval, dedicated "chemistry-only" exposure chambers[12] were used for these measurements. Samples collected with peepers and DGT probes were collected at the beginning (Day 8), middle (Day 27), and end (Day 57) of the study.

During the duration of the study and to ensure that exposure chambers were operating within design constraints (refer to Appendix A), general water quality parameters were routinely monitored in-house by laboratory personnel at the U of S, ATRF. Specifically, temperature, pH, dissolved oxygen (DO), and conductivity were monitored daily using respective YSI brand probes; while alkalinity, inorganic nitrogen (e.g., ammonia and nitrate), and hardness were monitored weekly using LaMotte Company colorimetric and titration test kits (TAI 2010a,c). A summary of analytical methods employed for in-house water quality measures is presented in Table 2-7.

In addition to the aforementioned in-house water quality performance measures, weekly PW (at 1 in. below the sediment surface), SWI, and OW samples were collected and submitted to CAS for chemical analyses. All samples were analyzed for TAL metals (dissolved and total fractions), major cations/anions[13], alkalinity, hardness, and organic carbon (dissolved and total fractions). All water samples (OW, SWI, and PW) were extracted using acid-cleaned and nanopure water rinsed HDPE syringes. With the exception of dissolved fractions, extracted samples were directly discharged into pre-preserved sampling containers, and transported at 4°C to CAS for chemical analysis. Samples in which analyses required the dissolved fraction were filtered through 0.45-µm polyethersulfone filters before being transferred into pre-preserved sampling containers and submitted for chemical analysis.

[11] For the purposes of this report "passive sampling" is used to broadly describe non-destructive sampling techniques (e.g., air-stones, pipettes, peepers, and DGT probes) that enabled the study to continue after sample extraction.

[12] As detailed within the QAPP (TAI 2010a,c; see Appendix A), exposure chambers designating as "chemistry-only" was to ensure that potential stress, if any, resulting from perturbations in deploying and retrieving DGT probes and peepers were not erroneously considered when interpreting biological endpoints. However, consistent with EPA's July 16, 2010 direction biological measurements were made from the "chemistry-only" exposure chambers and evaluated for this study.

[13] Major cations/anions as defined for this study include calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^{+}), sodium (Na^{+}), sulfate (SO_4^{2-}), chloride (Cl^{-}), and fluoride (F^{-}).

Following a 7-day equilibration period, peepers were extracted from designated "chemistry-only" exposure chambers and rinsed with deionized water to remove any residual particles from the 0.45-µm membrane surface. Using a plastic tip equipped pipette, peeper membranes were pierced and their contents immediately transferred into pre-cleaned HDPE or polypropylene vials (as provided by CAS), preserved, and transported to CAS for chemical analysis. Given the limited sample volumes associated with peepers, chemical analyses focused on dissolved metals. The total number of SWI and PW samples collected and analyzed using peepers during this study was 119.

As with the above-mentioned peepers, and following a 2-day period of equilibration, DGT probes were also carefully extracted from designated "chemistry-only" exposure chambers and rinsed with deionized water, removing any residual particles from the gel surface. Upon extraction and rinsing, DGT probes were sliced along the sediment-surface water line using a Teflon® coated blade. Respective top and bottom gel portions were further sliced into three equal stripes, transferred into dedicated 15-mL high-density polypropylene centrifuge tubes, preserved with 5-mL of 1-M HNO_3, and transported to CAS for chemical analysis. The total number of SWI and PW samples collected and analyzed using DGT probes during this study was 114.

A summary of analytical methods and associated detection limits employed by CAS for water (OW, SWI, and PW) samples in this study is presented in Table 2-8. In addition, a summary of sampling methods for water and sediment and when each type of sample was collected is presented in Table 2-9.

2.6 SAMPLING METHODS AND ANALYSES – BIOLOGICAL

During the course of the study, exposure chambers were visually inspected at least twice daily. As part of daily inspections, exposure chambers were monitored for sturgeon mortalities. If a larval sturgeon mortality was observed, the biological sample was removed using a disinfected fish net, blotted dry, weighed to the nearest 0.001 g, measured with calipers to the nearest 0.01 mm, and preserved in 10 percent formalin for a period of 24 hrs. At the end of the 24-hr preservation period, the formalin was replaced with 70 percent ethanol for long-term storage.

In addition to monitoring activities and as outlined in the QAPP (TAI 2010a,c) at the end of the study, all remaining surviving ELS sturgeon were sampled from respective exposure chambers. Surviving fish were captured using a disinfected fish net, euthanized with Tricaine®-S (MS-222), blotted dry, weighed and measured to the nearest 0.001 g and 0.01 mm, respectively, preserved in formalin, and stored at the U of S. Biological sampling activities at the end of the study were carried out over a period of 2 days. During study termination, biological sampling was initiated for all exposure chambers on September 21, 2010, and completed on September 22, 2010. Because test termination was conducted over

2 days and because of fish re-seeding during the first 24 hrs (any treatment with mortalities) or 48 hrs (H2O treatment), exposure duration ranged from 58 to 60 days, with all chambers likely containing fish exposed for 60 days.

Photographs illustrating general exposure conditions and set-up, exposure chambers, sampling methodologies, and activities completed during the course of the study are illustrated in Appendix D.

3 QUALITY ASSURANCE PROJECT PLAN DEVIATIONS AND MODIFICATIONS

This section provides a discussion of deviations or modifications to methods outlined within the QAPP (TAI 2010a,b,c; see Appendix A). This section also presents results of an internal peer review as conducted by EPA's, Office of Research and Development (ORD).

3.1 CHANGE REQUESTS

During the course of this study, four change request forms were submitted and approved by EPA. As noted within Section 1.0, a limited number of water-borne acute 96-hr toxicity tests using copper were completed for this study, refer to Appendix B. These acute 96-hr tests were intended to supplement parallel acute toxicity tests performed by the USGS, CERC on behalf of EPA; and to provide an inter-laboratory comparison of white sturgeon strain sensitivities (i.e., Sherman Creek Hatchery and Kootenay Trout Hatchery strains). Unfortunately, and as outlined in change request form (CRF) No. 1, sturgeon eggs could not be obtained from the Sherman Creek Hatchery for 96-hr acute toxicity tests conducted at the U of S, ATRF. As a result, 96-hr acute toxicity tests conducted at the U of S, ATRF were completed using sturgeon eggs obtained from the Kootenay Trout Hatchery. It was concluded that additional inter-laboratory comparisons of strain sensitivities were not a high priority, and that normalization using the BLM was sufficient. A copy of the EPA-approved CRF No. 1 and associated technical justification is provided in Appendix E.

As noted in Sections 2.2 and 2.5, DGT probes employed for this study and as evaluated during methods development work, require a 2-day equilibration period prior to sampling and subsequent chemical analyses. In preparing for collection of SWI and PW samples using DGT probes at Day 8 of the study, a discrepancy in the QAPP (TAI 2010a,c) was identified. Specifically, and as detailed in CRF No. 2, the QAPP inappropriately identified an equilibration period of 7 days for both DGT probes and peepers. To ensure that DGT probes were removed from designated "chemistry-only" exposure chambers at the appropriate time (i.e., 2 days after placement); a CRF was submitted for review and approval. As outlined in the CRF, implementing this change would not adversely affect data quality. A copy of the EPA-approved CRF No. 2 is provided in Appendix E.

Of the 42 exposure chambers, 11 were designated as "chemistry-only", in which peepers and DGT probes were installed and used to obtain additional water quality information within the top ±1 cm (±0.4 in.) of the sediment-water interface. Unfortunately, during routine cleaning operations of exposure chambers UMF-01-D (Day 22) and CTRL-D (Day 23), a number of sturgeon fry were lost. Given that these events occurred well beyond the 48-hr permissible reseeding window (TAI 2010a,c), these exposure chambers could no longer be used for biological measurements (e.g., mortality and growth). Nevertheless, in

an attempt to salvage information from these exposure chambers a CRF was submitted requesting that they be converted into and designated as "chemistry-only" replicates. A copy of the EPA-approved CRF No. 3 acknowledging that both UMF-01-D and CTRL-D be designated as "chemistry-only" exposure chambers is provided in Appendix E.

During routine in-house water quality measurements, a trend of increasing ammonia and nitrate concentrations were recorded within OW of exposure chambers. To ensure that inorganic nitrogen concentrations did not approach levels that could adversely affect study results, it was recommended that water flow-through rates be increased from 250 L/day to 375 L/day and then subsequently decreased when inorganic nitrogen levels reach acceptable levels. Upon review and consideration, EPA agreed and approved CRF No. 4 (see Appendix E).

Based on the above information and as detailed within Appendix E, CRFs associated with this study are not anticipated to adversely affect study objectives.

3.2 DEVIATION/CORRECTIVE ACTION REPORTS

During the course of this study, a total of 11 deviation/corrective action report (D/C) forms were submitted. Copies of all 11 EPA-approved D/C forms are provided in Appendix E. Based on the nature of the D/C forms submitted, they can be group into three general categories.

The first category is best described as *EPA-directed* and includes D/C form Nos. 04 and 07. Consistent with EPA's July 16, 2010 direction, substrates collected above the water line from the gravel bar at DME for methods development work, were included as part of this study[14]. As detailed in D/C No. 04, although DE substrates were incorporated in the study as directed, the exposure chamber used during actual methods development work did not contain critical design components (e.g., fish screens). As a result, the exposure chamber itself was not directly employed for this study. This deviation does not adversely affect data quality or study objectives as substrates from methods development work were incorporated as directed.

Similarly, at the request and direction of EPA it was requested that a limited number of water samples be collected from water distribution head tanks within the U of S, ATRF (refer to Figure 2-3) and analyzed for hardness. As identified and detailed in D/C No. 07, this deviation does not adversely affect data quality or study objectives.

The second category is best referred to as *field sampling* D/Cs and includes Nos. 03, 05, and 06. As noted in Section 2.4, the large volume of sediment required at each sampling location,

[14] For the purpose of this study, these materials are identified as "DE" (see Section 2.2).

necessitated a large number of individual 5-gal polyethylene buckets. To ensure that samples were efficiently and accurately tracked for subsequent compositing at the U of S, ATRF 5-gal buckets were assigned a dedicated Tag number and sequentially numbered in the field. As identified and detailed within D/C No. 03, this deviation does not adversely affect data quality or study objectives.

Similarly, during field sampling activities it was observed that the presence of coarse-grained substrates (e.g., gravels, cobbles, and boulders) and an armored river bed made collecting the target sediment volume (i.e., 50 gal per location) difficult. Therefore, it was acknowledged and agreed that the strict sampling acceptance criteria as outlined in the QAPP (TAI 2010a,c) were not critical and could be relaxed. As a result, and as outlined in D/C No. 05, it was agreed that any and all sediments collected at a designated sampling location, of the appropriate targeted grain-size (i.e., sands; TAI 2010a,c), be incorporated into the total sediment volume for that specific location. As identified and detailed in D/C No. 05, this deviation does not adversely affect data quality or study objectives.

During field sampling activities conducted within the LMF area, several samples appeared to have visual evidence of historic wood burning activities. As a result, to ensure that sediments were not adversely affected by such activities, it was suggested and approved that the sediment analyte list be expanded to include polycyclic aromatic hydrocarbons. As identified and detailed in D/C No. 06, this deviation does not adversely affect data quality or study objectives.

The third category is best referred to as *exposure chamber design* D/Cs and includes Nos. 01, 02, 08, 10 and 11. Of the above-listed, D/C Nos. 01 and 11 are associated with the number of RENA Micro Bubbler 6-in. ceramic airstones installed within exposure chambers. As detailed in Appendix E, limited manufacturer supplies of the aforementioned air-stones necessitated that the density of air-stones per exposure chamber be at the low end of the acceptable range (i.e., eight per exposure chamber). Given that this density remains within design criteria, this deviation does not adversely affect data quality or study objectives, see D/C No. 01. Similarly, to ensure that an acceptable density of air-stones was available for sediment containing exposure chambers, the density of air-stones for two of the five H2O control exposure chambers were respectively adjusted to 5 and 6 air-stones. Given that these exposure chambers did not contain any sediment, this deviation does not adversely affect data quality or study objectives, refer to D/C No. 11.

As detailed in the QAPP (TAI 2010a,c), it was anticipated that ELS of white sturgeon would be placed within exposure chambers 1 dph. As outlined in D/C No. 08, however, introduction of sturgeon larvae was delayed by 1 day, resulting in study initiation (transfer of sturgeon larvae into exposure chambers) occurring 2 dph. Although the study was not initiated as intended per the QAPP (TAI 2010a,c), it was initiated consistent with the American Society for Testing and Materials (ASTM) E1241-05 guidelines. As a result, it is

not expected that this time delay will adversely affect data quality or study objectives; refer to D/C No. 08.

During the initial 48 hrs of the study and as noted in Section 2.3, observations were made of escaping or otherwise entrained sturgeon larvae from exposure chambers. As detailed in D/C No. 08, spaces, compromised seals, and accessible porewater sampling tubes within the exposure chambers (as identified by the escaping fish) were addressed. Subsequently, efforts to relocate live fish and replace dead fish were undertaken for the affected exposure chambers. It was acknowledged that these efforts, coupled with the potential that some fish may have been flushed from the system, might result in differences in starting densities, but that these differences could be accounted for at the end of the study. As a result, and as identified in D/C No. 08, it is not expected that this will adversely affect data quality or study objectives.

As mentioned in Section 2.5, to ensure that exposure chambers were operating within design constraints, general water quality parameters (e.g., ammonia, conductivity, temperature, etc.) were routinely monitored in-house by laboratory personnel at the U of S, ATRF. Within the first 2 weeks of study initiation and during routine in-house monitoring activities, it was observed that flow rates, although within an acceptable range (0.17 to 0.2 L/min), were less than the target goal of 0.2 L/min. As a result, flow rates were temporarily increased and subsequently included during routine in-house measurements thereafter. As detailed in D/C No. 10, this deviation does not adversely affect data quality or study objectives.

Following designated equilibration periods and as outlined in the QAPP (TAI 2010a,c), peepers and DGT probes were sampled at the beginning, middle, and end of the study. Samples collected at the beginning of the study using these passive sampling devices occurred 1 day after the target date. As a result, as opposed to extracting DGT probes following a 2-day equilibration period, they were extracted after 3 days for the first (beginning) event. Similarly, peepers were extracted following an 8-day equilibration period, as opposed to the intended 7-day equilibration period. As detailed in D/C No. 02, this deviation is not anticipated to adversely affect data quality or study objectives.

One deviation (i.e., D/C No. 09) associated with the acute toxicity tests detailed in Appendix B was also recorded. The purpose of this D/C was to ensure that parallel acute toxicity tests being conducted at the U of S, ATRF, and the USGS, CERC were harmonized to the maximum extent possible. As a result, rather than initiating acute toxicity tests at 15 dph as outlined within the QAPP (TAI 2010a,c), acute toxicity tests were initiated at 16 dph. As detailed in D/C No. 09, this deviation is not anticipated to adversely affect data quality or study objectives.

In addition to the deviations listed above, it should be noted that morphological anomalies (e.g., tissue color, liver size, gut/stomach filling) were not recorded for all white sturgeon

surviving beyond 50 dph. Developmental abnormalities were recorded in laboratory notebooks, and digital photographs of sturgeon were taken (presented in Appendix I). As indicated in Appendix I, all fish were assessed for the external criteria listed, while a subset of fish were dissected and gut contents recorded. However, due to the extremely small size of internal organs at this lifestage and because more than 3,000 white sturgeon needed to be processed at study termination, it was not possible to evaluate and record morphological anomalies.

3.3 PEER REVIEW

At EPA's request, the ORD conducted an internal peer review of this study and work completed by the USGS, CERC. The primary purpose of the review was to evaluate materials associated with toxicity testing of white sturgeon conducted at both laboratories. To help focus their efforts, EPA assigned the following "charge questions":

1. Charge Question #1 - QAPP Development.
    a. DQO Adequacy. Did the data quality objectives support the development of data of sufficient quality for the intended use of the data? Were important/significant DQOs missing?
2. Charge Question #2 - QAPP Modification/Deviation. For each issue identified address the following:
    a. Modifications. Was the QAPP modified after conducting the tests or in response to events during testing? How does this impact the validity of the results? Were the QAPP modifications adequate and practicable for producing usable data?
    b. Deviations. Did deviations in method performance negate any or a substantial portion of the resulting data? What is your opinion on the effect of the deviations on the method performance?
3. Charge Question #3 - QAPP and Lab Performance.
    a. DQOs and Goals. Did the method performance meet the data quality objectives and overall goals in the QAPP?
    b. Unmet DQOs and Significance. What is your opinion on the significance of not meeting these DQOs and goals relative to the use of the results?
    c. High Control Mortality. In particular, high control mortality was encountered. What is the significance of this? How might analyses be done to account for this?

   d. Numbers of Fish Used. Similarly, accounting for all fish appeared problematic; fish were lost from some exposure tanks. What is the significance of this? How might analyses be done to account for this?

4. Charge Question #4 - Opinions on Data Usability.

   a. Data Evaluation and Use. The Peer Reviewers will render their opinions on whether and how the results might be used in light of the Quality Assurance (QA) methods peer review. The reviewers will provide potential analytical methods for using the data, if appropriate. The Peer Reviewers will not evaluate test results to determine an adverse risk level.

In short, peer reviewers confirmed that in consideration of change orders (Section 3.1) and deviation/corrective actions (Section 3.2), the method performance generally met DQOs and the overall study goal; and recommended that for those age categories with high control mortalities, effect concentrations should be viewed as uncertain. Peer reviewers "believe that toxicity testing of the organisms was undertaken before successful baseline culturing techniques were established for this species, especially during transition to exogenous feeding (page 7 of 9)." A copy of ORD's findings and recommendations is available in Appendix E.

4 VALIDATION ASSESSMENT

Environmental Standards Inc. (ESI) performed the independent quality assurance and data validation review of the 2010 white sturgeon sediment toxicity data produced by CAS of Kelso, Washington. The review was performed in accordance with requirements specified in the QAPP (TAI 2010a,c), and the following guidance:

"Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use" (EPA-540-R08-008; USEPA 2009)

"U.S. EPA Contract Laboratory Program National Functional Guidelines for Organic Data Review" (EPA/540/R-99/008; USEPA 1999)

"U.S. EPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review" (EPA/540/R-04-004; USEPA 2004)

Data were examined to determine usability of the analytical results and compliance relative to requirements specified above and the analytical methods. In addition, deliverables were evaluated for completeness and accuracy. Qualifier codes have been placed next to results on the data tables to enable the data user to quickly assess the qualitative and/or quantitative reliability of any result based on the criteria evaluated. EPA's quality assurance and quality control (QA/QC) chemist reviewed the draft data and data validation reports. Issues were resolved and EPA approved the data for public use on October 17, 2011. Data validation reports are available on the "Downloads" page of the project database (http://teck-ucr.exponent.com). The following sections summarize results of the validation. It should be noted that consistent with the QAPP (TAI 2010a), general in-house water quality parameters monitored (e.g., temperature, pH, DO, conductivity, and inorganic nitrogen) during the tests were not validated by ESI. These routine water quality parameters were monitored to ensure that toxicity tests were within design constraints at the time of testing.

4.1 OVERALL DATA QUALITY

Most (98 percent) of the data are useable, with qualifications presented in data validation reports and included in the project database. Only useable data were included in analyses and presented in figures, although all rejected data are in the project database (http://teck-ucr.exponent.com) and are presented in Tables 4-1 and 4-2 of this report. Data qualifiers were assigned to data by the laboratory and validators to signify when data were out of calibration range (i.e., below or above levels of quantification), where contaminated blanks compromised data interpretability, or if matrix spikes, internal standards, or other quality control metrics were exceeded. Tables 4-3 and 4-4 summarize the number of samples with

each type of data qualifier[15] by analyte. Information regarding how data qualifiers should be used is presented within the Draft UCR RI/FS Data Management Plan Amendment No 1 (TAI 2010g). It should be noted that samples with the greatest proportion of "U*" qualifiers (meaning that the analyte should be considered "not-detected" because it was detected in an associated blank at a similar level) were associated with non-standard sampling methods (i.e., DGTs).

Of the 50,698 analytical data points collected during this study, a total of 1,014 data points (2 percent) were rejected as follows:

- 910 results, out of 8,482 sediment data points (10 percent), for organochlorine pesticide compounds, PCB congeners, and PAH compounds were qualified as unusable due to exceeded sample preservation temperatures.
- 20 results, out of 8,482 sediment data points (0.2 percent), for molybdenum were qualified as unusable due to very low reporting limit (RL) standard recoveries.
- A total of 84 results, out of 42,216 aqueous data points (< 0.2 percent), for calcium, iron, and/or molybdenum were qualified as unusable due to very low RL standard recoveries.

Tables 4-1 and 4-2 present the details of rejected data and associated laboratory data package, or sample delivery group (SDG) number. In addition, all laboratory reports, data, and validation reports associated with rejected results can be found in the project database (http://teck-ucr.exponent.com).

4.2 SAMPLE TRANSPORT AND HOLDING TIMES

Validity of analytical data was evaluated with regard to sample preservation conditions and sample holding times from the date of collection to the date of analysis. As identified in Tables B-3 and B-4 of the QAPP (TAI 2010a), aqueous and sediment samples should be preserved at 4 ± 2°C. In cases where the sample receipt temperature was outside of the study-required range, and the associated analytical method did not specify preservation criteria, data were not qualified. Results for PCB congener 206 in two sediment samples and PAH compounds in 13 sediment samples were qualified as estimated due to receipt temperatures above the study and the method-specified range. Samples were delayed during border inspections when being shipped from the U of S (Canada) to CAS laboratory in Kelso, Washington (US).

[15] Data qualifiers are defined within the footnotes of Tables 4-3 and 4-4.

According to Table B-3 of the QAPP, aqueous samples for metals analysis should be preserved to a pH <2 su. When samples were received by the CAS laboratory the standard operating procedure (i.e., SOP SMO-GEN Sample Receiving) was followed and information documented on the CAS Cooler Receipt and Preservation Form for each SDG. The SOP required CAS to check the above referenced samples for the appropriate pH (i.e., <2 su) by pouring a small aliquot of sample from the sample container and measuring pH of that aliquot. In approximately 75 percent (610) of the 810 above referenced aqueous samples, CAS did not check for the appropriate pH due to limited sample volumes (e.g., in some cases 5 mL, of the required minimum sample volume of 15 to 20 mL to conduct metals analyses listed in Table B-3 of the QAPP). This allowed for conservation of sample volume to perform as many analyses as could be performed. However, in approximately 25 percent (200) of the aqueous samples, sample volume was not an issue and CAS was able to check pH and verify that the samples were in fact preserved properly (i.e., pH <2 su). As a result, although ESI was unable to verify that 75 percent of the aqueous samples were properly preserved, they did not qualify the metals data for these samples based on the assumption that the sampling technicians followed preservation requirements for metals analyses in Table B-3 of the QAPP, as was verified by the CAS laboratory when 200 aqueous samples checked were preserved properly. No transport holding times were exceeded.

4.2.1 Equipment Rinse Blanks

Results for calcium, iron, magnesium, sodium, aluminum, barium, copper, lead, manganese, molybdenum, nickel, zinc, cadmium, chromium, cobalt, silver, and/or antimony in several sediment samples were qualified as "not-detected" due to the presence of these analytes at similar concentrations in the associated rinse blanks.

Results for aluminum, antimony, barium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, molybdenum, nickel, potassium, silicon, silver, sodium, vanadium, zinc, mercury, chloride, fluoride, dissolved organic carbon, and/or total dissolved solids in several aqueous samples were qualified as "not-detected" due to the presence of these analytes at similar concentrations in the associated rinse blanks.

4.2.2 Laboratory Holding Times

Results for organochlorine pesticide compounds, PCB congeners, AVS/SEM, TOC, pH, and/or grain size in several sediment samples were qualified as estimated due to holding time exceedance. Samples were delayed during border inspections when being shipped from the U of S (Canada) to CAS laboratory in Kelso, Washington (US).

4.3 INORGANICS

All inorganic analyses were conducted by CAS in Kelso, Washington. Overall, the data reviewed are usable with the qualifications detailed in the validation reports and database.

4.3.1 Calibration

Results for thallium, selenium, beryllium, cobalt, iron, molybdenum, magnesium, calcium, and/or copper in several sediment samples were qualified as estimated due to out-of-criteria RL standard recoveries.

Results for thallium, sodium, beryllium, calcium, iron, copper, molybdenum, cobalt, magnesium, nickel, selenium, potassium, and/or manganese in several aqueous samples were qualified as estimated due to out-of-criteria RL standard recoveries.

4.3.2 Blanks

Results for iron, molybdenum, magnesium, selenium, thallium, calcium, arsenic, chromium, and/or nickel in several sediment samples were qualified as "not-detected" due to the presence of these analytes at similar concentrations in the associated laboratory blanks.

Results for beryllium, cobalt, iron, magnesium, manganese, molybdenum, potassium, silicon, silver, thallium, zinc, arsenic, and/or selenium in several aqueous samples were qualified as "not-detected" due to the presence of these analytes at similar concentrations in the associated laboratory blanks.

Results for sodium, calcium, chromium, copper, iron, potassium, molybdenum, thallium, and/or magnesium in several sediment samples were qualified as estimated due to significant negative instrument bias in the associated laboratory blanks.

Results for chromium, copper, potassium, calcium, iron, silicon, molybdenum, aluminum, magnesium, and/or sodium in several aqueous samples were qualified as estimated due to significant negative instrument bias in the associated laboratory blanks.

4.3.3 Matrix Spikes

Results for magnesium, potassium, aluminum, lead, and/or barium in several sediment samples were qualified as estimated due to out-of-criteria matrix spike recoveries.

4.3.4 Laboratory Control Samples

Results for iron and total dissolved solids (TDS) in several aqueous samples were qualified as estimated due to out-of-criteria laboratory control sample recoveries.

4.3.5 Laboratory and Field Duplicates

Results for arsenic, copper, iron, barium, aluminum, and/or grain size in several sediment samples were qualified as estimated due to laboratory duplicate imprecision.

Results for chromium, lead, zinc, and/or TDS in several aqueous samples were qualified as estimated due to laboratory duplicate imprecision.

Results for lead, thallium, mercury, barium, copper, nickel, zinc, cadmium, aluminum, antimony, chromium, manganese, vanadium, alkalinity, TDS in several aqueous samples were qualified as estimated due to field duplicate imprecision. Results for dissolved organic carbon (DOC) were qualified due to blank contamination.

4.3.6 Interference Check Samples

Results for beryllium, magnesium, and/or nickel in several sediment samples were qualified as estimated due to inductively-coupled plasma (ICP) interference.

4.3.7 Serial Dilutions

Results for calcium, chromium, lead, magnesium, and/or nickel in several sediment samples were qualified as estimated due to serial dilution imprecision.

Results for sodium, copper, aluminum, molybdenum, antimony, manganese, iron, zinc, magnesium, chromium, arsenic, barium, cadmium, cobalt, lead, nickel, vanadium, and/or calcium in several aqueous samples were qualified as estimated due to serial dilution imprecision.

4.4 POLYCHLORINATED BIPHENYL CONGENERS

Analysis of samples for PCB congeners was conducted by CAS in Kelso, Washington. Overall, data are usable with the qualifications presented in the validation reports and database.

4.4.1 Calibration

Results for PCB-149 in several sediment samples were qualified as estimated due to a calibration issue.

4.4.2 Blanks

An evaluation of laboratory blanks associated with PCB congener analyses revealed no contamination issues.

4.4.3 Co-elution

An evaluation of chromatograms associated with PCB congener analyses showed acceptable peak resolution and no co-elution issues.

4.4.4 Surrogate Recovery

All PCB congener surrogate recoveries were within acceptance limits.

4.4.5 Matrix Spikes

All PCB congener matrix spike results were within acceptance limits.

4.4.6 Laboratory Control Samples

All PCB congener laboratory control sample results were within acceptance limits.

4.5 ORGANOCHLORINE PESTICIDE COMPOUNDS

Analysis of samples for organochlorine pesticide compounds was conducted by CAS in Kelso, Washington. Overall, data are usable with qualifications presented in the validation reports and database.

4.5.1 Calibration

Instrument stability was demonstrated for organochlorine pesticide analyses and all initial and continuing calibration results were within acceptance limits.

4.5.2 Blanks

An evaluation of laboratory blanks associated with organochlorine pesticide analyses revealed no contamination issues.

4.5.3 Surrogates

All organochlorine pesticide surrogate recoveries were within acceptance limits.

4.5.4 Matrix Spikes

All organochlorine pesticide matrix spike results were within acceptance limits.

4.5.5 Laboratory Control Samples and Standard Reference Material

Results for 4,4′-DDD and 4,4′-DDE in two sediment samples were qualified as estimated due to low standard reference material recoveries.

4.6 POLYAROMATIC HYDROCARBON COMPOUNDS

Analysis of samples for PAH compounds was conducted by CAS in Kelso, Washington. Overall, the data are usable with the qualifications presented in the validation reports and database.

4.6.1 Calibration

Instrument stability was demonstrated for PAH analyses and all initial and continuing calibration results were within acceptance limits.

4.6.2 Blanks

Results for naphthalene in several sediment samples were qualified as ″not-detected″ due to its presence at a similar concentration in an associated laboratory blank.

4.6.3 Surrogates

All PAH surrogate recoveries were within acceptance limits.

4.6.4 Matrix Spikes

All PAH matrix spike results were within acceptance limits.

4.6.5 Laboratory Control Samples

All PAH laboratory control sample results were within acceptance limits.

5 RESULTS

Analytical and biological data were analyzed to characterize exposure conditions and to evaluate the effect of these conditions on white sturgeon survival and growth. Analytical data were analyzed on the basis of treatment, exposure chamber (i.e., replicate), and sampling depth categories (i.e., OW, SWI, and PW). Details regarding data (analytical and biological) processing are presented in the following section.

5.1 SEDIMENTS

With sediment sampling locations targeted in areas north of RM-703 (i.e., white sturgeon spawning- and/or nursing-grounds), it is reasonable that predominant sediment grain sizes collected and evaluated for this study were sand-sized particles, having diameters ranging from very coarse (< 2.0 mm) to very fine (≥ 62.5 μm) sands. As indicated in Table 5-1, the average grain size distribution of Site sediments were approximately 0.5 percent gravels, 97.3 percent sands, and 1.9 percent silts/clays. Reference sediments were slightly coarser having an average grain size distribution of 20.9 percent gravels, 76.5 percent sands, and 1.4 percent silts/clays.

As outlined in Section 2.1, the primary focus of this study was (under laboratory controlled conditions) to assess toxicity of ELS of white sturgeon to a gradient of COPCs associated with sediments; with a primary focus on those COPCs commonly associated with granulated slag (i.e., cadmium, copper, lead, and zinc). As a result, the following analyses are concomitantly centered on these four primary metals of interest. Data for all whole sediment COPCs are presented (as probability distribution plots) in Appendix F, with similar plots of the aforementioned primary metals of interest illustrated in Figure 5-1 (cadmium), Figure 5-2 (copper), Figure 5-3 (lead), and Figure 5-4 (zinc).

As indicated in Figures 5-1 through 5-4, sediment concentrations of cadmium, copper, lead, and zinc in samples collected for this study span the distribution of values observed in historical samples obtained at the Site (historical data are available in the UCR database at http://teck-ucr.exponent.com). In particular, reference samples have concentrations consistent with the low-end of the distribution of historical values for these metals (i.e., often extending below the 10th percentile). In contrast, Site samples have concentrations representative of the extreme end of the distribution of historical values for these metals, with values routinely exceeding the 90th percentile, the one exception was Cd, whose values were less than the 75th percentile. Based on these results, sediments evaluated for this study appear representative and consistent of the range of concentrations observed with Site sediments.

In addition (also illustrated in Figures 5-1 through 5-4), Site sediment concentrations in this study consistently exceeded respective threshold and probable effect concentrations (MacDonald et al. 2000). Although these effect concentrations were not necessarily developed to evaluate potential effects on demersal fish species such as white sturgeon, they are included herein to qualitatively assess the range and gradient of potential effects.

Exceedances of probable effect concentrations were further evaluated by the calculation of mean probable effect concentration quotient (mPECQ), which considered either the four primary metals of interest (cadmium, copper, lead, and zinc) and the eight metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc) commonly calculated to express potential effects for mixtures of metals in sediments (MacDonald et al. 2000). Figures 5-5 through 5-8 show sediment concentrations for arsenic, chromium, mercury, and nickel. As illustrated in Figure 5-9, the average mPECQ as calculated for the four study-specific primary metals of interest was 7.3 and ranged from a low of 0.03 to a high of 21. Considering all eight metals, the average mPECQ was 3.8 and ranged from a low of 0.02 to a high of 11. Not surprisingly, mPECQ values for the four primary metals are greater than values calculated for all eight metals because PECQ's for arsenic, chromium, mercury, and nickel are typically lower than for zinc, copper, lead, and cadmium at the Site; and reflects that sums of PECQ values are divided by eight rather than four.

In addition to whole sediment concentrations, EPA recognizes the utility of AVS and SEM for characterizing the potential toxicity of sediments contaminated with metals as part of the equilibrium sediment partitioning benchmark approach (USEPA 2005). As with the above mPECQ calculations, although the principles associated with AVS and SEM were developed based on benthic invertebrate data, the data and associated analyses presented below provide a measure of bioavailability of metals associated with sediments. As a result, this approach is used to assess the range and gradient of potential effects based on principles of bioavailability.

Specifically, these chemical characteristics (i.e., AVS and SEM) are used to define excess SEM (ΣSEM_X; the difference $\Sigma SEM - AVS$), and carbon-normalized excess SEM ($\Sigma SEM_{X,OC} = SEM_X/f_{OC}$) (Ankley et al. 1996; USEPA 2005). Based on these estimates of bioavailable metal, benthic organisms should be adequately protected in sediments if ΣSEM does not exceed AVS (i.e., $\Sigma SEM_X \leq 0$) when AVS $\geq$0.1 µmol/g. On the basis of ΣSEM_X, it has been shown that sediments with ΣSEM_X <1.7 µmol/gd pose low risk of adverse biological effects; whereas sediments with ΣSEM_X >120 µmol/gd may be expected to cause adverse biological effects. For ΣSEM_X between 1.7 and 120 µmol/gd, the potential for toxicity is uncertain. As illustrated in Figure 5-10, AVS concentrations for Site sediments associated with this study were >0.1 µmol/g; while ΣSEM_X levels lay within the range of uncertainty. As a result, these samples are further evaluated by considering carbon-normalization (i.e., division of ΣSEM_X by f_{OC}); see Figure 5-11.

A sediment with low carbon-normalized ΣSEM_X <130 μmol/g_{OC} should pose low risk of adverse biological effects due to SEMs (i.e., cadmium, copper, lead, or zinc). For sediments with high carbon-normalized ΣSEM_X >3000 μmol/g_{OC}, adverse biological effects due to SEMs may be expected. However, carbon-normalized ΣSEM_X for sediments with very low f_{OC} (i.e., <0.001) may be biased high because very little organic material is present for binding with metals; in these cases, carbon-normalized ΣSEM_X may not provide more information than does ΣSEM_X. There is currently no guidance regarding a minimum f_{OC} value for use in such calculations, although in the data used to derive the carbon-normalized ΣSEM_X benchmarks, only 12 out of >440 samples had f_{OC} lower than 0.001, with a minimum f_{OC} of 0.0005 (USEPA 2005). For sediments with intermediate carbon-normalized ΣSEM_X >130 μmol/g_{OC} and <3000 μmol/g_{OC}, there is considerable uncertainty about whether effects are expected. As illustrated in Figure 5-11, sediments evaluated in this study have carbon normalized excess ΣSEM values >3000 μmol/g_{OC}, and therefore effects from metals cannot be ruled out on the basis of AVS values alone. In these cases, sediment guidelines recommend further study (USEPA 2005), such as the biological and chemical evaluation of effects on white sturgeon as detailed herein.

5.2 DATA ANALYSIS AND STATISTICS FOR WATER SAMPLES

Unless otherwise specified all data analyses were done following the methods outlined in associated citations and conducted in the R programming environment (R version 2.9.1; R Development Core Team 2009).

5.2.1 General Water Quality Parameters

During the duration of the study and to ensure that exposure chambers were operating within design constraints, general water quality parameters were routinely monitored in-house by laboratory personnel at the U of S, ATRF. Specifically, temperature, pH, DO, and conductivity were monitored daily using respective YSI probes; while alkalinity, inorganic nitrogen (e.g., ammonia and nitrate), and hardness were monitored weekly using LaMotte Company colorimetric and titration test kits (TAI 2010a,c). A summary of in-house water quality measurements recorded during the duration of the study is presented in Table 5-2, and are graphically illustrated in Figures 5-12a through 5-12i, 5-13a through 5-13i, 5-14a through 5-14i, 5-15a through 5-15i, 5-16a through 5-16i, 5-17a through 5-17i, 5-18a through 5-18i, 5-19a through 5-19i, and 5-20a through 5-20i.

As indicated in Table 5-2, the average daily temperature recorded within overlying waters of all exposure chambers was approximately 15.5°C, which is within the test acceptance criteria; and instantaneous temperatures were within ± 3°C of 15°C (with the exception of two measurements collected on July 31, 2010, in replicate D of the GE treatment and replicate A of the LMF treatment) (TAI 2010a). Similarly, average DO concentrations within

all exposures chambers were maintained above the minimum test acceptability requirement of 70 percent, while all other water quality parameters did not vary by more than 50 percent. Therefore, routine water quality parameters measured within all exposure chambers met minimum test acceptability criteria throughout the duration of the study. A complete assessment of test acceptability requirements is provided in Table 5-3.

5.2.2 Analytical Laboratory Data

Analytical laboratory data were processed to ensure transparency and that data analyses, calculations, and graphics could be easily repeated. Analytical data were categorized based upon sample type (e.g., OW, SWI, and PW); treatment type (i.e., sediment source at LALL, GE, NP, UMF, LMF, LD, or DE); tank replicate[16]; and measurement type (e.g., dissolved and bulk metal). These categories allowed for the explicit and systematic processing of data to quantify and evaluate a wide-range of exposure conditions throughout the duration of the study.

Concentration data were summarized on the basis of sediment source, replicate tank, and depth categories within exposure chambers. In addition, water sampling techniques were factored into the analysis. As noted within Section 2.5, up to four distinct passive sampling techniques (i.e., ceramic air-stones, pipettes, peepers, and DGT probes) were employed in extracting SWI, and PW samples. Data for each of these sampling techniques were used to quantify concentrations of various analytes within exposure chambers.

5.2.2.1 Major Cation/Anion Water Quality Conditions

In addition to the general water quality parameters routinely monitored in-house by laboratory personnel at the U of S, ATRF (refer to Section 5.2.1), water quality was also measured and reported by CAS. A summary (means ± standard deviation) of major cation/anion and DOC measurements recorded during the study are presented within Table 5-4.

As indicated by the summary statistics, concentrations for major cations/anions (e.g., calcium, potassium, sodium, sulfate etc.) within OW and PW (at 2.5 cm depth) were consistent between treatments and for the duration of the study. Unlike major cations/anions, DOC concentrations were observed to be more variable among treatments (e.g., LALL and DE) and higher within PWs than OWs. As noted in Section 4.3, a sizeable number of measured DOC concentrations was qualified as estimated as a consequence of blank contamination. It is believed that DOC was inadvertently introduced into samples

[16] Up to six replicates (A, B, C, D, E, and F) were used per treatment as constrained by sediment volume collected.

during filtration at the time of collection. Of the 1,183 DOC samples collected during this study, 281 samples were affected and flagged as being associated with contaminated blanks. To be conservative (i.e., with respect to subsequent bioavailability modeling), a three-step process was used to correct all DOC concentrations (with the exception of five values) for this additional source of DOC. First, DOC concentrations were adjusted by subtracting 1.93 mg/L from measured concentrations. Second, all adjusted DOC concentrations less than a floor of 1.5 mg/L were reset to the floor value. Third, blank-corrected DOC concentrations were determined as the greater of either the adjusted DOC concentration or the 1.5-mg/L floor concentration. The average DOC concentration of 1.93 mg/L used in the first step of the blank correction process was determined from 185 samples with zero-added DOC and included 9 measurement blanks and another 176 samples from the acute water-only exposures. The floor DOC concentration of 1.5 mg/L was a reasonable lower bound for DOC concentrations in water used for these sturgeon exposures, and approximately represented the minimum organic carbon concentration in unfiltered water measured in 59 laboratory samples collected during the U of S 2009 white sturgeon acute toxicity tests (TAI 2011). It should be noted that the lowest measured DOC concentrations prior to blank correction (i.e., five samples from overlying water ranging in concentration from 0.85 to 1.49 mg/L) were roughly equal to the floor concentration. The DOC concentrations in these samples were used without correction (i.e., they were not adjusted up to the floor value). Summary statistics for reported DOC concentrations were corrected to account for blank contamination, and bioavailability modeling was performed with the adjusted DOC concentrations.

Water quality characteristics for SWI and PW (at 1 cm) are reported (as appropriate and applicable) using all three passive sampling devices. As indicated in Table 5-4, SWI concentrations of major cations/anions measured using suction (pipette) and peeper techniques were comparable, with calculated concentrations from DGT probes being very different. Given that DGT probes used in this study were specifically designed and deployed to measure the flux of the four primary metals of interest (TAI 2010a,b,c), calculated concentrations of major cations for the DGTs likely reflects resin saturation. Because diffusion coefficients are comparable in magnitude, fluxes of the hardness cations are on the order of 2,000 to 20,000 times higher than typical trace metal fluxes, and the potential therefore exists for the resin to become saturated over a time scale of hours rather than days (Zhang and Davison 1995, 1999). Data for PW quality at the 1 cm depth was limited because samples were collected via peepers and DGT probes only.

5.2.2.2 Dissolved Metal Concentrations in Exposure Chambers

Distribution of dissolved metal concentrations recorded during the duration of the study for all treatments and associated replicates, and for each passive sampling device are summarized using box-and-whisker plots (see Figures 5-21 through 5-41). For each box-and-whisker plot, recorded dissolved metal concentrations are illustrated as individual

circles. For samples where measured concentrations were non-detectable, a less than symbol (i.e., "<") plotted at the detection limit was incorporated into the box-and-whisker plots for illustration purposes only (as the true concentration is below this value). Measurements flagged during data validation due to blank contamination are illustrated as asterisks (i.e., "*"), and data qualified as "estimated" are represented with the symbol "E" at the estimated value. As previously mentioned, non-detectable concentrations (although plotted at the detection limit) have true concentrations that lay between zero and the detection limit. Given the large number of non-detectable concentrations recorded during this study, distributions as summarized by the box-and-whisker plots were determined using a maximum likelihood estimate (MLE) procedure, which considers the presence of non-detectable concentrations when estimating the mean, median, and variance for a given dataset. In short, for each distribution depicted in Figures 5-21 through 5-41, the MLE estimated 25th percentile was used as the lower edge of the box and the 75th percentile was used as the upper edge. The median is shown as a horizontal line. Whiskers extend to maximum and minimum measured values (exclusive of extreme values). Extreme values were identified as values that were more than 1.5 times the inter-quartile range (IQR) above the 75th or below the 25th percentiles, where the IQR is defined simply as the difference between the 75th and 25th percentiles. A consequence of using the MLE procedure to determine summary statistics and construct box-and-whisker plots is that data may appear elevated relative to the summary statistics conveyed by the box-and-whisker plots. This occurs because the procedure estimates the underlying distribution given the combination of detected and non-detected values. A detailed description of the MLE procedure employed is provided in Appendix G.

As outlined within the QAPP (TAI 2010a) and consistent with EPA's level-of-effort (USEPA 2010), the primary focus of this study was (under laboratory controlled conditions) to assess toxicity of ELS (including the hiding stage) of white sturgeon to COPCs associated with sediments, with a primary focus on those COPCs commonly associated with granulated slag (i.e., cadmium, copper, lead, and zinc). As a result, the following analyses presented herein are concomitantly centered on these four primary metals of interest.

Concentrations of cadmium, copper, and lead in overlying water typically varied over time and by chamber by a factor of ≤3 to 4. Concentrations of zinc in overlying water were more variable but were influenced by estimated values and non-detects. Concentrations of cadmium, copper, lead, and zinc in porewater tended to be more variable than concentrations in overlying water of the sediment-water interface. Concentrations in DE chambers tended to be more variable than measured in chambers for other sites. Table 5-5 provides a summary of dissolved metal concentrations for each treatment, sampling method, and sampling event.

Copper

As illustrated in Figure 5-29, detectable differences in measured concentrations between Site sediments and references occurred under laboratory conditions evaluated herein. Dissolved copper concentrations in control (H2O and CTRL) and reference sediment (LALL and GE) exposure chambers were consistently low for the duration of the study with an average concentration of ≤ 1 µg/L, for all sample types (i.e., OW, SWI, and PW). In comparison, elevated copper concentrations were recorded in samples containing UCR sediments with the highest concentrations being observed in PW samples collected at a depth of 2.5 cm. As illustrated in Figure 5-29, PW samples collected at a depth of 2.5 cm from exposure chambers containing DE substrates, and LD and UMF sediments were observed to have copper concentrations ≥10 µg/L. On the other hand, average PW copper concentrations at 2.5 cm for exposure chambers containing sediments from NP and LMF were closer to 3 µg/L and ≤ 1 µg/L, respectively.

As illustrated in Figure 5-29, porewater copper concentrations measured at 1 cm below the sediment surface using peepers averaged 3.08 µg/L while DGT probes averaged 3.22 µg/L with DGT probes tending to be more variable. Similarly, average copper concentrations measured at the SWI were most variable using DGT probes. Differences among average concentrations, achieved with any of the aforementioned sampling devices, appeared to be small and random suggesting that any of these sampling methods could be used to characterize metal concentrations in sediment PW and at the SWI.

Zinc

Bulk zinc concentrations varied widely between Site sediments and reference sediments; variations were approximately 3 orders of magnitude (refer to Figure 5-4). Despite those large differences in bulk sediment concentrations, zinc in OW, SWI, and PW were much more consistent (refer to Figure 5-41). Average dissolved zinc in PW varied by roughly a factor of 2 to 3. Dissolved zinc concentrations of OW in control (H2O and CTRL) and reference sediment (LALL and GE) exposure chambers were consistent, with an average concentration of ≤3 µg/L. Overlying water zinc concentrations in exposure chambers for Site sediments were somewhat higher, with average values ranging between 6 and 10 µg/L. Differences in SWI zinc concentrations between controls, references, and Site sediments were judged to be relatively small given variations by sampling technique. Average PW (at 1 cm) zinc concentrations from exposure chambers containing Site sediments were generally ≥10 µg/L and, as illustrated in Figure 5-41, varied depending on sampling technique, with DGT probes having the highest concentrations. Regardless of that variability, zinc concentrations in PW (at 1 cm) from Site sediments were somewhat greater than concentrations in control and/or reference sediments, although such differences were generally small. Zinc concentrations in PWs collected at 2.5 cm were highly variable, ranging from 1 to 1,000 µg/L across all treatments and largely qualified due to blank contamination as illustrated in Figure 5-41.

Cadmium and Lead

Average dissolved cadmium (Figure 5-26) and lead (Figure 5-31) concentrations within all exposure chambers (including Site sediments), for all sample types (i.e., OW, SWI, and PW), and all sampling techniques were generally ≤0.1 µg/L.

5.2.3 Biotic Ligand Model Application

The BLM was used to assess the toxicity and bioavailability of metals in the local aquatic environment to ELS sturgeon. This model takes into account factors such as pH, calcium concentrations (water hardness), sodium and DOC levels, which can all significantly affect bioavailability and resulting metal toxicity (Di Toro et al. 2001). Input files for application of the BLM were prepared using the above-mentioned analytical dataset, with model simulations utilizing conservative survival-based parameter files as developed from U of S, ATRF toxicity tests with ELS of white sturgeon. Application of the BLM resulted in 5,632 different BLM predictions for each metal of interest (i.e., cadmium, copper, lead, and zinc). Resulting BLM predicted effect concentrations were then evaluated against measured dissolved metal concentrations as recorded during the duration of this study. In a limited number of instances and where appropriate, assumptions and average values were used to complete BLM input data for a given sample within an exposure chamber. For instance, if sulfate and chloride values were not available within a given sample type as collected within an exposure chamber, the average value based on other samples collected within that exposure chamber were used.

As noted in Section 4.3 and illustrated in Section 5.2.2.1, a sizeable number of measured DOC concentrations were qualified as estimated due to blank contamination. Therefore, prior to being used and incorporated as a BLM input file measured DOC concentrations were "blank-corrected" to account for this imprecision. Specifically, given that the average DOC concentration recorded in QA/QC samples (i.e., measurement blanks and laboratory controls [H2O]) was 1.93 mg/L; DOC concentrations for all treatment exposure chambers and sample types were "blank-corrected: by subtracting 1.93 mg/L from the measured DOC concentration. To ensure that measured DOC concentrations were not "over-corrected" (e.g., a negative value), "blank-corrected" concentrations were not allowed to fall below the average DOC concentration for U of S, ATRF laboratory testing waters of 1.50 mg/L.

Biological endpoints modeled with the BLM were based on measured survival in white sturgeon toxicity tests (Entrix and U of S, ATRF 2011a,b). Calibration to these endpoints was accomplished by adjusting the critical accumulation of metal at the biotic ligand (BL). When multiple survival endpoints were measured and available (e.g., due to replicate testing), BLM calibration was based on the lowest observed endpoint so as to provide a conservative screening evaluation. As a result, BLM predictions are expected to conservatively evaluate whether any effects from exposure to any one of the primary metals

are anticipated. Because of these conservative assumptions, BLM predictions are not intended to predict metal concentrations where effects would actually be expected. Using this approach, resulting critical accumulation values at the BL for cadmium, copper, lead, and zinc were 2.5 nmol/g$_W$, 0.0042 nmol/g$_W$, 0.028 nmol/g$_W$, and 1.24 nmol/g$_W$, respectively.

BLM predictions were compared with observed concentrations for each metal of interest in OW, SWI, and PW (1 and 2.5 cm) sample types. To aid this comparison, toxic unit (TU) values were calculated by dividing respective measured metal concentrations by the BLM-predicted effects concentration. For a given treatment, replicate exposure chamber, and sample type, the geometric mean of measured exposure concentrations were calculated (or estimated using the MLE procedure), and used for the TU calculation. If more than 80 percent of measured concentrations were qualified (e.g., being below detection limit [BDL] or estimated) the MLE procedure was not used, and instead the calculated geometric mean was flagged as a "<" value. As detailed in Appendix G, this approach provides an upper bound of the exposure concentration, because the actual value will be lower than this estimate. A summary of calculated TUs for the primary metals of interest are illustrated within Figures 5-42 through 5-45.

As illustrated in Figures 5-42 through 5-45, under laboratory conditions evaluated herein and using the above-mentioned conservative BLM assumptions, copper was the only primary metal of interest that had calculated TUs slightly greater than one for some PW samples. For instance, PW collected at 2.5 cm from DE exposure chambers were elevated relative to other treatments, and may be a reflection that these materials were collected above the high water line. Exposure chambers containing LD sediments also had calculated TUs close to and in some instances (i.e., replicate chambers C and D) slightly in excess of one for copper.

A copy of BLM Input/Output Files associated with the abovementioned calculation is made available in Appendix H.

5.3 DATA ANALYSIS AND STATISTICS FOR BIOLOGICAL DATA

Biological data were analyzed to provide fish survival estimates at the end of toxicity tests and during the course of exposure (Table 5-6). Survival analysis considers and accounts for all fish introduced to exposure chambers, including those fish culled or "missing". In addition to fish survival being evaluated at test termination, survival data were stratified by key life stages (Table 5-7). Size data for fish surviving to test termination were used to quantify the effect of exposure treatments on fish size (Table 5-6 and Table 5-7).

Biological data were analyzed to determine if survival or growth of white sturgeon were adversely affected by exposure to UCR sediments, relative to fish exposed to reference sediments. As noted within Section 3.1, routine cleaning operations of exposure chambers

UMF-01-D (Day 22) and CTRL-D (Day 23) unfortunately resulted in a loss of sturgeon fry. As a result, these chambers were subsequently designated as "chemistry-only" and are therefore not considered in the following analysis of biological data.

Further documentation of biological data, including scans of lab books for sturgeon length, weight, and behavioral observations, and photos of sturgeon at test termination is presented in Appendix I Study Biological Data – Log Books and Termination Photos.

5.3.1 Survival Analysis

The Kaplan-Meier method (Kaplan and Meier 1958) was used to provide survival estimates during the course of the study. The Kaplan-Meier method allows for a transparent and consistent treatment of data for all exposure chambers, regardless of whether or not censoring due to lost fish occurred. The Kaplan-Meier method operates on the number of fish at risk at any given time point, and if a fish is removed for any reason (other than death), it is not counted as a mortality event, but rather, it decreases the number of fish at risk of dying at subsequent time points. Mathematically, the Kaplan-Meier method is a product limit formula, and can be described by (Equation 1):

$$\hat{S}(t_{(j)}) = \prod_{i=1}^{j} \hat{\Pr}[T > t_{(i)} \mid T \geq t_{(i)}] \qquad \text{(Equation 1)}$$

Where:

$\hat{S}(t_{(j)})$ = estimated survival probability at time *j*,

i = index of multiplication,

T = survival time, and

t = time-point of interest.

In practice, $\hat{S}(t_{(j)})$ can be determined directly from the survival data (Equation 2):

$$\hat{S}(t_{(j)}) = \prod_{i=1}^{j} \left(\frac{n_i - d_i}{n_i} \right) \qquad \text{(Equation 2)}$$

Where:

d_i = number of deaths at time *i*,

n_i = number or organisms at risk of dying at time *i*.

The effect of censoring due to lost fish can be incorporated in Equation 2 by defining $n_i = n_{i-1} - c_{i-1} - d_{i-1}$, such that the number of organisms censored (*c*) or died (*d*) at the previous time (i.e., time *i-1*) are removed from the risk set of interest (i.e., at time *i*). The ability to consider

censored observations in the survival probability function provides a direct means of accounting for effects of fish loss, while allowing lost fish to contribute to survival estimates up to the point at which those fish were lost from the exposure chamber. This methodology produced an end-of-test (EOT) survival estimate that accounted for all fish introduced into exposure chambers at the onset of the study; see Figure 5-46. In addition to the overall survival estimates presented in Figure 5-46, a complete summary and presentation of survival curves for each treatment and respective exposure chamber are provided in Appendix J.

As illustrated in Figure 5-46, survival curves for respective treatments demonstrated a consistent pattern with the greatest percentage of mortalities occurring within a narrow window (i.e., 18 to 24 dph[17]); while overall survival rates were greater than 80 percent. Exceptions were limited to two exposure chambers—a laboratory control and one Site-sediment. It is important to note that although these two treatments are identified as having the poorest overall survival rates, in both instances, this is attributable to a single replicate exposure chamber (CTRL-A) and (UMF-01-F); see Appendix J. Despite these minor exceptions, overall survival rates recorded for the study were greater than performance criterion (≥ 64 percent) specified in the QAPP (TAI 2010a; Table 5-3). Specifically, average survival of white sturgeon in the laboratory controls was 98 percent after 14 days of exposure and 85 percent after 25 days of exposure. Survival in laboratory controls on the 60th day of exposure was 80 percent. For comparison, in Ingersoll and Mebane (2013), survival of similar aged white sturgeon in laboratory controls ranged from 99 to 100 percent after 14 days of exposure and from 39 to 71 percent after 25 days of exposure. The increase in mortality during the transition to exogenous feeding observed in the present study and in Ingersoll and Mebane (2014) has also been observed in several other studies (e.g., Gisbert and Williot 1997; Bennett and Farrel 1998; Vardy et al. 2011).

As outlined in Section 1.1, the primary objective of this study was to see if survival and growth of white sturgeon were adversely affected when reared on Site sediments versus reference sediments. As a result, laboratory controls (H2O and CTRL treatments) were excluded from statistical analyses in addressing this question. End-of-test survival estimates were then statistically compared to test the null hypothesis that there was no difference in EOT survival among treatment groups. This statistical comparison was accomplished by conducting an analysis of variance (ANOVA with $\alpha = 0.05$). Because of a violation of parametric assumptions, a similar, but non-parametric Kruskal-Wallis test was conducted with $\alpha = 0.05$ (Kruskal 1952). Both statistical procedures were conducted on various permutations of the dataset, where the extreme value for UMF was either considered or ignored, and reference sites were included in the statistical test individually.

[17] As acknowledged within the QAPP and consistent with previous studies (TAI 2010a), the greatest proportion of mortalities occurs when fish are transitioning to exogenous feeding.

For all permutations of the statistical analysis, and with both ANOVA and Kruskal-Wallis, no statistical differences in survival were observed between Site and reference sediment exposures; see Table 5-8. As a result, these data indicate that survival evaluated under these laboratory conditions was not adversely affected by the type of sediment present in exposure chambers. Therefore, under the laboratory conditions evaluated herein, survival of white sturgeon was not adversely affected when reared on Site sediments versus reference sediments.

In addition to the end of test survival results, survival during critical life stages is shown in Table 5-7 for all treatments. The life stages for which survival was evaluated include test initiation to 14 dph, 15 to 24 dph, and 25 dph to test termination. Survival of white sturgeon from test initiation to 14 dph ranged from 96.5 to 100 percent for all tests. In the 15-to-24-dph life stage, which encompasses the transition to exogenous feeding stage, survival ranged from 71.7 to 94 percent, with the lowest survival observed in the CTRL test. From 25 dph to test termination, survival ranged from 90.2 to 96.8 percent.

5.3.2 Length and Weight

White sturgeon length, weight, and biomass data were summarized on the basis of sediment type and exposure tank using box-and-whisker plots (refer to Figure 5-47 and Figure 5-50). Each treatment (sediment type) depicted in Figure 5-47 and Figure 5-50, is summarized using a gray box-and-whisker plot with individual replicate exposure chambers within the treatment being illustrated with colored box-and-whisker plots. The colored box-and-whisker plots are arranged so that results from individual exposure chambers (e.g., A through F) progress from left to right.

As illustrated in Figure 5-47, the overall average weight and length of white sturgeon at EOT was approximately 0.5 g and 48 mm across all treatments. Size measurements in some treatments were consistent among replicate exposure chambers (e.g., H2O and LALL), while others were more variable (e.g., GE, LD, and UMF). Consistent with results of the survival analyses, a laboratory control was once again observed as the poorest performer. Unlike the survival analyses however where only one replicate exposure chamber performed poorly, each replicate exposure chamber for the H2O treatment consistently had the smallest fish with an average length and weight of 46 mm of 0.48 g, respectively. Biomass results are presented in two ways in Figure 5-50, with the top panel showing biomass calculated using the initial seeding density, and the bottom panel showing biomass calculated using the initial seeding density minus fish lost after the first 48 hrs of exposure. Consistent with the length and weight results, median biomass was lowest in the H2O exposure chamber. Biomass results for each exposure chamber are also presented in Table 5-9.

As with the survival analysis discussed in Section 5.2.4.1, statistical procedures were conducted with the exclusion of laboratory controls, recognizing that the laboratory control treatment (H2O) consistently had the smallest growth. To evaluate if growth of white sturgeon were adversely affected when reared on Site sediments versus reference sediments, laboratory controls (H2O and CTRL) were excluded from statistical analyses. The analysis of covariance (ANCOVA) was conducted with each reference site separately and with pooled references. Additional analyses were conducted to answer the same question, but with a little more specificity regarding the secondary hypotheses (i.e., the primary hypothesis is to assess if there is a difference among the growth endpoints, and the secondary hypothesis is to assess if fish exposed to treatment sediments were smaller than fish exposed to reference sediments). The approach initially taken was to conduct a nested ANOVA followed by a Dunnett's test (Dunnett 1955) to determine which values were significantly smaller than reference values. Results from the various statistical analyses were effectively the same, so only the ANCOVA results are described herein.

Multiple sets of ANCOVA analyses were performed to determine which variables (e.g., fish density, sediment site, etc.) had the greatest explanatory power. Length and weight of fish surviving to test termination were observed to vary as a function of number of fish (density) remaining at EOT. Fish density was not expected to affect growth because the loading rates calculated at the end of the tests (Table 5-9) were near the target loading rate of 0.1 g/L/24 hrs and well below the applicable ASTM standard of 0.5 g/L/24 hrs. In addition, appreciable variation in initial seeding densities was not anticipated. However, as a consequence of variation in initial seeding density, it was necessary to evaluate the potential for density-dependent effects and include density as a covariate if necessary. To assess the effect of sediment type on growth endpoints, it was assumed that the slope of the relationship between the endpoint (i.e., length or weight) and the number of fish surviving at EOT was equivalent for each sediment type. This assumption was unavoidable because of the unbalance in numbers of replicate exposure chambers (i.e., with only two replicate NP exposure chambers, the slope would have been strongly positive, when a reasonable slope is either zero or negative). This ANCOVA used one overall slope and an intercept for each data series, where data series indicates a specific sediment source. The statistical comparison is essentially a comparison of intercepts with a control or reference condition (see Figure 5-48 for weight and Figure 5-49 for length). Fish density within exposure chambers was the primary explanatory variable for variations in size; p-values for effect of fish density on length and weight were 7.81E-06 and 3.81E-06, respectively. The exception was a small but statistically significant reduction in fish size for the UMF treatment. An additional ANCOVA was conducted to evaluate the effect of temperature on fish size. Results of this additional ANCOVA indicate that temperature has a statistically significant influence on fish length and weight; p-values for the additional effect of temperature on length and weight were 0.0126 and 0.0283, respectively. When both fish density and temperature were included, fish from the LD and UMF treatments were statistically smaller

than fish from reference treatments; p-values for LD for length and weight were 0.0217 and 0.0472, respectively and p-values for UMF for length and weight were 0.000741 and 0.00141, respectively.

An analysis consistent with that performed for end-of-test survival was conducted with biomass results to determine if sturgeon were adversely affected by being reared on Site sediments versus reference sediments (Table 5-10). Biomass for fish exposed to the treatment sediments was not different than biomass for fish exposed to the GE reference sediment. Comparison of biomass for fish exposed to treatment sediments with biomass for fish exposed to the LALL reference sediment indicated that there was a difference when ANOVA was used (p-value = 0.0446), but no difference when Kruskal-Wallis was used (p-value = 0.0858). Because a difference was detected in the comparison of biomass in treatment exposures compared with the LALL exposure, a Dunnett's multiple comparison was used to identify which treatment was different than the LALL treatment. The Dunnett's procedure indicated that biomass was lower in fish exposed to UMF sediment compared with fish exposed to LALL sediment.

Physical and chemical characteristics of sediment samples were examined to explore potential causal explanations for the statistically smaller fish observed in UMF exposure chambers. Single variable correlation analyses were performed to identify relationships between fish size and various sediment characteristics (e.g., chemistry). No strong positive correlations with metal concentrations were observed. In addition, a multi-component discriminant analysis was conducted in an attempt to identify discriminators that could categorize fish as small, medium, or large. The multi-component discriminant analysis failed to provide descriptors that were able to predict size categories associated with the various sediments examined in this study. The difficulty in attempting to identify sediment-specific chemical or physical characteristics that can explain differences observed in fish size may be related to the relatively small magnitude of differences in fish size (e.g., ≤1 mm). A relationship between fish weight at test termination and number of surviving fish at test termination explained 57 percent of the variability. In the case of fish length, 53 percent of the variability in size is described by fish density. Three factors explained nearly 77 percent of the variation observed in size (length and weight): fish density, site, and water temperature. Fish density within exposure chambers explained 53 to 57 percent of the variation. Site and water temperature explained much less of the variability. Site explained 13 to 15 percent of the variability. Temperature explained 7 to 9 percent of the variability.

5.4 SYNOPSIS OF CHEMICAL AND BIOLOGICAL DATA

As outlined in Section 5.1, based on whole sediment concentrations in conjunction with principles of bioavailability (i.e., excess SEM), sediments had the potential to elicit adverse biological effects due to SEMs (e.g., cadmium, copper, lead, and zinc; the four primary

metals of interest for this study). As a result, additional data collected within interstitial (porewater) and overwater within exposure chambers was analyzed using the BLM to allow for more explicit consideration of bioavailability based on calculated metal accumulated at biotic ligands as the basis for predicting biological effects. As detailed in Section 5.2.3, this was carried out and illustrated with the use of calculating toxic units, which represent a ratio between measured metal concentrations in a given treatment and the BLM-predicted effect concentration. For the purpose of this study, BLM-predicted effect concentrations are metal-specific and were based on metal concentrations associated with a 20 percent reduction in survival.

Given this ratio and approach, the BLM analysis represents a conservative screening evaluation. It is important to note however that the interpretation of single point-estimate of PW toxic units over the duration of the exposure is not as straightforward; because the BLM was calibrated to estimate continuous concentrations associated with a 20 percent reduction in survival. A 20 percent level of effect was used for BLM application because concentrations associated with this level of effect are generally significantly different than those of corresponding control treatments but are not expected to have adverse effects at the population level (USEPA 2013). Using this approach, and on the basis of calculated individual toxic units (refer to Section 5.2.3), under the laboratory conditions evaluated for this study, copper was the only metal in which toxic units were >1 for a limited number of treatments and exposure chambers. Specifically, exposure chambers established using substrates from the gravel bar at Deadman's Eddy (DE) had TUs >1 in PWs collected at a depth of 2.5 cm; while sediments from the Little Dalles (LD) treatment had TUs ≥1 in PWs collected at a depth of 2.5 cm, and potentially at a depth of 1 cm in exposure chamber LD-01-D; see Figure 5-51. However, as illustrated within Figure 5-51, there is a lack of concordance between the analytical and biological data. As detailed within Section 5.2.4.1, survival of white sturgeon was not adversely affected by exposure to Site sediments or substrates (i.e., DE treatment) under the laboratory conditions of this study. Furthermore, although there were statistically significant differences in growth of white sturgeon these differences were largely explained by fish density. In addition, it cannot be overlooked that the smallest recorded growth measurements (length and weight) for white sturgeon under these laboratory conditions were consistently in a laboratory negative control (H2O). This fact was also recognized by the ORD peer review team.

6 DISCUSSION AND RECOMMENDATIONS

As an outcome of the data quality objective process, the purpose of this study and primary study question was (under laboratory controlled conditions) to assess toxicity of early life stages of white sturgeon (*A. transmontanus*) to a gradient of COPCs associated with sediments; with a primary focus on those COPCs commonly associated with granulated slag (i.e., cadmium, copper, lead, and zinc). Specifically, this study was designed to address the following questions:

- Is the survival and growth of white sturgeon adversely affected when reared on Site sediments versus reference sediments?, and
- If so, are these affects due to concentrations of sediment-associated COPCs?

Sediment samples used within this study did cover a wide-range of targeted COPC concentrations, were representative and consistent of the range of concentrations observed with Site sediments, and captured the upper concentration range (i.e., ≥ 90th percentile). Under the laboratory conditions evaluated for this study, survival of white sturgeon was not adversely affected when reared on Site versus reference sediments while growth (length and weight) were significantly correlated with fish density. Observed growth differences were not associated to any of the measured chemical factors including metal concentrations.

DQOs outlined in the EPA-approved QAPP for this study were met, and no additional white sturgeon toxicity testing has been required prior to conducting baseline ecological risk assessments. Consistent with Guidance (USEPA 1997), should EPA determine that there is insufficient information to support informed risk-based management decisions, additional data may be needed.

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FIGURES

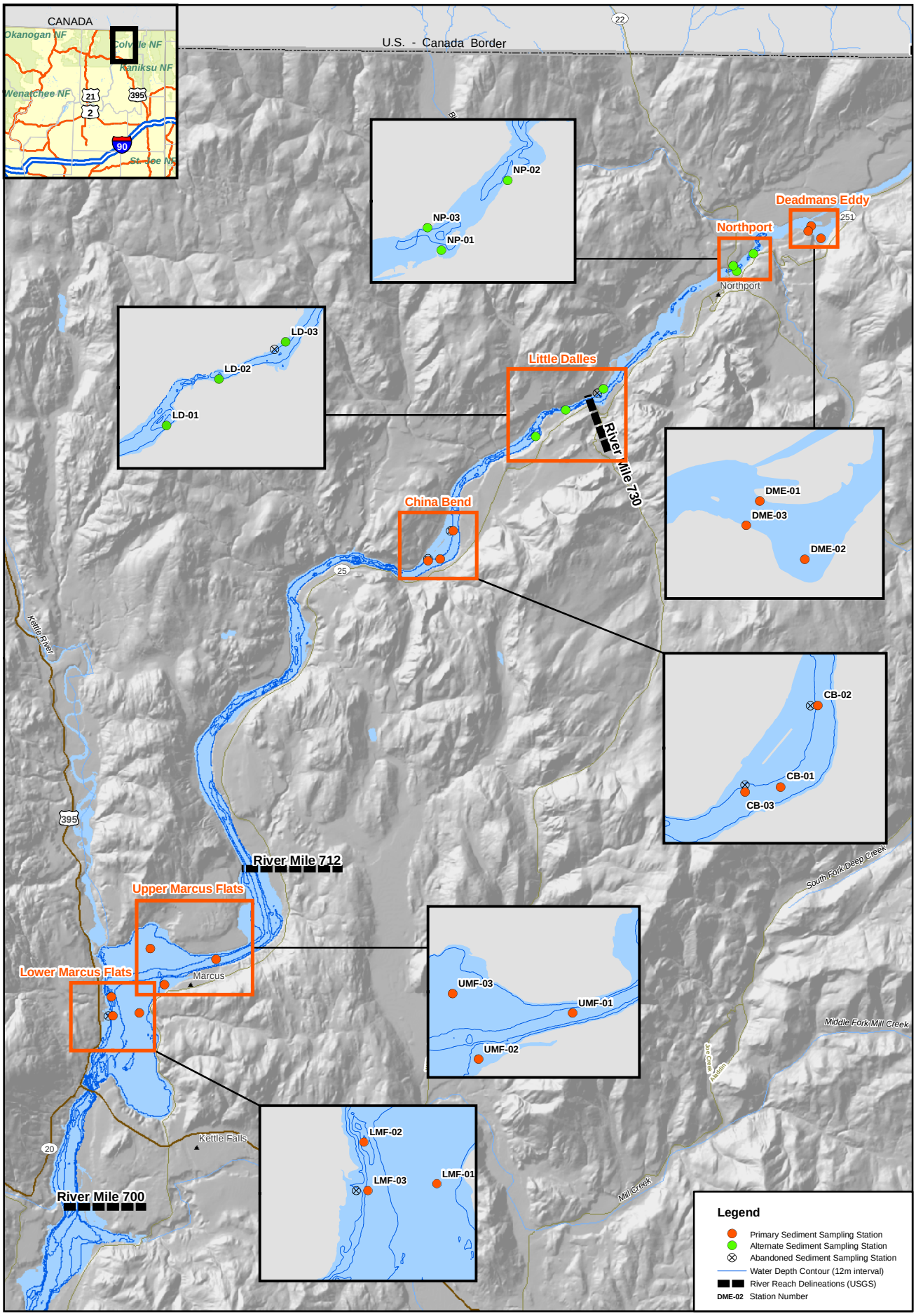


Figure 2-1. Site sampling areas

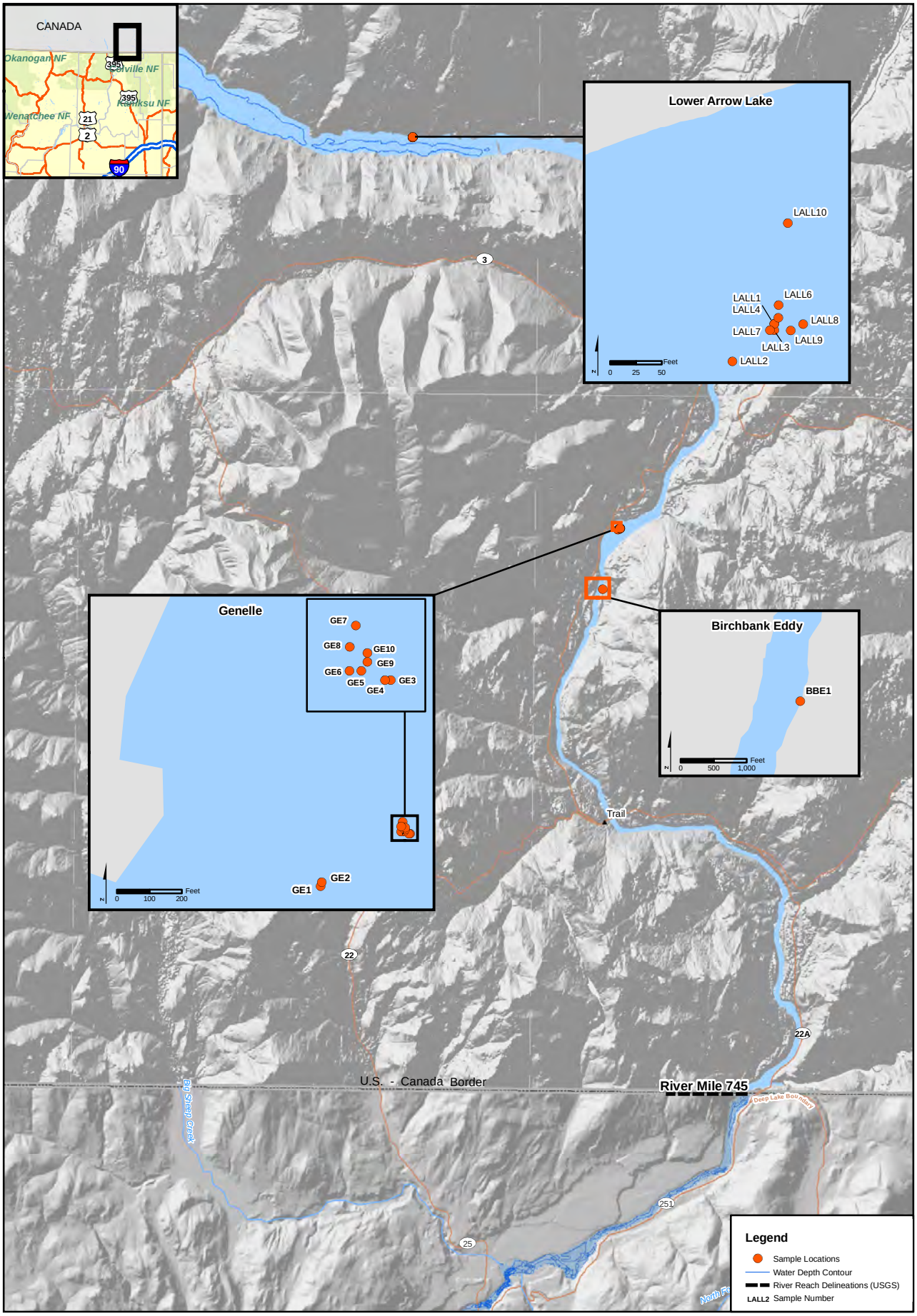


Figure 2-2. Reference sampling areas

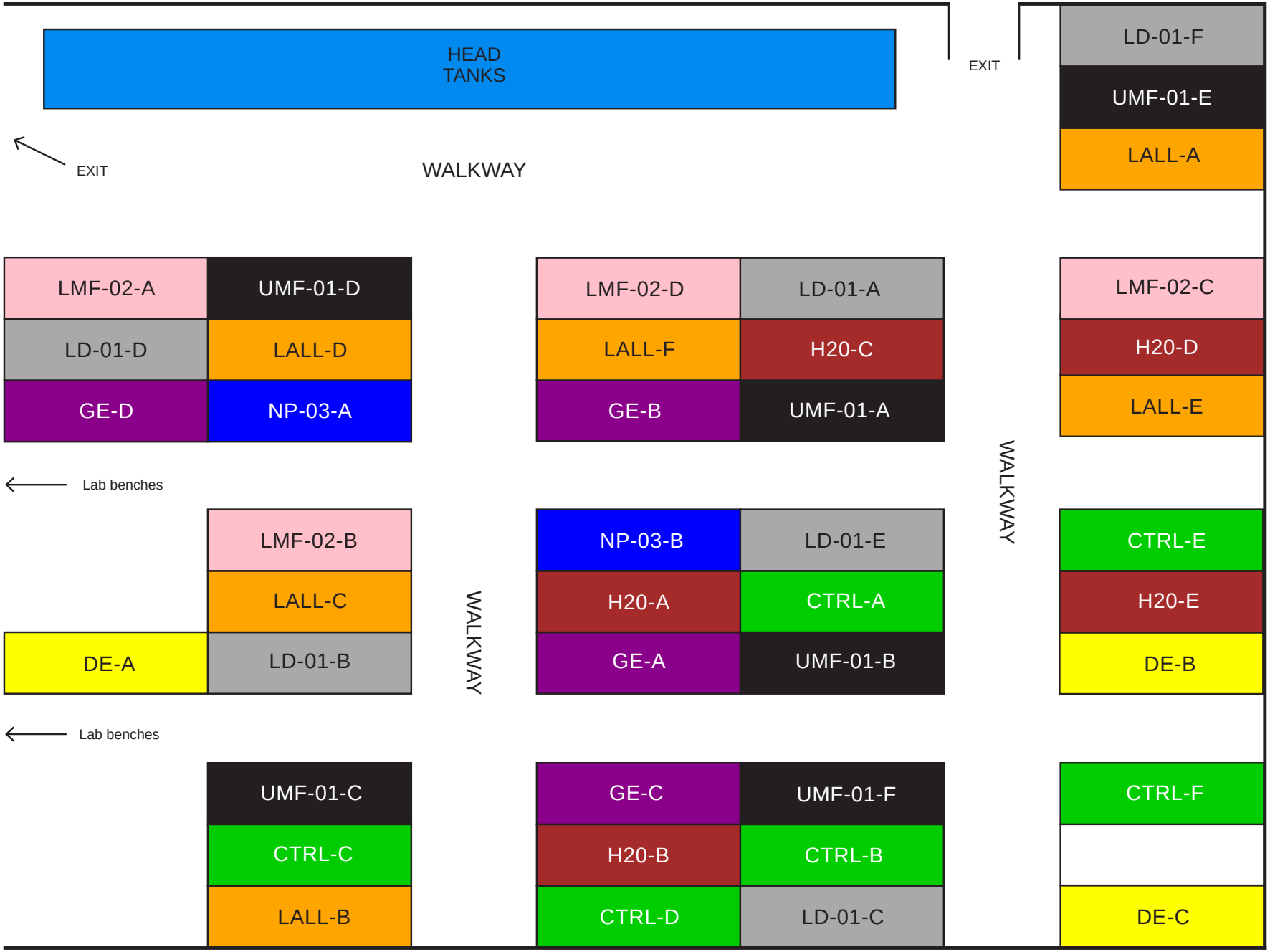
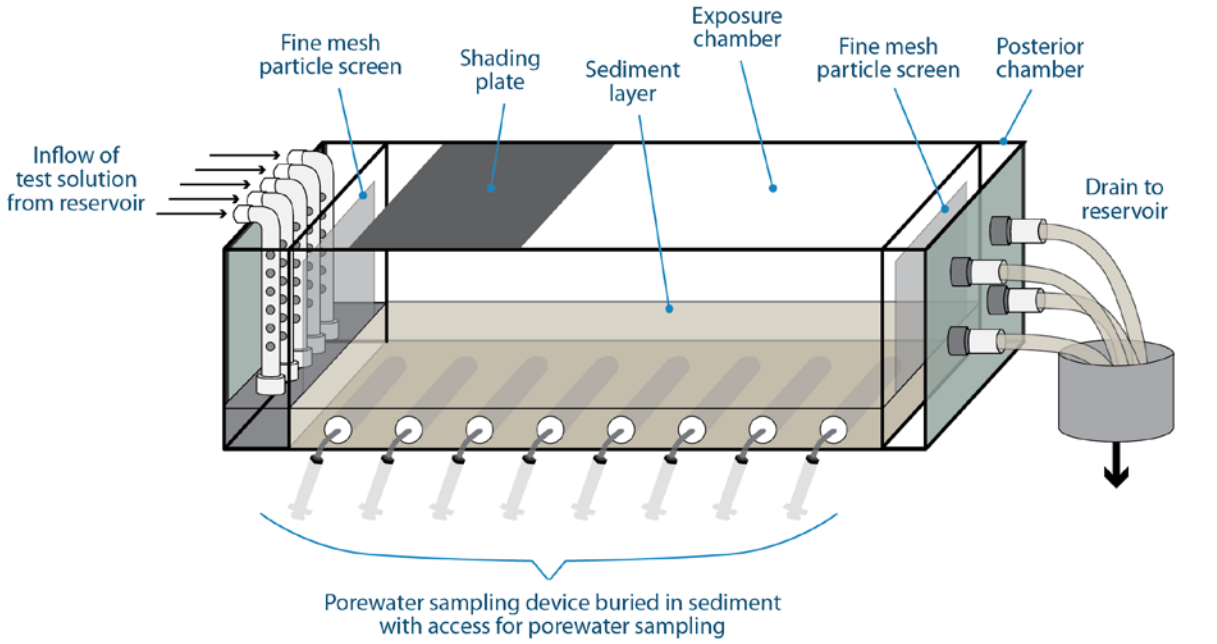


Figure 2-3. Floor plan of white sturgeon sediment toxicity exposure chambers (University of Saskatchewan, Aquatic Toxicity Research Facility)



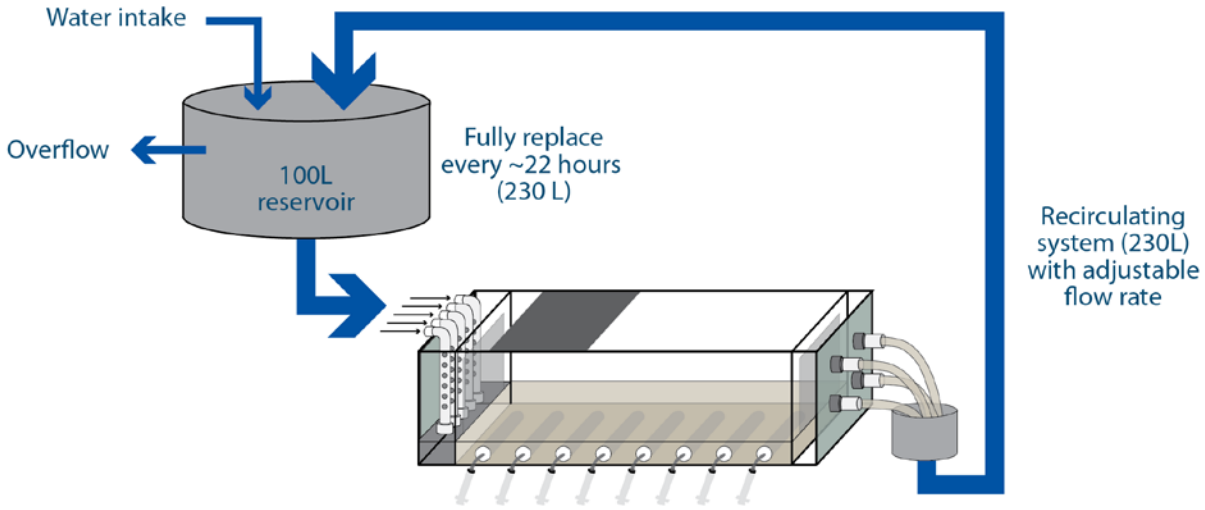


Figure 2-4. Test chamber design used in the chronic sediment exposures with early-life-stage white sturgeon

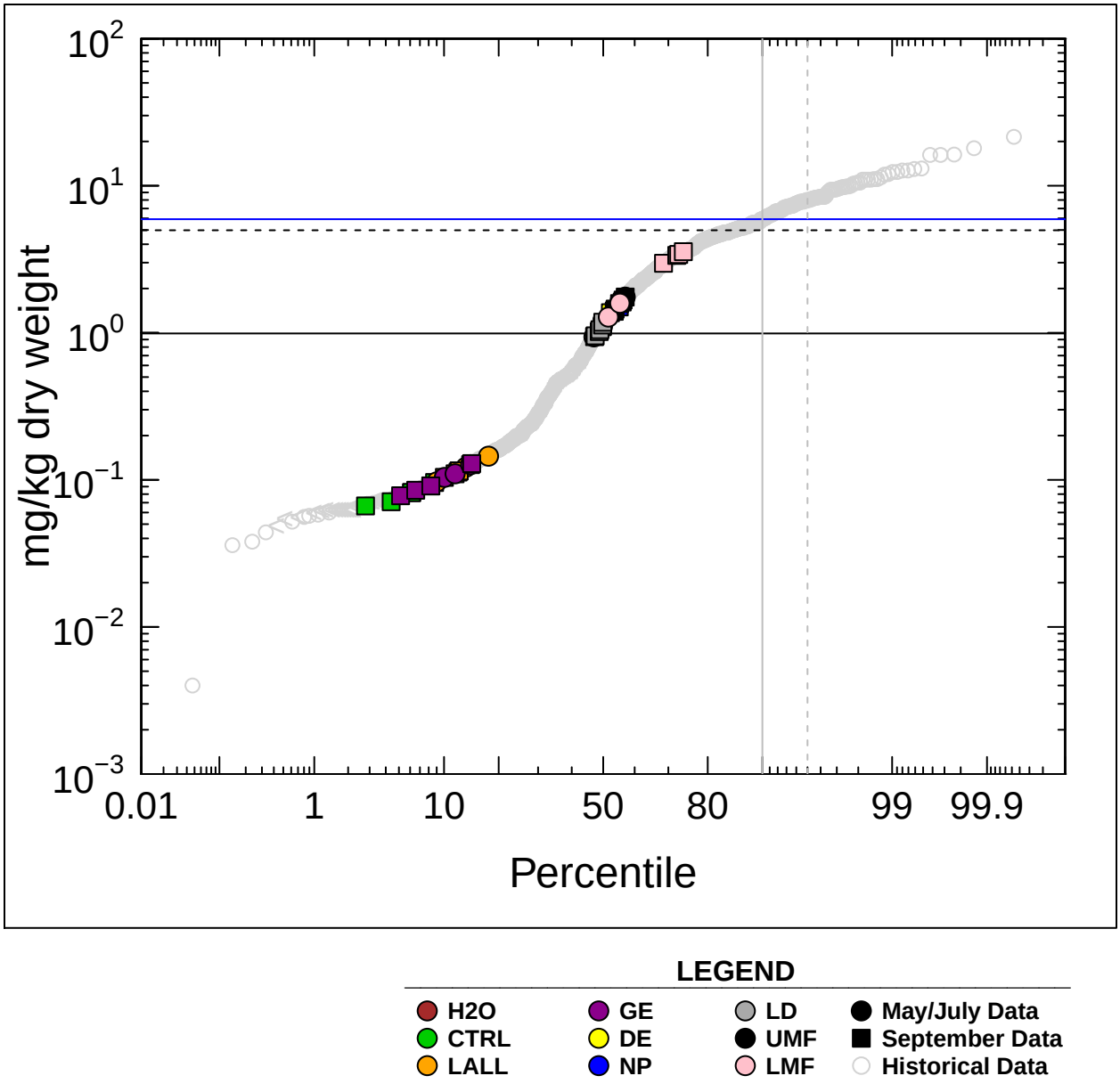


Figure 5−1. Bulk metal concentration for cadmium in sediment samples evaluated within white sturgeon sediment toxicity tests

Note: Metal concentrations identified as being below detection limits are illustrated with a less than symbol ("<") and are plotted at the detection limit. The 90th percentile of the distribution is designated with a solid horizontal blue line while a dashed line and a solid black line are used to identify the probable effect concentration and threshold effect concentration, respectively.

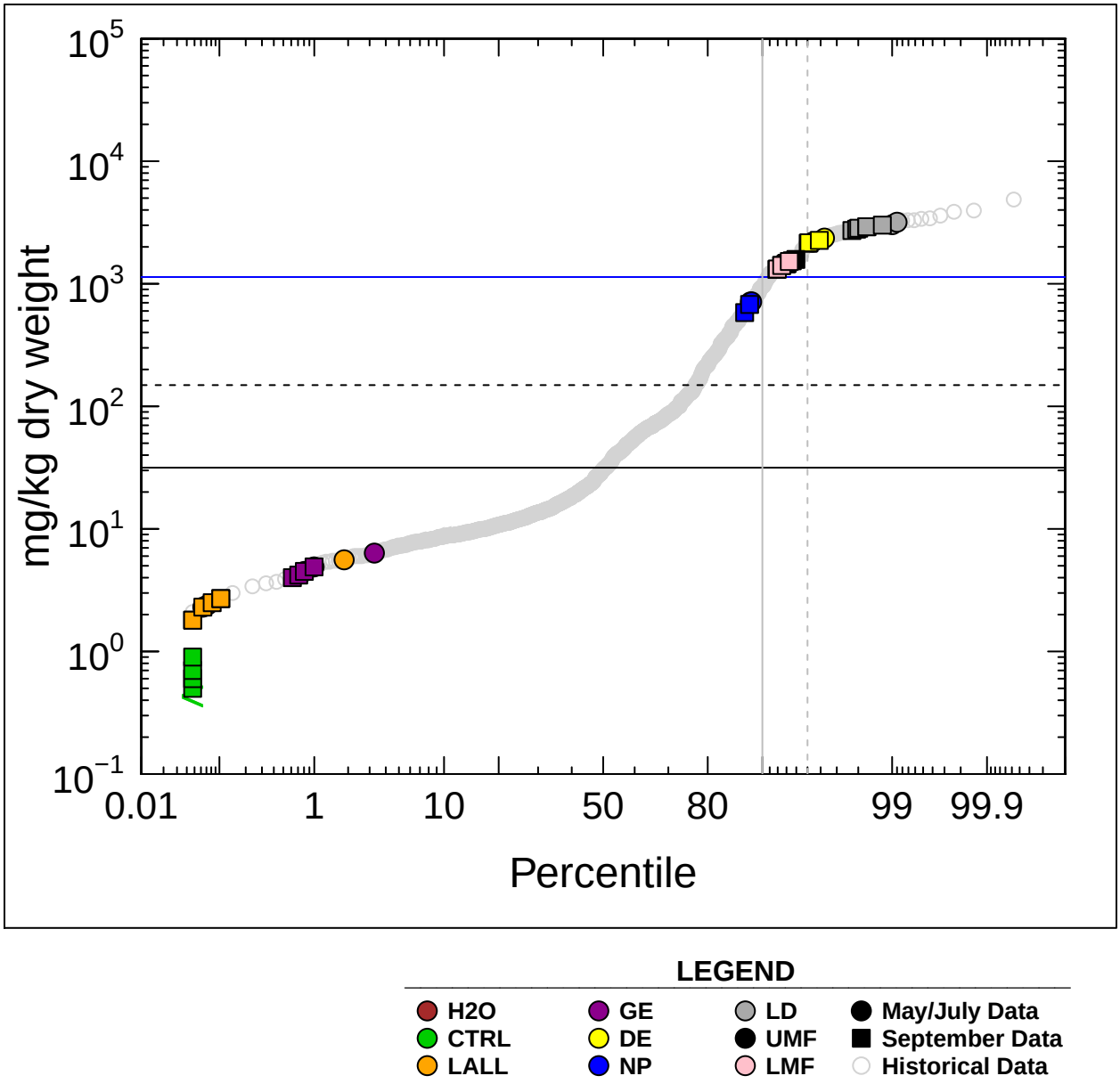


Figure 5−2. Bulk metal concentration for copper in sediment samples evaluated within white sturgeon sediment toxicity tests

Note: Metal concentrations identified as being below detection limits are illustrated with a less than symbol ("<") and are plotted at the detection limit. The 90th percentile of the distribution is designated with a solid horizontal blue line while a dashed line and a solid black line are used to identify the probable effect concentration and threshold effect concentration, respectively.

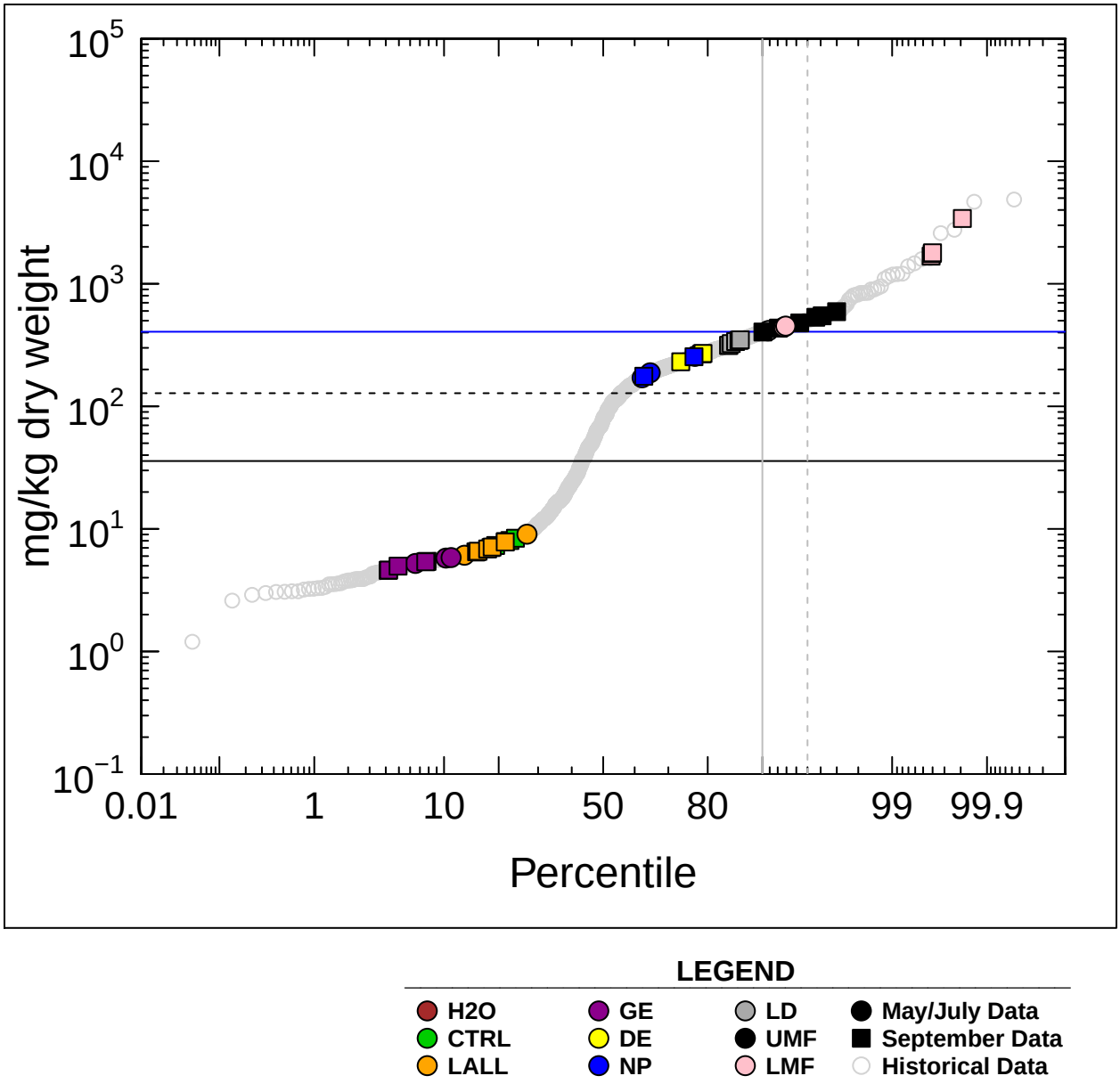


Figure 5−3. Bulk metal concentration for lead in sediment samples evaluated within white sturgeon sediment toxicity tests

Note: Metal concentrations identified as being below detection limits are illustrated with a less than symbol ("<") and are plotted at the detection limit. The 90th percentile of the distribution is designated with a solid horizontal blue line while a dashed line and a solid black line are used to identify the probable effect concentration and threshold effect concentration, respectively.

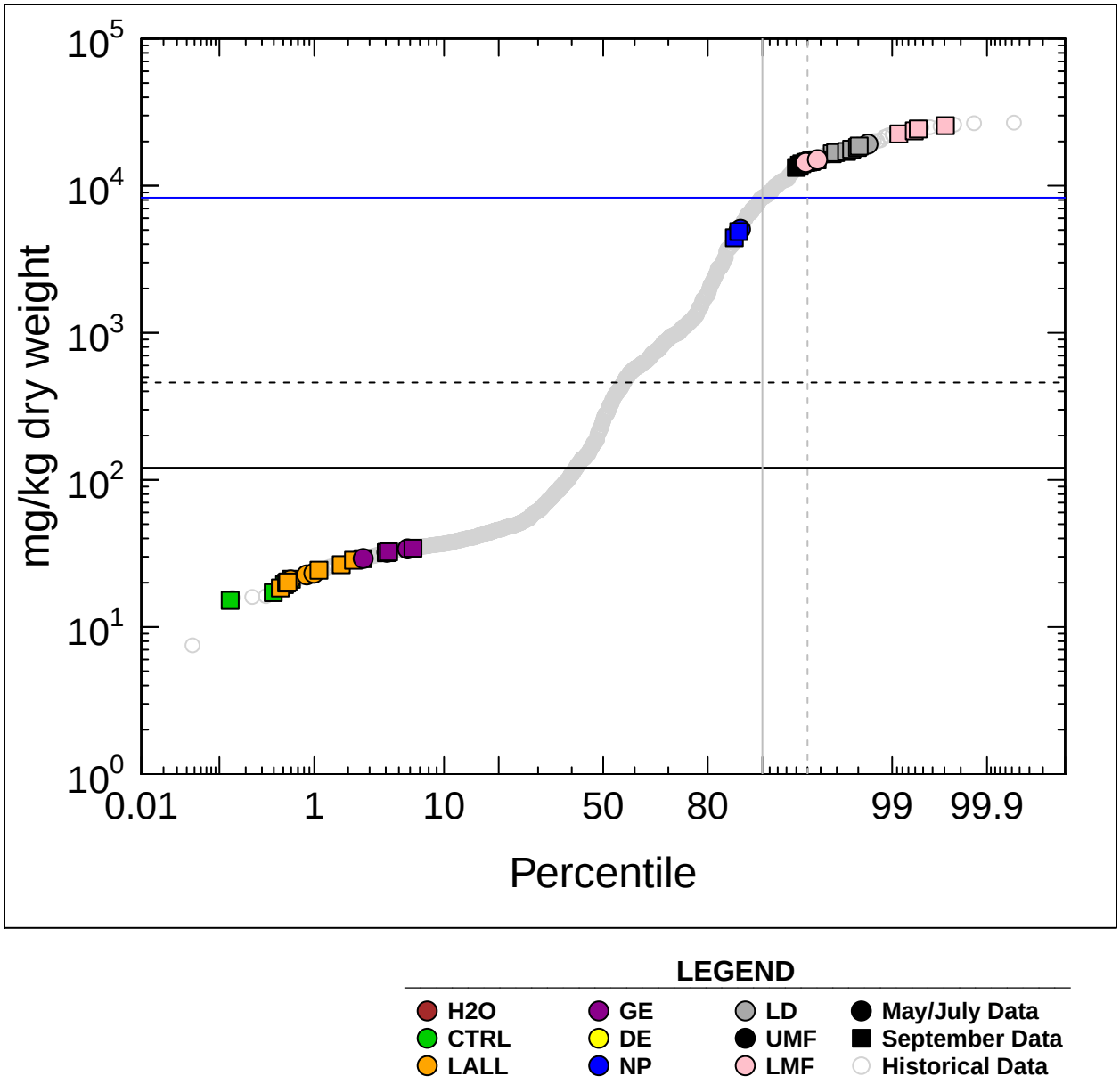


Figure 5−4. Bulk metal concentration for zinc in sediment samples evaluated within white sturgeon sediment toxicity tests

Note: Metal concentrations identified as being below detection limits are illustrated with a less than symbol ("<") and are plotted at the detection limit. The 90th percentile of the distribution is designated with a solid horizontal blue line while a dashed line and a solid black line are used to identify the probable effect concentration and threshold effect concentration, respectively.

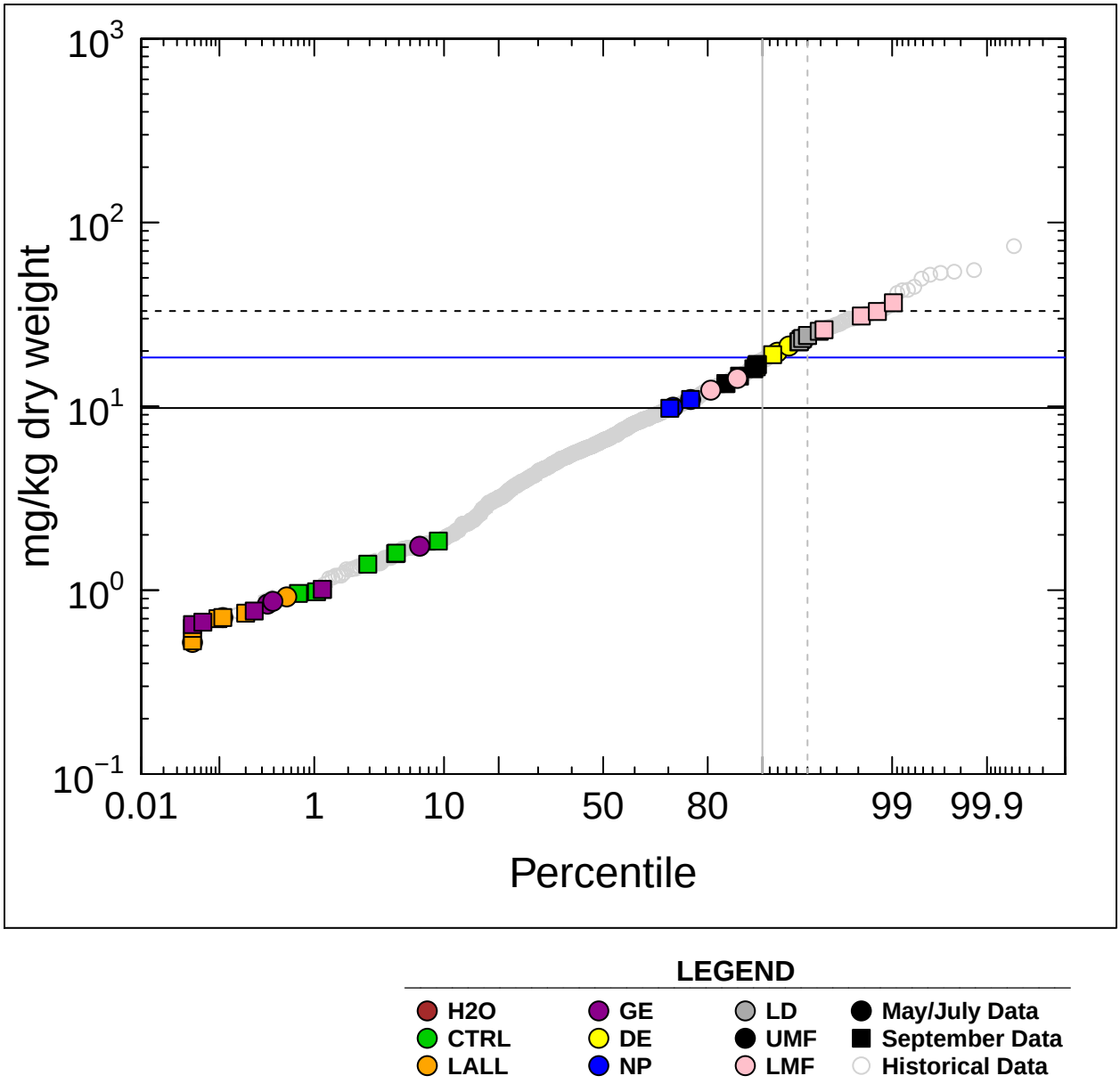


Figure 5−5. Bulk metal concentration for arsenic in sediment samples evaluated within white sturgeon sediment toxicity tests

Note: Metal concentrations identified as being below detection limits are illustrated with a less than symbol ("<") and are plotted at the detection limit. The 90th percentile of the distribution is designated with a solid horizontal blue line while a dashed line and a solid black line are used to identify the probable effect concentration and threshold effect concentration, respectively.

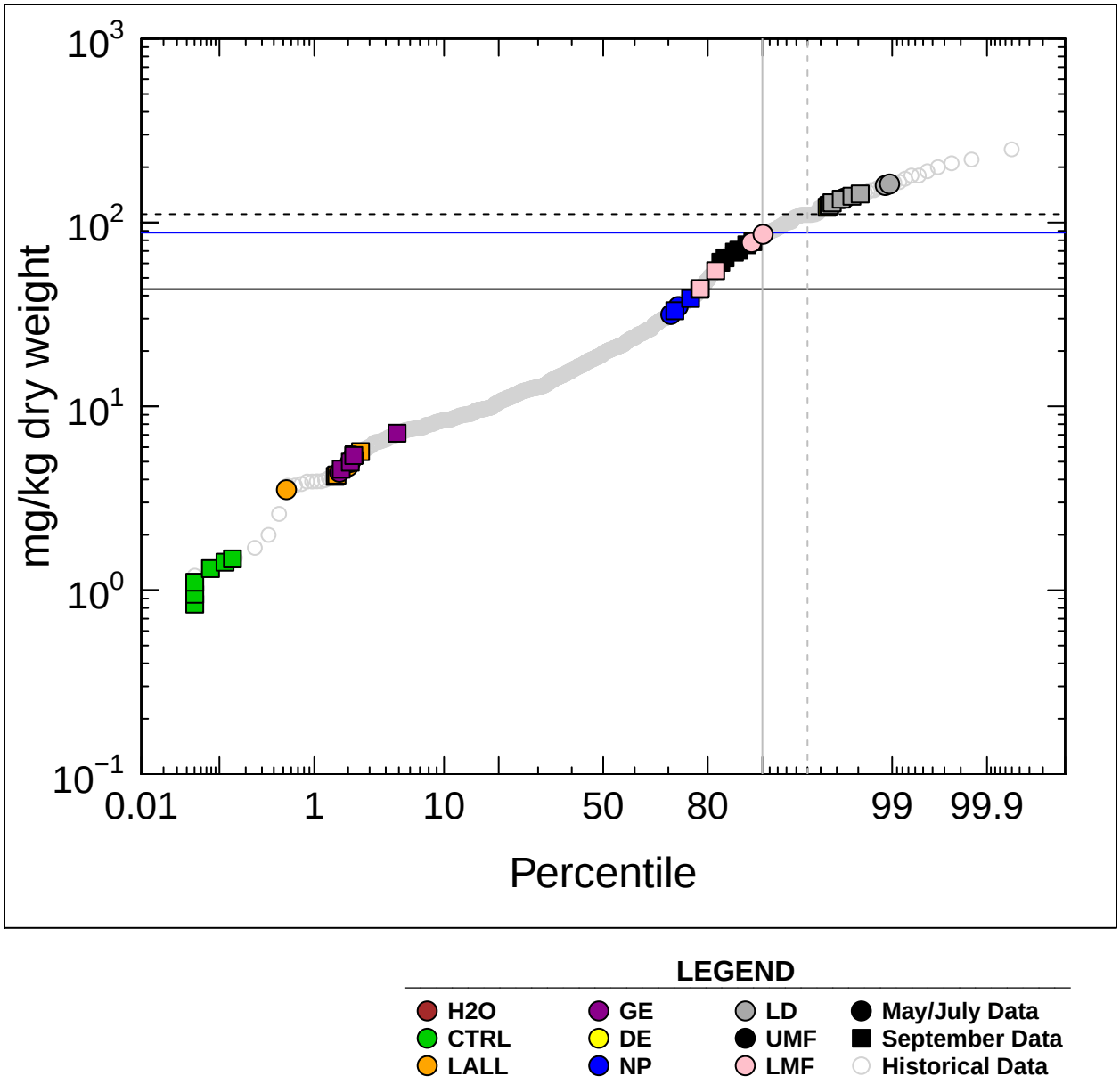


Figure 5−6. Bulk metal concentration for chromium in sediment samples evaluated within white sturgeon sediment toxicity tests

Note: Metal concentrations identified as being below detection limits are illustrated with a less than symbol ("<") and are plotted at the detection limit. The 90th percentile of the distribution is designated with a solid horizontal blue line while a dashed line and a solid black line are used to identify the probable effect concentration and threshold effect concentration, respectively.

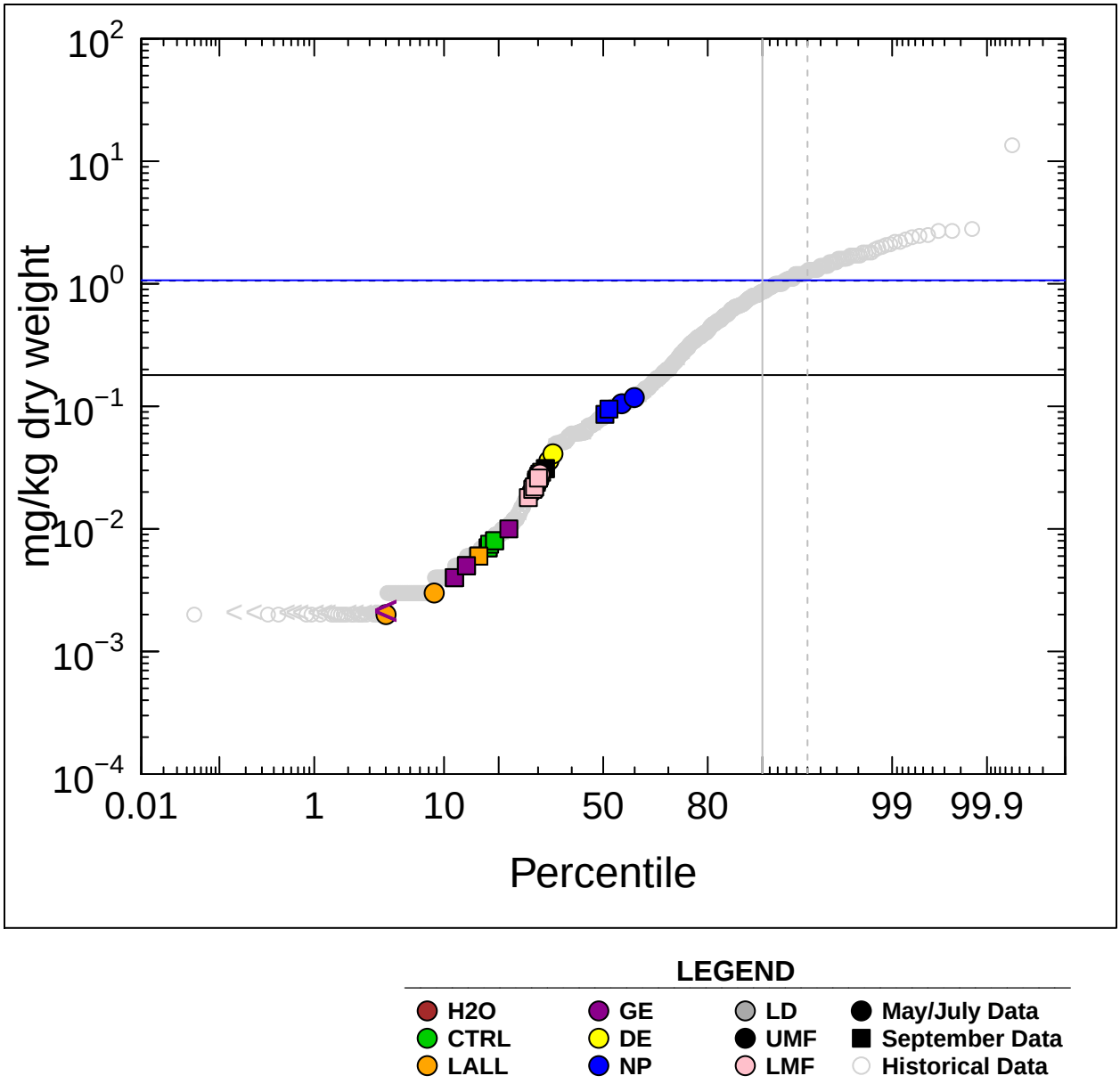


Figure 5−7. Bulk metal concentration for mercury in sediment samples evaluated within white sturgeon sediment toxicity tests

Note: Metal concentrations identified as being below detection limits are illustrated with a less than symbol ("<") and are plotted at the detection limit. The 90th percentile of the distribution is designated with a solid horizontal blue line while a dashed line and a solid black line are used to identify the probable effect concentration and threshold effect concentration, respectively.

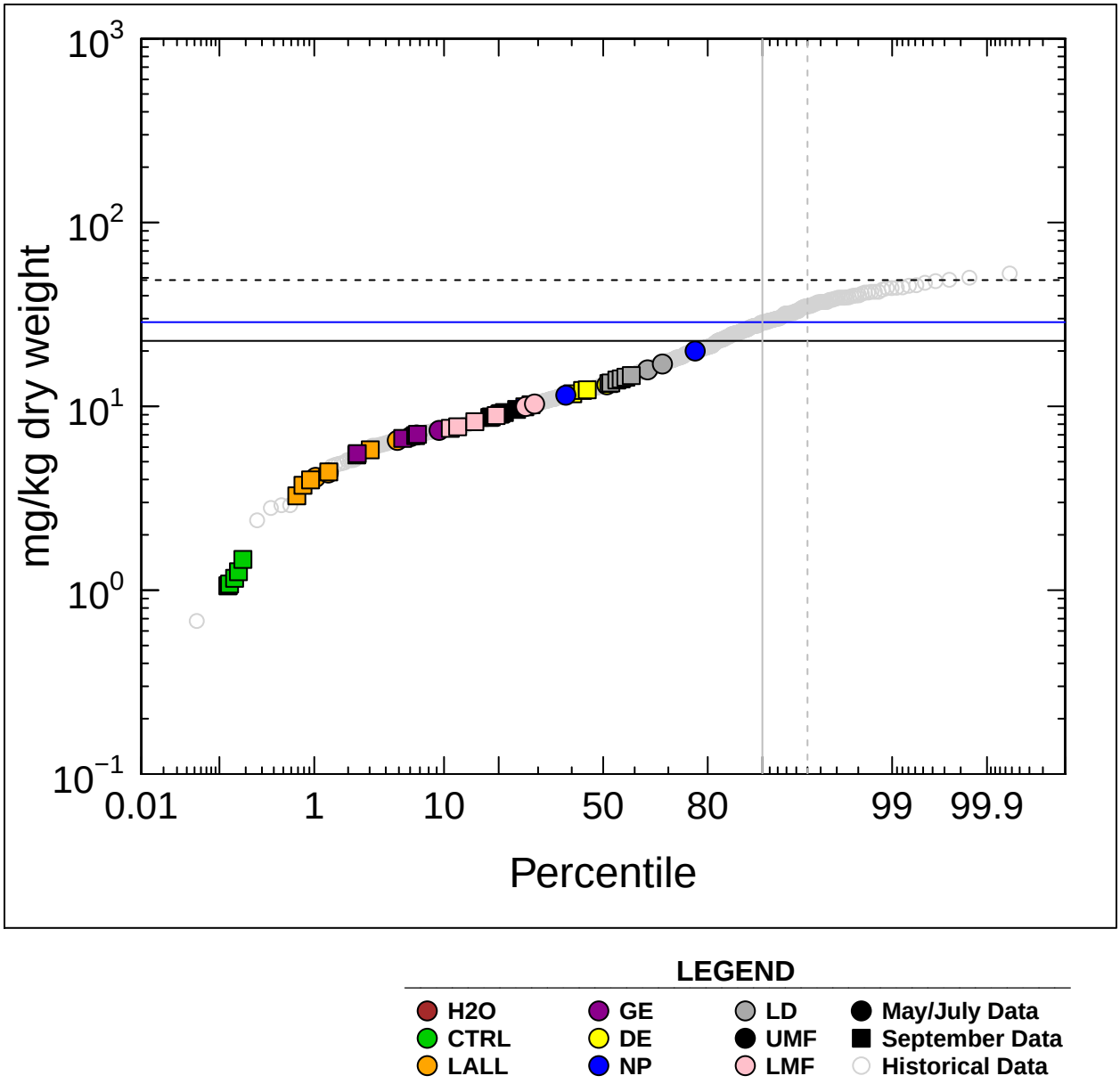


Figure 5−8. Bulk metal concentration for nickel in sediment samples evaluated within white sturgeon sediment toxicity tests

Note: Metal concentrations identified as being below detection limits are illustrated with a less than symbol ("<") and are plotted at the detection limit. The 90th percentile of the distribution is designated with a solid horizontal blue line while a dashed line and a solid black line are used to identify the probable effect concentration and threshold effect concentration, respectively.

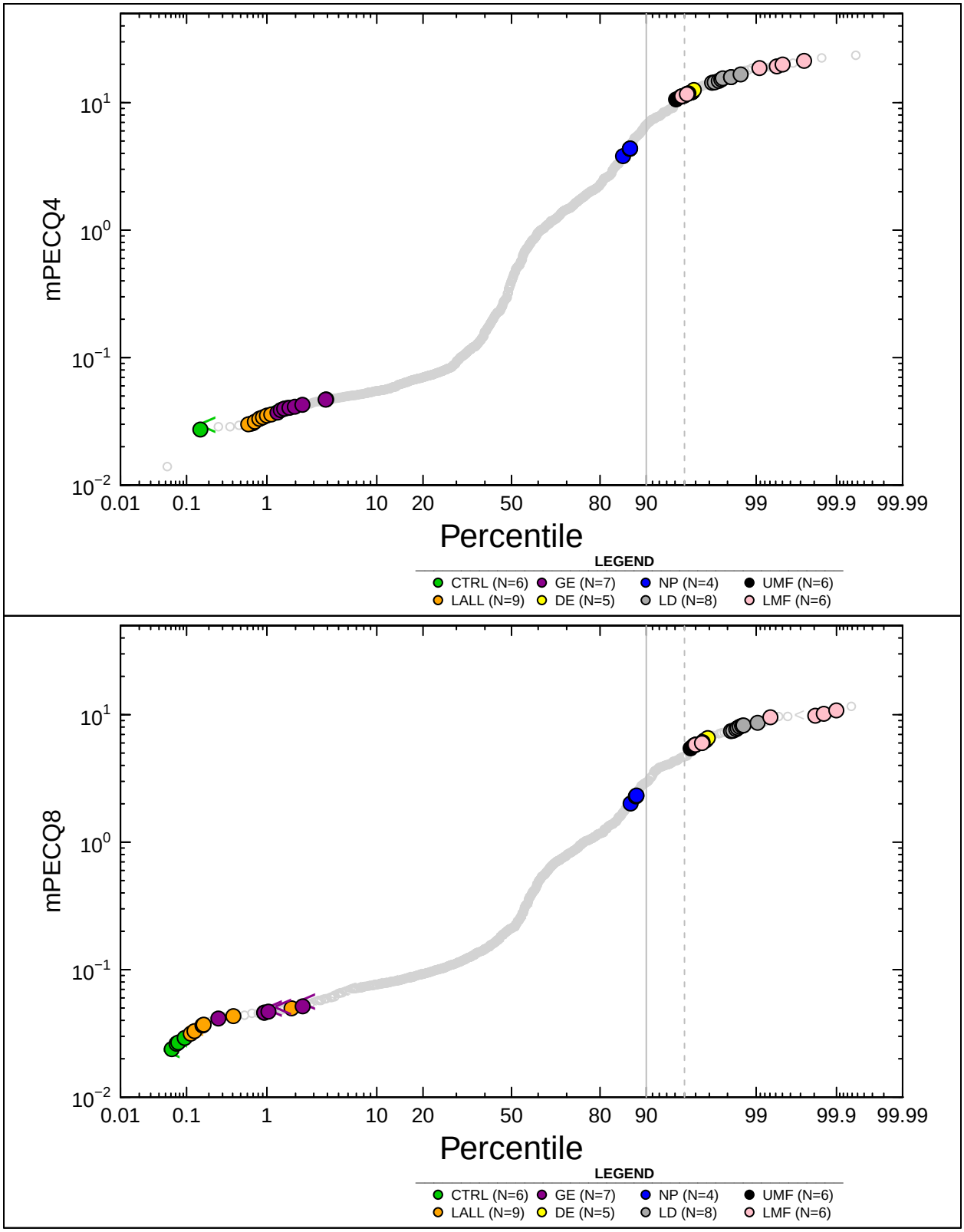


Figure 5−9. Mean probable effect concentration quotients calculated for the four primary metals of interest (top panel) and for eight metals of interest (bottom panel). Historical data are illustrated in light grey hollow symbols.

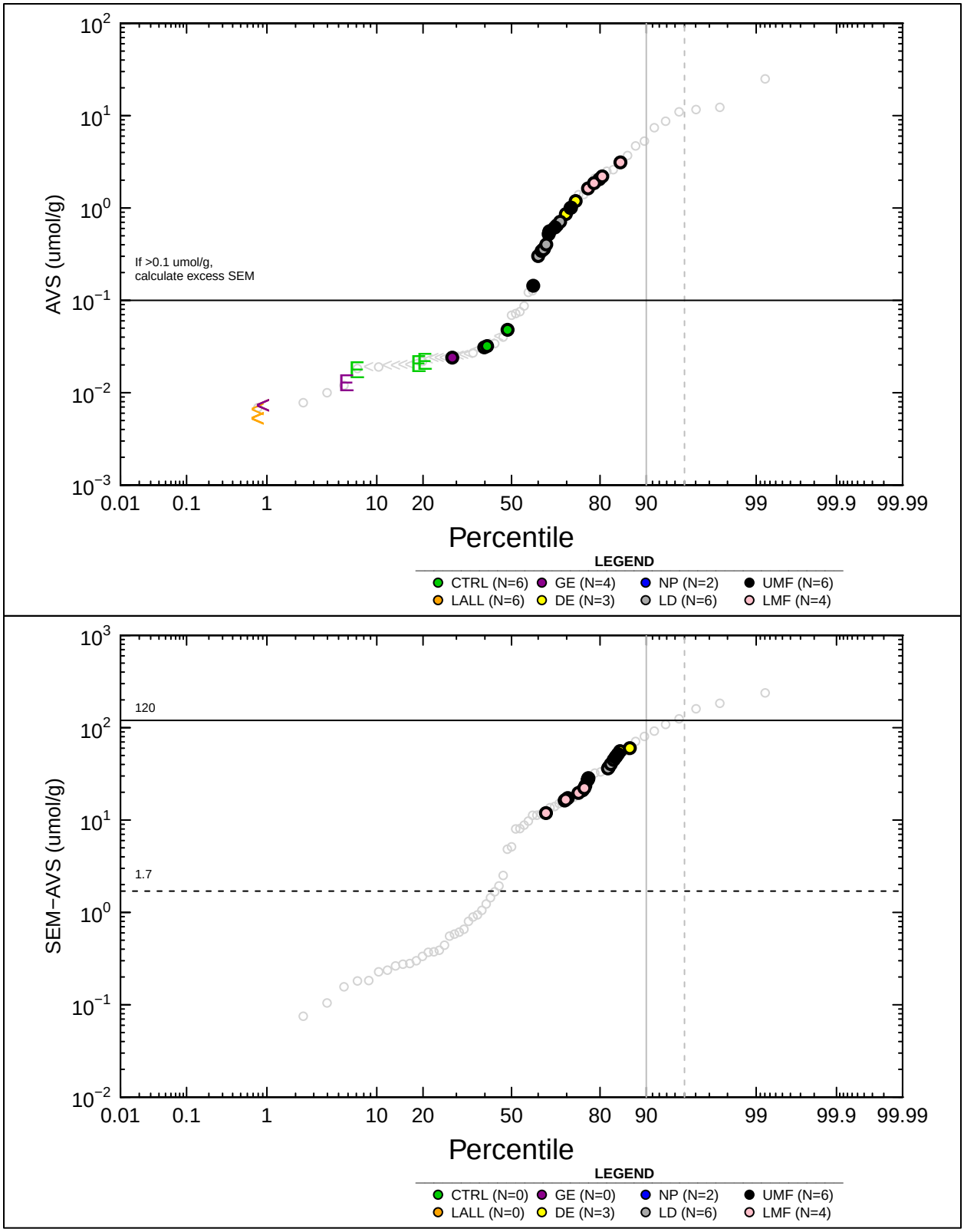


Figure 5−10. Acid volatile sulfide levels (top panel) and excess simultaneously extracted metal levels (bottom panel) in sediments for white sturgeon sediment toxicity tests

Note: Concentrations identified as being below detection limits are illustrated with a less than symbol ("<") and are plotted at the detection limit. Concentrations identified as "estimated" are illustrated with an ("E") and are plotted at the estimated value. Historical data are illustrated in light grey hollow symbols.

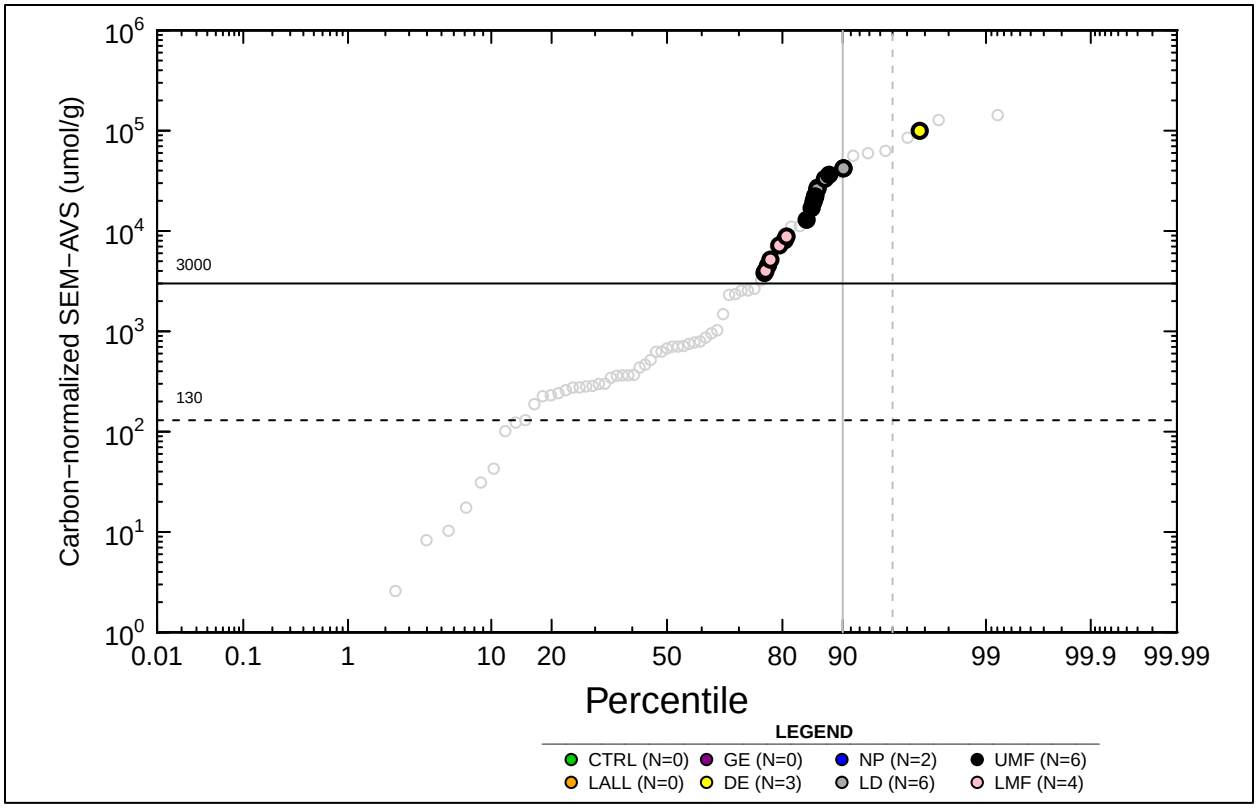
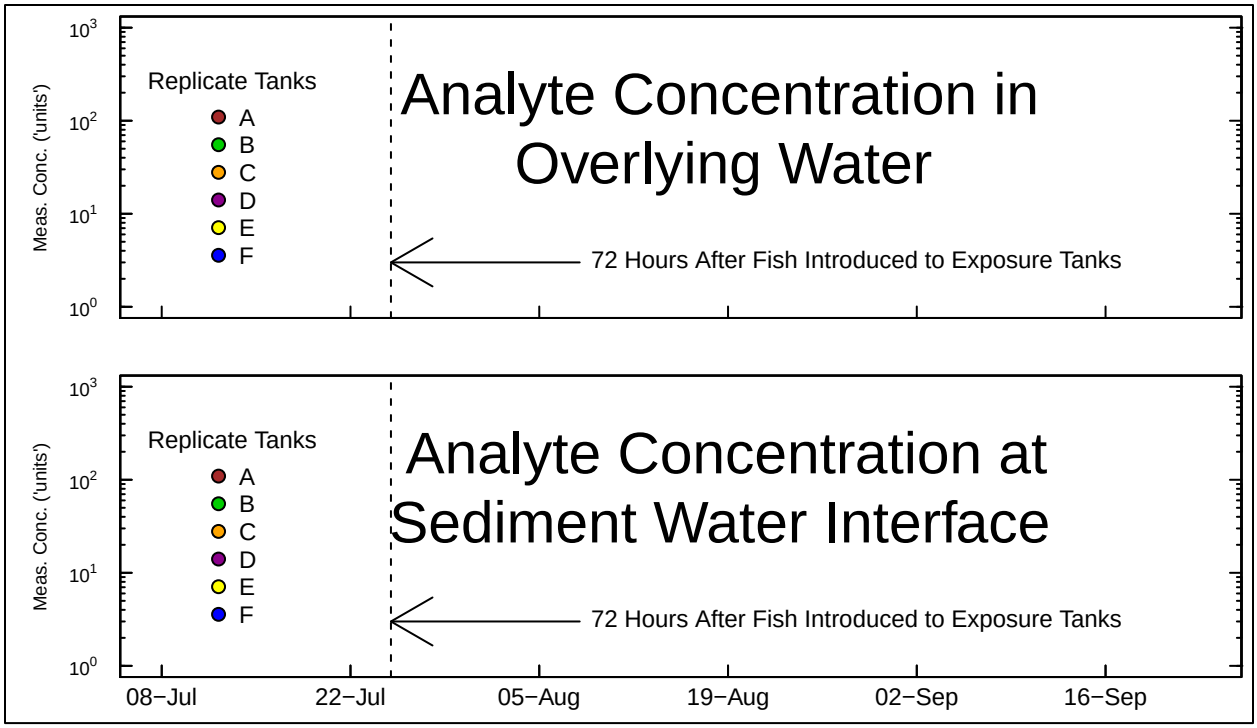


Figure 5−11. Carbon−normalized excess simultaneously extracted metals for the white sturgeon sediment toxicity tests. Historical data are illustrated in light grey hollow symbols



Legend and Template for Figures 5−12 through 5−20.

Figures 5−12 through 5−20 have been structured to be consistent with the above format. Data presented in this series of figures illustrate general water quality parameters measured at the U of S, ATRF for the duration of the study Water quality measurements recorded in the overlying water are illustrated in the top panel; while water quality measurements recorded at the sediment−water interface are illustrated in the bottom panel. It should be noted that "H2O" treatments (i.e., exposures) did not contain sediments, and as such water quality measurements are only available for the overlying water. Up to a maximum of six replicate chambers (tanks) are illustrated consistent with the above color scheme.

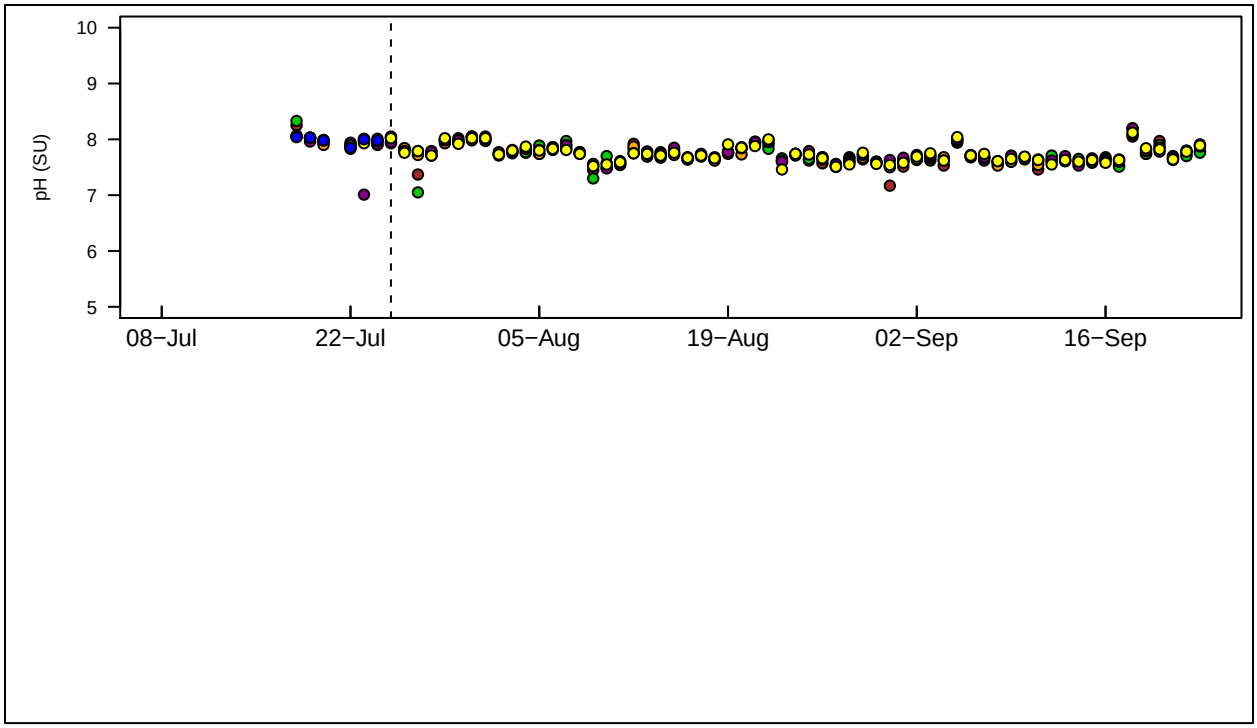


Figure 5−12a. Plot of water hydrogen ion activity (pH) for H2O exposure chambers (A, B, C, D, and E) for the duration of the study

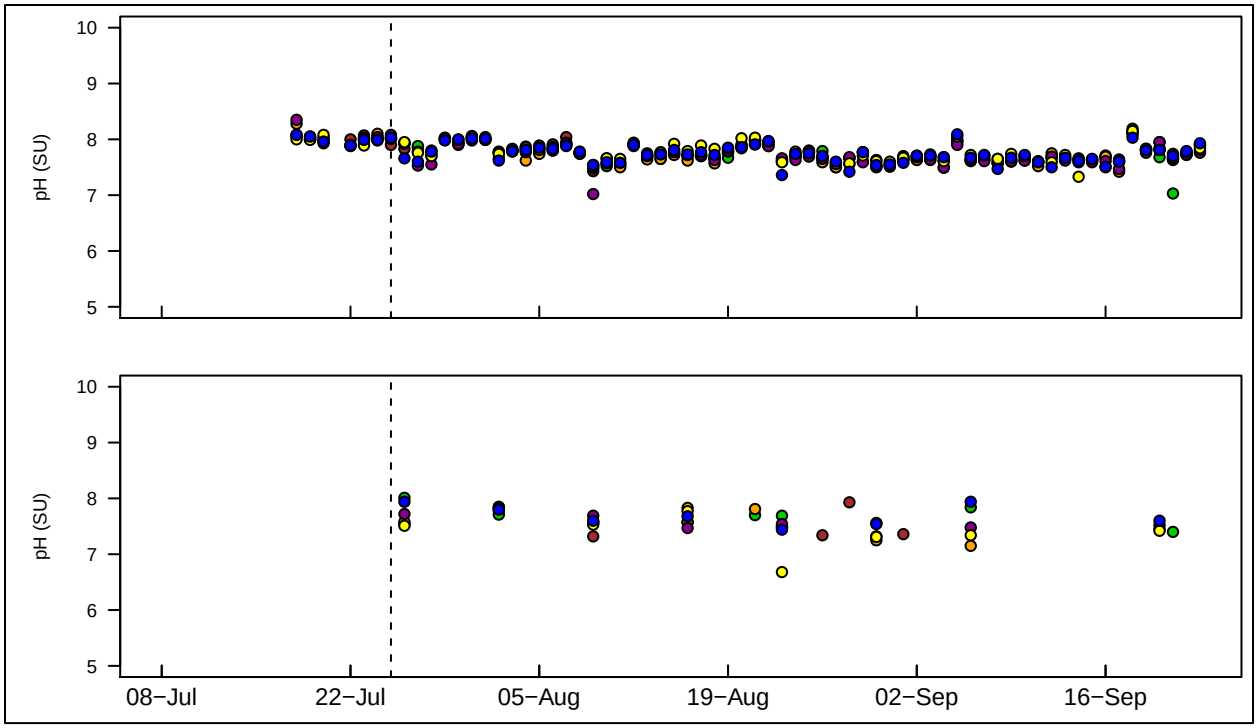


Figure 5−12b. Plot of water hydrogen ion activity (pH) for CTRL exposure chambers (A, B, C, D, E, and F) for the duration of the study

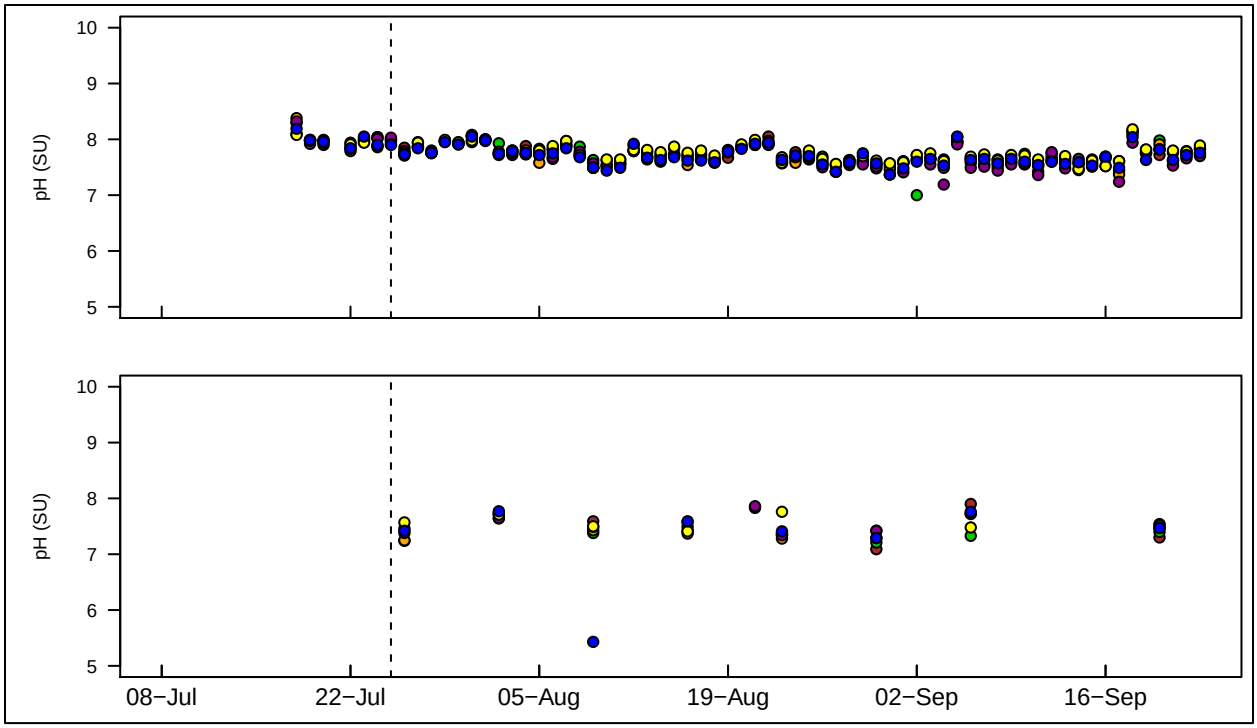


Figure 5−12c. Plot of water hydrogen ion activity (pH) for LALL exposure chambers (A, B, C, D, E, and F) for the duration of the study

Note: Low pH value between 05−Aug and 19−Aug is likely due to measurement error because it is inconsistent with the other replicates and also inconsistent with the associated pH measurement in the overlying water.

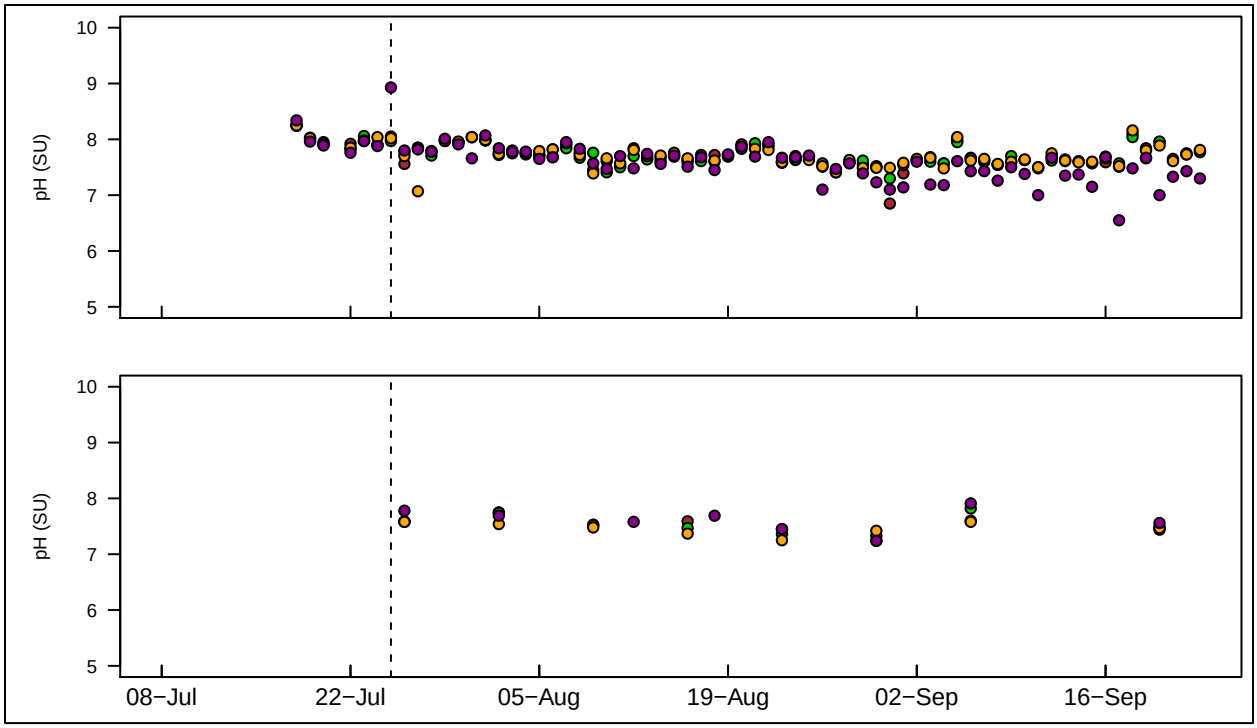


Figure 5−12d. Plot of water hydrogen ion activity (pH) for GE exposure chambers (A, B, C, and D) for the duration of the study

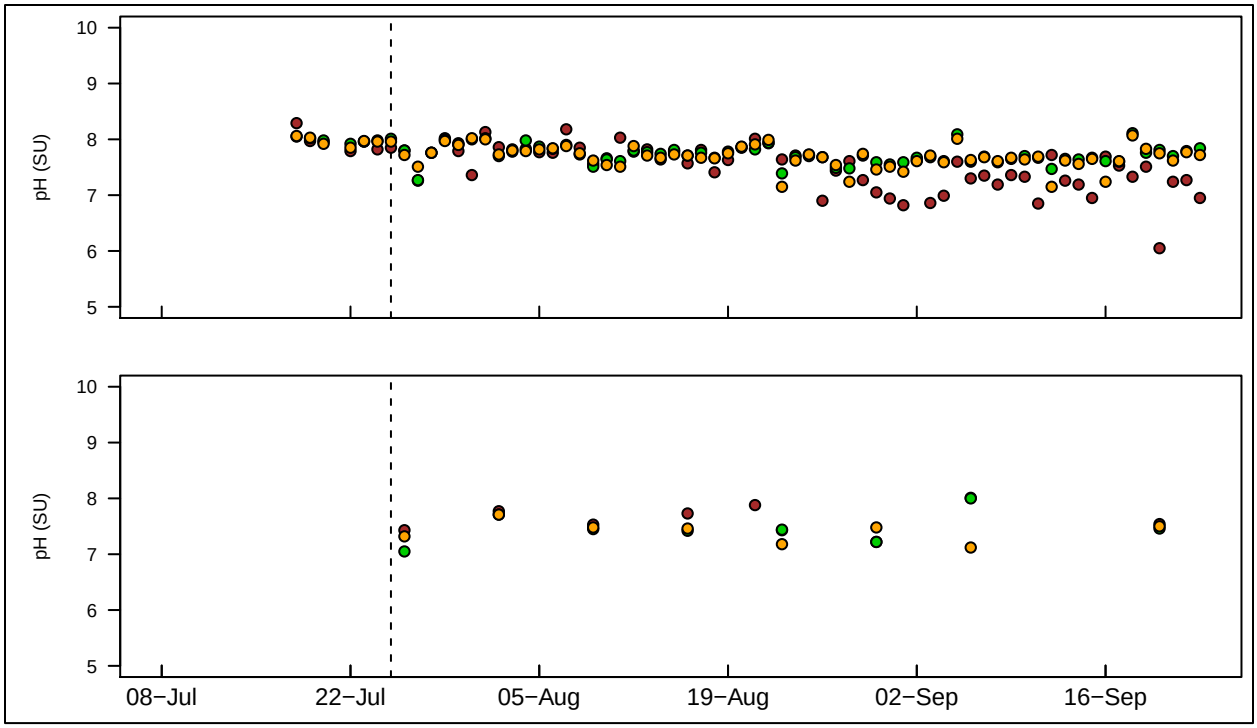


Figure 5−12e. Plot of water hydrogen ion activity (pH) for DE exposure chambers (A, B, and C) for the duration of the study

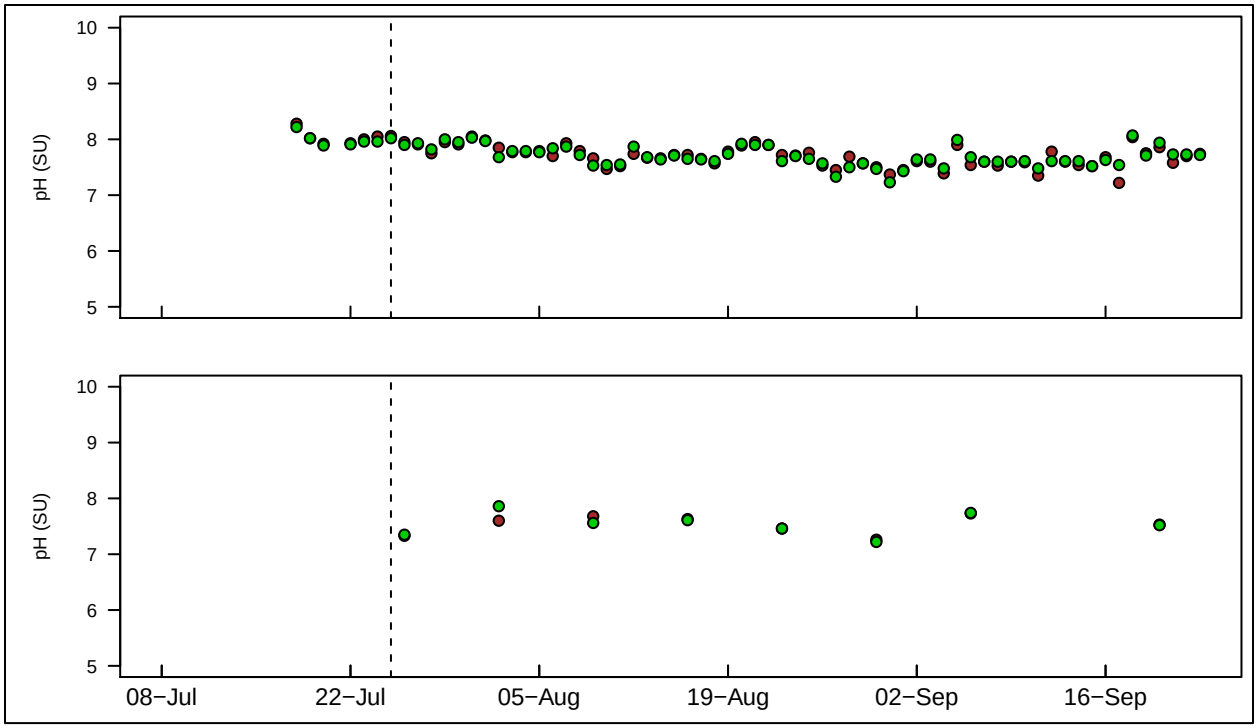


Figure 5−12f. Plot of water hydrogen ion activity (pH) for NP exposure chambers (A and B) for the duration of the study

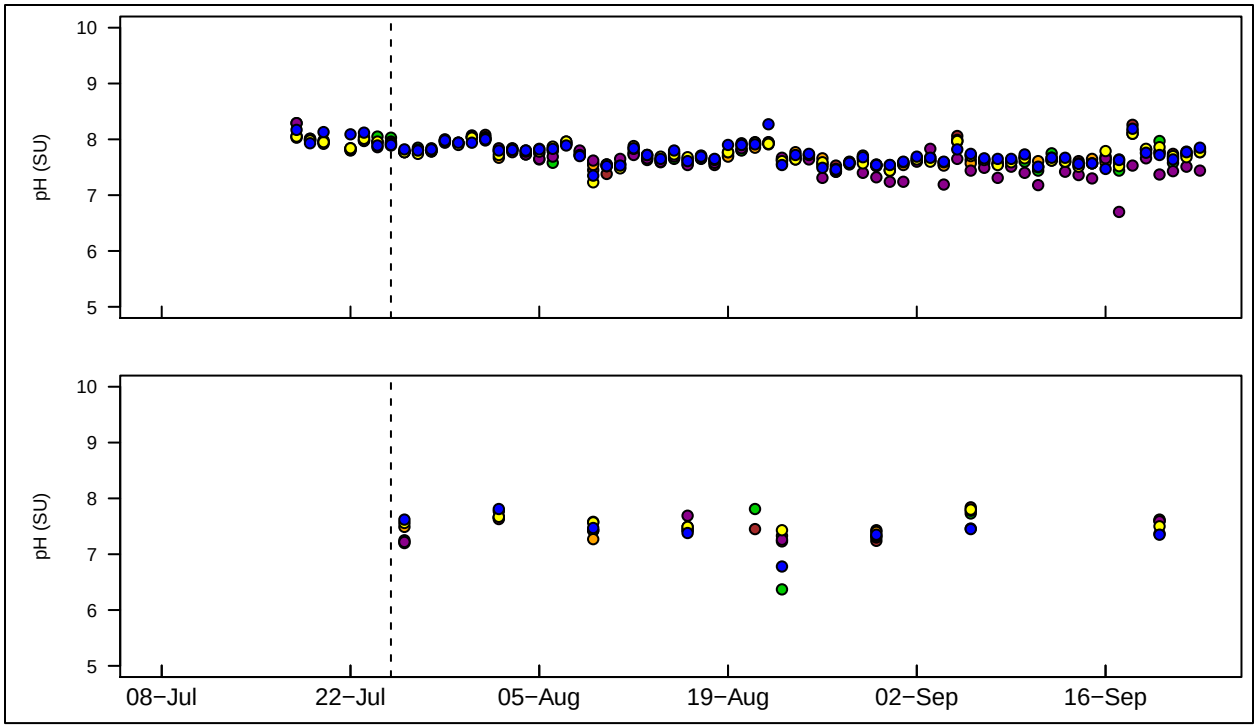


Figure 5−12g. Plot of water hydrogen ion activity (pH) for LD exposure chambers (A, B, C, D, E, and F) for the duration of the study

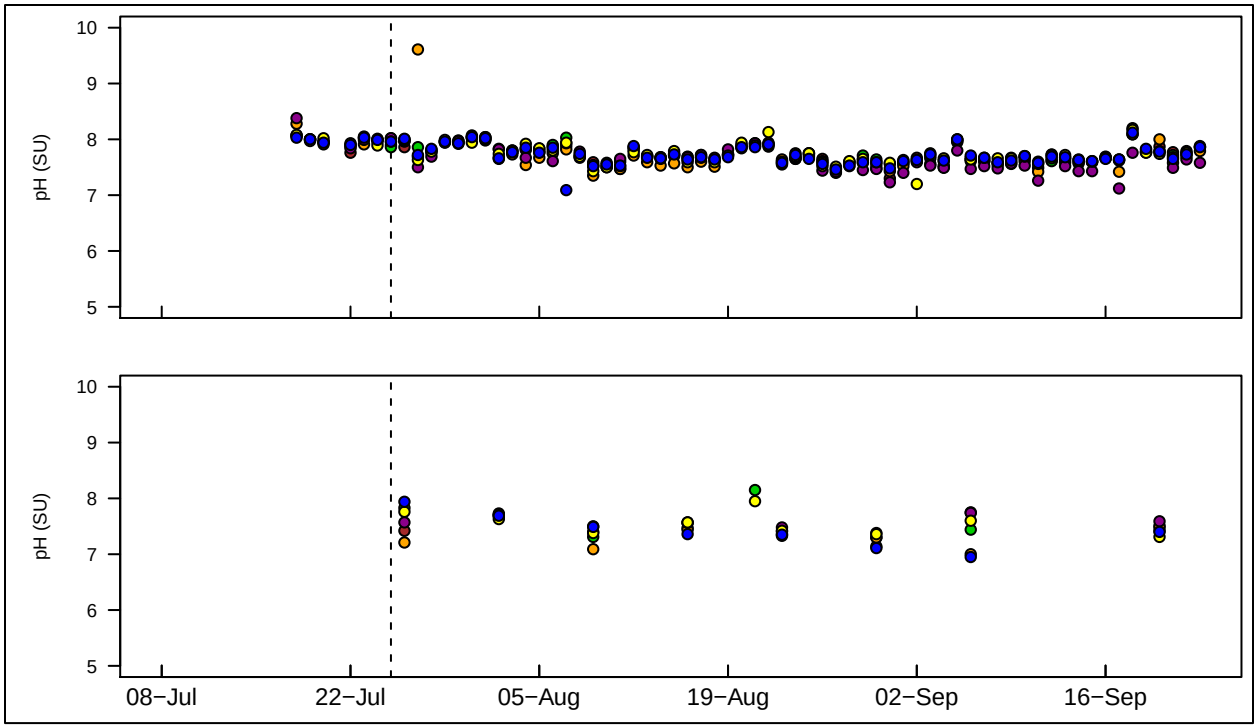


Figure 5−12h. Plot of water hydrogen ion activity (pH) for UMF exposure chambers (A, B, C, D, E, and F) for the duration of the study

Note: High pH value between 22−Jul and 05−Aug is likely due to measurement error because it is inconsistent with the other replicates and also inconsistent with the associated pH measurement in the sediment water interface.

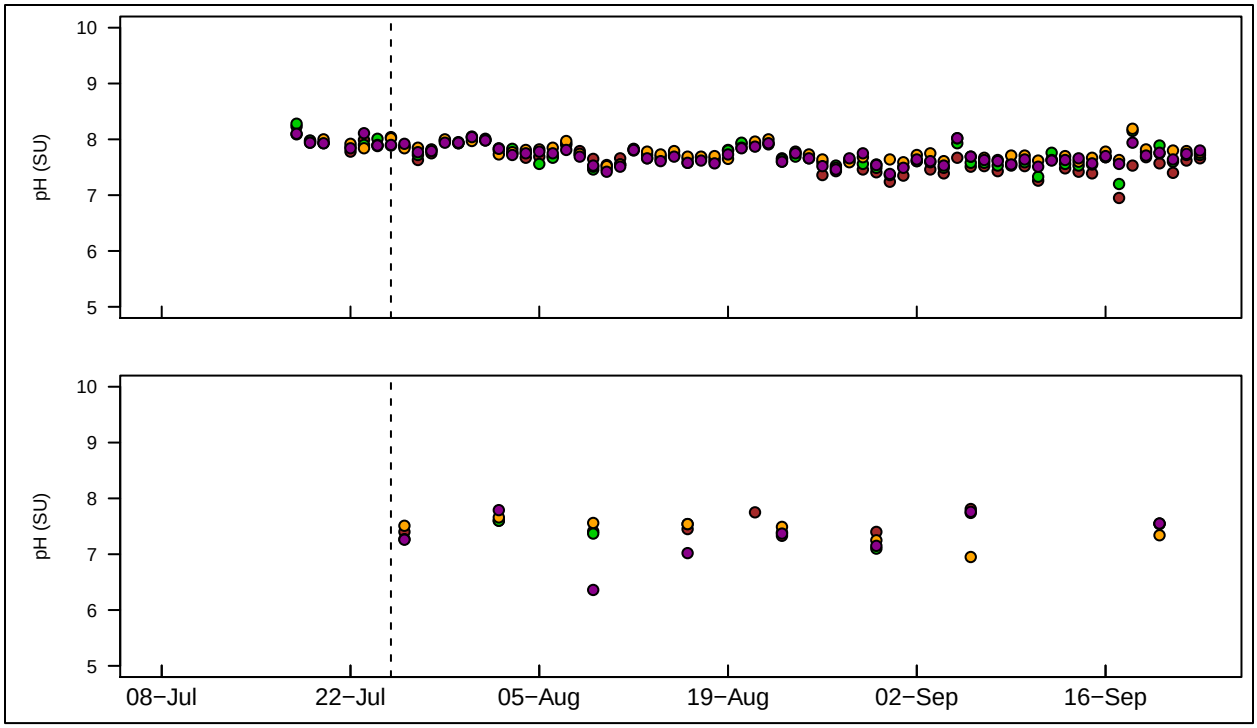


Figure 5−12i. Plot of water hydrogen ion activity (pH) for LMF exposure chambers (A, B, C, and D) for the duration of the study

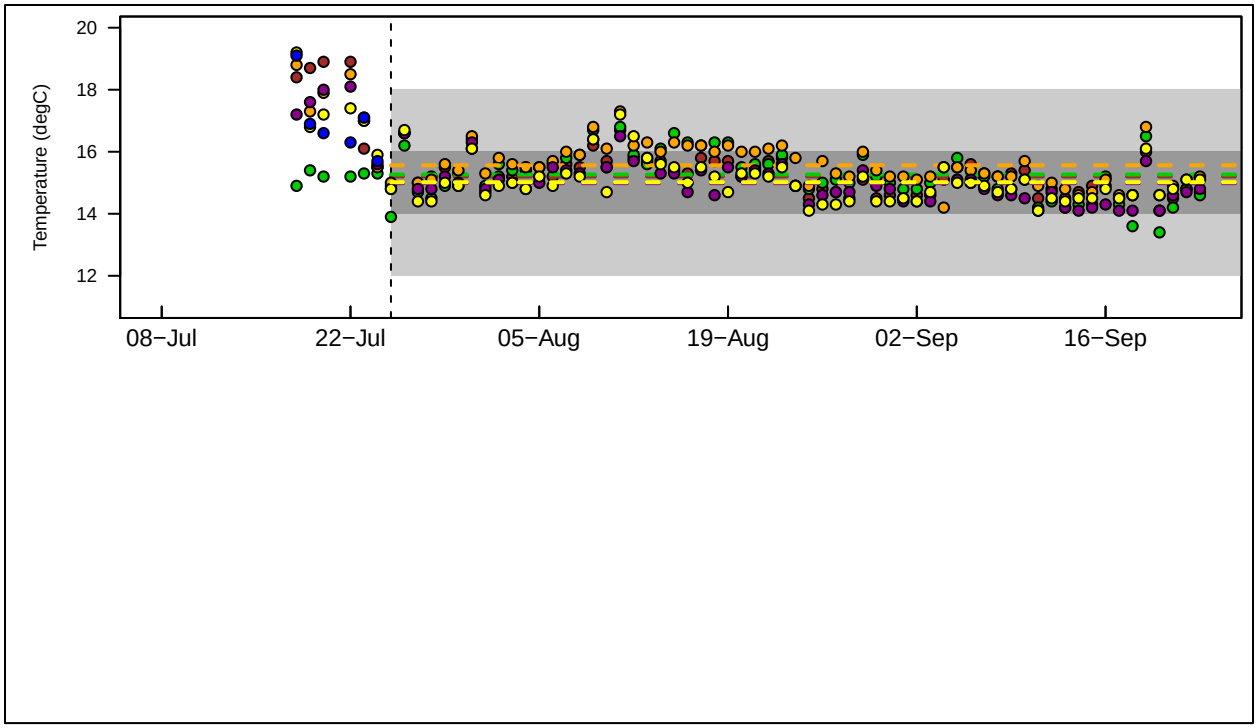


Figure 5−13a. Plot of water temperature for H2O exposure chambers (A, B, C, D, and E) for the duration of the study

Note: Average temperatures are illustrated with the dashed lines while test acceptance criteria are illustrated with the grey (average = 15±1°C) and light grey shading (instantaneous = 15±3°C).

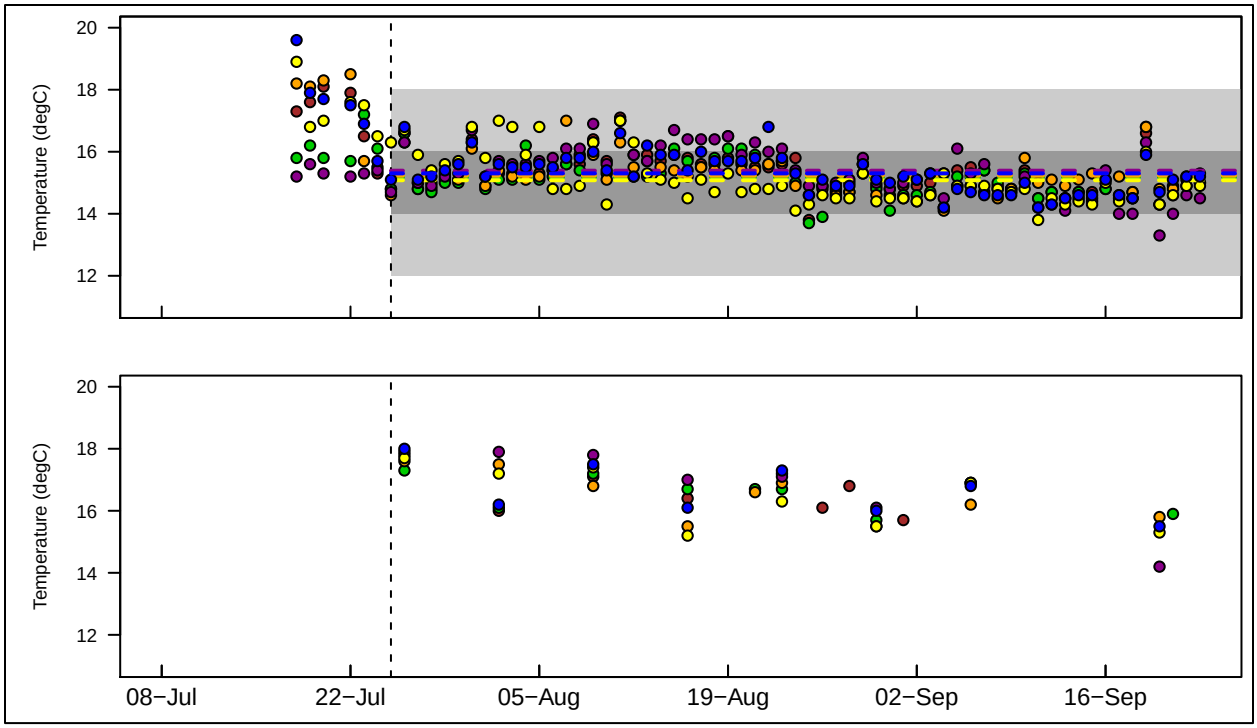


Figure 5−13b. Plot of water temperature for CTRL exposure chambers (A, B, C, D, E, and F) for the duration of the study

Note: Average temperatures are illustrated with the dashed lines while test acceptance criteria are illustrated with the grey (average = 15±1°C) and light grey shading (instantaneous = 15±3°C).

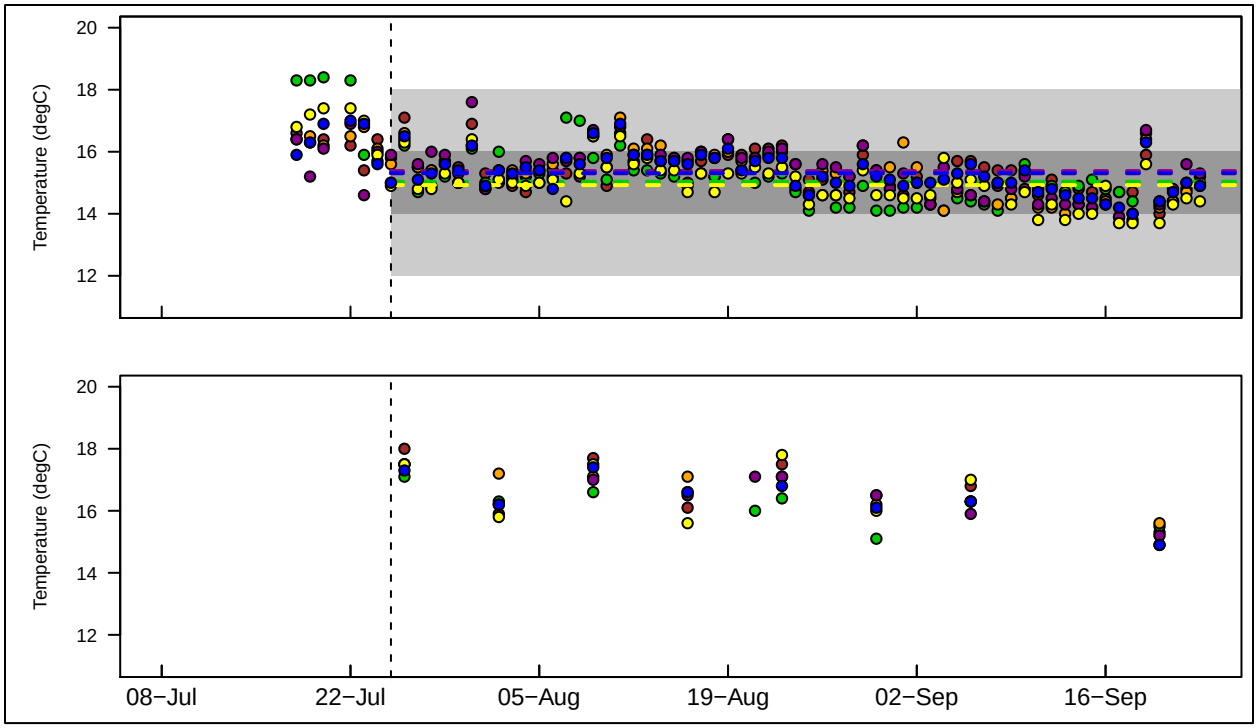


Figure 5−13c. Plot of water temperature for LALL exposure chambers (A, B, C, D, E, and F) for the duration of the study

Note: Average temperatures are illustrated with the dashed lines while test acceptance criteria are illustrated with the grey (average = 15±1°C) and light grey shading (instantaneous = 15±3°C).

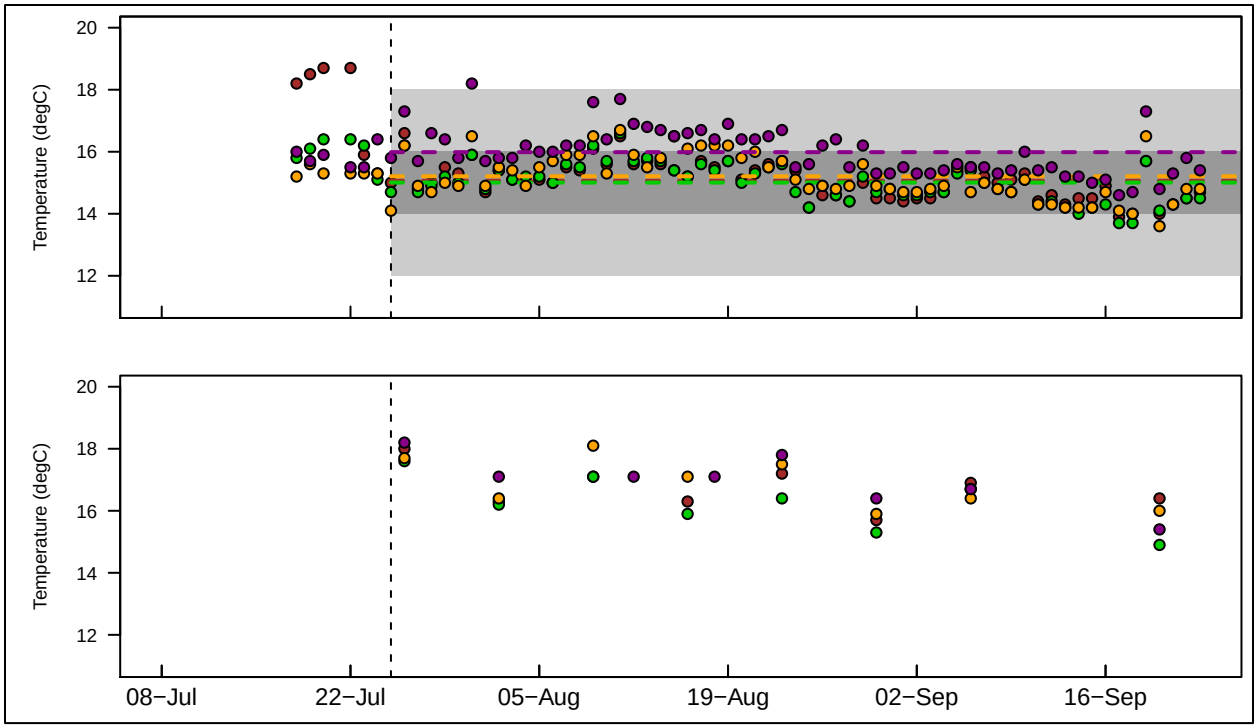


Figure 5−13d. Plot of water temperature for GE exposure chambers (A, B, C, and D) for the duration of the study

Note: Average temperatures are illustrated with the dashed lines while test acceptance criteria are illustrated with the grey (average = 15±1°C) and light grey shading (instantaneous = 15±3°C).

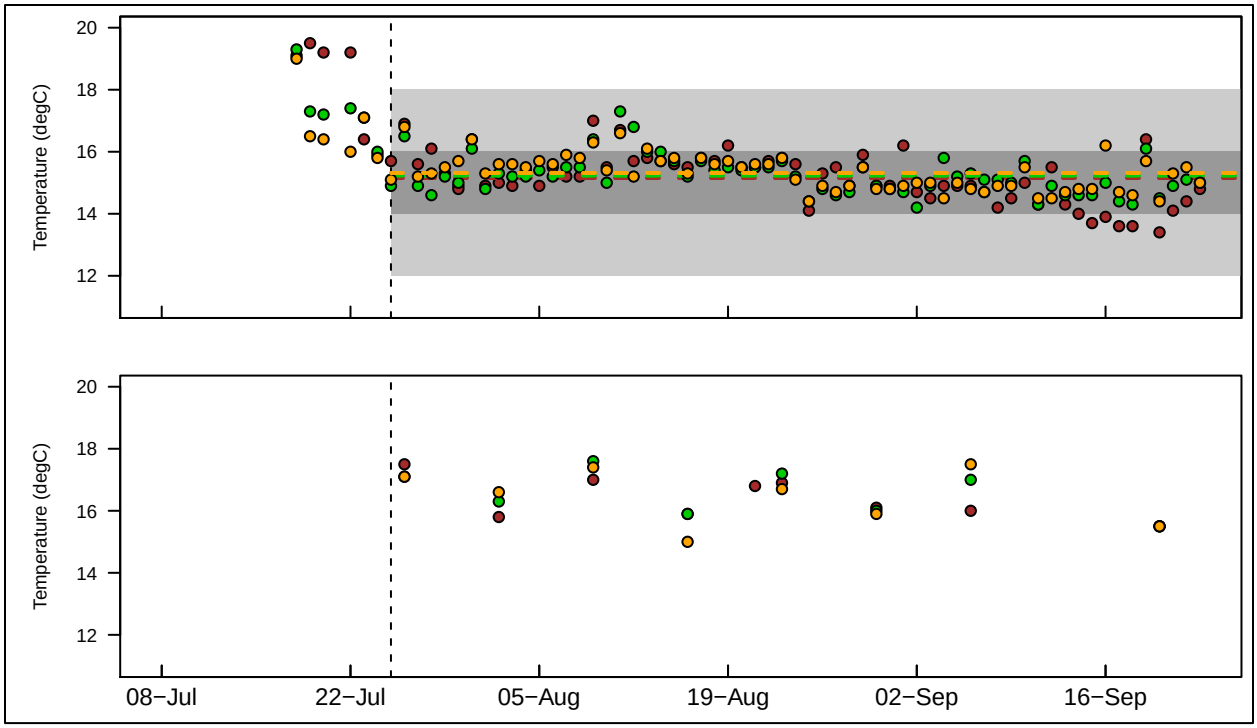


Figure 5−13e. Plot of water temperature for DE exposure chambers (A, B, and C) for the duration of the study

Note: Average temperatures are illustrated with the dashed lines while test acceptance criteria are illustrated with the grey (average = 15±1°C) and light grey shading (instantaneous = 15±3°C).

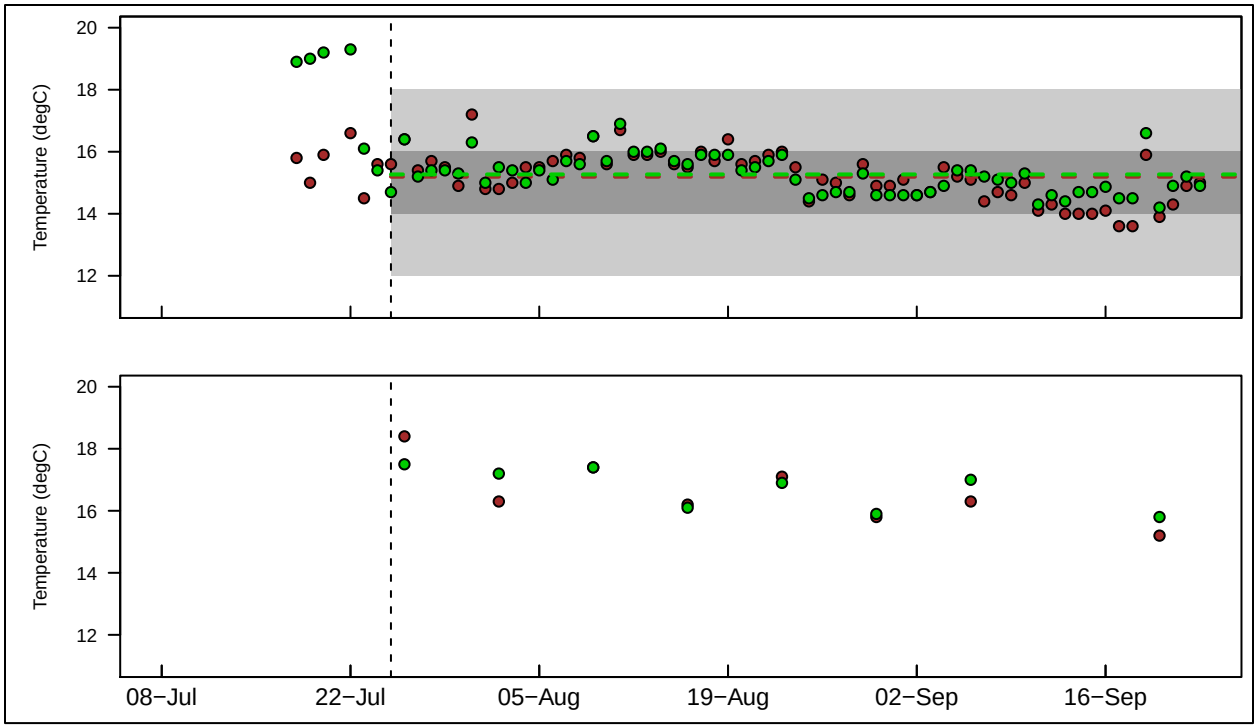


Figure 5−13f. Plot of water temperature for NP exposure chambers (A and B) for the duration of the study

Note: Average temperatures are illustrated with the dashed lines while test acceptance criteria are illustrated with the grey (average = 15±1°C) and light grey shading (instantaneous = 15±3°C).

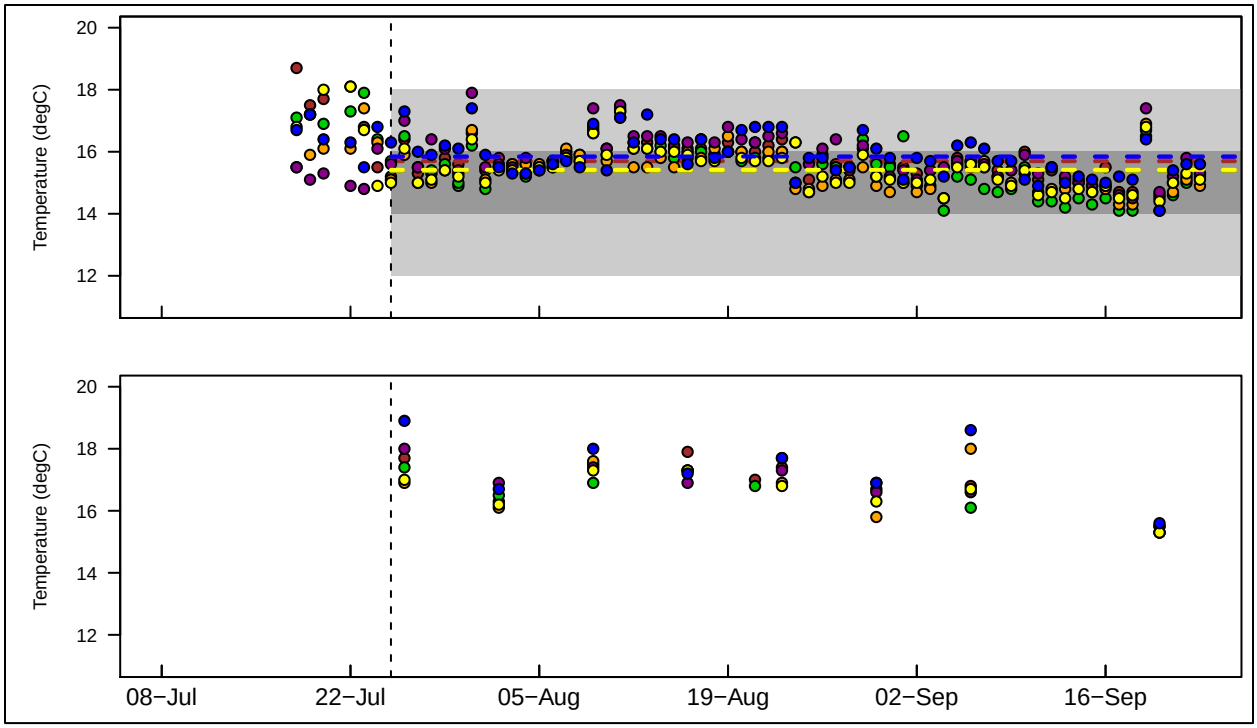


Figure 5−13g. Plot of water temperature for LD exposure chambers (A, B, C, D, E, and F) for the duration of the study

Note: Average temperatures are illustrated with the dashed lines while test acceptance criteria are illustrated with the grey (average = 15±1°C) and light grey shading (instantaneous = 15±3°C).

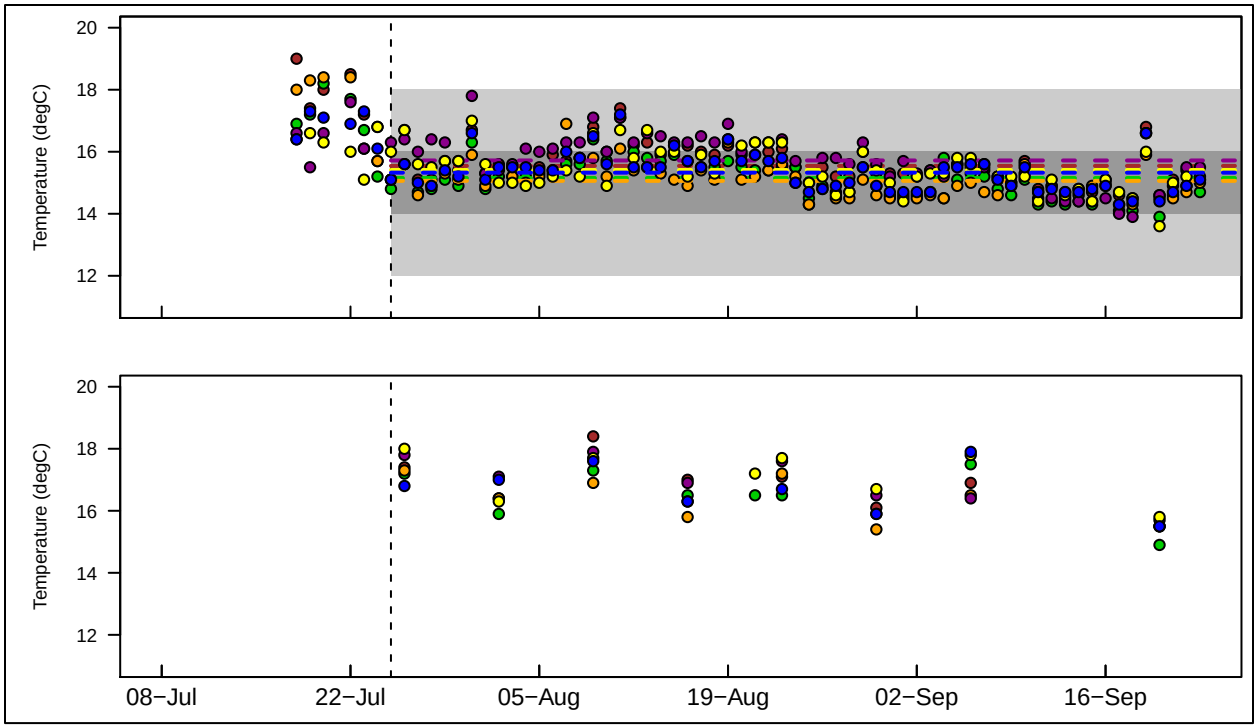


Figure 5−13h. Plot of water temperature for UMF exposure chambers (A, B, C, D, E, and F) for the duration of the study

Note: Average temperatures are illustrated with the dashed lines while test acceptance criteria are illustrated with the grey (average = 15±1°C) and light grey shading (instantaneous = 15±3°C).

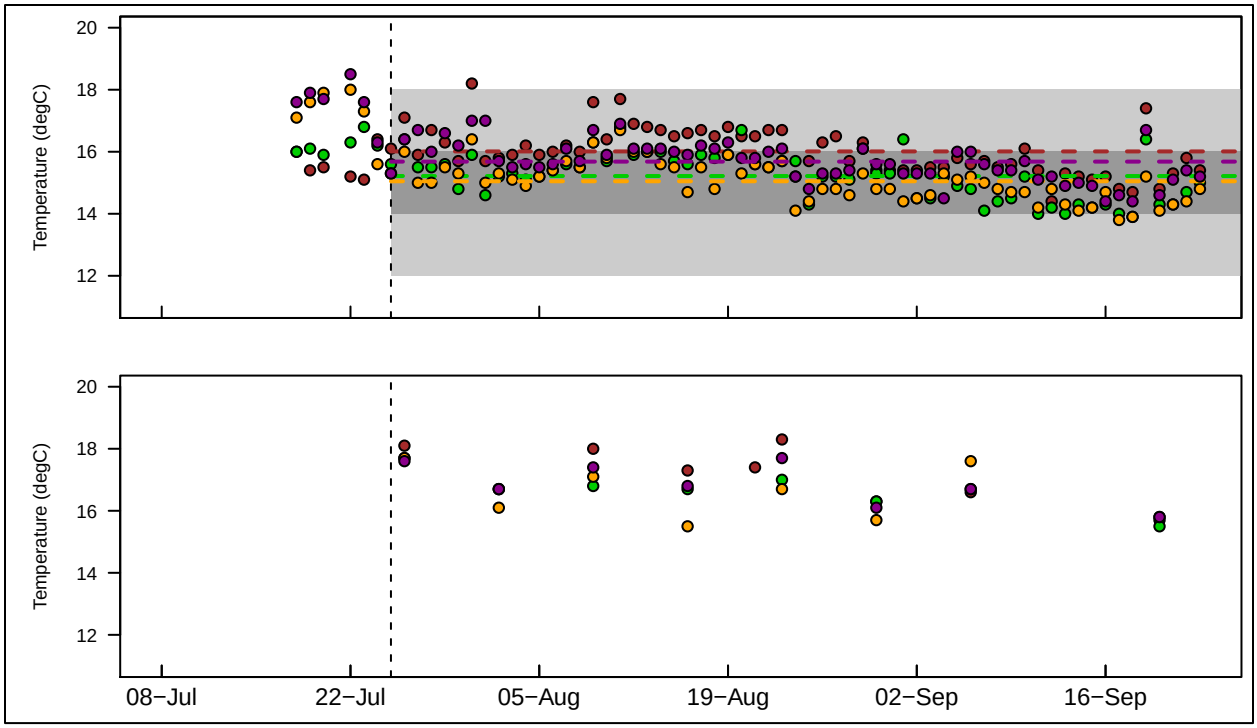


Figure 5−13i. Plot of water temperature for LMF exposure chambers (A, B, C, and D) for the duration of the study

Note: Average temperatures are illustrated with the dashed lines while test acceptance criteria are illustrated with the grey (average = 15±1°C) and light grey shading (instantaneous = 15±3°C).

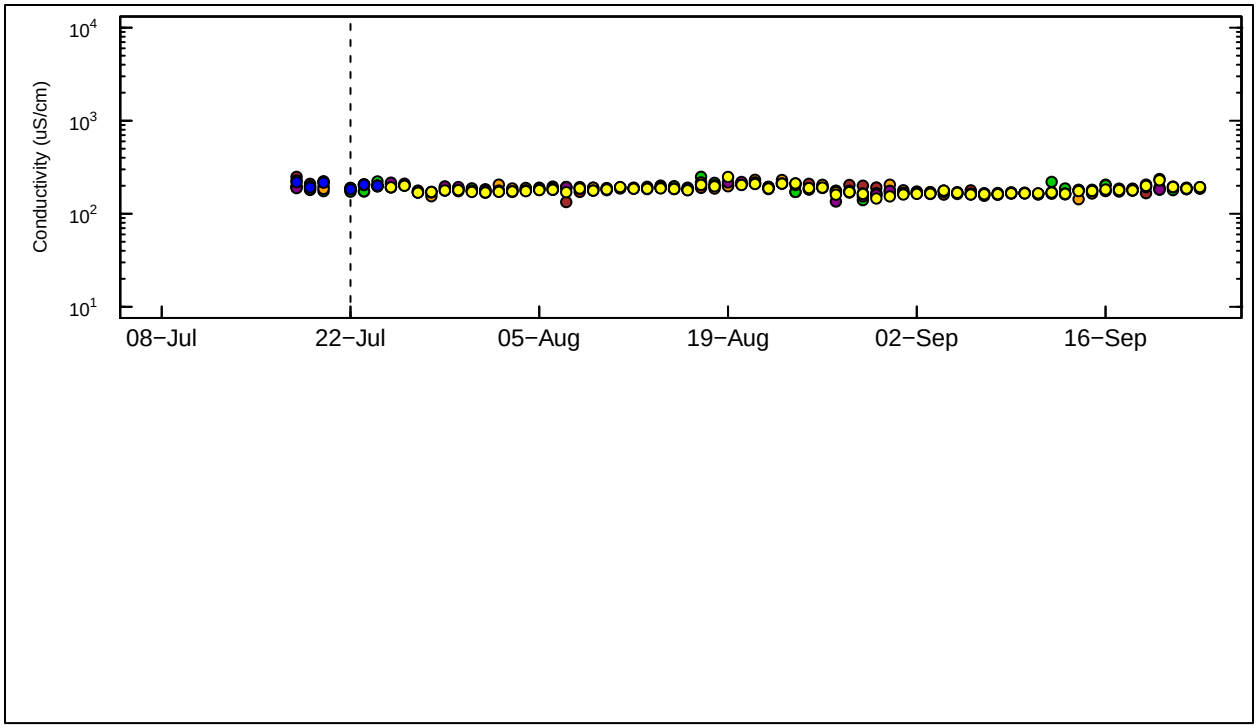


Figure 5−14a. Plot of water conductivity for H2O exposure chambers (A, B, C, D, and E) for the duration of the study

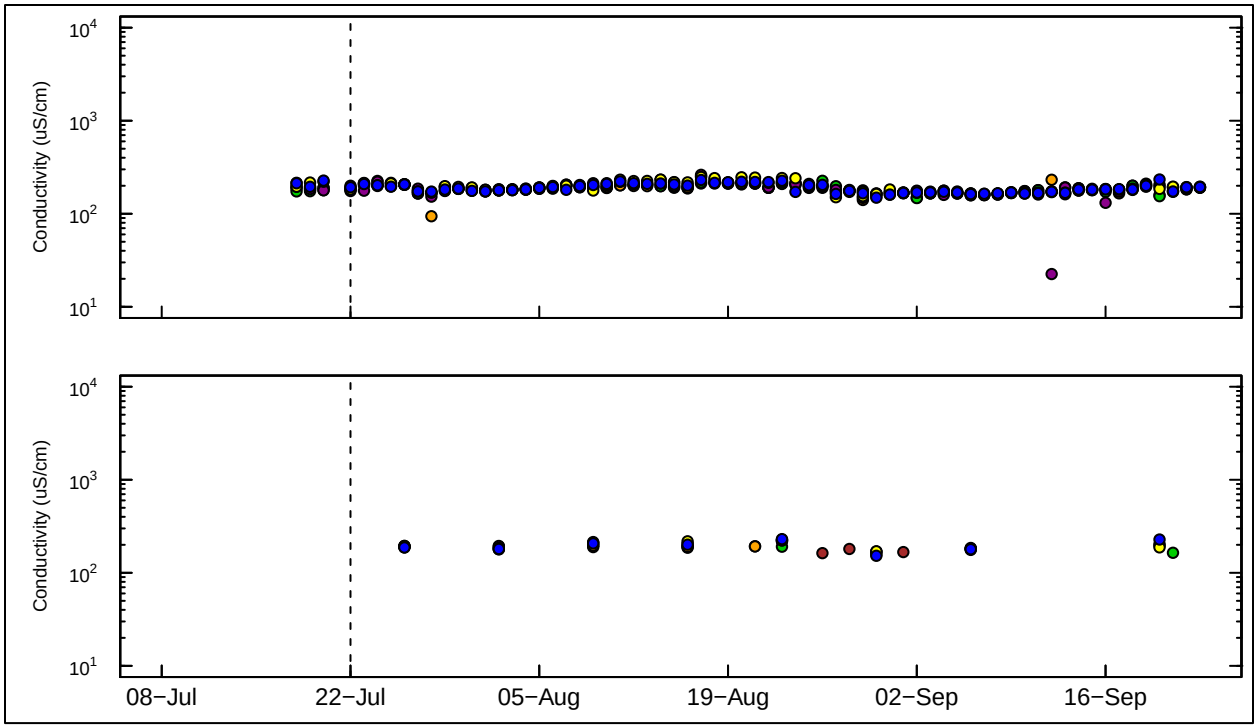


Figure 5−14b. Plot of water conductivity for CTRL exposure chambers (A, B, C, D, E, and F) for the duration of the study

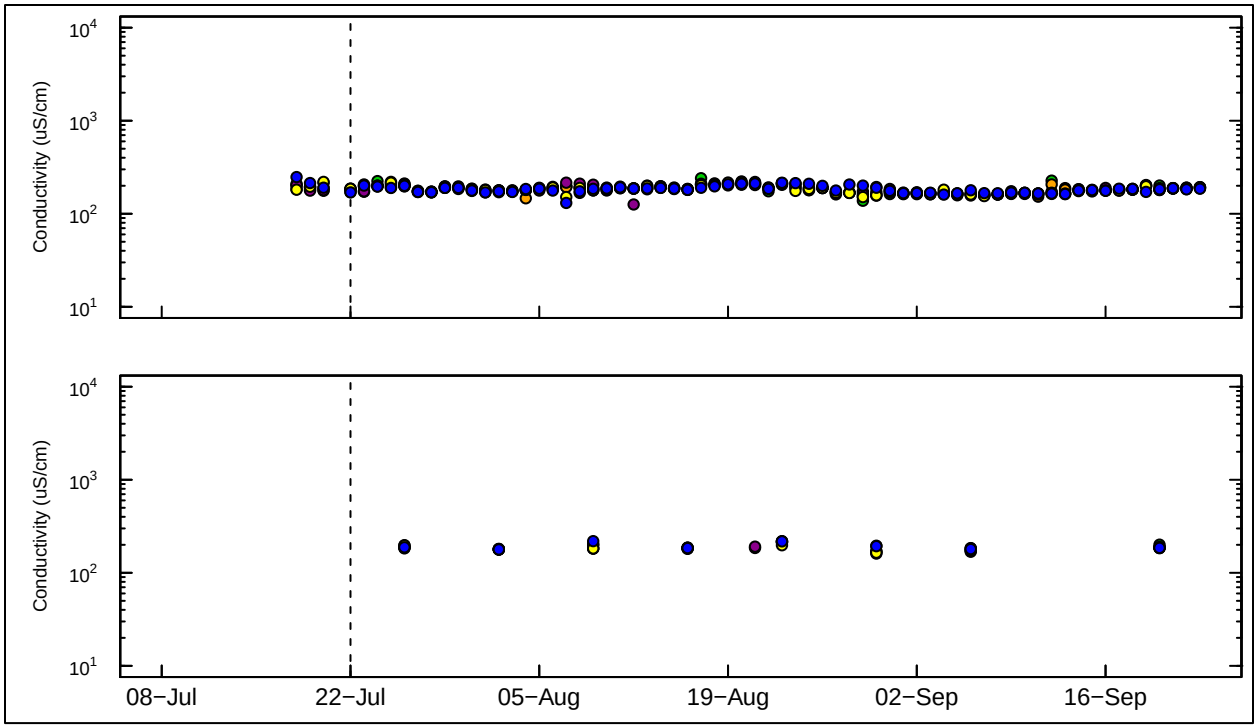


Figure 5−14c. Plot of water conductivity for LALL exposure chambers (A, B, C, D, E, and F) for the duration of the study

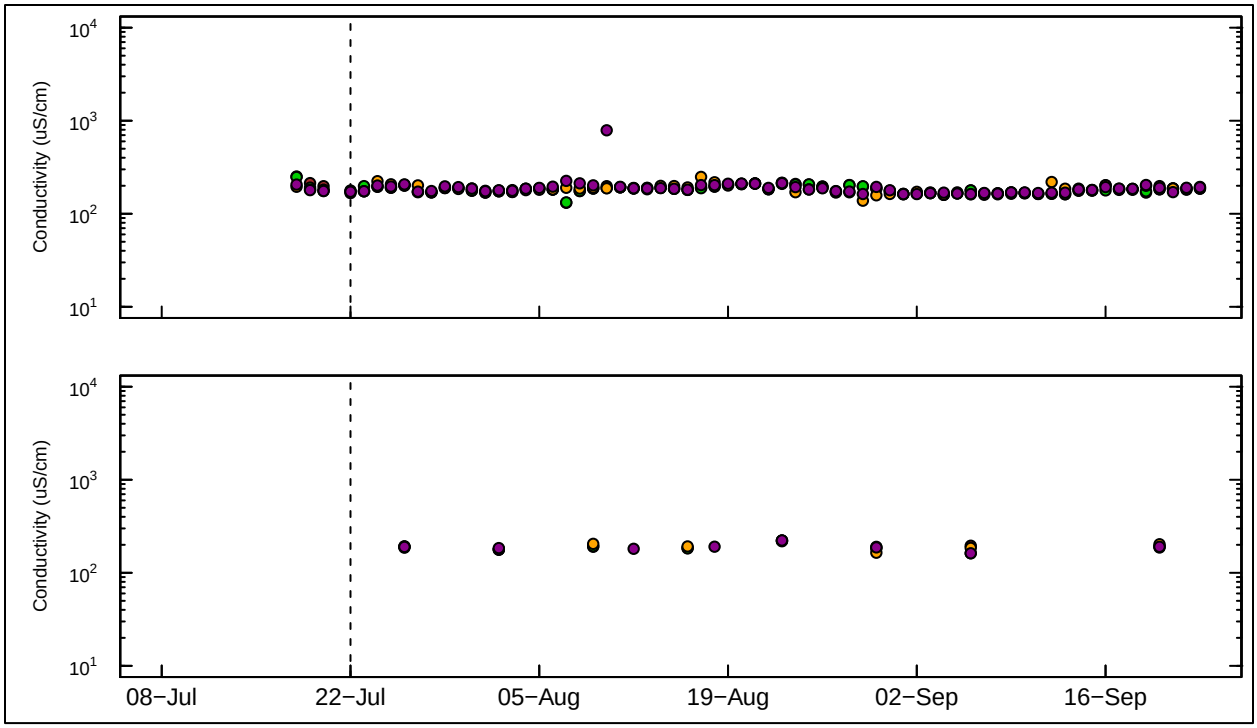


Figure 5−14d. Plot of water conductivity for GE exposure chambers (A, B, C, and D) for the duration of the study

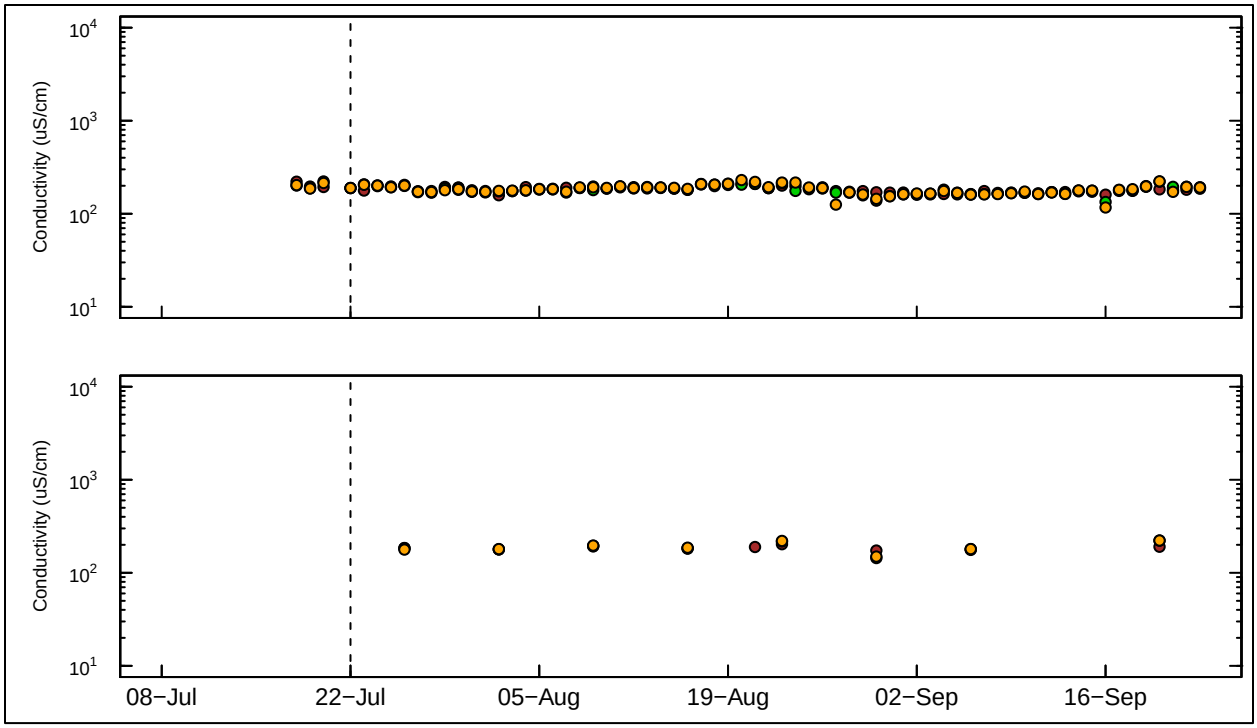


Figure 5−14e. Plot of water conductivity for DE exposure chambers (A, B, and C) for the duration of the study

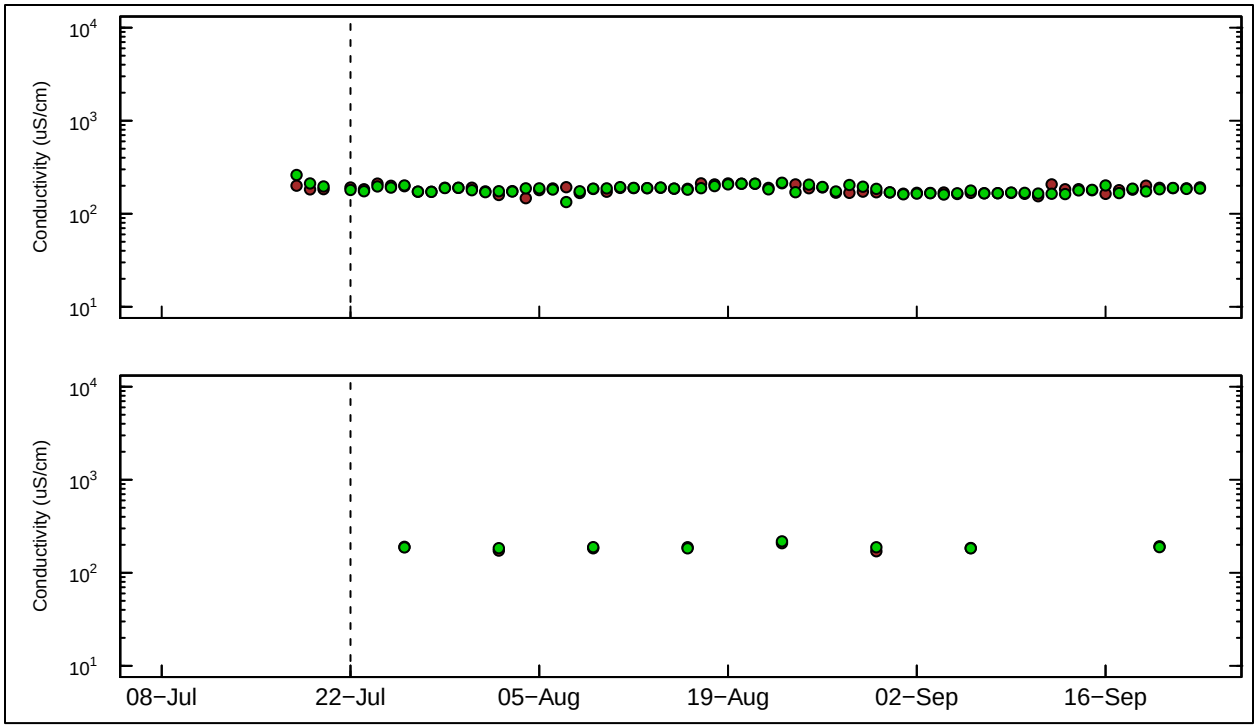


Figure 5−14f. Plot of water conductivity for NP exposure chambers (A and B) for the duration of the study

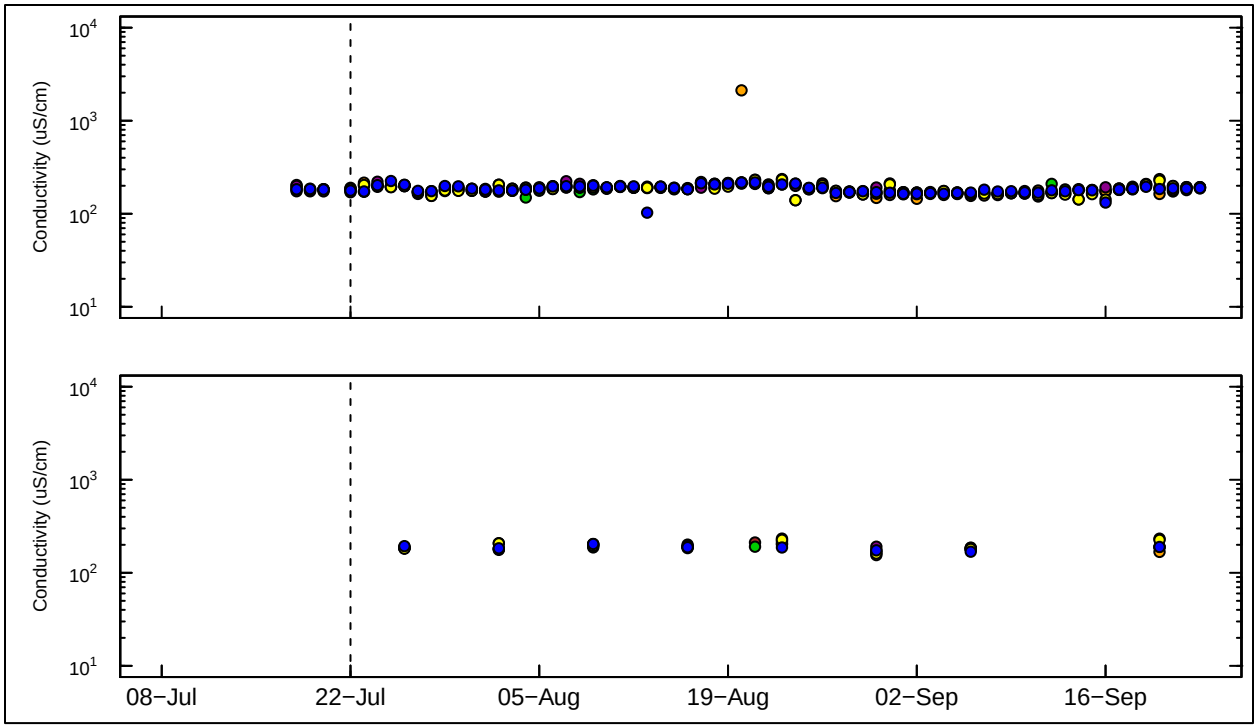


Figure 5−14g. Plot of water conductivity for LD exposure chambers (A, B, C, D, E, and F) for the duration of the study

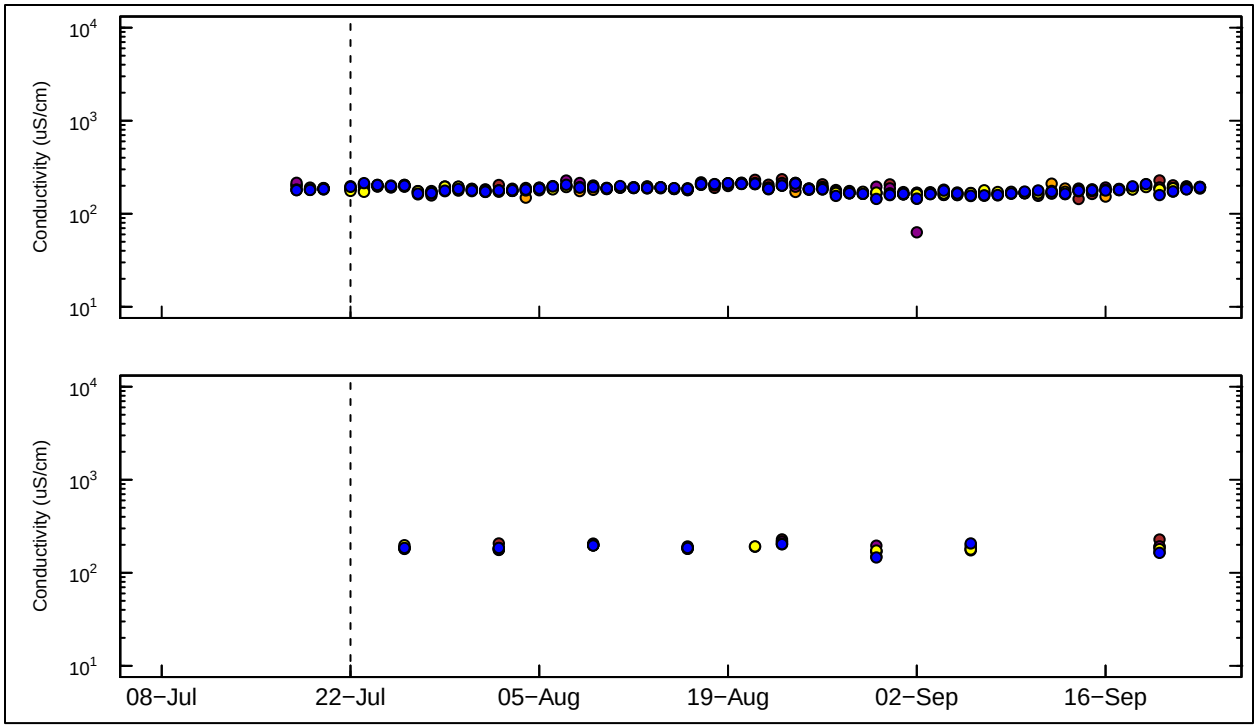


Figure 5−14h. Plot of water conductivity for UMF exposure chambers (A, B, C, D, E, and F) for the duration of the study

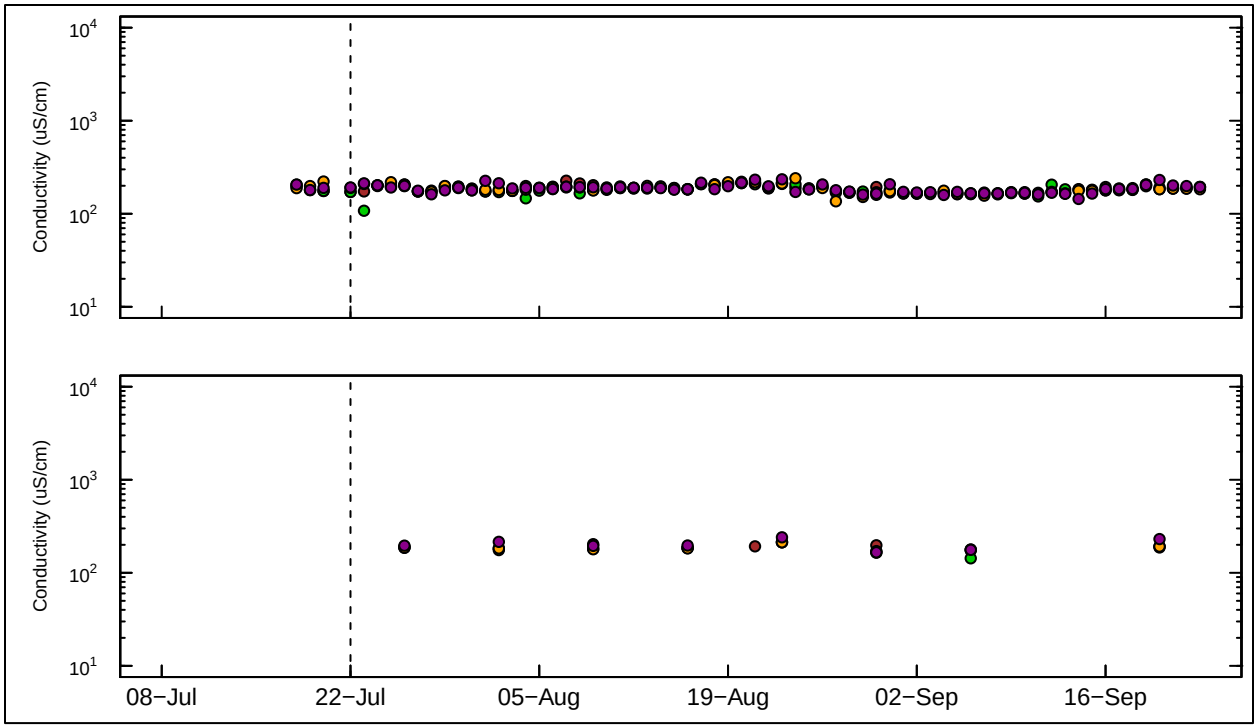


Figure 5−14i. Plot of water conductivity for LMF exposure chambers (A, B, C, and D) for the duration of the study

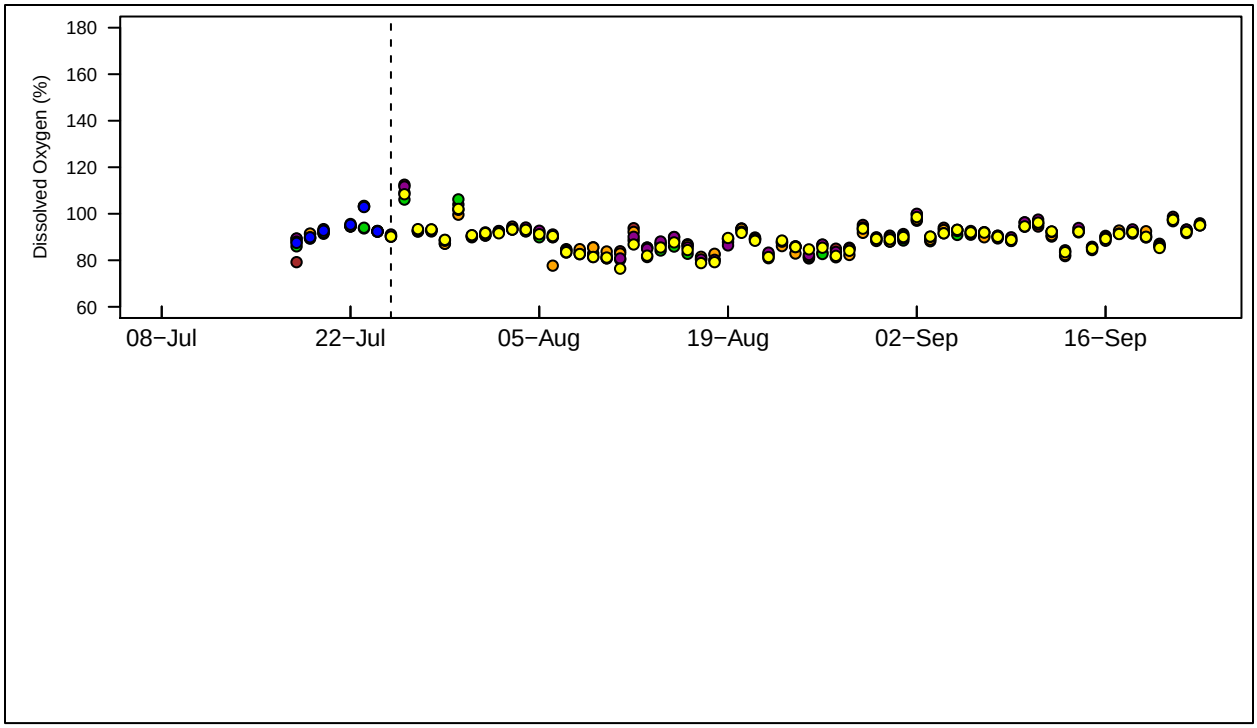


Figure 5−15a. Plot of dissolved oxygen for H2O exposure chambers (A, B, C, D, and E) for the duration of the study

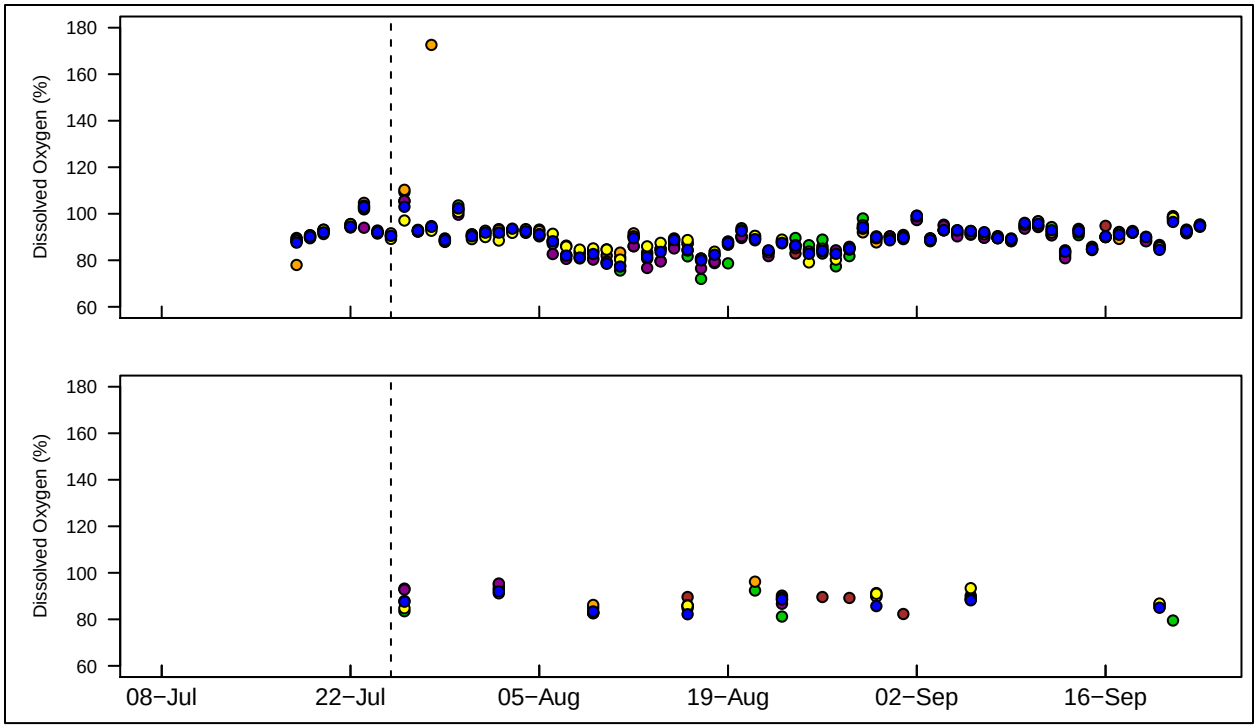


Figure 5−15b. Plot of dissolved oxygen for CTRL exposure chambers (A, B, C, D, E, and F) for the duration of the study

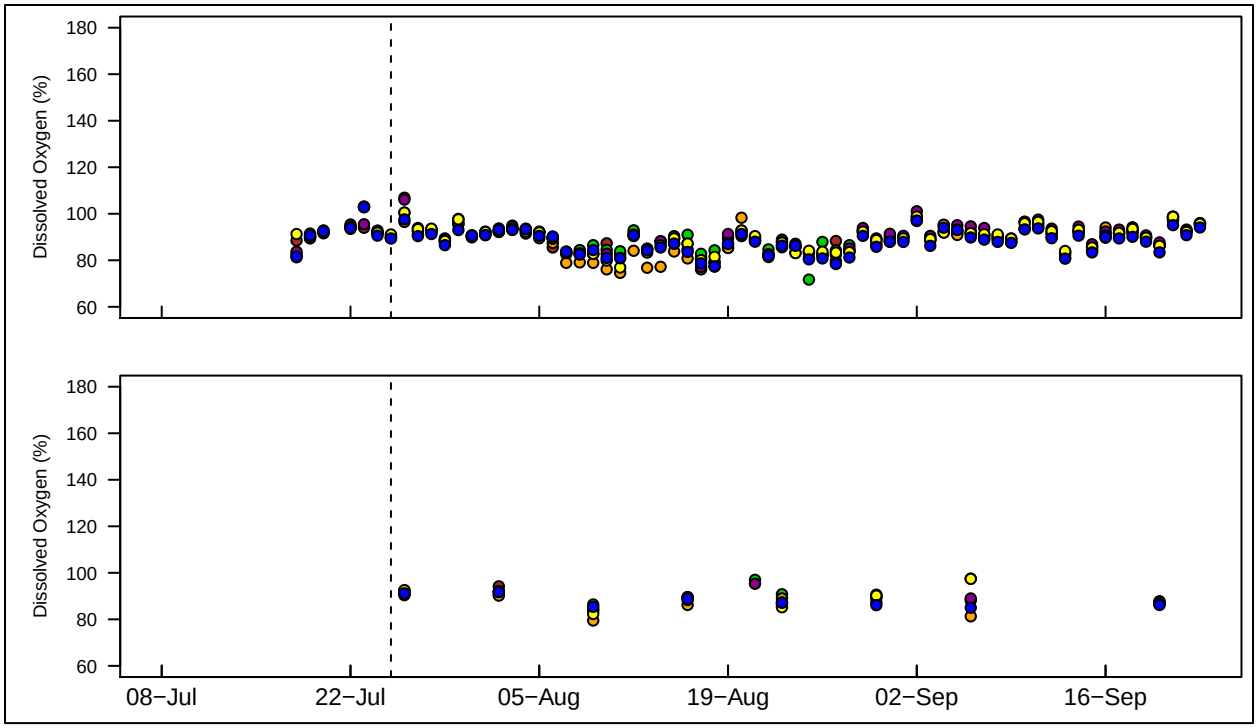


Figure 5−15c. Plot of dissolved oxygen for LALL exposure chambers (A, B, C, D, E, and F) for the duration of the study

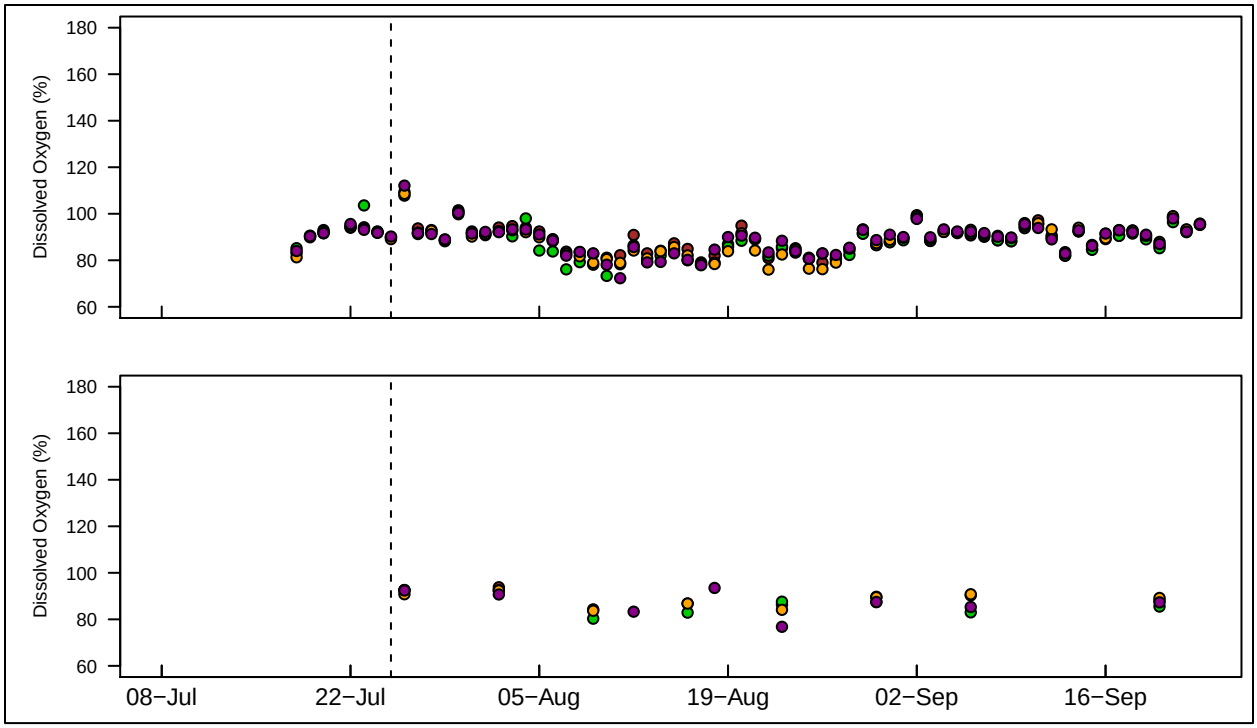


Figure 5−15d. Plot of dissolved oxygen for GE exposure chambers (A, B, C, and D) for the duration of the study

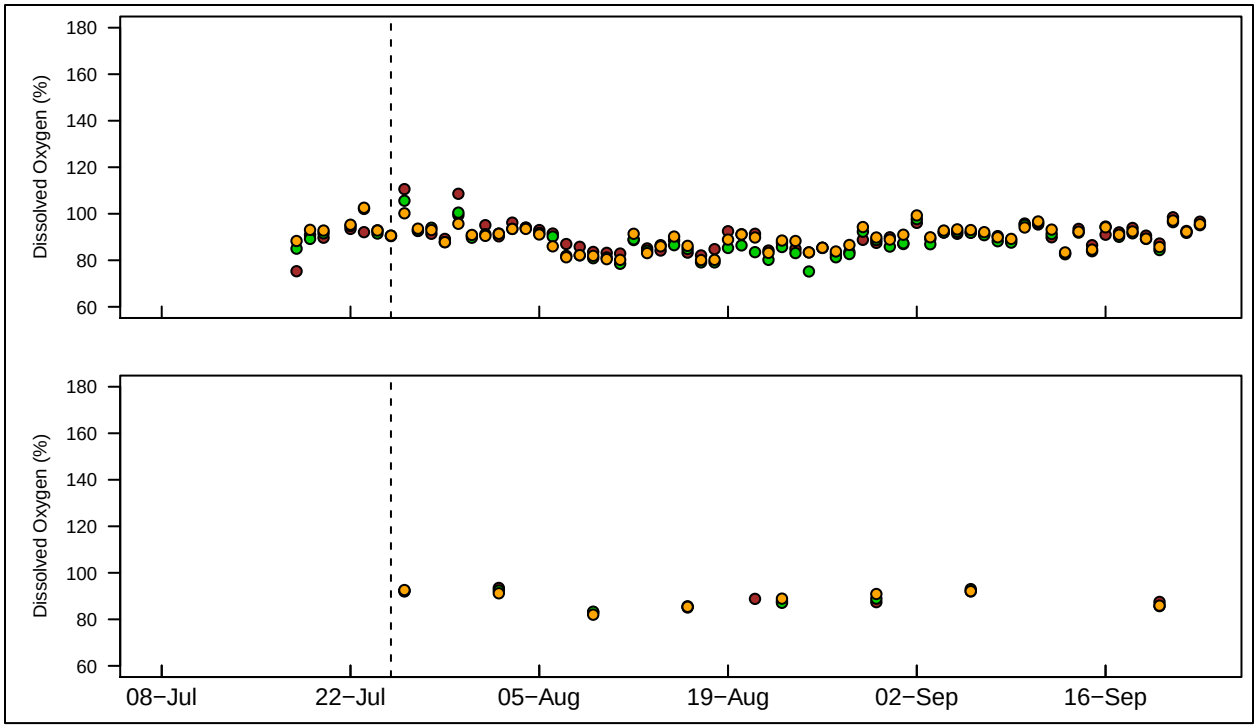


Figure 5−15e. Plot of dissolved oxygen for DE exposure chambers (A, B, and C) for the duration of the study

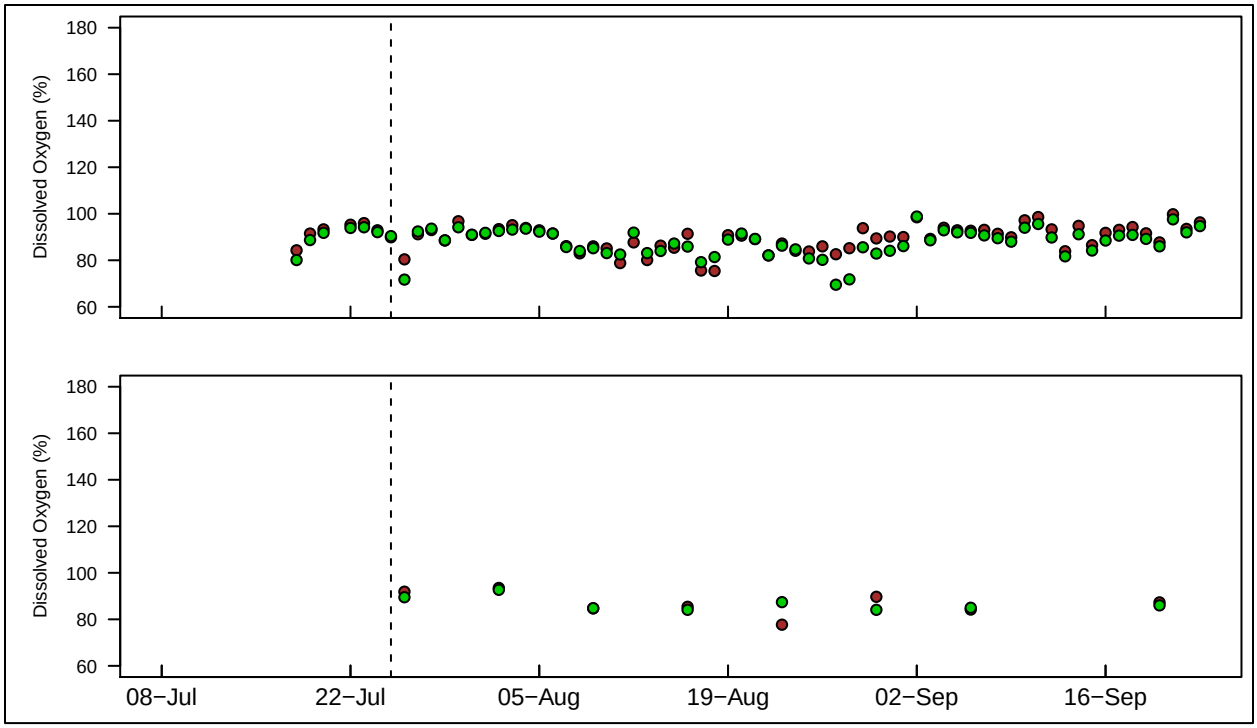


Figure 5−15f. Plot of dissolved oxygen for NP exposure chambers (A and B) for the duration of the study

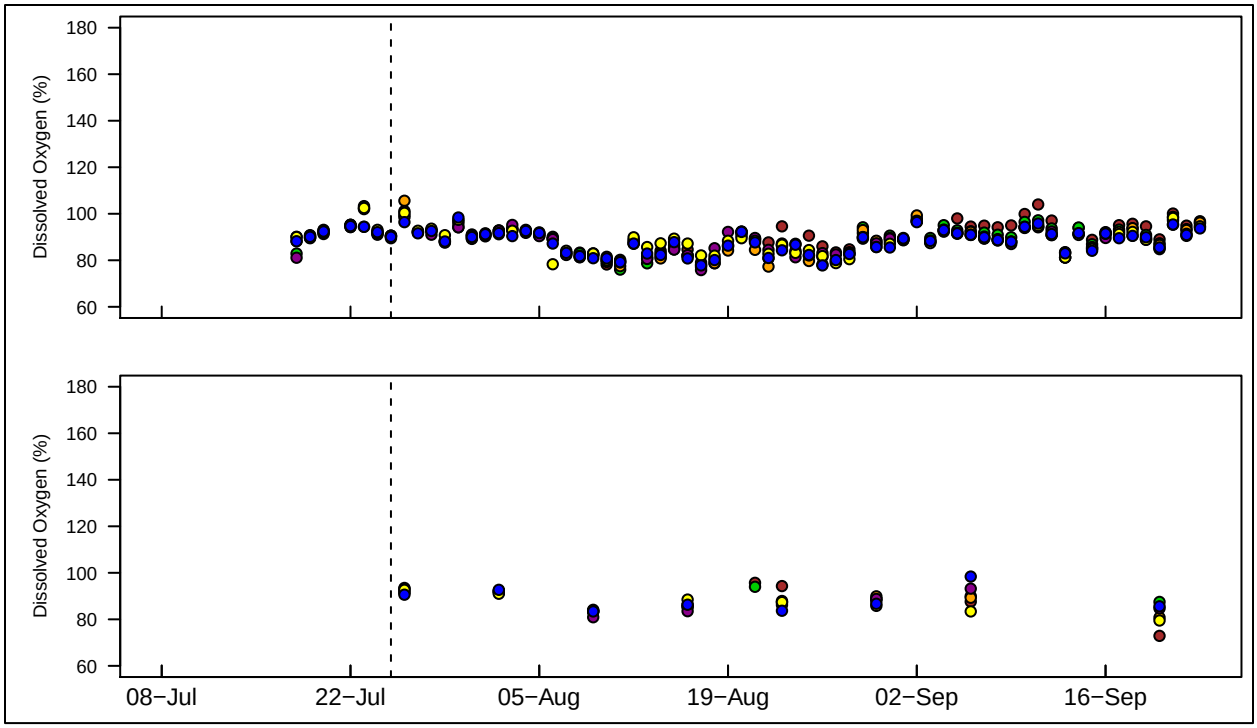


Figure 5−15g. Plot of dissolved oxygen for LD exposure chambers (A, B, C, D, E, and F) for the duration of the study

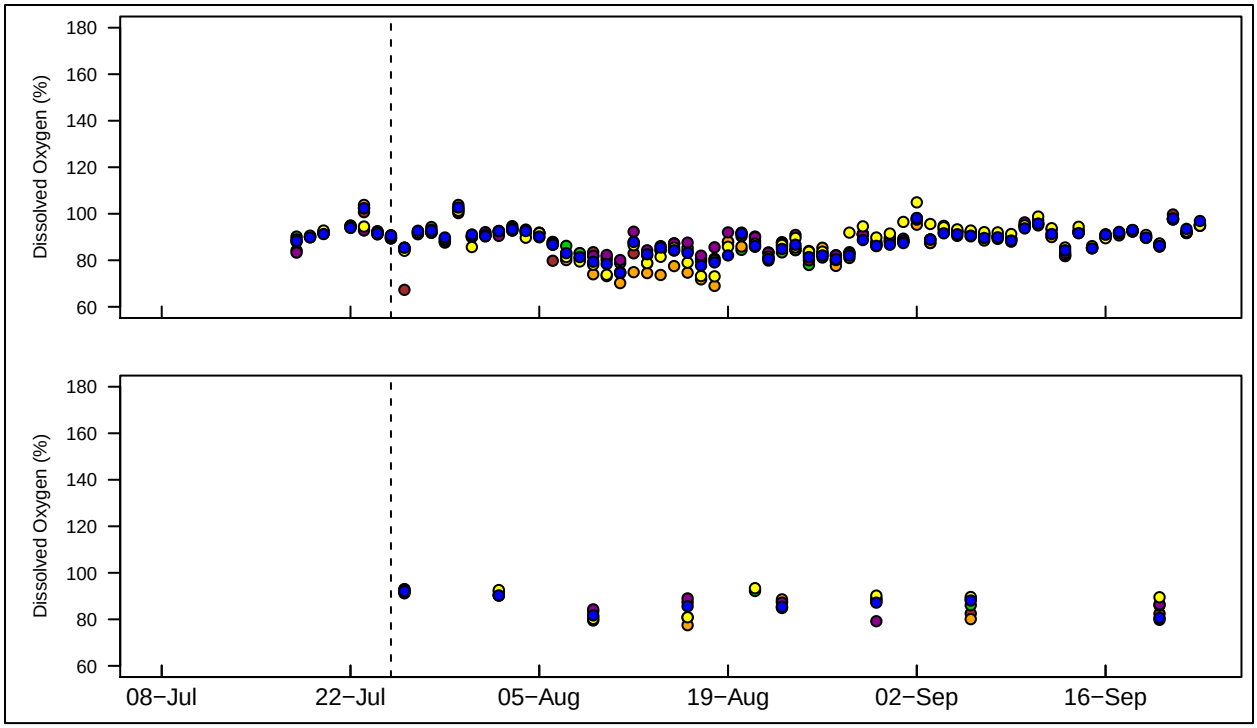


Figure 5−15h. Plot of dissolved oxygen for UMF exposure chambers (A, B, C, D, E, and F) for the duration of the study

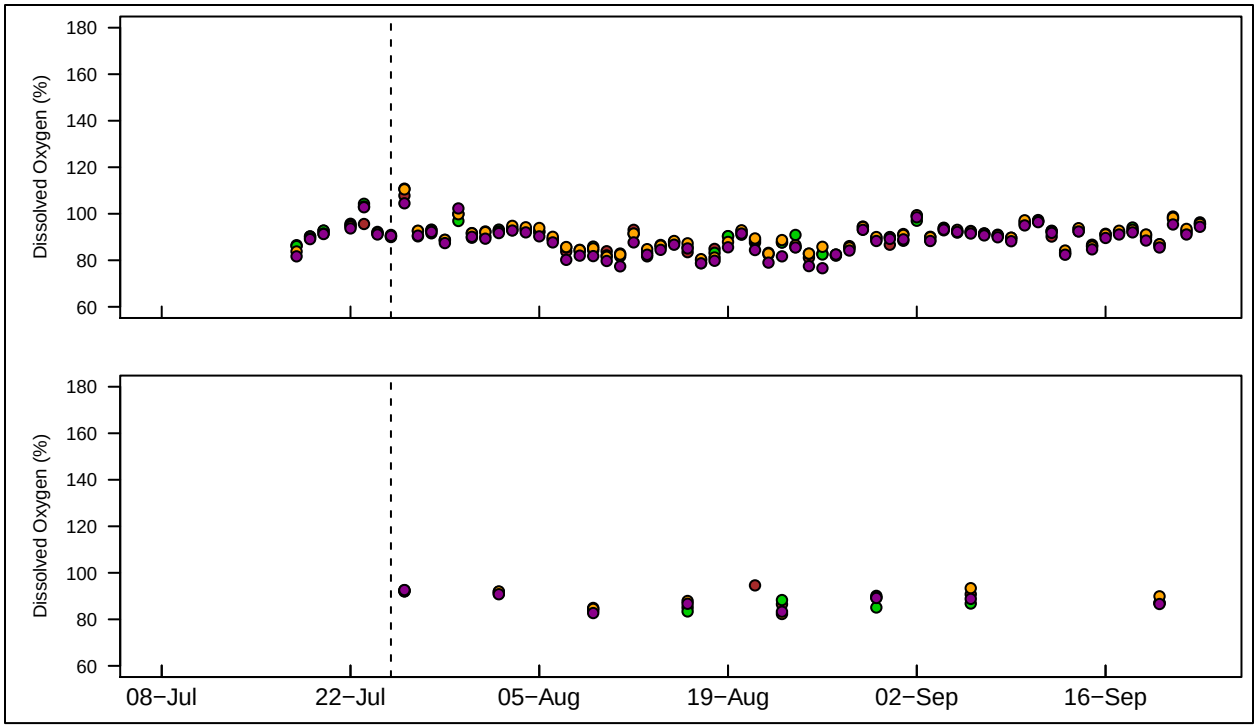


Figure 5−15i. Plot of dissolved oxygen for LMF exposure chambers (A, B, C, and D) for the duration of the study

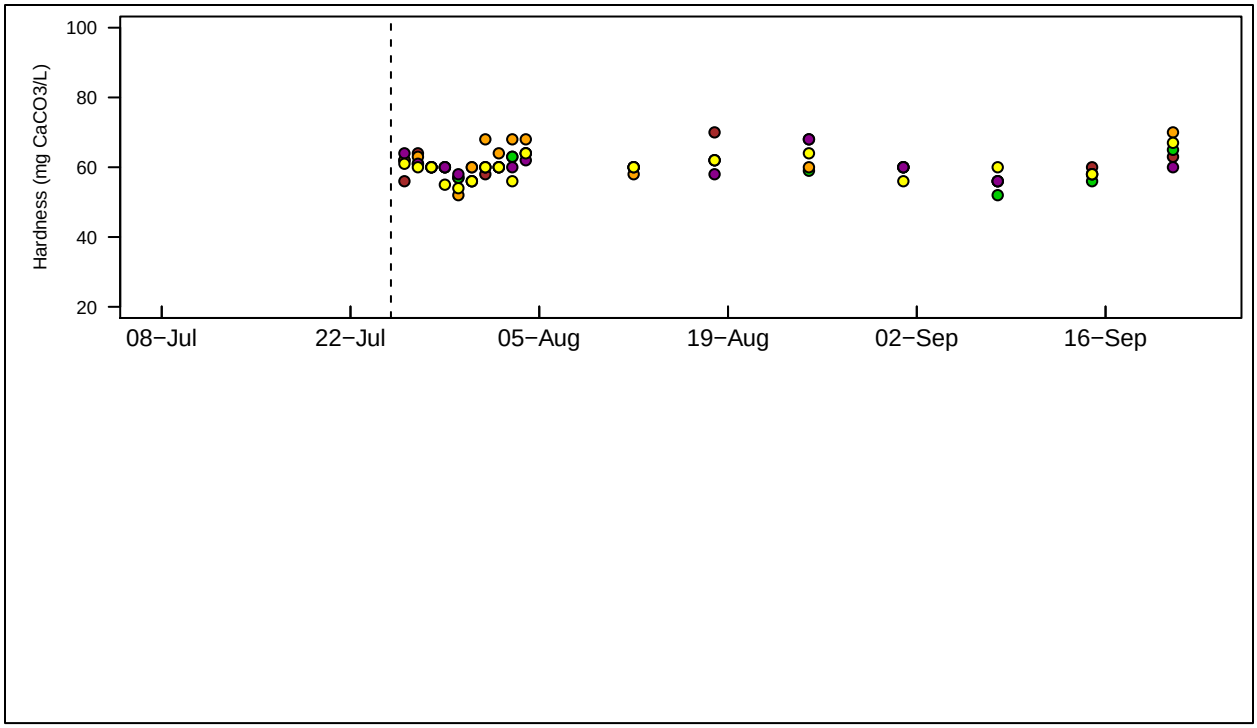


Figure 5−16a. Plot of hardness for H2O exposure chambers (A, B, C, D, and E) for the duration of the study

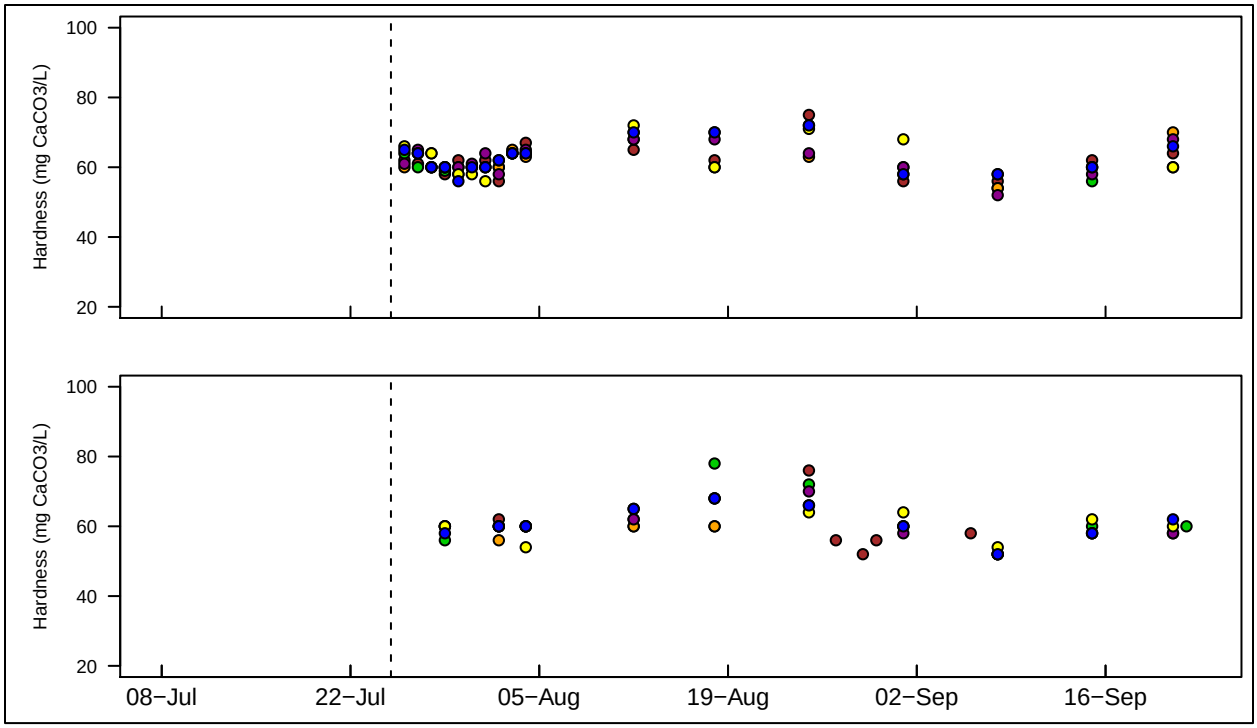


Figure 5−16b. Plot of hardness for CTRL exposure chambers (A, B, C, D, E, and F) for the duration of the study

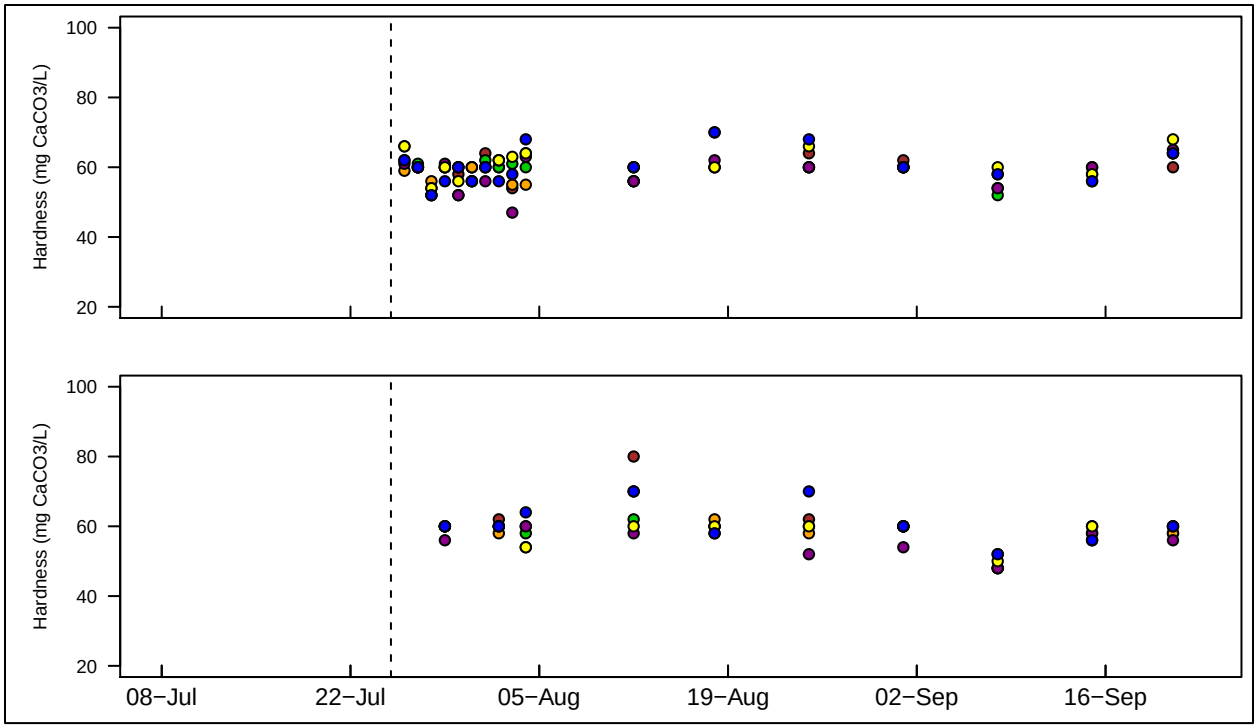


Figure 5−16c. Plot of hardness for LALL exposure chambers (A, B, C, D, E, and F) for the duration of the study

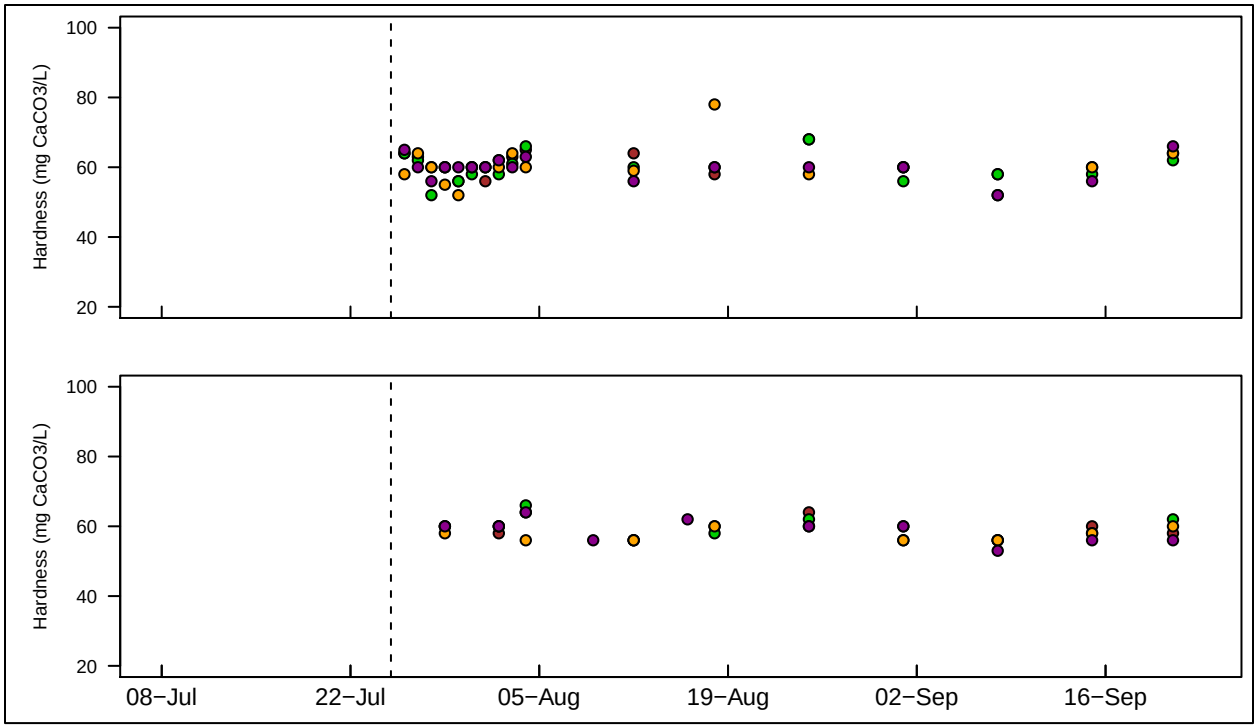


Figure 5−16d. Plot of hardness for GE exposure chambers (A, B, C, and D) for the duration of the study

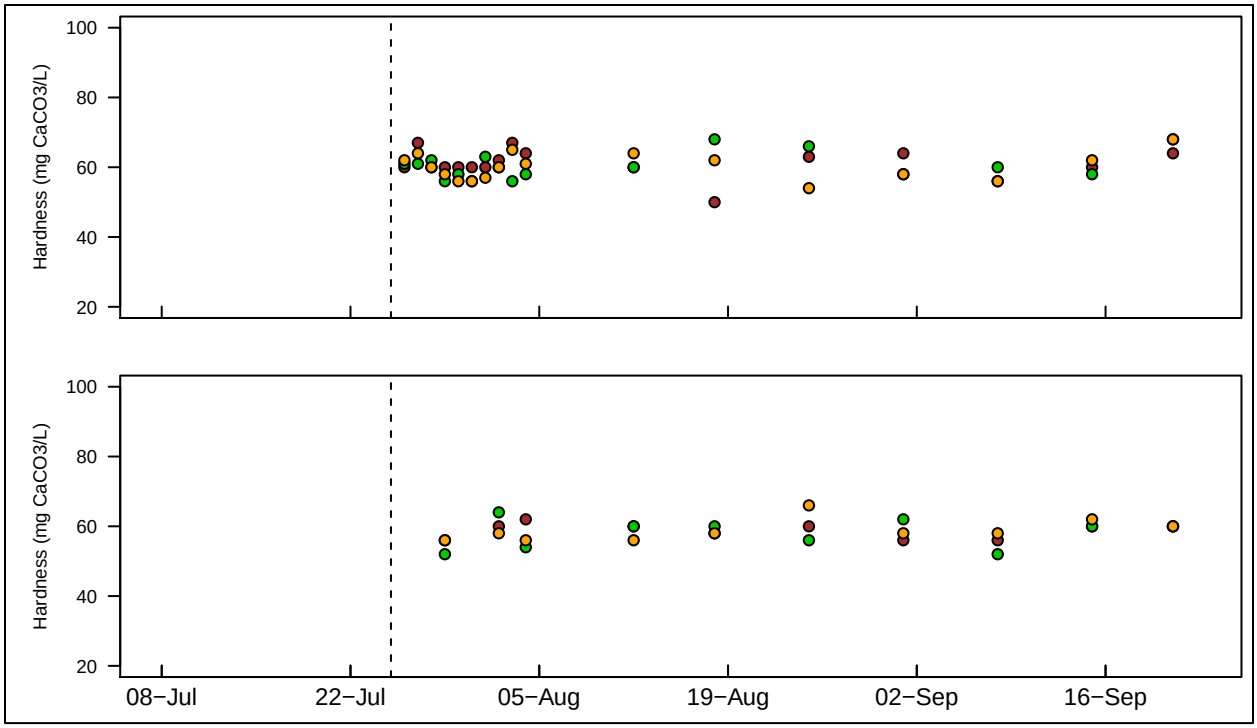


Figure 5−16e. Plot of hardness for DE exposure chambers (A, B, and C) for the duration of the study

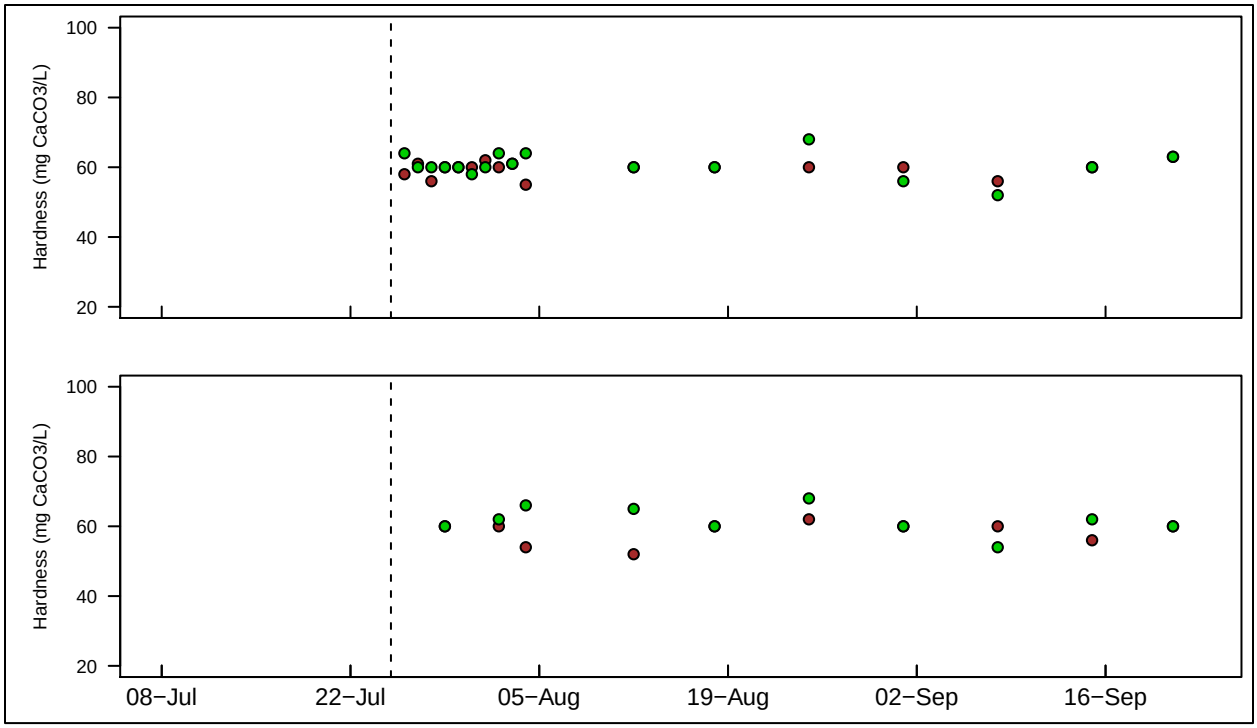


Figure 5−16f. Plot of hardness for NP exposure chambers (A and B) for the duration of the study

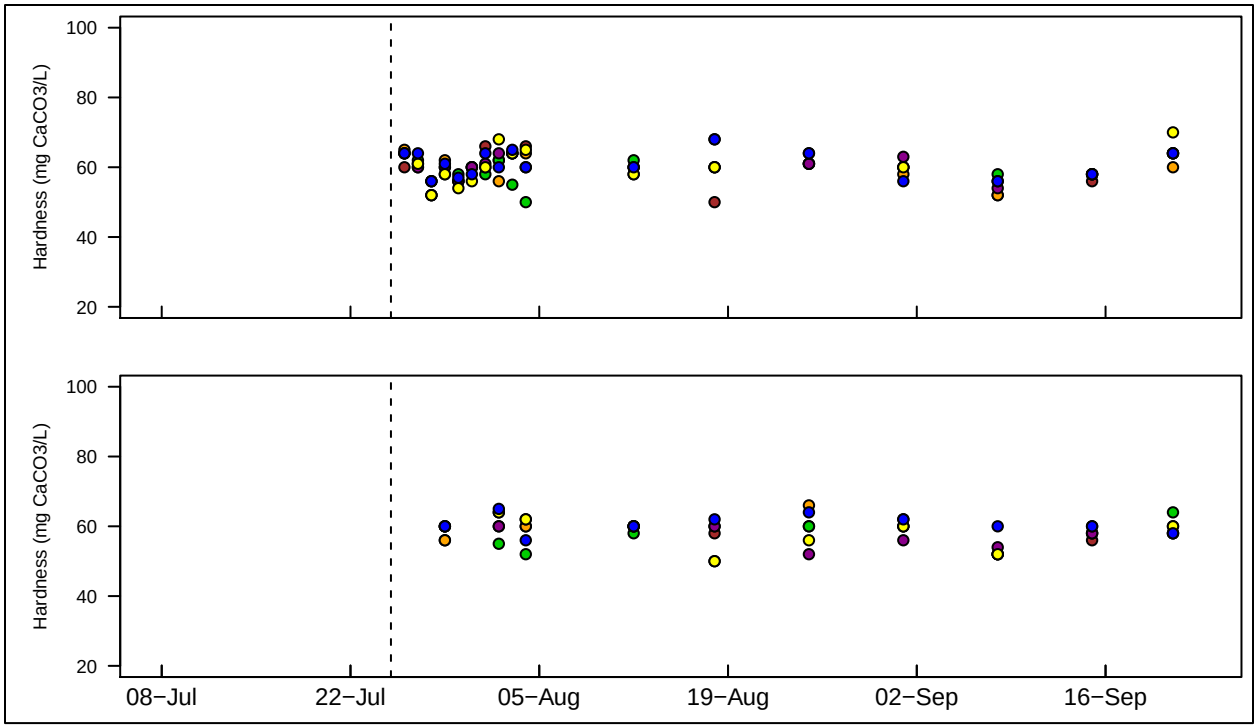


Figure 5−16g. Plot of hardness for LD exposure chambers (A, B, C, D, E, and F) for the duration of the study

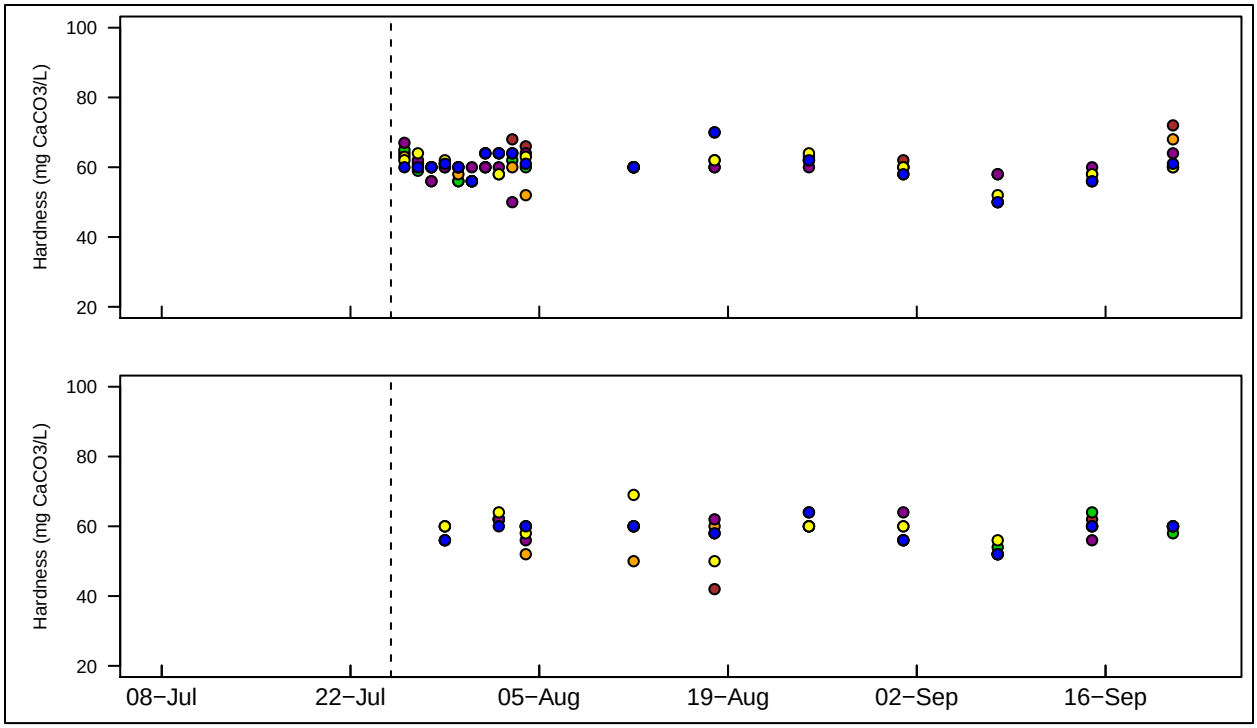


Figure 5−16h. Plot of hardness for UMF exposure chambers (A, B, C, D, E, and F) for the duration of the study

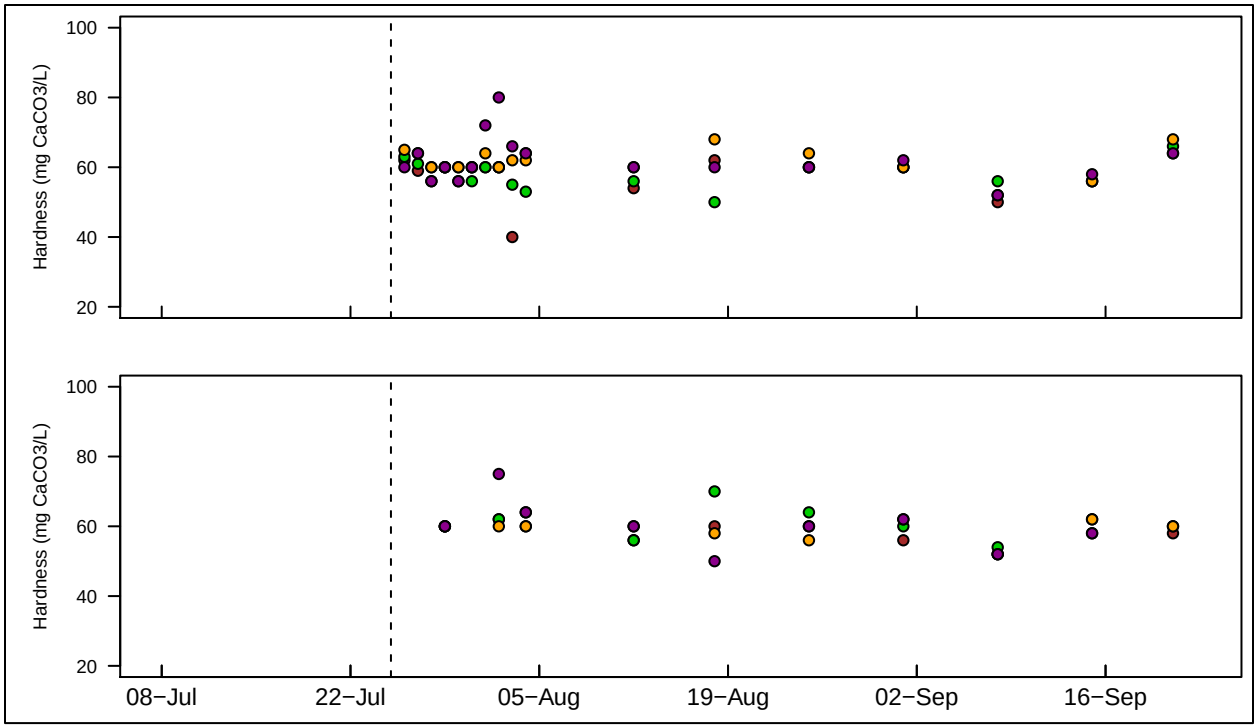


Figure 5−16i. Plot of hardness for LMF exposure chambers (A, B, C, and D) for the duration of the study

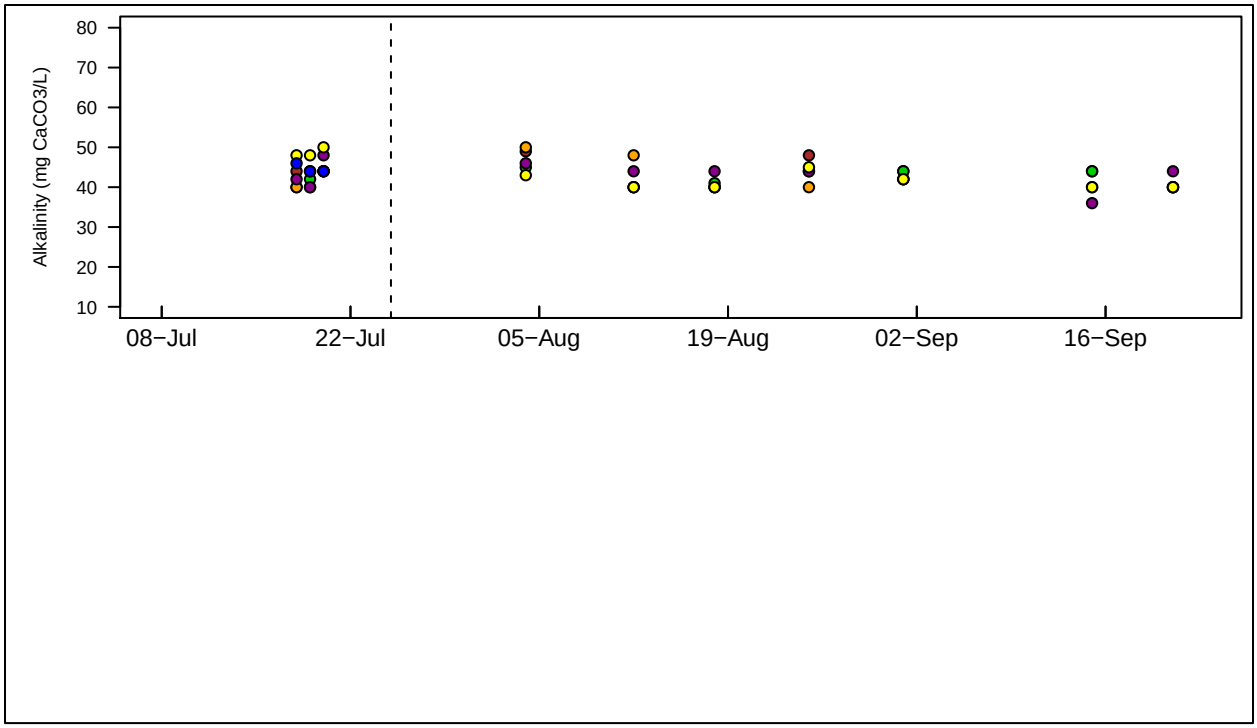


Figure 5−17a. Plot of alkalinity for H2O exposure chambers (A, B, C, D, and E) for the duration of the study

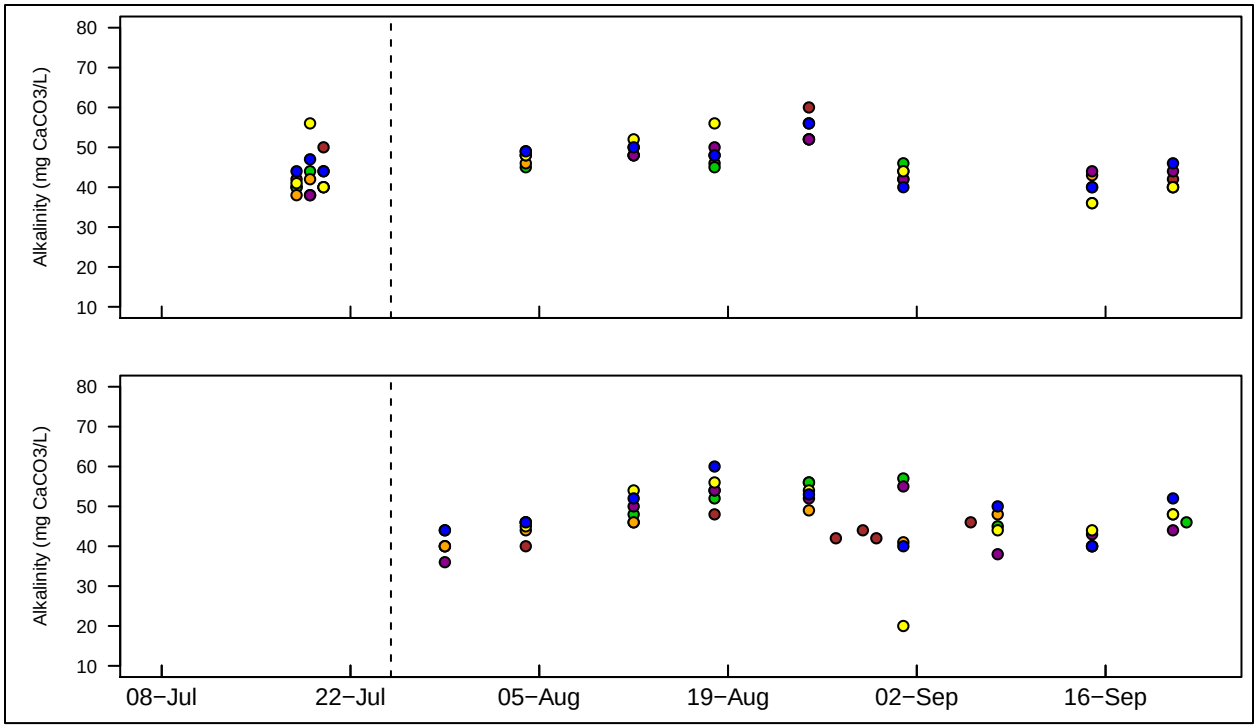


Figure 5−17b. Plot of alkalinity for CTRL exposure chambers (A, B, C, D, E, and F) for the duration of the study

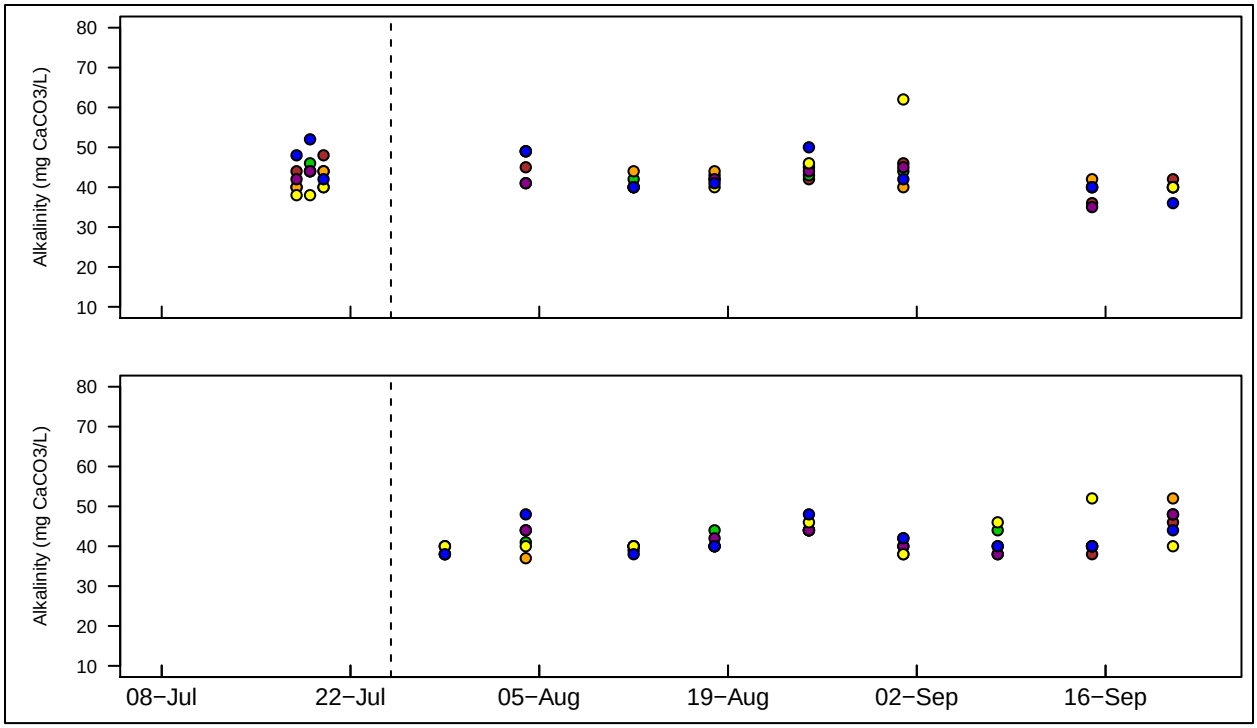


Figure 5−17c. Plot of alkalinity for LALL exposure chambers (A, B, C, D, E, and F) for the duration of the study

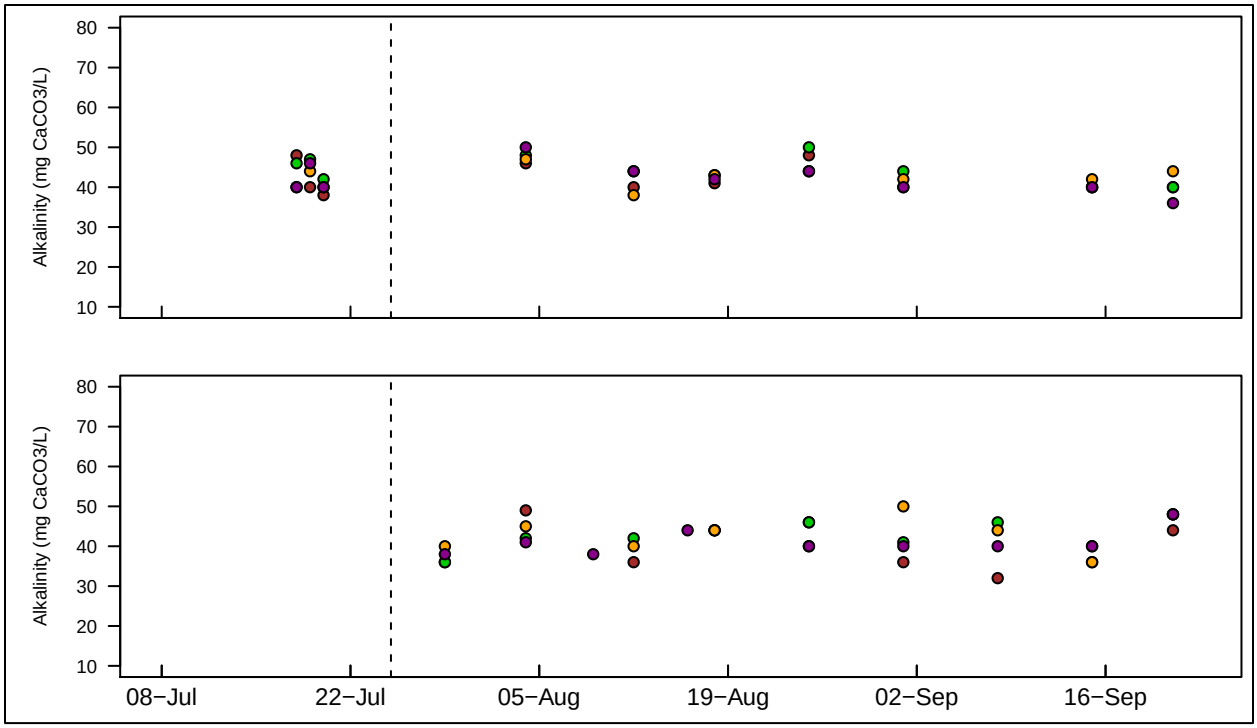


Figure 5−17d. Plot of alkalinity for GE exposure chambers (A, B, C, and D) for the duration of the study

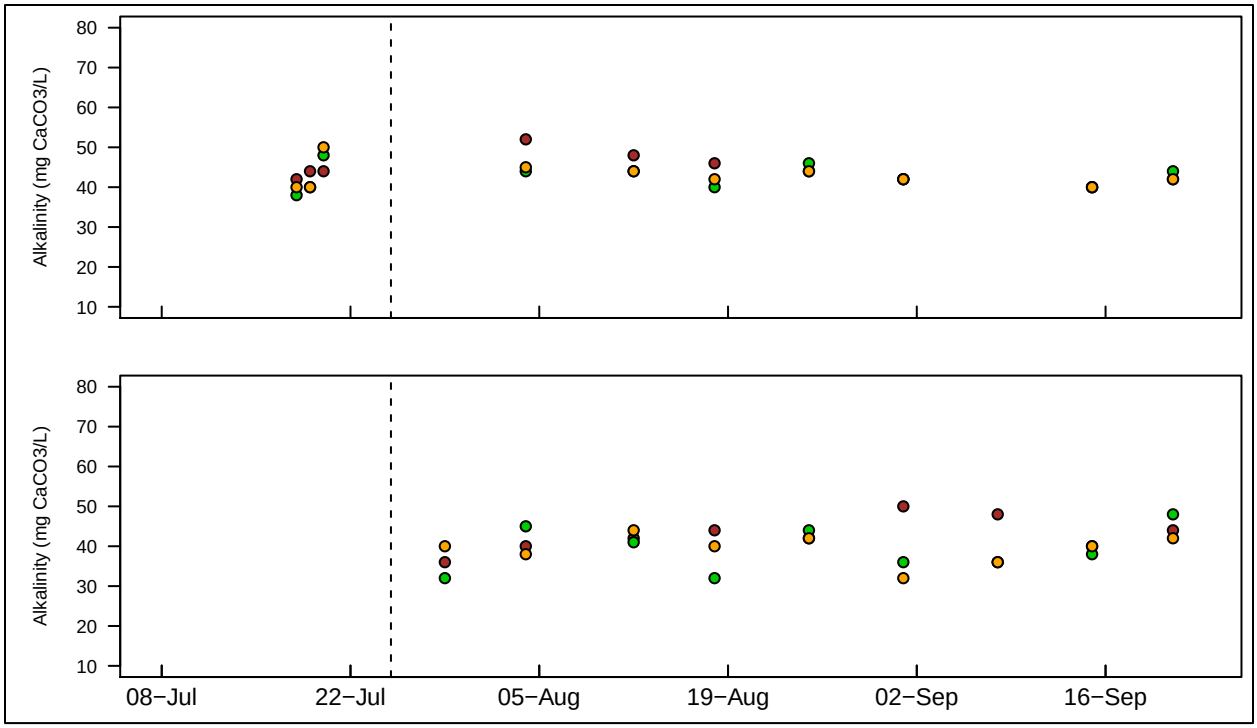


Figure 5−17e. Plot of alkalinity for DE exposure chambers (A, B, and C) for the duration of the study

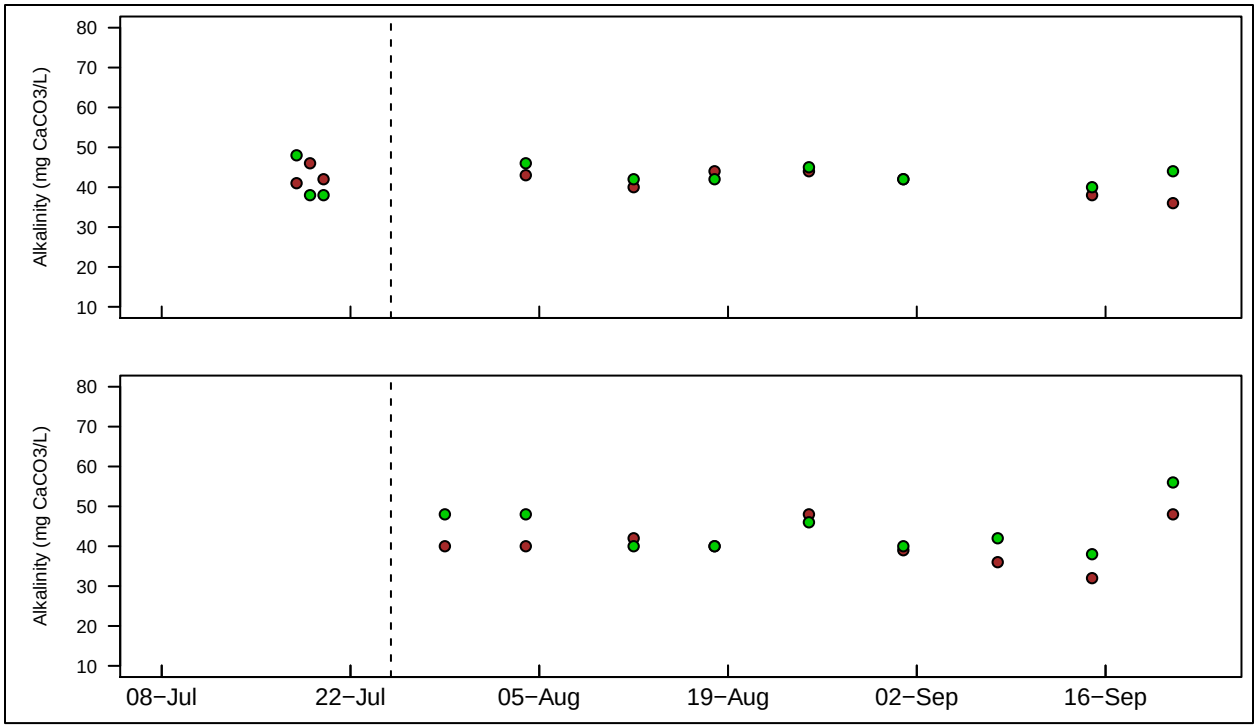


Figure 5−17f. Plot of alkalinity for NP exposure chambers (A and B) for the duration of the study

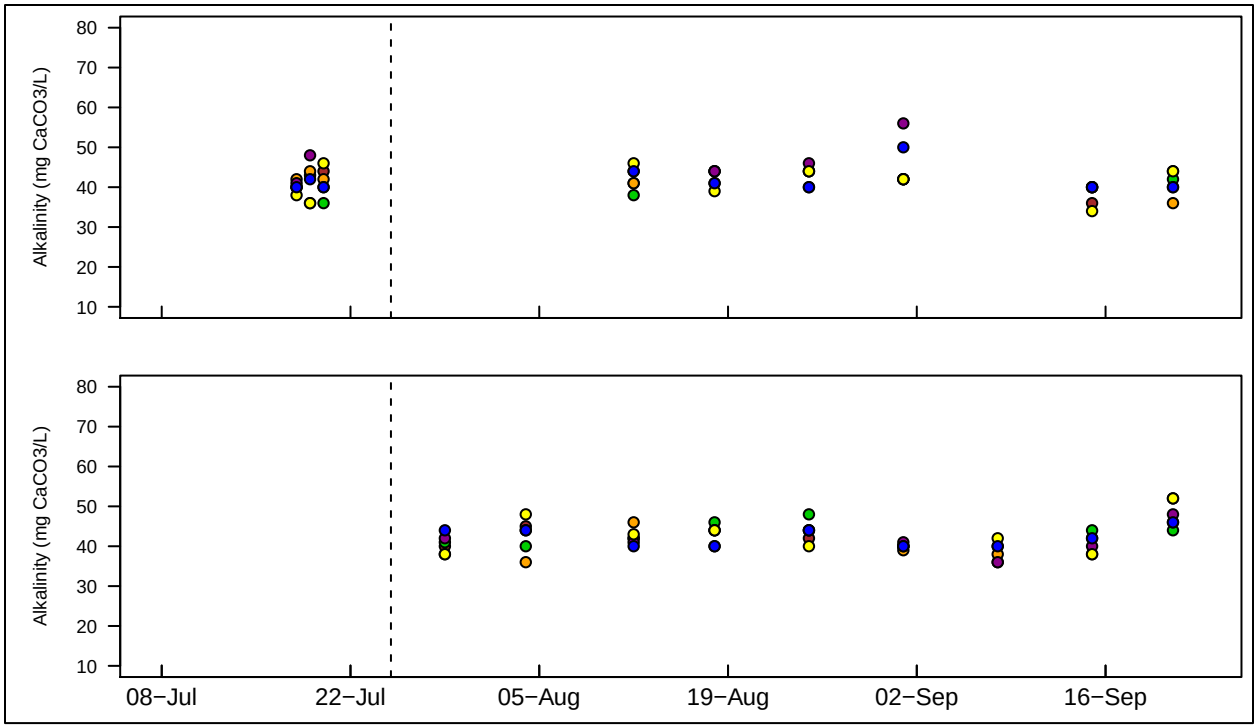


Figure 5−17g. Plot of alkalinity for LD exposure chambers (A, B, C, D, E, and F) for the duration of the study

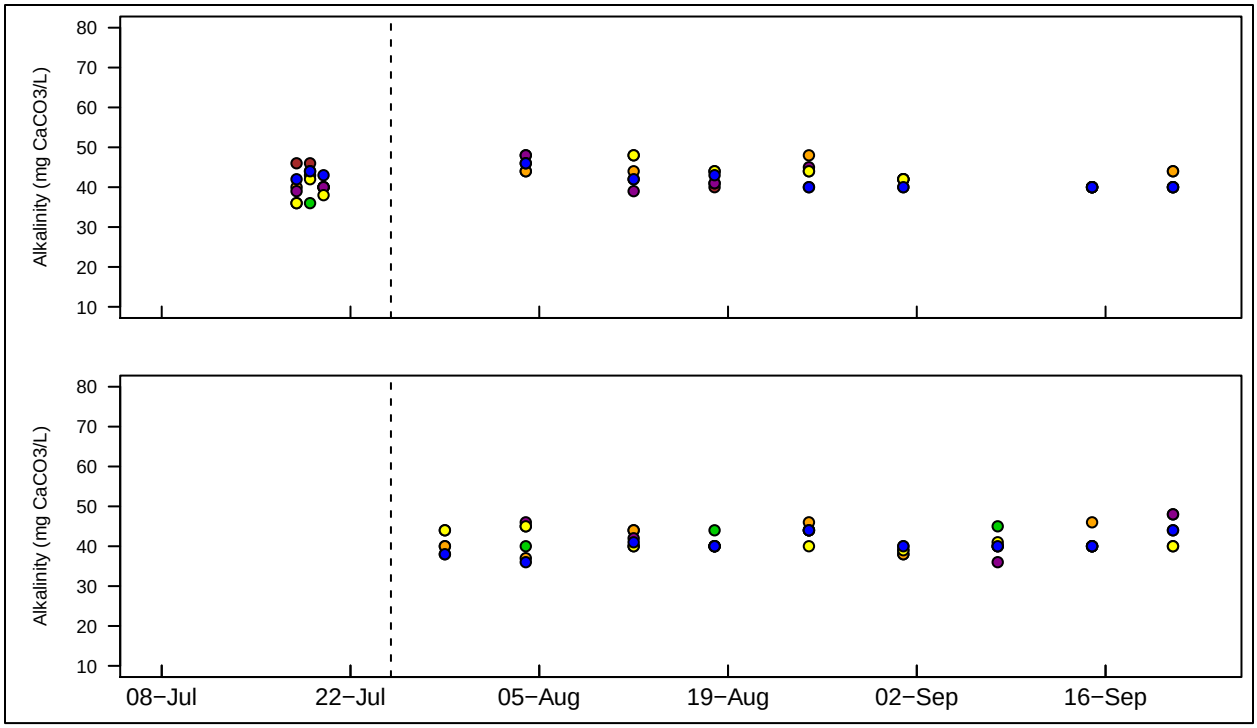


Figure 5−17h. Plot of alkalinity for UMF exposure chambers (A, B, C, D, E, and F) for the duration of the study

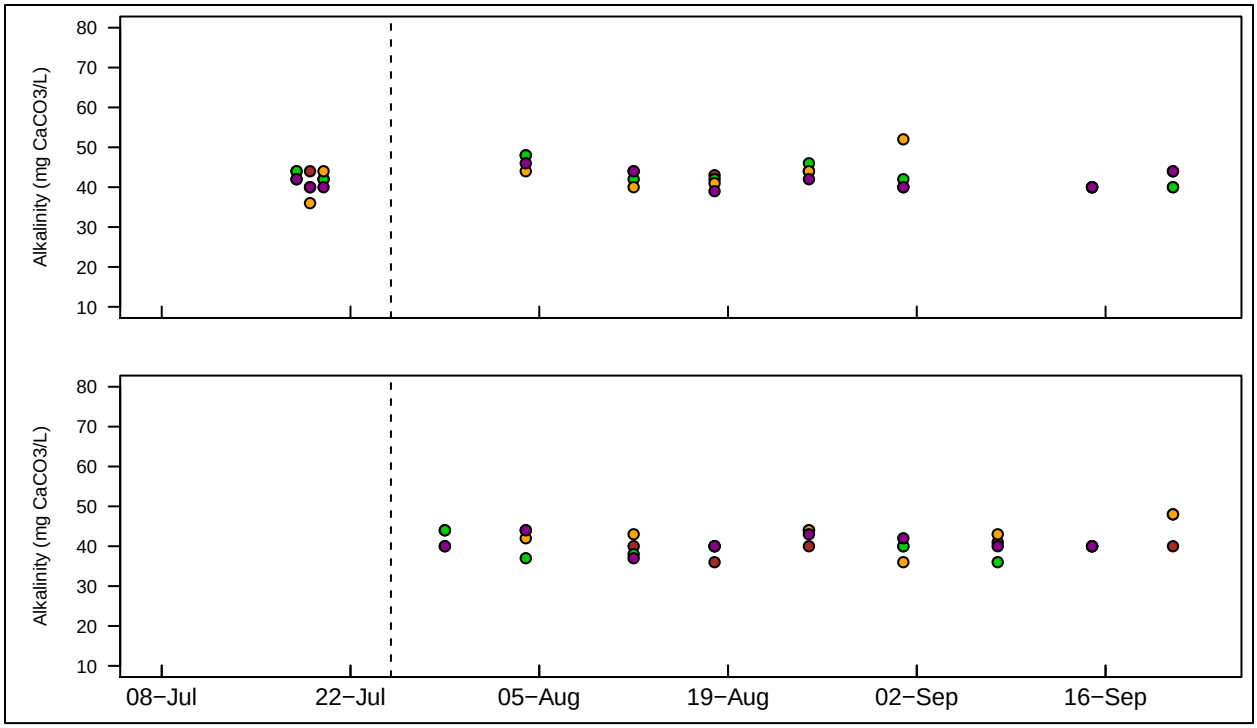


Figure 5−17i. Plot of alkalinity for LMF exposure chambers (A, B, C, and D) for the duration of the study

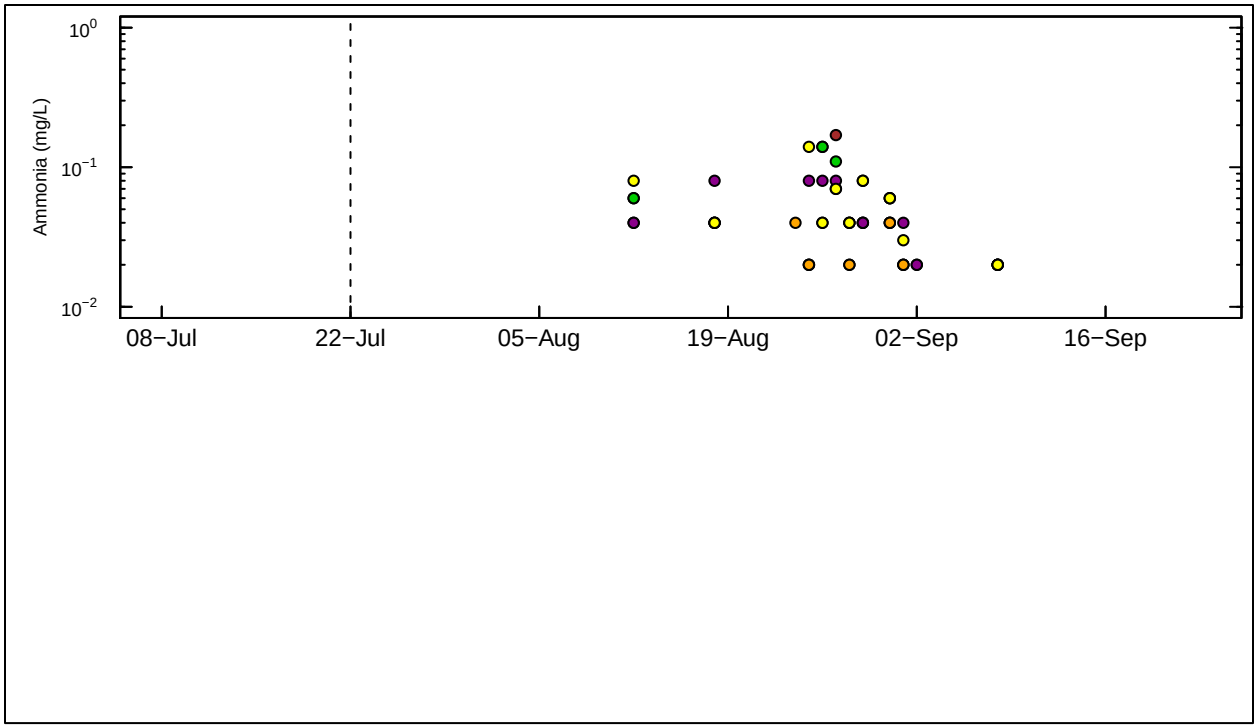


Figure 5−18a. Plot of ammonia for H2O exposure chambers (A, B, C, D, and E) for the duration of the study

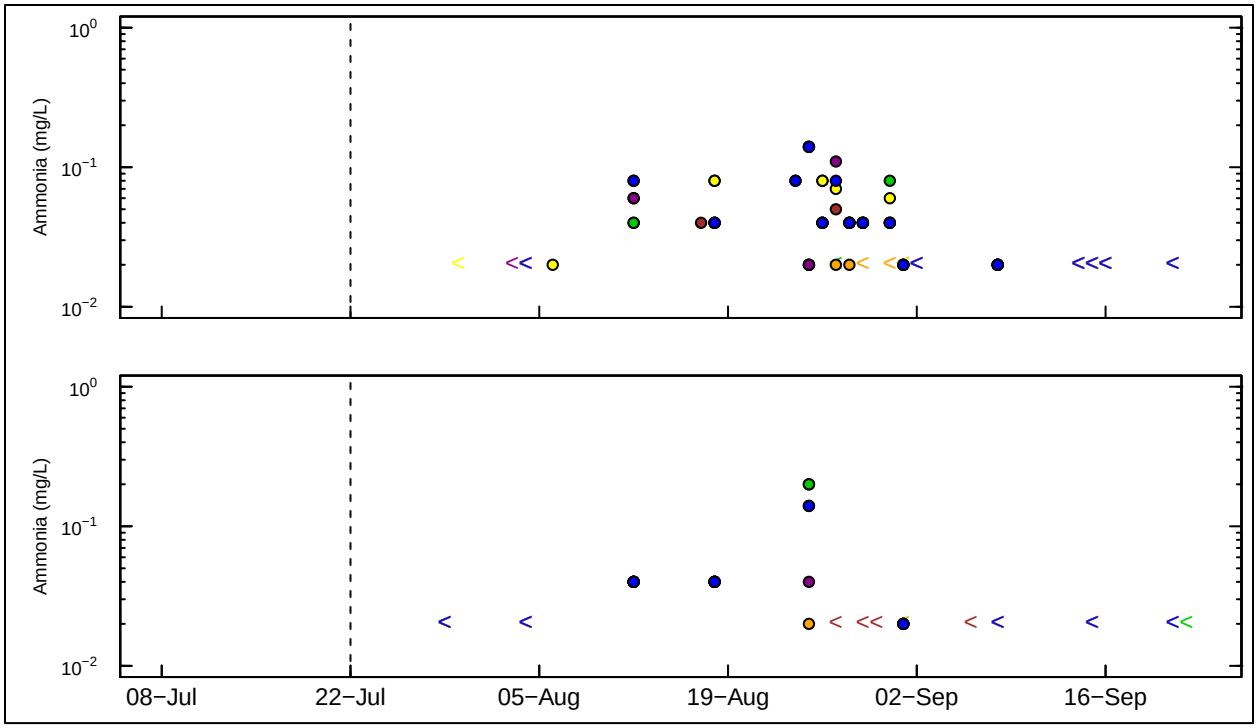


Figure 5−18b. Plot of ammonia for CTRL exposure chambers (A, B, C, D, E, and F) for the duration of the study

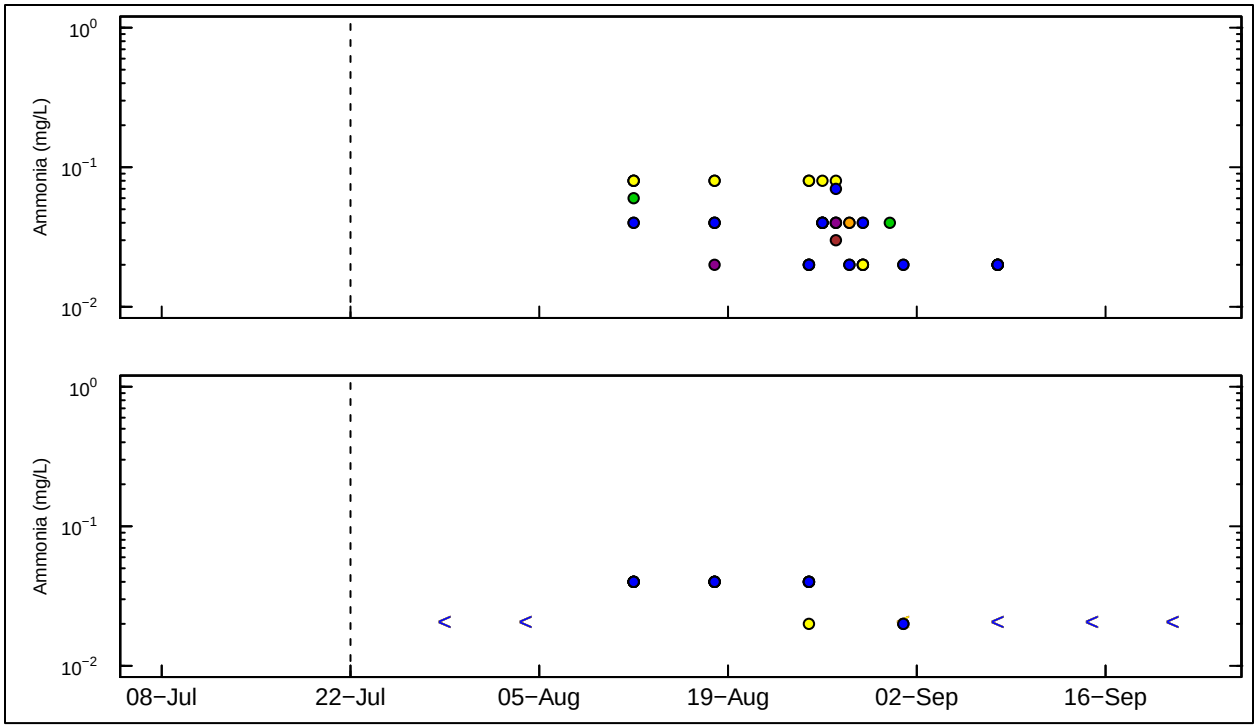


Figure 5−18c. Plot of ammonia for LALL exposure chambers (A, B, C, D, E, and F) for the duration of the study

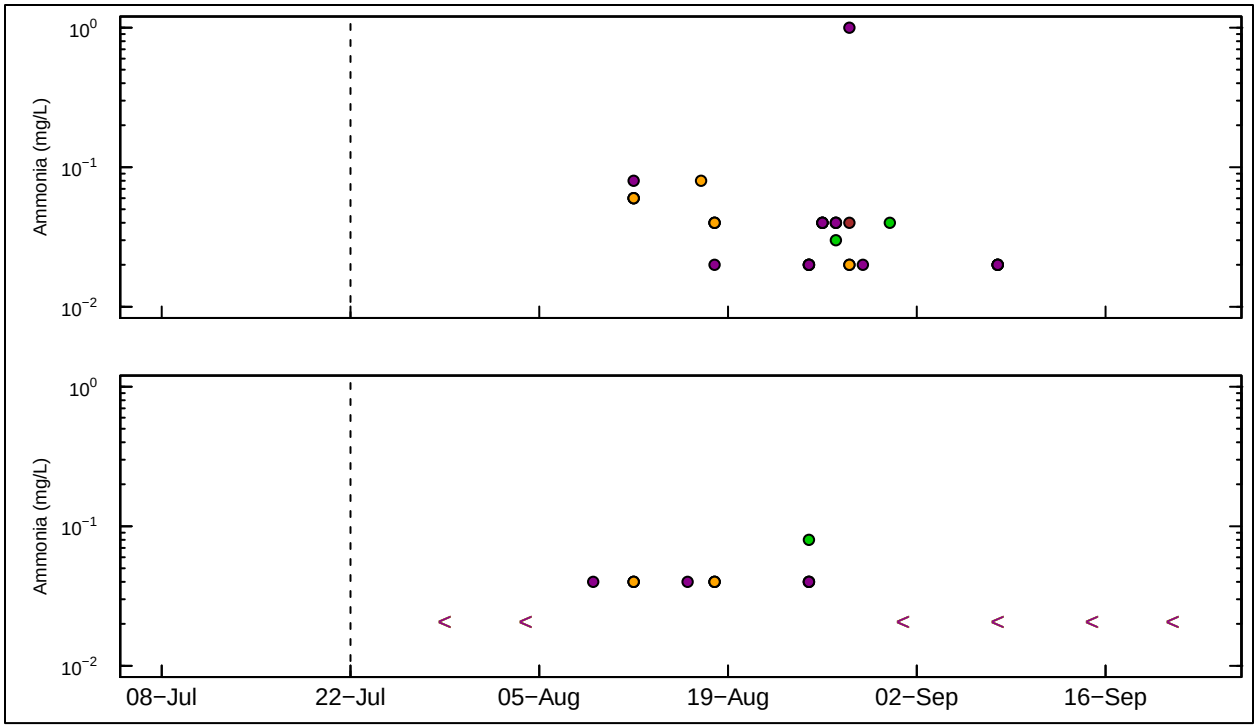


Figure 5−18d. Plot of ammonia for GE exposure chambers (A, B, C, and D) for the duration of the study

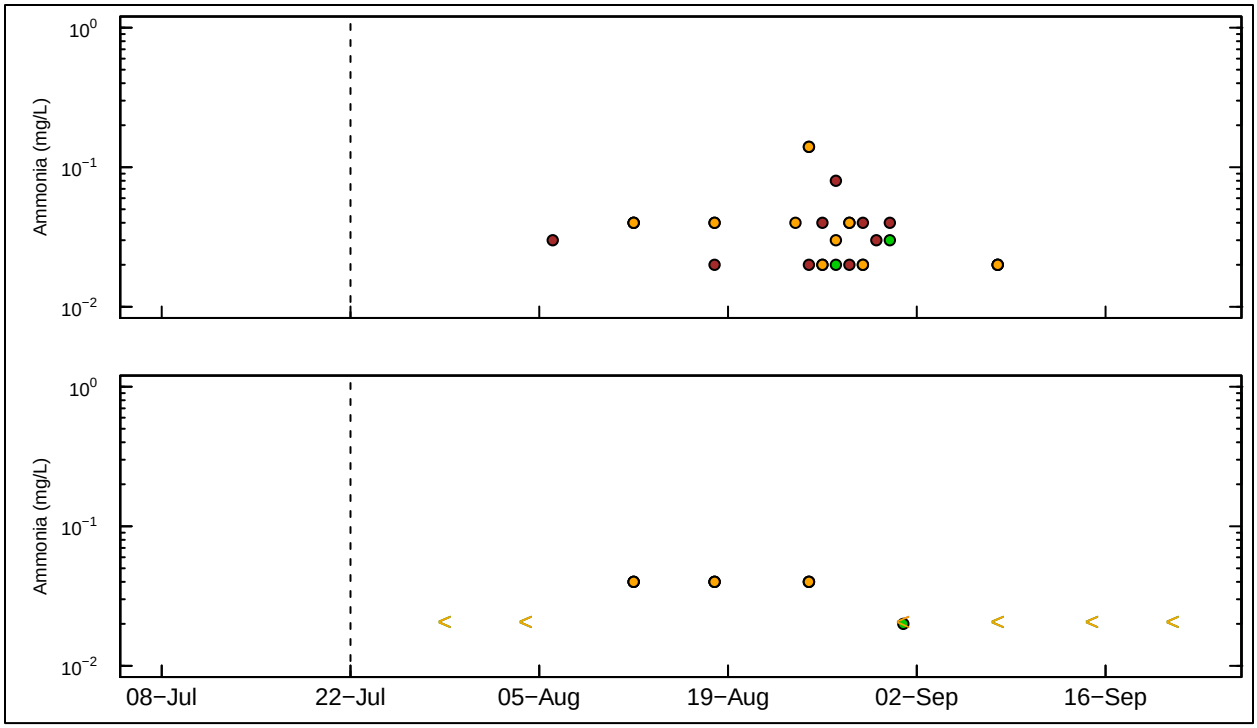


Figure 5−18e. Plot of ammonia for DE exposure chambers (A, B, and C) for the duration of the study

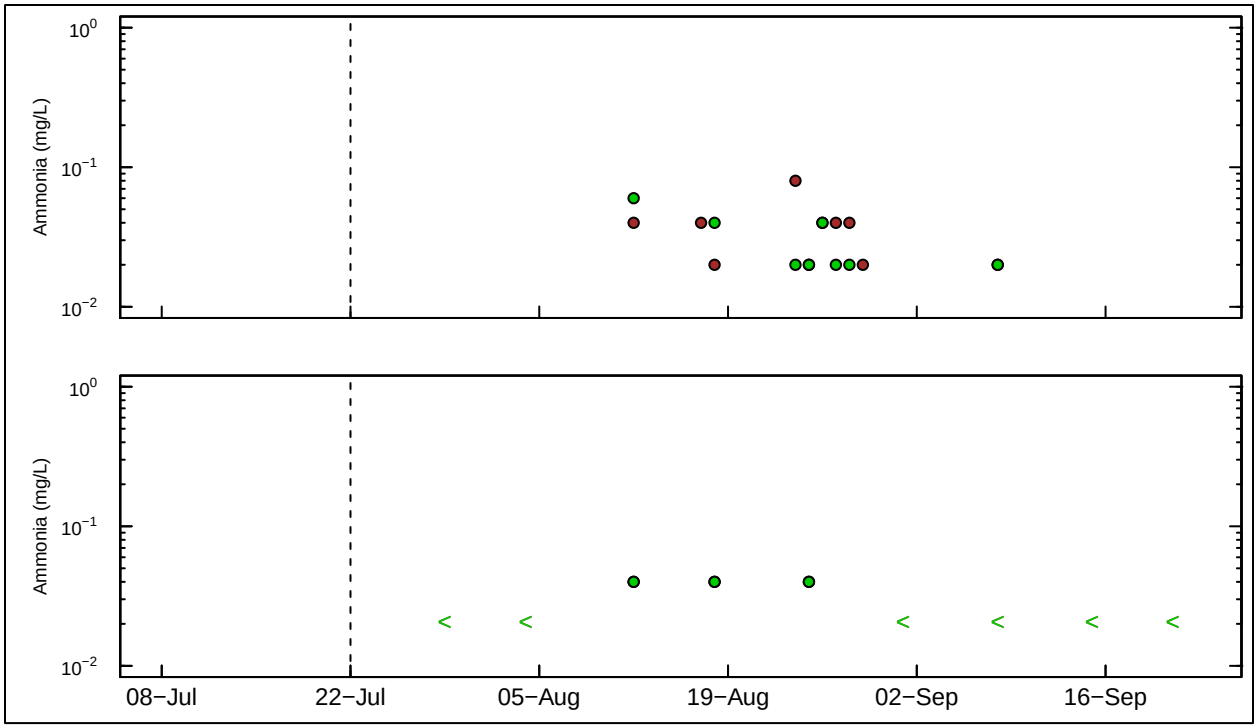


Figure 5−18f. Plot of ammonia for NP exposure chambers (A and B) for the duration of the study

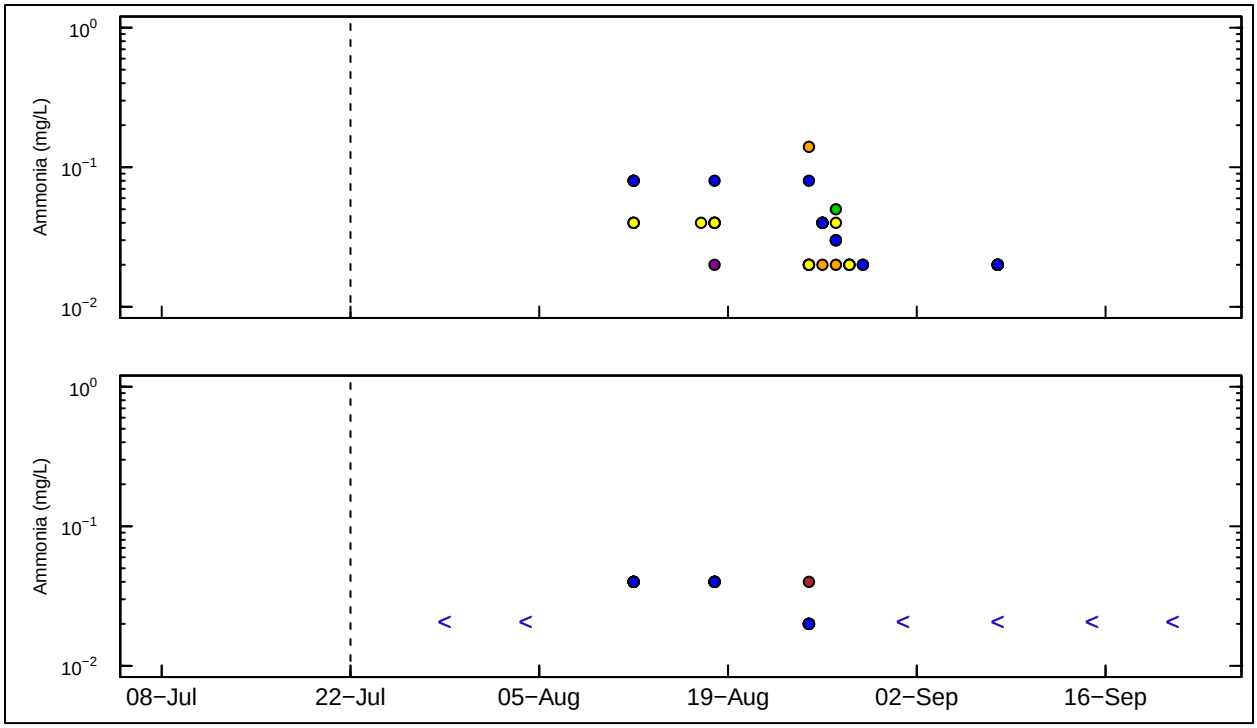


Figure 5−18g. Plot of ammonia for LD exposure chambers (A, B, C, D, E, and F) for the duration of the study

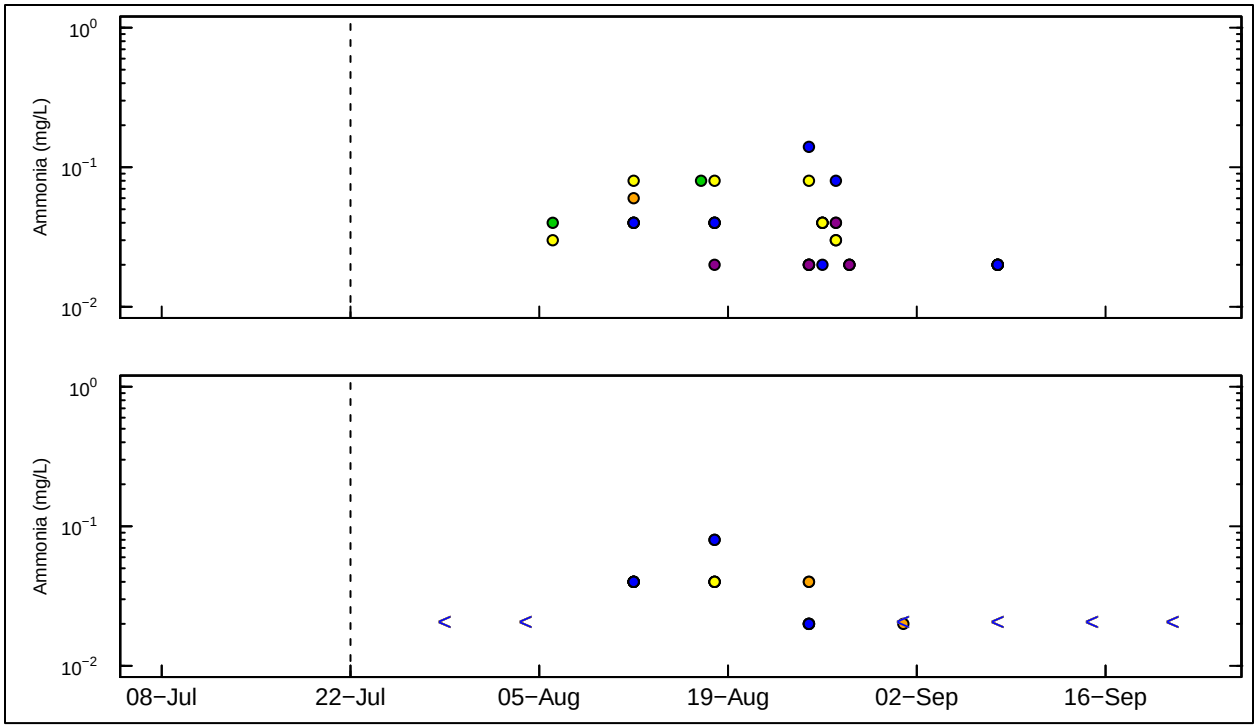


Figure 5−18h. Plot of ammonia for UMF exposure chambers (A, B, C, D, E, and F) for the duration of the study

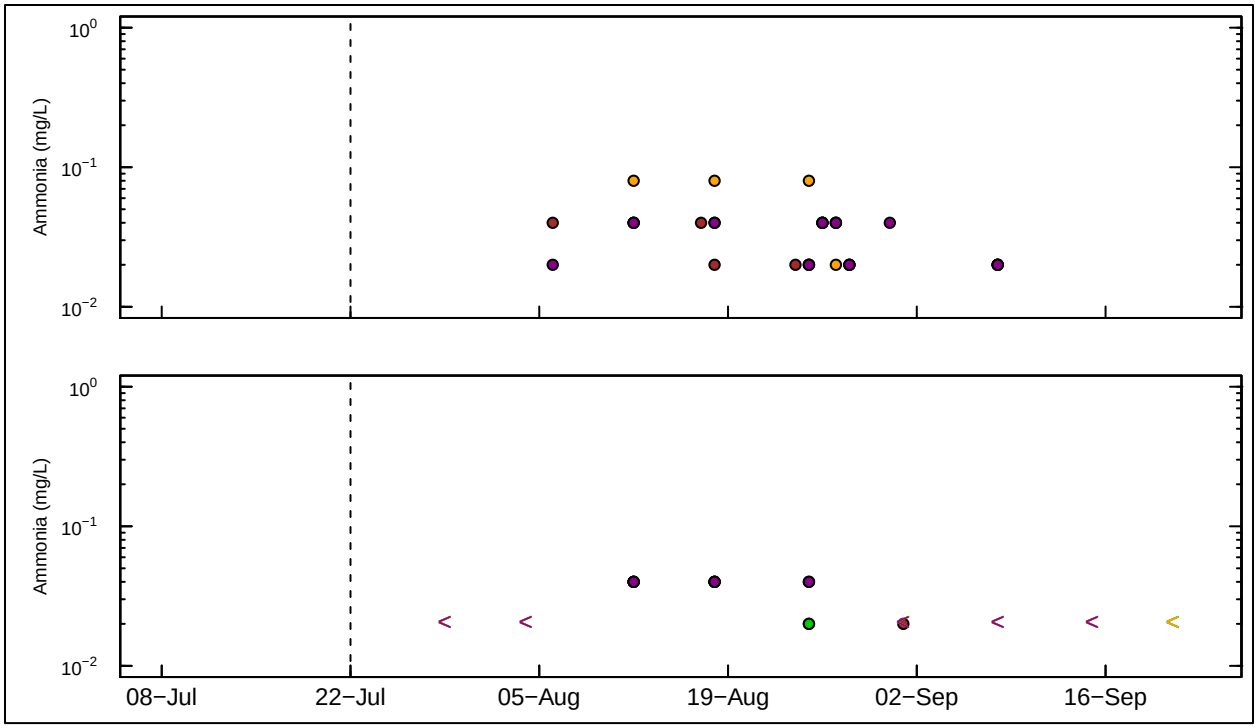


Figure 5−18i. Plot of ammonia for LMF exposure chambers (A, B, C, and D) for the duration of the study

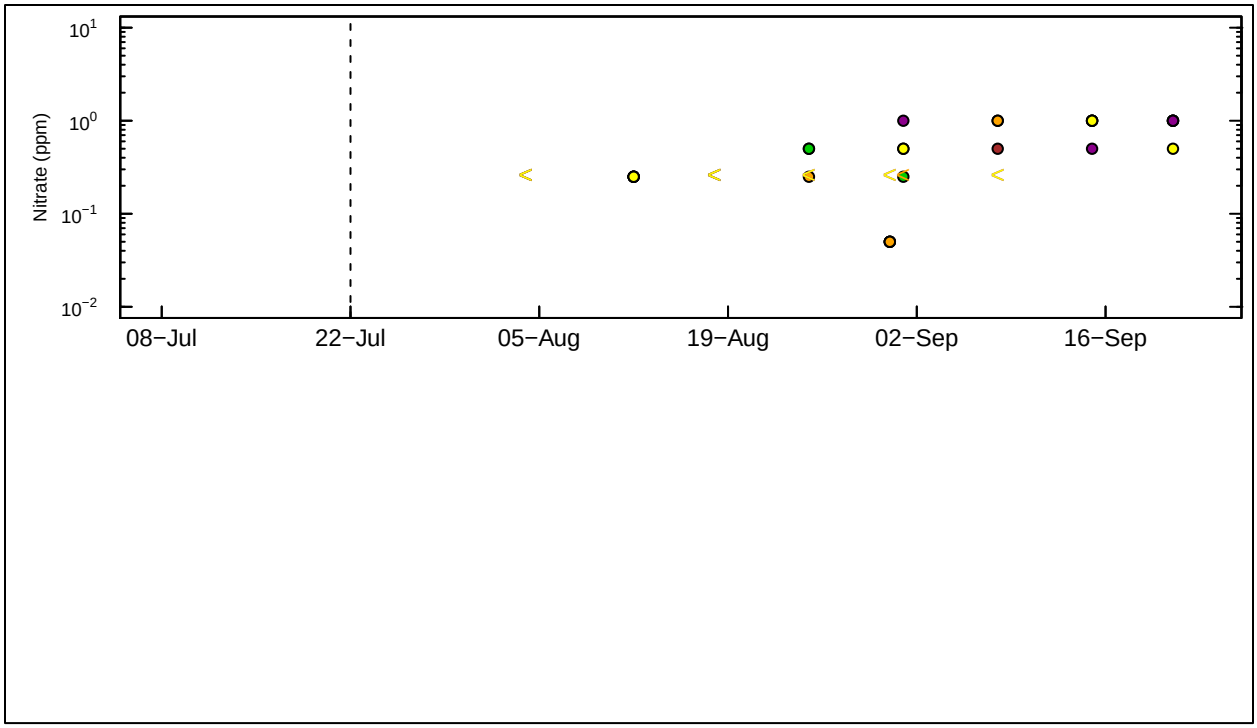


Figure 5−19a. Plot of nitrate for H2O exposure chambers (A, B, C, D, and E) for the duration of the study

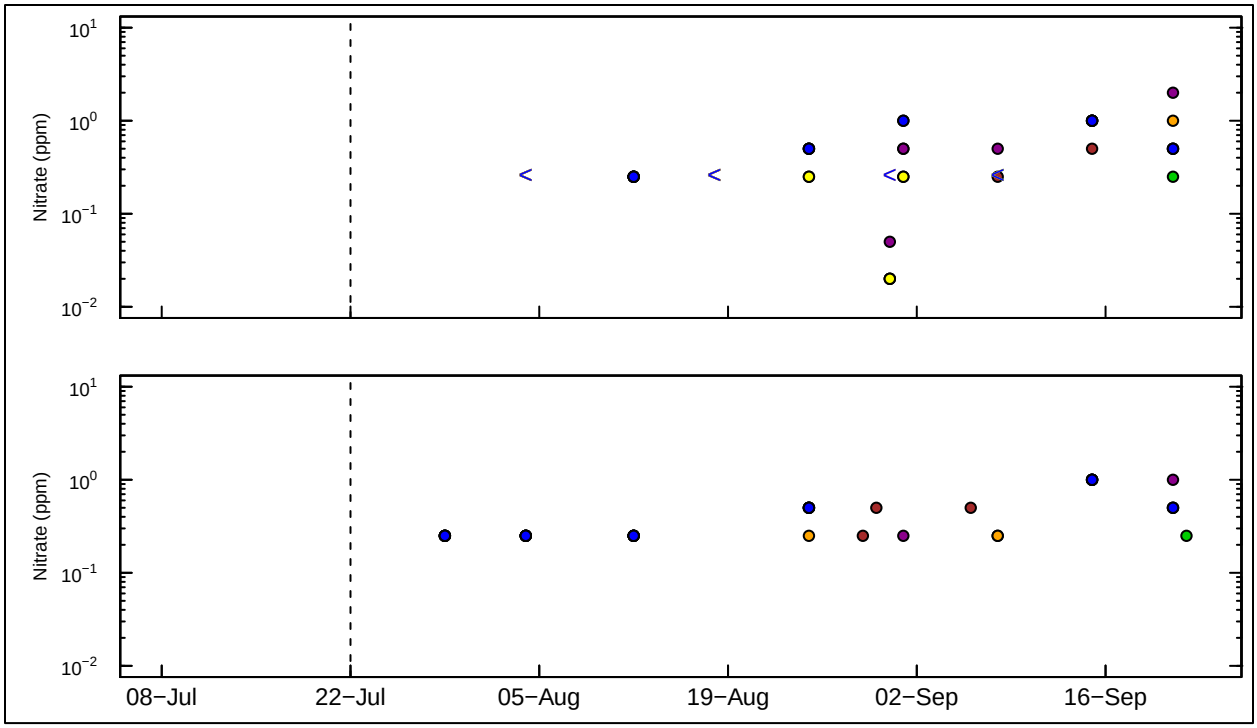


Figure 5−19b. Plot of nitrate for CTRL exposure chambers (A, B, C, D, E, and F) for the duration of the study

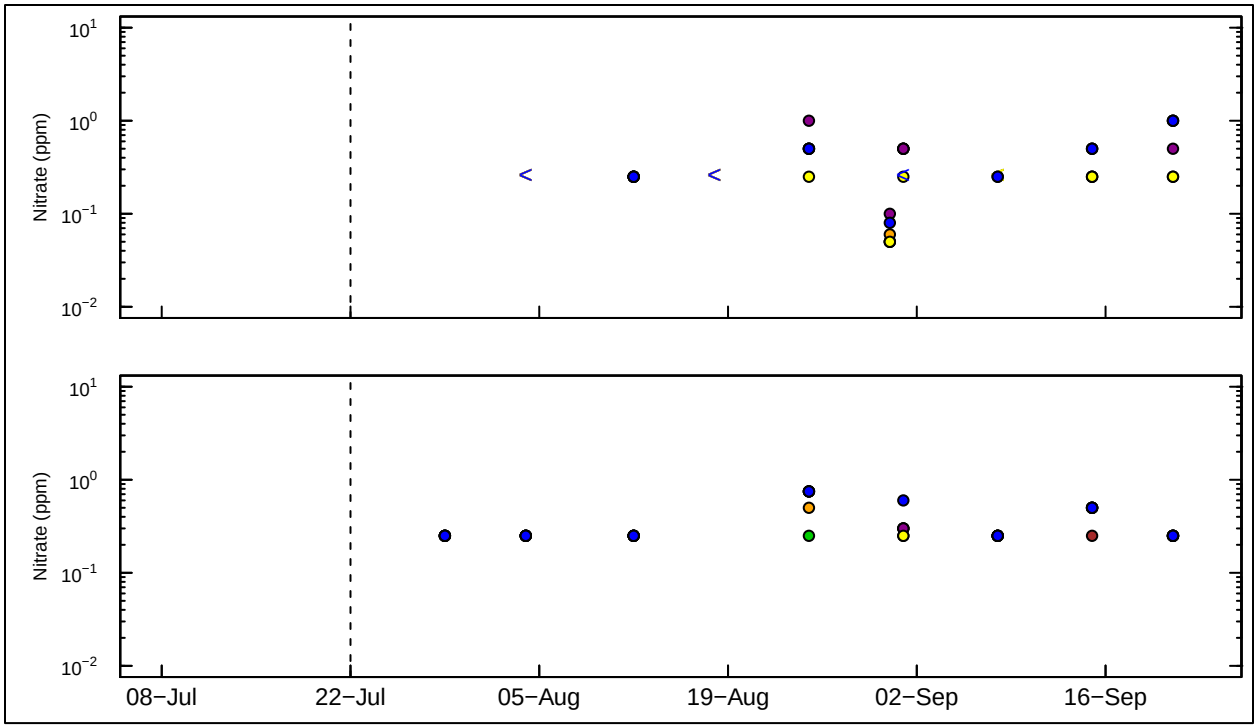


Figure 5−19c. Plot of nitrate for LALL exposure chambers (A, B, C, D, E, and F) for the duration of the study

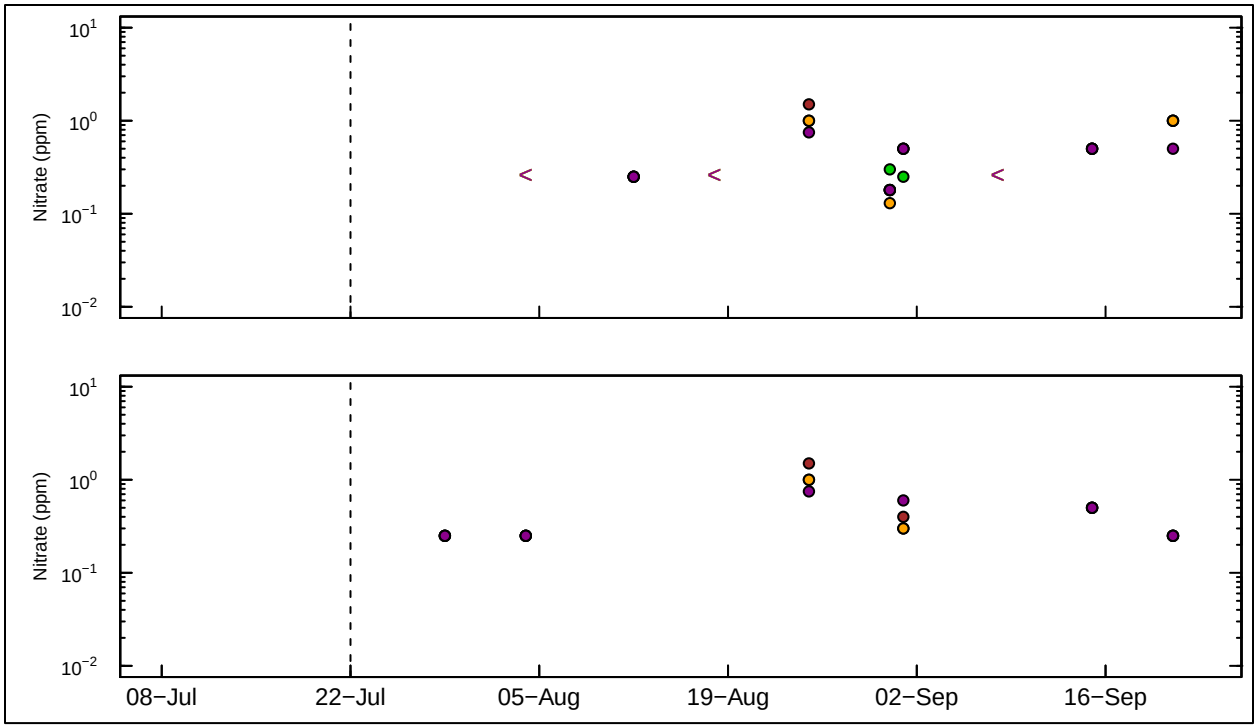


Figure 5−19d. Plot of nitrate for GE exposure chambers (A, B, C, and D) for the duration of the study

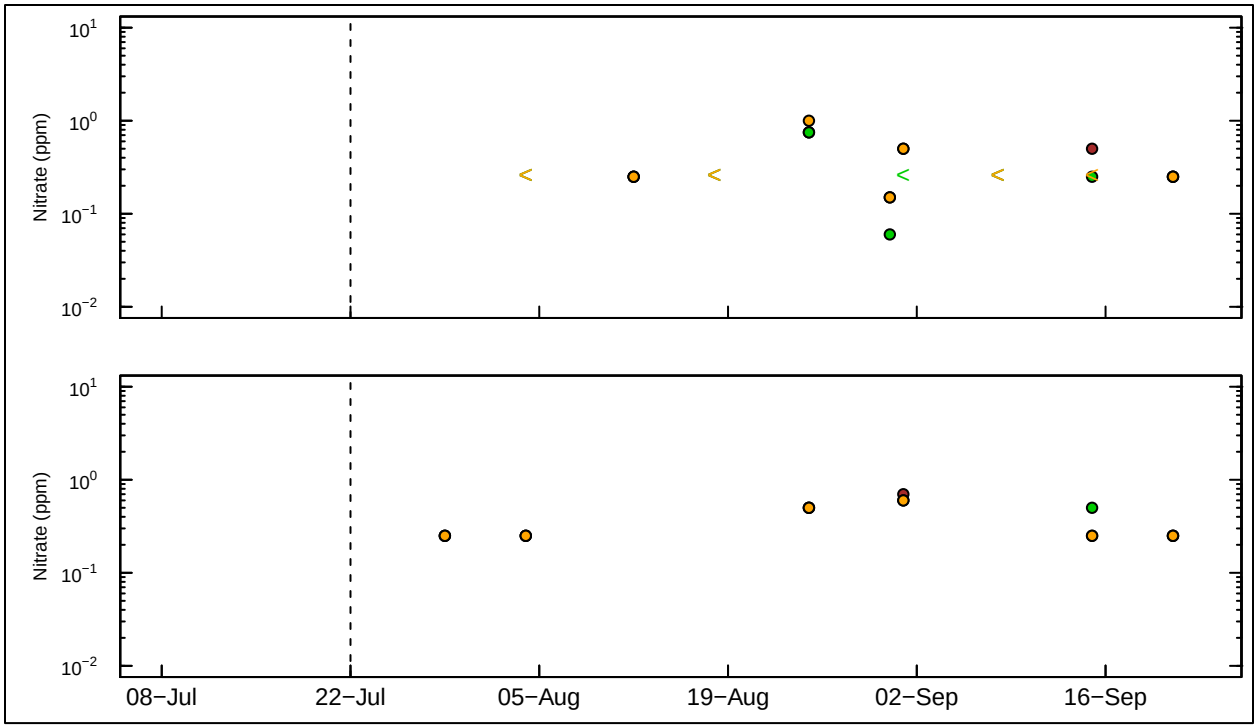


Figure 5−19e. Plot of nitrate for DE exposure chambers (A, B, and C) for the duration of the study

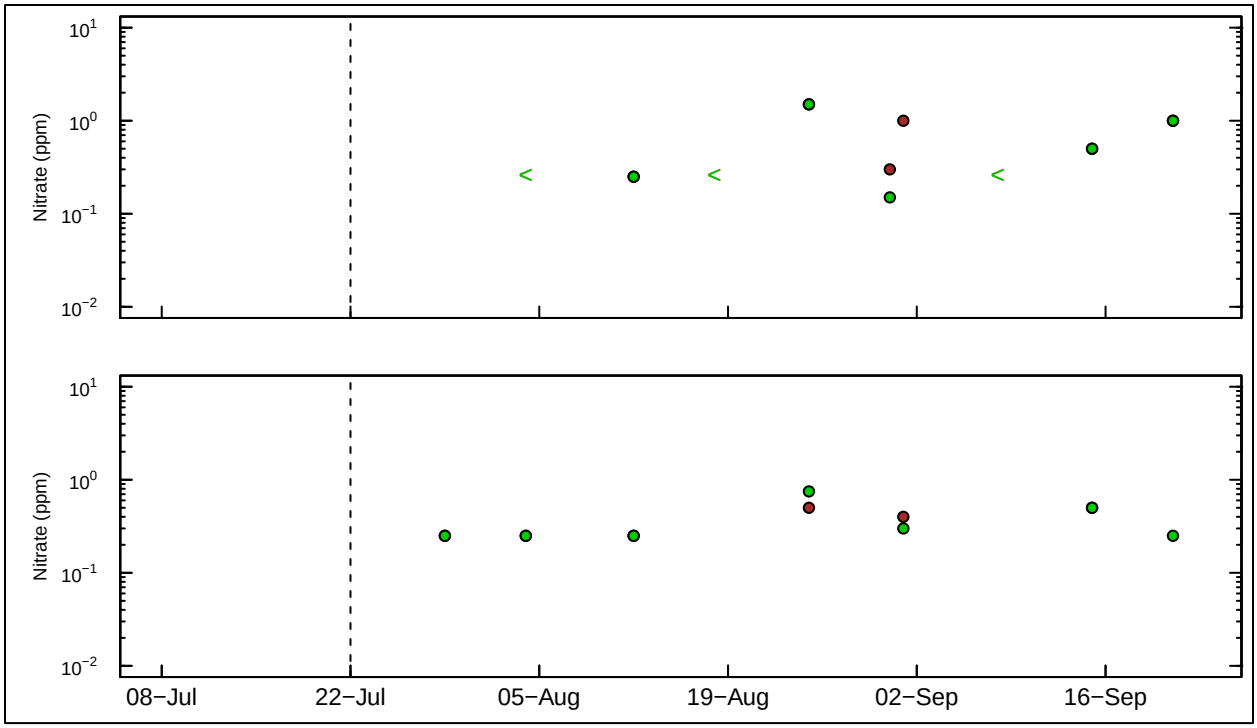


Figure 5−19f. Plot of nitrate for NP exposure chambers (A and B) for the duration of the study

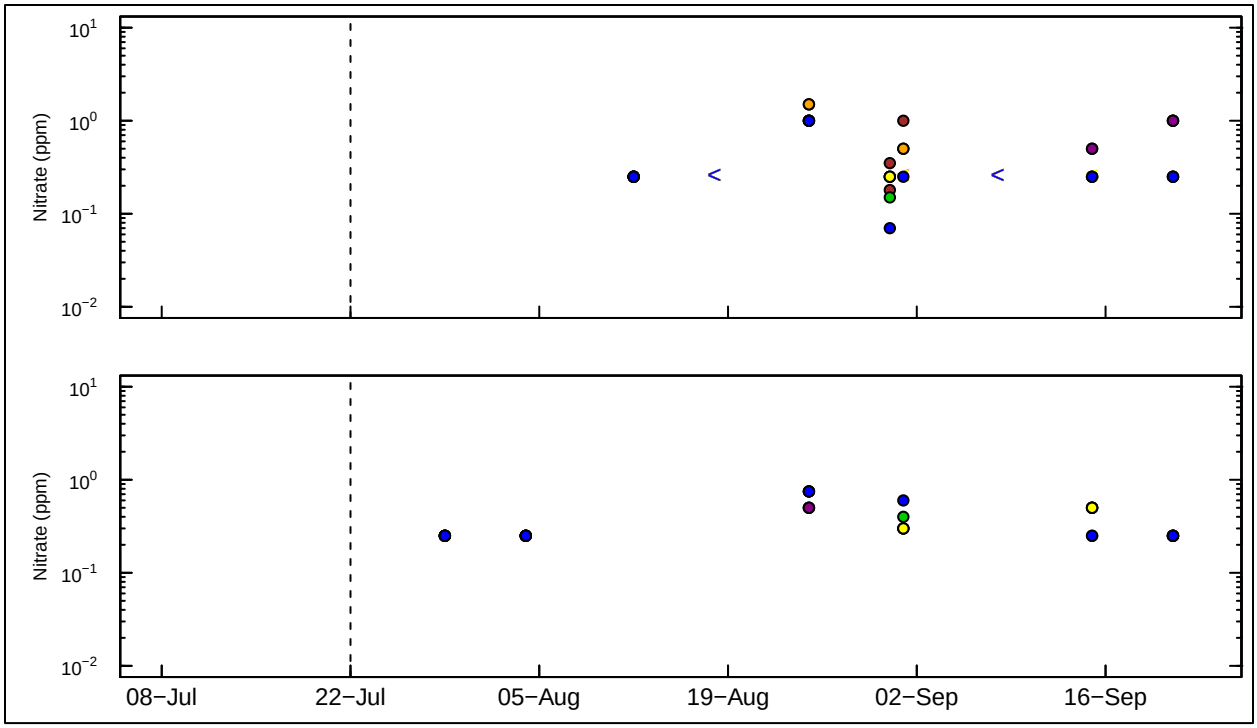


Figure 5−19g. Plot of nitrate for LD exposure chambers (A, B, C, D, E, and F) for the duration of the study

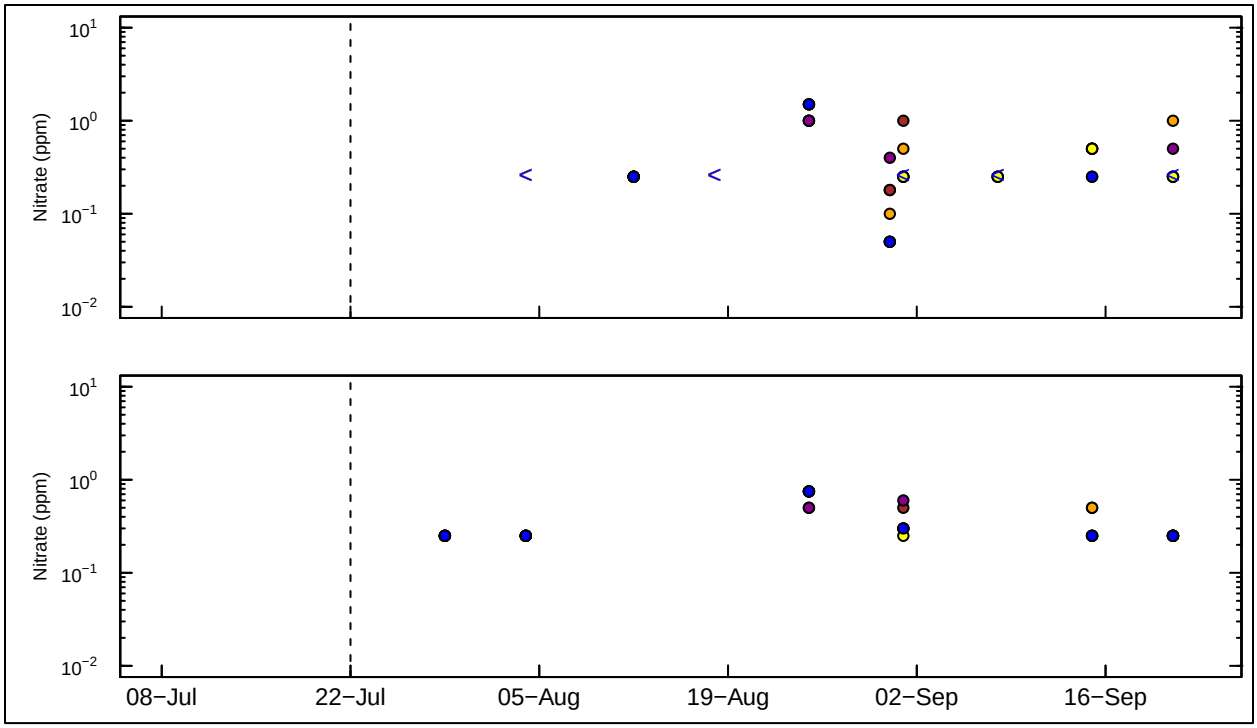


Figure 5−19h. Plot of nitrate for UMF exposure chambers (A, B, C, D, E, and F) for the duration of the study

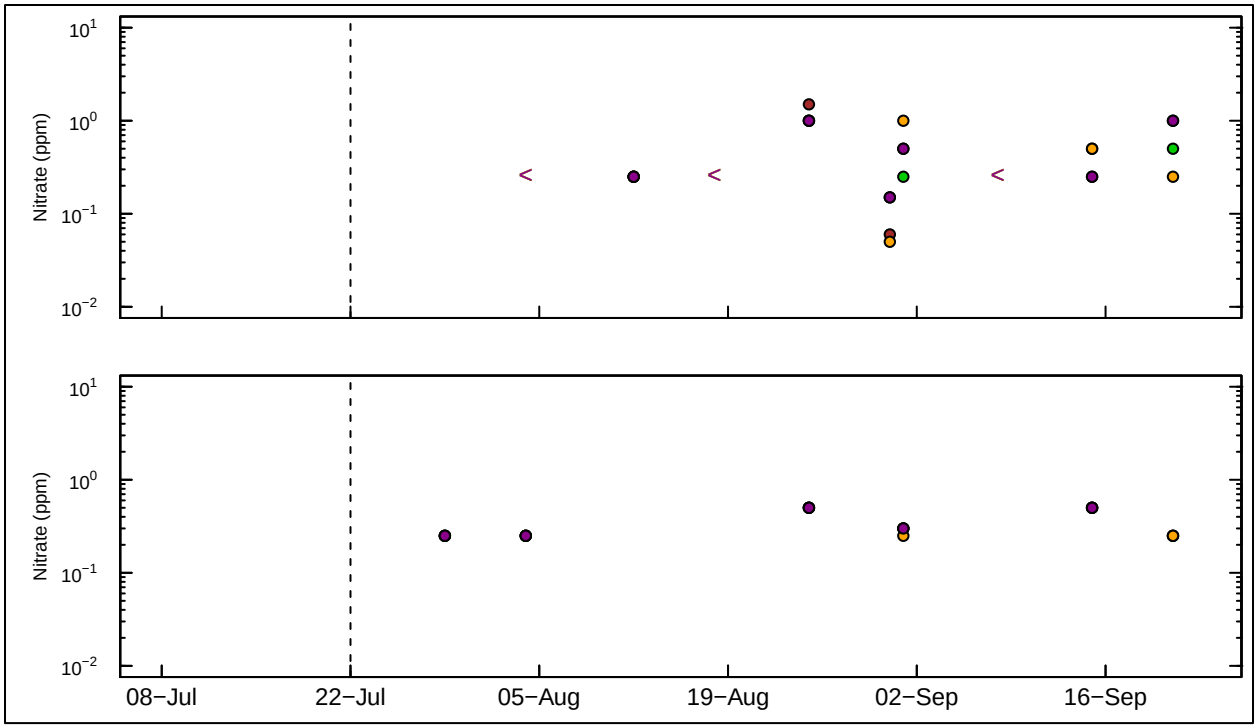


Figure 5−19i. Plot of nitrate for LMF exposure chambers (A, B, C, and D) for the duration of the study

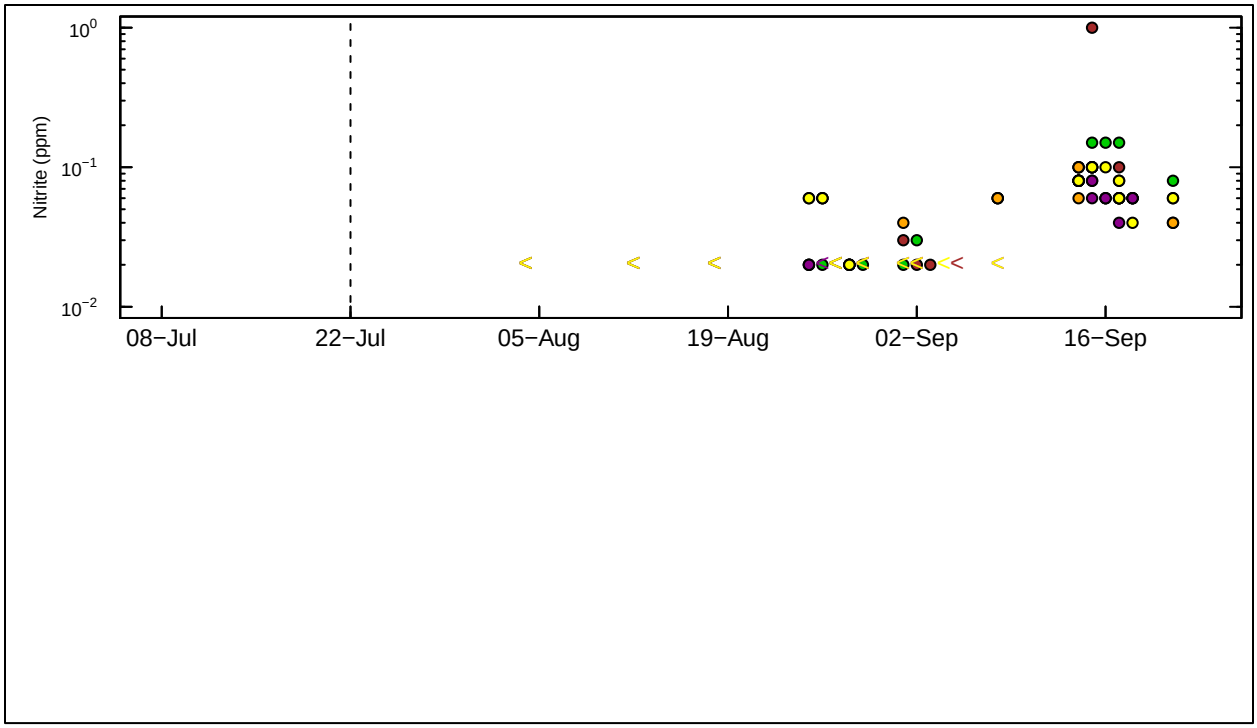


Figure 5−20a. Plot of nitrite for H2O exposure chambers (A, B, C, D, and E) for the duration of the study

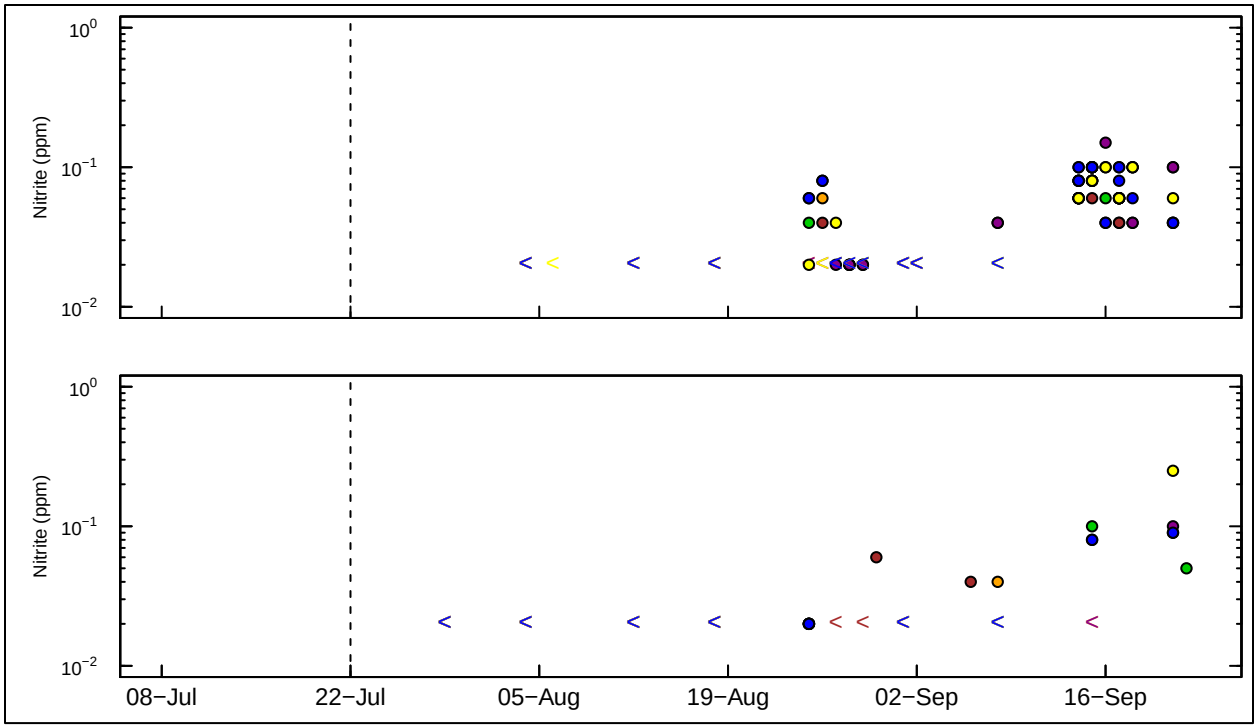


Figure 5−20b. Plot of nitrite for CTRL exposure chambers (A, B, C, D, E, and F) for the duration of the study

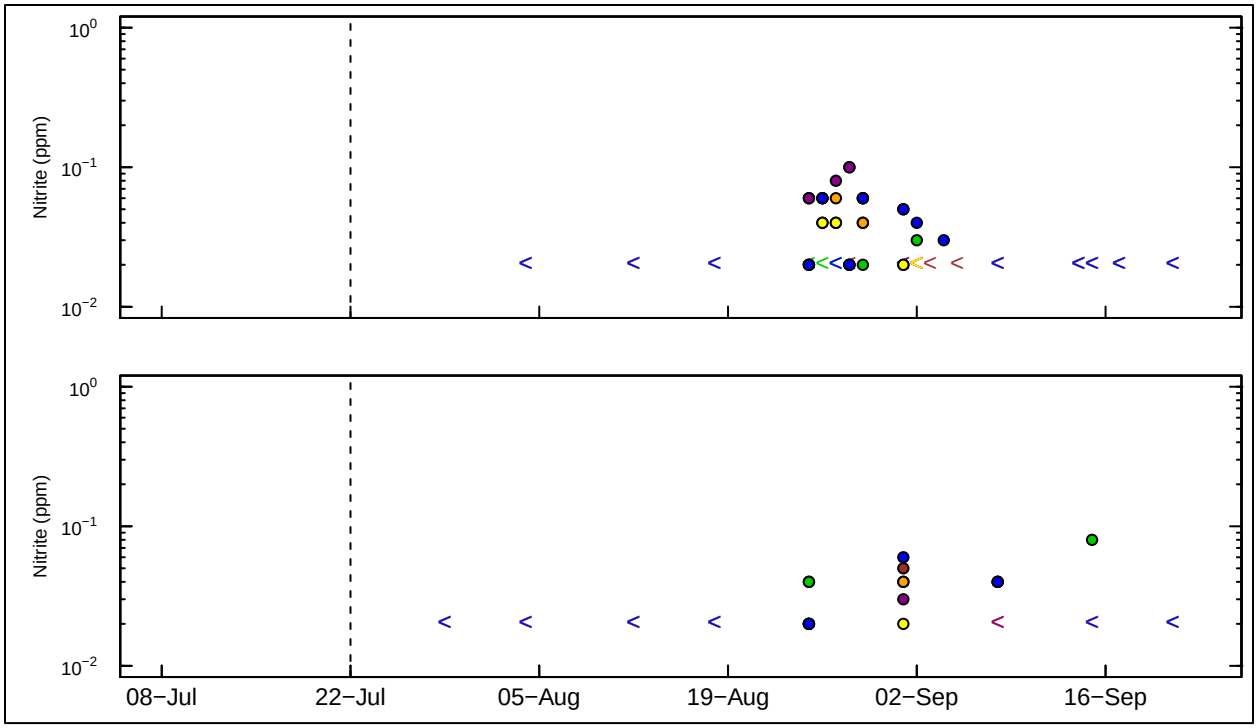


Figure 5−20c. Plot of nitrite for LALL exposure chambers (A, B, C, D, E, and F) for the duration of the study

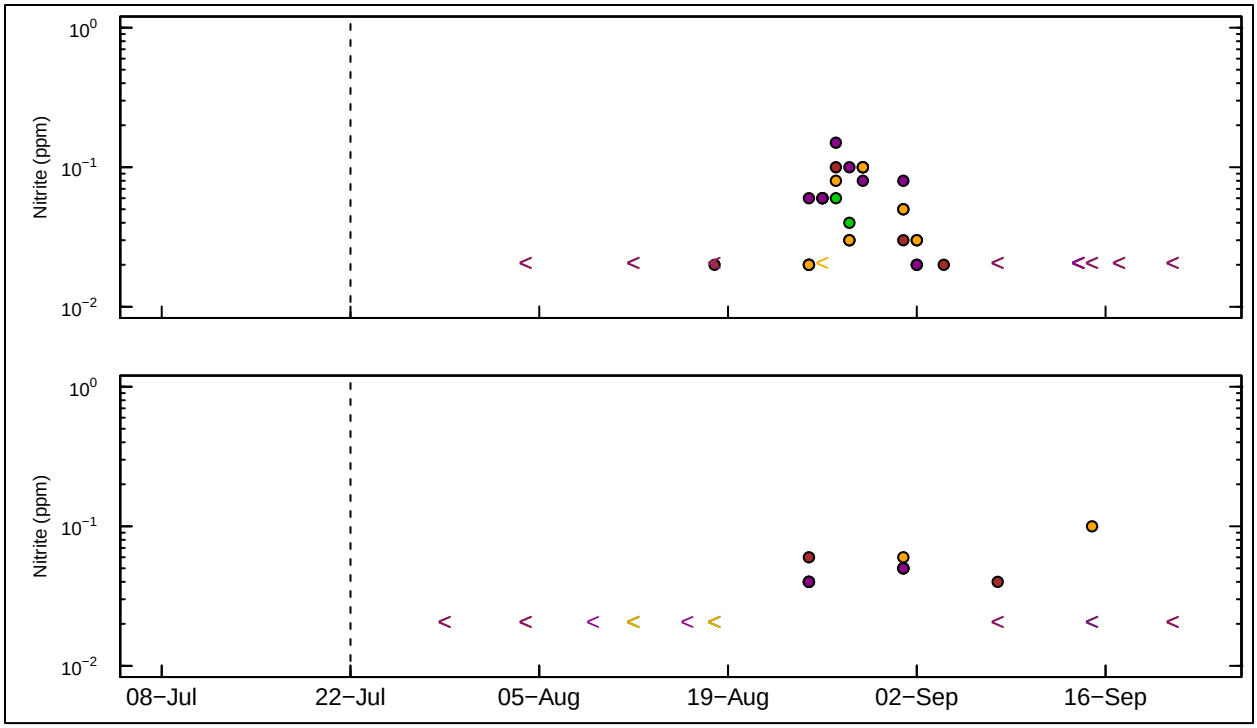


Figure 5−20d. Plot of nitrite for GE exposure chambers (A, B, C, and D) for the duration of the study

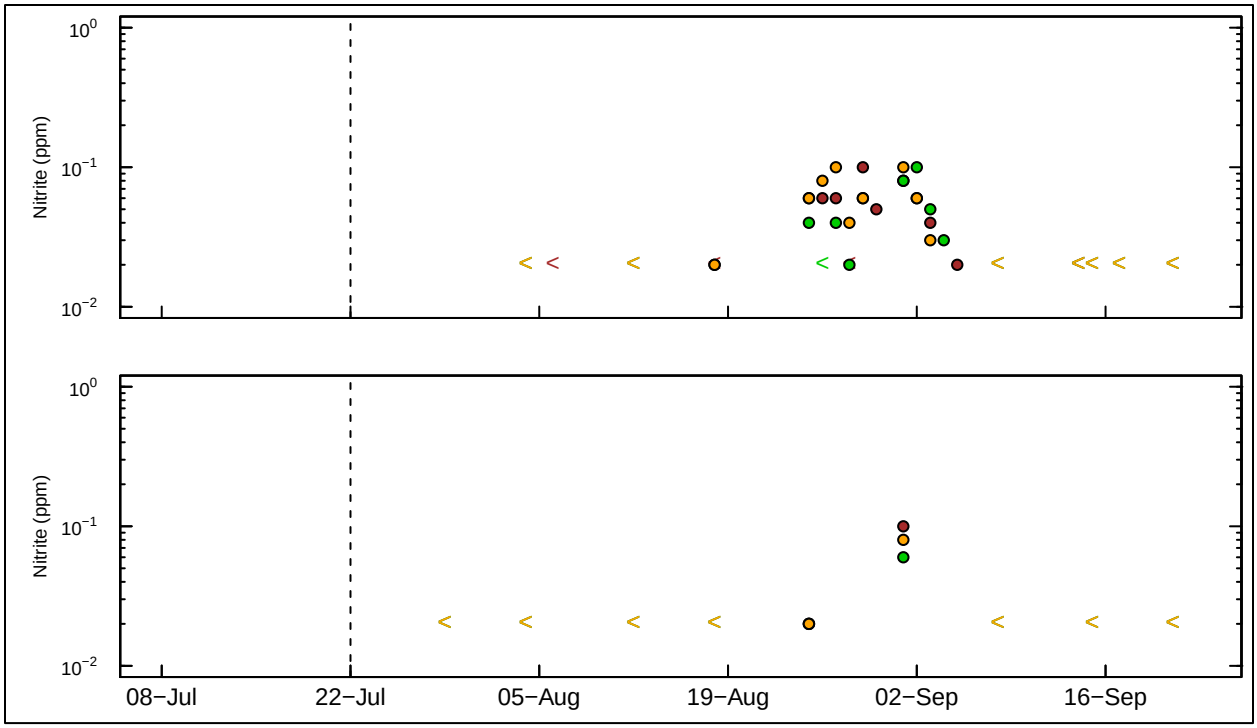


Figure 5−20e. Plot of nitrite for DE exposure chambers (A, B, and C) for the duration of the study

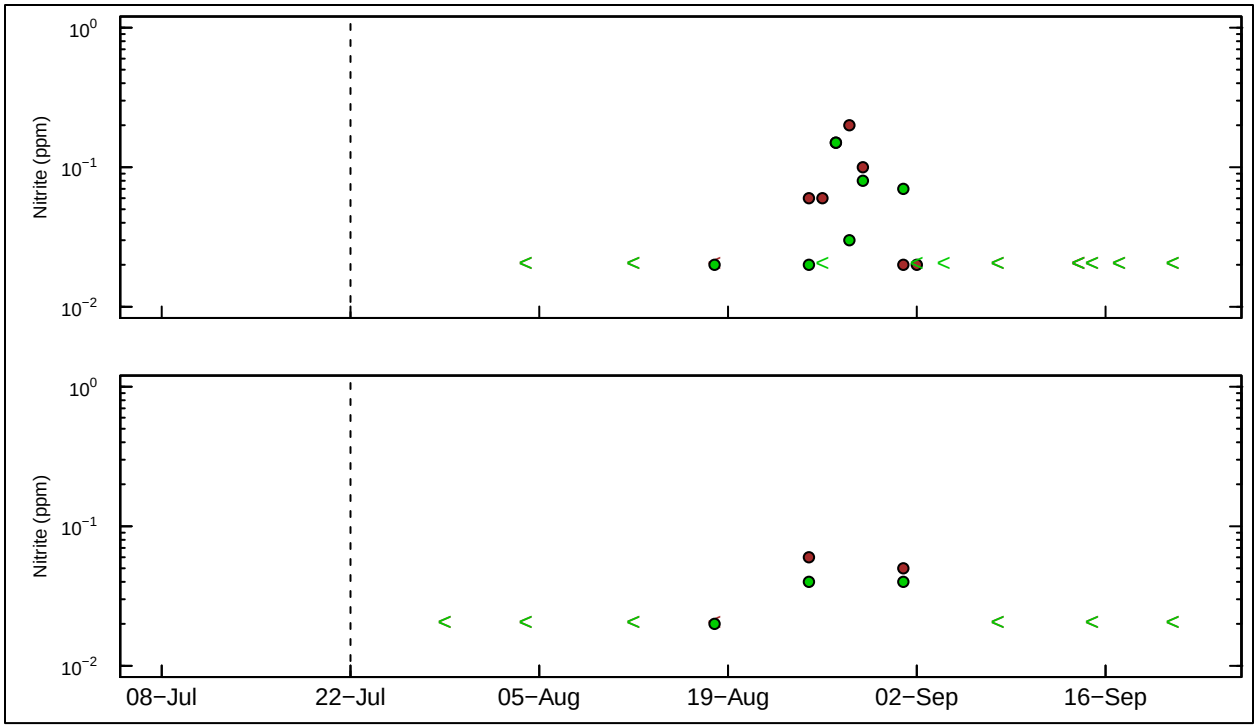


Figure 5−20f. Plot of nitrite for NP exposure chambers (A and B) for the duration of the study

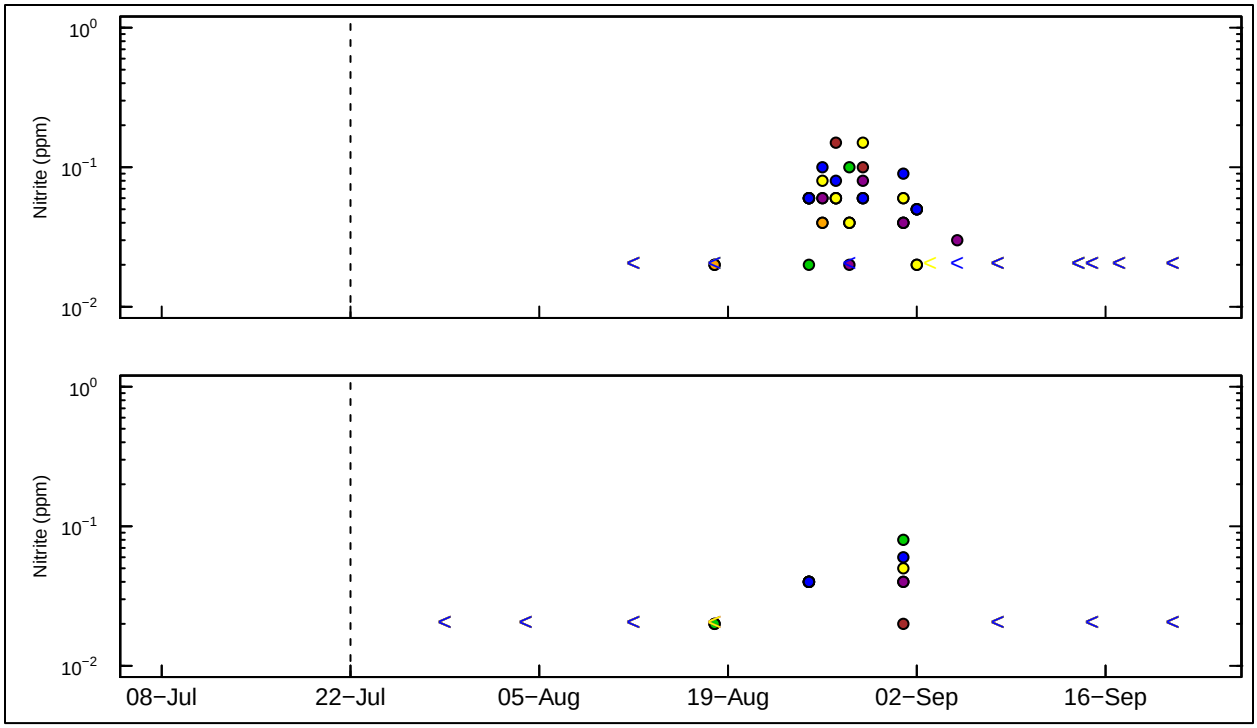


Figure 5−20g. Plot of nitrite for LD exposure chambers (A, B, C, D, E, and F) for the duration of the study

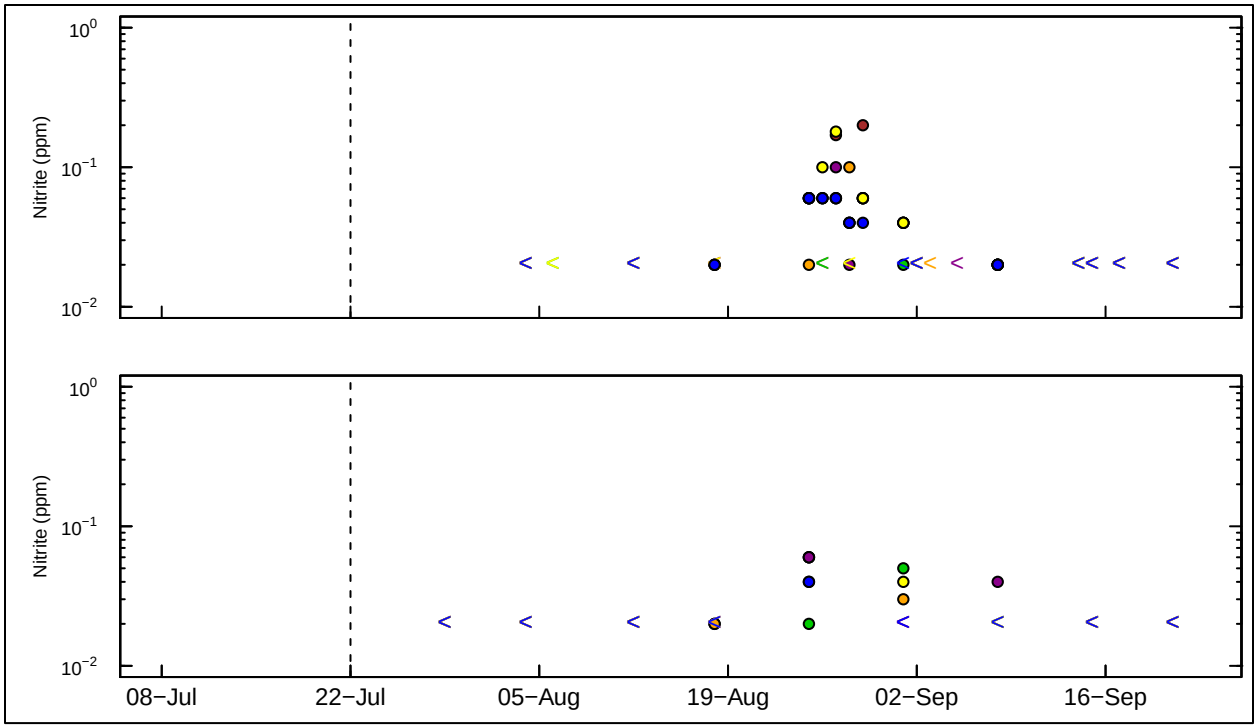


Figure 5−20h. Plot of nitrite for UMF exposure chambers (A, B, C, D, E, and F) for the duration of the study

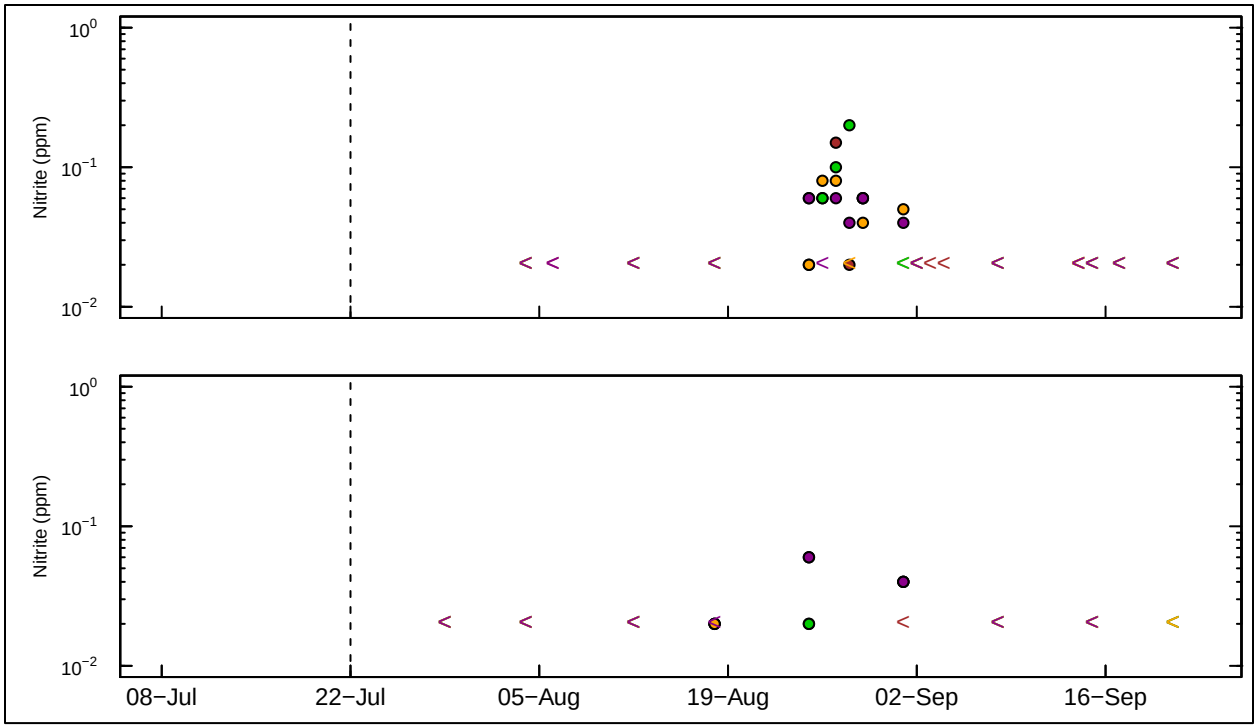


Figure 5−20i. Plot of nitrite for LMF exposure chambers (A, B, C, and D) for the duration of the study

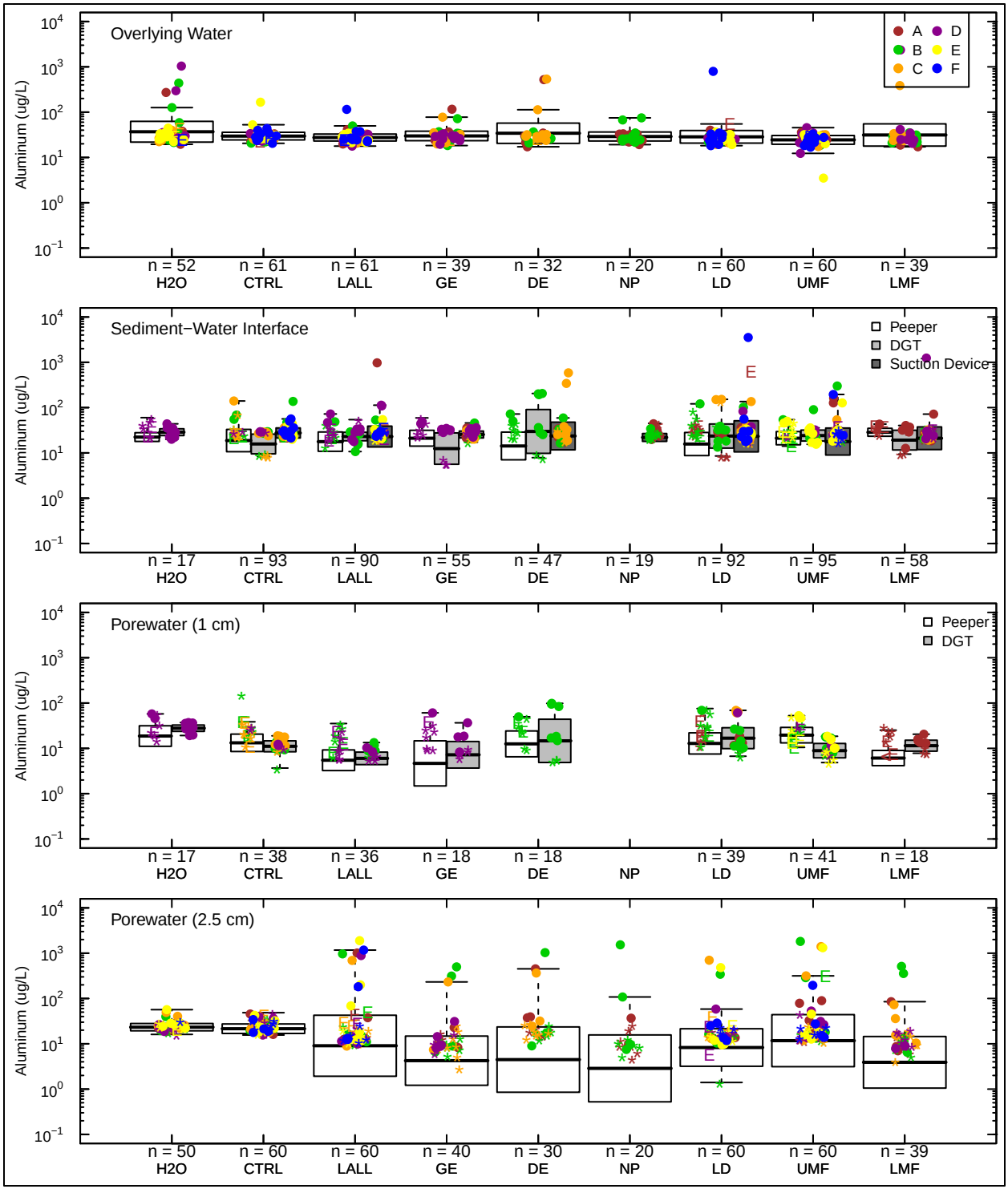


Figure 5−21. Summary of dissolved aluminum concentrations as a function of treatment and sample type

Note: Samples types are presented in the following order: overlying water (top panel), sediment water interface water (2nd panel), porewater at 1 cm (3rd panel), and porewater at 2.5 cm (bottom panel). Where appropriate and applicable, concentrations as determined from different sampling techniques are identified within the top right−hand corner of respective panels. Individual measurements are shown as circles, measurements below detection are illustrated with a less than symbol ("<") plotted at the detection limit, qualified samples due to blank contamination are illustrated with an asterisks (*), and data qualified as "estimated" are represented with the symbol "E" at the estimated value. The 25th and 75th percentiles from the MLE calculated distribution is used for the edges of the box, the median is shown as a horizontal line drawn through the middle of the box. Whiskers show maximum and minimum values exclusive of extreme values. Extreme values are values that are more than 1.5 times the interquartile range above the 75th or below the 25th percentiles.

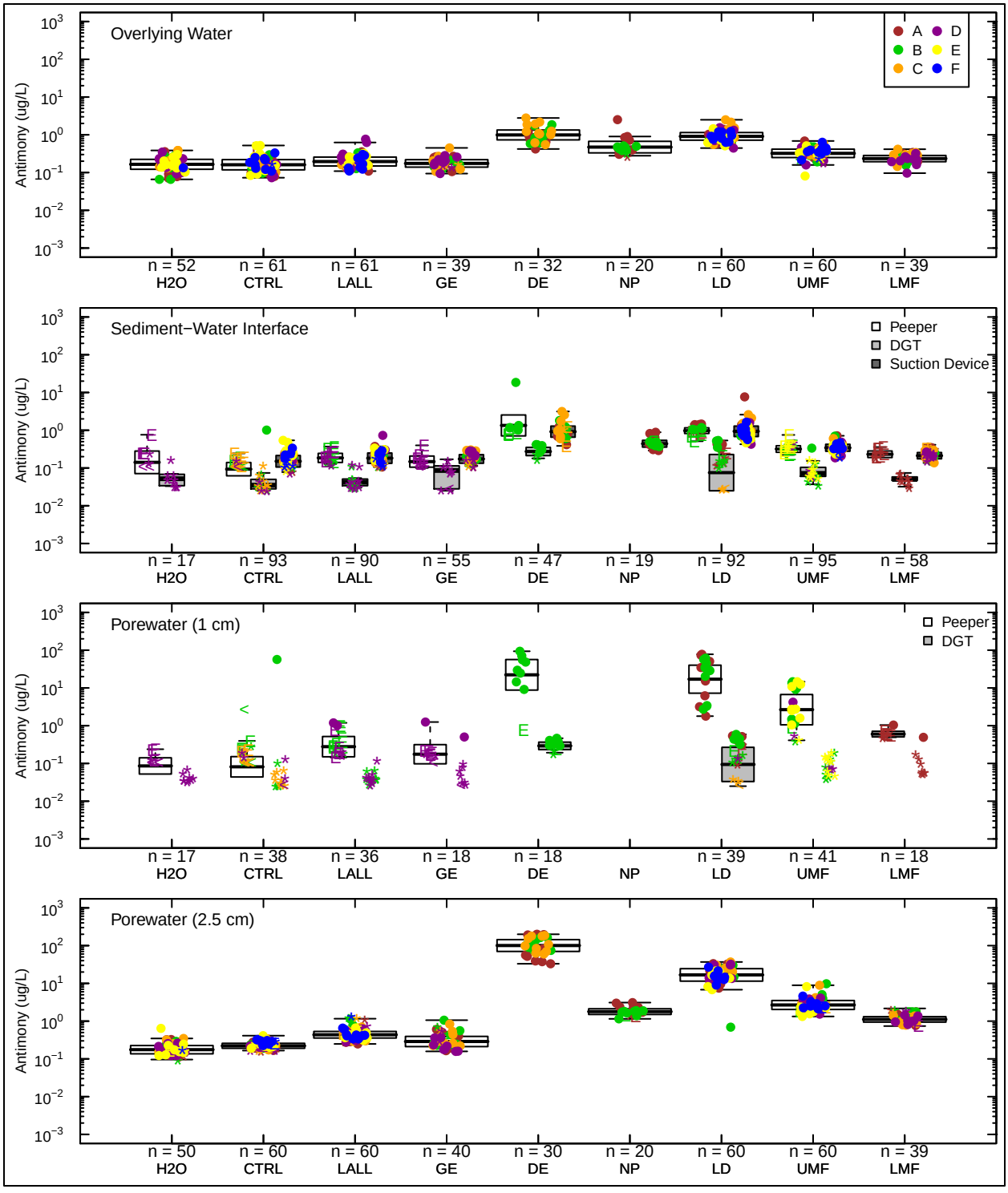


Figure 5−22. Summary of dissolved antimony concentrations as a function of treatment and sample type

Note: Samples types are presented in the following order: overlying water (top panel), sediment water interface water (2nd panel), porewater at 1 cm (3rd panel), and porewater at 2.5 cm (bottom panel). Where appropriate and applicable, concentrations as determined from different sampling techniques are identified within the top right−hand corner of respective panels. Individual measurements are shown as circles, measurements below detection are illustrated with a less than symbol ("<") plotted at the detection limit, qualified samples due to blank contamination are illustrated with an asterisks (*), and data qualified as "estimated" are represented with the symbol "E" at the estimated value. The 25th and 75th percentiles from the MLE calculated distribution is used for the edges of the box, the median is shown as a horizontal line drawn through the middle of the box. Whiskers show maximum and minimum values exclusive of extreme values. Extreme values are values that are more than 1.5 times the interquartile range above the 75th or below the 25th percentiles.

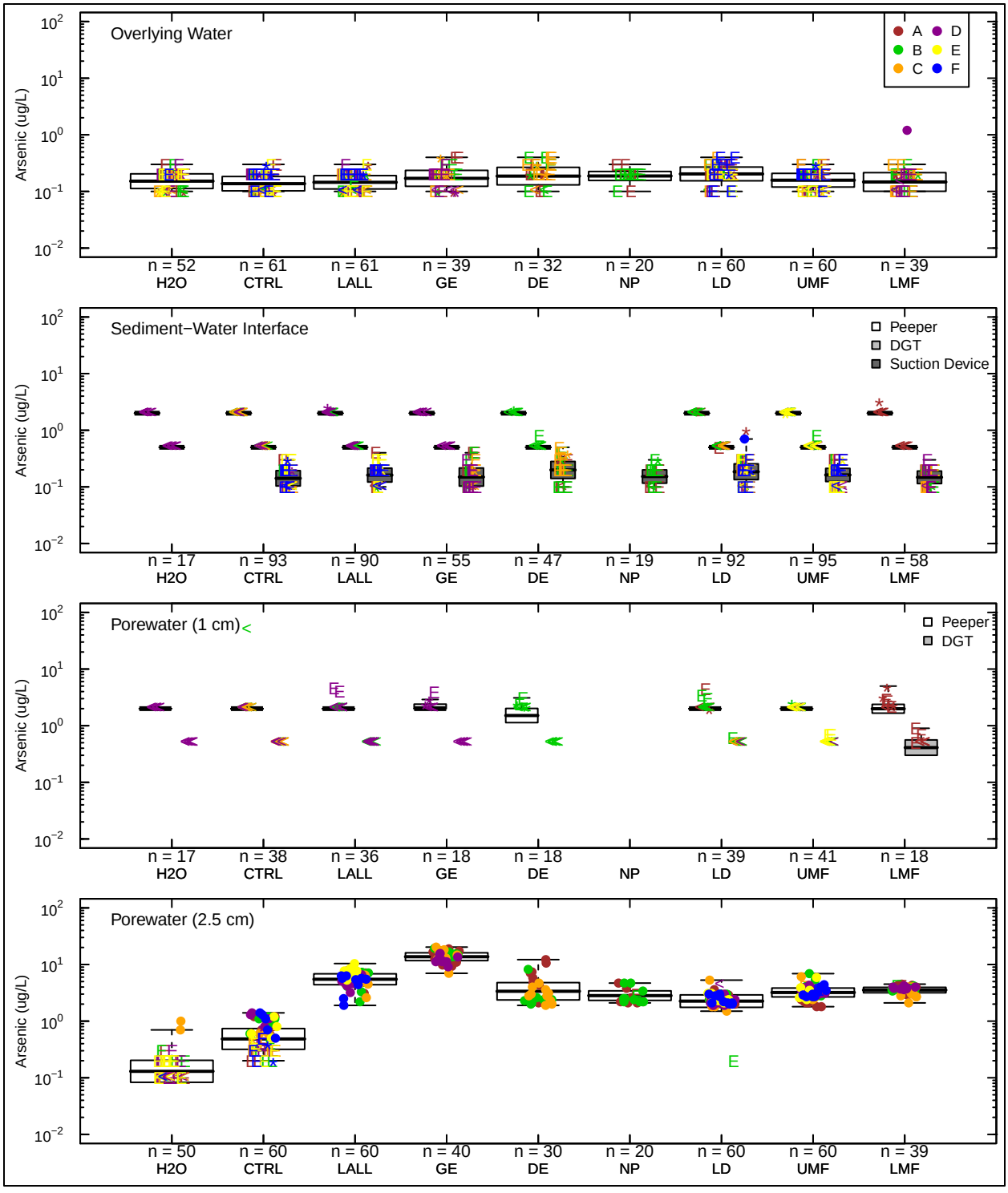


Figure 5−23. Summary of dissolved arsenic concentrations as a function of treatment and sample type

Note: Samples types are presented in the following order: overlying water (top panel), sediment water interface water (2nd panel), porewater at 1 cm (3rd panel), and porewater at 2.5 cm (bottom panel). Where appropriate and applicable, concentrations as determined from different sampling techniques are identified within the top right−hand corner of respective panels. Individual measurements are shown as circles, measurements below detection are illustrated with a less than symbol ("<") plotted at the detection limit, qualified samples due to blank contamination are illustrated with an asterisks (*), and data qualified as "estimated" are represented with the symbol "E" at the estimated value. The 25th and 75th percentiles from the MLE calculated distribution is used for the edges of the box, the median is shown as a horizontal line drawn through the middle of the box. Whiskers show maximum and minimum values exclusive of extreme values. Extreme values are values that are more than 1.5 times the interquartile range above the 75th or below the 25th percentiles.

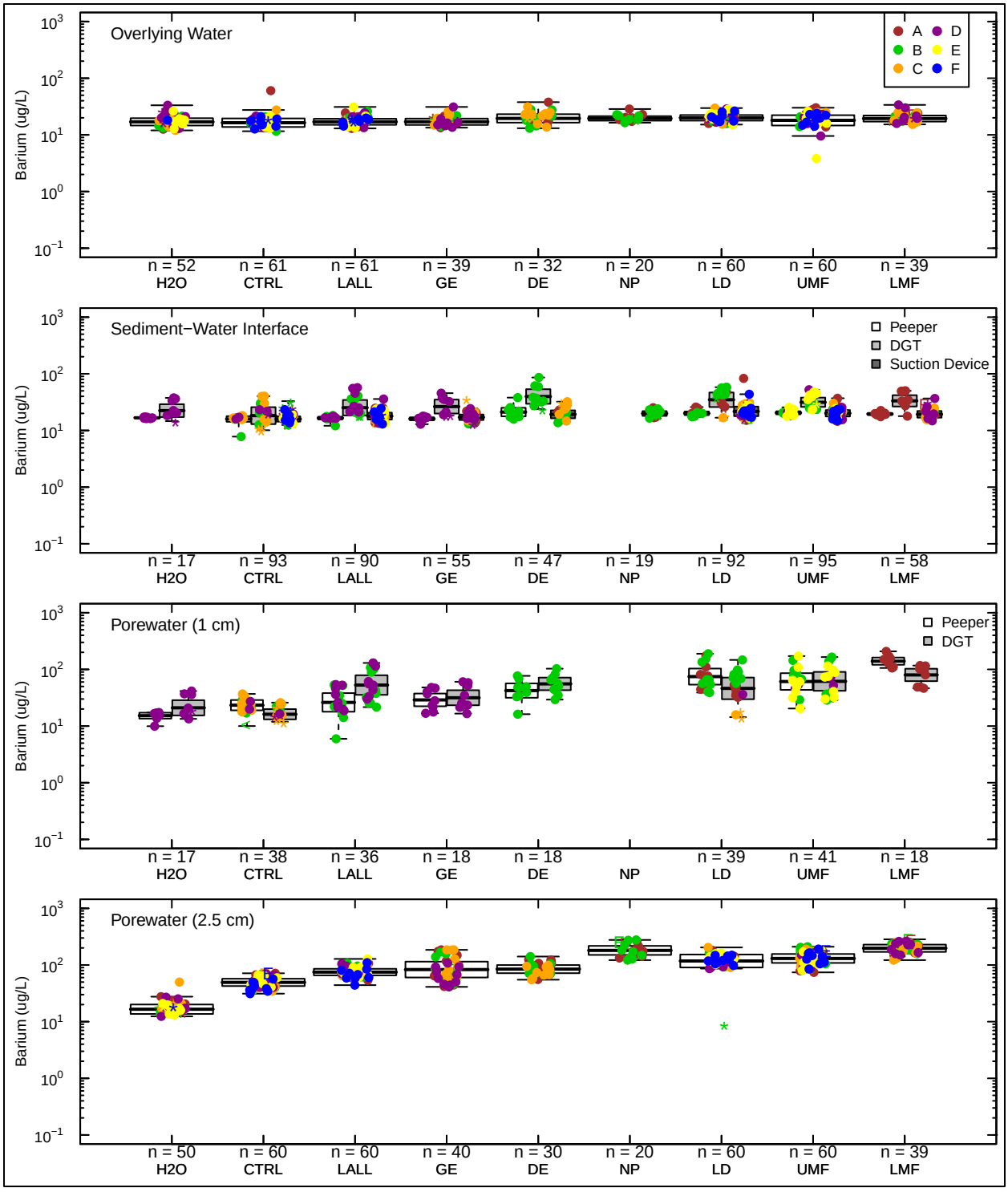


Figure 5−24. Summary of dissolved barium concentrations as a function of treatment and sample type

Note: Samples types are presented in the following order: overlying water (top panel), sediment water interface water (2nd panel), porewater at 1 cm (3rd panel), and porewater at 2.5 cm (bottom panel). Where appropriate and applicable, concentrations as determined from different sampling techniques are identified within the top right−hand corner of respective panels. Individual measurements are shown as circles, measurements below detection are illustrated with a less than symbol ("<") plotted at the detection limit, qualified samples due to blank contamination are illustrated with an asterisks (*), and data qualified as "estimated" are represented with the symbol "E" at the estimated value. The 25th and 75th percentiles from the MLE calculated distribution is used for the edges of the box, the median is shown as a horizontal line drawn through the middle of the box. Whiskers show maximum and minimum values exclusive of extreme values. Extreme values are values that are more than 1.5 times the interquartile range above the 75th or below the 25th percentiles.

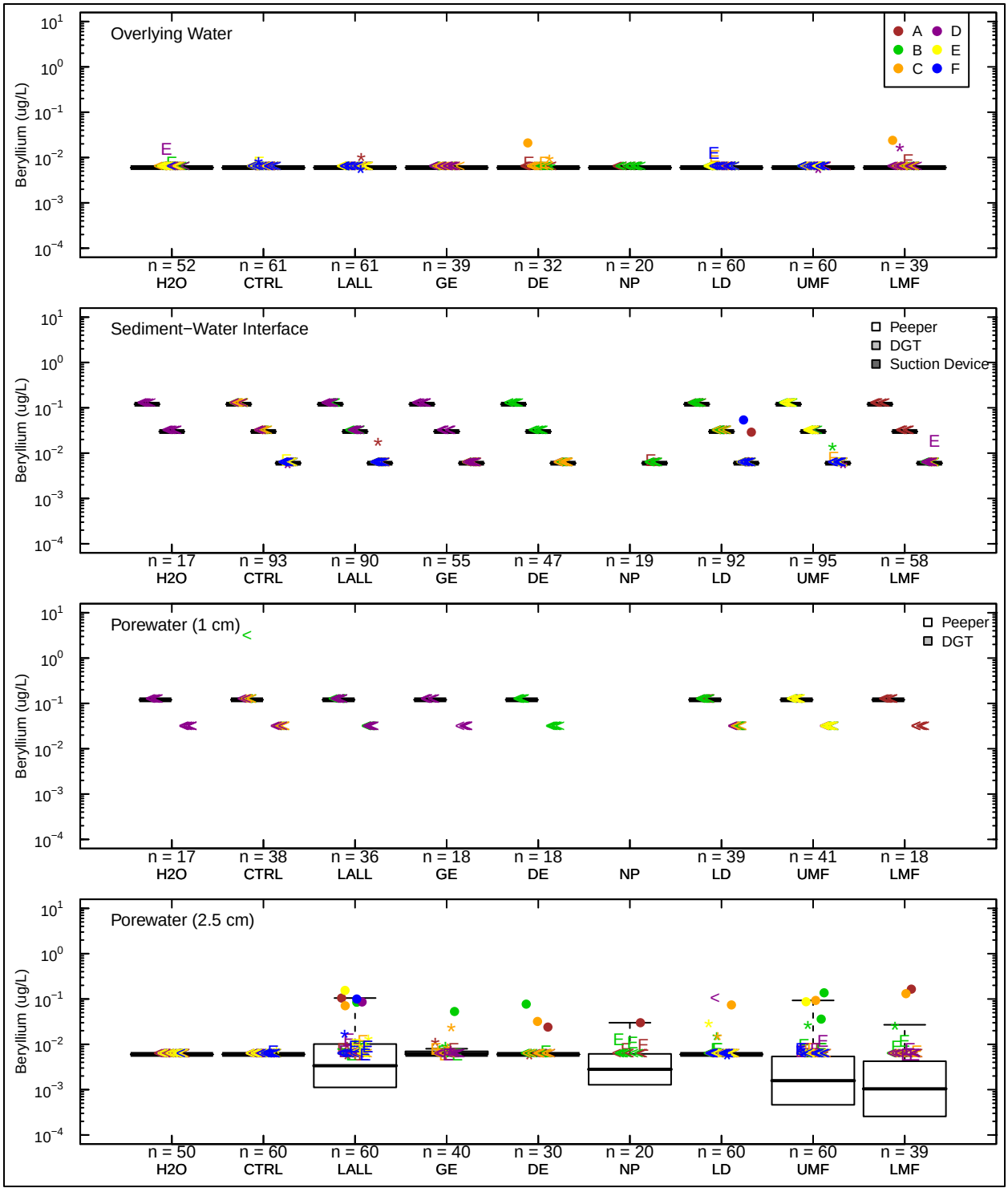


Figure 5−25. Summary of dissolved beryllium concentrations as a function of treatment and sample type

Note: Samples types are presented in the following order: overlying water (top panel), sediment water interface water (2nd panel), porewater at 1 cm (3rd panel), and porewater at 2.5 cm (bottom panel). Where appropriate and applicable, concentrations as determined from different sampling techniques are identified within the top right−hand corner of respective panels. Individual measurements are shown as circles, measurements below detection are illustrated with a less than symbol ("<") plotted at the detection limit, qualified samples due to blank contamination are illustrated with an asterisks (*), and data qualified as "estimated" are represented with the symbol "E" at the estimated value. The 25th and 75th percentiles from the MLE calculated distribution is used for the edges of the box, the median is shown as a horizontal line drawn through the middle of the box. Whiskers show maximum and minimum values exclusive of extreme values. Extreme values are values that are more than 1.5 times the interquartile range above the 75th or below the 25th percentiles.

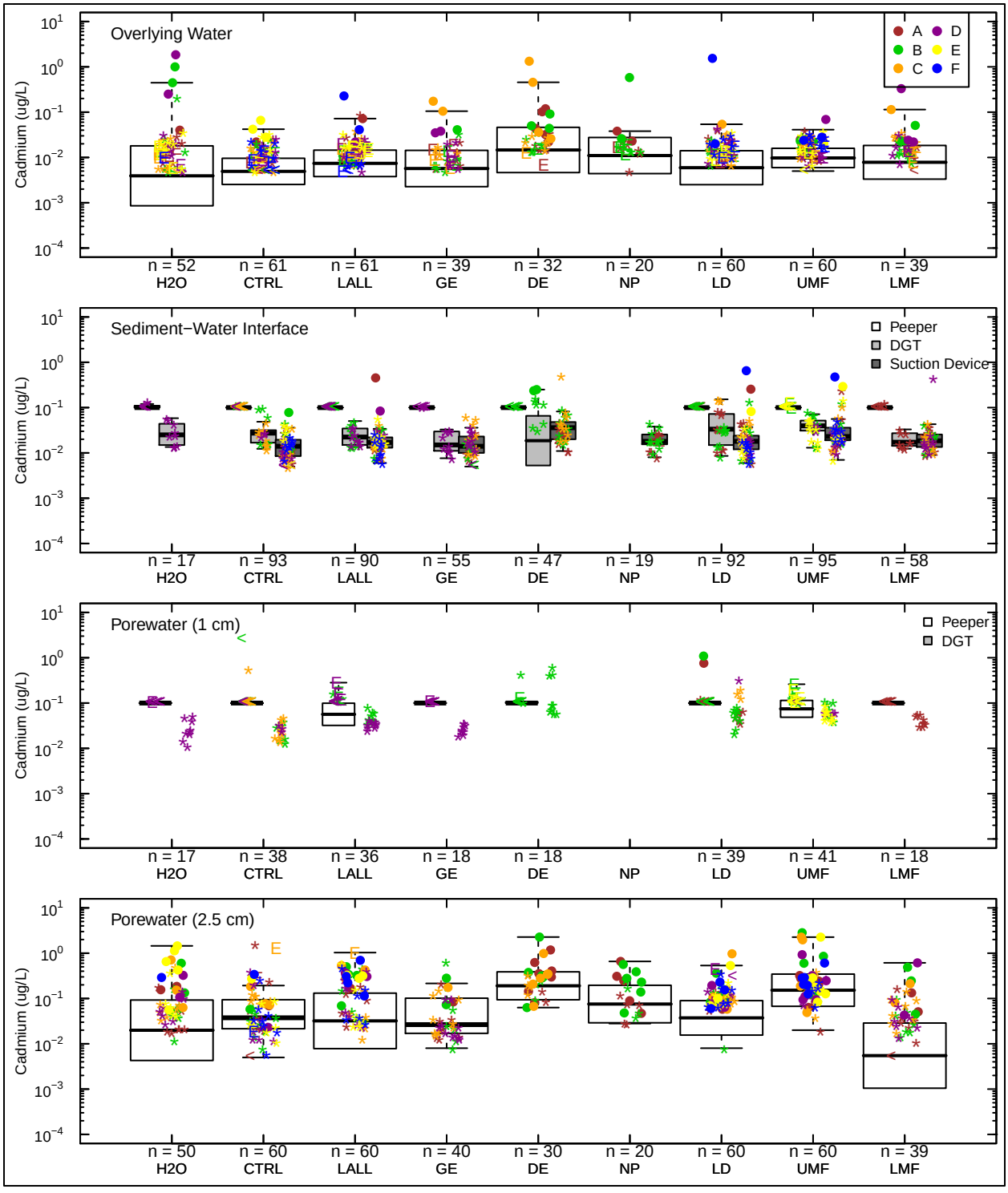


Figure 5−26. Summary of dissolved cadmium concentrations as a function of treatment and sample type

Note: Samples types are presented in the following order: overlying water (top panel), sediment water interface water (2nd panel), porewater at 1 cm (3rd panel), and porewater at 2.5 cm (bottom panel). Where appropriate and applicable, concentrations as determined from different sampling techniques are identified within the top right−hand corner of respective panels. Individual measurements are shown as circles, measurements below detection are illustrated with a less than symbol ("<") plotted at the detection limit, qualified samples due to blank contamination are illustrated with an asterisks (*), and data qualified as "estimated" are represented with the symbol "E" at the estimated value. The 25th and 75th percentiles from the MLE calculated distribution is used for the edges of the box, the median is shown as a horizontal line drawn through the middle of the box. Whiskers show maximum and minimum values exclusive of extreme values. Extreme values are values that are more than 1.5 times the interquartile range above the 75th or below the 25th percentiles.

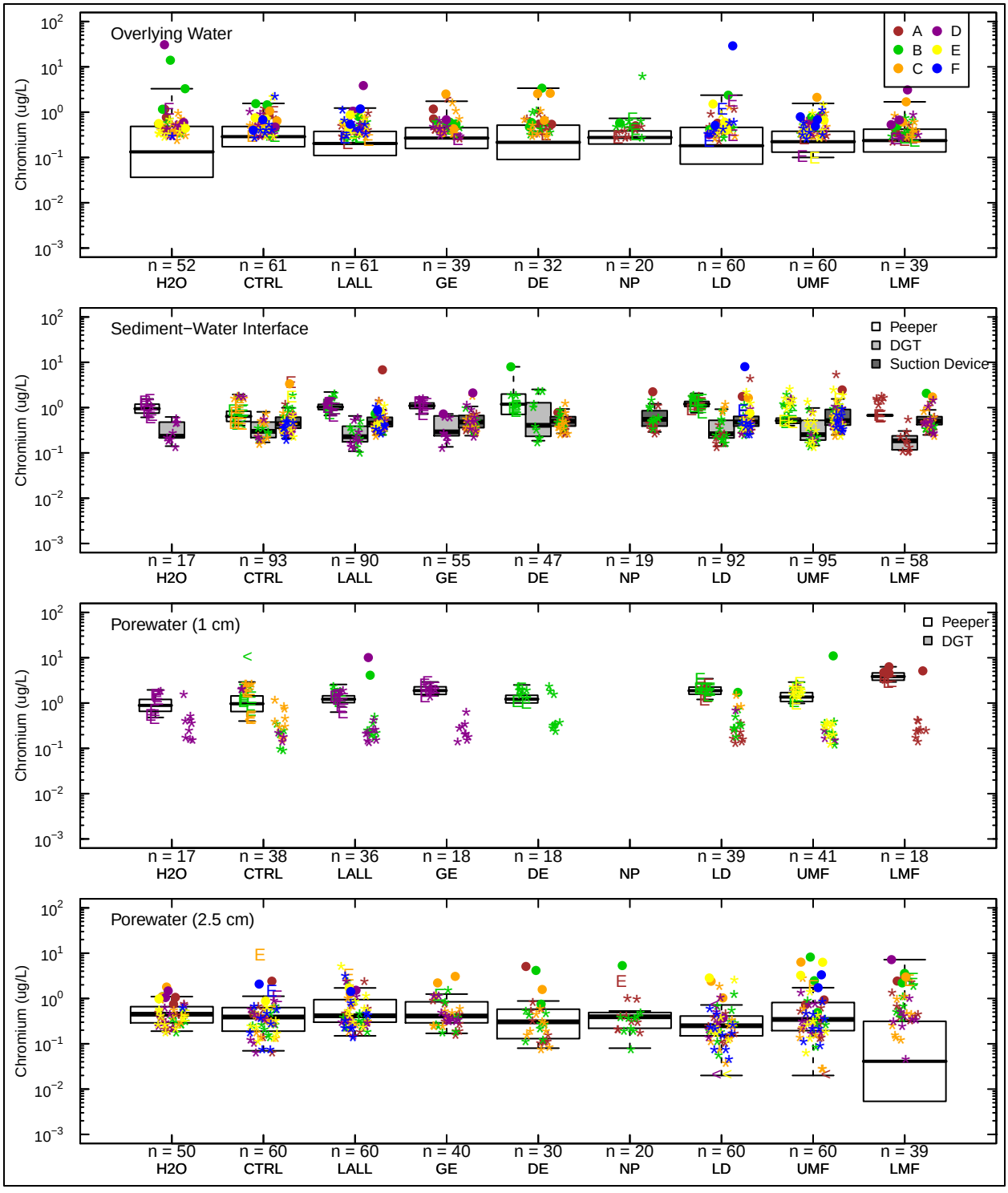


Figure 5−27. Summary of dissolved chromium concentrations as a function of treatment and sample type

Note: Samples types are presented in the following order: overlying water (top panel), sediment water interface water (2nd panel), porewater at 1 cm (3rd panel), and porewater at 2.5 cm (bottom panel). Where appropriate and applicable, concentrations as determined from different sampling techniques are identified within the top right−hand corner of respective panels. Individual measurements are shown as circles, measurements below detection are illustrated with a less than symbol ("<") plotted at the detection limit, qualified samples due to blank contamination are illustrated with an asterisks (*), and data qualified as "estimated" are represented with the symbol "E" at the estimated value. The 25th and 75th percentiles from the MLE calculated distribution is used for the edges of the box, the median is shown as a horizontal line drawn through the middle of the box. Whiskers show maximum and minimum values exclusive of extreme values. Extreme values are values that are more than 1.5 times the interquartile range above the 75th or below the 25th percentiles.

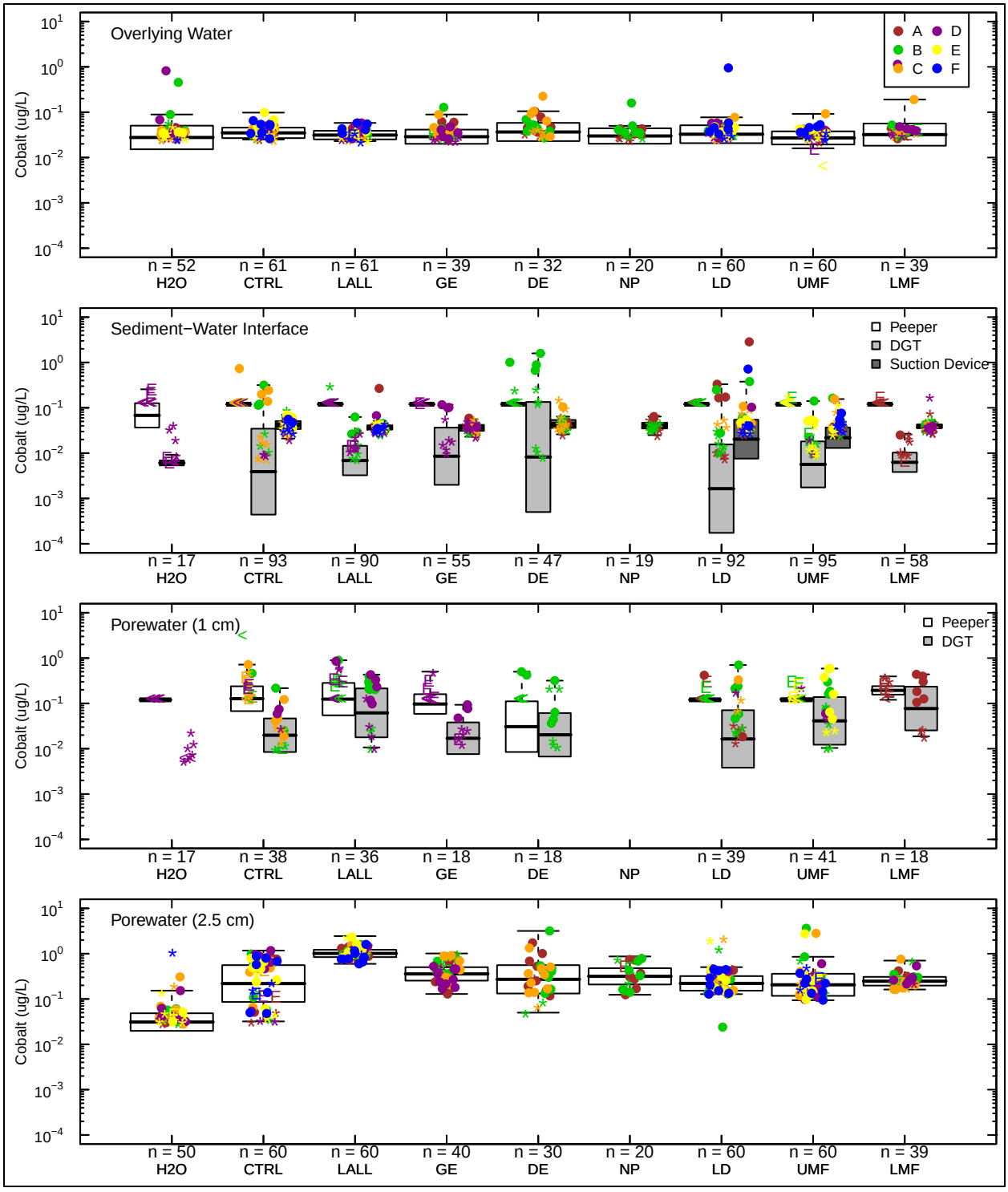


Figure 5−28. Summary of dissolved cobalt concentrations as a function of treatment and sample type

Note: Samples types are presented in the following order: overlying water (top panel), sediment water interface water (2nd panel), porewater at 1 cm (3rd panel), and porewater at 2.5 cm (bottom panel). Where appropriate and applicable, concentrations as determined from different sampling techniques are identified within the top right−hand corner of respective panels. Individual measurements are shown as circles, measurements below detection are illustrated with a less than symbol ("<") plotted at the detection limit, qualified samples due to blank contamination are illustrated with an asterisks (*), and data qualified as "estimated" are represented with the symbol "E" at the estimated value. The 25th and 75th percentiles from the MLE calculated distribution is used for the edges of the box, the median is shown as a horizontal line drawn through the middle of the box. Whiskers show maximum and minimum values exclusive of extreme values. Extreme values are values that are more than 1.5 times the interquartile range above the 75th or below the 25th percentiles.

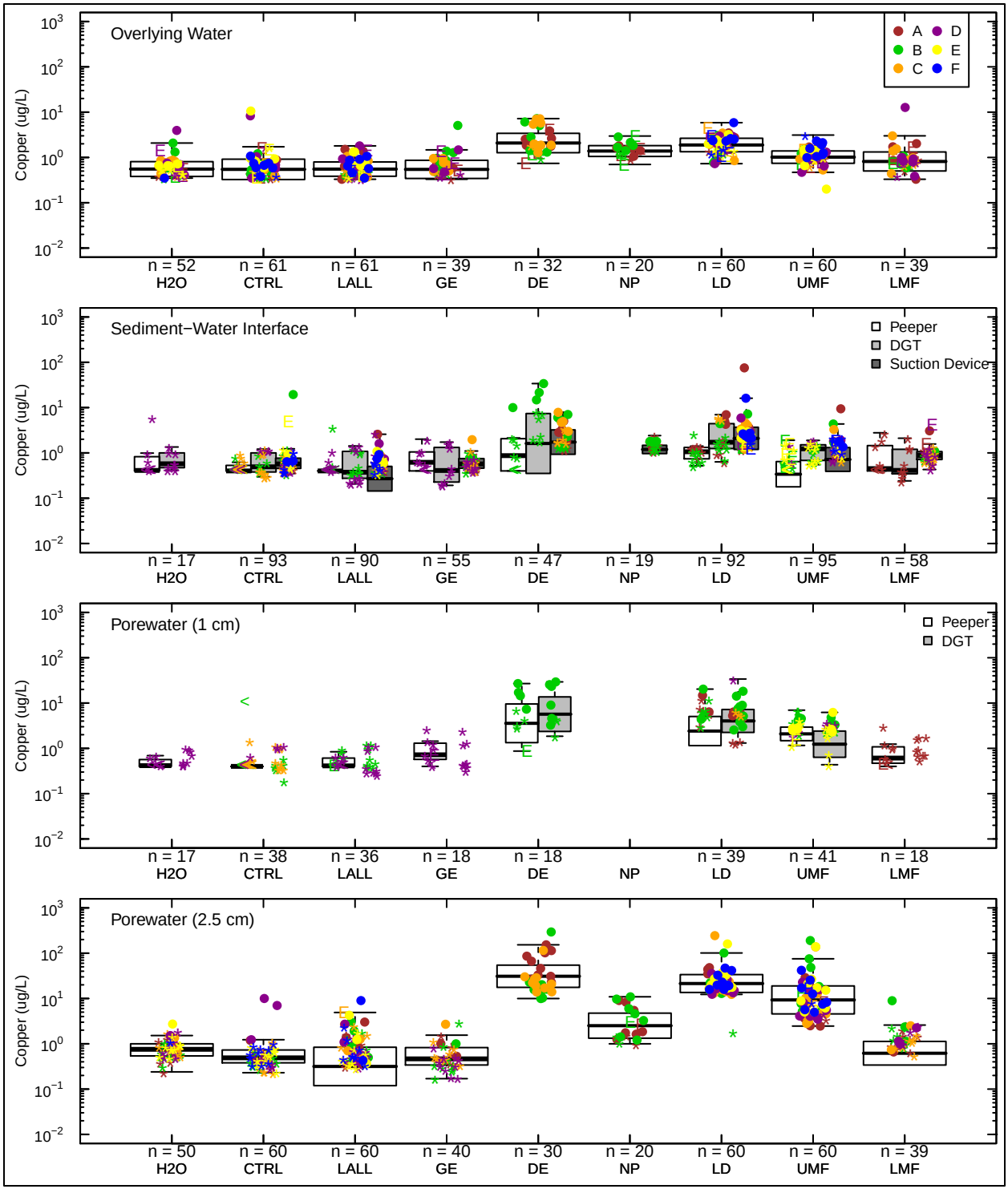


Figure 5−29. Summary of dissolved copper concentrations as a function of treatment and sample type

Note: Samples types are presented in the following order: overlying water (top panel), sediment water interface water (2nd panel), porewater at 1 cm (3rd panel), and porewater at 2.5 cm (bottom panel). Where appropriate and applicable, concentrations as determined from different sampling techniques are identified within the top right−hand corner of respective panels. Individual measurements are shown as circles, measurements below detection are illustrated with a less than symbol ("<") plotted at the detection limit, qualified samples due to blank contamination are illustrated with an asterisks (*), and data qualified as "estimated" are represented with the symbol "E" at the estimated value. The 25th and 75th percentiles from the MLE calculated distribution is used for the edges of the box, the median is shown as a horizontal line drawn through the middle of the box. Whiskers show maximum and minimum values exclusive of extreme values. Extreme values are values that are more than 1.5 times the interquartile range above the 75th or below the 25th percentiles.

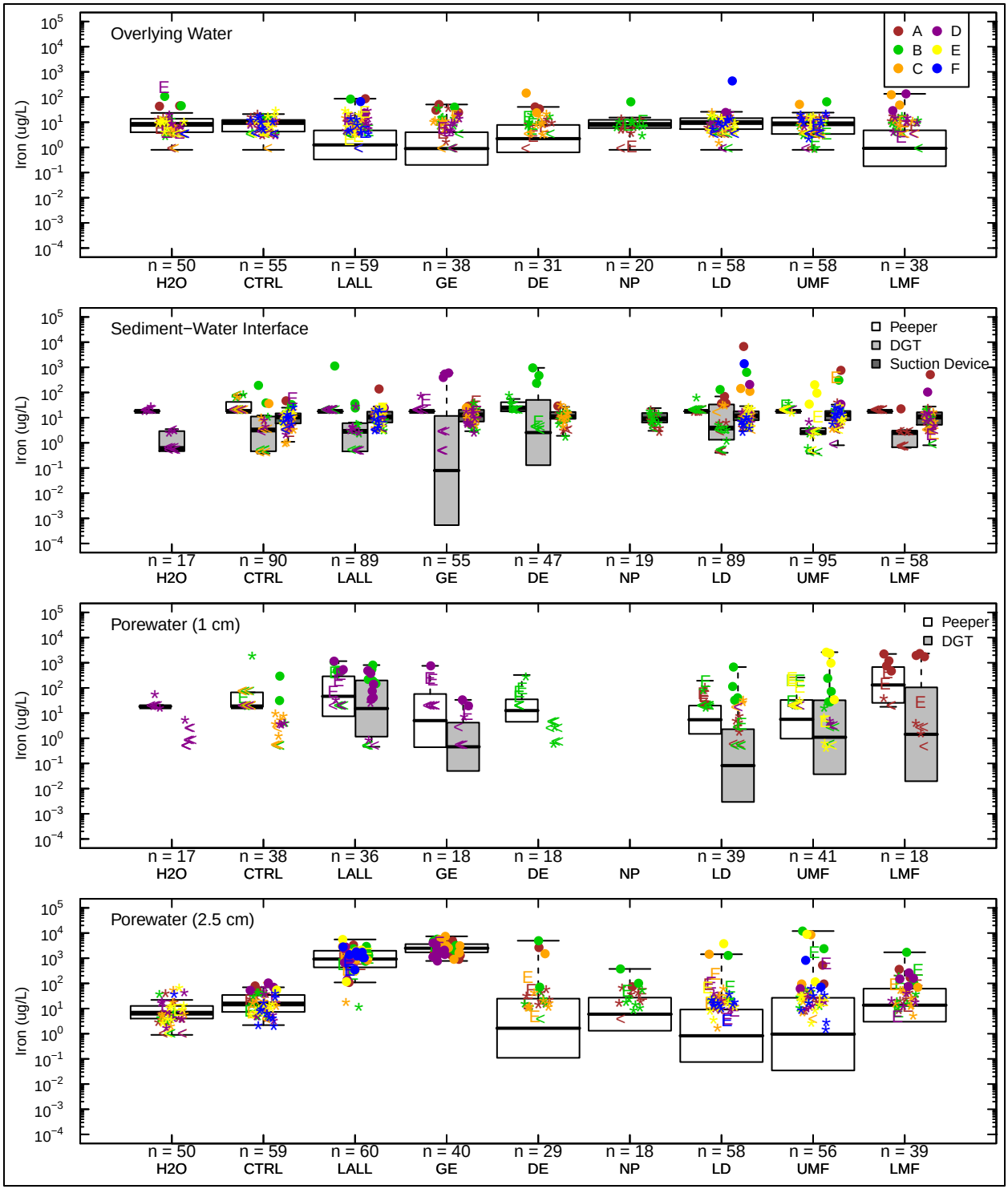


Figure 5−30. Summary of dissolved iron concentrations as a function of treatment and sample type

Note: Samples types are presented in the following order: overlying water (top panel), sediment water interface water (2nd panel), porewater at 1 cm (3rd panel), and porewater at 2.5 cm (bottom panel). Where appropriate and applicable, concentrations as determined from different sampling techniques are identified within the top right−hand corner of respective panels. Individual measurements are shown as circles, measurements below detection are illustrated with a less than symbol ("<") plotted at the detection limit, qualified samples due to blank contamination are illustrated with an asterisks (*), and data qualified as "estimated" are represented with the symbol "E" at the estimated value. The 25th and 75th percentiles from the MLE calculated distribution is used for the edges of the box, the median is shown as a horizontal line drawn through the middle of the box. Whiskers show maximum and minimum values exclusive of extreme values. Extreme values are values that are more than 1.5 times the interquartile range above the 75th or below the 25th percentiles.

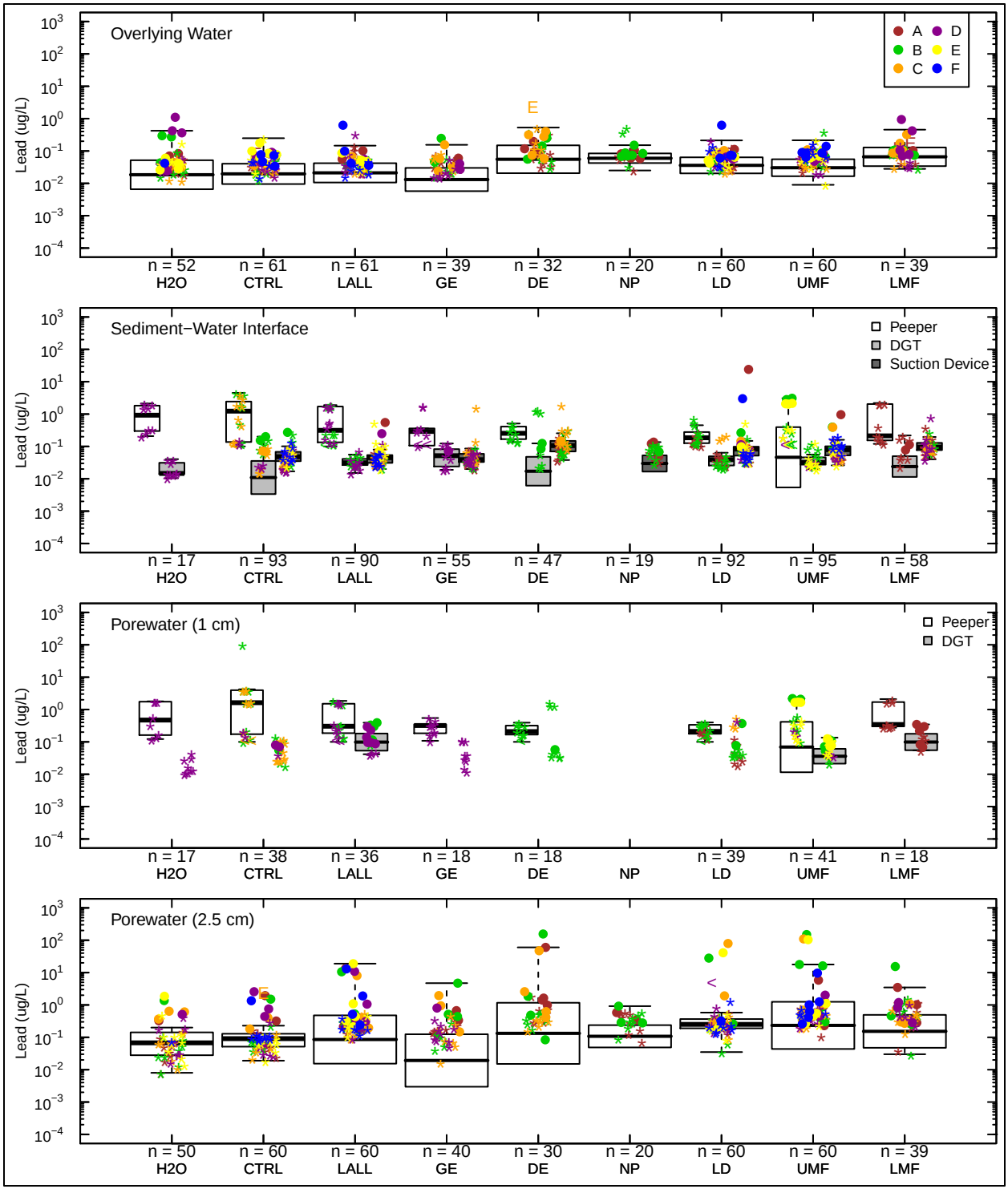


Figure 5−31. Summary of dissolved lead concentrations as a function of treatment and sample type

Note: Samples types are presented in the following order: overlying water (top panel), sediment water interface water (2nd panel), porewater at 1 cm (3rd panel), and porewater at 2.5 cm (bottom panel). Where appropriate and applicable, concentrations as determined from different sampling techniques are identified within the top right−hand corner of respective panels. Individual measurements are shown as circles, measurements below detection are illustrated with a less than symbol ("<") plotted at the detection limit, qualified samples due to blank contamination are illustrated with an asterisks (*), and data qualified as "estimated" are represented with the symbol "E" at the estimated value. The 25th and 75th percentiles from the MLE calculated distribution is used for the edges of the box, the median is shown as a horizontal line drawn through the middle of the box. Whiskers show maximum and minimum values exclusive of extreme values. Extreme values are values that are more than 1.5 times the interquartile range above the 75th or below the 25th percentiles.

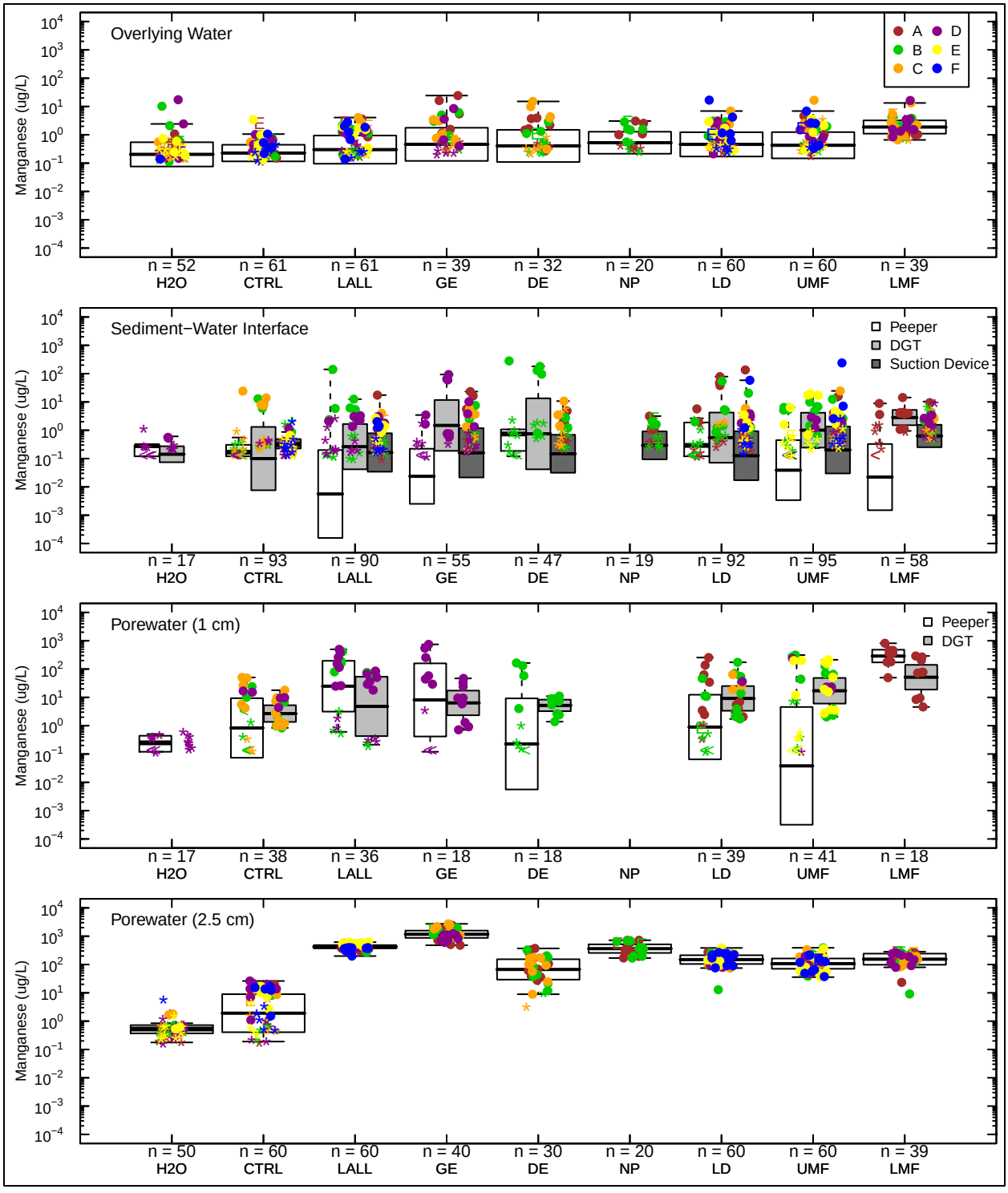


Figure 5−32. Summary of dissolved manganese concentrations as a function of treatment and sample type

Note: Samples types are presented in the following order: overlying water (top panel), sediment water interface water (2nd panel), porewater at 1 cm (3rd panel), and porewater at 2.5 cm (bottom panel). Where appropriate and applicable, concentrations as determined from different sampling techniques are identified within the top right−hand corner of respective panels. Individual measurements are shown as circles, measurements below detection are illustrated with a less than symbol ("<") plotted at the detection limit, qualified samples due to blank contamination are illustrated with an asterisks (*), and data qualified as "estimated" are represented with the symbol "E" at the estimated value. The 25th and 75th percentiles from the MLE calculated distribution is used for the edges of the box, the median is shown as a horizontal line drawn through the middle of the box. Whiskers show maximum and minimum values exclusive of extreme values. Extreme values are values that are more than 1.5 times the interquartile range above the 75th or below the 25th percentiles.

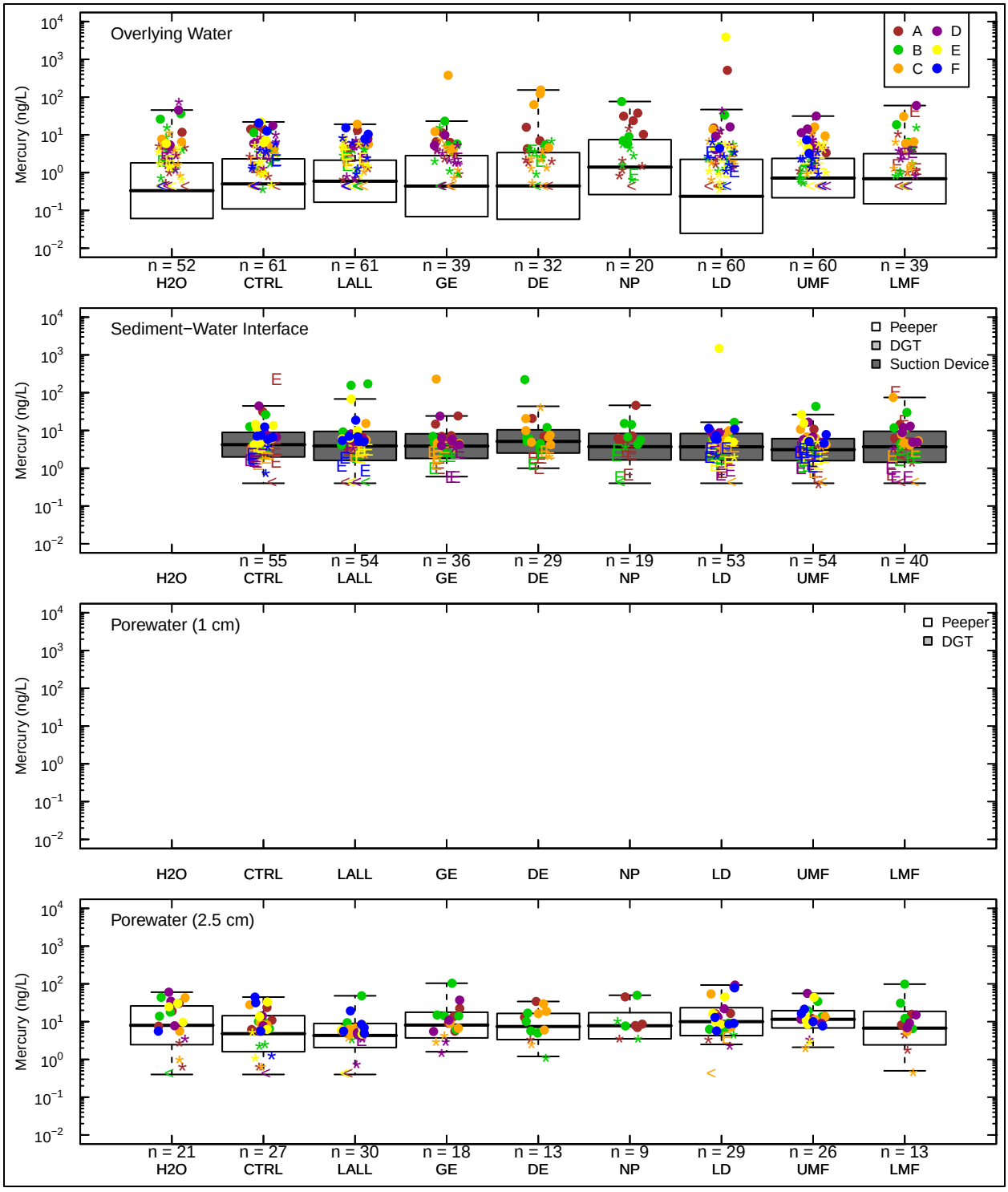


Figure 5−33. Summary of dissolved mercury concentrations as a function of treatment and sample type

Note: Samples types are presented in the following order: overlying water (top panel), sediment water interface water (2nd panel), porewater at 1 cm (3rd panel), and porewater at 2.5 cm (bottom panel). Where appropriate and applicable, concentrations as determined from different sampling techniques are identified within the top right−hand corner of respective panels. Individual measurements are shown as circles, measurements below detection are illustrated with a less than symbol ("<") plotted at the detection limit, qualified samples due to blank contamination are illustrated with an asterisks (*), and data qualified as "estimated" are represented with the symbol "E" at the estimated value. The 25th and 75th percentiles from the MLE calculated distribution is used for the edges of the box, the median is shown as a horizontal line drawn through the middle of the box. Whiskers show maximum and minimum values exclusive of extreme values. Extreme values are values that are more than 1.5 times the interquartile range above the 75th or below the 25th percentiles.

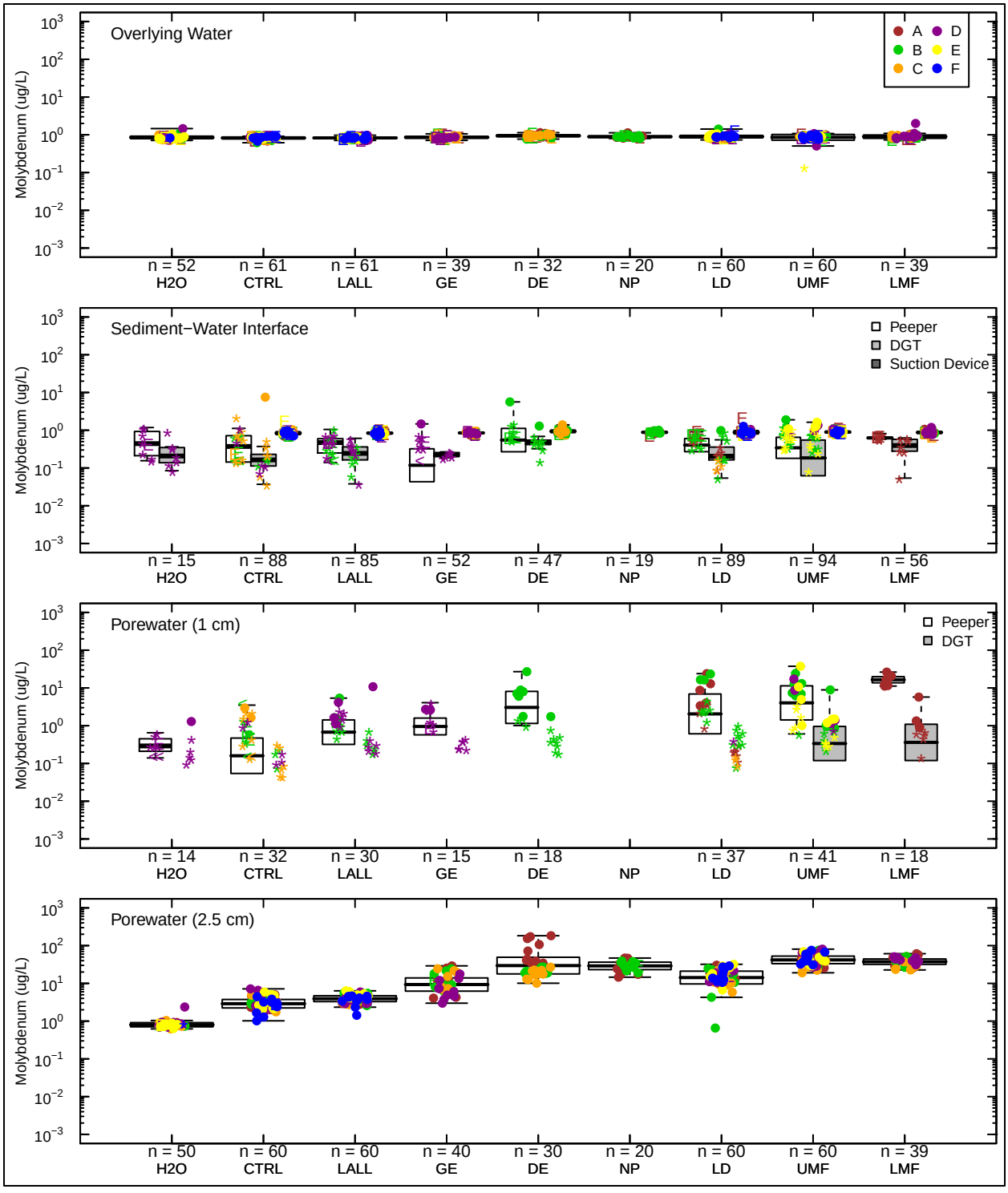


Figure 5−34. Summary of dissolved molybdenum concentrations as a function of treatment and sample type

Note: Samples types are presented in the following order: overlying water (top panel), sediment water interface water (2nd panel), porewater at 1 cm (3rd panel), and porewater at 2.5 cm (bottom panel). Where appropriate and applicable, concentrations as determined from different sampling techniques are identified within the top right−hand corner of respective panels. Individual measurements are shown as circles, measurements below detection are illustrated with a less than symbol ("<") plotted at the detection limit, qualified samples due to blank contamination are illustrated with an asterisks (*), and data qualified as "estimated" are represented with the symbol "E" at the estimated value. The 25th and 75th percentiles from the MLE calculated distribution is used for the edges of the box, the median is shown as a horizontal line drawn through the middle of the box. Whiskers show maximum and minimum values exclusive of extreme values. Extreme values are values that are more than 1.5 times the interquartile range above the 75th or below the 25th percentiles.

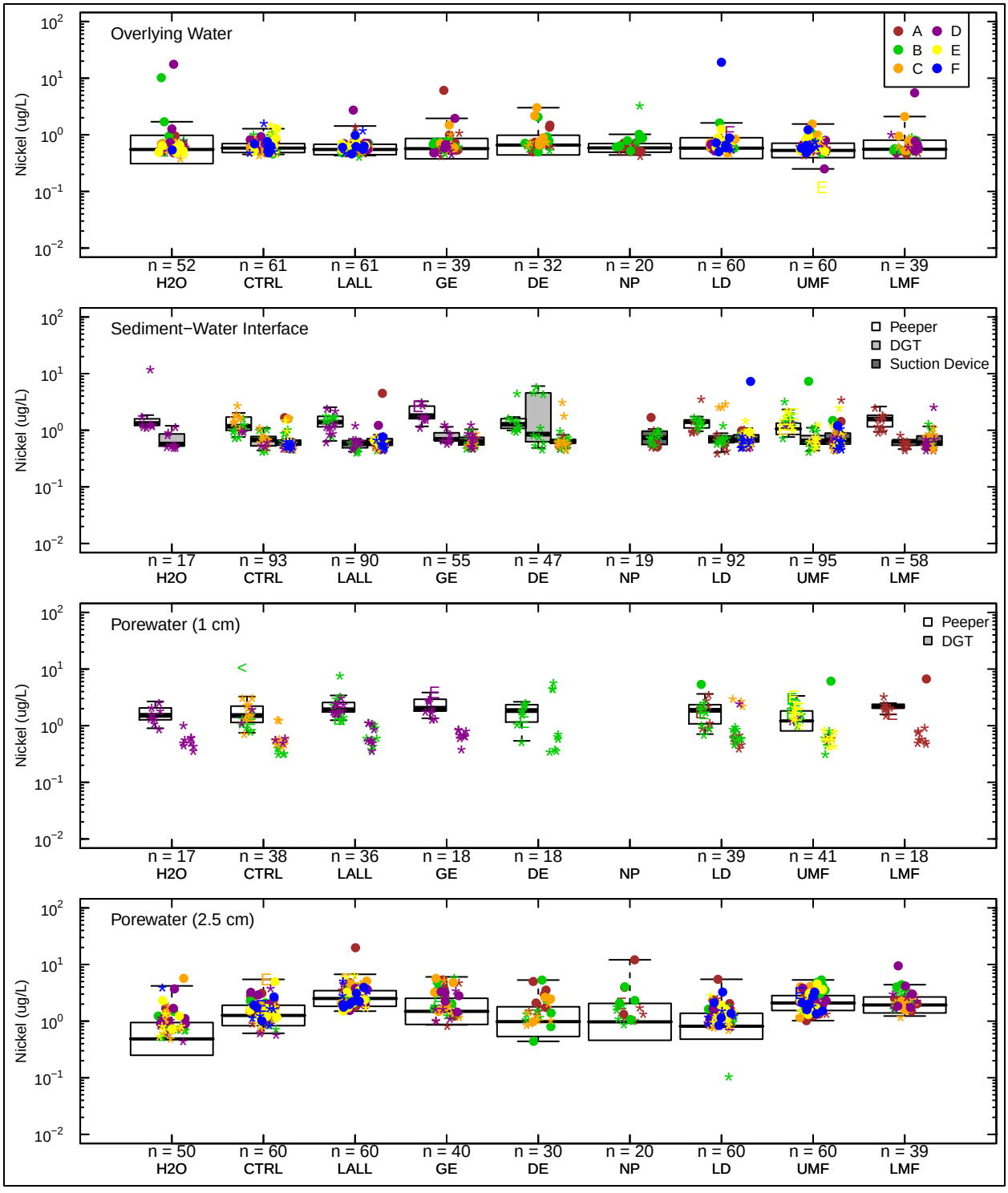


Figure 5−35. Summary of dissolved nickel concentrations as a function of treatment and sample type

Note: Samples types are presented in the following order: overlying water (top panel), sediment water interface water (2nd panel), porewater at 1 cm (3rd panel), and porewater at 2.5 cm (bottom panel). Where appropriate and applicable, concentrations as determined from different sampling techniques are identified within the top right−hand corner of respective panels. Individual measurements are shown as circles, measurements below detection are illustrated with a less than symbol ("<") plotted at the detection limit, qualified samples due to blank contamination are illustrated with an asterisks (*), and data qualified as "estimated" are represented with the symbol "E" at the estimated value. The 25th and 75th percentiles from the MLE calculated distribution is used for the edges of the box, the median is shown as a horizontal line drawn through the middle of the box. Whiskers show maximum and minimum values exclusive of extreme values. Extreme values are values that are more than 1.5 times the interquartile range above the 75th or below the 25th percentiles.

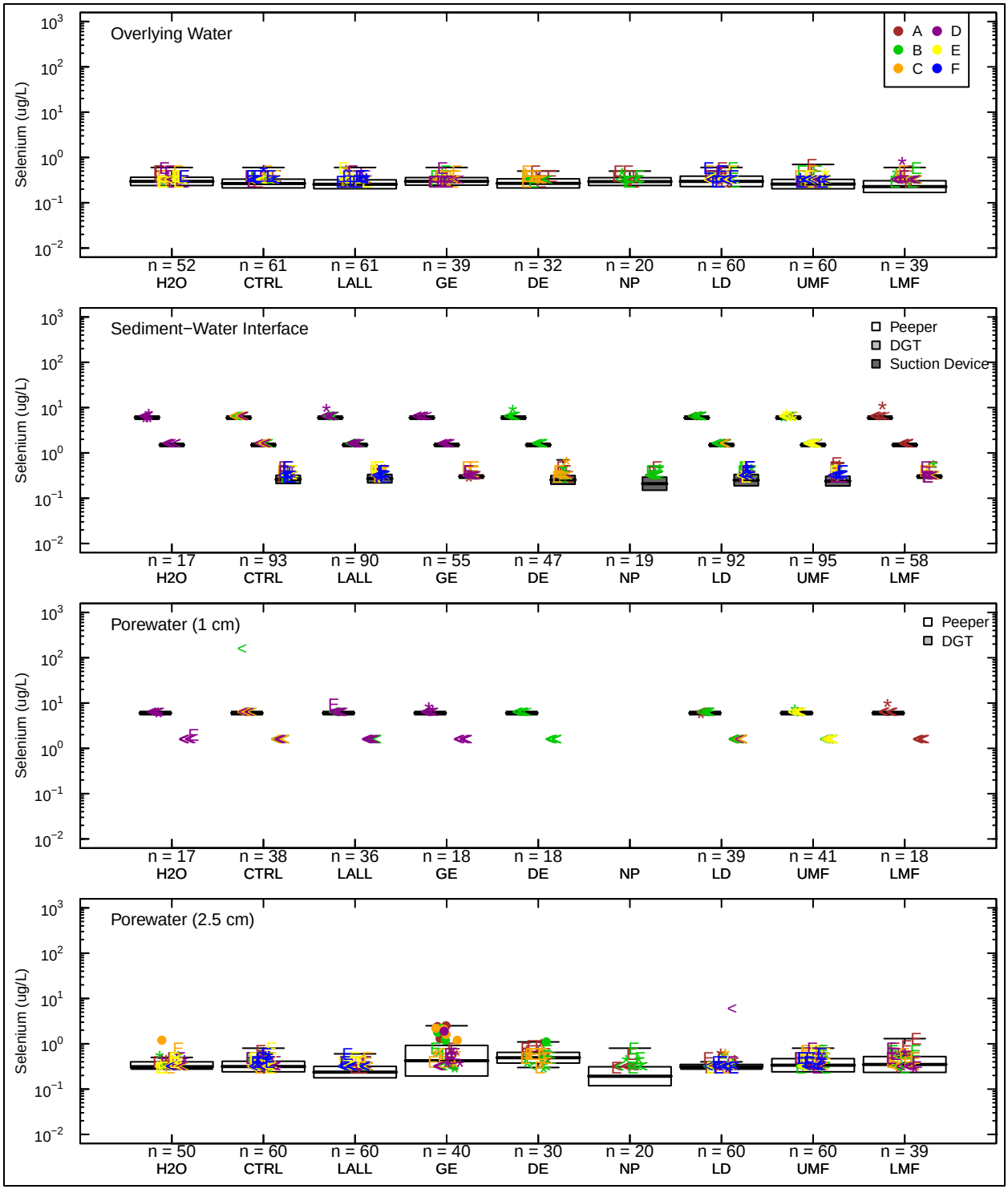


Figure 5−36. Summary of dissolved selenium concentrations as a function of treatment and sample type

Note: Samples types are presented in the following order: overlying water (top panel), sediment water interface water (2nd panel), porewater at 1 cm (3rd panel), and porewater at 2.5 cm (bottom panel). Where appropriate and applicable, concentrations as determined from different sampling techniques are identified within the top right−hand corner of respective panels. Individual measurements are shown as circles, measurements below detection are illustrated with a less than symbol ("<") plotted at the detection limit, qualified samples due to blank contamination are illustrated with an asterisks (*), and data qualified as "estimated" are represented with the symbol "E" at the estimated value. The 25th and 75th percentiles from the MLE calculated distribution is used for the edges of the box, the median is shown as a horizontal line drawn through the middle of the box. Whiskers show maximum and minimum values exclusive of extreme values. Extreme values are values that are more than 1.5 times the interquartile range above the 75th or below the 25th percentiles.

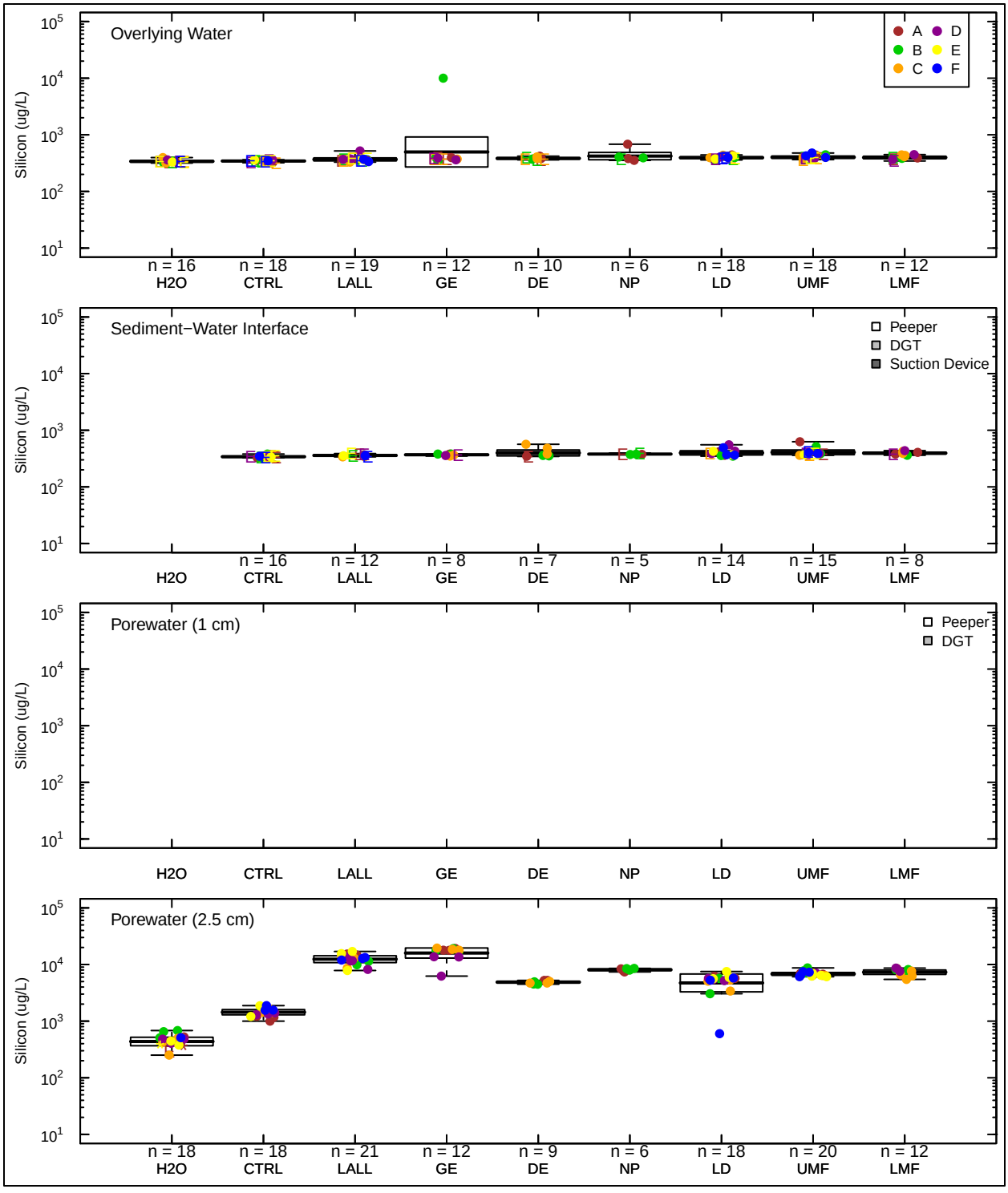


Figure 5−37. Summary of dissolved silicon concentrations as a function of treatment and sample type

Note: Samples types are presented in the following order: overlying water (top panel), sediment water interface water (2nd panel), porewater at 1 cm (3rd panel), and porewater at 2.5 cm (bottom panel). Where appropriate and applicable, concentrations as determined from different sampling techniques are identified within the top right−hand corner of respective panels. Individual measurements are shown as circles, measurements below detection are illustrated with a less than symbol ("<") plotted at the detection limit, qualified samples due to blank contamination are illustrated with an asterisks (*), and data qualified as "estimated" are represented with the symbol "E" at the estimated value. The 25th and 75th percentiles from the MLE calculated distribution is used for the edges of the box, the median is shown as a horizontal line drawn through the middle of the box. Whiskers show maximum and minimum values exclusive of extreme values. Extreme values are values that are more than 1.5 times the interquartile range above the 75th or below the 25th percentiles.

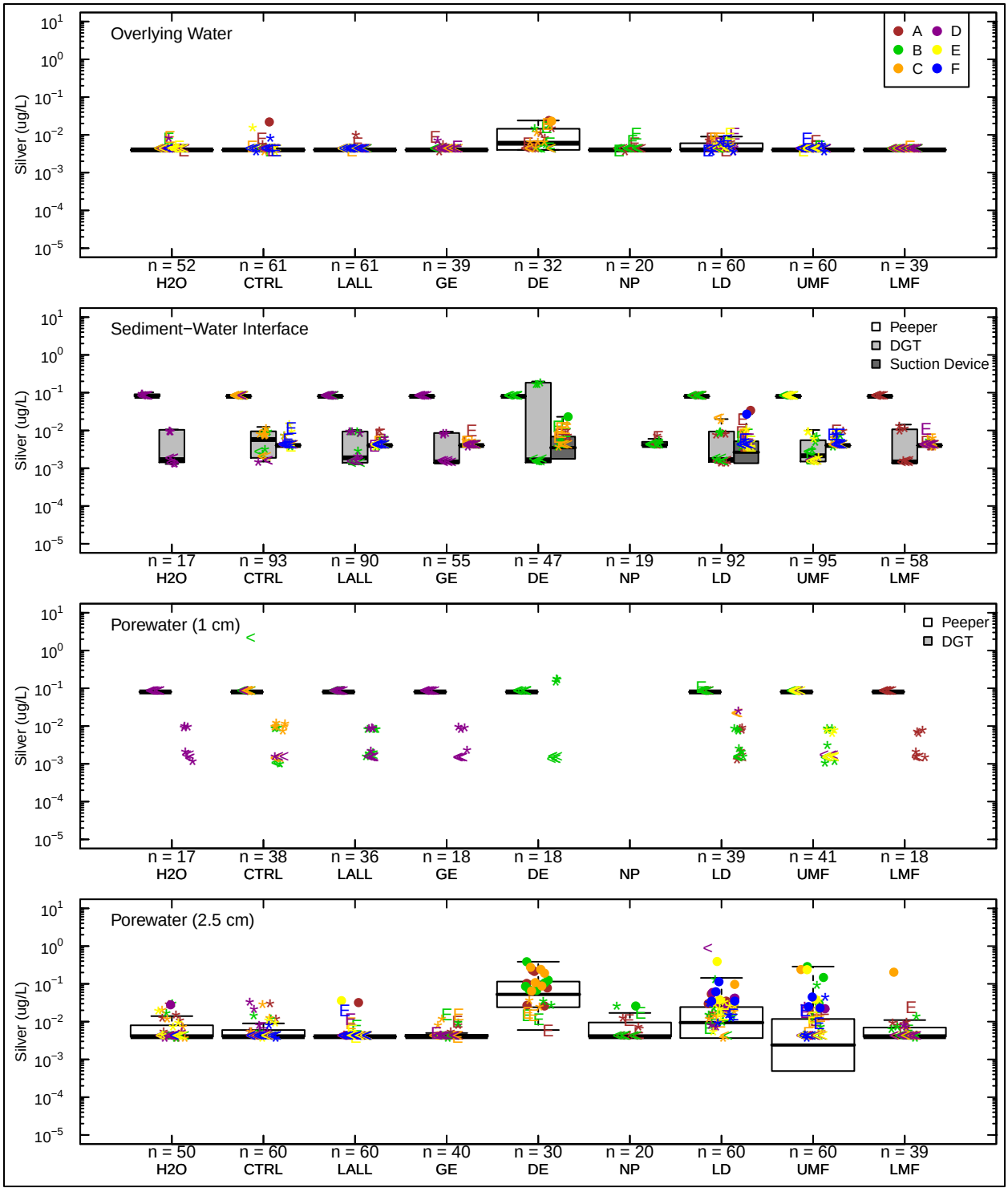


Figure 5−38. Summary of dissolved silver concentrations as a function of treatment and sample type

Note: Samples types are presented in the following order: overlying water (top panel), sediment water interface water (2nd panel), porewater at 1 cm (3rd panel), and porewater at 2.5 cm (bottom panel). Where appropriate and applicable, concentrations as determined from different sampling techniques are identified within the top right−hand corner of respective panels. Individual measurements are shown as circles, measurements below detection are illustrated with a less than symbol ("<") plotted at the detection limit, qualified samples due to blank contamination are illustrated with an asterisks (*), and data qualified as "estimated" are represented with the symbol "E" at the estimated value. The 25th and 75th percentiles from the MLE calculated distribution is used for the edges of the box, the median is shown as a horizontal line drawn through the middle of the box. Whiskers show maximum and minimum values exclusive of extreme values. Extreme values are values that are more than 1.5 times the interquartile range above the 75th or below the 25th percentiles.

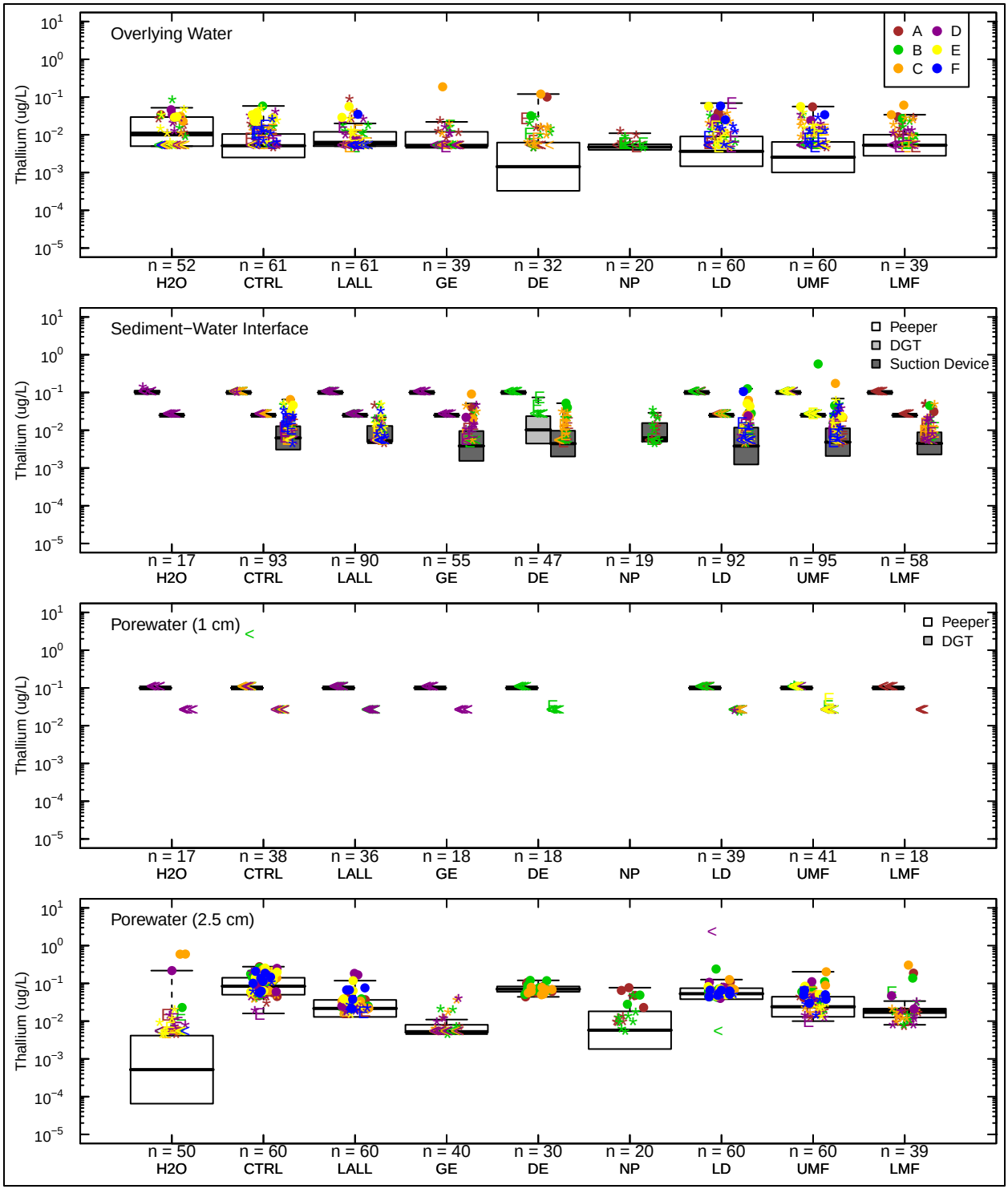


Figure 5−39. Summary of dissolved thallium concentrations as a function of treatment and sample type

Note: Samples types are presented in the following order: overlying water (top panel), sediment water interface water (2nd panel), porewater at 1 cm (3rd panel), and porewater at 2.5 cm (bottom panel). Where appropriate and applicable, concentrations as determined from different sampling techniques are identified within the top right−hand corner of respective panels. Individual measurements are shown as circles, measurements below detection are illustrated with a less than symbol ("<") plotted at the detection limit, qualified samples due to blank contamination are illustrated with an asterisks (*), and data qualified as "estimated" are represented with the symbol "E" at the estimated value. The 25th and 75th percentiles from the MLE calculated distribution is used for the edges of the box, the median is shown as a horizontal line drawn through the middle of the box. Whiskers show maximum and minimum values exclusive of extreme values. Extreme values are values that are more than 1.5 times the interquartile range above the 75th or below the 25th percentiles.

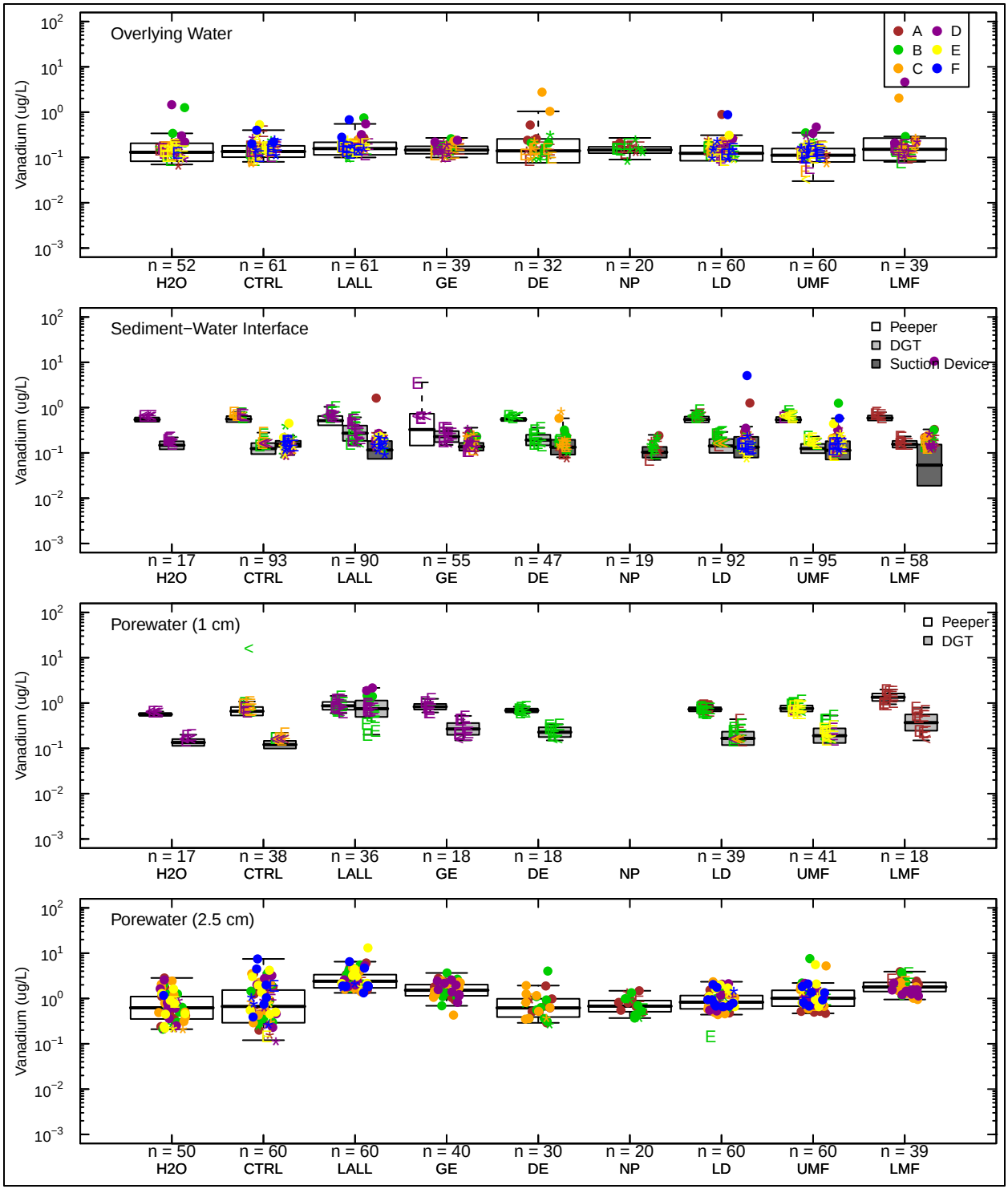


Figure 5−40. Summary of dissolved vanadium concentrations as a function of treatment and sample type

Note: Samples types are presented in the following order: overlying water (top panel), sediment water interface water (2nd panel), porewater at 1 cm (3rd panel), and porewater at 2.5 cm (bottom panel). Where appropriate and applicable, concentrations as determined from different sampling techniques are identified within the top right−hand corner of respective panels. Individual measurements are shown as circles, measurements below detection are illustrated with a less than symbol ("<") plotted at the detection limit, qualified samples due to blank contamination are illustrated with an asterisks (*), and data qualified as "estimated" are represented with the symbol "E" at the estimated value. The 25th and 75th percentiles from the MLE calculated distribution is used for the edges of the box, the median is shown as a horizontal line drawn through the middle of the box. Whiskers show maximum and minimum values exclusive of extreme values. Extreme values are values that are more than 1.5 times the interquartile range above the 75th or below the 25th percentiles.

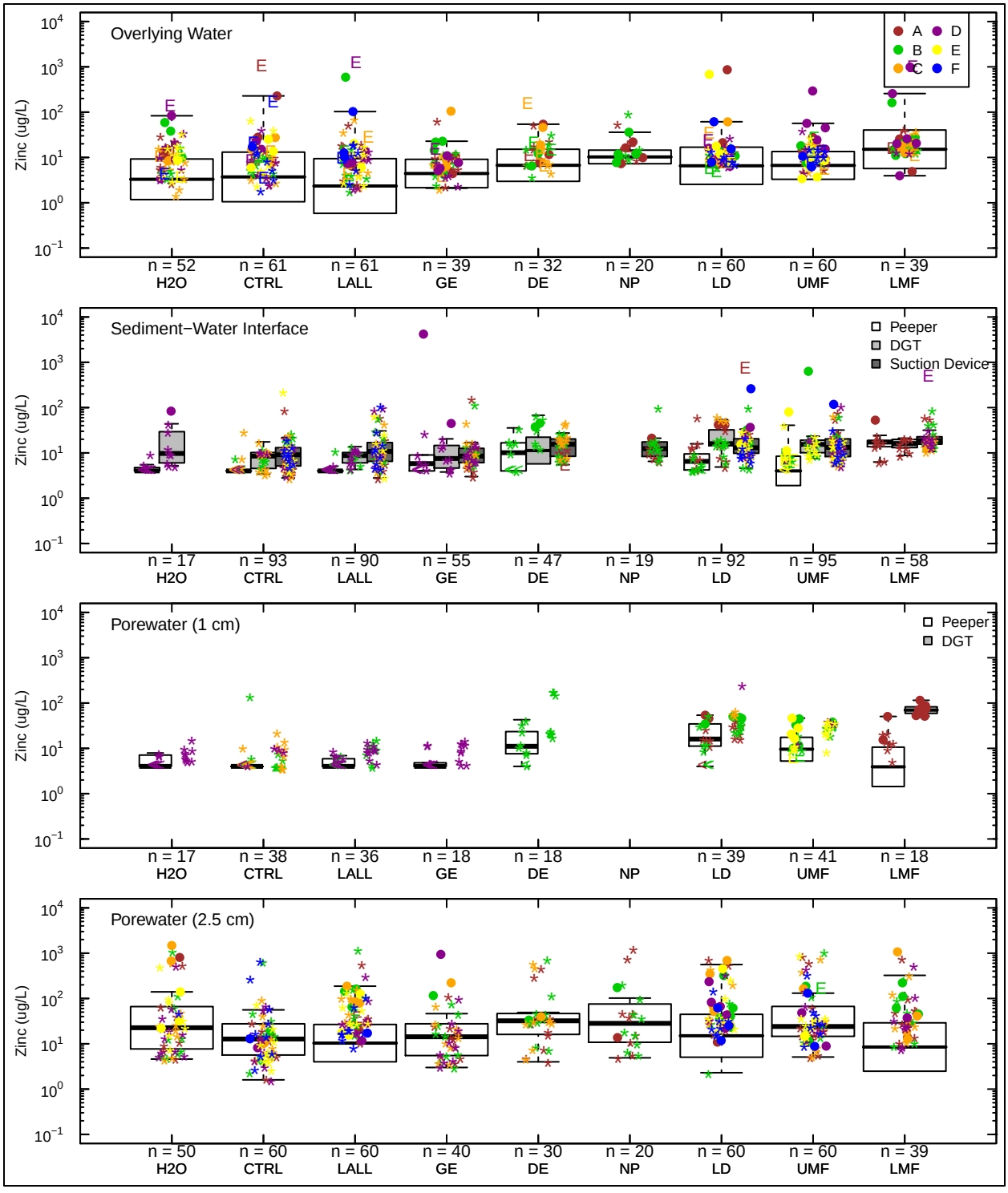


Figure 5−41. Summary of dissolved zinc concentrations as a function of treatment and sample type

Note: Samples types are presented in the following order: overlying water (top panel), sediment water interface water (2nd panel), porewater at 1 cm (3rd panel), and porewater at 2.5 cm (bottom panel). Where appropriate and applicable, concentrations as determined from different sampling techniques are identified within the top right−hand corner of respective panels. Individual measurements are shown as circles, measurements below detection are illustrated with a less than symbol ("<") plotted at the detection limit, qualified samples due to blank contamination are illustrated with an asterisks (*), and data qualified as "estimated" are represented with the symbol "E" at the estimated value. The 25th and 75th percentiles from the MLE calculated distribution is used for the edges of the box, the median is shown as a horizontal line drawn through the middle of the box. Whiskers show maximum and minimum values exclusive of extreme values. Extreme values are values that are more than 1.5 times the interquartile range above the 75th or below the 25th percentiles.

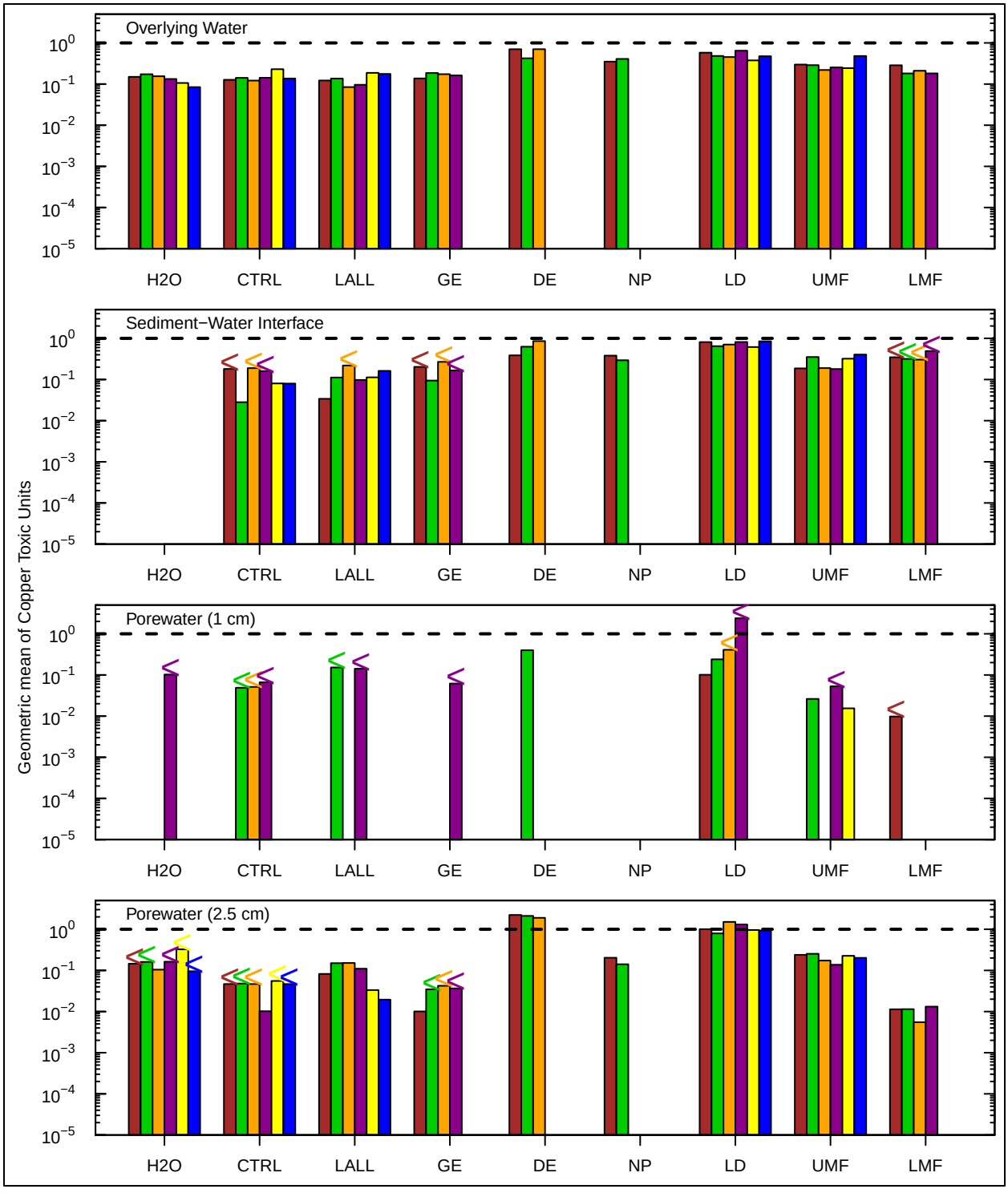


Figure 5−42 Geometric mean toxic units (TUs) for dissolved copper as a function of treatment and sample type

Note: if 80% or fewer of measured concentrations were qualified (i.e., censored), maximum likelihood estimate procedures were used to derive geometric mean TUs. These calculations are identified with a less than symbol ("<") positioned above respective columns. Sample types (e.g., porewater) are identified in the top left−hand corner of each plot, with replicate exposure chambers illustrated using the color scheme defined in Figure 2−3. The dashed line represents a TU of 1.

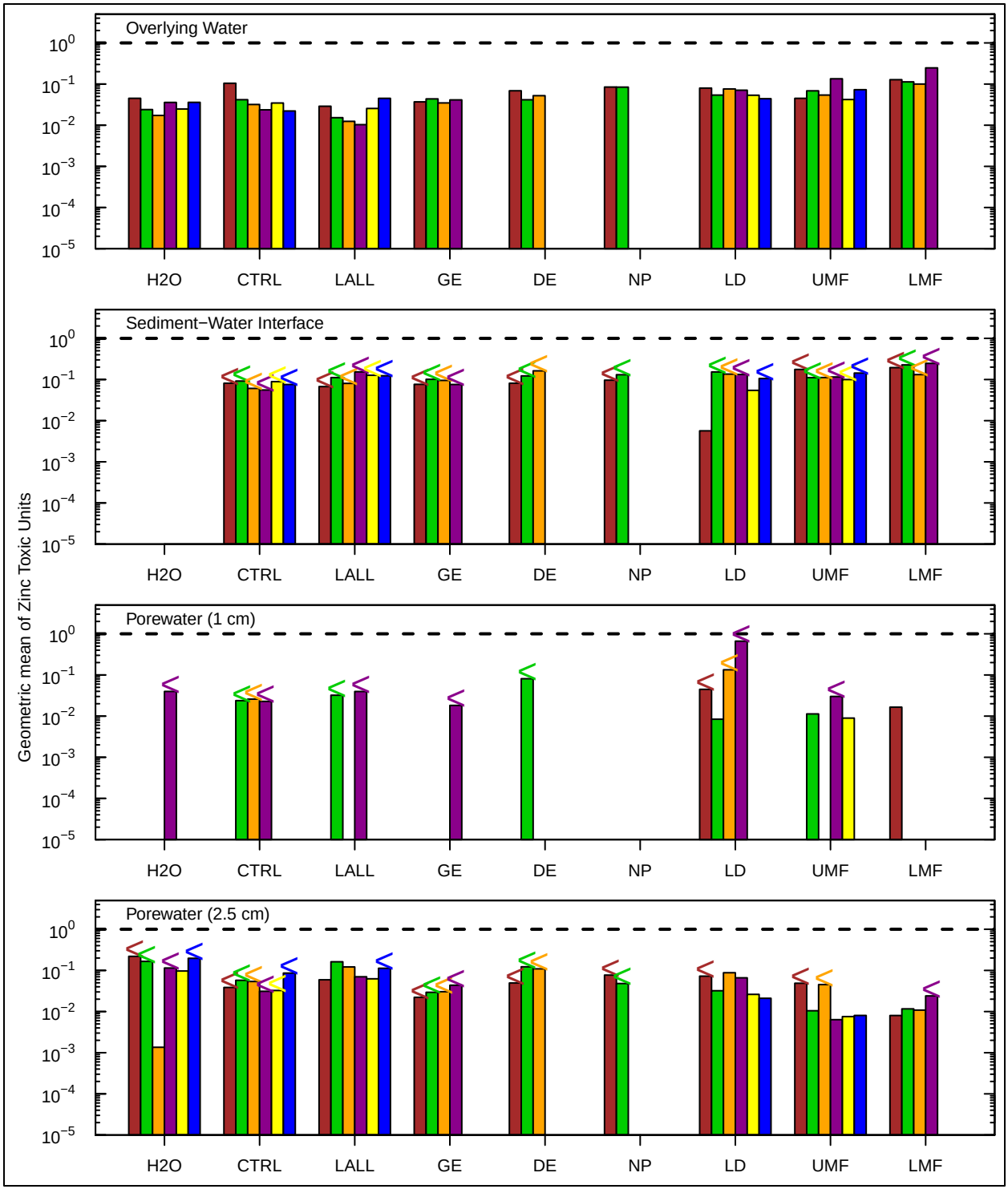


Figure 5−43 Geometric mean toxic units (TUs) for dissolved zinc as a function of treatment and sample type

Note: if 80% or fewer of measured concentrations were qualified (i.e., censored), maximum likelihood estimate procedures were used to derive geometric mean TUs. These calculations are identified with a less than symbol ("<") positioned above respective columns. Sample types (e.g., porewater) are identified in the top left−hand corner of each plot, with replicate exposure chambers illustrated using the color scheme defined in Figure 2−3. The dashed line represents a TU of 1.

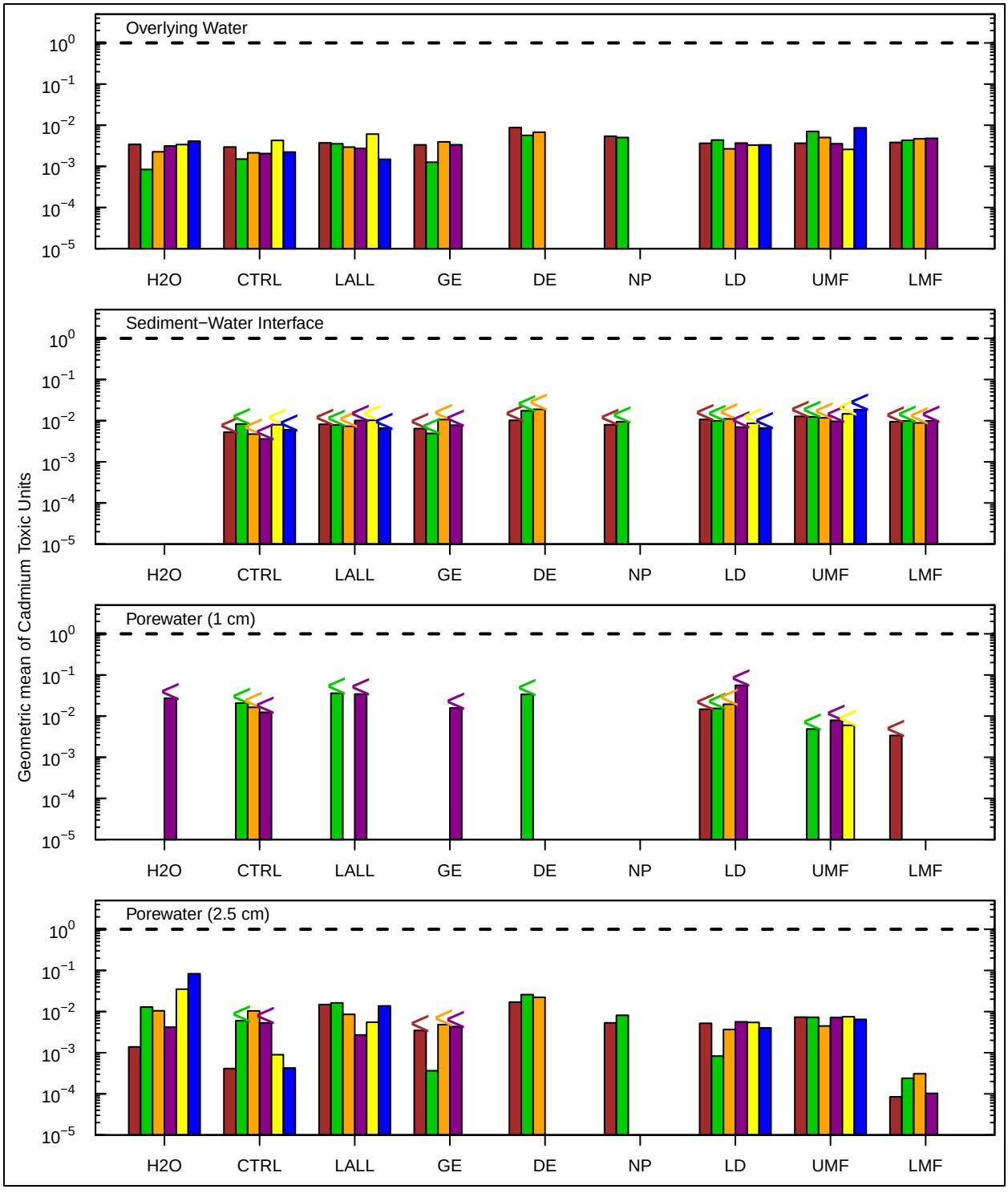


Figure 5−44 Geometric mean toxic units (TUs) for dissolved cadmium as a function of treatment and sample type

Note: if 80% or fewer of measured concentrations were qualified (i.e., censored), maximum likelihood estimate procedures were used to derive geometric mean TUs. These calculations are identified with a less than symbol ("<") positioned above respective columns. Sample types (e.g., porewater) are identified in the top left−hand corner of each plot, with replicate exposure chambers illustrated using the color scheme defined in Figure 2−3. The dashed line represents a TU of 1.

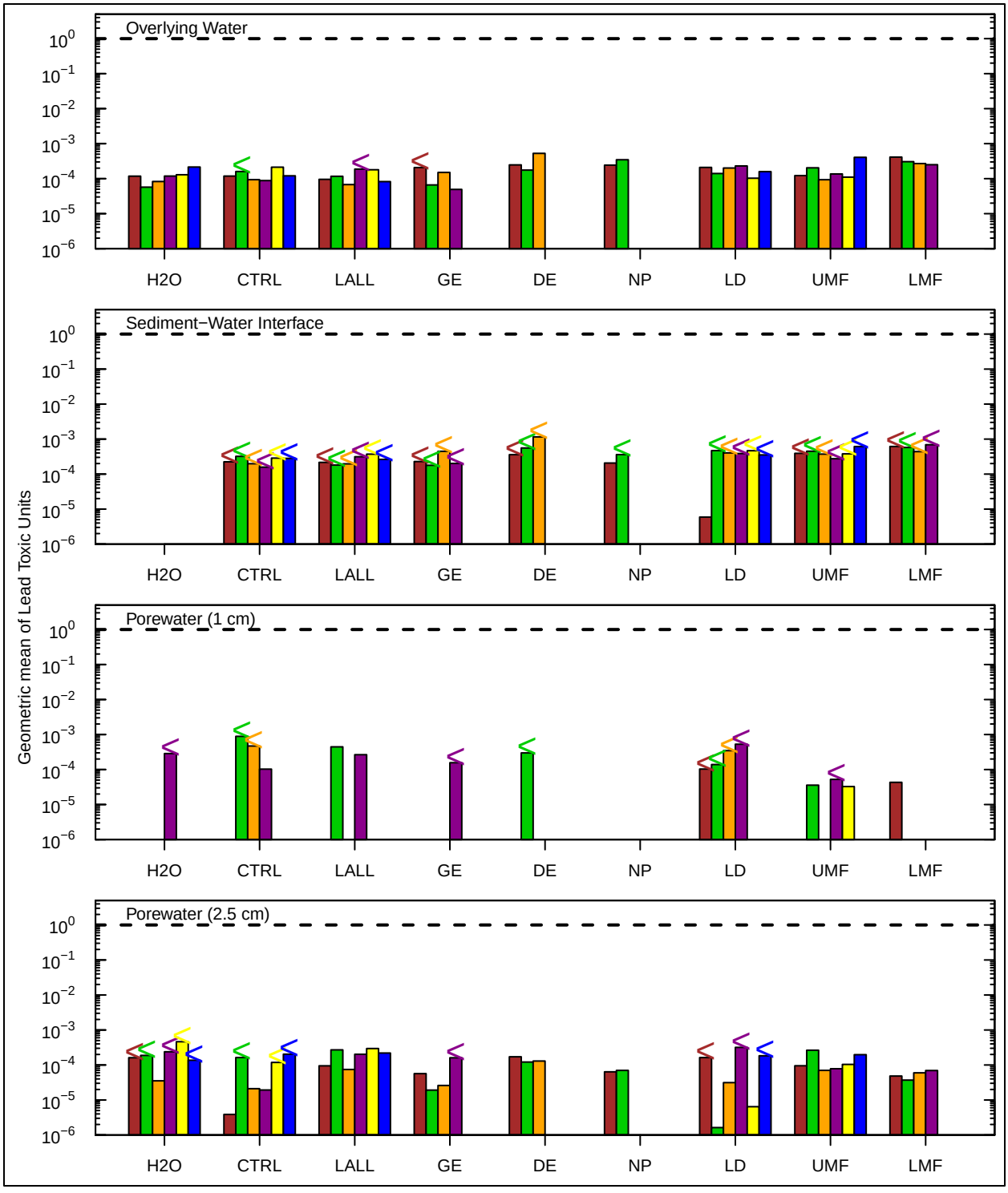


Figure 5−45 Geometric mean toxic units (TUs) for dissolved lead as a function of treatment and sample type

Note: if 80% or fewer of measured concentrations were qualified (i.e., censored), maximum likelihood estimate procedures were used to derive geometric mean TUs. These calculations are identified with a less than symbol ("<") positioned above respective columns. Sample types (e.g., porewater) are identified in the top left−hand corner of each plot, with replicate exposure chambers illustrated using the color scheme defined in Figure 2−3. The dashed line represents a TU of 1.

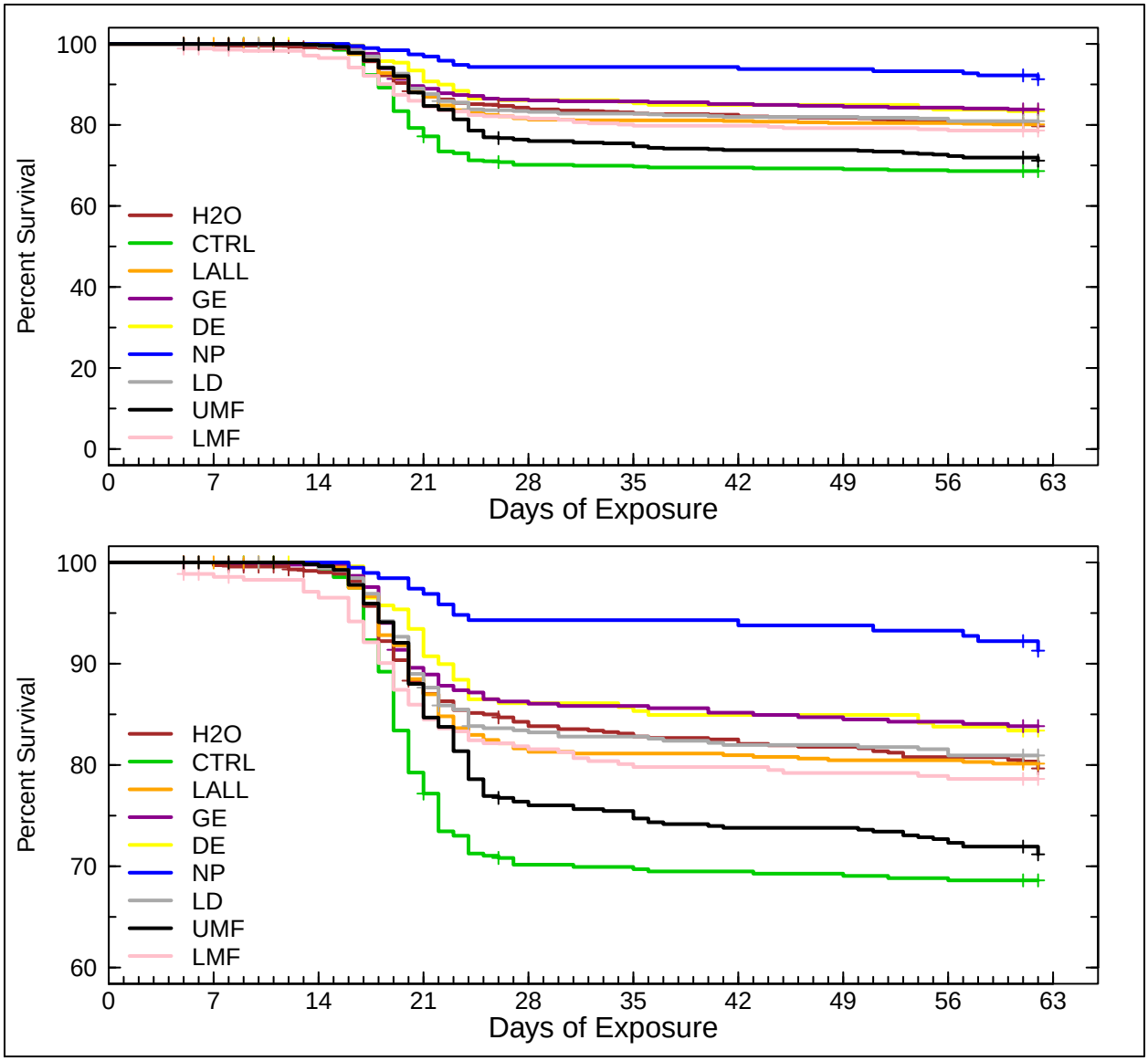


Figure 5-46. Survival analysis applied to sturgeon toxicity results from each treatment (replicates pooled) to give overall treatment-specific survival curves. Data are shown with the survival scale ranging from 0 to 100% (top panel) and from 60% to 100% (bottom panel).

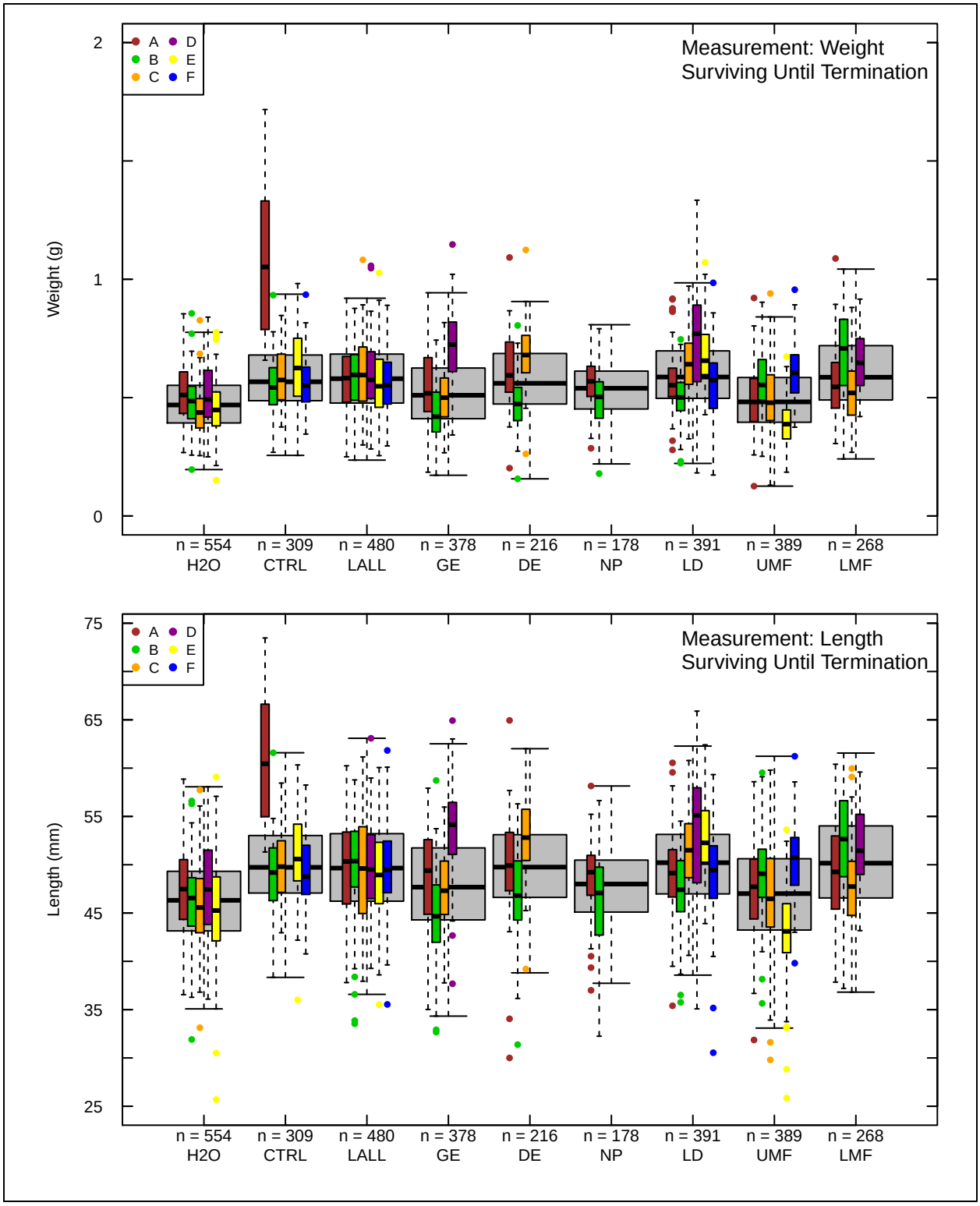


Figure 5-47. Growth of white sturgeon as a function of treatment at the end of the study

Note: For each treatment, a gray box−and−whisker plot is provided as a treatment level summary. Smaller, colored box−and− whisker plots are provided as summaries for replicate exposure chambers within a treatment. The number of fish included in length and weight calculations for each treatment is provided along the x−axis.

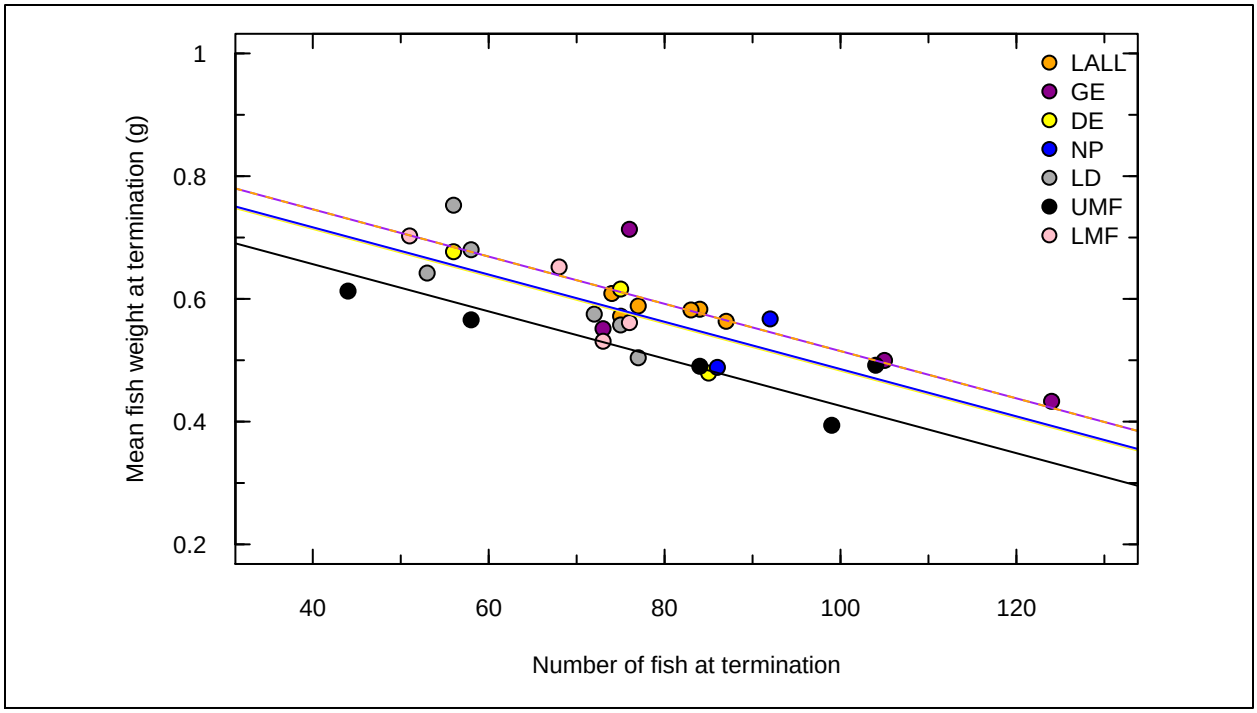


Figure 5−48. Average fish weight and number of surviving fish until study termination

Note: Data shown represent the average weight of fish surviving until study termination in exposure chambers. Lines represent linear predictors for each sediment treatment after application of an ANCOVA. For the ANCOVA, data from the two reference locations were pooled. The applied ANCOVA utilized a common slope assumption.

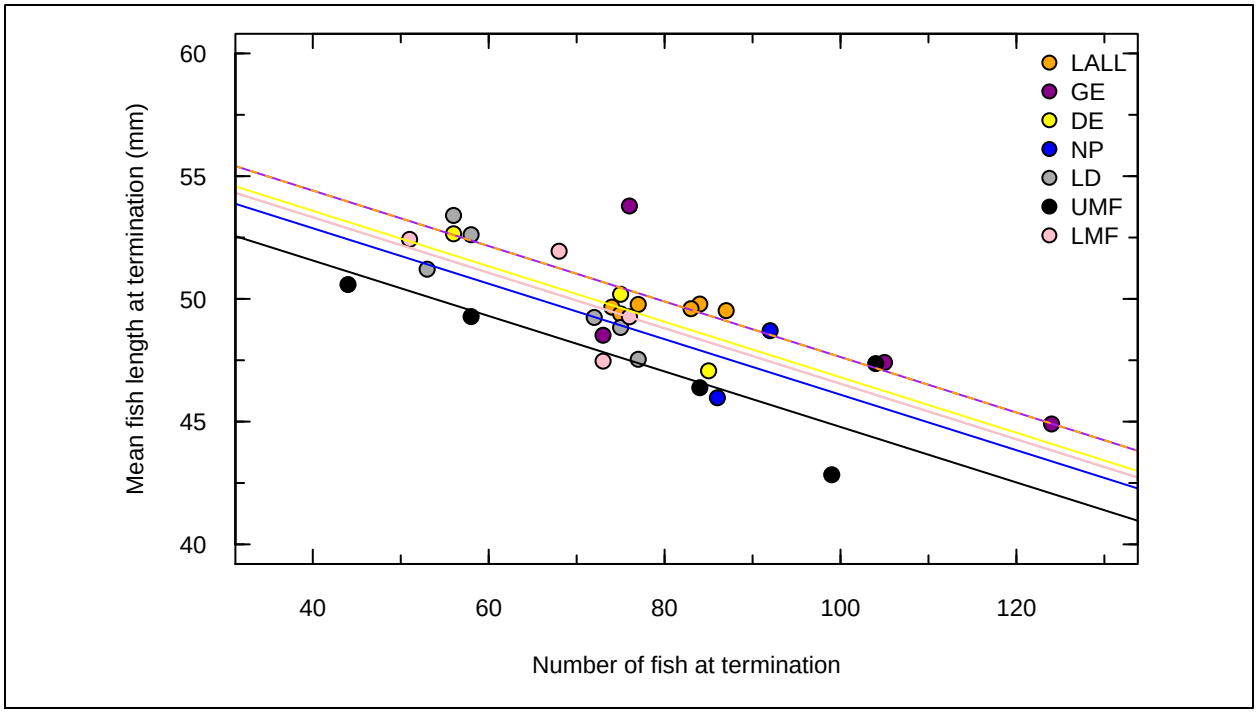


Figure 5−49. Average fish length and number of surviving fish until study termination

Note: Data shown represent the average length of fish surviving until study termination in exposure chambers. Lines represent linear predictors for each sediment treatment after application of an ANCOVA. For the ANCOVA, data from the two reference locations were pooled. The applied ANCOVA utilized a common slope assumption.

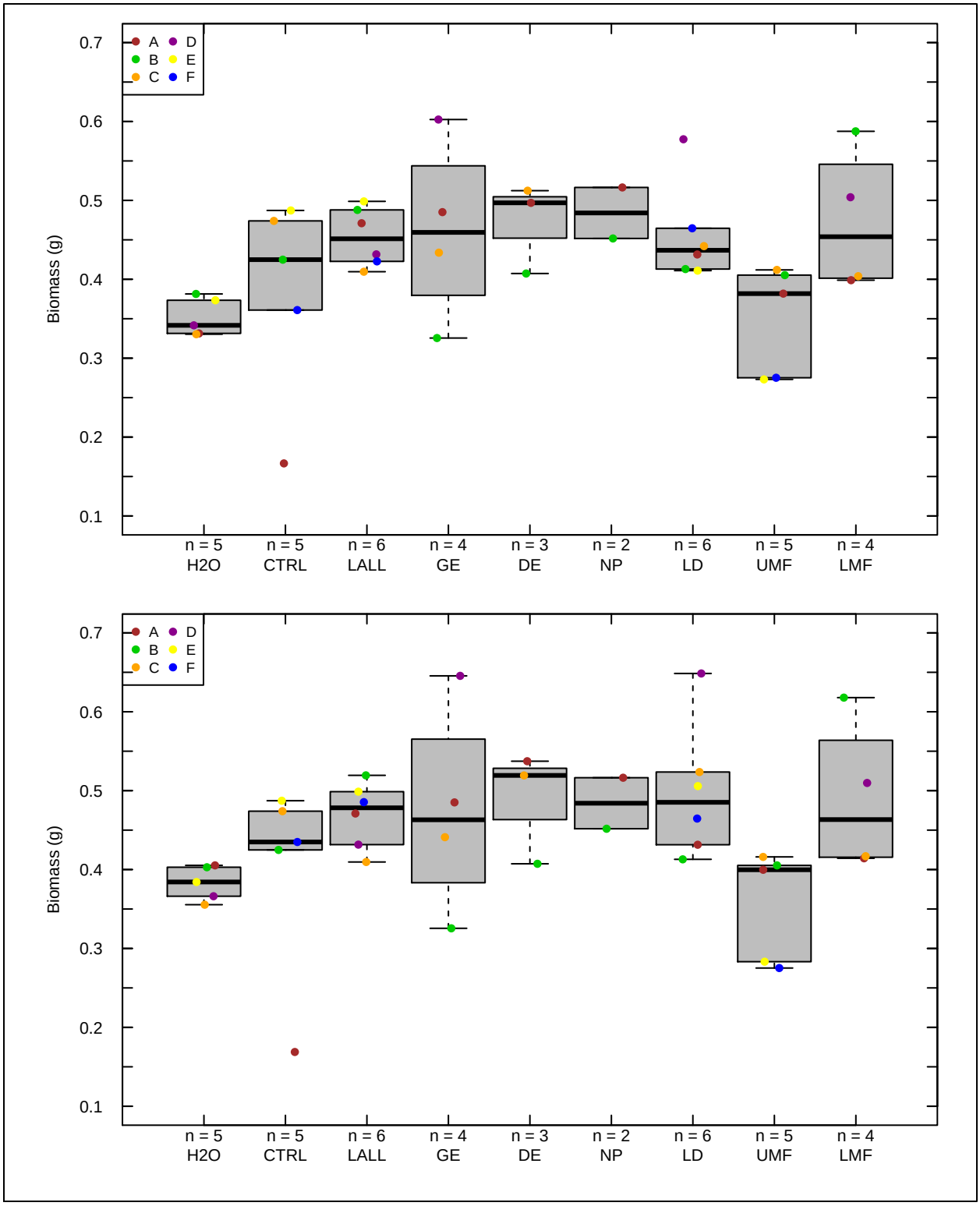


Figure 5−50. Biomass of white sturgeon as a function of treatment at the end of study. Top panel shows biomass calculated using initial seeding density and bottom panel shows biomass calculated using initial seeding density minus the number of non-mortality fish losses after the first 48 hours of exposure.

Note: The number of replicate chambers included in the biomass calculation for each treatment is provided along the x−axis.

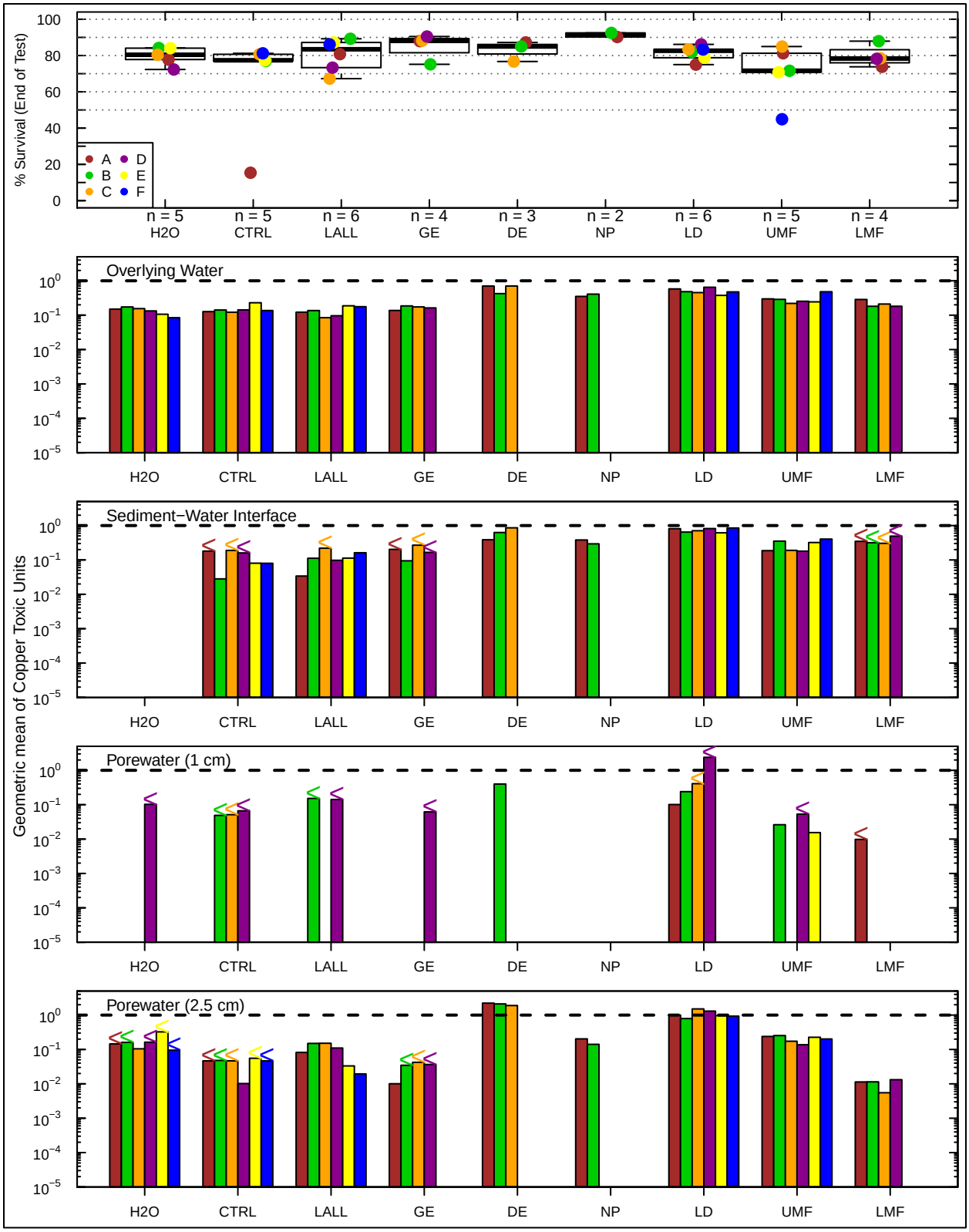


Figure 5−51. Geometric mean toxic units (TUs) for dissolved copper as a function of treatment and sample type relative to percent survival

Note: Samples types (e.g., porewater) are identified in the top left−hand corner of the bottom four panels, with replicate exposure chambers illustrated using the color scheme defined in Figure 2−3. The dashed line represents a TU of 1.

TABLES

Table 2-1. Test Acceptability Requirements of a 60-Day Early Life-Stage Sediment Toxicity Test with White Sturgeon (*A. transmontanus*)

Acceptability Criteria	
1	Freshly fertilized eggs from at least 2 to 4 different females and males are to be used (time between hatching and initiation of study must not exceed 24 hours)
2	Average hatching rate of eggs in the lab water controls should not be less than 60%, or within 90% confidence interval of that observed at the hatchery for the same fish
3	Average survival of fry until swim-up in the lab water controls should be greater or equal to 80%, or within 90% confidence interval of that observed at the hatchery for the same fish
4	Average survival of fry from the start to finish of exposure in the lab water controls should be greater or equal to 64%
5	All water quality parameters with the exception of DO and temperature should not vary by more than 50% during the exposure
6	Dissolved oxygen should be maintained above 70% saturation
7	Average daily temperature should be maintained at 15 ± 1°C; the instantaneous temperature must always be within ± 3°C of 15°C
Additional Acceptability Criteria	
1	All organisms must be from the same source
2	Hatchability in the lab water controls should be comparable to those observed at the Kootenay Trout Hatchery for the fish from the same fertilization event
3	All test systems and chambers should be identical and should be run under the same recirculating conditions for each study, except if otherwise stated in the protocols
4	Natural physico-chemical conditions of the control lab water should be within the tolerance limit for white sturgeon early life-stages
5	Food should be obtained and tested for possible comparability with white sturgeon early life-stages prior to initiation of the studies
6	Reference toxicant (copper) will be tested in acute toxicity (96hr) water-only exposure, using a life stage previously tested at U of S and fish from the same batch of fish used in the sediment study

Notes:
DO - dissolved oxygen

Table 2-2. Universal Transverse Mercator (UTM) Coordinates of Sediment Sample

Sample Area Description	Sample Location	River Mile	UTM Coordinates (Min-Max Range)		UTM Coordinates (Midpoint)	
			Northing	Easting	Northing	Easting
References						
Lower Arrow Lakes	LALL	788	5465790 - 5465831	440467 - 440485	5465810.5	440476
Genelle	GE	766	5450155 - 5450216	448668 - 448753	5450185.5	448710.5
Birchbank Eddy	BBE	764	5447789.379	448050.484	5447789.379	448050.484
Site Sediments/Substrates						
Deadman's Eddy	DME01	737	5420947 - 5420951	446394 - 446398	5420949	446396
	DME02		5420438 - 5420441	446801 - 446805	5420439.5	446803
	DME02		5420744 - 5420748	446280 - 446283	5420746	446281.5
Deadman's Eddy	DE	738	5421094 - 5421133	447142 - 447027	5421113.5	447084.5
Northport	NP01	735	5419142 - 5419146	443438 - 443442	5419144	443440
	NP02		5419834 - 5419837	444099 - 444103	5419835.5	444101
	NP03		5419360 - 5419370	443303 - 443309	5419365	443306
China Bend	CB01	723	5408762 - 5408765	432126 - 432130	5408763.5	432128
	CB02		5408771-5408774	432118 - 432122	5408772.5	432120
	CB03		5407581 - 5407585	431103 - 431107	5407583	431105
Little Dalles	LD01	729	5412540 - 5412561	435417 - 435434	5412550.5	435425.5
	LD02		5413584 - 5413587	436596 - 436599	5413585.5	436597.5
	LD03		5414444 - 5414447	438120 - 438123	5414445.5	438121.5
Upper Marcus Flats	UMF01	706	5391675 - 5391680	422643 - 422648	5391677.5	422645.5
	UMF02		5390645 - 5390654	420587 - 420597	5390649.5	420592
	UMF03		5392080 - 5392080	420014 - 420021	5392080	420017.5
Lower Marcus Flats	LMF01	704	5389527 - 5389530	419587 - 419605	5389528.5	419596
	LMF02		5390150 - 5390167	418460 - 418474	5390158.5	418467
	LMF03		5389403 - 5389419	418537 - 418542	5389411	418539.5

Notes:

Per the QAPP (TAI 2010a,b,c) several grab attempts were required to attain the required sediment volume. For a detailed breakdown of coordinates per grab, please refer to Appendix A of this report.

Table 2-3. Volumes of Sediment Collected for White Sturgeon Sediment Toxicity Tests

Sample Area Description	Sample Location	River Mile	Volume (gal)
References			
Lower Arrow Lakes	LALL	788	50
Genelle	GE	766	50
Birchbank	BBE	764	0
Site Sediments/Substrates			
Deadman's Eddy	DME-01	737	0
	DME-02		
	DME-02		
Gravel Bar at DME	DE	738	50
Northport	NP-01	735	0
	NP-02		0
	NP-03		15
China Bend	CB-01	723	0
	CB-02		0
	CB-03		0
Little Dalles	LD-01	729	50
	LD-02		0
	LD-03		0
Upper Marcus Flats	UMF-01	706	50
	UMF-02		50
	UMF-03		50
Lower Marcus Flats	LMF-01	704	50
	LMF-02		25
	LMF-03		5

Table 2-4. Number of Replicate Exposure Chambers Evaluated During the Course of the Study

Treatment Group	No. of Replicate Exposure Chambers	No. of Chemistry-Only Chambers
Site Sediments/Substrates		
DE	2	1
NP-03	2	0
LD-01	6	2
UMF-01	6	2
LMF-02	4	1
References		
LALL	6	2
GE	4	1
Laboratory Controls		
CTRL	6	2
H2O	5	1
Totals	41	12

Notes:
CTRL - artificial substrate control
DE - substrates as collected above the water line from the gravel bar at DME
GE - Genelle Eddy
H2O - water-only control
LALL - Lower Arrow Lakes
LD - Little Dalles
LMF - Lower Marcus Flats
NP - Northport
UMF - Upper Marcus Flats

Table 2-5. Seeding Density of Sturgeon in Replicate Exposure Chambers as Determined within the first 48 hours of the Study

	Exposure Chamber Replicate Designation						Summary Statistics			
Treatment Group	A	B	C	D	E	F	Minimum	Maximum	Mean	Standard Deviation
Site Sediments/Substrates										
DE	93 (1)	100	74	0	0	0	74	100	87	13
LD-01	96 (1)	94 (1)	77	73	96 (1)	90 (2)	73	77	75	2
NP-03	100	93 (1)	0	0	0	0	100	100	100	0
UMF-01	134 (1)	81	100	na	140	98 (2)	81	140	107	25
LMF-02	107	61 (1)	96	88	0	0	88	107	97	8
References										
LALL	104	99 (2)	110	105	86 (1)	116 (2)	104	110	106	3
GE	83	165	121	90	0	0	83	165	115	32
Laboratory Controls										
CTRL	79	87 (2)	88	na	84 (3)	147	79	147	105	30
H2O	159 (1,2)	131	170 (1,1)	149	142 (1,1)	0	131	149	140	9

Notes:

Seeding density was calculated as the sum of three components.

Component 1 = number of mortalities recorded during the course of the study

Component 2 = number of lost/escaped fish recorded during the study

Component 3 = number of fish that survived as determined at the termination of the study

Numbers in parentheses indicate numbers of dead fish removed and replaced during the first 24 (first number) and 48 (second number) hours.

na - not available. Due to gaps between the screen and exposure chamber wall, an unknown number of seeded fish escaped not permitting a reliable calculation.

CTRL - artificial substrate control

DE - substrates as collected above the water line from the gravel bar at DME

GE - Genelle Eddy

H2O - water-only control

LALL - Lower Arrow Lakes

LD - Little Dalles

LMF - Lower Marcus Flats

NP - Northport

UMF - Upper Marcus Flats

Table 2-6. Sediment Analytical Methods and Associated Method Detection Limits and Method Reporting Limits

Analyte Type	Analyte	Analytical Method	Units	Planned Method Reporting Limits (mg/kg dw)	Minimum MDL	Maximum MDL	Minimum MRL	Maximum MRL	Number of 1X MRL Exceedances/ Total Analyses	Number of 10X MRL Exceedances/ Total Analyses
Conventionals										
	Organic carbon	D412982M	percent	NA	0.02	0.02	0.05	0.05	NA	NA
	pH	EPA 9045D	SU	NA	--	--	--	--	--	--
	Solids	EPA 160.3	percent	NA	--	--	--	--	--	--
	Sulfide-AVS	EPA 821 R91-SEM	µmol/g	NA	0.003	0.14	0.016	0.72	NA	NA
Grain Size										
	Clay	PSEP	percent	--	--	--	--	--	--	--
	Coarse gravel	PSEP	percent	--	--	--	--	--	--	--
	Coarse sand	PSEP	percent	--	--	--	--	--	--	--
	Cobbles	PSEP	percent	--	--	--	--	--	--	--
	Fine gravel	PSEP	percent	--	--	--	--	--	--	--
	Fine sand	PSEP	percent	--	--	--	--	--	--	--
	Med. sand	PSEP	percent	--	--	--	--	--	--	--
	Medium gravel	PSEP	percent	--	--	--	--	--	--	--
	Silt	PSEP	percent	--	--	--	--	--	--	--
	Very coarse gravel	PSEP	percent	--	--	--	--	--	--	--
	Very coarse sand	PSEP	percent	--	--	--	--	--	--	--
	Very fine gravel	PSEP	percent	--	--	--	--	--	--	--
	Very fine sand	PSEP	percent	--	--	--	--	--	--	--
Metals/Metalloids										
	Aluminum	EPA 6010B	mg/kg	20	0.3	4.9	7.8	124	19/59	0/59
	Antimony	EPA 6010C-AVS-SEM	µmol/g	--	0.0041	0.0522	0.0041	0.0522	--	--
	Antimony	EPA 6020	mg/kg	0.08	0.008	0.213	0.043	0.213	6/59	0/59
	Arsenic	EPA 6010C-AVS-SEM	µmol/g	--	0.0013	0.17	0.0013	0.17	--	--
	Arsenic	EPA 6020	mg/kg	2	0.04	0.1	0.38	1	0/59	0/59
	Barium	EPA 6010B	mg/kg	20	0.05	0.74	1.55	24.7	19/59	0/59
	Beryllium	EPA 6010B	mg/kg	0.09	0.03	0.05	0.08	0.12	53/59	0/59
	Cadmium	EPA 6010C-AVS-SEM	µmol/g	--	0.00005	0.0056	0.00005	0.0056	--	--
	Cadmium	EPA 6020	mg/kg	0.2	0.003	0.008	0.015	0.04	0/59	0/59
	Calcium	EPA 6010B	mg/kg	500	1.6	24.7	7.8	124	0/59	0/59
	Chromium	EPA 6010C-AVS-SEM	µmol/g	--	0.0011	0.0122	0.0011	0.0122	--	--
	Chromium	EPA 6020	mg/kg	500	0.01	0.59	0.15	7.83	0/59	0/59
	Cobalt	EPA 6010B	mg/kg	8.7	0.16	2.5	0.39	6.18	0/59	0/59
	Copper	EPA 6010B	mg/kg	5	0.2	3.7	0.5	7.4	19/59	0/59
	Copper	EPA 6010C-AVS-SEM	µmol/g	--	0.0015	0.0031	0.0015	0.0031	--	--
	Iron	EPA 6010B	mg/kg	6.3	0.5	8.7	3.1	49.4	32/59	0/59
	Lead	EPA 6010C-AVS-SEM	µmol/g	--	0.002	0.031	0.002	0.031	--	--
	Lead	EPA 6020	mg/kg	10	0.005	1.08	0.038	9	0/59	0/59
	Magnesium	EPA 6010B	mg/kg	500	0.2	3.7	3.1	49.4	0/59	0/59

Table 2-6. Sediment Analytical Methods and Associated Method Detection Limits and Method Reporting Limits

Analyte Type	Analyte	Analytical Method	Units	Planned Method Reporting Limits (mg/kg dw)	Minimum MDL	Maximum MDL	Minimum MRL	Maximum MRL	Number of 1X MRL Exceedances/ Total Analyses	Number of 10X MRL Exceedances/ Total Analyses
Metals/Metalloids (continued)										
	Manganese	EPA 6010B	mg/kg	7.2	0.02	0.4	0.16	24.7	11/59	0/59
	Mercury	EPA 7470A-SEM	µmol/g	--	0.00004	0.00008	0.00004	0.00008	--	--
	Mercury	EPA 7471A	mg/kg	1.5	0.002	0.002	0.015	0.023	0/58	0/58
	Molybdenum	EPA 6020	mg/kg	0.0036	0.01	0.14	0.04	0.14	56/56	56/56
	Nickel	EPA 6010B	mg/kg	4.5	0.06	0.1	0.31	0.5	0/59	0/59
	Nickel	EPA 6010C-AVS-SEM	µmol/g	--	0.002	0.007	0.002	0.007	--	--
	Potassium	EPA 6010B	mg/kg	--	16	235	58	940	--	--
	Selenium	EPA 6020	mg/kg	2	0.1	0.4	0.8	2	0/59	0/59
	Silver	EPA 6020	mg/kg	0.1	0.004	0.047	0.017	0.047	0/59	0/59
	Sodium	EPA 6010B	mg/kg	--	3.1	44	31	443	--	--
	Thallium	EPA 6020	mg/kg	2.5	0.002	0.044	0.015	0.044	0/59	0/59
	Vanadium	EPA 6010B	mg/kg	5	0.2	3.7	0.8	12.4	18/59	0/59
	Zinc	EPA 6010B	mg/kg	24.2	0.2	3.7	1	24.7	1/59	0/59
	Zinc	EPA 6010C-AVS-SEM	µmol/g	--	0.0015	0.0268	0.0015	0.0268	--	--
Polycyclic Aromatic Hydrocarbons										
	2-Methylnaphthalene	EPA 8270C-SIM	µg/kg	--	0.46	0.46	2.6	3.2	--	--
	Acenaphthylene	EPA 8270C-SIM	µg/kg	--	0.59	0.59	2.8	2.8	--	--
	Anthracene	EPA 8270C-SIM	µg/kg	--	0.58	0.58	2.8	2.8	--	--
	Benzo(e)pyrene	EPA 8270C-SIM	µg/kg	--	0.61	0.61	2.7	3.1	--	--
	Benzo[a]anthracene	EPA 8270C-SIM	µg/kg	--	0.72	0.72	2.6	3	--	--
	Benzo[a]pyrene	EPA 8270C-SIM	µg/kg	--	0.76	0.76	2.8	3	--	--
	Benzo[b]fluoranthene	EPA 8270C-SIM	µg/kg	--	0.92	0.92	2.8	3.1	--	--
	Benzo[g,h,i]perylene	EPA 8270C-SIM	µg/kg	--	0.85	0.85	2.8	3	--	--
	Benzo[k]fluoranthene	EPA 8270C-SIM	µg/kg	--	0.87	0.87	2.8	2.8	--	--
	Chrysene	EPA 8270C-SIM	µg/kg	--	0.8	0.8	2.7	3	--	--
	Dibenzo[a,h]anthracene	EPA 8270C-SIM	µg/kg	--	0.8	0.8	2.8	2.8	--	--
	Fluoranthene	EPA 8270C-SIM	µg/kg	--	0.98	0.98	2.6	3	--	--
	Fluorene	EPA 8270C-SIM	µg/kg	--	0.61	0.61	2.7	2.7	--	--
	Indeno[1,2,3-cd]pyrene	EPA 8270C-SIM	µg/kg	--	0.87	0.87	2.8	2.8	--	--
	Naphthalene	EPA 8270C-SIM	µg/kg	--	1.6	6.3	2.6	6.3	--	--
	Perylene	EPA 8270C-SIM	µg/kg	--	0.72	0.72	2.8	2.8	--	--
	Phenanthrene	EPA 8270C-SIM	µg/kg	--	1.4	1.4	2.7	3.2	--	--
	Pyrene	EPA 8270C-SIM	µg/kg	--	0.76	0.76	2.6	3.1	--	--
Polychlorinated Biphenyls										
	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl (PCB-206)	EPA 8082	µg/kg	--	0.031	0.031	0.29	0.3	--	--
	2,2',3,3',4,4',5,5'-Octachlorobiphenyl (PCB-194)	EPA 8082	µg/kg	--	0.043	0.043	0.29	0.29	--	--
	2,2',3,3',4,4',5,6-Octachlorobiphenyl (PCB-195)	EPA 8082	µg/kg	--	0.031	0.031	0.29	0.29	--	--
	2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB-170)	EPA 8082	µg/kg	--	0.026	0.026	0.29	0.29	--	--

Table 2-6. Sediment Analytical Methods and Associated Method Detection Limits and Method Reporting Limits

Analyte Type	Analyte	Analytical Method	Units	Planned Method Reporting Limits (mg/kg dw)	Minimum MDL	Maximum MDL	Minimum MRL	Maximum MRL	Number of 1X MRL Exceedances/ Total Analyses	Number of 10X MRL Exceedances/ Total Analyses
Polychlorinated Biphenyls (continued)										
	2,2',3,3',4,4'-Hexachlorobiphenyl (PCB-128)	EPA 8082	µg/kg	--	0.031	0.031	0.29	0.29	--	--
	2,2',3,3',4,5',6,6'-Octachlorobiphenyl (PCB-201)	EPA 8082	µg/kg	--	0.041	0.041	0.29	0.29	--	--
	2,2',3,3',4,5',6'-Heptachlorobiphenyl (PCB-177)	EPA 8082	µg/kg	--	0.052	0.052	0.29	0.29	--	--
	2,2',3,3',4,5,6'-Heptachlorobiphenyl (PCB-174)	EPA 8082	µg/kg	--	0.03	0.03	0.29	0.29	--	--
	2,2',3,3',4,6'-Hexachlorobiphenyl (PCB-132)	EPA 8082	µg/kg	--	0.075	0.075	0.29	0.29	--	--
	2,2',3,4,4',5,5',6-Octachlorobiphenyl (PCB-203)	EPA 8082	µg/kg	--	0.039	0.039	0.29	0.29	--	--
	2,2',3,4,4',5,5'-Heptachlorobiphenyl (PCB-180)	EPA 8082	µg/kg	--	0.095	0.095	0.29	0.29	--	--
	2,2',3,4,4',5',6-Heptachlorobiphenyl (PCB-183)	EPA 8082	µg/kg	--	0.081	0.081	0.29	0.29	--	--
	2,2',3,4,4',5'-Hexachlorobiphenyl (PCB-138)	EPA 8082	µg/kg	--	0.064	0.064	0.29	0.29	--	--
	2,2',3,4,4',6,6'-Heptachlorobiphenyl (PCB-184)	EPA 8082	µg/kg	--	0.052	0.052	0.29	0.29	--	--
	2,2',3,4',5,5',6-Heptachlorobiphenyl (PCB-187)	EPA 8082	µg/kg	--	0.047	0.047	0.29	0.29	--	--
	2,2',3,4,5,5'-Hexachlorobiphenyl (PCB-141)	EPA 8082	µg/kg	--	0.035	0.035	0.29	0.29	--	--
	2,2',3,4',5',6-Hexachlorobiphenyl (PCB-149)	EPA 8082	µg/kg	--	0.067	0.067	0.29	0.29	--	--
	2,2',3,4',5'-Pentachlorobiphenyl (PCB-97)	EPA 8082	µg/kg	--	0.053	0.053	0.29	0.29	--	--
	2,2',3,4',5-Pentachlorobiphenyl (PCB-90)	EPA 8082	µg/kg	--	0.035	0.035	0.29	0.29	--	--
	2,2',3,4,5'-Pentachlorobiphenyl (PCB-87)	EPA 8082	µg/kg	--	0.038	0.038	0.29	0.29	--	--
	2,2',3,5,5',6-Hexachlorobiphenyl (PCB-151)	EPA 8082	µg/kg	--	0.043	0.043	0.29	0.29	--	--
	2,2',3,5',6-Pentachlorobiphenyl (PCB-95)	EPA 8082	µg/kg	--	0.049	0.049	0.29	0.29	--	--
	2,2',3,5'-Tetrachlorobiphenyl (PCB-44)	EPA 8082	µg/kg	--	0.065	0.065	0.29	0.29	--	--
	2,2',4,4',5,5'-Hexachlorobiphenyl (PCB-153)	EPA 8082	µg/kg	--	0.038	0.038	0.29	0.29	--	--
	2,2',4,4',5-Pentachlorobiphenyl (PCB-99)	EPA 8082	µg/kg	--	0.045	0.045	0.29	0.29	--	--
	2,2',4,5,5'-Pentachlorobiphenyl (PCB-101)	EPA 8082	µg/kg	--	0.049	0.049	0.29	0.29	--	--
	2,2',4,5'-Tetrachlorobiphenyl (PCB-49)	EPA 8082	µg/kg	--	0.058	0.058	0.29	0.29	--	--
	2,2',5,5'-Tetrachlorobiphenyl (PCB-52)	EPA 8082	µg/kg	--	0.059	0.059	0.29	0.29	--	--
	2,2',5-Trichlorobiphenyl (PCB-18)	EPA 8082	µg/kg	--	0.096	0.096	0.29	0.29	--	--
	2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB-189)	EPA 8082	µg/kg	--	0.029	0.029	0.29	0.29	--	--
	2,3,3',4,4',5'-Hexachlorobiphenyl (PCB-157)	EPA 8082	µg/kg	--	0.031	0.031	0.29	0.29	--	--
	2,3,3',4,4',5-Hexachlorobiphenyl (PCB-156)	EPA 8082	µg/kg	--	0.042	0.042	0.29	0.29	--	--
	2,3,3',4,4',6-Hexachlorobiphenyl (PCB-158)	EPA 8082	µg/kg	--	0.028	0.028	0.29	0.29	--	--
	2,3,3',4,4'-Pentachlorobiphenyl (PCB-105)	EPA 8082	µg/kg	--	0.033	0.033	0.29	0.29	--	--
	2,3,3',4',6-Pentachlorobiphenyl (PCB-110)	EPA 8082	µg/kg	--	0.035	0.035	0.29	0.29	--	--
	2,3,3',4'-Tetrachlorobiphenyl (PCB-56)	EPA 8082	µg/kg	--	0.046	0.046	0.29	0.29	--	--
	2,3',4,4',5,5'-Hexachlorobiphenyl (PCB-167)	EPA 8082	µg/kg	--	0.046	0.046	0.29	0.29	--	--
	2,3',4,4',5',6-Hexachlorobiphenyl (PCB-168)	EPA 8082	µg/kg	--	0.027	0.027	0.29	0.29	--	--
	2,3,4,4',5,6-Hexachlorobiphenyl (PCB-166)	EPA 8082	µg/kg	--	0.03	0.03	0.29	0.29	--	--
	2,3',4,4',5'-Pentachlorobiphenyl (PCB-123)	EPA 8082	µg/kg	--	0.067	0.067	0.29	0.29	--	--
	2,3',4,4',5-Pentachlorobiphenyl (PCB-118)	EPA 8082	µg/kg	--	0.031	0.031	0.29	0.29	--	--
	2,3,4,4',5-Pentachlorobiphenyl (PCB-114)	EPA 8082	µg/kg	--	0.023	0.023	0.29	0.29	--	--

Table 2-6. Sediment Analytical Methods and Associated Method Detection Limits and Method Reporting Limits

Analyte Type	Analyte	Analytical Method	Units	Planned Method Reporting Limits (mg/kg dw)	Minimum MDL	Maximum MDL	Minimum MRL	Maximum MRL	Number of 1X MRL Exceedances/ Total Analyses	Number of 10X MRL Exceedances/ Total Analyses
Polychlorinated Biphenyls (continued)										
	2,3',4,4',6-Pentachlorobiphenyl (PCB-119)	EPA 8082	µg/kg	--	0.046	0.046	0.29	0.29	--	--
	2,3',4,4'-Tetrachlorobiphenyl (PCB-66)	EPA 8082	µg/kg	--	0.035	0.035	0.29	0.29	--	--
	2,3,4,4'-Tetrachlorobiphenyl (PCB-60)	EPA 8082	µg/kg	--	0.039	0.039	0.29	0.29	--	--
	2,3',4',5-Tetrachlorobiphenyl (PCB-70)	EPA 8082	µg/kg	--	0.051	0.051	0.29	0.29	--	--
	2,3',4'-Trichlorobiphenyl (PCB-33)	EPA 8082	µg/kg	--	0.11	0.11	0.29	0.29	--	--
	2,3-Dichlorobiphenyl (PCB-5)	EPA 8082	µg/kg	--	0.13	0.13	0.29	0.29	--	--
	2,4,4',5-Tetrachlorobiphenyl (PCB-74)	EPA 8082	µg/kg	--	0.044	0.044	0.29	0.29	--	--
	2,4,4'-Trichlorobiphenyl (PCB-28)	EPA 8082	µg/kg	--	0.064	0.064	0.29	0.29	--	--
	2,4',5-Trichlorobiphenyl (PCB-31)	EPA 8082	µg/kg	--	0.056	0.056	0.29	0.29	--	--
	2,4'-Dichlorobiphenyl (PCB-8)	EPA 8082	µg/kg	--	0.21	0.21	0.29	0.29	--	--
	2-Chlorobiphenyl (PCB 1)	EPA 8082	µg/kg	--	1.2	1.2	5.8	5.8	--	--
	3,3',4,4',5,5'-Hexachlorobiphenyl (PCB-169)	EPA 8082	µg/kg	--	0.041	0.041	0.29	0.29	--	--
	3,3',4,4',5-Pentachlorobiphenyl (PCB-126)	EPA 8082	µg/kg	--	0.043	0.043	0.29	0.29	--	--
	3,3',4,4'-Tetrachlorobiphenyl (PCB-77)	EPA 8082	µg/kg	--	0.047	0.047	0.29	0.29	--	--
	3,4,4',5-Tetrachlorobiphenyl (PCB-81)	EPA 8082	µg/kg	--	0.05	0.05	0.29	0.29	--	--
	3,4,4'-Trichlorobiphenyl (PCB-37)	EPA 8082	µg/kg	--	0.052	0.052	0.29	0.29	--	--
	Decachlorobiphenyl (PCB 209)	EPA 8082	µg/kg	--	0.041	0.041	0.29	0.29	--	--
Pesticides/Herbicides										
	2,4'-DDD	EPA 8081A	µg/kg	--	0.13	0.13	0.58	0.58	--	--
	2,4'-DDE	EPA 8081A	µg/kg	--	0.16	0.16	0.58	0.58	--	--
	2,4'-DDT	EPA 8081A	µg/kg	--	0.058	0.058	0.58	0.58	--	--
	4,4'-DDD	EPA 8081A	µg/kg	--	0.11	0.11	0.58	0.58	--	--
	4,4'-DDE	EPA 8081A	µg/kg	--	0.11	0.11	0.58	0.58	--	--
	4,4'-DDT	EPA 8081A	µg/kg	--	0.17	0.17	0.58	0.58	--	--
Semivolatile Organics										
	Carbazole	EPA 8270C-SIM	µg/kg	--	2.3	2.3	2.8	2.8	--	--

Notes:

Yellow highlighted detection limits exceed the planned detection limit.

All analyses were performed by Columbia Analytical Services

MDL - method detection limit

MRL - method reporting limit

-- - information not available

Table 2-7. Summary of Analytical Methods Used for In-house Water Quality Measurements

Parameter	Unit	Method
Temperature	°C	YSI Probe
pH	su	YSI Probe
Dissolved oxygen	mg/L	YSI Probe
Conductivity	µS/cm	YSI Probe
Hardness	mg/L as $CaCO_3$	LaMotte Kit 4424-DR-LT
Alkalinity	mg/L as $CaCO_3$	LaMotte Kit 4491-DR
Ammonia-nitrogen	mg/L as N	LaMotte Kit 3304
Nitrate-nitrogen	mg/L as N	LaMotte Kit 3319
Nitrite-nitrogen	mg/L as N	LaMotte Kit 7674

Table 2-8. Water Analytical Methods and Associated Method Detection Limits and Method Reporting Limits

Analyte Type	Analyte	Analytical Method	Units	Measurement Basis	Proposed MDL	Proposed MRL	Minimum MDL	Maximum MDL	Minimum MRL	Maximum MRL	Number of 1X MDL Exceedances/ Total Analyses	Number of 10X MDL Exceedances/ Total Analyses	Number of 1X MRL Exceedances/ Total Analyses	Number of 10X MRL Exceedances/ Total Analyses
Conventionals														
	Alkalinity	SM 2320B	mg/L	Total	1	2	1	26.5	2	26.5	640/645	1/645	640/645	1/645
	Fluoride	EPA 300.0	mg/L	Total	0.006	0.2	0.01	0.38	0.4	2	1215/1215	36/1215	1215/1215	0/1215
	Hardness as CaCO3	SM 2340B	mg/L	Dissolved	0.7	2	0.4	2	0.4	2	114/1041	0/1041	0/1041	0/1041
	Hardness as CaCO3	SM 2340B	mg/L	Total	0.7	2	0.4	0.4	0.4	0.4	0/292	0/292	0/292	0/292
	Organic carbon	SM 5310C	mg/L	Dissolved	--	--	0.02	24.5	0.05	24.5	0/1221	0/1221	0/1221	0/1221
	Sulfate	EPA 300.0	mg/L	Total	0.007	0.2	0.01	0.2	0.2	4	1215/1215	1209/1215	1211/1215	2/1215
	Total dissolved solids	SM 2540C	mg/L	Total	--	--	5	205	5	205	0/645	0/645	0/645	0/645
Metals/Metalloids														
	Aluminum	EPA 6010B	µg/L	Dissolved	0.3	2	2.2	2.2	55.6	55.6	1/1	0/1	1/1	1/1
	Aluminum	EPA 6020	µg/L	Dissolved	0.3	2	0.3	242	2	242	621/1451	536/1451	620/1451	361/1451
	Antimony	EPA 6010B	µg/L	Dissolved	0.03	0.05	3.3	3.3	55.6	55.6	1/1	1/1	1/1	1/1
	Antimony	EPA 6020	µg/L	Dissolved	0.03	0.05	0.005	2.38	0.05	2.38	360/1451	44/1451	389/1451	141/1451
	Arsenic	EPA 6010B	µg/L	Dissolved	0.08	0.5	4.4	4.4	111	111	1/1	1/1	1/1	1/1
	Arsenic	EPA 6020	µg/L	Dissolved	0.08	0.5	0.1	3.3	0.5	10	1451/1451	120/1451	239/1451	119/1451
	Barium	EPA 6010B	µg/L	Dissolved	0.02	0.05	0.4	0.4	5.6	5.6	1/1	1/1	1/1	1/1
	Barium	EPA 6020	µg/L	Dissolved	0.02	0.05	0.02	45.3	0.05	45.3	440/1451	347/1451	440/1451	347/1451
	Beryllium	EPA 6010B	µg/L	Dissolved	0.008	0.02	0.1	0.1	5.56	5.56	1/1	1/1	1/1	1/1
	Beryllium	EPA 6020	µg/L	Dissolved	0.008	0.02	0.006	0.12	0.02	0.4	256/1451	119/1451	238/1451	119/1451
	Cadmium	EPA 6010B	µg/L	Dissolved	0.008	0.02	0.3	0.3	5.6	5.6	1/1	1/1	1/1	1/1
	Cadmium	EPA 6020	µg/L	Dissolved	0.008	0.02	0.005	1.6	0.02	1.6	1020/1451	356/1451	691/1451	189/1451
	Calcium	EPA 6010B	µg/L	Dissolved	30	50	6	9940	50	9940	122/1452	3/1452	676/1452	122/1452
	Chloride ion	EPA_300.0	mg/L	Total	9	200	0.03	8.17	0.2	8.17	0/1215	0/1215	0/1215	0/1215
	Chromium	EPA 6010B	µg/L	Dissolved	0.07	0.2	0.7	0.7	5.6	5.6	1/1	0/1	1/1	1/1
	Chromium	EPA 6020	µg/L	Dissolved	0.07	0.2	0.02	8.62	0.2	8.62	1232/1451	314/1451	1159/1451	173/1451
	Cobalt	EPA 6010B	µg/L	Dissolved	0.005	0.02	0.4	0.4	11.1	11.1	1/1	1/1	1/1	1/1
	Cobalt	EPA 6020	µg/L	Dissolved	0.005	0.02	0.006	2.44	0.02	2.44	1451/1451	281/1451	796/1451	168/1451
	Copper	EPA 6010B	µg/L	Dissolved	0.02	0.1	0.9	0.9	11.1	11.1	1/1	1/1	1/1	1/1
	Copper	EPA 6020	µg/L	Dissolved	0.02	0.1	0.02	13	0.1	13	804/1451	794/1451	804/1451	392/1451
	Iron	EPA 6010B	µg/L	Dissolved	3	20	0.8	222	20	444	1082/1452	99/1452	737/1452	121/1452
	Lead	EPA 6010B	µg/L	Dissolved	0.009	0.02	4.4	4.4	55.6	55.6	1/1	1/1	1/1	1/1
	Lead	EPA 6020	µg/L	Dissolved	0.009	0.02	0.005	4.52	0.02	4.52	1126/1451	577/1451	1095/1451	359/1451
	Magnesium	EPA 6010B	µg/L	Dissolved	0.7	20	0.3	7240	20	7240	486/1452	48/1452	674/1452	121/1452
	Manganese	EPA 6010B	µg/L	Dissolved	0.02	0.05	0.2	0.22	5.56	5.6	3/3	2/3	3/3	3/3
	Manganese	EPA 6020	µg/L	Dissolved	0.02	0.05	0.006	11.1	0.05	11.1	739/1449	571/1449	740/1449	360/1449
	Mercury	EPA 1631E	ng/L	Dissolved	1E-10	2.5E-10	0.24	81.2	4	100	965/965	965/965	965/965	965/965
	Mercury	EPA 1631E	ng/L	Total	1E-10	2.5E-10	0.4	1.3	4	4	18/18	18/18	18/18	18/18
	Molybdenum	EPA 6010B	µg/L	Dissolved	0.03	0.05	0.7	0.7	11.1	11.1	1/1	1/1	1/1	1/1
	Molybdenum	EPA 6020	µg/L	Dissolved	0.03	0.05	0.007	2.21	0.05	2.21	250/1451	121/1451	271/1451	153/1451
	Nickel	EPA 6010B	µg/L	Dissolved	0.07	0.2	0.8	0.8	22.2	22.2	1/1	1/1	1/1	1/1
	Nickel	EPA 6020	µg/L	Dissolved	0.07	0.2	0.02	12.7	0.2	12.7	920/1451	559/1451	920/1451	291/1451
	Potassium	EPA 6010B	µg/L	Dissolved	1.3	4	40	2250	400	8890	1452/1452	1452/1452	1452/1452	1452/1452
	Selenium	EPA 6010B	µg/L	Dissolved	0.4	1	5.6	5.6	111	111	1/1	1/1	1/1	1/1
	Selenium	EPA 6020	µg/L	Dissolved	0.4	1	0.3	12	1	20	297/1451	119/1451	235/1451	119/1451
	Silicon	EPA 6010B	µg/L	Dissolved	--	--	4	414	200	444	0/348	0/348	0/348	0/348
	Silver	EPA 6010B	µg/L	Dissolved	0.009	0.02	0.8	0.8	11.1	11.1	1/1	1/1	1/1	1/1
	Silver	EPA 6020	µg/L	Dissolved	0.009	0.02	0.004	0.214	0.02	0.4	321/1451	44/1451	268/1451	134/1451
	Sodium	EPA 6010B	µg/L	Dissolved	50	100	20	13800	100	13800	237/1452	117/1452	797/1452	212/1452
	Thallium	EPA 6010B	µg/L	Dissolved	0.003	0.02	2.2	2.2	111	111	1/1	1/1	1/1	1/1
	Thallium	EPA 6020	µg/L	Dissolved	0.003	0.02	0.005	0.233	0.02	0.4	1451/1451	228/1451	429/1451	121/1451
	Vanadium	EPA 6010B	µg/L	Dissolved	0.08	0.2	1.1	1.1	11.1	11.1	1/1	1/1	1/1	1/1
	Vanadium	EPA 6020	µg/L	Dissolved	0.08	0.2	0.03	2.26	0.2	4	682/1451	41/1451	369/1451	121/1451
	Zinc	EPA 6010B	µg/L	Dissolved	0.1	0.5	0.8	0.8	11.1	11.1	1/1	0/1	1/1	1/1
	Zinc	EPA 6020	µg/L	Dissolved	0.1	0.5	0.2	1250	0.5	1250	1451/1451	1157/1451	1164/1451	1047/1451

Notes:
Yellow highlighted detection limits exceed the planned detection or reporting limit.
All analyses were performed by Columbia Analytical Services.
MDL - method detection limit
MRL - method reporting limit
-- - information not available

Table 2-9. Summary of Analytical Sample Types Collected During the Study

Sample Type	Medium	Sampling Method	Treatment	Tank	Date (Number of samples collected on a given date is provided below)																																
					7/18/2010	7/19/2010	7/20/2010	7/23/2010	7/26/2010	7/29/2010	8/1/2010	8/2/2010	8/4/2010	8/9/2010	8/12/2010	8/16/2010	8/18/2010	8/20/2010	8/21/2010	8/23/2010	8/25/2010	8/26/2010	8/27/2010	8/28/2010	8/29/2010	8/30/2010	9/1/2010	9/6/2010	9/8/2010	9/13/2010	9/15/2010	9/19/2010	9/20/2010	9/21/2010	9/22/2010	9/23/2010
Organic Carbon	Overlying Water	Pipette	H2O	A				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	H2O	B				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	H2O	C				1	1			1		1		2				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	H2O	D				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	H2O	E				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	H2O	F				1																												
Organic Carbon	Overlying Water	Pipette	CTRL	A				1	1			1		1		1				2					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	CTRL	B				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	CTRL	C				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	CTRL	D				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	CTRL	E				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	CTRL	F				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	LALL	A				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	LALL	B				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	LALL	C				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	LALL	D				1	1			2		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	LALL	E				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	LALL	F				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	GE	A				1	1			1		1		1				1							1		1			1			
Organic Carbon	Overlying Water	Pipette	GE	B				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	GE	C				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	GE	D				1	1			1		1		1				1							2		1			1			
Organic Carbon	Overlying Water	Pipette	DE	A				1	1			1		1		1				1					1		1		2			1			
Organic Carbon	Overlying Water	Pipette	DE	B				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	DE	C				1	2			1		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	NP	A				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	NP	B				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	LD	A				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	LD	B				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	LD	C				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	LD	D				1	1			1				1				1					2		1		1			1			
Organic Carbon	Overlying Water	Pipette	LD	E				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	LD	F				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	UMF	A				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	UMF	B				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	UMF	C				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	UMF	D				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	UMF	E				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	UMF	F				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	LMF	A				1	1			1		1		1				1					1				1			2			
Organic Carbon	Overlying Water	Pipette	LMF	B				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	LMF	C				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Overlying Water	Pipette	LMF	D				1	1			1		1		1				1					1				1			1			

Table 2-9. Summary of Analytical Sample Types Collected During the Study

					Date (Number of samples collected on a given date is provided below)																																
Sample Type	Medium	Sampling Method	Treatment	Tank	7/18/2010	7/19/2010	7/20/2010	7/23/2010	7/26/2010	7/29/2010	8/1/2010	8/2/2010	8/4/2010	8/9/2010	8/12/2010	8/16/2010	8/18/2010	8/20/2010	8/21/2010	8/23/2010	8/25/2010	8/26/2010	8/27/2010	8/28/2010	8/29/2010	8/30/2010	9/1/2010	9/6/2010	9/8/2010	9/13/2010	9/15/2010	9/19/2010	9/20/2010	9/21/2010	9/22/2010	9/23/2010
Metals	Overlying Water	Pipette	H2O	A				1	1			1		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	H2O	B				1	1			1		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	H2O	C				1	1			1		1		2				1						1		1		1			1			
Metals	Overlying Water	Pipette	H2O	D				1	1			1		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	H2O	E				1	1			1		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	H2O	F				1																												
Metals	Overlying Water	Pipette	CTRL	A				1	1			1		1		1				2						1		1		1			1			
Metals	Overlying Water	Pipette	CTRL	B				1	1			1		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	CTRL	C				1	1			1		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	CTRL	D				1	1			1		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	CTRL	E				1	1			1		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	CTRL	F				1	1			1		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	LALL	A				1	1			1		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	LALL	B				1	1			1		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	LALL	C				1	1			1		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	LALL	D				1	1			2		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	LALL	E				1	1			1		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	LALL	F				1	1			1		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	GE	A				1	1			1		1		1				1								1		1			1			
Metals	Overlying Water	Pipette	GE	B				1	1			1		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	GE	C				1	1			1		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	GE	D				1	1			1		1		1				1								2		1			1			
Metals	Overlying Water	Pipette	DE	A				1	1			1		1		1				1						1		1		2			1			
Metals	Overlying Water	Pipette	DE	B				1	1			1		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	DE	C				1	2			1		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	NP	A				1	1			1		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	NP	B				1	1			1		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	LD	A				1	1			1		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	LD	B				1	1			1		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	LD	C				1	1			1		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	LD	D				1	1			1				1				1						2		1		1			1			
Metals	Overlying Water	Pipette	LD	E				1	1			1		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	LD	F				1	1			1		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	UMF	A				1	1			1		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	UMF	B				1	1			1		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	UMF	C				1	1			1		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	UMF	D				1	1			1		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	UMF	E				1	1			1		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	UMF	F				1	1			1		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	LMF	A				1	1			1		1		1				1						1				1			2			
Metals	Overlying Water	Pipette	LMF	B				1	1			1		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	LMF	C				1	1			1		1		1				1						1		1		1			1			
Metals	Overlying Water	Pipette	LMF	D				1	1			1		1		1				1						1				1			1			

Table 2-9. Summary of Analytical Sample Types Collected During the Study

Sample Type	Medium	Sampling Method	Treatment	Tank	Date (Number of samples collected on a given date is provided below)																																		
					7/18/2010	7/19/2010	7/20/2010	7/23/2010	7/26/2010	7/29/2010	8/1/2010	8/2/2010	8/4/2010	8/9/2010	8/12/2010	8/16/2010	8/18/2010	8/20/2010	8/21/2010	8/23/2010	8/25/2010	8/26/2010	8/27/2010	8/28/2010	8/29/2010	8/30/2010	9/1/2010	9/6/2010	9/8/2010	9/13/2010	9/15/2010	9/19/2010	9/20/2010	9/21/2010	9/22/2010	9/23/2010
Hardness or Alkalinity	Sediment-Water Interface	Pipette	CTRL	A					1	1		2	1	1	1	1	1			2	1		1		1	2		2		1			1				
Hardness or Alkalinity	Sediment-Water Interface	Pipette	CTRL	B					1	1		2	1	1	1	1	1			1	1					1	1	1	1	1	1		1		1		
Hardness or Alkalinity	Sediment-Water Interface	Pipette	CTRL	C					1	1		2	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	CTRL	D					1	1		2	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	CTRL	E					1	1		2	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	CTRL	F					1	1		2	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	LALL	A					1	1		2	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	LALL	B					1	1		2	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	LALL	C					1	1		2	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	LALL	D					1	1		2	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	LALL	E					1	1		2	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	LALL	F					1	1		2	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	GE	A					1	1		2	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	GE	B					1	1		2	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	GE	C					1	1		2	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	GE	D					1	1		2	1	2		2				1	1					1	1	2	1	1	1		1	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	DE	A					1	1		2	1	1	1	1	1			1	1					1	1	1	1	2	1		1	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	DE	B					1	1		2	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	DE	C					2	1		2	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	NP	A					1	1		2	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	NP	B					1	1		3	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	LD	A					1	1		2	1	1	1	1	1			1	1						1	1	1	1	1		1	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	LD	B					1	1		2	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	LD	C					1	1		2	1	1	1	1	1			1	1					2	1	1	1	1	1		1	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	LD	D					1	1		2	1		1	1	1			1	1					1	1	1	1	1	1		1	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	LD	E					1	1		2	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	LD	F					1	1		2	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	UMF	A					1	1		2	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	UMF	B					1	1		2	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	UMF	C					1	1		2	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	UMF	D					1	1		2	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	UMF	E					1	1		2	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	UMF	F					1	1		2	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	LMF	A					1	1		2	1	1	1	2	1			1	1					2	1	1	1	1	1		2	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	LMF	B					1	1		2	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	LMF	C					1	1		2	1	2	1	1	1			1	1					1	1	1	1	1	1		1	1			
Hardness or Alkalinity	Sediment-Water Interface	Pipette	LMF	D					1	1		2	1	1	1	1	1			1	1					1	1	1	1	1	1		1				
Hardness or Alkalinity	Sediment-Water Interface	DGT	H2O	D							3							3														3				
Hardness or Alkalinity	Sediment-Water Interface	DGT	CTRL	B							3							3																		
Hardness or Alkalinity	Sediment-Water Interface	DGT	CTRL	C							3							3														3				
Hardness or Alkalinity	Sediment-Water Interface	DGT	CTRL	D																												3				
Hardness or Alkalinity	Sediment-Water Interface	DGT	LALL	B							3							3														3				
Hardness or Alkalinity	Sediment-Water Interface	DGT	LALL	D							3							3														3				

Table 2-9. Summary of Analytical Sample Types Collected During the Study

Sample Type	Medium	Sampling Method	Treatment	Tank	Date (Number of samples collected on a given date is provided below)																																
					7/18/2010	7/19/2010	7/20/2010	7/23/2010	7/26/2010	7/29/2010	8/1/2010	8/2/2010	8/4/2010	8/9/2010	8/12/2010	8/16/2010	8/18/2010	8/20/2010	8/21/2010	8/23/2010	8/25/2010	8/26/2010	8/27/2010	8/28/2010	8/29/2010	8/30/2010	9/1/2010	9/6/2010	9/8/2010	9/13/2010	9/15/2010	9/19/2010	9/20/2010	9/21/2010	9/22/2010	9/23/2010
Hardness or Alkalinity	Sediment-Water Interface	DGT	GE	D							3							3													3				
Hardness or Alkalinity	Sediment-Water Interface	DGT	DE	B							3							3													3				
Hardness or Alkalinity	Sediment-Water Interface	DGT	LD	A							3							3													3				
Hardness or Alkalinity	Sediment-Water Interface	DGT	LD	B							3							3													3				
Hardness or Alkalinity	Sediment-Water Interface	DGT	LD	C																											3				
Hardness or Alkalinity	Sediment-Water Interface	DGT	UMF	B							3							3													3				
Hardness or Alkalinity	Sediment-Water Interface	DGT	UMF	D																											3				
Hardness or Alkalinity	Sediment-Water Interface	DGT	UMF	E							3							3													3				
Hardness or Alkalinity	Sediment-Water Interface	DGT	LMF	A							3							3													3				
Hardness or Alkalinity	Porewater (1 cm)	DGT	H2O	D							3							3													3				
Hardness or Alkalinity	Porewater (1 cm)	DGT	CTRL	B							3							3																	
Hardness or Alkalinity	Porewater (1 cm)	DGT	CTRL	C							3							3													3				
Hardness or Alkalinity	Porewater (1 cm)	DGT	CTRL	D																											3				
Hardness or Alkalinity	Porewater (1 cm)	DGT	LALL	B							3							3													3				
Hardness or Alkalinity	Porewater (1 cm)	DGT	LALL	D							3							3													3				
Hardness or Alkalinity	Porewater (1 cm)	DGT	GE	D							3							3													3				
Hardness or Alkalinity	Porewater (1 cm)	DGT	DE	B							3							3													3				
Hardness or Alkalinity	Porewater (1 cm)	DGT	LD	A							3							3													2				
Hardness or Alkalinity	Porewater (1 cm)	DGT	LD	B							3							3													3				
Hardness or Alkalinity	Porewater (1 cm)	DGT	LD	C																											3				
Hardness or Alkalinity	Porewater (1 cm)	DGT	LD	D																											1				
Hardness or Alkalinity	Porewater (1 cm)	DGT	UMF	B							3							3													3				
Hardness or Alkalinity	Porewater (1 cm)	DGT	UMF	D																											3				
Hardness or Alkalinity	Porewater (1 cm)	DGT	UMF	E							3							3													3				
Hardness or Alkalinity	Porewater (1 cm)	DGT	LMF	A							3							3													3				
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	H2O	A	1	1	1	1	1			1		1		1				1						1		1		1			1				
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	H2O	B	1	1	1	1				1		1		1				1						1		1		1			1				
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	H2O	C	1	1	1	1	1			1		1		1				1						1		1		1			1				
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	H2O	D	1	1	1	1	1			1		1		1				1						1		1		1			1				
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	H2O	E				1	1			1		1		1				1						1		1		1			1				
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	H2O	F	1	1	1	1																													
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	CTRL	A	1	1	1	1	1			1		1		1				1						1		1		1			1				
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	CTRL	B	1	1	1	1	1			1		1		1				1						1		1		1			1				
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	CTRL	C	1	1	1	1	1			1		1		1				1						1		1		1			1				
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	CTRL	D	1	1	1	1	1			1		1		1				1						1		1		1			1				
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	CTRL	E	1	1	1	1	1			1		1		1				1						1		1		1			1				
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	CTRL	F	1	1	1	1	1			1		1		1				1						1		1		1			1				
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	LALL	A	1	1	1	1	1			1		1		1				1						1		1		1			1				
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	LALL	B	1	1	1	1	1			1		1		1				1						1		1		1			1				
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	LALL	C	1	1	1	1	1			1		1		1				1						1		1		1			1				
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	LALL	D	1	1	1	1	1			1		1		1				1						1		1		1			1				
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	LALL	E	1	1	1	1	1			1		1		1				1						1		1		1			1				
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	LALL	F	1	1	1	1	1			1		1		1				1						1		1		1			1				

Table 2-9. Summary of Analytical Sample Types Collected During the Study

Sample Type	Medium	Sampling Method	Treatment	Tank	Date (Number of samples collected on a given date is provided below)																																		
					7/18/2010	7/19/2010	7/20/2010	7/23/2010	7/26/2010	7/29/2010	8/1/2010	8/2/2010	8/4/2010	8/9/2010	8/12/2010	8/16/2010	8/18/2010	8/20/2010	8/21/2010	8/23/2010	8/25/2010	8/26/2010	8/27/2010	8/28/2010	8/29/2010	8/30/2010	9/1/2010	9/6/2010	9/8/2010	9/13/2010	9/15/2010	9/19/2010	9/20/2010	9/21/2010	9/22/2010	9/23/2010
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	GE	A	1	1	1	1	1			1		1		1				1						1		1		1			1						
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	GE	B	1	1	1	1	1			1		1		1				1						1		1		1			1						
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	GE	C	1	1	1	1	1			1		1		1				1						1		1		1			1						
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	GE	D	1	1	1	1	1			1		1		1				1						1		1		1			1						
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	DE	A	1	1	1	1	1			1		1		1				1						1		1		1			1						
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	DE	B	1	1	1	1	1			1		1		1				1						1		1		1			1						
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	DE	C	1	1	1	1	1			1		1		1				1						1		1		1			1						
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	NP	A	1	1	1	1	1			1		1		1				1						1		1		1			1						
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	NP	B	1	1	1	1	1			1		1		1				1						1		1		1			1						
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	LD	A	1	1	1	1	1			1		1		1				1						1		1		1			1						
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	LD	B	1	1	1	1	1			1		1		1				1						1		1		1			1						
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	LD	C	1	1	1	1	1			1		1		1				1						1		1		1			1						
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	LD	D	1	1	1	1	1			1		1		1				1						1		1		1			1						
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	LD	E	1	1	1	1	1			1		1		1				1						1		1		1			1						
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	LD	F	1	1	1	1	1			1		1		1				1						1		1		1			1						
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	UMF	A	1	1	1	1	1			1		1		1				1						1		1		1			1						
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	UMF	B	1	1	1	1	1			1		1		1				1						1		1		1			1						
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	UMF	C	1	1	1	1	1			1		1		1				1						1		1		1			1						
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	UMF	D		1	1	1	1			1		1		1				1						1		1		1			1						
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	UMF	E	1	1	1	1	1			1		1		1				1						1		1		1			1						
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	UMF	F	1	1	1	1	1			1		1		1				1						1		1		1			1						
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	LMF	A	1	1	1	1	1			1		1		1				1						1		1		1			1						
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	LMF	B	1		1	1	1			1		1		1				1						1		1		1			1						
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	LMF	C	1		1	1	1			1		1		1				1						1		1		1			1						
Hardness or Alkalinity	Porewater (2.5 cm)	Airstone	LMF	D	1		1	1				1		1		1				1						1		1		1			1						
Conventionals	Sediment-Water Interface	Pipette	CTRL	A					2			2		2		2				3		1		1	1	1		1			1						
Conventionals	Sediment-Water Interface	Pipette	CTRL	B					2			2		2		2			1	2						2		2		1			1	1				
Conventionals	Sediment-Water Interface	Pipette	CTRL	C					2			2		2		2			1	2						2		2		1			2						
Conventionals	Sediment-Water Interface	Pipette	CTRL	D					2			2		2		2				2						2		2		1			2						
Conventionals	Sediment-Water Interface	Pipette	CTRL	E					2			2		2		2				2						2		2		1			2						
Conventionals	Sediment-Water Interface	Pipette	CTRL	F					2			2		2		2				2						2		2		1			2						
Conventionals	Sediment-Water Interface	Pipette	LALL	A					2			2		2		2				2						2		2		1			2						
Conventionals	Sediment-Water Interface	Pipette	LALL	B					2			2		2		2			1	2						2		2		1			2						
Conventionals	Sediment-Water Interface	Pipette	LALL	C					2			2		2		2				2						2		2		1			2						
Conventionals	Sediment-Water Interface	Pipette	LALL	D					2			2		2		2			1	2						2		2		1			2						
Conventionals	Sediment-Water Interface	Pipette	LALL	E					2			2		2		2				2						2		2		1			2						
Conventionals	Sediment-Water Interface	Pipette	LALL	F					2			2		2		2				2						2		2		1			2						
Conventionals	Sediment-Water Interface	Pipette	GE	A					2			2		2		2				2						2		2		1			2						
Conventionals	Sediment-Water Interface	Pipette	GE	B					2			2		2		2				2						2		2		1			2						
Conventionals	Sediment-Water Interface	Pipette	GE	C					2			2		2		2				2						2		2		1			2						
Conventionals	Sediment-Water Interface	Pipette	GE	D					2			2		1	1	1	1			2						2		3		1			2						
Conventionals	Sediment-Water Interface	Pipette	DE	A					2			2		2		2			1	2						2		2		2			2						
Conventionals	Sediment-Water Interface	Pipette	DE	B					2			2		2		2				2						2		2		1			2						

Table 2-9. Summary of Analytical Sample Types Collected During the Study

Sample Type	Medium	Sampling Method	Treatment	Tank	Date (Number of samples collected on a given date is provided below)																																
					7/18/2010	7/19/2010	7/20/2010	7/23/2010	7/26/2010	7/29/2010	8/1/2010	8/2/2010	8/4/2010	8/9/2010	8/12/2010	8/16/2010	8/18/2010	8/20/2010	8/21/2010	8/23/2010	8/25/2010	8/26/2010	8/27/2010	8/28/2010	8/29/2010	8/30/2010	9/1/2010	9/6/2010	9/8/2010	9/13/2010	9/15/2010	9/19/2010	9/20/2010	9/21/2010	9/22/2010	9/23/2010
Conventionals	Sediment-Water Interface	Pipette	DE	C					3			2		2		2				2						2		2		1			2			
Conventionals	Sediment-Water Interface	Pipette	NP	A					2			2		2		2				2						2		2		1			2			
Conventionals	Sediment-Water Interface	Pipette	NP	B					2			3		2		2				2						2		2		1			2			
Conventionals	Sediment-Water Interface	Pipette	LD	A					2			2		2		2			1	2						1		2		1			2			
Conventionals	Sediment-Water Interface	Pipette	LD	B					2			2		2		2			1	2						2		2		1			2			
Conventionals	Sediment-Water Interface	Pipette	LD	C					2			2		2		2				2						3		2		1			2			
Conventionals	Sediment-Water Interface	Pipette	LD	D					2			2		1		2				2						2		2		1			2			
Conventionals	Sediment-Water Interface	Pipette	LD	E					2			2		2		2				2						2		2		1			2			
Conventionals	Sediment-Water Interface	Pipette	LD	F					2			2		2		2				2						2		2		1			2			
Conventionals	Sediment-Water Interface	Pipette	UMF	A					2			2		2		2				2						2		2		1			2			
Conventionals	Sediment-Water Interface	Pipette	UMF	B					2			2		2		2			1	2						2		2		1			2			
Conventionals	Sediment-Water Interface	Pipette	UMF	C					2			2		2		2				2						2		2		1			2			
Conventionals	Sediment-Water Interface	Pipette	UMF	D					2			2		2		2				2						2		2		1			2			
Conventionals	Sediment-Water Interface	Pipette	UMF	E					2			2		2		2			1	2						2		2		1			2			
Conventionals	Sediment-Water Interface	Pipette	UMF	F					2			2		2		2				2						2		2		1			2			
Conventionals	Sediment-Water Interface	Pipette	LMF	A					2			2		2		3			1	2						3		2		1			3			
Conventionals	Sediment-Water Interface	Pipette	LMF	B					2			2		2		2				2						2		2		1			2			
Conventionals	Sediment-Water Interface	Pipette	LMF	C					2			2		3		2				2						2		2		1			2			
Conventionals	Sediment-Water Interface	Pipette	LMF	D					2			2		2		2				2						2		2		1			2			
Conventionals	Porewater (2.5 cm)	Airstone	H2O	A	1	1	1	2	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	H2O	B	1	1	1	2	1			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	H2O	C	1	1	1	2	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	H2O	D	1	1	1	2	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	H2O	E				2	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	H2O	F	1	1	1	2																													
Conventionals	Porewater (2.5 cm)	Airstone	CTRL	A	1	1	1	1	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	CTRL	B	1	1	1	2	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	CTRL	C	1	1	1	2	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	CTRL	D	1	1	1	2	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	CTRL	E	1	1	1	2	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	CTRL	F	1	1	1	2	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	LALL	A	1	1	1	2	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	LALL	B	1	1	1	2	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	LALL	C	1	1	1	2	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	LALL	D	1	1	1	1	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	LALL	E	1	1	1	2	1			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	LALL	F	1	1	1	2	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	GE	A	1	1	1	2	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	GE	B	1	1	1	2	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	GE	C	1	1	1	2	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	GE	D	1	1	1	2	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	DE	A	1	1	1	2	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	DE	B	1	1	1	2	2			2		2		2				2						2		2		2			2			

Table 2-9. Summary of Analytical Sample Types Collected During the Study

Sample Type	Medium	Sampling Method	Treatment	Tank	Date (Number of samples collected on a given date is provided below)																																
					7/18/2010	7/19/2010	7/20/2010	7/23/2010	7/26/2010	7/29/2010	8/1/2010	8/2/2010	8/4/2010	8/9/2010	8/12/2010	8/16/2010	8/18/2010	8/20/2010	8/21/2010	8/23/2010	8/25/2010	8/26/2010	8/27/2010	8/28/2010	8/29/2010	8/30/2010	9/1/2010	9/6/2010	9/8/2010	9/13/2010	9/15/2010	9/19/2010	9/20/2010	9/21/2010	9/22/2010	9/23/2010
Conventionals	Porewater (2.5 cm)	Airstone	DE	C	1	1	1	2	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	NP	A	1	1	1	2	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	NP	B	1	1	1	2	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	LD	A	1	1	1	2	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	LD	B	1	1	1	2	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	LD	C	1	1	1	2	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	LD	D	1	1	1	2	2			2		1		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	LD	E	1	1	1	2	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	LD	F	1	1	1	2	1			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	UMF	A	1	1	1	2	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	UMF	B	1	1		2	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	UMF	C	1	1	1	2	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	UMF	D		1	1	2	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	UMF	E		1	1	2	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	UMF	F	1	1	1	2	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	LMF	A	1	1	1	2	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	LMF	B	1		1	2	1			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	LMF	C			1	2	2			2		2		2				2						2		2		2			2			
Conventionals	Porewater (2.5 cm)	Airstone	LMF	D	1		1	2	1			2		2		2				2						2		2		2			2			
Conventionals	Bulk Sediment	Sediment	CTRL	A																																	1
Conventionals	Bulk Sediment	Sediment	CTRL	B																																	1
Conventionals	Bulk Sediment	Sediment	CTRL	C																																	1
Conventionals	Bulk Sediment	Sediment	CTRL	D																																	1
Conventionals	Bulk Sediment	Sediment	CTRL	E																																	1
Conventionals	Bulk Sediment	Sediment	CTRL	F																																	1
Conventionals	Bulk Sediment	Sediment	LALL	A																																	1
Conventionals	Bulk Sediment	Sediment	LALL	B																																	1
Conventionals	Bulk Sediment	Sediment	LALL	C																																	1
Conventionals	Bulk Sediment	Sediment	LALL	D																																	1
Conventionals	Bulk Sediment	Sediment	LALL	E																																	1
Conventionals	Bulk Sediment	Sediment	LALL	F																																	1
Conventionals	Bulk Sediment	Sediment	GE	A																																	1
Conventionals	Bulk Sediment	Sediment	GE	B																																	1
Conventionals	Bulk Sediment	Sediment	GE	C																																	1
Conventionals	Bulk Sediment	Sediment	GE	D																																	1
Conventionals	Bulk Sediment	Sediment	DE	A																																	1
Conventionals	Bulk Sediment	Sediment	DE	B																																	1
Conventionals	Bulk Sediment	Sediment	DE	C																																	1
Conventionals	Bulk Sediment	Sediment	NP	A																																	1
Conventionals	Bulk Sediment	Sediment	NP	B																																	1
Conventionals	Bulk Sediment	Sediment	LD	A																																	1
Conventionals	Bulk Sediment	Sediment	LD	B																																	1
Conventionals	Bulk Sediment	Sediment	LD	C																																	1

Table 2-9. Summary of Analytical Sample Types Collected During the Study

Sample Type	Medium	Sampling Method	Treatment	Tank	Date (Number of samples collected on a given date is provided below)																															
					7/18/2010	7/19/2010	7/20/2010	7/23/2010	7/26/2010	7/29/2010	8/1/2010	8/2/2010	8/4/2010	8/9/2010	8/12/2010	8/16/2010	8/18/2010	8/20/2010	8/21/2010	8/23/2010	8/25/2010	8/26/2010	8/27/2010	8/28/2010	8/29/2010	8/30/2010	9/1/2010	9/6/2010	9/8/2010	9/13/2010	9/15/2010	9/19/2010	9/20/2010	9/21/2010	9/22/2010	9/23/2010
Conventionals	Bulk Sediment	Sediment	LD	D																																1
Conventionals	Bulk Sediment	Sediment	LD	E																																1
Conventionals	Bulk Sediment	Sediment	LD	F																																1
Conventionals	Bulk Sediment	Sediment	UMF	A																																1
Conventionals	Bulk Sediment	Sediment	UMF	B																																1
Conventionals	Bulk Sediment	Sediment	UMF	C																																1
Conventionals	Bulk Sediment	Sediment	UMF	D																																1
Conventionals	Bulk Sediment	Sediment	UMF	E																																1
Conventionals	Bulk Sediment	Sediment	UMF	F																																1
Conventionals	Bulk Sediment	Sediment	LMF	A																																1
Conventionals	Bulk Sediment	Sediment	LMF	B																																1
Conventionals	Bulk Sediment	Sediment	LMF	C																																1
Conventionals	Bulk Sediment	Sediment	LMF	D																																1
Organic Carbon	Sediment-Water Interface	Pipette	CTRL	A					1			1		1		1				2					1		1		1			1			
Organic Carbon	Sediment-Water Interface	Pipette	CTRL	B					1			1		1		1				1					1		1		1			1			
Organic Carbon	Sediment-Water Interface	Pipette	CTRL	C					1			1		1		1				1					1		1		1			1			
Organic Carbon	Sediment-Water Interface	Pipette	CTRL	D					1			1		1		1				1					1		1		1			1			
Organic Carbon	Sediment-Water Interface	Pipette	CTRL	E					1			1		1		1				1					1		1		1			1			
Organic Carbon	Sediment-Water Interface	Pipette	CTRL	F					1			1		1		1				1					1		1		1			1			
Organic Carbon	Sediment-Water Interface	Pipette	LALL	A					1			1		1		1				1					1		1		1			1			
Organic Carbon	Sediment-Water Interface	Pipette	LALL	B					1			1		1		1				1					1		1		1			1			
Organic Carbon	Sediment-Water Interface	Pipette	LALL	C					1			1		1		1				1					1		1		1			1			
Organic Carbon	Sediment-Water Interface	Pipette	LALL	D					1			1		1		1				1					1		1		1			1			
Organic Carbon	Sediment-Water Interface	Pipette	LALL	E					1			1		1		1				1					1		1		1			1			
Organic Carbon	Sediment-Water Interface	Pipette	LALL	F					1			1		1		1				1					1		1		1			1			
Organic Carbon	Sediment-Water Interface	Pipette	GE	A					1			1		1		1				1					1		1		1			1			
Organic Carbon	Sediment-Water Interface	Pipette	GE	B					1			1		1		1				1					1		1		1			1			
Organic Carbon	Sediment-Water Interface	Pipette	GE	C					1			1		1		1				1					1		1		1			1			
Organic Carbon	Sediment-Water Interface	Pipette	GE	D					1			1		1		1				1					1		2		1			1			
Organic Carbon	Sediment-Water Interface	Pipette	DE	A					1			1		1		1				1					1		1		2			1			
Organic Carbon	Sediment-Water Interface	Pipette	DE	B					1			1		1		1				1					1		1		1			1			
Organic Carbon	Sediment-Water Interface	Pipette	DE	C					2			1		1		1				1					1		1		1			1			
Organic Carbon	Sediment-Water Interface	Pipette	NP	A					1			1		1		1				1					1		1		1			1			
Organic Carbon	Sediment-Water Interface	Pipette	NP	B					1			2		1		1				1					1		1		1			1			
Organic Carbon	Sediment-Water Interface	Pipette	LD	A					1			1		1		1				1							1		1			1			
Organic Carbon	Sediment-Water Interface	Pipette	LD	B					1			1		1		1				1					1		1		1			1			
Organic Carbon	Sediment-Water Interface	Pipette	LD	C					1			1		1		1				1					2		1		1			1			
Organic Carbon	Sediment-Water Interface	Pipette	LD	D					1			1				1				1					1		1		1			1			
Organic Carbon	Sediment-Water Interface	Pipette	LD	E					1			1		1		1				1					1		1		1			1			
Organic Carbon	Sediment-Water Interface	Pipette	LD	F					1			1		1		1				1					1		1		1			1			
Organic Carbon	Sediment-Water Interface	Pipette	UMF	A					1			1		1		1				1					1		1		1			1			
Organic Carbon	Sediment-Water Interface	Pipette	UMF	B					1			1		1		1				1					1		1		1			1			
Organic Carbon	Sediment-Water Interface	Pipette	UMF	C					1			1		1		1				1					1		1		1			1			

Table 2-9. Summary of Analytical Sample Types Collected During the Study

Sample Type	Medium	Sampling Method	Treatment	Tank	Date (Number of samples collected on a given date is provided below)																																
					7/18/2010	7/19/2010	7/20/2010	7/23/2010	7/26/2010	7/29/2010	8/1/2010	8/2/2010	8/4/2010	8/9/2010	8/12/2010	8/16/2010	8/18/2010	8/20/2010	8/21/2010	8/23/2010	8/25/2010	8/26/2010	8/27/2010	8/28/2010	8/29/2010	8/30/2010	9/1/2010	9/6/2010	9/8/2010	9/13/2010	9/15/2010	9/19/2010	9/20/2010	9/21/2010	9/22/2010	9/23/2010
Organic Carbon	Sediment-Water Interface	Pipette	UMF	D					1			1		1		1				1					1		1		1			1			
Organic Carbon	Sediment-Water Interface	Pipette	UMF	E					1			1		1		1				1					1		1		1			1			
Organic Carbon	Sediment-Water Interface	Pipette	UMF	F					1			1		1		1				1					1		1		1			1			
Organic Carbon	Sediment-Water Interface	Pipette	LMF	A					1			1		1		2				1					2		1		1			2			
Organic Carbon	Sediment-Water Interface	Pipette	LMF	B					1			1		1		1				1					1		1		1			1			
Organic Carbon	Sediment-Water Interface	Pipette	LMF	C					1			1		2		1				1					1		1		1			1			
Organic Carbon	Sediment-Water Interface	Pipette	LMF	D					1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	H2O	A				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	H2O	B				1				1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	H2O	C				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	H2O	D				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	H2O	E				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	H2O	F				1																												
Organic Carbon	Porewater (2.5 cm)	Airstone	CTRL	A				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	CTRL	B				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	CTRL	C				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	CTRL	D				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	CTRL	E				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	CTRL	F				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	LALL	A				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	LALL	B				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	LALL	C				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	LALL	D				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	LALL	E				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	LALL	F				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	GE	A				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	GE	B				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	GE	C				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	GE	D				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	DE	A				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	DE	B				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	DE	C				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	NP	A				1	1			1				1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	NP	B				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	LD	A				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	LD	B				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	LD	C				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	LD	D				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	LD	E				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	LD	F				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	UMF	A				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	UMF	B				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	UMF	C				1	1			1		1		1				1					1		1		1			1			

Table 2-9. Summary of Analytical Sample Types Collected During the Study

Sample Type	Medium	Sampling Method	Treatment	Tank	Date (Number of samples collected on a given date is provided below)																																
					7/18/2010	7/19/2010	7/20/2010	7/23/2010	7/26/2010	7/29/2010	8/1/2010	8/2/2010	8/4/2010	8/9/2010	8/12/2010	8/16/2010	8/18/2010	8/20/2010	8/21/2010	8/23/2010	8/25/2010	8/26/2010	8/27/2010	8/28/2010	8/29/2010	8/30/2010	9/1/2010	9/6/2010	9/8/2010	9/13/2010	9/15/2010	9/19/2010	9/20/2010	9/21/2010	9/22/2010	9/23/2010
Organic Carbon	Porewater (2.5 cm)	Airstone	UMF	D				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	UMF	E				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	UMF	F				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	LMF	A				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	LMF	B				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	LMF	C				1	1			1		1		1				1					1		1		1			1			
Organic Carbon	Porewater (2.5 cm)	Airstone	LMF	D				1				1		1		1				1					1		1		1			1			
Organic Carbon	Bulk Sediment	Sediment	CTRL	A																																	1
Organic Carbon	Bulk Sediment	Sediment	CTRL	B																																	1
Organic Carbon	Bulk Sediment	Sediment	CTRL	C																																	1
Organic Carbon	Bulk Sediment	Sediment	CTRL	D																																	1
Organic Carbon	Bulk Sediment	Sediment	CTRL	E																																	1
Organic Carbon	Bulk Sediment	Sediment	CTRL	F																																	1
Organic Carbon	Bulk Sediment	Sediment	LALL	A																																	1
Organic Carbon	Bulk Sediment	Sediment	LALL	B																																	1
Organic Carbon	Bulk Sediment	Sediment	LALL	C																																	1
Organic Carbon	Bulk Sediment	Sediment	LALL	D																																	1
Organic Carbon	Bulk Sediment	Sediment	LALL	E																																	1
Organic Carbon	Bulk Sediment	Sediment	LALL	F																																	1
Organic Carbon	Bulk Sediment	Sediment	GE	A																																	1
Organic Carbon	Bulk Sediment	Sediment	GE	B																																	1
Organic Carbon	Bulk Sediment	Sediment	GE	C																																	1
Organic Carbon	Bulk Sediment	Sediment	GE	D																																	1
Organic Carbon	Bulk Sediment	Sediment	DE	A																																	1
Organic Carbon	Bulk Sediment	Sediment	DE	B																																	1
Organic Carbon	Bulk Sediment	Sediment	DE	C																																	1
Organic Carbon	Bulk Sediment	Sediment	NP	A																																	1
Organic Carbon	Bulk Sediment	Sediment	NP	B																																	1
Organic Carbon	Bulk Sediment	Sediment	LD	A																																	1
Organic Carbon	Bulk Sediment	Sediment	LD	B																																	1
Organic Carbon	Bulk Sediment	Sediment	LD	C																																	1
Organic Carbon	Bulk Sediment	Sediment	LD	D																																	1
Organic Carbon	Bulk Sediment	Sediment	LD	E																																	1
Organic Carbon	Bulk Sediment	Sediment	LD	F																																	1
Organic Carbon	Bulk Sediment	Sediment	UMF	A																																	1
Organic Carbon	Bulk Sediment	Sediment	UMF	B																																	1
Organic Carbon	Bulk Sediment	Sediment	UMF	C																																	1
Organic Carbon	Bulk Sediment	Sediment	UMF	D																																	1
Organic Carbon	Bulk Sediment	Sediment	UMF	E																																	1
Organic Carbon	Bulk Sediment	Sediment	UMF	F																																	1
Organic Carbon	Bulk Sediment	Sediment	LMF	A																																	1
Organic Carbon	Bulk Sediment	Sediment	LMF	B																																	1
Organic Carbon	Bulk Sediment	Sediment	LMF	C																																	1

Table 2-9. Summary of Analytical Sample Types Collected During the Study

Sample Type	Medium	Sampling Method	Treatment	Tank	Date (Number of samples collected on a given date is provided below)																																
					7/18/2010	7/19/2010	7/20/2010	7/23/2010	7/26/2010	7/29/2010	8/1/2010	8/2/2010	8/4/2010	8/9/2010	8/12/2010	8/16/2010	8/18/2010	8/20/2010	8/21/2010	8/23/2010	8/25/2010	8/26/2010	8/27/2010	8/28/2010	8/29/2010	8/30/2010	9/1/2010	9/6/2010	9/8/2010	9/13/2010	9/15/2010	9/19/2010	9/20/2010	9/21/2010	9/22/2010	9/23/2010
Organic Carbon	Bulk Sediment	Sediment	LMF	D																																	1
Metals	Sediment-Water Interface	Pipette	CTRL	A					1			1		1		1				2					1		1		1			1			
Metals	Sediment-Water Interface	Pipette	CTRL	B					1			1		1		1				1					1		1		1			1			
Metals	Sediment-Water Interface	Pipette	CTRL	C					1			1		1		1				1					1		1		1			1			
Metals	Sediment-Water Interface	Pipette	CTRL	D					1			1		1		1				1					1		1		1			1			
Metals	Sediment-Water Interface	Pipette	CTRL	E					1			1		1		1				1					1		1		1			1			
Metals	Sediment-Water Interface	Pipette	CTRL	F					1			1		1		1				1					1		1		1			1			
Metals	Sediment-Water Interface	Pipette	LALL	A					1			1		1		1				1					1		1		1			1			
Metals	Sediment-Water Interface	Pipette	LALL	B					1			1		1		1				1					1		1		1			1			
Metals	Sediment-Water Interface	Pipette	LALL	C					1			1		1		1				1					1		1		1			1			
Metals	Sediment-Water Interface	Pipette	LALL	D					1			1		1		1				1					1		1		1			1			
Metals	Sediment-Water Interface	Pipette	LALL	E					1			1		1		1				1					1		1		1			1			
Metals	Sediment-Water Interface	Pipette	LALL	F					1			1		1		1				1					1		1		1			1			
Metals	Sediment-Water Interface	Pipette	GE	A					1			1		1		1				1					1		1		1			1			
Metals	Sediment-Water Interface	Pipette	GE	B					1			1		1		1				1					1		1		1			1			
Metals	Sediment-Water Interface	Pipette	GE	C					1			1		1		1				1					1		1		1			1			
Metals	Sediment-Water Interface	Pipette	GE	D					1			1		1		1				1					1		2		1			1			
Metals	Sediment-Water Interface	Pipette	DE	A					1			1		1		1				1					1		1		2			1			
Metals	Sediment-Water Interface	Pipette	DE	B					1			1		1		1				1					1		1		1			1			
Metals	Sediment-Water Interface	Pipette	DE	C					2			1		1		1				1					1		1		1			1			
Metals	Sediment-Water Interface	Pipette	NP	A					1			1		1		1				1					1		1		1			1			
Metals	Sediment-Water Interface	Pipette	NP	B					1			2		1		1				1					1		1		1			1			
Metals	Sediment-Water Interface	Pipette	LD	A					1			1		1		1				1							1		1			1			
Metals	Sediment-Water Interface	Pipette	LD	B					1			1		1		1				1					1		1		1			1			
Metals	Sediment-Water Interface	Pipette	LD	C					1			1		1		1				1					2		1		1			1			
Metals	Sediment-Water Interface	Pipette	LD	D					1			1				1				1					1		1		1			1			
Metals	Sediment-Water Interface	Pipette	LD	E					1			1		1		1				1					1		1		1			1			
Metals	Sediment-Water Interface	Pipette	LD	F					1			1		1		1				1					1		1		1			1			
Metals	Sediment-Water Interface	Pipette	UMF	A					1			1		1		1				1					1		1		1			1			
Metals	Sediment-Water Interface	Pipette	UMF	B					1			1		1		1				1					1		1		1			1			
Metals	Sediment-Water Interface	Pipette	UMF	C					1			1		1		1				1					1		1		1			1			
Metals	Sediment-Water Interface	Pipette	UMF	D					1			1		1		1				1					1		1		1			1			
Metals	Sediment-Water Interface	Pipette	UMF	E					1			1		1		1				1					1		1		1			1			
Metals	Sediment-Water Interface	Pipette	UMF	F					1			1		1		1				1					1		1		1			1			
Metals	Sediment-Water Interface	Pipette	LMF	A					1			1		1		2				1					2		1		1			2			
Metals	Sediment-Water Interface	Pipette	LMF	B					1			1		1		1				1					1		1		1			1			
Metals	Sediment-Water Interface	Pipette	LMF	C					1			1		2		1				1					1		1		1			1			
Metals	Sediment-Water Interface	Pipette	LMF	D					1			1		1		1				1					1		1		1			1			
Metals	Sediment-Water Interface	Peeper	H2O	D							3							3													2				
Metals	Sediment-Water Interface	Peeper	CTRL	B							3							3													3				
Metals	Sediment-Water Interface	Peeper	CTRL	C							3							3													3				
Metals	Sediment-Water Interface	Peeper	CTRL	D																											2				
Metals	Sediment-Water Interface	Peeper	LALL	B							3							3													3				

Table 2-9. Summary of Analytical Sample Types Collected During the Study

Sample Type	Medium	Sampling Method	Treatment	Tank	Date (Number of samples collected on a given date is provided below)																																
					7/18/2010	7/19/2010	7/20/2010	7/23/2010	7/26/2010	7/29/2010	8/1/2010	8/2/2010	8/4/2010	8/9/2010	8/12/2010	8/16/2010	8/18/2010	8/20/2010	8/21/2010	8/23/2010	8/25/2010	8/26/2010	8/27/2010	8/28/2010	8/29/2010	8/30/2010	9/1/2010	9/6/2010	9/8/2010	9/13/2010	9/15/2010	9/19/2010	9/20/2010	9/21/2010	9/22/2010	9/23/2010
Metals	Sediment-Water Interface	Peeper	LALL	D							3							3												3				
Metals	Sediment-Water Interface	Peeper	GE	D							3							3												3				
Metals	Sediment-Water Interface	Peeper	DE	B							3							3												3				
Metals	Sediment-Water Interface	Peeper	LD	A							3							3												3				
Metals	Sediment-Water Interface	Peeper	LD	B							3							3												3				
Metals	Sediment-Water Interface	Peeper	UMF	B							3							3												3				
Metals	Sediment-Water Interface	Peeper	UMF	D																										2				
Metals	Sediment-Water Interface	Peeper	UMF	E							3							3												3				
Metals	Sediment-Water Interface	Peeper	LMF	A							3							3												3				
Metals	Sediment-Water Interface	DGT	H2O	D							3							3												3				
Metals	Sediment-Water Interface	DGT	CTRL	B							3							3																
Metals	Sediment-Water Interface	DGT	CTRL	C							3							3												3				
Metals	Sediment-Water Interface	DGT	CTRL	D																										3				
Metals	Sediment-Water Interface	DGT	LALL	B							3							3												3				
Metals	Sediment-Water Interface	DGT	LALL	D							3							3												3				
Metals	Sediment-Water Interface	DGT	GE	D							3							3												3				
Metals	Sediment-Water Interface	DGT	DE	B							3							3												3				
Metals	Sediment-Water Interface	DGT	LD	A							3							3												3				
Metals	Sediment-Water Interface	DGT	LD	B							3							3												3				
Metals	Sediment-Water Interface	DGT	LD	C																										3				
Metals	Sediment-Water Interface	DGT	UMF	B							3							3												3				
Metals	Sediment-Water Interface	DGT	UMF	D																										3				
Metals	Sediment-Water Interface	DGT	UMF	E							3							3												3				
Metals	Sediment-Water Interface	DGT	LMF	A							3							3												3				
Metals	Porewater (1 cm)	Peeper	H2O	D							3							3												2				
Metals	Porewater (1 cm)	Peeper	CTRL	B							3							3												3				
Metals	Porewater (1 cm)	Peeper	CTRL	C							3							3												3				
Metals	Porewater (1 cm)	Peeper	CTRL	D																										2				
Metals	Porewater (1 cm)	Peeper	LALL	B							3							3												3				
Metals	Porewater (1 cm)	Peeper	LALL	D							3							3												3				
Metals	Porewater (1 cm)	Peeper	GE	D							3							3												3				
Metals	Porewater (1 cm)	Peeper	DE	B							3							3												3				
Metals	Porewater (1 cm)	Peeper	LD	A							3							3												3				
Metals	Porewater (1 cm)	Peeper	LD	B							3							3												3				
Metals	Porewater (1 cm)	Peeper	UMF	B							3							3												3				
Metals	Porewater (1 cm)	Peeper	UMF	D																										2				
Metals	Porewater (1 cm)	Peeper	UMF	E							3							3												3				
Metals	Porewater (1 cm)	Peeper	LMF	A							3							3												3				
Metals	Porewater (1 cm)	DGT	H2O	D							3							3												3				
Metals	Porewater (1 cm)	DGT	CTRL	B							3							3																
Metals	Porewater (1 cm)	DGT	CTRL	C							3							3												3				
Metals	Porewater (1 cm)	DGT	CTRL	D																										3				
Metals	Porewater (1 cm)	DGT	LALL	B							3							3												3				

Table 2-9. Summary of Analytical Sample Types Collected During the Study

					Date (Number of samples collected on a given date is provided below)																																		
Sample Type	Medium	Sampling Method	Treatment	Tank	7/18/2010	7/19/2010	7/20/2010	7/23/2010	7/26/2010	7/29/2010	8/1/2010	8/2/2010	8/4/2010	8/9/2010	8/12/2010	8/16/2010	8/18/2010	8/20/2010	8/21/2010	8/23/2010	8/25/2010	8/26/2010	8/27/2010	8/28/2010	8/29/2010	8/30/2010	9/1/2010	9/6/2010	9/8/2010	9/13/2010	9/15/2010	9/19/2010	9/20/2010	9/21/2010	9/22/2010	9/23/2010
Metals	Porewater (1 cm)	DGT	LALL	D							3							3													3				
Metals	Porewater (1 cm)	DGT	GE	D							3							3													3				
Metals	Porewater (1 cm)	DGT	DE	B							3							3													3				
Metals	Porewater (1 cm)	DGT	LD	A							3							3													2				
Metals	Porewater (1 cm)	DGT	LD	B							3							3													3				
Metals	Porewater (1 cm)	DGT	LD	C																											3				
Metals	Porewater (1 cm)	DGT	LD	D																											1				
Metals	Porewater (1 cm)	DGT	UMF	B							3							3													3				
Metals	Porewater (1 cm)	DGT	UMF	D																											3				
Metals	Porewater (1 cm)	DGT	UMF	E							3							3													3				
Metals	Porewater (1 cm)	DGT	LMF	A							3							3													3				
Metals	Porewater (2.5 cm)	Airstone	H2O	A				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	H2O	B				1				1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	H2O	C				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	H2O	D				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	H2O	E				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	H2O	F				1																											
Metals	Porewater (2.5 cm)	Airstone	CTRL	A				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	CTRL	B				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	CTRL	C				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	CTRL	D				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	CTRL	E				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	CTRL	F				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	LALL	A				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	LALL	B				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	LALL	C				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	LALL	D				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	LALL	E				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	LALL	F				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	GE	A				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	GE	B				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	GE	C				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	GE	D				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	DE	A				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	DE	B				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	DE	C				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	NP	A				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	NP	B				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	LD	A				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	LD	B				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	LD	C				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	LD	D				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	LD	E				1	1			1		1		1				1					1		1		1			1			

Table 2-9. Summary of Analytical Sample Types Collected During the Study

Sample Type	Medium	Sampling Method	Treatment	Tank	Date (Number of samples collected on a given date is provided below)																																
					7/18/2010	7/19/2010	7/20/2010	7/23/2010	7/26/2010	7/29/2010	8/1/2010	8/2/2010	8/4/2010	8/9/2010	8/12/2010	8/16/2010	8/18/2010	8/20/2010	8/21/2010	8/23/2010	8/25/2010	8/26/2010	8/27/2010	8/28/2010	8/29/2010	8/30/2010	9/1/2010	9/6/2010	9/8/2010	9/13/2010	9/15/2010	9/19/2010	9/20/2010	9/21/2010	9/22/2010	9/23/2010
Metals	Porewater (2.5 cm)	Airstone	LD	F				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	UMF	A				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	UMF	B				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	UMF	C				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	UMF	D				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	UMF	E				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	UMF	F				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	LMF	A				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	LMF	B				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	LMF	C				1	1			1		1		1				1					1		1		1			1			
Metals	Porewater (2.5 cm)	Airstone	LMF	D				1				1		1		1				1					1		1		1			1			
Metals	Bulk Sediment	Sediment	CTRL	A																																	1
Metals	Bulk Sediment	Sediment	CTRL	B																																	1
Metals	Bulk Sediment	Sediment	CTRL	C																																	1
Metals	Bulk Sediment	Sediment	CTRL	D																																	1
Metals	Bulk Sediment	Sediment	CTRL	E																																	1
Metals	Bulk Sediment	Sediment	CTRL	F																																	1
Metals	Bulk Sediment	Sediment	LALL	A																																	1
Metals	Bulk Sediment	Sediment	LALL	B																																	1
Metals	Bulk Sediment	Sediment	LALL	C																																	1
Metals	Bulk Sediment	Sediment	LALL	D																																	1
Metals	Bulk Sediment	Sediment	LALL	E																																	1
Metals	Bulk Sediment	Sediment	LALL	F																																	1
Metals	Bulk Sediment	Sediment	GE	A																																	1
Metals	Bulk Sediment	Sediment	GE	B																																	1
Metals	Bulk Sediment	Sediment	GE	C																																	1
Metals	Bulk Sediment	Sediment	GE	D																																	1
Metals	Bulk Sediment	Sediment	DE	A																																	1
Metals	Bulk Sediment	Sediment	DE	B																																	1
Metals	Bulk Sediment	Sediment	DE	C																																	1
Metals	Bulk Sediment	Sediment	NP	A																																	1
Metals	Bulk Sediment	Sediment	NP	B																																	1
Metals	Bulk Sediment	Sediment	LD	A																																	1
Metals	Bulk Sediment	Sediment	LD	B																																	1
Metals	Bulk Sediment	Sediment	LD	C																																	1
Metals	Bulk Sediment	Sediment	LD	D																																	1
Metals	Bulk Sediment	Sediment	LD	E																																	1
Metals	Bulk Sediment	Sediment	LD	F																																	1
Metals	Bulk Sediment	Sediment	UMF	A																																	1
Metals	Bulk Sediment	Sediment	UMF	B																																	1
Metals	Bulk Sediment	Sediment	UMF	C																																	1
Metals	Bulk Sediment	Sediment	UMF	D																																	1
Metals	Bulk Sediment	Sediment	UMF	E																																	1

Table 2-9. Summary of Analytical Sample Types Collected During the Study

Sample Type	Medium	Sampling Method	Treatment	Tank	Date (Number of samples collected on a given date is provided below)																														
					7/18/2010	7/19/2010	7/20/2010	7/23/2010	7/26/2010	7/29/2010	8/1/2010	8/2/2010	8/4/2010	8/9/2010	8/12/2010	8/16/2010	8/18/2010	8/20/2010	8/21/2010	8/23/2010	8/25/2010	8/26/2010	8/27/2010	8/28/2010	8/29/2010	8/30/2010	9/1/2010	9/6/2010	9/8/2010	9/13/2010	9/15/2010	9/19/2010	9/20/2010	9/21/2010	9/22/2010	9/23/2010
Metals	Bulk Sediment	Sediment	UMF	F																															1
Metals	Bulk Sediment	Sediment	LMF	A																															1
Metals	Bulk Sediment	Sediment	LMF	B																															1
Metals	Bulk Sediment	Sediment	LMF	C																															1
Metals	Bulk Sediment	Sediment	LMF	D																															1
AVS and SEM	Bulk Sediment	Sediment	CTRL	A																															1
AVS and SEM	Bulk Sediment	Sediment	CTRL	B																															1
AVS and SEM	Bulk Sediment	Sediment	CTRL	C																															1
AVS and SEM	Bulk Sediment	Sediment	CTRL	D																															1
AVS and SEM	Bulk Sediment	Sediment	CTRL	E																															1
AVS and SEM	Bulk Sediment	Sediment	CTRL	F																															1
AVS and SEM	Bulk Sediment	Sediment	LALL	A																															1
AVS and SEM	Bulk Sediment	Sediment	LALL	B																															1
AVS and SEM	Bulk Sediment	Sediment	LALL	C																															1
AVS and SEM	Bulk Sediment	Sediment	LALL	D																															1
AVS and SEM	Bulk Sediment	Sediment	LALL	E																															1
AVS and SEM	Bulk Sediment	Sediment	LALL	F																															1
AVS and SEM	Bulk Sediment	Sediment	GE	A																															1
AVS and SEM	Bulk Sediment	Sediment	GE	B																															1
AVS and SEM	Bulk Sediment	Sediment	GE	C																															1
AVS and SEM	Bulk Sediment	Sediment	GE	D																															1
AVS and SEM	Bulk Sediment	Sediment	DE	A																															1
AVS and SEM	Bulk Sediment	Sediment	DE	B																															1
AVS and SEM	Bulk Sediment	Sediment	DE	C																															1
AVS and SEM	Bulk Sediment	Sediment	NP	A																															1
AVS and SEM	Bulk Sediment	Sediment	NP	B																															1
AVS and SEM	Bulk Sediment	Sediment	LD	A																															1
AVS and SEM	Bulk Sediment	Sediment	LD	B																															1
AVS and SEM	Bulk Sediment	Sediment	LD	C																															1
AVS and SEM	Bulk Sediment	Sediment	LD	D																															1
AVS and SEM	Bulk Sediment	Sediment	LD	E																															1
AVS and SEM	Bulk Sediment	Sediment	LD	F																															1
AVS and SEM	Bulk Sediment	Sediment	UMF	A																															1
AVS and SEM	Bulk Sediment	Sediment	UMF	B																															1
AVS and SEM	Bulk Sediment	Sediment	UMF	C																															1
AVS and SEM	Bulk Sediment	Sediment	UMF	D																															1
AVS and SEM	Bulk Sediment	Sediment	UMF	E																															1
AVS and SEM	Bulk Sediment	Sediment	UMF	F																															1
AVS and SEM	Bulk Sediment	Sediment	LMF	A																															1
AVS and SEM	Bulk Sediment	Sediment	LMF	B																															1
AVS and SEM	Bulk Sediment	Sediment	LMF	C																															1
AVS and SEM	Bulk Sediment	Sediment	LMF	D																															1
Nutrients	Sediment-Water Interface	Pipette	CTRL	A					1	1		1	1	1	1	1	1			2	1		1		1	2		2		1			1		

Table 2-9. Summary of Analytical Sample Types Collected During the Study

					Date (Number of samples collected on a given date is provided below)																																		
Sample Type	Medium	Sampling Method	Treatment	Tank	7/18/2010	7/19/2010	7/20/2010	7/23/2010	7/26/2010	7/29/2010	8/1/2010	8/2/2010	8/4/2010	8/9/2010	8/12/2010	8/16/2010	8/18/2010	8/20/2010	8/21/2010	8/23/2010	8/25/2010	8/26/2010	8/27/2010	8/28/2010	8/29/2010	8/30/2010	9/1/2010	9/6/2010	9/8/2010	9/13/2010	9/15/2010	9/19/2010	9/20/2010	9/21/2010	9/22/2010	9/23/2010
Nutrients	Sediment-Water Interface	Pipette	CTRL	B					1	1		1	1	1	1	1	1			1	1					1	1	1	1	1	1		1		1	
Nutrients	Sediment-Water Interface	Pipette	CTRL	C					1	1		1	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1		
Nutrients	Sediment-Water Interface	Pipette	CTRL	D					1	1		1	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1		
Nutrients	Sediment-Water Interface	Pipette	CTRL	E					1	1		1	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1		
Nutrients	Sediment-Water Interface	Pipette	CTRL	F					1	1		1	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1		
Nutrients	Sediment-Water Interface	Pipette	LALL	A					1	1		1	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1		
Nutrients	Sediment-Water Interface	Pipette	LALL	B					1	1		1	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1		
Nutrients	Sediment-Water Interface	Pipette	LALL	C					1	1		1	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1		
Nutrients	Sediment-Water Interface	Pipette	LALL	D					1	1		1	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1		
Nutrients	Sediment-Water Interface	Pipette	LALL	E					1	1		1	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1		
Nutrients	Sediment-Water Interface	Pipette	LALL	F					1	1		1	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1		
Nutrients	Sediment-Water Interface	Pipette	GE	A					1	1		1	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1		
Nutrients	Sediment-Water Interface	Pipette	GE	B					1	1		1	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1		
Nutrients	Sediment-Water Interface	Pipette	GE	C					1	1		1	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1		
Nutrients	Sediment-Water Interface	Pipette	GE	D					1	1		1	1	2		2				1	1					1	1	2	1	1	1		1	1		
Nutrients	Sediment-Water Interface	Pipette	DE	A					1	1		1	1	1	1	1	1			1	1					1	1	1	1	2	1		1	1		
Nutrients	Sediment-Water Interface	Pipette	DE	B					1	1		1	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1		
Nutrients	Sediment-Water Interface	Pipette	DE	C					2	1		1	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1		
Nutrients	Sediment-Water Interface	Pipette	NP	A					1	1		1	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1		
Nutrients	Sediment-Water Interface	Pipette	NP	B					1	1		2	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1		
Nutrients	Sediment-Water Interface	Pipette	LD	A					1	1		1	1	1	1	1	1			1	1						1	1	1	1	1		1	1		
Nutrients	Sediment-Water Interface	Pipette	LD	B					1	1		1	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1		
Nutrients	Sediment-Water Interface	Pipette	LD	C					1	1		1	1	1	1	1	1			1	1					2	1	1	1	1	1		1	1		
Nutrients	Sediment-Water Interface	Pipette	LD	D					1	1		1	1		1	1	1			1	1					1	1	1	1	1	1		1	1		
Nutrients	Sediment-Water Interface	Pipette	LD	E					1	1		1	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1		
Nutrients	Sediment-Water Interface	Pipette	LD	F					1	1		1	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1		
Nutrients	Sediment-Water Interface	Pipette	UMF	A					1	1		1	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1		
Nutrients	Sediment-Water Interface	Pipette	UMF	B					1	1		1	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1		
Nutrients	Sediment-Water Interface	Pipette	UMF	C					1	1		1	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1		
Nutrients	Sediment-Water Interface	Pipette	UMF	D					1	1		1	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1		
Nutrients	Sediment-Water Interface	Pipette	UMF	E					1	1		1	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1		
Nutrients	Sediment-Water Interface	Pipette	UMF	F					1	1		1	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1		
Nutrients	Sediment-Water Interface	Pipette	LMF	A					1	1		1	1	1	1	2	1			1	1					2	1	1	1	1	1		2	1		
Nutrients	Sediment-Water Interface	Pipette	LMF	B					1	1		1	1	1	1	1	1			1	1					1	1	1	1	1	1		1	1		
Nutrients	Sediment-Water Interface	Pipette	LMF	C					1	1		1	1	2	1	1	1			1	1					1	1	1	1	1	1		1	1		
Nutrients	Sediment-Water Interface	Pipette	LMF	D					1	1		1	1	1	1	1	1			1	1					1	1	1	1	1	1		1			
Nutrients	Porewater (2.5 cm)	Airstone	H2O	A				1	1			1		1		1				1						1		1		1			1			
Nutrients	Porewater (2.5 cm)	Airstone	H2O	B				1				1		1		1				1						1		1		1			1			
Nutrients	Porewater (2.5 cm)	Airstone	H2O	C				1	1			1		1		1				1						1		1		1			1			
Nutrients	Porewater (2.5 cm)	Airstone	H2O	D				1	1			1		1		1				1						1		1		1			1			
Nutrients	Porewater (2.5 cm)	Airstone	H2O	E				1	1			1		1		1				1						1		1		1			1			
Nutrients	Porewater (2.5 cm)	Airstone	H2O	F				1																												
Nutrients	Porewater (2.5 cm)	Airstone	CTRL	A				1	1			1		1		1				1						1		1		1			1			

Table 2-9. Summary of Analytical Sample Types Collected During the Study

Sample Type	Medium	Sampling Method	Treatment	Tank	Date (Number of samples collected on a given date is provided below)																																
					7/18/2010	7/19/2010	7/20/2010	7/23/2010	7/26/2010	7/29/2010	8/1/2010	8/2/2010	8/4/2010	8/9/2010	8/12/2010	8/16/2010	8/18/2010	8/20/2010	8/21/2010	8/23/2010	8/25/2010	8/26/2010	8/27/2010	8/28/2010	8/29/2010	8/30/2010	9/1/2010	9/6/2010	9/8/2010	9/13/2010	9/15/2010	9/19/2010	9/20/2010	9/21/2010	9/22/2010	9/23/2010
Nutrients	Porewater (2.5 cm)	Airstone	CTRL	B				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	CTRL	C				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	CTRL	D				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	CTRL	E				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	CTRL	F				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	LALL	A				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	LALL	B				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	LALL	C				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	LALL	D				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	LALL	E				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	LALL	F				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	GE	A				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	GE	B				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	GE	C				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	GE	D				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	DE	A				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	DE	B				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	DE	C				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	NP	A				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	NP	B				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	LD	A				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	LD	B				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	LD	C				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	LD	D				1	1			1				1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	LD	E				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	LD	F				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	UMF	A				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	UMF	B				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	UMF	C				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	UMF	D				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	UMF	E				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	UMF	F				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	LMF	A				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	LMF	B				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	LMF	C				1	1			1		1		1				1						1		1		1			1				
Nutrients	Porewater (2.5 cm)	Airstone	LMF	D				1				1		1		1				1						1		1		1			1				
Physical Chemistry	Sediment-Water Interface	Pipette	CTRL	A					1			1		1		1				1		1		1			1										
Physical Chemistry	Sediment-Water Interface	Pipette	CTRL	B					1			1		1		1			1	1						1		1						1			
Physical Chemistry	Sediment-Water Interface	Pipette	CTRL	C					1			1		1		1			1	1						1		1					1				
Physical Chemistry	Sediment-Water Interface	Pipette	CTRL	D					1			1		1		1				1						1		1					1				
Physical Chemistry	Sediment-Water Interface	Pipette	CTRL	E					1			1		1		1				1						1		1					1				
Physical Chemistry	Sediment-Water Interface	Pipette	CTRL	F					1			1		1		1				1						1		1					1				
Physical Chemistry	Sediment-Water Interface	Pipette	LALL	A					1			1		1		1				1						1		1					1				

Table 2-9. Summary of Analytical Sample Types Collected During the Study

					Date (Number of samples collected on a given date is provided below)																																
Sample Type	Medium	Sampling Method	Treatment	Tank	7/18/2010	7/19/2010	7/20/2010	7/23/2010	7/26/2010	7/29/2010	8/1/2010	8/2/2010	8/4/2010	8/9/2010	8/12/2010	8/16/2010	8/18/2010	8/20/2010	8/21/2010	8/23/2010	8/25/2010	8/26/2010	8/27/2010	8/28/2010	8/29/2010	8/30/2010	9/1/2010	9/6/2010	9/8/2010	9/13/2010	9/15/2010	9/19/2010	9/20/2010	9/21/2010	9/22/2010	9/23/2010
Physical Chemistry	Sediment-Water Interface	Pipette	LALL	B					1			1		1		1			1	1					1		1					1			
Physical Chemistry	Sediment-Water Interface	Pipette	LALL	C					1			1		1		1				1					1		1					1			
Physical Chemistry	Sediment-Water Interface	Pipette	LALL	D					1			1		1		1			1	1					1		1					1			
Physical Chemistry	Sediment-Water Interface	Pipette	LALL	E					1			1		1		1				1					1		1					1			
Physical Chemistry	Sediment-Water Interface	Pipette	LALL	F					1			1		1		1				1					1		1					1			
Physical Chemistry	Sediment-Water Interface	Pipette	GE	A					1			1		1		1				1					1		1					1			
Physical Chemistry	Sediment-Water Interface	Pipette	GE	B					1			1		1		1				1					1		1					1			
Physical Chemistry	Sediment-Water Interface	Pipette	GE	C					1			1		1		1				1					1		1					1			
Physical Chemistry	Sediment-Water Interface	Pipette	GE	D					1			1			1		1			1					1		1					1			
Physical Chemistry	Sediment-Water Interface	Pipette	DE	A					1			1		1		1			1	1					1		1					1			
Physical Chemistry	Sediment-Water Interface	Pipette	DE	B					1			1		1		1				1					1		1					1			
Physical Chemistry	Sediment-Water Interface	Pipette	DE	C					1			1		1		1				1					1		1					1			
Physical Chemistry	Sediment-Water Interface	Pipette	NP	A					1			1		1		1				1					1		1					1			
Physical Chemistry	Sediment-Water Interface	Pipette	NP	B					1			1		1		1				1					1		1					1			
Physical Chemistry	Sediment-Water Interface	Pipette	LD	A					1			1		1		1			1	1					1		1					1			
Physical Chemistry	Sediment-Water Interface	Pipette	LD	B					1			1		1		1			1	1					1		1					1			
Physical Chemistry	Sediment-Water Interface	Pipette	LD	C					1			1		1		1				1					1		1					1			
Physical Chemistry	Sediment-Water Interface	Pipette	LD	D					1			1		1		1				1					1		1					1			
Physical Chemistry	Sediment-Water Interface	Pipette	LD	E					1			1		1		1				1					1		1					1			
Physical Chemistry	Sediment-Water Interface	Pipette	LD	F					1			1		1		1				1					1		1					1			
Physical Chemistry	Sediment-Water Interface	Pipette	UMF	A					1			1		1		1				1					1		1					1			
Physical Chemistry	Sediment-Water Interface	Pipette	UMF	B					1			1		1		1			1	1					1		1					1			
Physical Chemistry	Sediment-Water Interface	Pipette	UMF	C					1			1		1		1				1					1		1					1			
Physical Chemistry	Sediment-Water Interface	Pipette	UMF	D					1			1		1		1				1					1		1					1			
Physical Chemistry	Sediment-Water Interface	Pipette	UMF	E					1			1		1		1			1	1					1		1					1			
Physical Chemistry	Sediment-Water Interface	Pipette	UMF	F					1			1		1		1				1					1		1					1			
Physical Chemistry	Sediment-Water Interface	Pipette	LMF	A					1			1		1		1			1	1					1		1					1			
Physical Chemistry	Sediment-Water Interface	Pipette	LMF	B					1			1		1		1				1					1		1					1			
Physical Chemistry	Sediment-Water Interface	Pipette	LMF	C					1			1		1		1				1					1		1					1			
Physical Chemistry	Sediment-Water Interface	Pipette	LMF	D					1			1		1		1				1					1		1					1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	H2O	A	1	1	1	1	1			1		1		1				1					1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	H2O	B	1	1	1	1	1			1		1		1				1					1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	H2O	C	1	1	1	1	1			1		1		1				1					1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	H2O	D	1	1	1	1	1			1		1		1				1					1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	H2O	E				1	1			1		1		1				1					1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	H2O	F	1	1	1	1																											
Physical Chemistry	Porewater (2.5 cm)	Airstone	CTRL	A	1	1	1	1	1			1		1		1				1					1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	CTRL	B	1	1	1	1	1			1		1		1				1					1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	CTRL	C	1	1	1	1	1			1		1		1				1					1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	CTRL	D	1	1	1	1	1			1		1		1				1					1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	CTRL	E	1	1	1	1	1			1		1		1				1					1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	CTRL	F	1	1	1	1	1			1		1		1				1					1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	LALL	A	1	1	1	1	1			1		1		1				1					1		1		1			1			

Table 2-9. Summary of Analytical Sample Types Collected During the Study

					Date (Number of samples collected on a given date is provided below)																																
Sample Type	Medium	Sampling Method	Treatment	Tank	7/18/2010	7/19/2010	7/20/2010	7/23/2010	7/26/2010	7/29/2010	8/1/2010	8/2/2010	8/4/2010	8/9/2010	8/12/2010	8/16/2010	8/18/2010	8/20/2010	8/21/2010	8/23/2010	8/25/2010	8/26/2010	8/27/2010	8/28/2010	8/29/2010	8/30/2010	9/1/2010	9/6/2010	9/8/2010	9/13/2010	9/15/2010	9/19/2010	9/20/2010	9/21/2010	9/22/2010	9/23/2010
Physical Chemistry	Porewater (2.5 cm)	Airstone	LALL	B	1	1	1	1	1			1		1		1				1						1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	LALL	C	1	1	1	1	1			1		1		1				1						1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	LALL	D	1	1	1	1	1			1		1		1				1						1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	LALL	E	1	1	1	1				1		1		1				1						1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	LALL	F	1	1	1	1	1			1		1		1				1						1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	GE	A	1	1	1	1	1			1		1		1				1						1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	GE	B	1	1	1	1	1			1		1		1				1						1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	GE	C	1	1	1	1	1			1		1		1				1						1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	GE	D	1	1	1	1	1			1		1		1				1						1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	DE	A	1	1	1	1	1			1		1		1				1						1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	DE	B	1	1	1	1	1			1		1		1				1						1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	DE	C	1	1	1	1	1			1		1		1				1						1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	NP	A	1	1	1	1	1			1		1		1				1						1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	NP	B	1	1	1	1	1			1		1		1				1						1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	LD	A	1	1	1	1	1			1		1		1				1						1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	LD	B	1	1	1	1	1			1		1		1				1						1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	LD	C	1	1	1	1	1			1		1		1				1						1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	LD	D	1	1	1	1	1			1		1		1				1						1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	LD	E	1	1	1	1	1			1		1		1				1						1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	LD	F	1	1	1	1	1			1		1		1				1						1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	UMF	A	1	1	1	1	1			1		1		1				1						1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	UMF	B	1	1		1	1			1		1		1				1						1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	UMF	C	1	1	1	1	1			1		1		1				1						1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	UMF	D		1	1	1	1			1		1		1				1						1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	UMF	E		1	1	1	1			1		1		1				1						1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	UMF	F	1	1	1	1	1			1		1		1				1						1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	LMF	A	1	1	1	1	1			1		1		1				1						1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	LMF	B	1		1	1				1		1		1				1						1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	LMF	C			1	1	1			1		1		1				1						1		1		1			1			
Physical Chemistry	Porewater (2.5 cm)	Airstone	LMF	D			1	1	1			1		1		1				1						1		1		1			1			

Notes:

Only Metals and Organic Carbon are shown for Overlying Water

CTRL - artificial substrate control

DE - substrates as collected above the water line from the gravel bar at DME

DME - Deadman's Eddy

DOC - dissolved organic carbon

GE - Genelle Eddy

H2O - water-only control

LALL - Lower Arrow Lakes

LD - Little Dalles

LMF - Lower Marcus Flats

NP - Northport

UMF - Upper Marcus Flats

Table 4-1. Summary of Sediment Sample Rejected Data

Location ID	Sample Delivery Group	Sample ID	Sample Collection Date/Time	Sample Material	Media Analyzed	Basis	Analyte	Concentration	Units	Lab Qualifier	Validator Qualifier	MDL	MRL
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.27
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,5'-Octachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,5'-Octachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,5'-Octachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,5'-Octachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,5'-Octachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,5'-Octachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,5'-Octachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,5'-Octachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,5'-Octachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,5'-Octachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,5'-Octachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,5'-Octachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,5'-Octachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,5'-Octachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,6-Octachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,6-Octachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,6-Octachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,6-Octachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,6-Octachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,6-Octachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,6-Octachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,6-Octachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,6-Octachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,6-Octachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,6-Octachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,6-Octachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,6-Octachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5,6-Octachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5-Heptachlorobiphenyl	0.026	µg/kg	U	R	0.026	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5-Heptachlorobiphenyl	0.026	µg/kg	U	R	0.026	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5-Heptachlorobiphenyl	0.026	µg/kg	U	R	0.026	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5-Heptachlorobiphenyl	0.026	µg/kg	U	R	0.026	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5-Heptachlorobiphenyl	0.026	µg/kg	U	R	0.026	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5-Heptachlorobiphenyl	0.026	µg/kg	U	R	0.026	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5-Heptachlorobiphenyl	0.026	µg/kg	U	R	0.026	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5-Heptachlorobiphenyl	0.026	µg/kg	U	R	0.026	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5-Heptachlorobiphenyl	0.026	µg/kg	U	R	0.026	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5-Heptachlorobiphenyl	0.026	µg/kg	U	R	0.026	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5-Heptachlorobiphenyl	0.026	µg/kg	U	R	0.026	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5-Heptachlorobiphenyl	0.026	µg/kg	U	R	0.026	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5-Heptachlorobiphenyl	0.026	µg/kg	U	R	0.026	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4',5-Heptachlorobiphenyl	0.026	µg/kg	U	R	0.026	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4'-Hexachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4'-Hexachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4'-Hexachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4'-Hexachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4'-Hexachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.28

Table 4-1. Summary of Sediment Sample Rejected Data

Location ID	Sample Delivery Group	Sample ID	Sample Collection Date/Time	Sample Material	Media Analyzed	Basis	Analyte	Concentration	Units	Lab Qualifier	Validator Qualifier	MDL	MRL
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4'-Hexachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4'-Hexachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4'-Hexachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4'-Hexachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4'-Hexachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4'-Hexachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4'-Hexachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4'-Hexachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,4'-Hexachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,5',6,6'-Octachlorobiphenyl	0.041	µg/kg	U	R	0.041	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,5',6,6'-Octachlorobiphenyl	0.041	µg/kg	U	R	0.041	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,5',6,6'-Octachlorobiphenyl	0.041	µg/kg	U	R	0.041	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,5',6,6'-Octachlorobiphenyl	0.041	µg/kg	U	R	0.041	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,5',6,6'-Octachlorobiphenyl	0.041	µg/kg	U	R	0.041	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,5',6,6'-Octachlorobiphenyl	0.041	µg/kg	U	R	0.041	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,5',6,6'-Octachlorobiphenyl	0.041	µg/kg	U	R	0.041	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,5',6,6'-Octachlorobiphenyl	0.041	µg/kg	U	R	0.041	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,5',6,6'-Octachlorobiphenyl	0.041	µg/kg	U	R	0.041	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,5',6,6'-Octachlorobiphenyl	0.041	µg/kg	U	R	0.041	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,5',6,6'-Octachlorobiphenyl	0.041	µg/kg	U	R	0.041	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,5',6,6'-Octachlorobiphenyl	0.041	µg/kg	U	R	0.041	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,5',6,6'-Octachlorobiphenyl	0.041	µg/kg	U	R	0.041	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,5',6,6'-Octachlorobiphenyl	0.041	µg/kg	U	R	0.041	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,5',6'-Heptachlorobiphenyl	0.052	µg/kg	U	R	0.052	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,5',6'-Heptachlorobiphenyl	0.052	µg/kg	U	R	0.052	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,5',6'-Heptachlorobiphenyl	0.052	µg/kg	U	R	0.052	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,5',6'-Heptachlorobiphenyl	0.052	µg/kg	U	R	0.052	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,5',6'-Heptachlorobiphenyl	0.052	µg/kg	U	R	0.052	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,5',6'-Heptachlorobiphenyl	0.052	µg/kg	U	R	0.052	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,5',6'-Heptachlorobiphenyl	0.052	µg/kg	U	R	0.052	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,5',6'-Heptachlorobiphenyl	0.052	µg/kg	U	R	0.052	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,5',6'-Heptachlorobiphenyl	0.052	µg/kg	U	R	0.052	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,5',6'-Heptachlorobiphenyl	0.052	µg/kg	U	R	0.052	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,5',6'-Heptachlorobiphenyl	0.052	µg/kg	U	R	0.052	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,5',6'-Heptachlorobiphenyl	0.052	µg/kg	U	R	0.052	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,5',6'-Heptachlorobiphenyl	0.052	µg/kg	U	R	0.052	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,3',4,5',6'-Heptachlorobiphenyl	0.052	µg/kg	U	R	0.052	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5,5'-Heptachlorobiphenyl	0.095	µg/kg	U	R	0.095	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5,5'-Heptachlorobiphenyl	0.095	µg/kg	U	R	0.095	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5,5'-Heptachlorobiphenyl	0.095	µg/kg	U	R	0.095	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5,5'-Heptachlorobiphenyl	0.095	µg/kg	U	R	0.095	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5,5'-Heptachlorobiphenyl	0.095	µg/kg	U	R	0.095	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5,5'-Heptachlorobiphenyl	0.095	µg/kg	U	R	0.095	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5,5'-Heptachlorobiphenyl	0.095	µg/kg	U	R	0.095	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5,5'-Heptachlorobiphenyl	0.095	µg/kg	U	R	0.095	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5,5'-Heptachlorobiphenyl	0.095	µg/kg	U	R	0.095	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5,5'-Heptachlorobiphenyl	0.095	µg/kg	U	R	0.095	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5,5'-Heptachlorobiphenyl	0.095	µg/kg	U	R	0.095	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5,5'-Heptachlorobiphenyl	0.095	µg/kg	U	R	0.095	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5,5'-Heptachlorobiphenyl	0.095	µg/kg	U	R	0.095	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5,5'-Heptachlorobiphenyl	0.095	µg/kg	U	R	0.095	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5',6-Heptachlorobiphenyl	0.081	µg/kg	U	R	0.081	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5',6-Heptachlorobiphenyl	0.081	µg/kg	U	R	0.081	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5',6-Heptachlorobiphenyl	0.081	µg/kg	U	R	0.081	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5',6-Heptachlorobiphenyl	0.081	µg/kg	U	R	0.081	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5',6-Heptachlorobiphenyl	0.081	µg/kg	U	R	0.081	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5',6-Heptachlorobiphenyl	0.081	µg/kg	U	R	0.081	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5',6-Heptachlorobiphenyl	0.081	µg/kg	U	R	0.081	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5',6-Heptachlorobiphenyl	0.081	µg/kg	U	R	0.081	0.28

Table 4-1. Summary of Sediment Sample Rejected Data

Location ID	Sample Delivery Group	Sample ID	Sample Collection Date/Time	Sample Material	Media Analyzed	Basis	Analyte	Concentration	Units	Lab Qualifier	Validator Qualifier	MDL	MRL
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5',6-Heptachlorobiphenyl	0.081	µg/kg	U	R	0.081	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5',6-Heptachlorobiphenyl	0.081	µg/kg	U	R	0.081	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5',6-Heptachlorobiphenyl	0.081	µg/kg	U	R	0.081	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5',6-Heptachlorobiphenyl	0.081	µg/kg	U	R	0.081	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5',6-Heptachlorobiphenyl	0.081	µg/kg	U	R	0.081	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5',6-Heptachlorobiphenyl	0.081	µg/kg	U	R	0.081	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5'-Hexachlorobiphenyl	0.064	µg/kg	U	R	0.064	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5'-Hexachlorobiphenyl	0.064	µg/kg	U	R	0.064	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5'-Hexachlorobiphenyl	0.064	µg/kg	U	R	0.064	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5'-Hexachlorobiphenyl	0.064	µg/kg	U	R	0.064	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5'-Hexachlorobiphenyl	0.064	µg/kg	U	R	0.064	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5'-Hexachlorobiphenyl	0.064	µg/kg	U	R	0.064	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5'-Hexachlorobiphenyl	0.064	µg/kg	U	R	0.064	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5'-Hexachlorobiphenyl	0.064	µg/kg	U	R	0.064	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5'-Hexachlorobiphenyl	0.064	µg/kg	U	R	0.064	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5'-Hexachlorobiphenyl	0.064	µg/kg	U	R	0.064	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5'-Hexachlorobiphenyl	0.064	µg/kg	U	R	0.064	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5'-Hexachlorobiphenyl	0.064	µg/kg	U	R	0.064	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5'-Hexachlorobiphenyl	0.064	µg/kg	U	R	0.064	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,4,4',5'-Hexachlorobiphenyl	0.064	µg/kg	U	R	0.064	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,4',5,5',6-Heptachlorobiphenyl	0.047	µg/kg	U	R	0.047	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,4',5,5',6-Heptachlorobiphenyl	0.047	µg/kg	U	R	0.047	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',3,4',5,5',6-Heptachlorobiphenyl	0.047	µg/kg	U	R	0.047	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',3,4',5,5',6-Heptachlorobiphenyl	0.047	µg/kg	U	R	0.047	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4',5,5',6-Heptachlorobiphenyl	0.047	µg/kg	U	R	0.047	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4',5,5',6-Heptachlorobiphenyl	0.047	µg/kg	U	R	0.047	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4',5,5',6-Heptachlorobiphenyl	0.047	µg/kg	U	R	0.047	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4',5,5',6-Heptachlorobiphenyl	0.047	µg/kg	U	R	0.047	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4',5,5',6-Heptachlorobiphenyl	0.047	µg/kg	U	R	0.047	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4',5,5',6-Heptachlorobiphenyl	0.047	µg/kg	U	R	0.047	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4',5,5',6-Heptachlorobiphenyl	0.047	µg/kg	U	R	0.047	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4',5,5',6-Heptachlorobiphenyl	0.047	µg/kg	U	R	0.047	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,4',5,5',6-Heptachlorobiphenyl	0.047	µg/kg	U	R	0.047	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,4',5,5',6-Heptachlorobiphenyl	0.047	µg/kg	U	R	0.047	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,4',5,6-Hexachlorobiphenyl	0.067	µg/kg	U	R	0.067	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,4',5,6-Hexachlorobiphenyl	0.067	µg/kg	U	R	0.067	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',3,4',5,6-Hexachlorobiphenyl	0.067	µg/kg	U	R	0.067	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',3,4',5,6-Hexachlorobiphenyl	0.067	µg/kg	U	R	0.067	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4',5,6-Hexachlorobiphenyl	0.067	µg/kg	U	R	0.067	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4',5,6-Hexachlorobiphenyl	0.067	µg/kg	U	R	0.067	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4',5,6-Hexachlorobiphenyl	0.067	µg/kg	U	R	0.067	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4',5,6-Hexachlorobiphenyl	0.067	µg/kg	U	R	0.067	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4',5,6-Hexachlorobiphenyl	0.067	µg/kg	U	R	0.067	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4',5,6-Hexachlorobiphenyl	0.067	µg/kg	U	R	0.067	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4',5,6-Hexachlorobiphenyl	0.067	µg/kg	U	R	0.067	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4',5,6-Hexachlorobiphenyl	0.067	µg/kg	U	R	0.067	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,4',5,6-Hexachlorobiphenyl	0.067	µg/kg	U	R	0.067	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,4',5,6-Hexachlorobiphenyl	0.067	µg/kg	U	R	0.067	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,4,5'-Pentachlorobiphenyl	0.038	µg/kg	U	R	0.038	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,4,5'-Pentachlorobiphenyl	0.038	µg/kg	U	R	0.038	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',3,4,5'-Pentachlorobiphenyl	0.038	µg/kg	U	R	0.038	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',3,4,5'-Pentachlorobiphenyl	0.038	µg/kg	U	R	0.038	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4,5'-Pentachlorobiphenyl	0.038	µg/kg	U	R	0.038	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4,5'-Pentachlorobiphenyl	0.038	µg/kg	U	R	0.038	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4,5'-Pentachlorobiphenyl	0.038	µg/kg	U	R	0.038	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4,5'-Pentachlorobiphenyl	0.038	µg/kg	U	R	0.038	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4,5'-Pentachlorobiphenyl	0.038	µg/kg	U	R	0.038	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4,5'-Pentachlorobiphenyl	0.038	µg/kg	U	R	0.038	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4,5'-Pentachlorobiphenyl	0.038	µg/kg	U	R	0.038	0.32

Table 4-1. Summary of Sediment Sample Rejected Data

Location ID	Sample Delivery Group	Sample ID	Sample Collection Date/Time	Sample Material	Media Analyzed	Basis	Analyte	Concentration	Units	Lab Qualifier	Validator Qualifier	MDL	MRL
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,4,5'-Pentachlorobiphenyl	0.038	µg/kg	U	R	0.038	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,4,5'-Pentachlorobiphenyl	0.038	µg/kg	U	R	0.038	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,4,5'-Pentachlorobiphenyl	0.038	µg/kg	U	R	0.038	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,5,5',6-Hexachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,5,5',6-Hexachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',3,5,5',6-Hexachlorobiphenyl	0.16	µg/kg	Ui	R	0.16	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',3,5,5',6-Hexachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,5,5',6-Hexachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,5,5',6-Hexachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,5,5',6-Hexachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,5,5',6-Hexachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,5,5',6-Hexachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,5,5',6-Hexachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,5,5',6-Hexachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,5,5',6-Hexachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,5,5',6-Hexachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,5,5',6-Hexachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,5'-Tetrachlorobiphenyl	0.065	µg/kg	U	R	0.065	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,5'-Tetrachlorobiphenyl	0.065	µg/kg	U	R	0.065	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',3,5'-Tetrachlorobiphenyl	0.065	µg/kg	U	R	0.065	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',3,5'-Tetrachlorobiphenyl	0.065	µg/kg	U	R	0.065	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,5'-Tetrachlorobiphenyl	0.065	µg/kg	U	R	0.065	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,5'-Tetrachlorobiphenyl	0.065	µg/kg	U	R	0.065	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,5'-Tetrachlorobiphenyl	0.065	µg/kg	U	R	0.065	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,5'-Tetrachlorobiphenyl	0.065	µg/kg	U	R	0.065	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,5'-Tetrachlorobiphenyl	0.065	µg/kg	U	R	0.065	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,5'-Tetrachlorobiphenyl	0.065	µg/kg	U	R	0.065	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,5'-Tetrachlorobiphenyl	0.065	µg/kg	U	R	0.065	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',3,5'-Tetrachlorobiphenyl	0.065	µg/kg	U	R	0.065	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,5'-Tetrachlorobiphenyl	0.065	µg/kg	U	R	0.065	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',3,5'-Tetrachlorobiphenyl	0.065	µg/kg	U	R	0.065	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',4,4',5,5'-Hexachlorobiphenyl	0.038	µg/kg	U	R	0.038	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',4,4',5,5'-Hexachlorobiphenyl	0.038	µg/kg	U	R	0.038	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',4,4',5,5'-Hexachlorobiphenyl	0.038	µg/kg	U	R	0.038	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',4,4',5,5'-Hexachlorobiphenyl	0.038	µg/kg	U	R	0.038	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',4,4',5,5'-Hexachlorobiphenyl	0.038	µg/kg	U	R	0.038	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',4,4',5,5'-Hexachlorobiphenyl	0.038	µg/kg	U	R	0.038	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',4,4',5,5'-Hexachlorobiphenyl	0.038	µg/kg	U	R	0.038	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',4,4',5,5'-Hexachlorobiphenyl	0.038	µg/kg	U	R	0.038	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',4,4',5,5'-Hexachlorobiphenyl	0.038	µg/kg	U	R	0.038	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',4,4',5,5'-Hexachlorobiphenyl	0.038	µg/kg	U	R	0.038	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',4,4',5,5'-Hexachlorobiphenyl	0.038	µg/kg	U	R	0.038	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',4,4',5,5'-Hexachlorobiphenyl	0.038	µg/kg	U	R	0.038	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',4,4',5,5'-Hexachlorobiphenyl	0.038	µg/kg	U	R	0.038	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',4,4',5,5'-Hexachlorobiphenyl	0.038	µg/kg	U	R	0.038	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',4,4',5-Pentachlorobiphenyl	0.045	µg/kg	U	R	0.045	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',4,4',5-Pentachlorobiphenyl	0.045	µg/kg	U	R	0.045	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',4,4',5-Pentachlorobiphenyl	0.045	µg/kg	U	R	0.045	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',4,4',5-Pentachlorobiphenyl	0.045	µg/kg	U	R	0.045	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',4,4',5-Pentachlorobiphenyl	0.045	µg/kg	U	R	0.045	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',4,4',5-Pentachlorobiphenyl	0.045	µg/kg	U	R	0.045	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',4,4',5-Pentachlorobiphenyl	0.045	µg/kg	U	R	0.045	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',4,4',5-Pentachlorobiphenyl	0.045	µg/kg	U	R	0.045	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',4,4',5-Pentachlorobiphenyl	0.045	µg/kg	U	R	0.045	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',4,4',5-Pentachlorobiphenyl	0.045	µg/kg	U	R	0.045	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',4,4',5-Pentachlorobiphenyl	0.045	µg/kg	U	R	0.045	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',4,4',5-Pentachlorobiphenyl	0.045	µg/kg	U	R	0.045	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',4,4',5-Pentachlorobiphenyl	0.045	µg/kg	U	R	0.045	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',4,4',5-Pentachlorobiphenyl	0.045	µg/kg	U	R	0.045	0.32

Table 4-1. Summary of Sediment Sample Rejected Data

Location ID	Sample Delivery Group	Sample ID	Sample Collection Date/Time	Sample Material	Media Analyzed	Basis	Analyte	Concentration	Units	Lab Qualifier	Validator Qualifier	MDL	MRL
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',4,5,5'-Pentachlorobiphenyl	0.049	µg/kg	U	R	0.049	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',4,5,5'-Pentachlorobiphenyl	0.049	µg/kg	U	R	0.049	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',4,5,5'-Pentachlorobiphenyl	0.049	µg/kg	U	R	0.049	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',4,5,5'-Pentachlorobiphenyl	0.049	µg/kg	U	R	0.049	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',4,5,5'-Pentachlorobiphenyl	0.049	µg/kg	U	R	0.049	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',4,5,5'-Pentachlorobiphenyl	0.049	µg/kg	U	R	0.049	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',4,5,5'-Pentachlorobiphenyl	0.049	µg/kg	U	R	0.049	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',4,5,5'-Pentachlorobiphenyl	0.049	µg/kg	U	R	0.049	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',4,5,5'-Pentachlorobiphenyl	0.049	µg/kg	U	R	0.049	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',4,5,5'-Pentachlorobiphenyl	0.049	µg/kg	U	R	0.049	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',4,5,5'-Pentachlorobiphenyl	0.049	µg/kg	U	R	0.049	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',4,5,5'-Pentachlorobiphenyl	0.049	µg/kg	U	R	0.049	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',4,5,5'-Pentachlorobiphenyl	0.049	µg/kg	U	R	0.049	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',4,5,5'-Pentachlorobiphenyl	0.049	µg/kg	U	R	0.049	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',4,5'-Tetrachlorobiphenyl	0.058	µg/kg	U	R	0.058	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',4,5'-Tetrachlorobiphenyl	0.058	µg/kg	U	R	0.058	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',4,5'-Tetrachlorobiphenyl	0.058	µg/kg	U	R	0.058	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',4,5'-Tetrachlorobiphenyl	0.058	µg/kg	U	R	0.058	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',4,5'-Tetrachlorobiphenyl	0.058	µg/kg	U	R	0.058	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',4,5'-Tetrachlorobiphenyl	0.058	µg/kg	U	R	0.058	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',4,5'-Tetrachlorobiphenyl	0.058	µg/kg	U	R	0.058	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',4,5'-Tetrachlorobiphenyl	0.058	µg/kg	U	R	0.058	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',4,5'-Tetrachlorobiphenyl	0.058	µg/kg	U	R	0.058	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',4,5'-Tetrachlorobiphenyl	0.058	µg/kg	U	R	0.058	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',4,5'-Tetrachlorobiphenyl	0.058	µg/kg	U	R	0.058	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',4,5'-Tetrachlorobiphenyl	0.058	µg/kg	U	R	0.058	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',4,5'-Tetrachlorobiphenyl	0.058	µg/kg	U	R	0.058	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',4,5'-Tetrachlorobiphenyl	0.058	µg/kg	U	R	0.058	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',5,5'-Tetrachlorobiphenyl	0.059	µg/kg	U	R	0.059	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',5,5'-Tetrachlorobiphenyl	0.059	µg/kg	U	R	0.059	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',5,5'-Tetrachlorobiphenyl	0.059	µg/kg	U	R	0.059	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',5,5'-Tetrachlorobiphenyl	0.059	µg/kg	U	R	0.059	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',5,5'-Tetrachlorobiphenyl	0.059	µg/kg	U	R	0.059	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',5,5'-Tetrachlorobiphenyl	0.059	µg/kg	U	R	0.059	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',5,5'-Tetrachlorobiphenyl	0.059	µg/kg	U	R	0.059	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',5,5'-Tetrachlorobiphenyl	0.059	µg/kg	U	R	0.059	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',5,5'-Tetrachlorobiphenyl	0.059	µg/kg	U	R	0.059	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',5,5'-Tetrachlorobiphenyl	0.059	µg/kg	U	R	0.059	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',5,5'-Tetrachlorobiphenyl	0.059	µg/kg	U	R	0.059	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',5,5'-Tetrachlorobiphenyl	0.059	µg/kg	U	R	0.059	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',5,5'-Tetrachlorobiphenyl	0.059	µg/kg	U	R	0.059	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',5,5'-Tetrachlorobiphenyl	0.059	µg/kg	U	R	0.059	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',5-Trichlorobiphenyl	0.096	µg/kg	U	R	0.096	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',5-Trichlorobiphenyl	0.096	µg/kg	U	R	0.096	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',5-Trichlorobiphenyl	0.096	µg/kg	U	R	0.096	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,2',5-Trichlorobiphenyl	0.096	µg/kg	U	R	0.096	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',5-Trichlorobiphenyl	0.096	µg/kg	U	R	0.096	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',5-Trichlorobiphenyl	0.096	µg/kg	U	R	0.096	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',5-Trichlorobiphenyl	0.096	µg/kg	U	R	0.096	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',5-Trichlorobiphenyl	0.096	µg/kg	U	R	0.096	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',5-Trichlorobiphenyl	0.096	µg/kg	U	R	0.096	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',5-Trichlorobiphenyl	0.096	µg/kg	U	R	0.096	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',5-Trichlorobiphenyl	0.096	µg/kg	U	R	0.096	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,2',5-Trichlorobiphenyl	0.096	µg/kg	U	R	0.096	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',5-Trichlorobiphenyl	0.096	µg/kg	U	R	0.096	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,2',5-Trichlorobiphenyl	0.096	µg/kg	U	R	0.096	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5,5'-Heptachlorobiphenyl	0.029	µg/kg	U	R	0.029	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5,5'-Heptachlorobiphenyl	0.029	µg/kg	U	R	0.029	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5,5'-Heptachlorobiphenyl	0.029	µg/kg	U	R	0.029	0.3

Table 4-1. Summary of Sediment Sample Rejected Data

Location ID	Sample Delivery Group	Sample ID	Sample Collection Date/Time	Sample Material	Media Analyzed	Basis	Analyte	Concentration	Units	Lab Qualifier	Validator Qualifier	MDL	MRL
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5,5'-Heptachlorobiphenyl	0.029	µg/kg	U	R	0.029	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5,5'-Heptachlorobiphenyl	0.029	µg/kg	U	R	0.029	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5,5'-Heptachlorobiphenyl	0.029	µg/kg	U	R	0.029	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5,5'-Heptachlorobiphenyl	0.029	µg/kg	U	R	0.029	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5,5'-Heptachlorobiphenyl	0.029	µg/kg	U	R	0.029	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5,5'-Heptachlorobiphenyl	0.029	µg/kg	U	R	0.029	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5,5'-Heptachlorobiphenyl	0.029	µg/kg	U	R	0.029	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5,5'-Heptachlorobiphenyl	0.029	µg/kg	U	R	0.029	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5,5'-Heptachlorobiphenyl	0.029	µg/kg	U	R	0.029	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5,5'-Heptachlorobiphenyl	0.029	µg/kg	U	R	0.029	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5,5'-Heptachlorobiphenyl	0.029	µg/kg	U	R	0.029	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5'-Hexachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5'-Hexachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5'-Hexachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5'-Hexachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5'-Hexachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5'-Hexachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5'-Hexachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5'-Hexachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5'-Hexachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5'-Hexachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5'-Hexachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5'-Hexachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5'-Hexachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5'-Hexachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5-Hexachlorobiphenyl	0.042	µg/kg	U	R	0.042	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5-Hexachlorobiphenyl	0.042	µg/kg	U	R	0.042	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5-Hexachlorobiphenyl	0.042	µg/kg	U	R	0.042	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5-Hexachlorobiphenyl	0.042	µg/kg	U	R	0.042	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5-Hexachlorobiphenyl	0.042	µg/kg	U	R	0.042	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5-Hexachlorobiphenyl	0.042	µg/kg	U	R	0.042	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5-Hexachlorobiphenyl	0.042	µg/kg	U	R	0.042	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5-Hexachlorobiphenyl	0.042	µg/kg	U	R	0.042	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5-Hexachlorobiphenyl	0.042	µg/kg	U	R	0.042	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5-Hexachlorobiphenyl	0.042	µg/kg	U	R	0.042	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5-Hexachlorobiphenyl	0.042	µg/kg	U	R	0.042	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5-Hexachlorobiphenyl	0.042	µg/kg	U	R	0.042	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5-Hexachlorobiphenyl	0.042	µg/kg	U	R	0.042	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',5-Hexachlorobiphenyl	0.042	µg/kg	U	R	0.042	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',6-Hexachlorobiphenyl	0.028	µg/kg	U	R	0.028	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',6-Hexachlorobiphenyl	0.028	µg/kg	U	R	0.028	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',6-Hexachlorobiphenyl	0.028	µg/kg	U	R	0.028	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',6-Hexachlorobiphenyl	0.028	µg/kg	U	R	0.028	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',6-Hexachlorobiphenyl	0.028	µg/kg	U	R	0.028	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',6-Hexachlorobiphenyl	0.028	µg/kg	U	R	0.028	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',6-Hexachlorobiphenyl	0.028	µg/kg	U	R	0.028	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',6-Hexachlorobiphenyl	0.028	µg/kg	U	R	0.028	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',6-Hexachlorobiphenyl	0.028	µg/kg	U	R	0.028	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',6-Hexachlorobiphenyl	0.028	µg/kg	U	R	0.028	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',6-Hexachlorobiphenyl	0.028	µg/kg	U	R	0.028	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',6-Hexachlorobiphenyl	0.028	µg/kg	U	R	0.028	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',6-Hexachlorobiphenyl	0.028	µg/kg	U	R	0.028	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3,3',4,4',6-Hexachlorobiphenyl	0.028	µg/kg	U	R	0.028	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3,3',4,4'-Pentachlorobiphenyl	0.033	µg/kg	U	R	0.033	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3,3',4,4'-Pentachlorobiphenyl	0.033	µg/kg	U	R	0.033	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,3,3',4,4'-Pentachlorobiphenyl	0.033	µg/kg	U	R	0.033	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,3,3',4,4'-Pentachlorobiphenyl	0.033	µg/kg	U	R	0.033	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4'-Pentachlorobiphenyl	0.033	µg/kg	U	R	0.033	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4'-Pentachlorobiphenyl	0.033	µg/kg	U	R	0.033	0.28

Table 4-1. Summary of Sediment Sample Rejected Data

Location ID	Sample Delivery Group	Sample ID	Sample Collection Date/Time	Sample Material	Media Analyzed	Basis	Analyte	Concentration	Units	Lab Qualifier	Validator Qualifier	MDL	MRL
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4'-Pentachlorobiphenyl	0.033	µg/kg	U	R	0.033	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4'-Pentachlorobiphenyl	0.033	µg/kg	U	R	0.033	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4'-Pentachlorobiphenyl	0.033	µg/kg	U	R	0.033	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4'-Pentachlorobiphenyl	0.033	µg/kg	U	R	0.033	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4'-Pentachlorobiphenyl	0.033	µg/kg	U	R	0.033	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4,4'-Pentachlorobiphenyl	0.033	µg/kg	U	R	0.033	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3,3',4,4'-Pentachlorobiphenyl	0.033	µg/kg	U	R	0.033	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3,3',4,4'-Pentachlorobiphenyl	0.033	µg/kg	U	R	0.033	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3,3',4',6-Pentachlorobiphenyl	0.035	µg/kg	U	R	0.035	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3,3',4',6-Pentachlorobiphenyl	0.035	µg/kg	U	R	0.035	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,3,3',4',6-Pentachlorobiphenyl	0.035	µg/kg	U	R	0.035	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,3,3',4',6-Pentachlorobiphenyl	0.035	µg/kg	U	R	0.035	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4',6-Pentachlorobiphenyl	0.035	µg/kg	U	R	0.035	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4',6-Pentachlorobiphenyl	0.035	µg/kg	U	R	0.035	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4',6-Pentachlorobiphenyl	0.035	µg/kg	U	R	0.035	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4',6-Pentachlorobiphenyl	0.035	µg/kg	U	R	0.035	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4',6-Pentachlorobiphenyl	0.035	µg/kg	U	R	0.035	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4',6-Pentachlorobiphenyl	0.035	µg/kg	U	R	0.035	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4',6-Pentachlorobiphenyl	0.035	µg/kg	U	R	0.035	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,3',4',6-Pentachlorobiphenyl	0.035	µg/kg	U	R	0.035	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3,3',4',6-Pentachlorobiphenyl	0.035	µg/kg	U	R	0.035	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3,3',4',6-Pentachlorobiphenyl	0.035	µg/kg	U	R	0.035	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3',4,4',5,5'-Hexachlorobiphenyl	0.046	µg/kg	U	R	0.046	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3',4,4',5,5'-Hexachlorobiphenyl	0.046	µg/kg	U	R	0.046	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,3',4,4',5,5'-Hexachlorobiphenyl	0.046	µg/kg	U	R	0.046	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,3',4,4',5,5'-Hexachlorobiphenyl	0.046	µg/kg	U	R	0.046	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',5,5'-Hexachlorobiphenyl	0.046	µg/kg	U	R	0.046	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',5,5'-Hexachlorobiphenyl	0.046	µg/kg	U	R	0.046	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',5,5'-Hexachlorobiphenyl	0.046	µg/kg	U	R	0.046	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',5,5'-Hexachlorobiphenyl	0.046	µg/kg	U	R	0.046	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',5,5'-Hexachlorobiphenyl	0.046	µg/kg	U	R	0.046	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',5,5'-Hexachlorobiphenyl	0.046	µg/kg	U	R	0.046	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',5,5'-Hexachlorobiphenyl	0.046	µg/kg	U	R	0.046	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',5,5'-Hexachlorobiphenyl	0.046	µg/kg	U	R	0.046	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3',4,4',5,5'-Hexachlorobiphenyl	0.046	µg/kg	U	R	0.046	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3',4,4',5,5'-Hexachlorobiphenyl	0.046	µg/kg	U	R	0.046	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3',4,4',5,6-Hexachlorobiphenyl	0.027	µg/kg	U	R	0.027	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3',4,4',5,6-Hexachlorobiphenyl	0.027	µg/kg	U	R	0.027	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,3',4,4',5,6-Hexachlorobiphenyl	0.027	µg/kg	U	R	0.027	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,3',4,4',5,6-Hexachlorobiphenyl	0.027	µg/kg	U	R	0.027	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',5,6-Hexachlorobiphenyl	0.027	µg/kg	U	R	0.027	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',5,6-Hexachlorobiphenyl	0.027	µg/kg	U	R	0.027	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',5,6-Hexachlorobiphenyl	0.027	µg/kg	U	R	0.027	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',5,6-Hexachlorobiphenyl	0.027	µg/kg	U	R	0.027	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',5,6-Hexachlorobiphenyl	0.027	µg/kg	U	R	0.027	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',5,6-Hexachlorobiphenyl	0.027	µg/kg	U	R	0.027	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',5,6-Hexachlorobiphenyl	0.027	µg/kg	U	R	0.027	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',5,6-Hexachlorobiphenyl	0.027	µg/kg	U	R	0.027	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3',4,4',5,6-Hexachlorobiphenyl	0.027	µg/kg	U	R	0.027	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3',4,4',5,6-Hexachlorobiphenyl	0.027	µg/kg	U	R	0.027	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3,4,4',5-Pentachlorobiphenyl	0.023	µg/kg	U	R	0.023	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3,4,4',5-Pentachlorobiphenyl	0.023	µg/kg	U	R	0.023	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,3,4,4',5-Pentachlorobiphenyl	0.023	µg/kg	U	R	0.023	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,3,4,4',5-Pentachlorobiphenyl	0.023	µg/kg	U	R	0.023	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,4,4',5-Pentachlorobiphenyl	0.023	µg/kg	U	R	0.023	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,4,4',5-Pentachlorobiphenyl	0.023	µg/kg	U	R	0.023	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,4,4',5-Pentachlorobiphenyl	0.023	µg/kg	U	R	0.023	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,4,4',5-Pentachlorobiphenyl	0.023	µg/kg	U	R	0.023	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,4,4',5-Pentachlorobiphenyl	0.023	µg/kg	U	R	0.023	0.3

Table 4-1. Summary of Sediment Sample Rejected Data

Location ID	Sample Delivery Group	Sample ID	Sample Collection Date/Time	Sample Material	Media Analyzed	Basis	Analyte	Concentration	Units	Lab Qualifier	Validator Qualifier	MDL	MRL
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,4,4',5-Pentachlorobiphenyl	0.023	µg/kg	U	R	0.023	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,4,4',5-Pentachlorobiphenyl	0.023	µg/kg	U	R	0.023	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3,4,4',5-Pentachlorobiphenyl	0.023	µg/kg	U	R	0.023	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3,4,4',5-Pentachlorobiphenyl	0.023	µg/kg	U	R	0.023	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3,4,4',5-Pentachlorobiphenyl	0.023	µg/kg	U	R	0.023	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3',4,4',5'-Pentachlorobiphenyl	0.067	µg/kg	U	R	0.067	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3',4,4',5'-Pentachlorobiphenyl	0.067	µg/kg	U	R	0.067	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,3',4,4',5'-Pentachlorobiphenyl	0.067	µg/kg	U	R	0.067	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,3',4,4',5'-Pentachlorobiphenyl	0.067	µg/kg	U	R	0.067	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',5'-Pentachlorobiphenyl	0.067	µg/kg	U	R	0.067	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',5'-Pentachlorobiphenyl	0.067	µg/kg	U	R	0.067	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',5'-Pentachlorobiphenyl	0.067	µg/kg	U	R	0.067	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',5'-Pentachlorobiphenyl	0.067	µg/kg	U	R	0.067	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',5'-Pentachlorobiphenyl	0.067	µg/kg	U	R	0.067	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',5'-Pentachlorobiphenyl	0.067	µg/kg	U	R	0.067	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',5'-Pentachlorobiphenyl	0.067	µg/kg	U	R	0.067	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',5'-Pentachlorobiphenyl	0.067	µg/kg	U	R	0.067	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3',4,4',5'-Pentachlorobiphenyl	0.067	µg/kg	U	R	0.067	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3',4,4',5'-Pentachlorobiphenyl	0.067	µg/kg	U	R	0.067	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3',4,4',5-Pentachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3',4,4',5-Pentachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,3',4,4',5-Pentachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,3',4,4',5-Pentachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',5-Pentachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',5-Pentachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',5-Pentachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',5-Pentachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',5-Pentachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',5-Pentachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',5-Pentachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',5-Pentachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3',4,4',5-Pentachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3',4,4',5-Pentachlorobiphenyl	0.031	µg/kg	U	R	0.031	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3',4,4',6-Pentachlorobiphenyl	0.046	µg/kg	U	R	0.046	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3',4,4',6-Pentachlorobiphenyl	0.046	µg/kg	U	R	0.046	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,3',4,4',6-Pentachlorobiphenyl	0.046	µg/kg	U	R	0.046	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,3',4,4',6-Pentachlorobiphenyl	0.046	µg/kg	U	R	0.046	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',6-Pentachlorobiphenyl	0.046	µg/kg	U	R	0.046	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',6-Pentachlorobiphenyl	0.046	µg/kg	U	R	0.046	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',6-Pentachlorobiphenyl	0.046	µg/kg	U	R	0.046	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',6-Pentachlorobiphenyl	0.046	µg/kg	U	R	0.046	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',6-Pentachlorobiphenyl	0.046	µg/kg	U	R	0.046	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',6-Pentachlorobiphenyl	0.046	µg/kg	U	R	0.046	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',6-Pentachlorobiphenyl	0.046	µg/kg	U	R	0.046	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4',6-Pentachlorobiphenyl	0.046	µg/kg	U	R	0.046	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3',4,4',6-Pentachlorobiphenyl	0.046	µg/kg	U	R	0.046	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3',4,4',6-Pentachlorobiphenyl	0.046	µg/kg	U	R	0.046	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3',4,4'-Tetrachlorobiphenyl	0.035	µg/kg	U	R	0.035	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3',4,4'-Tetrachlorobiphenyl	0.035	µg/kg	U	R	0.035	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,3',4,4'-Tetrachlorobiphenyl	0.035	µg/kg	U	R	0.035	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,3',4,4'-Tetrachlorobiphenyl	0.035	µg/kg	U	R	0.035	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4'-Tetrachlorobiphenyl	0.035	µg/kg	U	R	0.035	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4'-Tetrachlorobiphenyl	0.035	µg/kg	U	R	0.035	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4'-Tetrachlorobiphenyl	0.035	µg/kg	U	R	0.035	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4'-Tetrachlorobiphenyl	0.035	µg/kg	U	R	0.035	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4'-Tetrachlorobiphenyl	0.035	µg/kg	U	R	0.035	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4'-Tetrachlorobiphenyl	0.035	µg/kg	U	R	0.035	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4'-Tetrachlorobiphenyl	0.035	µg/kg	U	R	0.035	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4,4'-Tetrachlorobiphenyl	0.035	µg/kg	U	R	0.035	0.31

Table 4-1. Summary of Sediment Sample Rejected Data

Location ID	Sample Delivery Group	Sample ID	Sample Collection Date/Time	Sample Material	Media Analyzed	Basis	Analyte	Concentration	Units	Lab Qualifier	Validator Qualifier	MDL	MRL
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3',4,4'-Tetrachlorobiphenyl	0.035	µg/kg	U	R	0.035	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3',4,4'-Tetrachlorobiphenyl	0.035	µg/kg	U	R	0.035	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3',4',5-Tetrachlorobiphenyl	0.051	µg/kg	U	R	0.051	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3',4',5-Tetrachlorobiphenyl	0.051	µg/kg	U	R	0.051	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,3',4',5-Tetrachlorobiphenyl	0.051	µg/kg	U	R	0.051	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,3',4',5-Tetrachlorobiphenyl	0.051	µg/kg	U	R	0.051	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4',5-Tetrachlorobiphenyl	0.051	µg/kg	U	R	0.051	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4',5-Tetrachlorobiphenyl	0.051	µg/kg	U	R	0.051	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4',5-Tetrachlorobiphenyl	0.051	µg/kg	U	R	0.051	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4',5-Tetrachlorobiphenyl	0.051	µg/kg	U	R	0.051	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4',5-Tetrachlorobiphenyl	0.051	µg/kg	U	R	0.051	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4',5-Tetrachlorobiphenyl	0.051	µg/kg	U	R	0.051	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4',5-Tetrachlorobiphenyl	0.051	µg/kg	U	R	0.051	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,3',4',5-Tetrachlorobiphenyl	0.051	µg/kg	U	R	0.051	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3',4',5-Tetrachlorobiphenyl	0.051	µg/kg	U	R	0.051	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,3',4',5-Tetrachlorobiphenyl	0.051	µg/kg	U	R	0.051	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,4,4',5-Tetrachlorobiphenyl	0.044	µg/kg	U	R	0.044	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,4,4',5-Tetrachlorobiphenyl	0.044	µg/kg	U	R	0.044	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,4,4',5-Tetrachlorobiphenyl	0.044	µg/kg	U	R	0.044	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,4,4',5-Tetrachlorobiphenyl	0.044	µg/kg	U	R	0.044	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4,4',5-Tetrachlorobiphenyl	0.044	µg/kg	U	R	0.044	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4,4',5-Tetrachlorobiphenyl	0.044	µg/kg	U	R	0.044	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4,4',5-Tetrachlorobiphenyl	0.044	µg/kg	U	R	0.044	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4,4',5-Tetrachlorobiphenyl	0.044	µg/kg	U	R	0.044	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4,4',5-Tetrachlorobiphenyl	0.044	µg/kg	U	R	0.044	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4,4',5-Tetrachlorobiphenyl	0.044	µg/kg	U	R	0.044	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4,4',5-Tetrachlorobiphenyl	0.044	µg/kg	U	R	0.044	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4,4',5-Tetrachlorobiphenyl	0.044	µg/kg	U	R	0.044	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,4,4',5-Tetrachlorobiphenyl	0.044	µg/kg	U	R	0.044	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,4,4',5-Tetrachlorobiphenyl	0.044	µg/kg	U	R	0.044	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,4,4'-Trichlorobiphenyl	0.064	µg/kg	U	R	0.064	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,4,4'-Trichlorobiphenyl	0.064	µg/kg	U	R	0.064	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,4,4'-Trichlorobiphenyl	0.064	µg/kg	U	R	0.064	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,4,4'-Trichlorobiphenyl	0.064	µg/kg	U	R	0.064	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4,4'-Trichlorobiphenyl	0.064	µg/kg	U	R	0.064	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4,4'-Trichlorobiphenyl	0.064	µg/kg	U	R	0.064	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4,4'-Trichlorobiphenyl	0.064	µg/kg	U	R	0.064	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4,4'-Trichlorobiphenyl	0.064	µg/kg	U	R	0.064	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4,4'-Trichlorobiphenyl	0.064	µg/kg	U	R	0.064	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4,4'-Trichlorobiphenyl	0.064	µg/kg	U	R	0.064	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4,4'-Trichlorobiphenyl	0.064	µg/kg	U	R	0.064	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4,4'-Trichlorobiphenyl	0.064	µg/kg	U	R	0.064	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,4,4'-Trichlorobiphenyl	0.064	µg/kg	U	R	0.064	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,4,4'-Trichlorobiphenyl	0.064	µg/kg	U	R	0.064	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,4'-DDD	0.13	µg/kg	U	R	0.13	0.53
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,4'-DDD	0.13	µg/kg	U	R	0.13	0.54
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,4'-DDD	0.13	µg/kg	U	R	0.13	0.59
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,4'-DDD	0.13	µg/kg	U	R	0.13	0.58
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4'-DDD	0.13	µg/kg	U	R	0.13	0.56
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4'-DDD	0.13	µg/kg	U	R	0.13	0.55
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4'-DDD	0.13	µg/kg	U	R	0.13	0.55
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4'-DDD	0.13	µg/kg	U	R	0.13	0.56
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4'-DDD	0.13	µg/kg	U	R	0.13	0.59
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4'-DDD	0.13	µg/kg	U	R	0.13	0.58
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4'-DDD	0.13	µg/kg	U	R	0.13	0.63
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4'-DDD	0.13	µg/kg	U	R	0.13	0.61
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,4'-DDD	0.13	µg/kg	U	R	0.13	0.6
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,4'-DDD	0.13	µg/kg	U	R	0.13	0.64
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,4'-DDE	0.16	µg/kg	U	R	0.16	0.53

Table 4-1. Summary of Sediment Sample Rejected Data

Location ID	Sample Delivery Group	Sample ID	Sample Collection Date/Time	Sample Material	Media Analyzed	Basis	Analyte	Concentration	Units	Lab Qualifier	Validator Qualifier	MDL	MRL
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,4'-DDE	0.16	µg/kg	U	R	0.16	0.54
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,4'-DDE	0.16	µg/kg	U	R	0.16	0.59
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,4'-DDE	0.16	µg/kg	U	R	0.16	0.58
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4'-DDE	0.16	µg/kg	U	R	0.16	0.56
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4'-DDE	0.16	µg/kg	U	R	0.16	0.55
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4'-DDE	0.16	µg/kg	U	R	0.16	0.55
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4'-DDE	0.16	µg/kg	U	R	0.16	0.56
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4'-DDE	0.16	µg/kg	U	R	0.16	0.59
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4'-DDE	0.16	µg/kg	U	R	0.16	0.58
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4'-DDE	0.16	µg/kg	U	R	0.16	0.63
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4'-DDE	0.16	µg/kg	U	R	0.16	0.61
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,4'-DDE	0.16	µg/kg	U	R	0.16	0.6
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,4'-DDE	0.16	µg/kg	U	R	0.16	0.64
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,4'-DDT	0.058	µg/kg	U	R	0.058	0.53
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,4'-DDT	0.058	µg/kg	U	R	0.058	0.54
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,4'-DDT	0.058	µg/kg	U	R	0.058	0.59
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,4'-DDT	0.058	µg/kg	U	R	0.058	0.58
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4'-DDT	0.058	µg/kg	U	R	0.058	0.56
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4'-DDT	0.058	µg/kg	U	R	0.058	0.55
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4'-DDT	0.058	µg/kg	U	R	0.058	0.55
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4'-DDT	0.058	µg/kg	U	R	0.058	0.56
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4'-DDT	0.058	µg/kg	U	R	0.058	0.59
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4'-DDT	0.058	µg/kg	U	R	0.058	0.58
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4'-DDT	0.058	µg/kg	U	R	0.058	0.63
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4'-DDT	0.058	µg/kg	U	R	0.058	0.61
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,4'-DDT	0.058	µg/kg	U	R	0.058	0.6
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,4'-DDT	0.058	µg/kg	U	R	0.058	0.64
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,4'-Dichlorobiphenyl	0.21	µg/kg	U	R	0.21	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,4'-Dichlorobiphenyl	0.21	µg/kg	U	R	0.21	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	2,4'-Dichlorobiphenyl	0.21	µg/kg	U	R	0.21	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	2,4'-Dichlorobiphenyl	0.21	µg/kg	U	R	0.21	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4'-Dichlorobiphenyl	0.21	µg/kg	U	R	0.21	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4'-Dichlorobiphenyl	0.21	µg/kg	U	R	0.21	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4'-Dichlorobiphenyl	0.21	µg/kg	U	R	0.21	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4'-Dichlorobiphenyl	0.21	µg/kg	U	R	0.21	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4'-Dichlorobiphenyl	0.21	µg/kg	U	R	0.21	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4'-Dichlorobiphenyl	0.21	µg/kg	U	R	0.21	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4'-Dichlorobiphenyl	0.21	µg/kg	U	R	0.21	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	2,4'-Dichlorobiphenyl	0.21	µg/kg	U	R	0.21	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	2,4'-Dichlorobiphenyl	0.21	µg/kg	U	R	0.21	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	2,4'-Dichlorobiphenyl	0.21	µg/kg	U	R	0.21	0.32
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	2-Methylnaphthalene	0.46	µg/kg	U	R	0.46	2.7
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	3,3',4,4',5,5'-Hexachlorobiphenyl	0.041	µg/kg	U	R	0.041	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	3,3',4,4',5,5'-Hexachlorobiphenyl	0.041	µg/kg	U	R	0.041	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	3,3',4,4',5,5'-Hexachlorobiphenyl	0.041	µg/kg	U	R	0.041	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	3,3',4,4',5,5'-Hexachlorobiphenyl	0.041	µg/kg	U	R	0.041	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	3,3',4,4',5,5'-Hexachlorobiphenyl	0.041	µg/kg	U	R	0.041	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	3,3',4,4',5,5'-Hexachlorobiphenyl	0.041	µg/kg	U	R	0.041	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	3,3',4,4',5,5'-Hexachlorobiphenyl	0.041	µg/kg	U	R	0.041	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	3,3',4,4',5,5'-Hexachlorobiphenyl	0.041	µg/kg	U	R	0.041	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	3,3',4,4',5,5'-Hexachlorobiphenyl	0.041	µg/kg	U	R	0.041	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	3,3',4,4',5,5'-Hexachlorobiphenyl	0.041	µg/kg	U	R	0.041	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	3,3',4,4',5,5'-Hexachlorobiphenyl	0.041	µg/kg	U	R	0.041	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	3,3',4,4',5,5'-Hexachlorobiphenyl	0.041	µg/kg	U	R	0.041	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	3,3',4,4',5,5'-Hexachlorobiphenyl	0.041	µg/kg	U	R	0.041	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	3,3',4,4',5,5'-Hexachlorobiphenyl	0.041	µg/kg	U	R	0.041	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	3,3',4,4',5-Pentachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	3,3',4,4',5-Pentachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	3,3',4,4',5-Pentachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.3

Table 4-1. Summary of Sediment Sample Rejected Data

Location ID	Sample Delivery Group	Sample ID	Sample Collection Date/Time	Sample Material	Media Analyzed	Basis	Analyte	Concentration	Units	Lab Qualifier	Validator Qualifier	MDL	MRL
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	3,3',4,4',5-Pentachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	3,3',4,4',5-Pentachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	3,3',4,4',5-Pentachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	3,3',4,4',5-Pentachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	3,3',4,4',5-Pentachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	3,3',4,4',5-Pentachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	3,3',4,4',5-Pentachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	3,3',4,4',5-Pentachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	3,3',4,4',5-Pentachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	3,3',4,4',5-Pentachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	3,3',4,4',5-Pentachlorobiphenyl	0.043	µg/kg	U	R	0.043	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	3,3',4,4'-Tetrachlorobiphenyl	0.047	µg/kg	U	R	0.047	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	3,3',4,4'-Tetrachlorobiphenyl	0.047	µg/kg	U	R	0.047	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	3,3',4,4'-Tetrachlorobiphenyl	0.047	µg/kg	U	R	0.047	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	3,3',4,4'-Tetrachlorobiphenyl	0.047	µg/kg	U	R	0.047	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	3,3',4,4'-Tetrachlorobiphenyl	0.047	µg/kg	U	R	0.047	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	3,3',4,4'-Tetrachlorobiphenyl	0.047	µg/kg	U	R	0.047	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	3,3',4,4'-Tetrachlorobiphenyl	0.047	µg/kg	U	R	0.047	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	3,3',4,4'-Tetrachlorobiphenyl	0.047	µg/kg	U	R	0.047	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	3,3',4,4'-Tetrachlorobiphenyl	0.047	µg/kg	U	R	0.047	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	3,3',4,4'-Tetrachlorobiphenyl	0.047	µg/kg	U	R	0.047	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	3,3',4,4'-Tetrachlorobiphenyl	0.047	µg/kg	U	R	0.047	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	3,3',4,4'-Tetrachlorobiphenyl	0.047	µg/kg	U	R	0.047	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	3,3',4,4'-Tetrachlorobiphenyl	0.047	µg/kg	U	R	0.047	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	3,3',4,4'-Tetrachlorobiphenyl	0.047	µg/kg	U	R	0.047	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	3,4,4',5-Tetrachlorobiphenyl	0.05	µg/kg	U	R	0.05	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	3,4,4',5-Tetrachlorobiphenyl	0.05	µg/kg	U	R	0.05	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	3,4,4',5-Tetrachlorobiphenyl	0.05	µg/kg	U	R	0.05	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	3,4,4',5-Tetrachlorobiphenyl	0.05	µg/kg	U	R	0.05	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	3,4,4',5-Tetrachlorobiphenyl	0.05	µg/kg	U	R	0.05	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	3,4,4',5-Tetrachlorobiphenyl	0.05	µg/kg	U	R	0.05	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	3,4,4',5-Tetrachlorobiphenyl	0.05	µg/kg	U	R	0.05	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	3,4,4',5-Tetrachlorobiphenyl	0.05	µg/kg	U	R	0.05	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	3,4,4',5-Tetrachlorobiphenyl	0.05	µg/kg	U	R	0.05	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	3,4,4',5-Tetrachlorobiphenyl	0.05	µg/kg	U	R	0.05	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	3,4,4',5-Tetrachlorobiphenyl	0.05	µg/kg	U	R	0.05	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	3,4,4',5-Tetrachlorobiphenyl	0.05	µg/kg	U	R	0.05	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	3,4,4',5-Tetrachlorobiphenyl	0.05	µg/kg	U	R	0.05	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	3,4,4',5-Tetrachlorobiphenyl	0.05	µg/kg	U	R	0.05	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	3,4,4'-Trichlorobiphenyl	0.052	µg/kg	U	R	0.052	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	3,4,4'-Trichlorobiphenyl	0.052	µg/kg	U	R	0.052	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	3,4,4'-Trichlorobiphenyl	0.052	µg/kg	U	R	0.052	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	3,4,4'-Trichlorobiphenyl	0.052	µg/kg	U	R	0.052	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	3,4,4'-Trichlorobiphenyl	0.052	µg/kg	U	R	0.052	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	3,4,4'-Trichlorobiphenyl	0.052	µg/kg	U	R	0.052	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	3,4,4'-Trichlorobiphenyl	0.052	µg/kg	U	R	0.052	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	3,4,4'-Trichlorobiphenyl	0.052	µg/kg	U	R	0.052	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	3,4,4'-Trichlorobiphenyl	0.052	µg/kg	U	R	0.052	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	3,4,4'-Trichlorobiphenyl	0.052	µg/kg	U	R	0.052	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	3,4,4'-Trichlorobiphenyl	0.052	µg/kg	U	R	0.052	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	3,4,4'-Trichlorobiphenyl	0.052	µg/kg	U	R	0.052	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	3,4,4'-Trichlorobiphenyl	0.052	µg/kg	U	R	0.052	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	3,4,4'-Trichlorobiphenyl	0.052	µg/kg	U	R	0.052	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	4,4'-DDD	0.11	µg/kg	U	R	0.11	0.53
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	4,4'-DDD	0.11	µg/kg	U	R	0.11	0.54
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	4,4'-DDD	0.11	µg/kg	U	R	0.11	0.59
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	4,4'-DDD	0.11	µg/kg	U	R	0.11	0.58
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	4,4'-DDD	0.11	µg/kg	U	R	0.11	0.56
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	4,4'-DDD	0.11	µg/kg	U	R	0.11	0.55

Table 4-1. Summary of Sediment Sample Rejected Data

Location ID	Sample Delivery Group	Sample ID	Sample Collection Date/Time	Sample Material	Media Analyzed	Basis	Analyte	Concentration	Units	Lab Qualifier	Validator Qualifier	MDL	MRL
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	4,4'-DDD	0.11	µg/kg	U	R	0.11	0.55
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	4,4'-DDD	0.11	µg/kg	U	R	0.11	0.56
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	4,4'-DDD	0.11	µg/kg	U	R	0.11	0.59
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	4,4'-DDD	0.11	µg/kg	U	R	0.11	0.58
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	4,4'-DDD	0.11	µg/kg	U	R	0.11	0.63
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	4,4'-DDD	0.11	µg/kg	U	R	0.11	0.61
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	4,4'-DDD	0.11	µg/kg	U	R	0.11	0.6
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	4,4'-DDD	0.11	µg/kg	U	R	0.11	0.64
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	4,4'-DDE	0.11	µg/kg	U	R	0.11	0.53
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	4,4'-DDE	0.14	µg/kg	Ui	R	0.14	0.54
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	4,4'-DDE	0.25	µg/kg	Ui	R	0.25	0.59
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	4,4'-DDE	0.11	µg/kg	U	R	0.11	0.58
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	4,4'-DDE	0.11	µg/kg	U	R	0.11	0.56
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	4,4'-DDE	0.11	µg/kg	U	R	0.11	0.55
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	4,4'-DDE	0.11	µg/kg	U	R	0.11	0.55
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	4,4'-DDE	0.18	µg/kg	Ui	R	0.18	0.56
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	4,4'-DDE	0.15	µg/kg	Ui	R	0.15	0.59
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	4,4'-DDE	0.15	µg/kg	Ui	R	0.15	0.58
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	4,4'-DDE	0.11	µg/kg	U	R	0.11	0.63
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	4,4'-DDE	0.11	µg/kg	U	R	0.11	0.61
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	4,4'-DDE	0.11	µg/kg	U	R	0.11	0.6
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	4,4'-DDE	0.21	µg/kg	Ui	R	0.21	0.64
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	4,4'-DDT	0.17	µg/kg	U	R	0.17	0.53
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	4,4'-DDT	0.17	µg/kg	U	R	0.17	0.54
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	4,4'-DDT	0.17	µg/kg	U	R	0.17	0.59
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	4,4'-DDT	0.17	µg/kg	U	R	0.17	0.58
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	4,4'-DDT	0.17	µg/kg	U	R	0.17	0.56
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	4,4'-DDT	0.17	µg/kg	U	R	0.17	0.55
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	4,4'-DDT	0.17	µg/kg	U	R	0.17	0.55
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	4,4'-DDT	0.17	µg/kg	U	R	0.17	0.56
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	4,4'-DDT	0.17	µg/kg	U	R	0.17	0.59
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	4,4'-DDT	0.17	µg/kg	U	R	0.17	0.58
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	4,4'-DDT	0.17	µg/kg	U	R	0.17	0.63
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	4,4'-DDT	0.17	µg/kg	U	R	0.17	0.61
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	4,4'-DDT	0.17	µg/kg	U	R	0.17	0.6
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	4,4'-DDT	0.17	µg/kg	U	R	0.17	0.64
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Acenaphthene	0.76	µg/kg	U	R	0.76	2.6
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	Acenaphthene	0.76	µg/kg	U	R	0.76	2.7
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	Acenaphthene	0.76	µg/kg	U	R	0.76	2.9
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	Acenaphthene	0.76	µg/kg	U	R	0.76	2.9
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Acenaphthene	0.76	µg/kg	U	R	0.76	2.8
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Acenaphthene	0.76	µg/kg	U	R	0.76	2.8
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Acenaphthene	0.76	µg/kg	U	R	0.76	2.7
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Acenaphthene	0.76	µg/kg	U	R	0.76	2.8
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Acenaphthene	0.76	µg/kg	U	R	0.76	3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Acenaphthene	0.76	µg/kg	U	R	0.76	2.9
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Acenaphthene	0.76	µg/kg	U	R	0.76	3.1
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Acenaphthene	0.76	µg/kg	U	R	0.76	3.1
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Acenaphthene	0.76	µg/kg	U	R	0.76	2.9
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	Acenaphthene	0.76	µg/kg	U	R	0.76	3.2
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Acenaphthylene	0.59	µg/kg	U	R	0.59	2.6
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	Acenaphthylene	0.59	µg/kg	U	R	0.59	2.7
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	Acenaphthylene	0.59	µg/kg	U	R	0.59	2.9
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	Acenaphthylene	0.59	µg/kg	U	R	0.59	2.9
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Acenaphthylene	0.59	µg/kg	U	R	0.59	2.7
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Acenaphthylene	0.59	µg/kg	U	R	0.59	2.8
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Acenaphthylene	0.59	µg/kg	U	R	0.59	3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Acenaphthylene	0.59	µg/kg	U	R	0.59	2.9
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Acenaphthylene	0.59	µg/kg	U	R	0.59	3.1

Table 4-1. Summary of Sediment Sample Rejected Data

Location ID	Sample Delivery Group	Sample ID	Sample Collection Date/Time	Sample Material	Media Analyzed	Basis	Analyte	Concentration	Units	Lab Qualifier	Validator Qualifier	MDL	MRL
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Acenaphthylene	0.59	µg/kg	U	R	0.59	3.1
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Acenaphthylene	0.59	µg/kg	U	R	0.59	2.9
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	Acenaphthylene	0.59	µg/kg	U	R	0.59	3.2
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Anthracene	0.58	µg/kg	U	R	0.58	2.6
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	Anthracene	0.58	µg/kg	U	R	0.58	2.7
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	Anthracene	0.58	µg/kg	U	R	0.58	2.9
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	Anthracene	0.58	µg/kg	U	R	0.58	2.9
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Anthracene	0.58	µg/kg	U	R	0.58	2.7
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Anthracene	0.58	µg/kg	U	R	0.58	2.8
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Anthracene	0.58	µg/kg	U	R	0.58	3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Anthracene	0.58	µg/kg	U	R	0.58	2.9
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Anthracene	0.58	µg/kg	U	R	0.58	3.1
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Anthracene	0.58	µg/kg	U	R	0.58	3.1
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Anthracene	0.58	µg/kg	U	R	0.58	2.9
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	Anthracene	0.58	µg/kg	U	R	0.58	3.2
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Benzo(e)pyrene	0.61	µg/kg	U	R	0.61	2.6
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	Benzo(e)pyrene	0.61	µg/kg	U	R	0.61	2.9
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	Benzo(e)pyrene	0.61	µg/kg	U	R	0.61	2.9
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Benzo(e)pyrene	0.61	µg/kg	U	R	0.61	2.7
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Benzo(e)pyrene	0.61	µg/kg	U	R	0.61	2.8
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Benzo(e)pyrene	0.61	µg/kg	U	R	0.61	2.9
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Benzo(e)pyrene	0.61	µg/kg	U	R	0.61	3.1
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Benzo(e)pyrene	0.61	µg/kg	U	R	0.61	2.9
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	Benzo(e)pyrene	0.61	µg/kg	U	R	0.61	3.2
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	Benzo[a]anthracene	0.72	µg/kg	U	R	0.72	2.9
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	Benzo[a]anthracene	0.72	µg/kg	U	R	0.72	2.9
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Benzo[a]anthracene	0.72	µg/kg	U	R	0.72	2.7
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Benzo[a]anthracene	0.72	µg/kg	U	R	0.72	2.8
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Benzo[a]anthracene	0.72	µg/kg	U	R	0.72	2.9
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Benzo[a]anthracene	0.72	µg/kg	U	R	0.72	3.1
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Benzo[a]anthracene	0.72	µg/kg	U	R	0.72	3.1
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Benzo[a]anthracene	0.72	µg/kg	U	R	0.72	2.9
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	Benzo[a]anthracene	0.72	µg/kg	U	R	0.72	3.2
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Benzo[a]pyrene	0.76	µg/kg	U	R	0.76	2.6
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	Benzo[a]pyrene	0.76	µg/kg	U	R	0.76	2.7
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	Benzo[a]pyrene	2.1	µg/kg	Ui	R	2.1	2.9
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	Benzo[a]pyrene	1.7	µg/kg	Ui	R	1.7	2.9
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Benzo[a]pyrene	0.76	µg/kg	U	R	0.76	2.7
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Benzo[a]pyrene	0.76	µg/kg	U	R	0.76	2.8
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Benzo[a]pyrene	0.76	µg/kg	U	R	0.76	2.9
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Benzo[a]pyrene	0.76	µg/kg	U	R	0.76	3.1
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Benzo[a]pyrene	0.76	µg/kg	U	R	0.76	3.1
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Benzo[a]pyrene	0.76	µg/kg	U	R	0.76	2.9
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	Benzo[a]pyrene	0.76	µg/kg	U	R	0.76	3.2
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Benzo[b]fluoranthene	0.92	µg/kg	U	R	0.92	2.6
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	Benzo[b]fluoranthene	0.92	µg/kg	U	R	0.92	2.7
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	Benzo[b]fluoranthene	0.92	µg/kg	U	R	0.92	2.9
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	Benzo[b]fluoranthene	0.92	µg/kg	U	R	0.92	2.9
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Benzo[b]fluoranthene	0.92	µg/kg	U	R	0.92	2.7
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Benzo[b]fluoranthene	0.92	µg/kg	U	R	0.92	2.8
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Benzo[b]fluoranthene	0.92	µg/kg	U	R	0.92	2.9
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Benzo[b]fluoranthene	0.92	µg/kg	U	R	0.92	3.1
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Benzo[b]fluoranthene	0.92	µg/kg	U	R	0.92	2.9
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	Benzo[b]fluoranthene	0.92	µg/kg	U	R	0.92	3.2
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Benzo[g,h,i]perylene	0.85	µg/kg	U	R	0.85	2.6
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	Benzo[g,h,i]perylene	0.85	µg/kg	U	R	0.85	2.7
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	Benzo[g,h,i]perylene	0.85	µg/kg	U	R	0.85	2.9
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	Benzo[g,h,i]perylene	0.85	µg/kg	U	R	0.85	2.9
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Benzo[g,h,i]perylene	0.85	µg/kg	U	R	0.85	2.7

Table 4-1. Summary of Sediment Sample Rejected Data

Location ID	Sample Delivery Group	Sample ID	Sample Collection Date/Time	Sample Material	Media Analyzed	Basis	Analyte	Concentration	Units	Lab Qualifier	Validator Qualifier	MDL	MRL
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Benzo[g,h,i]perylene	0.85	µg/kg	U	R	0.85	2.8
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Benzo[g,h,i]perylene	0.85	µg/kg	U	R	0.85	2.9
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Benzo[g,h,i]perylene	0.85	µg/kg	U	R	0.85	3.1
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Benzo[g,h,i]perylene	0.85	µg/kg	U	R	0.85	3.1
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Benzo[g,h,i]perylene	0.85	µg/kg	U	R	0.85	2.9
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	Benzo[g,h,i]perylene	0.85	µg/kg	U	R	0.85	3.2
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Benzo[k]fluoranthene	0.87	µg/kg	U	R	0.87	2.6
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	Benzo[k]fluoranthene	0.87	µg/kg	U	R	0.87	2.7
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	Benzo[k]fluoranthene	0.87	µg/kg	U	R	0.87	2.9
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	Benzo[k]fluoranthene	0.87	µg/kg	U	R	0.87	2.9
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Benzo[k]fluoranthene	0.87	µg/kg	U	R	0.87	2.7
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Benzo[k]fluoranthene	0.87	µg/kg	U	R	0.87	2.8
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Benzo[k]fluoranthene	0.87	µg/kg	U	R	0.87	3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Benzo[k]fluoranthene	0.87	µg/kg	U	R	0.87	2.9
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Benzo[k]fluoranthene	0.87	µg/kg	U	R	0.87	3.1
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Benzo[k]fluoranthene	0.87	µg/kg	U	R	0.87	3.1
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Benzo[k]fluoranthene	0.87	µg/kg	U	R	0.87	2.9
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	Benzo[k]fluoranthene	0.87	µg/kg	U	R	0.87	3.2
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Carbazole	2.3	µg/kg	U	R	2.3	2.6
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	Carbazole	2.3	µg/kg	U	R	2.3	2.7
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	Carbazole	2.3	µg/kg	U	R	2.3	2.9
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	Carbazole	2.3	µg/kg	U	R	2.3	2.9
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Carbazole	2.3	µg/kg	U	R	2.3	2.8
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Carbazole	2.3	µg/kg	U	R	2.3	2.7
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Carbazole	2.3	µg/kg	U	R	2.3	2.8
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Carbazole	2.3	µg/kg	U	R	2.3	3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Carbazole	2.3	µg/kg	U	R	2.3	2.9
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Carbazole	2.3	µg/kg	U	R	2.3	3.1
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Carbazole	2.3	µg/kg	U	R	2.3	3.1
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Carbazole	2.3	µg/kg	U	R	2.3	2.9
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	Carbazole	2.3	µg/kg	U	R	2.3	3.2
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Chrysene	0.8	µg/kg	U	R	0.8	2.6
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	Chrysene	0.8	µg/kg	U	R	0.8	2.9
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	Chrysene	0.8	µg/kg	U	R	0.8	2.9
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Chrysene	0.8	µg/kg	U	R	0.8	2.7
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Chrysene	0.8	µg/kg	U	R	0.8	2.8
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Chrysene	0.8	µg/kg	U	R	0.8	2.9
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Chrysene	0.8	µg/kg	U	R	0.8	3.1
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Chrysene	0.8	µg/kg	U	R	0.8	3.1
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Chrysene	0.8	µg/kg	U	R	0.8	2.9
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	Chrysene	0.8	µg/kg	U	R	0.8	3.2
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Decachlorobiphenyl (PCB 209)	0.041	µg/kg	U	R	0.041	0.27
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	Decachlorobiphenyl (PCB 209)	0.041	µg/kg	U	R	0.041	0.27
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	Decachlorobiphenyl (PCB 209)	0.041	µg/kg	U	R	0.041	0.3
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	Decachlorobiphenyl (PCB 209)	0.041	µg/kg	U	R	0.041	0.29
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Decachlorobiphenyl (PCB 209)	0.041	µg/kg	U	R	0.041	0.28
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Decachlorobiphenyl (PCB 209)	0.041	µg/kg	U	R	0.041	0.28
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Decachlorobiphenyl (PCB 209)	0.041	µg/kg	U	R	0.041	0.28
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Decachlorobiphenyl (PCB 209)	0.041	µg/kg	U	R	0.041	0.28
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Decachlorobiphenyl (PCB 209)	0.041	µg/kg	U	R	0.041	0.3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Decachlorobiphenyl (PCB 209)	0.041	µg/kg	U	R	0.041	0.29
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Decachlorobiphenyl (PCB 209)	0.041	µg/kg	U	R	0.041	0.32
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Decachlorobiphenyl (PCB 209)	0.041	µg/kg	U	R	0.041	0.31
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Decachlorobiphenyl (PCB 209)	0.041	µg/kg	U	R	0.041	0.3
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	Decachlorobiphenyl (PCB 209)	0.041	µg/kg	U	R	0.041	0.32
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Dibenzo[a,h]anthracene	0.8	µg/kg	U	R	0.8	2.6
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	Dibenzo[a,h]anthracene	0.8	µg/kg	U	R	0.8	2.7
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	Dibenzo[a,h]anthracene	0.8	µg/kg	U	R	0.8	2.9
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	Dibenzo[a,h]anthracene	0.8	µg/kg	U	R	0.8	2.9

Table 4-1. Summary of Sediment Sample Rejected Data

Location ID	Sample Delivery Group	Sample ID	Sample Collection Date/Time	Sample Material	Media Analyzed	Basis	Analyte	Concentration	Units	Lab Qualifier	Validator Qualifier	MDL	MRL
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Dibenzo[a,h]anthracene	0.8	µg/kg	U	R	0.8	2.7
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Dibenzo[a,h]anthracene	0.8	µg/kg	U	R	0.8	2.8
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Dibenzo[a,h]anthracene	0.8	µg/kg	U	R	0.8	3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Dibenzo[a,h]anthracene	0.8	µg/kg	U	R	0.8	2.9
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Dibenzo[a,h]anthracene	0.8	µg/kg	U	R	0.8	3.1
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Dibenzo[a,h]anthracene	0.8	µg/kg	U	R	0.8	3.1
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Dibenzo[a,h]anthracene	0.8	µg/kg	U	R	0.8	2.9
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	Dibenzo[a,h]anthracene	0.8	µg/kg	U	R	0.8	3.2
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Dibenzothiophene	0.4	µg/kg	U	R	0.4	2.6
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	Dibenzothiophene	0.4	µg/kg	U	R	0.4	2.7
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	Dibenzothiophene	0.4	µg/kg	U	R	0.4	2.9
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	Dibenzothiophene	0.4	µg/kg	U	R	0.4	2.9
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Dibenzothiophene	0.4	µg/kg	U	R	0.4	2.8
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Dibenzothiophene	0.4	µg/kg	U	R	0.4	2.8
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Dibenzothiophene	0.4	µg/kg	U	R	0.4	2.7
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Dibenzothiophene	0.4	µg/kg	U	R	0.4	2.8
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Dibenzothiophene	0.4	µg/kg	U	R	0.4	3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Dibenzothiophene	0.4	µg/kg	U	R	0.4	2.9
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Dibenzothiophene	0.4	µg/kg	U	R	0.4	3.1
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Dibenzothiophene	0.4	µg/kg	U	R	0.4	3.1
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Dibenzothiophene	0.4	µg/kg	U	R	0.4	2.9
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	Dibenzothiophene	0.4	µg/kg	U	R	0.4	3.2
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	Fluoranthene	0.98	µg/kg	U	R	0.98	2.9
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	Fluoranthene	0.98	µg/kg	U	R	0.98	2.9
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Fluoranthene	0.98	µg/kg	U	R	0.98	2.7
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Fluoranthene	0.98	µg/kg	U	R	0.98	2.8
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Fluoranthene	0.98	µg/kg	U	R	0.98	2.9
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Fluoranthene	0.98	µg/kg	U	R	0.98	3.1
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Fluoranthene	0.98	µg/kg	U	R	0.98	3.1
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Fluoranthene	0.98	µg/kg	U	R	0.98	2.9
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	Fluoranthene	0.98	µg/kg	U	R	0.98	3.2
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Fluorene	0.61	µg/kg	U	R	0.61	2.6
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	Fluorene	0.61	µg/kg	U	R	0.61	2.9
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	Fluorene	0.61	µg/kg	U	R	0.61	2.9
LALL	K1007678	LALL definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Fluorene	0.61	µg/kg	U	R	0.61	2.8
LALL	K1007678	LALL definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Fluorene	0.61	µg/kg	U	R	0.61	2.8
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Fluorene	0.61	µg/kg	U	R	0.61	2.7
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Fluorene	0.61	µg/kg	U	R	0.61	2.8
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Fluorene	0.61	µg/kg	U	R	0.61	3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Fluorene	0.61	µg/kg	U	R	0.61	2.9
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Fluorene	0.61	µg/kg	U	R	0.61	3.1
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Fluorene	0.61	µg/kg	U	R	0.61	3.1
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Fluorene	0.61	µg/kg	U	R	0.61	2.9
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	Fluorene	0.61	µg/kg	U	R	0.61	3.2
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Indeno[1,2,3-cd]pyrene	0.87	µg/kg	U	R	0.87	2.6
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	Indeno[1,2,3-cd]pyrene	0.87	µg/kg	U	R	0.87	2.7
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	Indeno[1,2,3-cd]pyrene	0.87	µg/kg	U	R	0.87	2.9
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	Indeno[1,2,3-cd]pyrene	0.87	µg/kg	U	R	0.87	2.9
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Indeno[1,2,3-cd]pyrene	0.87	µg/kg	U	R	0.87	2.7
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Indeno[1,2,3-cd]pyrene	0.87	µg/kg	U	R	0.87	2.8
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Indeno[1,2,3-cd]pyrene	0.87	µg/kg	U	R	0.87	3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Indeno[1,2,3-cd]pyrene	0.87	µg/kg	U	R	0.87	2.9
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Indeno[1,2,3-cd]pyrene	0.87	µg/kg	U	R	0.87	3.1
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Indeno[1,2,3-cd]pyrene	0.87	µg/kg	U	R	0.87	3.1
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Indeno[1,2,3-cd]pyrene	0.87	µg/kg	U	R	0.87	2.9
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	Indeno[1,2,3-cd]pyrene	0.87	µg/kg	U	R	0.87	3.2
GE	K1009298	GE-D INF SED_0820	2010-08-20 00:00:00	Sediment	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
GE	K1009298	GE-D MID SED_0820	2010-08-20 00:00:00	Sediment	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
GE	K1009298	GE-D OUF SED_0820	2010-08-20 00:00:00	Sediment	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25

Table 4-1. Summary of Sediment Sample Rejected Data

Location ID	Sample Delivery Group	Sample ID	Sample Collection Date/Time	Sample Material	Media Analyzed	Basis	Analyte	Concentration	Units	Lab Qualifier	Validator Qualifier	MDL	MRL
LALL	K1009302	LALL-B INF SED_0820	2010-08-20 00:00:00	Sediment	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
LALL	K1009302	LALL-B MID SED_0820	2010-08-20 00:00:00	Sediment	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
LALL	K1009302	LALL-B OUF SED_0820	2010-08-20 00:00:00	Sediment	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
LALL	K1009301	LALL-D INF SED_0820	2010-08-20 00:00:00	Sediment	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
LALL	K1009301	LALL-D MID SED_0820	2010-08-20 00:00:00	Sediment	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
LALL	K1009301	LALL-D OUF SED_0820	2010-08-20 00:00:00	Sediment	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
LD-01	K1009301	LD-01-A MID SED_0820	2010-08-20 00:00:00	Sediment	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
LD-01	K1009301	LD-01-A OUF SED_0820	2010-08-20 00:00:00	Sediment	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
QC	K1009298	Ctrl-B INF SED_0820	2010-08-20 00:00:00	Sediment	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
QC	K1009298	Ctrl-B MID SED_0820	2010-08-20 00:00:00	Sediment	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
QC	K1009298	Ctrl-B OUF SED_0820	2010-08-20 00:00:00	Sediment	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
QC	K1009298	Ctrl-C INF SED_0820	2010-08-20 00:00:00	Sediment	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
QC	K1009298	Ctrl-C MID SED_0820	2010-08-20 00:00:00	Sediment	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
QC	K1009298	Ctrl-C OUF SED_0820	2010-08-20 00:00:00	Sediment	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
QC	K1009303	H2O-D INF BTM_0820	2010-08-20 00:00:00	Sediment	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
QC	K1009303	H2O-D MID BTM_0820	2010-08-20 00:00:00	Sediment	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
QC	K1009303	H2O-D OUF BTM_0820	2010-08-20 00:00:00	Sediment	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Perylene	0.72	µg/kg	U	R	0.72	2.6
DME	K1007678	DE definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	Perylene	0.72	µg/kg	U	R	0.72	2.7
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	Perylene	0.72	µg/kg	U	R	0.72	2.9
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	Perylene	0.72	µg/kg	U	R	0.72	2.9
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Perylene	0.72	µg/kg	U	R	0.72	2.7
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Perylene	0.72	µg/kg	U	R	0.72	2.8
LMF-02	K1007678	LMF-02 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Perylene	0.72	µg/kg	U	R	0.72	3
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Perylene	0.72	µg/kg	U	R	0.72	2.9
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Perylene	0.72	µg/kg	U	R	0.72	3.1
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Perylene	0.72	µg/kg	U	R	0.72	3.1
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Perylene	0.72	µg/kg	U	R	0.72	2.9
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	Perylene	0.72	µg/kg	U	R	0.72	3.2
DME	K1007678	DE definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Phenanthrene	1.4	µg/kg	U	R	1.4	2.6
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	Phenanthrene	1.4	µg/kg	U	R	1.4	2.9
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	Phenanthrene	1.4	µg/kg	U	R	1.4	2.9
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Phenanthrene	1.4	µg/kg	U	R	1.4	2.7
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Phenanthrene	1.4	µg/kg	U	R	1.4	2.8
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Phenanthrene	1.4	µg/kg	U	R	1.4	2.9
NP-03	K1007678	NP-03 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Phenanthrene	1.4	µg/kg	U	R	1.4	3.1
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Phenanthrene	1.4	µg/kg	U	R	1.4	3.1
GE	K1007678	GE definitive rep 1	2010-07-15 00:00:00	Sediment	Definitive	dw	Pyrene	0.76	µg/kg	U	R	0.76	2.9
GE	K1007678	GE definitive rep 2	2010-07-15 00:00:00	Sediment	Definitive	dw	Pyrene	0.76	µg/kg	U	R	0.76	2.9
LD-01	K1007678	LD-01 definitive rep 1	2010-07-16 00:00:00	Sediment	Definitive	dw	Pyrene	0.76	µg/kg	U	R	0.76	2.7
LD-01	K1007678	LD-01 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Pyrene	0.76	µg/kg	U	R	0.76	2.8
LMF-02	K1007678	LMF-02 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Pyrene	0.76	µg/kg	U	R	0.76	2.9
NP-03	K1007678	NP-03 definitive rep 2	2010-07-16 00:00:00	Sediment	Definitive	dw	Pyrene	0.76	µg/kg	U	R	0.76	3.1
QC	K1007678	Lab ref. definitive rep 1	2010-07-17 00:00:00	Sediment	Definitive	dw	Pyrene	0.76	µg/kg	U	R	0.76	2.9
QC	K1007678	Lab ref. definitive rep 2	2010-07-17 00:00:00	Sediment	Definitive	dw	Pyrene	0.76	µg/kg	U	R	0.76	3.2

Notes:
DME - Deadman's Eddy
GE - Genelle Eddy
LALL - Lower Arrow Lakes
LD - Little Dalles
LMF - Lower Marcus Flats
LOD - level of detection
LOQ - level of quantification
MDL - method detection limit
MRL - method reporting limit
NP - Northport
QC - quality control
R - unusable result; analyte may or may not be present in this sample
U - this analyte was not detected at or above the associated detection limit
Ui - the analyte was analyzed for, but was not detected ("non-detect") at or above the MRL/MDL; the MRL/MDL or LOQ/LOD is elevated due to a matrix interference

Table 4-2. Summary of Water Sample Rejected Data

Location ID	Sample Delivery Group	Sample ID	Sample Collection Date/Time	Sample Material	Media Analyzed	Basis	Analyte	Concentration	Units	Lab Qualifier	Validator Qualifier	MDL	MRL
Blank_SedTox10	K1008731	Blank_0811	2010-08-11 00:00:00	Water	Blank	Dissolved	Calcium	6	µg/L	U	R	6	50
Blank_SedTox10	K1008889	SWI Ctrl RNS_0816	2010-08-16 00:00:00	Rinsate	SWI	Dissolved	Calcium	6	µg/L	U	R	6	50
Blank_SedTox10	K1008889	SWI LALL RNS_0816	2010-08-16 00:00:00	Rinsate	SWI	Dissolved	Calcium	6	µg/L	U	R	6	50
Blank_SedTox10	K1009652	PW Ctrl Rinsate_0906	2010-09-06 00:00:00	Rinsate	Porewater	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
Blank_SedTox10	K1009652	PW DE Rinsate_0906	2010-09-06 00:00:00	Rinsate	Porewater	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
Blank_SedTox10	K1009644	PW GE Rinsate_0906	2010-09-06 00:00:00	Rinsate	Porewater	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
Blank_SedTox10	K1009652	PW LD-01 RNS_0906	2010-09-06 00:00:00	Rinsate	Porewater	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
Blank_SedTox10	K1009644	PW LMF-02 RNS_0906	2010-09-06 00:00:00	Rinsate	Porewater	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
Blank_SedTox10	K1009644	PW NP-03 RNS_0906	2010-09-06 00:00:00	Rinsate	Porewater	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
Blank_SedTox10	K1009697	SWI DE-B RNS_0906	2010-09-06 00:00:00	Rinsate	SWI	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
Blank_SedTox10	K1009697	SWI GE-C RNS_0906	2010-09-06 00:00:00	Rinsate	SWI	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
Blank_SedTox10	K1009697	SWI LALL-D RNS_0906	2010-09-06 00:00:00	Rinsate	SWI	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
DME	K1009661	OW DE-B_0906	2010-09-06 00:00:00	OverWater	OverWater	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
DME	K1009644	PW DE-B_0906	2010-09-06 00:00:00	Porewater	Porewater	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
GE	K1009697	OW GE-D_0906_2	2010-09-06 00:00:00	OverWater	OverWater	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
LALL	K1009661	OW LALL-B_0906	2010-09-06 00:00:00	OverWater	OverWater	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
LALL	K1009661	OW LALL-E_0906	2010-09-06 00:00:00	OverWater	OverWater	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
LALL	K1009697	SWI LALL-C_0906	2010-09-06 00:00:00	SWI	SWI	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
LD-01	K1009661	OW LD-01-E_0906	2010-09-06 00:00:00	OverWater	OverWater	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
LD-01	K1009697	OW LD-01-F_0906	2010-09-06 00:00:00	OverWater	OverWater	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
LD-01	K1009652	PW LD-01-A_0906	2010-09-06 00:00:00	Porewater	Porewater	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
LD-01	K1009652	PW LD-01-B_0906	2010-09-06 00:00:00	Porewater	Porewater	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
LD-01	K1009697	SWI LD-01-B_0906	2010-09-06 00:00:00	SWI	SWI	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
LD-01	K1009697	SWI LD-01-D_0906	2010-09-06 00:00:00	SWI	SWI	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
LD-01	K1009697	SWI LD-01-E_0906	2010-09-06 00:00:00	SWI	SWI	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
LMF-02	K1009661	OW LMF-02-C_0906	2010-09-06 00:00:00	OverWater	OverWater	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
NP-03	K1009644	PW NP-03-A_0906	2010-09-06 00:00:00	Porewater	Porewater	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
NP-03	K1009644	PW NP-03-B_0906	2010-09-06 00:00:00	Porewater	Porewater	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
QC	K1009661	OW Ctrl-A_0906	2010-09-06 00:00:00	OverWater	OverWater	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
QC	K1009661	OW Ctrl-B_0906	2010-09-06 00:00:00	OverWater	OverWater	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
QC	K1009661	OW Ctrl-C_0906	2010-09-06 00:00:00	OverWater	OverWater	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
QC	K1009661	OW Ctrl-D_0906	2010-09-06 00:00:00	OverWater	OverWater	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
QC	K1009661	OW Ctrl-E_0906	2010-09-06 00:00:00	OverWater	OverWater	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
QC	K1009661	OW Ctrl-F_0906	2010-09-06 00:00:00	OverWater	OverWater	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
QC	K1009661	OW H2O-D_0906	2010-09-06 00:00:00	OverWater	OverWater	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
QC	K1009661	OW H2O-E_0906	2010-09-06 00:00:00	OverWater	OverWater	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
QC	K1009652	PW Ctrl-E_0906	2010-09-06 00:00:00	Porewater	Porewater	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
QC	K1009697	SWI Ctrl-A_0906	2010-09-06 00:00:00	SWI	SWI	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
QC	K1009697	SWI Ctrl-D_0906	2010-09-06 00:00:00	SWI	SWI	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
QC	K1009697	SWI Ctrl-E_0906	2010-09-06 00:00:00	SWI	SWI	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
UMF-01	K1009661	OW UMF-01-C_0906	2010-09-06 00:00:00	OverWater	OverWater	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
UMF-01	K1009697	OW UMF-01-E_0906	2010-09-06 00:00:00	OverWater	OverWater	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
UMF-01	K1009644	PW UMF-01-A_0906	2010-09-06 00:00:00	Porewater	Porewater	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
UMF-01	K1009644	PW UMF-01-B_0906	2010-09-06 00:00:00	Porewater	Porewater	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
UMF-01	K1009644	PW UMF-01-C_0906	2010-09-06 00:00:00	Porewater	Porewater	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
UMF-01	K1009644	PW UMF-01-D_0906	2010-09-06 00:00:00	Porewater	Porewater	Dissolved	Iron	0.8	µg/L	U	R	0.8	20
Blank_SedTox10	K1009407	Blank_0830	2010-08-30 00:00:00	Water	Blank	Dissolved	Molybdenum	0.007	µg/L	U	R	0.007	0.05
Blank_SedTox10	K1009301	Decon Blank 1_0818	2010-08-18 00:00:00	Decon	DGT_Decon_Blank	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
Blank_SedTox10	K1009301	Decon Blank 2_0818	2010-08-18 00:00:00	Decon	DGT_Decon_Blank	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25

Table 4-2. Summary of Water Sample Rejected Data

Location ID	Sample Delivery Group	Sample ID	Sample Collection Date/Time	Sample Material	Media Analyzed	Basis	Analyte	Concentration	Units	Lab Qualifier	Validator Qualifier	MDL	MRL
Blank_SedTox10	K1009301	Decon Blank 3_0818	2010-08-18 00:00:00	Decon	DGT_Decon_Blank	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
Blank_SedTox10	K1009301	Decon Blank 4_0818	2010-08-18 00:00:00	Decon	DGT_Decon_Blank	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
Blank_SedTox10	K1009302	Decon Blank 6_0818	2010-08-18 00:00:00	Decon	DGT_Decon_Blank	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
Blank_SedTox10	K1009303	MB 2_0820	2010-08-20 00:00:00	Water	DGT_Method_Blank	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
Blank_SedTox10	K1009303	MB 3_0820	2010-08-20 00:00:00	Water	DGT_Method_Blank	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
Blank_SedTox10	K1009303	MB 4_0820	2010-08-20 00:00:00	Water	DGT_Method_Blank	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
Blank_SedTox10	K1009305	MB 5_0820	2010-08-20 00:00:00	Water	DGT_Method_Blank	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
Blank_SedTox10	K1009305	MB 6_0820	2010-08-20 00:00:00	Water	DGT_Method_Blank	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
Blank_SedTox10	K1009407	PW Ctrl Rinsate_0830	2010-08-30 00:00:00	Rinsate	Porewater	Dissolved	Molybdenum	0.007	µg/L	U	R	0.007	0.05
Blank_SedTox10	K1009648	PW H2O Rinsate_0906	2010-09-06 00:00:00	Rinsate	Porewater	Dissolved	Molybdenum	0.007	µg/L	U	R	0.007	0.05
Blank_SedTox10	K1009407	PW LALL Rinsate_0830	2010-08-30 00:00:00	Rinsate	Porewater	Dissolved	Molybdenum	0.007	µg/L	U	R	0.007	0.05
Blank_SedTox10	K1009648	PW LALL Rinsate_0906	2010-09-06 00:00:00	Rinsate	Porewater	Dissolved	Molybdenum	0.007	µg/L	U	R	0.007	0.05
Blank_SedTox10	K1009407	PW Rinsate Blank	2010-08-30 00:00:00	Rinsate	Porewater	Dissolved	Molybdenum	0.007	µg/L	U	R	0.007	0.05
Blank_SedTox10	K1009648	PW UMF-01 RNS_0906	2010-09-06 00:00:00	Rinsate	Porewater	Dissolved	Molybdenum	0.007	µg/L	U	R	0.007	0.05
GE	K1009298	GE-D INF H2O_0820	2010-08-20 00:00:00	Water	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
GE	K1009298	GE-D MID H2O_0820	2010-08-20 00:00:00	Water	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
GE	K1009298	GE-D OUF H2O_0820	2010-08-20 00:00:00	Water	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
LALL	K1009302	LALL-B INF H2O_0820	2010-08-20 00:00:00	Water	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
LALL	K1009302	LALL-B MID H2O_0820	2010-08-20 00:00:00	Water	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
LALL	K1009302	LALL-B OUF H2O_0820	2010-08-20 00:00:00	Water	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
LALL	K1009301	LALL-D INF H2O_0820	2010-08-20 00:00:00	Water	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
LALL	K1009301	LALL-D OUF H2O_0820	2010-08-20 00:00:00	Water	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
LD-01	K1009298	LD-01-A INF H2O_0820	2010-08-20 00:00:00	Water	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
LD-01	K1009298	LD-01-A MID H2O_0820	2010-08-20 00:00:00	Water	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
LD-01	K1009302	LD-01-B OUF H2O_0820	2010-08-20 00:00:00	Water	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
LMF-02	K1009303	LMF02-A MID H2O_0820	2010-08-20 00:00:00	Water	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
LMF-02	K1009303	LMF-02-A OUF H2O	2010-08-20 00:00:00	Water	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
QC	K1009298	Ctrl-B INF H2O_0820	2010-08-20 00:00:00	Water	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
QC	K1009298	Ctrl-B MID H2O_0820	2010-08-20 00:00:00	Water	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
QC	K1009298	Ctrl-B OUF H2O_0820	2010-08-20 00:00:00	Water	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
QC	K1009298	Ctrl-C MID H2O_0820	2010-08-20 00:00:00	Water	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
QC	K1009298	Ctrl-C OUF H2O_0820	2010-08-20 00:00:00	Water	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
QC	K1009303	H2O-D MID top_0820	2010-08-20 00:00:00	Water	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
QC	K1009303	H2O-D OUF top_0820	2010-08-20 00:00:00	Water	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25
UMF-01	K1009301	UMF01-B INF H2O_0820	2010-08-20 00:00:00	Water	DGT	Dissolved	Molybdenum	0.035	µg/L	U	R	0.035	0.25

Notes:
DGT - diffusive gradient thin-film
DME - Deadman's Eddy
GE - Genelle Eddy
LALL - Lower Arrow Lakes
LD - Little Dalles
LMF - Lower Marcus Flats
MDL - method detection limit
MRL - method reporting limit
NP - Northport
QC - quality control
R - unusable result; analyte may or may not be present in this sample
SWI - sediment-water interface
U - this analyte was not detected at or above the associated detection limit
UMF - Upper Marcus Flats

Table 4-3. Summary of Qualifiers for Sediment Samples

Lab	Analyte Name	Number of Samples Analyzed	Rejected Results	Accepted Results	Count of Results with No Flags	Count of Accepted Results Laboratory Flags							Count of Accepted Results Validator (ESI) Flags				Laboratory Flags, % of Accepted Results							Validator (ESI) Flags, % of Accepted Results			
						*	J	N	N*	U	U,N	X	J	U	U*	UJ	*	J	N	N*	U	U,N	X	J	U	U*	UJ
CAS	Hardness as $CaCO_3$	114	0 (0%)	114 (100%)	114	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CAS	Organic carbon	54	0 (0%)	54 (100%)	34	0	0	0	0	0	0	1	20	0	0	0	0	0	0	0	0	0	1.9	37	0	0	0
CAS	pH	54	0 (0%)	54 (100%)	13	0	0	0	0	0	0	0	41	0	0	0	0	0	0	0	0	0	0	75.9	0	0	0
CAS	Solids	54	0 (0%)	54 (100%)	54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CAS	Sulfide-AVS	54	0 (0%)	54 (100%)	34	0	6	0	0	13	0	1	7	13	0	0	0	11.1	0	0	24.1	0	1.9	13	24.1	0	0
CAS	Clay	23	0 (0%)	23 (100%)	3	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	87	0	0	0
CAS	Coarse gravel	23	0 (0%)	23 (100%)	17	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	26.1
CAS	Coarse sand	23	0 (0%)	23 (100%)	17	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	26.1	0	0	0
CAS	Cobbles	23	0 (0%)	23 (100%)	17	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	26.1
CAS	Fine gravel	23	0 (0%)	23 (100%)	17	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	26.1
CAS	Fine sand	23	0 (0%)	23 (100%)	2	0	0	0	0	0	0	0	21	0	0	0	0	0	0	0	0	0	0	91.3	0	0	0
CAS	Med. sand	23	0 (0%)	23 (100%)	17	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	26.1	0	0	0
CAS	Medium gravel	23	0 (0%)	23 (100%)	15	0	0	0	0	0	0	0	1	0	0	7	0	0	0	0	0	0	0	4.3	0	0	30.4
CAS	Silt	23	0 (0%)	23 (100%)	1	0	0	0	0	0	0	0	22	0	0	0	0	0	0	0	0	0	0	95.7	0	0	0
CAS	Very coarse gravel	23	0 (0%)	23 (100%)	17	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	26.1
CAS	Very coarse sand	23	0 (0%)	23 (100%)	17	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	26.1	0	0	0
CAS	Very fine gravel	23	0 (0%)	23 (100%)	4	0	0	0	0	0	0	0	18	0	0	1	0	0	0	0	0	0	0	78.3	0	0	4.3
CAS	Very fine sand	23	0 (0%)	23 (100%)	17	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	26.1	0	0	0
CAS	Aluminum	271	0 (0%)	271 (100%)	97	19	88	21	0	3	0	0	64	3	105	0	7	32.5	7.7	0	1.1	0	0	23.6	1.1	38.7	0
CAS	Antimony	325	0 (0%)	325 (100%)	120	0	151	0	0	43	0	0	31	42	131	1	0	46.5	0	0	13.2	0	0	9.5	12.9	40.3	0.3
CAS	Arsenic	325	0 (0%)	325 (100%)	60	0	28	0	0	231	0	0	24	230	10	1	0	8.6	0	0	71.1	0	0	7.4	70.8	3.1	0.3
CAS	Barium	271	0 (0%)	271 (100%)	237	2	0	0	20	1	0	0	20	1	11	0	0.7	0	0	7.4	0.4	0	0	7.4	0.4	4.1	0
CAS	Beryllium	271	0 (0%)	271 (100%)	27	0	18	0	0	217	0	0	27	217	0	0	0	6.6	0	0	80.1	0	0	10	80.1	0	0
CAS	Cadmium	325	0 (0%)	325 (100%)	95	0	20	7	0	81	7	0	19	80	123	8	0	6.2	2.2	0	24.9	2.2	0	5.8	24.6	37.8	2.5
CAS	Calcium	271	0 (0%)	271 (100%)	241	0	1	0	0	0	0	0	29	0	1	0	0	0.4	0	0	0	0	0	10.7	0	0.4	0
CAS	Chromium	325	0 (0%)	325 (100%)	91	2	127	0	0	4	0	0	74	2	154	2	0.6	39.1	0	0	1.2	0	0	22.8	0.6	47.4	0.6
CAS	Cobalt	271	0 (0%)	271 (100%)	105	0	61	0	0	61	0	0	37	55	68	6	0	22.5	0	0	22.5	0	0	13.7	20.3	25.1	2.2
CAS	Copper	311	0 (0%)	311 (100%)	117	0	33	0	0	39	0	0	14	29	141	10	0	10.6	0	0	12.5	0	0	4.5	9.3	45.3	3.2
CAS	Iron	271	0 (0%)	271 (100%)	95	1	66	0	0	105	0	0	27	65	44	40	0.4	24.4	0	0	38.7	0	0	10	24	16.2	14.8
CAS	Lead	325	0 (0%)	325 (100%)	90	0	70	14	0	8	0	0	52	8	175	0	0	21.5	4.3	0	2.5	0	0	16	2.5	53.8	0
CAS	Magnesium	271	0 (0%)	271 (100%)	254	0	1	0	2	0	0	0	16	0	1	0	0	0.4	0	0.7	0	0	0	5.9	0	0.4	0
CAS	Manganese	271	0 (0%)	271 (100%)	212	0	20	0	0	15	0	0	1	15	43	0	0	7.4	0	0	5.5	0	0	0.4	5.5	15.9	0
CAS	Mercury	108	0 (0%)	108 (100%)	27	0	23	0	0	58	0	0	23	57	0	1	0	21.3	0	0	53.7	0	0	21.3	52.8	0	0.9
CAS	Molybdenum	269	20 (7%)	249 (93%)	113	0	52	0	0	3	0	0	4	3	129	0	0	20.9	0	0	1.2	0	0	1.6	1.2	51.8	0
CAS	Nickel	311	0 (0%)	311 (100%)	58	0	100	11	0	12	2	0	32	14	196	0	0	32.2	3.5	0	3.9	0.6	0	10.3	4.5	63	0
CAS	Potassium	271	0 (0%)	271 (100%)	52	0	122	2	0	95	0	0	124	53	0	42	0	45	0.7	0	35.1	0	0	45.8	19.6	0	15.5
CAS	Selenium	271	0 (0%)	271 (100%)	20	0	17	0	0	228	0	0	17	224	6	4	0	6.3	0	0	84.1	0	0	6.3	82.7	2.2	1.5
CAS	Silver	271	0 (0%)	271 (100%)	43	0	27	0	0	155	0	0	4	155	69	0	0	10	0	0	57.2	0	0	1.5	57.2	25.5	0
CAS	Sodium	271	0 (0%)	271 (100%)	139	0	12	0	0	2	0	0	16	1	114	1	0	4.4	0	0	0.7	0	0	5.9	0.4	42.1	0.4
CAS	Thallium	271	0 (0%)	271 (100%)	41	0	8	0	0	211	0	0	9	211	10	0	0	3	0	0	77.9	0	0	3.3	77.9	3.7	0
CAS	Vanadium	271	0 (0%)	271 (100%)	57	2	154	0	0	58	0	0	154	58	0	0	0.7	56.8	0	0	21.4	0	0	56.8	21.4	0	0
CAS	Zinc	311	0 (0%)	311 (100%)	104	17	21	0	0	38	0	0	4	38	148	0	5.5	6.8	0	0	12.2	0	0	1.3	12.2	47.6	0
CAS	2-Methylnaphthalene	14	1 (7%)	13 (93%)	0	0	10	0	0	0	0	0	13	0	0	0	0	76.9	0	0	0	0	0	100	0	0	0
CAS	Acenaphthene	14	14 (100%)	0 (0%)	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
CAS	Acenaphthylene	14	12 (86%)	2 (14%)	0	0	2	0	0	0	0	0	2	0	0	0	0	100	0	0	0	0	0	100	0	0	0
CAS	Anthracene	14	12 (86%)	2 (14%)	0	0	2	0	0	0	0	0	2	0	0	0	0	100	0	0	0	0	0	100	0	0	0
CAS	Benzo(e)pyrene	14	9 (64%)	5 (36%)	0	0	3	0	0	0	0	0	5	0	0	0	0	60	0	0	0	0	0	100	0	0	0
CAS	Benzo[a]anthracene	14	9 (64%)	5 (36%)	0	0	3	0	0	0	0	0	5	0	0	0	0	60	0	0	0	0	0	100	0	0	0
CAS	Benzo[a]pyrene	14	11 (79%)	3 (21%)	0	0	1	0	0	0	0	0	3	0	0	0	0	33.3	0	0	0	0	0	100	0	0	0
CAS	Benzo[b]fluoranthene	14	10 (71%)	4 (29%)	0	0	2	0	0	0	0	0	4	0	0	0	0	50	0	0	0	0	0	100	0	0	0
CAS	Benzo[g,h,i]perylene	14	11 (79%)	3 (21%)	0	0	1	0	0	0	0	0	3	0	0	0	0	33.3	0	0	0	0	0	100	0	0	0
CAS	Benzo[k]fluoranthene	14	12 (86%)	2 (14%)	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	100	0	0	0
CAS	Chrysene	14	10 (71%)	4 (29%)	0	0	2	0	0	0	0	0	4	0	0	0	0	50	0	0	0	0	0	100	0	0	0
CAS	Dibenzo[a,h]anthracene	14	12 (86%)	2 (14%)	0	0	1	0	0	0	0	0	2	0	0	0	0	50	0	0	0	0	0	100	0	0	0
CAS	Fluoranthene	14	9 (64%)	5 (36%)	0	0	3	0	0	0	0	0	5	0	0	0	0	60	0	0	0	0	0	100	0	0	0
CAS	Fluorene	14	13 (93%)	1 (7%)	0	0	1	0	0	0	0	0	1	0	0	0	0	100	0	0	0	0	0	100	0	0	0
CAS	Indeno[1,2,3-cd]pyrene	14	12 (86%)	2 (14%)	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	100	0	0	0
CAS	Naphthalene	14	0 (0%)	14 (100%)	0	0	11	0	0	0	0	0	0	0	14	0	0	78.6	0	0	0	0	0	0	0	100	0
CAS	Perylene	14	12 (86%)	2 (14%)	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	100	0	0	0
CAS	Phenanthrene	14	8 (57%)	6 (43%)	0	0	3	0	0	0	0	0	6	0	0	0	0	50	0	0	0	0	0	100	0	0	0
CAS	Pyrene	14	8 (57%)	6 (43%)	0	0	4	0	0	0	0	0	6	0	0	0	0	66.7	0	0	0	0	0	100	0	0	0

Table 4-3. Summary of Qualifiers for Sediment Samples

Lab	Analyte Name	Number of Samples Analyzed	Rejected Results	Accepted Results	Count of Results with No Flags	Count of Accepted Results Laboratory Flags							Count of Accepted Results Validator (ESI) Flags				Laboratory Flags, % of Accepted Results							Validator (ESI) Flags, % of Accepted Results			
						*	J	N	N*	U	U,N	X	J	U	U*	UJ	*	J	N	N*	U	U,N	X	J	U	U*	UJ
CAS	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl (PCB-206)	16	12 (75%)	4 (25%)	0	0	2	0	0	2	0	0	2	1	0	1	0	50	0	0	50	0	0	50	25	0	25
CAS	2,2',3,3',4,4',5,5'-Octachlorobiphenyl (PCB-194)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,2',3,3',4,4',5,6-Octachlorobiphenyl (PCB-195)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB-170)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,2',3,3',4,4'-Hexachlorobiphenyl (PCB-128)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,2',3,3',4,5',6,6'-Octachlorobiphenyl (PCB-201)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,2',3,3',4,5,6'-Heptachlorobiphenyl (PCB-174)	2	0 (0%)	2 (100%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,2',3,3',4,5',6-Heptachlorobiphenyl (PCB-177)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,2',3,3',4,6'-Hexachlorobiphenyl (PCB-132)	2	0 (0%)	2 (100%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,2',3,4,4',5,5',6-Octachlorobiphenyl (PCB-203)	2	0 (0%)	2 (100%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,2',3,4,4',5,5'-Heptachlorobiphenyl (PCB-180)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,2',3,4,4',5',6-Heptachlorobiphenyl (PCB-183)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,2',3,4,4',5'-Hexachlorobiphenyl (PCB-138)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,2',3,4,4',6,6'-Heptachlorobiphenyl (PCB-184)	2	0 (0%)	2 (100%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,2',3,4',5,5',6-Heptachlorobiphenyl (PCB-187)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,2',3,4,5,5'-Hexachlorobiphenyl (PCB-141)	2	0 (0%)	2 (100%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,2',3,4',5',6-Hexachlorobiphenyl (PCB-149)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,2',3,4,5'-Pentachlorobiphenyl (PCB-87)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,2',3,4',5-Pentachlorobiphenyl (PCB-90)	2	0 (0%)	2 (100%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,2',3,4',5'-Pentachlorobiphenyl (PCB-97)	2	0 (0%)	2 (100%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,2',3,5,5',6-Hexachlorobiphenyl (PCB-151)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,2',3,5',6-Pentachlorobiphenyl (PCB-95)	2	0 (0%)	2 (100%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,2',3,5'-Tetrachlorobiphenyl (PCB-44)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,2',4,4',5,5'-Hexachlorobiphenyl (PCB-153)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,2',4,4',5-Pentachlorobiphenyl (PCB-99)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,2',4,5,5'-Pentachlorobiphenyl (PCB-101)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,2',4,5'-Tetrachlorobiphenyl (PCB-49)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,2',5,5'-Tetrachlorobiphenyl (PCB-52)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,2',5-Trichlorobiphenyl (PCB-18)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB-189)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,3,3',4,4',5-Hexachlorobiphenyl (PCB-156)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,3,3',4,4',5'-Hexachlorobiphenyl (PCB-157)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,3,3',4,4',6-Hexachlorobiphenyl (PCB-158)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,3,3',4,4'-Pentachlorobiphenyl (PCB-105)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,3,3',4',6-Pentachlorobiphenyl (PCB-110)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,3,3',4'-Tetrachlorobiphenyl (PCB-56)	2	0 (0%)	2 (100%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,3',4,4',5,5'-Hexachlorobiphenyl (PCB-167)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,3,4,4',5,6-Hexachlorobiphenyl (PCB-166)	2	0 (0%)	2 (100%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,3',4,4',5',6-Hexachlorobiphenyl (PCB-168)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,3,4,4',5-Pentachlorobiphenyl (PCB-114)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,3',4,4',5-Pentachlorobiphenyl (PCB-118)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,3',4,4',5'-Pentachlorobiphenyl (PCB-123)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,3',4,4',6-Pentachlorobiphenyl (PCB-119)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,3,4,4'-Tetrachlorobiphenyl (PCB-60)	2	0 (0%)	2 (100%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,3',4,4'-Tetrachlorobiphenyl (PCB-66)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,3',4,5-Tetrachlorobiphenyl (PCB-70)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,3',4'-Trichlorobiphenyl (PCB-33)	2	0 (0%)	2 (100%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,3-Dichlorobiphenyl (PCB-5)	2	0 (0%)	2 (100%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,4,4',5-Tetrachlorobiphenyl (PCB-74)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,4,4'-Trichlorobiphenyl (PCB-28)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,4',5-Trichlorobiphenyl (PCB-31)	2	0 (0%)	2 (100%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,4'-Dichlorobiphenyl (PCB-8)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2-Chlorobiphenyl (2Cl11pBiphenyl)	2	0 (0%)	2 (100%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	3,3',4,4',5,5'-Hexachlorobiphenyl (PCB-169)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	3,3',4,4',5-Pentachlorobiphenyl (PCB-126)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	3,3',4,4'-Tetrachlorobiphenyl (PCB-77)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	3,4,4',5-Tetrachlorobiphenyl (PCB-81)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	3,4,4'-Trichlorobiphenyl (PCB-37)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	Decachlorobiphenyl (PCB-209) (DecClBiphenyl)	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,4'-DDD	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	2,4'-DDE	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50

Table 4-3. Summary of Qualifiers for Sediment Samples

Lab	Analyte Name	Number of Samples Analyzed	Rejected Results	Accepted Results	Count of Results with No Flags	Count of Accepted Results Laboratory Flags							Count of Accepted Results Validator (ESI) Flags				Laboratory Flags, % of Accepted Results							Validator (ESI) Flags, % of Accepted Results			
						*	J	N	N*	U	U,N	X	J	U	U*	UJ	*	J	N	N*	U	U,N	X	J	U	U*	UJ
CAS	2,4'-DDT	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	4,4'-DDD	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	100	0	0	0	0	0	100
CAS	4,4'-DDE	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	100	0	0	0	0	0	100
CAS	4,4'-DDT	16	14 (88%)	2 (13%)	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	100	0	0	0	50	0	50
CAS	Carbazole	14	13 (93%)	1 (7%)	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	100	0	0	0
CAS	Dibenzothiophene	14	14 (100%)	0 (0%)	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Notes:

Data excludes lab replicates and QC sample data.

-- No accepted results

ESI

J	Quantitation is approximate due to limitations identified during the QA review (data validation).
U	This analyte was not detected at or above the associated detection limit.
U*	This analyte should be considered "not-detected" because it was detected in an associated blank at a similar level.
UJ	This analyte was not detected, but the detection limit is probably higher due to a low bias identified during the QA review.

CAS

*	The result is an outlier. See case narrative.
J	The result is an estimated value that was detected outside the quanitition range.
N	The matrix spike sample recovery is not within control limits. See case narrative.
U	The analyte was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL.
X	See case narrative.
MDL	method detection limit
MRL	method reporting limit

Table 4-4. Summary of Qualifiers for Water Samples

Lab	Analyte Name	Number of Samples Analyzed	Rejected Results	Accepted Results	Count of Results with No Flags	Count of Accepted Results Laboratory Flags						Count of Accepted Results Validator (ESI) Flags				Laboratory Flags, % of Accepted Results						Validator (ESI) Flags, % of Accepted Results			
						*	<	B	iU	J	U	J	U	U*	UJ	*	<	B	iU	J	U	J	U	U*	UJ
CAS	Alkalinity	645	0 (0%)	645 (100%)	625	0	0	15	0	1	0	3	0	2	0	0	0	2.3	0	0.2	0	0.5	0	0.3	0
CAS	Fluoride	1215	0 (0%)	1215 (100%)	140	0	0	0	1	1070	4	1035	5	35	0	0	0	0	0.1	88.1	0.3	85.2	0.4	2.9	0
CAS	Hardness as $CaCO_3$	1333	0 (0%)	1333 (100%)	1331	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0.2	0	0.2	0	0
CAS	Organic carbon	1221	0 (0%)	1221 (100%)	927	0	0	0	0	0	0	13	0	281	0	0	0	0	0	0	0	1.1	0	23	0
CAS	Sulfate	1215	0 (0%)	1215 (100%)	1215	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CAS	Total dissolved solids	645	0 (0%)	645 (100%)	502	0	0	0	46	0	13	46	47	38	12	0	0	0	7.1	0	2	7.1	7.3	5.9	1.9
CAS	Aluminum	1452	0 (0%)	1452 (100%)	890	0	0	0	0	84	0	63	0	499	0	0	0	0	0	5.8	0	4.3	0	34.4	0
CAS	Antimony	1452	0 (0%)	1452 (100%)	1058	0	0	0	0	184	20	101	20	273	0	0	0	0	0	12.7	1.4	7	1.4	18.8	0
CAS	Arsenic	1452	0 (0%)	1452 (100%)	335	0	0	0	0	787	312	702	312	103	0	0	0	0	0	54.2	21.5	48.3	21.5	7.1	0
CAS	Barium	1452	0 (0%)	1452 (100%)	1201	0	0	0	0	0	0	23	0	228	0	0	0	0	0	0	0	1.6	0	15.7	0
CAS	Beryllium	1452	0 (0%)	1452 (100%)	26	0	0	0	0	108	1314	63	1157	49	157	0	0	0	0	7.4	90.5	4.3	79.7	3.4	10.8
CAS	Cadmium	1452	0 (0%)	1452 (100%)	223	0	0	0	0	514	137	113	137	979	0	0	0	0	0	35.4	9.4	7.8	9.4	67.4	0
CAS	Calcium	1452	0 (0%)	1452 (100%)	1347	0	0	0	0	0	1	101	1	3	0	0	0	0	0	0	0.1	7	0.1	0.2	0
CAS	Chloride ion	1215	0 (0%)	1215 (100%)	1172	0	0	0	0	0	0	0	0	43	0	0	0	0	0	0	0	0	0	3.5	0
CAS	Chromium	1452	0 (0%)	1452 (100%)	162	0	0	0	0	229	6	113	5	1171	1	0	0	0	0	15.8	0.4	7.8	0.3	80.6	0.1
CAS	Cobalt	1452	0 (0%)	1452 (100%)	655	0	0	0	0	59	114	39	110	644	4	0	0	0	0	4.1	7.9	2.7	7.6	44.4	0.3
CAS	Copper	1452	0 (0%)	1452 (100%)	574	0	0	0	0	63	48	88	28	742	20	0	0	0	0	4.3	3.3	6.1	1.9	51.1	1.4
CAS	Iron	1452	34 (2%)	1418 (98%)	192	0	0	0	0	778	254	113	179	859	75	0	0	0	0	54.9	17.9	8	12.6	60.6	5.3
CAS	Lead	1452	0 (0%)	1452 (100%)	332	15	0	0	0	95	12	6	12	1102	0	1	0	0	0	6.5	0.8	0.4	0.8	75.9	0
CAS	Magnesium	1452	0 (0%)	1452 (100%)	1415	0	0	0	0	1	0	34	0	3	0	0	0	0	0	0.1	0	2.3	0	0.2	0
CAS	Manganese	1452	0 (0%)	1452 (100%)	756	0	0	0	0	52	35	35	35	626	0	0	0	0	0	3.6	2.4	2.4	2.4	43.1	0
CAS	Mercury	983	0 (0%)	983 (100%)	435	0	0	0	0	359	58	174	58	316	0	0	0	0	0	36.5	5.9	17.7	5.9	32.1	0
CAS	Molybdenum	1452	21 (1%)	1431 (99%)	1064	0	0	0	0	134	11	174	11	182	0	0	0	0	0	9.4	0.8	12.2	0.8	12.7	0
CAS	Nickel	1452	0 (0%)	1452 (100%)	510	0	0	0	0	120	0	30	0	912	0	0	0	0	0	8.3	0	2.1	0	62.8	0
CAS	Potassium	1452	0 (0%)	1452 (100%)	1166	0	0	0	0	132	103	132	60	51	43	0	0	0	0	9.1	7.1	9.1	4.1	3.5	3
CAS	Selenium	1452	0 (0%)	1452 (100%)	13	0	0	0	0	543	895	418	824	127	70	0	0	0	0	37.4	61.6	28.8	56.7	8.7	4.8
CAS	Silicon	348	0 (0%)	348 (100%)	266	0	0	0	0	80	0	80	0	2	0	0	0	0	0	23	0	23	0	0.6	0
CAS	Silver	1452	0 (0%)	1452 (100%)	63	0	0	0	0	339	972	127	972	290	0	0	0	0	0	23.3	66.9	8.7	66.9	20	0
CAS	Sodium	1452	0 (0%)	1452 (100%)	1217	0	0	0	0	8	0	117	0	118	0	0	0	0	0	0.6	0	8.1	0	8.1	0
CAS	Thallium	1452	0 (0%)	1452 (100%)	259	0	0	0	0	451	526	169	525	498	1	0	0	0	0	31.1	36.2	11.6	36.2	34.3	0.1
CAS	Vanadium	1452	0 (0%)	1452 (100%)	435	0	0	0	0	720	138	424	138	455	0	0	0	0	0	49.6	9.5	29.2	9.5	31.3	0
CAS	Zinc	1452	0 (0%)	1452 (100%)	235	19	0	0	0	43	52	69	52	1096	0	1.3	0	0	0	3	3.6	4.8	3.6	75.5	0
U of S	Alkalinity	873	0 (0%)	873 (100%)	873	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA	NA	NA
U of S	Conductivity	3661	0 (0%)	3661 (100%)	3661	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA	NA	NA
U of S	Dissolved oxygen - % saturation adjusted for temperature	3663	0 (0%)	3663 (100%)	3663	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA	NA	NA
U of S	Hardness	1516	0 (0%)	1516 (100%)	1516	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA	NA	NA
U of S	pH	3664	0 (0%)	3664 (100%)	3664	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA	NA	NA
U of S	Ammonia	730	0 (0%)	730 (100%)	475	0	255	0	0	0	0	0	0	0	0	0	34.9	0	0	0	0	NA	NA	NA	NA
U of S	Nitrate	612	0 (0%)	612 (100%)	487	0	125	0	0	0	0	0	0	0	0	0	20.4	0	0	0	0	NA	NA	NA	NA
U of S	Nitrite	1047	0 (0%)	1047 (100%)	439	0	608	0	0	0	0	0	0	0	0	0	58.1	0	0	0	0	NA	NA	NA	NA
U of S	Temperature	3665	0 (0%)	3665 (100%)	3665	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA	NA	NA

Notes:

Data excludes lab replicates and QC sample data.

NA - Not available

ESI

J	Quantitation is approximate due to limitations identified during the QA review (data validation).
U	This analyte was not detected at or above the associated detection limit.
U*	This analyte should be considered "not-detected" because it was detected in an associated blank at a similar level.
UJ	This analyte was not detected, but the detection limit is probably higher due to a low bias identified during the QA review.

U of S

<	Less than

CAS

*	The result is an outlier. See case narrative.
B	The analyte was found in the associated method blank at a level that is significant relative to the sample result as defined by DOD or NELAC standards.
i	The MRL/MDL or LOQ/LOD is elevated due to a matrix interference.
J	The result is an estimated value that was detected outside the quanitition range.
U	The analyte was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL.

DOD	Department of Defense
NELAC	National Environmental Laboratory Accreditation Conference
MRL	method reporting limit
MDL	method detection limit
LOQ	level of quantification
LOD	level of detection

Table 5-1. Summary of Grain Size Distribution for Sediments Evaluated in Exposure Chambers

			Exposure Chamber Treatment						
Aggregate Name	Grain Size (Range)	Units	DE	NP	LD	UMF	LMF	GE	LALL
Cobbles	64 to < 256	mm	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Very coarse gravel	32 to < 64	mm	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Coarse gravel	16 to < 32	mm	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%
Medium gravel	8 to < 16	mm	0.0%	0.0%	0.0%	0.0%	0.0%	5.2%	9.0%
Fine gravel	4 to < 8	mm	0.2%	0.7%	0.0%	0.0%	0.0%	6.7%	5.0%
Very fine gravel	2 to < 4	mm	0.8%	0.1%	0.0%	0.4%	0.3%	6.8%	8.3%
Very coarse sand	1 to < 2	mm	2.0%	0.3%	0.5%	2.6%	3.5%	12.9%	13.7%
Coarse sand	0.5 to < 1	mm	42.4%	1.0%	33.1%	38.8%	44.7%	37.0%	20.3%
Medium sand	0.25 to < 0.5	mm	47.6%	50.0%	59.7%	49.9%	41.3%	23.6%	25.0%
Fine sand	125 to < 250	µm	5.4%	39.3%	5.2%	5.3%	3.1%	3.7%	13.1%
Very fine sand	62.5 to < 125	µm	1.4%	5.5%	1.3%	1.1%	1.6%	1.6%	2.1%
Silt	< 62.5	µm	0.5%	1.6%	0.5%	0.9%	2.3%	0.6%	1.2%
Clay	< 62.5	µm	0.3%	1.0%	0.5%	0.3%	1.6%	0.5%	0.6%
Overall General Grain Size Distribution									
		Gravels	1.0%	0.8%	0.0%	0.4%	0.3%	18.6%	23.1%
		Sands	98.7%	96.2%	99.8%	97.6%	94.1%	78.8%	74.2%
		Clay/Silt	0.8%	2.6%	1.0%	1.2%	3.9%	1.1%	1.8%
Total Organic Carbon Content									
		Average (%)	0.15	0.28	0.14	0.23	0.29	0.13	0.07
		Standard Deviation	0.09	0.25	0.02	0.18	0.09	0.07	0.02
		n	3	2	6	6	4	4	6

Notes:
DE - substrates as collected above the water line from the gravel bar at DME
DME - Deadman's Eddy
GE - Genelle Eddy
LALL - Lower Arrow Lakes
LD - Little Dalles
LMF - Lower Marcus Flats
NP - Northport
UMF - Upper Marcus Flats

Table 5-2. Summary of General Water Quality Parameters Monitored at the U of S, ATRF During the Duration of the Study

Treatment	pH (su)	Temperature (°C)	Conductivity (µS/cm)	DO (% Saturation)	Ammonia (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Alkalinity (mg/L as $CaCO_3$)	Hardness (mg/L as $CaCO_3$)
Overlying Water (OW)									
H2O	7.76 (± 0.176)	15.4 (± 0.94)	185 (± 18)	89.9 (± 5.5)	0.0517 (± 0.0354)	0.459 (± 0.33)	0.0482 (± 0.0607)	43.1 (± 3.14)	60.5 (± 3.7)
CTRL	7.76 (± 0.178)	15.4 (± 0.88)	189 (± 22.9)	89.7 (± 6.9)	0.037 (± 0.0274)	0.428 (± 0.357)	0.0422 (± 0.0302)	45.3 (± 5.46)	62.2 (± 4.4)
LALL	7.74 (± 0.185)	15.3 (± 0.82)	184 (± 16.8)	89.3 (± 5.4)	0.0404 (± 0.0221)	0.341 (± 0.228)	0.0286 (± 0.0177)	42.8 (± 4.28)	59.6 (± 4.03)
GE	7.69 (± 0.248)	15.4 (± 0.86)	187 (± 40.7)	88.8 (± 6.2)	0.0674 (± 0.174)	0.451 (± 0.325)	0.037 (± 0.0296)	42.8 (± 3.44)	60.3 (± 4.14)
DE	7.67 (± 0.293)	15.4 (± 0.99)	183 (± 17.8)	89.5 (± 5.4)	0.0393 (± 0.0307)	0.328 (± 0.21)	0.0388 (± 0.0259)	43.3 (± 3.23)	60.6 (± 3.84)
NP	7.73 (± 0.199)	15.4 (± 0.96)	184 (± 16.7)	88.8 (± 5.7)	0.0333 (± 0.0168)	0.556 (± 0.458)	0.0432 (± 0.0466)	42 (± 3.1)	60.1 (± 2.92)
LD	7.72 (± 0.199)	15.7 (± 0.77)	189 (± 98.2)	89 (± 5.5)	0.0377 (± 0.0248)	0.442 (± 0.361)	0.0393 (± 0.0283)	41.7 (± 3.71)	60 (± 4.03)
UMF	7.73 (± 0.211)	15.5 (± 0.85)	184 (± 17.3)	88.5 (± 6.1)	0.0398 (± 0.0252)	0.404 (± 0.357)	0.0359 (± 0.0333)	42.1 (± 2.98)	60.3 (± 3.99)
LMF	7.72 (± 0.191)	15.6 (± 0.88)	185 (± 17.8)	89.7 (± 5.5)	0.035 (± 0.0176)	0.428 (± 0.347)	0.0344 (± 0.032)	42.5 (± 2.93)	59.9 (± 5.37)
Sediment-Water Interface (SWI) Water									
H2O	ND	ND	ND	ND	ND	ND	ND	ND	ND
CTRL	7.58 (± 0.238)	16.6 (± 0.85)	192 (± 18.5)	88 (± 3.9)	0.0359 (± 0.0401)	0.425 (± 0.267)	0.0341 (± 0.0377)	46.4 (± 6.76)	60.6 (± 5.3)
LALL	7.46 (± 0.346)	16.5 (± 0.79)	188 (± 13.8)	88.9 (± 3.8)	0.0263 (± 0.00938)	0.333 (± 0.158)	0.0252 (± 0.0119)	41.8 (± 3.6)	59 (± 5.21)
GE	7.53 (± 0.165)	16.7 (± 0.83)	190 (± 15.3)	87.7 (± 4.1)	0.0278 (± 0.0129)	0.452 (± 0.32)	0.0292 (± 0.0176)	41.7 (± 4.41)	58.9 (± 2.84)
DE	7.5 (± 0.253)	16.5 (± 0.75)	188 (± 19.2)	88.6 (± 3.5)	0.0267 (± 0.00961)	0.369 (± 0.161)	0.0267 (± 0.02)	40.4 (± 4.77)	58.5 (± 3.19)
NP	7.53 (± 0.181)	16.7 (± 0.84)	188 (± 11.4)	86.8 (± 4)	0.0267 (± 0.0097)	0.362 (± 0.158)	0.0261 (± 0.0124)	42.4 (± 5.63)	60 (± 3.9)
LD	7.46 (± 0.256)	16.9 (± 0.83)	191 (± 17.1)	87.9 (± 4.7)	0.0248 (± 0.00863)	0.365 (± 0.164)	0.0255 (± 0.0122)	42.2 (± 3.57)	58.6 (± 3.7)
UMF	7.48 (± 0.239)	16.7 (± 0.81)	189 (± 16.7)	86.7 (± 4.5)	0.0267 (± 0.0135)	0.354 (± 0.173)	0.0244 (± 0.0109)	41.4 (± 2.9)	58.5 (± 4.32)
LMF	7.42 (± 0.287)	16.8 (± 0.78)	190 (± 19.2)	88.3 (± 3.5)	0.0257 (± 0.00917)	0.343 (± 0.118)	0.024 (± 0.0106)	41 (± 2.96)	59.6 (± 4.59)

Notes:

Data are displayed as average ± standard deviation.

Test acceptability criteria:

Average water temperature should be 15 ± 1°C; with instantaneous measurements at 15 ± 3°C.

Dissolved oxygen (DO) should be ≥ 70%.

All other measurements should not vary by more than 50%.

All water quality data are reported as the mean (± standard deviation)

CTRL - artificial substrate control

DE - substrates as collected above the water line from the gravel bar at DME

DME - Deadman's Eddy

GE - Genelle Eddy

H2O - water-only control

LALL - Lower Arrow Lakes

LD - Little Dalles

LMF - Lower Marcus Flats

ND - not determined

NP - Northport

UMF - Upper Marcus Flats

Table 5−3. Assessment of Test Acceptability Requirements of a 60-Day Early Life-Stage Sediment Toxicity Test with White Sturgeon *(A. transmontanus)*

	Acceptability Criteria	**Assessment of Acceptability**
1	Freshly fertilized eggs from at least 2 to 4 different females and males are to be used (time between hatching and initiation of study must not exceed 24 hours)	Eggs from three females and sperm from four adult male sturgeon were used (Section 2.3).
2	Average hatching rate of eggs in the lab water controls should not be less than 60%, or within 90% confidence interval of that observed at the hatchery for the same fish	Average hatching rate of eggs in the laboratory controls waters was >85%.
3	Average survival of fry until swim-up in the lab water controls should be greater or equal to 80%, or within 90% confidence interval of that observed at the hatchery for the same fish	Average survival of fry in lab water controls up to day 14 was >99%; this duration includes the swim-up phase (Figure 5-46; Table 5-7).
4	Average survival of fry from the start to finish of exposure in the lab water controls should be greater or equal to 64%	Average survival of fry in lab water controls until test termination was 80% (Figure 5-46; Tables 5-6 and 5-7).
5	All water quality parameters with the exception of DO and temperature should not vary by more than 50% during the exposure	This is indicated within Table 5-2 and illustrated within Figures 5-12, 5-14, 5-16 through 5-20.
6	Dissolved oxygen should be maintained above 70% saturation	This is indicated within Table 5-2 and illustrated within Figure set 5-15.
7	Average daily temperature should be maintained at 15 ± 1°C; the instantaneous temperature must always be within ± 3°C of 15°C	As measured in overlying water, this is indicated within Table 5-2 and illustrated within Figure set 5-13. All instantaneous temperatures measured during this study were within ± 3°C of 15°C, with the exception of two measurements on July 31, 2010 in the following tanks: GE-D and LMF-A. There was a total of 2604 instantaneous temperature measurements taken during this study.
	Additional Acceptability Criteria	
1	All organisms must be from the same source	Fertilized white sturgeon eggs were obtained from the Kootenay Trout Hatchery (Section 2.3).
2	Hatchability in the lab water controls should be comparable to those observed at the Kootenay Trout Hatchery for the fish from the same fertilization event	From the July 7, 2010 fertilization event, hatching success (as reported by the hatchery) was 80%.
3	All test systems and chambers should be identical and should be run under the same recirculating conditions for each study, except if otherwise stated in the protocols	Details regarding the exposure chambers are described in Section 2.2.
4	Natural physico-chemical conditions of the control lab water should be within the tolerance limit for white sturgeon early life-stages	Conditions summarized in Table 5-2 and illustrated in Figures 5-12 through 5-20 are within the tolerance limits of white sturgeon early life stages.
5	Food should be obtained and tested for possible comparability with white sturgeon early life-stages prior to initiation of the studies	Commercially available fish foods used within this study were supplied by San Francisco Bay Brand, Inc. A copy of the nutritional analysis of the bloodworms used in this study were made available by the vendor. Every package was guaranteed to meet the following criteria: crude protein minimum at 4%, crude fat minimum at 0.4%, crude fiber maximum at 0.7%, and maximum moisture at 95%.
6	Reference toxicant (copper) will be tested in acute toxicity (96hr) water-only exposure, using a life stage previously tested at U of S and fish from the same batch of fish used in the sediment study	Acute copper toxicity tests are described in Appendix B.

Notes:
DO - dissolved oxygen

Table 5-4. Summary of General Water Quality Data Collected During the Study

Treatment	Hardness (mg/L as $CaCO_3$)	Alkalinity (mg/L as $CaCO_3$)	DOC (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Sulfate (mg/L)	Chloride (mg/L)
Overlying Water (OW)									
H2O	70.9 (± 44.1)	39.5 (± 4.45)	2.38 (± 3.83)	14.8 (± 17.7)	8.27 (± 0.791)	14.7 (± 1.76)	1.74 (± 0.193)	48.9 (± 6.18)	6.34 (± 0.599)
CTRL	65.1 (± 11.4)	43.1 (± 6.69)	1.97 (± 0.783)	12.8 (± 4.15)	8.05 (± 0.695)	14.1 (± 1.23)	1.67 (± 0.167)	48.4 (± 5.3)	6.21 (± 0.849)
LALL	61.9 (± 4.29)	38.7 (± 4.02)	2.72 (± 4.32)	11.3 (± 1.19)	8.16 (± 0.491)	14.2 (± 0.941)	1.71 (± 0.119)	48.9 (± 4.55)	6.31 (± 0.588)
GE	60.1 (± 10.9)	37.6 (± 6.95)	1.77 (± 0.446)	11 (± 2.1)	7.95 (± 1.43)	14.4 (± 1.14)	1.67 (± 0.3)	49.3 (± 4.63)	6.46 (± 0.9)
DE	75.5 (± 62.8)	38.8 (± 4.43)	2.28 (± 3.11)	16.8 (± 25.2)	8.16 (± 0.773)	14.9 (± 3.08)	1.72 (± 0.171)	48.9 (± 5.83)	6.4 (± 1.21)
NP	62.4 (± 3.56)	38.6 (± 3.31)	1.88 (± 0.525)	11.6 (± 0.781)	8.14 (± 0.57)	14.1 (± 0.978)	1.7 (± 0.137)	49.9 (± 5.87)	6.49 (± 0.678)
LD	64.4 (± 19.7)	39.8 (± 5.42)	2.24 (± 2.46)	12.2 (± 7.47)	8.22 (± 0.919)	14.5 (± 1.81)	1.72 (± 0.213)	49.2 (± 5.79)	6.33 (± 0.687)
UMF	61.3 (± 5.8)	38.6 (± 4.5)	1.82 (± 0.508)	11.2 (± 1.26)	8.09 (± 0.719)	14.2 (± 1.26)	1.7 (± 0.165)	48.4 (± 4.73)	6.22 (± 0.681)
LMF	76.4 (± 63.6)	39.5 (± 4.33)	2.22 (± 1.74)	16.5 (± 23.2)	8.56 (± 2.22)	15 (± 4.77)	1.79 (± 0.547)	48.8 (± 7.29)	6.38 (± 0.622)
Sediment-Water Interface (SWI) Water									
Pipette Suction Method									
CTRL	65.9 (± 10.4)	45.1 (± 7.01)	2.1 (± 1.29)	13.2 (± 3.53)	8.03 (± 0.757)	14.1 (± 1.22)	1.67 (± 0.168)	48.2 (± 4.6)	6.19 (± 0.736)
LALL	66.4 (± 40.1)	38.8 (± 4.16)	2.2 (± 1.32)	13.2 (± 15.8)	8.13 (± 0.607)	14.4 (± 1.36)	1.71 (± 0.167)	49.1 (± 4.2)	6.42 (± 1.24)
GE	61.5 (± 4.83)	39.3 (± 3.58)	1.95 (± 0.621)	11.1 (± 0.992)	8.2 (± 0.663)	14.4 (± 1.24)	1.74 (± 0.166)	49.1 (± 4.25)	6.38 (± 0.5)
DE	68.8 (± 28.6)	39.3 (± 4.99)	2.22 (± 2.36)	13.9 (± 9.9)	8.28 (± 1.3)	14.5 (± 1.88)	1.74 (± 0.217)	48.4 (± 5.94)	6.21 (± 0.764)
NP	61.2 (± 2.83)	39.4 (± 2.65)	2.11 (± 1.06)	11.2 (± 0.666)	8.07 (± 0.418)	14.3 (± 1.03)	1.7 (± 0.162)	49.2 (± 4.93)	6.27 (± 0.379)
LD	75.5 (± 93.2)	39.9 (± 5.74)	2.41 (± 2.17)	16.7 (± 36.7)	8.19 (± 0.85)	14.5 (± 1.94)	1.72 (± 0.196)	48.8 (± 5.82)	6.28 (± 0.788)
UMF	65.5 (± 25.6)	38.6 (± 4.44)	2.1 (± 0.851)	13 (± 10.1)	8.01 (± 0.605)	14.2 (± 1.25)	1.7 (± 0.164)	48.4 (± 5.09)	6.22 (± 0.753)
LMF	65.4 (± 25.9)	40 (± 4.35)	2.02 (± 0.662)	12.6 (± 9.33)	8.25 (± 0.863)	14.6 (± 2.25)	1.76 (± 0.32)	49.7 (± 5.34)	6.42 (± 0.687)
Peeper									
CTRL	ND	ND	ND	12.3 (± 1.95)	7.79 (± 0.913)	13.1 (± 1.51)	1.64 (± 0.38)	ND	ND
LALL	ND	ND	ND	10.3 (± 1.43)	7.89 (± 0.364)	13.3 (± 0.803)	1.89 (± 0.396)	ND	ND
GE	ND	ND	ND	9.98 (± 1.52)	7.77 (± 0.694)	13.1 (± 1.34)	1.93 (± 0.358)	ND	ND
DE	ND	ND	ND	11.1 (± 3.27)	7.84 (± 0.368)	13.1 (± 1.21)	1.7 (± 0.273)	ND	ND
NP	ND	ND	ND	ND	ND	ND	ND	ND	ND
LD	ND	ND	ND	10.7 (± 1.26)	8.08 (± 0.227)	13.6 (± 0.775)	1.8 (± 0.339)	ND	ND
UMF	ND	ND	ND	10.7 (± 1.13)	8 (± 0.315)	13.6 (± 0.874)	1.85 (± 0.365)	ND	ND
LMF	ND	ND	ND	10.3 (± 1.45)	7.82 (± 0.441)	13.2 (± 0.948)	1.86 (± 0.217)	ND	ND
Thin-Film Diffusive Gradient Probe									
CTRL	22.8 (± 6.28)	ND	ND	5.25 (± 1.7)	0.867 (± 0.273)	1.57 (± 0.633)	0.217 (± 0.0243)	ND	ND
LALL	18.2 (± 4.58)	ND	ND	3.5 (± 0.868)	1 (± 0.266)	1.93 (± 0.957)	0.23 (± 0.0448)	ND	ND
GE	16.7 (± 4.18)	ND	ND	3.28 (± 0.904)	0.901 (± 0.194)	1.72 (± 0.387)	0.221 (± 0.0254)	ND	ND
DE	56.3 (± 49.8)	ND	ND	13.5 (± 13.1)	4.41 (± 4.9)	2.25 (± 0.685)	0.252 (± 0.0457)	ND	ND
NP	ND	ND	ND	ND	ND	ND	ND	ND	ND
LD	32.2 (± 29.1)	ND	ND	7.58 (± 8.59)	1.98 (± 2.28)	1.66 (± 0.704)	0.226 (± 0.0291)	ND	ND
UMF	19 (± 5.39)	ND	ND	3.81 (± 0.984)	0.988 (± 0.328)	1.49 (± 0.52)	0.23 (± 0.0367)	ND	ND
LMF	21.9 (± 7.18)	ND	ND	4.33 (± 1.39)	1.16 (± 0.398)	1.17 (± 0.433)	0.224 (± 0.0237)	ND	ND

Table 5-4. Summary of General Water Quality Data Collected During the Study

Treatment	Hardness (mg/L as $CaCO_3$)	Alkalinity (mg/L as $CaCO_3$)	DOC (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Sulfate (mg/L)	Chloride (mg/L)
Porewater (PW) @ 1-cm									
Peeper									
CTRL	ND	ND	ND	21.5 (± 7.03)	7.96 (± 0.386)	13.4 (± 1.04)	3.02 (± 5.85)	ND	ND
LALL	ND	ND	ND	12.5 (± 1.61)	7 (± 1.15)	12.8 (± 0.83)	2.37 (± 0.473)	ND	ND
GE	ND	ND	ND	15.3 (± 3.64)	7.78 (± 0.536)	13.6 (± 0.52)	3.04 (± 0.795)	ND	ND
DE	ND	ND	ND	19 (± 6.11)	8.11 (± 0.953)	13 (± 0.859)	2.07 (± 0.214)	ND	ND
NP	ND	ND	ND	ND	ND	ND	ND	ND	ND
LD	ND	ND	ND	26.1 (± 9.22)	8.42 (± 0.787)	12.8 (± 1.19)	2.34 (± 0.52)	ND	ND
UMF	ND	ND	ND	23.9 (± 11.1)	7.84 (± 1.15)	13.1 (± 1.18)	2.97 (± 0.663)	ND	ND
LMF	ND	ND	ND	47.5 (± 10.2)	12.2 (± 1.46)	13.7 (± 0.996)	3.95 (± 0.421)	ND	ND
Thin-Film Diffusive Gradient Probe									
CTRL	19.3 (± 3.48)	ND	ND	4.67 (± 0.9)	0.638 (± 0.121)	1.63 (± 0.397)	0.217 (± 0.0239)	ND	ND
LALL	16.4 (± 4.49)	ND	ND	2.88 (± 0.675)	1.04 (± 0.349)	3.11 (± 2.23)	0.273 (± 0.113)	ND	ND
GE	15.2 (± 2.22)	ND	ND	2.87 (± 0.399)	0.876 (± 0.142)	1.71 (± 0.434)	0.217 (± 0.025)	ND	ND
DE	60.2 (± 62.2)	ND	ND	13.6 (± 15)	5.5 (± 6.67)	3.32 (± 1.59)	0.286 (± 0.0869)	ND	ND
NP	ND	ND	ND	ND	ND	ND	ND	ND	ND
LD	34.4 (± 34.1)	ND	ND	8.87 (± 11)	1.94 (± 2.17)	1.67 (± 0.862)	0.228 (± 0.0291)	ND	ND
UMF	16.7 (± 4.32)	ND	ND	3.51 (± 0.821)	0.79 (± 0.264)	1.9 (± 1.19)	0.239 (± 0.0369)	ND	ND
LMF	22.6 (± 2.71)	ND	ND	4.79 (± 0.566)	1.06 (± 0.237)	1.6 (± 0.548)	0.245 (± 0.0441)	ND	ND
Porewater (PW) @ 2.5-cm									
Airstone									
CTRL	104 (± 16.8)	ND	4.89 (± 2.86)	27.6 (± 5.16)	8.56 (± 1.02)	14.1 (± 0.77)	2.09 (± 0.34)	48.2 (± 4.19)	11 (± 25.2)
LALL	75.6 (± 8.94)	ND	6.9 (± 2.96)	21.4 (± 2.99)	5.39 (± 0.905)	13.1 (± 1.37)	4.17 (± 0.82)	45.8 (± 7.7)	6.86 (± 1.26)
GE	137 (± 48.5)	ND	16.4 (± 11)	40 (± 15.8)	9.28 (± 2.56)	17.3 (± 3.25)	7.96 (± 3.61)	28 (± 17.6)	7.64 (± 1.27)
DE	119 (± 32.6)	ND	7.35 (± 7.07)	36.1 (± 8.1)	7.97 (± 1.51)	14.9 (± 1.49)	3.22 (± 0.818)	57.9 (± 14.4)	8.54 (± 3.1)
NP	208 (± 42)	ND	8.96 (± 9.89)	62.3 (± 11.7)	12.8 (± 3.19)	14 (± 6.39)	3.79 (± 0.568)	81.9 (± 11.3)	8.05 (± 1.48)
LD	154 (± 31.8)	ND	9.52 (± 7.86)	44.3 (± 9.2)	10.6 (± 2.19)	11.7 (± 2.92)	2.98 (± 1.18)	60.4 (± 10.4)	7.63 (± 2.07)
UMF	180 (± 32)	ND	15.7 (± 9.7)	57.9 (± 10.5)	8.74 (± 1.75)	13.2 (± 1.97)	6.41 (± 1.3)	53.3 (± 8.21)	8.95 (± 11.2)
LMF	235 (± 41.8)	ND	25.4 (± 12.1)	70.2 (± 12.7)	14.6 (± 2.63)	15.1 (± 1.63)	6.12 (± 0.814)	50.1 (± 13.8)	8.34 (± 2.44)

Notes:

All water quality data are reported as the mean (± standard deviation).

CTRL - artificial substrate control

DE - substrates as collected above the water line from the gravel bar at DME

DME - Deadman's Eddy

DOC - dissolved organic carbon

GE - Genelle Eddy

H2O - water-only control

LALL - Lower Arrow Lakes

LD - Little Dalles

LMF - Lower Marcus Flats

ND - not determined

NP - Northport

UMF - Upper Marcus Flats

Table 5-5. Summary of Dissolved Metals (Cadmium, Copper, Lead, Zinc, Arsenic, Chromium, Mercury, and Nickel) Data Collected during the Study

Date	Medium	Sampling Method	Treatment	Cadmium µg/L	Copper µg/L	Lead µg/L	Zinc µg/L	Arsenic µg/L	Chromium µg/L	Mercury ng/L	Nickel µg/L
7/23/2010	Overlying Water	Pipette	H2O	0.0068 (± 0.0042)	0.39 (± 0.076)	0.037 (± 0.026)	10 (± 3.1)	0.15 (± 0.077)	0.24 (± 0.17)	0.2	0.6 (± 0.086)
7/23/2010	Overlying Water	Pipette	CTRL	0.0061 (± 0.004)	0.37 (± 0.02)	0.028 (± 0.026)	11 (± 6)	0.13 (± 0.061)	0.22 (± 0.077)	0.21 (± 0.022)	0.57 (± 0.077)
7/23/2010	Overlying Water	Pipette	LALL	0.012 (± 0.0064)	0.4 (± 0.064)	0.018 (± 0.013)	8.3 (± 3.9)	0.15 (± 0.055)	0.78 (± 1.5)	0.2	0.89 (± 0.9)
7/23/2010	Overlying Water	Pipette	GE	0.0091 (± 0.0036)	0.6 (± 0.24)	0.023 (± 0.0072)	9.2 (± 4.5)	0.11 (± 0.063)	0.23 (± 0.11)	0.2	0.59 (± 0.036)
7/23/2010	Overlying Water	Pipette	DE	0.012 (± 0.0046)	1.1 (± 0.28)	0.035 (± 0.021)	9 (± 2.9)	0.17 (± 0.058)	0.3 (± 0.21)	0.2	0.73 (± 0.14)
7/23/2010	Overlying Water	Pipette	NP	0.019 (± 0.0092)	1.1 (± 0.55)	0.067 (± 0.0099)	15 (± 3.9)	0.25 (± 0.071)	0.36 (± 0.31)	0.55 (± 0.49)	0.8 (± 0.12)
7/23/2010	Overlying Water	Pipette	LD	0.0087 (± 0.0025)	0.89 (± 0.16)	0.016 (± 0.0038)	8.7 (± 3.2)	0.15 (± 0.055)	0.3 (± 0.16)	0.2	0.67 (± 0.12)
7/23/2010	Overlying Water	Pipette	UMF	0.012 (± 0.0075)	0.79 (± 0.39)	0.029 (± 0.03)	11 (± 5.5)	0.16 (± 0.066)	0.35 (± 0.27)	0.33 (± 0.25)	0.62 (± 0.15)
7/23/2010	Overlying Water	Pipette	LMF	0.0044 (± 0.0025)	0.44 (± 0.11)	0.032 (± 0.028)	13 (± 10)	0.15 (± 0.12)	0.24 (± 0.058)	0.2	0.55 (± 0.013)
7/23/2010	Porewater (2.5 cm)	Airstone	H2O	0.25 (± 0.44)	0.34 (± 0.15)	0.036 (± 0.025)	11 (± 8)	0.1 (± 0.077)	0.25 (± 0.16)	6.5 (± 12)	0.82 (± 0.66)
7/23/2010	Porewater (2.5 cm)	Airstone	CTRL	0.027 (± 0.018)	0.3 (± 0.065)	0.043 (± 0.021)	12 (± 5.3)	0.38 (± 0.075)	0.3 (± 0.084)	0.65 (± 0.37)	0.64 (± 0.26)
7/23/2010	Porewater (2.5 cm)	Airstone	LALL	0.43 (± 0.15)	0.97 (± 0.23)	0.59 (± 0.75)	15 (± 7)	3.2 (± 1.1)	0.23 (± 0.16)	1.7 (± 2.1)	2.1 (± 0.67)
7/23/2010	Porewater (2.5 cm)	Airstone	GE	0.042 (± 0.039)	0.75 (± 0.51)	1.6 (± 2.1)	11 (± 8.1)	16 (± 3.2)	0.58 (± 0.26)	3.1 (± 2.8)	2.5 (± 0.52)
7/23/2010	Porewater (2.5 cm)	Airstone	DE	0.31 (± 0.042)	24 (± 6)	0.15 (± 0.014)	20 (± 4.7)	2.2 (± 0.26)	0.23 (± 0.074)	1 (± 0.57)	0.64 (± 0.18)
7/23/2010	Porewater (2.5 cm)	Airstone	NP	0.29 (± 0.021)	9.4 (± 0.47)	0.21 (± 0.011)	22 (± 4.2)	4.7	0.16 (± 0.074)	1.9	0.93 (± 0.0035)
7/23/2010	Porewater (2.5 cm)	Airstone	LD	0.33 (± 0.37)	110 (± 83)	25 (± 32)	250 (± 280)	3.2 (± 1.1)	0.59 (± 0.54)	5.2 (± 6)	0.96 (± 0.39)
7/23/2010	Porewater (2.5 cm)	Airstone	UMF	0.39 (± 0.28)	35 (± 22)	5.3 (± 6.6)	64 (± 75)	3.8 (± 0.33)	0.47 (± 0.25)	7.3 (± 7.4)	1.9 (± 1.2)
7/23/2010	Porewater (2.5 cm)	Airstone	LMF	0.16 (± 0.22)	3 (± 4)	5 (± 7.1)	68 (± 100)	3.3 (± 0.41)	0.26 (± 0.23)	10 (± 14)	1.4 (± 0.3)
7/26/2010	Overlying Water	Pipette	H2O	0.0036 (± 0.0015)	0.22 (± 0.049)	0.019 (± 0.0059)	4.4 (± 1.6)	0.17 (± 0.067)	0.21 (± 0.024)	0.43 (± 0.035)	0.33 (± 0.042)
7/26/2010	Overlying Water	Pipette	CTRL	0.0037 (± 0.0013)	0.41 (± 0.34)	0.022 (± 0.013)	4.8 (± 2.1)	0.12 (± 0.068)	0.17 (± 0.025)	0.9 (± 0.89)	0.27 (± 0.044)
7/26/2010	Overlying Water	Pipette	LALL	0.0062 (± 0.0029)	0.21 (± 0.043)	0.022 (± 0.017)	3.3 (± 2.3)	0.13 (± 0.075)	0.18 (± 0.028)	0.58 (± 0.24)	0.27 (± 0.044)
7/26/2010	Overlying Water	Pipette	GE	0.0038 (± 0.0018)	0.24 (± 0.053)	0.018 (± 0.012)	2.9 (± 2.1)	0.18 (± 0.05)	0.18 (± 0.031)	0.75 (± 0.35)	0.31 (± 0.059)
7/26/2010	Overlying Water	Pipette	DE	0.039 (± 0.053)	0.88 (± 0.12)	0.69 (± 1.1)	5.9 (± 2.4)	0.2 (± 0.082)	0.22 (± 0.11)	0.9 (± 0.82)	0.63 (± 0.57)
7/26/2010	Overlying Water	Pipette	NP	0.0063 (± 0.0053)	0.54 (± 0.11)	0.14 (± 0.17)	6.2 (± 2.3)	0.2	0.25 (± 0.14)	0.4 (± 0.071)	0.32 (± 0.14)
7/26/2010	Overlying Water	Pipette	LD	0.0055 (± 0.00071)	0.76 (± 0.19)	0.031 (± 0.016)	5.2 (± 0.8)	0.23 (± 0.052)	0.22 (± 0.062)	0.51 (± 0.2)	0.33 (± 0.027)
7/26/2010	Overlying Water	Pipette	UMF	0.0083 (± 0.005)	0.64 (± 0.47)	0.072 (± 0.072)	5.7 (± 2.7)	0.17 (± 0.052)	0.21 (± 0.063)	0.58 (± 0.21)	0.32 (± 0.04)
7/26/2010	Overlying Water	Pipette	LMF	0.0071 (± 0.0019)	0.26 (± 0.061)	0.021 (± 0.0092)	8 (± 2)	0.088 (± 0.025)	0.15 (± 0.022)	0.54 (± 0.12)	0.28 (± 0.039)
7/26/2010	Sediment-Water Interface	Pipette	CTRL	0.0078 (± 0.0079)	0.28 (± 0.098)	0.029 (± 0.024)	30 (± 43)	0.17 (± 0.098)	0.18 (± 0.062)	1.5 (± 0.97)	0.32 (± 0.12)
7/26/2010	Sediment-Water Interface	Pipette	LALL	0.0068 (± 0.0023)	0.27 (± 0.13)	0.013 (± 0.0033)	23 (± 22)	0.14 (± 0.066)	0.18 (± 0.03)	0.63 (± 0.77)	0.3 (± 0.055)
7/26/2010	Sediment-Water Interface	Pipette	GE	0.004 (± 0.0011)	0.32 (± 0.13)	0.21 (± 0.39)	41 (± 33)	0.14 (± 0.075)	0.2 (± 0.051)	3.3 (± 2.8)	0.31 (± 0.056)
7/26/2010	Sediment-Water Interface	Pipette	DE	0.079 (± 0.12)	1.1 (± 0.62)	0.29 (± 0.44)	13 (± 11)	0.2 (± 0.082)	0.36 (± 0.24)	6.3 (± 10)	0.8 (± 0.65)
7/26/2010	Sediment-Water Interface	Pipette	NP	0.006 (± 0.00071)	0.7 (± 0.1)	0.019 (± 0.0028)	7.9 (± 2.3)	0.15 (± 0.071)	0.34 (± 0.28)	0.45 (± 0.35)	0.39 (± 0.17)
7/26/2010	Sediment-Water Interface	Pipette	LD	0.0063 (± 0.0032)	0.89 (± 0.34)	0.068 (± 0.098)	6.4 (± 3.2)	0.13 (± 0.052)	0.18 (± 0.028)	1.6 (± 1.1)	0.34 (± 0.064)
7/26/2010	Sediment-Water Interface	Pipette	UMF	0.008 (± 0.0036)	0.55 (± 0.28)	0.025 (± 0.013)	13 (± 21)	0.13 (± 0.061)	0.22 (± 0.091)	1 (± 0.7)	0.3 (± 0.053)
7/26/2010	Sediment-Water Interface	Pipette	LMF	0.0075 (± 0.0034)	0.29 (± 0.053)	0.053 (± 0.055)	12 (± 7)	0.16 (± 0.075)	0.17 (± 0.028)	0.73 (± 0.81)	0.28 (± 0.033)
7/26/2010	Porewater (2.5 cm)	Airstone	H2O	0.43 (± 0.68)	0.42 (± 0.034)	0.028 (± 0.0092)	7.5 (± 4.7)	0.063 (± 0.025)	0.22 (± 0.089)	24 (± 15)	0.86 (± 0.1)
7/26/2010	Porewater (2.5 cm)	Airstone	CTRL	0.081 (± 0.13)	0.28 (± 0.14)	0.03 (± 0.016)	4.2 (± 2.5)	0.25 (± 0.1)	0.27 (± 0.083)	10 (± 12)	0.6 (± 0.39)
7/26/2010	Porewater (2.5 cm)	Airstone	LALL	0.38 (± 0.078)	1.1 (± 0.6)	0.36 (± 0.15)	25 (± 19)	4.1 (± 1.3)	0.2 (± 0.082)	6.1 (± 2.7)	3.6 (± 0.88)
7/26/2010	Porewater (2.5 cm)	Airstone	GE	0.085 (± 0.069)	1.1 (± 1.1)	0.78 (± 0.79)	8.9 (± 4.2)	14 (± 2.5)	0.84 (± 0.93)	32 (± 49)	4.7 (± 1.3)
7/26/2010	Porewater (2.5 cm)	Airstone	DE	0.31 (± 0.029)	22 (± 1.1)	1.6 (± 1.1)	19 (± 3.7)	2.1 (± 0.12)	0.26 (± 0.075)	14 (± 14)	0.64 (± 0.033)
7/26/2010	Porewater (2.5 cm)	Airstone	NP	0.52 (± 0.19)	9.6 (± 1.9)	0.3 (± 0.014)	21 (± 2.9)	4.5 (± 0.28)	0.11 (± 0.0035)	25 (± 28)	1.7 (± 0.92)
7/26/2010	Porewater (2.5 cm)	Airstone	LD	0.12 (± 0.066)	34 (± 17)	0.6 (± 0.68)	15 (± 6.9)	2.6 (± 1.2)	0.29 (± 0.37)	26 (± 38)	1.3 (± 0.62)
7/26/2010	Porewater (2.5 cm)	Airstone	UMF	0.31 (± 0.15)	23 (± 13)	3.5 (± 7)	38 (± 64)	4 (± 0.69)	0.55 (± 0.94)	16 (± 9.3)	3.1 (± 0.87)
7/26/2010	Porewater (2.5 cm)	Airstone	LMF	0.029 (± 0.017)	0.85 (± 0.26)	0.6 (± 0.23)	19 (± 5.6)	3.4 (± 0.75)	0.23 (± 0.052)	2.5	2.9 (± 0.97)
8/1/2010	Sediment-Water Interface	Peeper	H2O	0.053 (± 0.0058)	1.1 (± 1.6)	0.45 (± 0.53)	2.9 (± 1.6)	1	1.4 (± 0.18)	ND	2.6 (± 3.2)
8/1/2010	Sediment-Water Interface	Peeper	CTRL	0.05	0.21 (± 0.014)	1.5 (± 0.92)	2.4 (± 0.76)	1	0.64 (± 0.36)	ND	0.75 (± 0.19)
8/1/2010	Sediment-Water Interface	Peeper	LALL	0.05	0.26 (± 0.14)	0.15 (± 0.063)	2.1 (± 0.29)	1.1 (± 0.12)	1.2 (± 0.079)	ND	0.9 (± 0.27)
8/1/2010	Sediment-Water Interface	Peeper	GE	0.05	0.23 (± 0.043)	0.15 (± 0.034)	2.4 (± 0.47)	1	1.2 (± 0.18)	ND	1.1 (± 0.45)

Table 5-5. Summary of Dissolved Metals (Cadmium, Copper, Lead, Zinc, Arsenic, Chromium, Mercury, and Nickel) Data Collected during the Study

Date	Medium	Sampling Method	Treatment	Cadmium µg/L	Copper µg/L	Lead µg/L	Zinc µg/L	Arsenic µg/L	Chromium µg/L	Mercury ng/L	Nickel µg/L
8/1/2010	Sediment-Water Interface	Peeper	DE	0.05	0.2	0.21 (± 0.049)	2 (± 0.029)	1.1 (± 0.12)	1 (± 0.43)	ND	0.52 (± 0.023)
8/1/2010	Sediment-Water Interface	Peeper	LD	0.05	0.43 (± 0.11)	0.17 (± 0.13)	6.9 (± 12)	1	1.3 (± 0.16)	ND	0.7 (± 0.11)
8/1/2010	Sediment-Water Interface	Peeper	UMF	0.05	0.21 (± 0.016)	0.18 (± 0.024)	5.9 (± 7.1)	1	0.6 (± 0.061)	ND	0.81 (± 0.48)
8/1/2010	Sediment-Water Interface	Peeper	LMF	0.05	0.2	0.14 (± 0.056)	4.5 (± 2.1)	1.2 (± 0.38)	0.72 (± 0.096)	ND	0.65 (± 0.28)
8/1/2010	Sediment-Water Interface	DGT	H2O	0.0071 (± 0.00035)	0.22 (± 0.015)	0.019 (± 0.0026)	40 (± 38)	0.25	0.27 (± 0.038)	ND	0.5 (± 0.089)
8/1/2010	Sediment-Water Interface	DGT	CTRL	0.0077 (± 0.00086)	0.2 (± 0.014)	0.052 (± 0.017)	4 (± 2.5)	0.25	0.23 (± 0.095)	ND	0.33 (± 0.14)
8/1/2010	Sediment-Water Interface	DGT	LALL	0.008 (± 0.0013)	0.15 (± 0.046)	0.019 (± 0.0058)	3.4 (± 1.3)	0.25	0.16 (± 0.087)	ND	0.25 (± 0.026)
8/1/2010	Sediment-Water Interface	DGT	GE	0.0065 (± 0.0011)	0.2 (± 0.035)	0.052 (± 0.01)	3.2 (± 0.78)	0.25	0.2 (± 0.12)	ND	0.42 (± 0.14)
8/1/2010	Sediment-Water Interface	DGT	DE	0.069 (± 0.012)	3.6 (± 0.61)	0.63 (± 0.058)	28 (± 5.6)	0.25	1 (± 0.35)	ND	2.6 (± 0.39)
8/1/2010	Sediment-Water Interface	DGT	LD	0.0061 (± 0.0011)	0.48 (± 0.13)	0.021 (± 0.0072)	4.5 (± 2.5)	0.25	0.2 (± 0.14)	ND	0.33 (± 0.16)
8/1/2010	Sediment-Water Interface	DGT	UMF	0.01 (± 0.0062)	0.37 (± 0.11)	0.039 (± 0.024)	110 (± 260)	0.34 (± 0.22)	0.26 (± 0.16)	ND	1.5 (± 2.8)
8/1/2010	Sediment-Water Interface	DGT	LMF	0.0073 (± 0.0014)	0.23 (± 0.044)	0.092 (± 0.015)	7.6 (± 1.8)	0.25	0.19 (± 0.096)	ND	0.34 (± 0.077)
8/1/2010	Porewater (1 cm)	Peeper	H2O	0.05	0.2	0.19 (± 0.11)	2.5 (± 0.84)	1	1.4 (± 0.13)	ND	1 (± 0.39)
8/1/2010	Porewater (1 cm)	Peeper	CTRL	0.25 (± 0.49)	1 (± 2)	9.9 (± 19)	14 (± 28)	5 (± 9.8)	1.3 (± 1.8)	ND	1.3 (± 1.8)
8/1/2010	Porewater (1 cm)	Peeper	LALL	0.14 (± 0.087)	0.31 (± 0.12)	0.15 (± 0.023)	2.6 (± 0.63)	1	1.3 (± 0.18)	ND	1.7 (± 1.1)
8/1/2010	Porewater (1 cm)	Peeper	GE	0.07 (± 0.035)	0.72 (± 0.56)	0.2 (± 0.088)	4.8 (± 2.1)	1.2 (± 0.23)	1.8 (± 0.34)	ND	1.3 (± 0.27)
8/1/2010	Porewater (1 cm)	Peeper	DE	0.05	1.8 (± 0.4)	0.17 (± 0.026)	5.4 (± 0.92)	1.1 (± 0.1)	0.93 (± 0.18)	ND	0.55 (± 0.27)
8/1/2010	Porewater (1 cm)	Peeper	LD	0.05	2.7 (± 0.99)	0.14 (± 0.054)	6.4 (± 1.3)	1 (± 0.061)	1.9 (± 0.37)	ND	0.48 (± 0.077)
8/1/2010	Porewater (1 cm)	Peeper	UMF	0.05	2.4 (± 0.84)	0.18 (± 0.045)	5.1 (± 0.57)	1.1 (± 0.12)	1.2 (± 0.22)	ND	0.74 (± 0.19)
8/1/2010	Porewater (1 cm)	Peeper	LMF	0.05	0.31 (± 0.2)	0.17 (± 0.013)	6.4 (± 1.3)	1.8 (± 0.69)	4.4 (± 0.42)	ND	1.1 (± 0.086)
8/1/2010	Porewater (1 cm)	DGT	H2O	0.0082 (± 0.0027)	0.23 (± 0.02)	0.018 (± 0.0041)	5 (± 2.6)	0.25	0.43 (± 0.36)	ND	0.38 (± 0.15)
8/1/2010	Porewater (1 cm)	DGT	CTRL	0.008 (± 0.00083)	0.22 (± 0.02)	0.056 (± 0.0077)	4.7 (± 3.9)	0.25	0.26 (± 0.15)	ND	0.35 (± 0.24)
8/1/2010	Porewater (1 cm)	DGT	LALL	0.022 (± 0.0032)	0.2 (± 0.036)	0.036 (± 0.016)	2.9 (± 0.92)	0.25	1.8 (± 4.1)	ND	0.3 (± 0.15)
8/1/2010	Porewater (1 cm)	DGT	GE	0.013 (± 0.0026)	0.24 (± 0.0095)	0.055 (± 0.0005)	3.8 (± 1.4)	0.25	0.14 (± 0.042)	ND	0.36 (± 0.13)
8/1/2010	Porewater (1 cm)	DGT	DE	0.25 (± 0.055)	26 (± 3)	0.7 (± 0.094)	88 (± 7.9)	0.25	1 (± 0.21)	ND	2.6 (± 0.38)
8/1/2010	Porewater (1 cm)	DGT	LD	0.019 (± 0.007)	4.3 (± 1.4)	0.035 (± 0.018)	14 (± 2.2)	0.25	0.15 (± 0.032)	ND	0.29 (± 0.086)
8/1/2010	Porewater (1 cm)	DGT	UMF	0.024 (± 0.0029)	1.8 (± 0.77)	0.059 (± 0.0061)	13 (± 2.8)	0.25	2 (± 4.4)	ND	1.3 (± 2.4)
8/1/2010	Porewater (1 cm)	DGT	LMF	0.018 (± 0.0017)	0.4 (± 0.077)	0.069 (± 0.011)	76 (± 34)	0.25	1.8 (± 2.9)	ND	2.4 (± 3.7)
8/2/2010	Overlying Water	Pipette	H2O	0.0047 (± 0.0033)	0.25 (± 0.041)	0.031 (± 0.033)	36 (± 60)	0.08 (± 0.027)	0.32 (± 0.048)	2.2 (± 0.16)	0.39 (± 0.033)
8/2/2010	Overlying Water	Pipette	CTRL	0.0038 (± 0.002)	2 (± 4.2)	0.017 (± 0.0091)	39 (± 67)	0.067 (± 0.026)	0.46 (± 0.53)	2.4 (± 1.7)	0.4 (± 0.13)
8/2/2010	Overlying Water	Pipette	LALL	0.005 (± 0.00071)	0.23 (± 0.038)	0.041 (± 0.056)	92 (± 220)	0.079 (± 0.027)	0.29 (± 0.04)	2 (± 1.4)	0.35 (± 0.051)
8/2/2010	Overlying Water	Pipette	GE	0.0046 (± 0.0013)	0.26 (± 0.046)	0.025 (± 0.011)	37 (± 48)	0.13 (± 0.087)	0.28 (± 0.024)	2 (± 0.21)	1.8 (± 2.9)
8/2/2010	Overlying Water	Pipette	DE	0.0097 (± 0.0042)	1 (± 0.74)	0.048 (± 0.016)	11 (± 0.82)	0.05	0.24 (± 0.018)	2.1 (± 0.13)	0.35 (± 0.028)
8/2/2010	Overlying Water	Pipette	NP	0.0073 (± 0.00035)	0.56 (± 0.042)	0.026 (± 0.012)	17 (± 15)	0.15 (± 0.071)	0.3 (± 0.06)	1.6 (± 1.1)	0.37 (± 0.099)
8/2/2010	Overlying Water	Pipette	LD	0.0043 (± 0.00082)	0.65 (± 0.073)	0.017 (± 0.0031)	4.9 (± 1.2)	0.12 (± 0.041)	0.62 (± 0.86)	1.8 (± 0.78)	0.57 (± 0.52)
8/2/2010	Overlying Water	Pipette	UMF	0.0065 (± 0.0014)	0.73 (± 0.64)	0.026 (± 0.0071)	53 (± 120)	0.092 (± 0.058)	0.63 (± 0.74)	1.8 (± 0.72)	0.58 (± 0.48)
8/2/2010	Overlying Water	Pipette	LMF	0.007 (± 0.0014)	0.41 (± 0.043)	0.033 (± 0.012)	310 (± 490)	0.088 (± 0.025)	0.36 (± 0.1)	1.7 (± 0.82)	0.45 (± 0.11)
8/2/2010	Sediment-Water Interface	Pipette	CTRL	0.0048 (± 0.0025)	1.1 (± 1.9)	0.017 (± 0.005)	8.6 (± 3)	0.075 (± 0.027)	0.36 (± 0.18)	2.2 (± 0.77)	0.44 (± 0.18)
8/2/2010	Sediment-Water Interface	Pipette	LALL	0.0073 (± 0.0031)	0.45 (± 0.45)	0.02 (± 0.0052)	5.6 (± 3)	0.058 (± 0.02)	0.24 (± 0.029)	2.8 (± 1.9)	0.32 (± 0.059)
8/2/2010	Sediment-Water Interface	Pipette	GE	0.006 (± 0.0024)	0.23 (± 0.075)	0.02 (± 0.0082)	5.4 (± 2.6)	0.075 (± 0.029)	0.28 (± 0.078)	1.9 (± 0.15)	0.32 (± 0.061)
8/2/2010	Sediment-Water Interface	Pipette	DE	0.0077 (± 0.002)	0.71 (± 0.13)	0.05 (± 0.013)	9.6 (± 4.3)	0.13 (± 0.058)	0.29 (± 0.035)	6.5 (± 4.8)	0.34 (± 0.045)
8/2/2010	Sediment-Water Interface	Pipette	NP	0.006 (± 0.0026)	0.55 (± 0.02)	0.021 (± 0.0064)	3.6 (± 0.54)	0.083 (± 0.029)	0.39 (± 0.19)	3.1 (± 0.93)	0.44 (± 0.075)
8/2/2010	Sediment-Water Interface	Pipette	LD	0.0048 (± 0.0026)	1.4 (± 0.15)	0.019 (± 0.0046)	3.8 (± 1.3)	0.083 (± 0.026)	0.28 (± 0.043)	3 (± 1.2)	0.39 (± 0.062)
8/2/2010	Sediment-Water Interface	Pipette	UMF	0.01 (± 0.003)	1.1 (± 0.75)	0.036 (± 0.0096)	8 (± 3.3)	0.092 (± 0.02)	0.3 (± 0.08)	2.6 (± 0.7)	0.81 (± 0.5)
8/2/2010	Sediment-Water Interface	Pipette	LMF	0.0088 (± 0.003)	0.33 (± 0.046)	0.032 (± 0.005)	13 (± 6.3)	0.088 (± 0.025)	0.24 (± 0.025)	1.9 (± 0.22)	0.34 (± 0.064)
8/2/2010	Porewater (2.5 cm)	Airstone	H2O	0.12 (± 0.18)	0.83 (± 1.1)	0.08 (± 0.098)	160 (± 290)	0.09 (± 0.022)	0.28 (± 0.032)	ND	1.2 (± 0.24)
8/2/2010	Porewater (2.5 cm)	Airstone	CTRL	0.04 (± 0.071)	0.38 (± 0.4)	0.036 (± 0.009)	34 (± 8.5)	0.25 (± 0.055)	0.28 (± 0.045)	ND	1 (± 0.96)
8/2/2010	Porewater (2.5 cm)	Airstone	LALL	0.18 (± 0.11)	0.54 (± 0.19)	0.17 (± 0.05)	210 (± 210)	5.4 (± 1.3)	0.24 (± 0.068)	ND	4.2 (± 0.62)

Table 5-5. Summary of Dissolved Metals (Cadmium, Copper, Lead, Zinc, Arsenic, Chromium, Mercury, and Nickel) Data Collected during the Study

Date	Medium	Sampling Method	Treatment	Cadmium µg/L	Copper µg/L	Lead µg/L	Zinc µg/L	Arsenic µg/L	Chromium µg/L	Mercury ng/L	Nickel µg/L
8/2/2010	Porewater (2.5 cm)	Airstone	GE	0.0065 (± 0.0018)	0.33 (± 0.1)	0.17 (± 0.05)	45 (± 9.5)	18 (± 3)	0.22 (± 0.028)	ND	3.9 (± 0.68)
8/2/2010	Porewater (2.5 cm)	Airstone	DE	0.45 (± 0.15)	21 (± 5.1)	0.17 (± 0.013)	200 (± 130)	2.2 (± 0.12)	0.28 (± 0.14)	ND	1.4 (± 0.88)
8/2/2010	Porewater (2.5 cm)	Airstone	NP	0.076 (± 0.018)	5.7 (± 0.38)	0.27 (± 0.013)	250 (± 200)	3.6 (± 0.28)	0.1 (± 0.0071)	ND	3 (± 1.3)
8/2/2010	Porewater (2.5 cm)	Airstone	LD	0.065 (± 0.013)	29 (± 5.5)	0.095 (± 0.018)	110 (± 94)	2.7 (± 0.28)	0.14 (± 0.038)	ND	1.5 (± 0.66)
8/2/2010	Porewater (2.5 cm)	Airstone	UMF	0.37 (± 0.27)	15 (± 4)	0.6 (± 0.69)	140 (± 110)	3.9 (± 0.38)	0.17 (± 0.057)	ND	3.6 (± 0.27)
8/2/2010	Porewater (2.5 cm)	Airstone	LMF	0.017 (± 0.0024)	1 (± 0.28)	0.5 (± 0.15)	79 (± 55)	3.8 (± 0.35)	0.25 (± 0.017)	ND	2.2 (± 1.3)
8/9/2010	Overlying Water	Pipette	H2O	0.58 (± 0.83)	1.6 (± 1.5)	0.29 (± 0.46)	30 (± 33)	0.24 (± 0.055)	9.3 (± 13)	9.8 (± 9.1)	6 (± 7.7)
8/9/2010	Overlying Water	Pipette	CTRL	0.016 (± 0.013)	0.81 (± 0.23)	0.066 (± 0.028)	14 (± 6.5)	0.22 (± 0.041)	0.62 (± 0.15)	8.2 (± 4.2)	0.74 (± 0.084)
8/9/2010	Overlying Water	Pipette	LALL	0.021 (± 0.025)	0.66 (± 0.081)	0.058 (± 0.029)	8.7 (± 2.8)	0.17 (± 0.052)	0.39 (± 0.1)	8.2 (± 5.2)	0.64 (± 0.038)
8/9/2010	Overlying Water	Pipette	GE	0.016 (± 0.015)	0.94 (± 0.38)	0.039 (± 0.0078)	7.7 (± 5.6)	0.3 (± 0.082)	0.59 (± 0.13)	6.7 (± 3.1)	1 (± 0.63)
8/9/2010	Overlying Water	Pipette	DE	0.039 (± 0.0095)	4.8 (± 1.9)	0.22 (± 0.086)	13 (± 2)	0.3 (± 0.1)	0.56 (± 0.096)	8.6 (± 6.3)	0.73 (± 0.064)
8/9/2010	Overlying Water	Pipette	NP	0.025 (± 0.0021)	1.6 (± 0.3)	0.081 (± 0.0085)	13 (± 4)	0.2	0.62 (± 0.16)	15 (± 12)	0.82 (± 0.28)
8/9/2010	Overlying Water	Pipette	LD	0.32 (± 0.68)	3.3 (± 1.4)	0.17 (± 0.26)	21 (± 23)	0.3 (± 0.071)	6.2 (± 13)	6.8 (± 4.7)	4.5 (± 8.2)
8/9/2010	Overlying Water	Pipette	UMF	0.012 (± 0.0023)	1.3 (± 0.39)	0.053 (± 0.024)	15 (± 15)	0.2 (± 0.063)	0.55 (± 0.14)	7.3 (± 5.4)	0.79 (± 0.21)
8/9/2010	Overlying Water	Pipette	LMF	0.019 (± 0.0048)	0.91 (± 0.056)	0.092 (± 0.017)	260 (± 480)	0.2	0.53 (± 0.14)	8.4 (± 6.9)	0.76 (± 0.17)
8/9/2010	Sediment-Water Interface	Pipette	CTRL	0.019 (± 0.029)	0.35 (± 0.077)	0.041 (± 0.0092)	3.6 (± 1.6)	0.22 (± 0.075)	0.36 (± 0.31)	5.8 (± 1.5)	0.4 (± 0.22)
8/9/2010	Sediment-Water Interface	Pipette	LALL	0.01 (± 0.0056)	0.32 (± 0.052)	0.022 (± 0.005)	5.4 (± 1.4)	0.22 (± 0.041)	0.34 (± 0.23)	6.3 (± 1.6)	0.33 (± 0.052)
8/9/2010	Sediment-Water Interface	Pipette	GE	0.0076 (± 0.0045)	0.31 (± 0.036)	0.027 (± 0.0038)	3.7 (± 0.63)	0.28 (± 0.096)	0.23 (± 0.036)	5.5 (± 1.3)	0.35 (± 0.08)
8/9/2010	Sediment-Water Interface	Pipette	DE	0.023 (± 0.012)	4.5 (± 1.8)	0.1 (± 0.047)	8.5 (± 4.5)	0.33 (± 0.058)	0.3 (± 0.14)	6.8 (± 0.74)	0.37 (± 0.11)
8/9/2010	Sediment-Water Interface	Pipette	NP	0.0073 (± 0.0025)	1.5 (± 0.4)	0.059 (± 0.013)	8.3 (± 0.32)	0.2	0.26 (± 0.021)	5.7 (± 0.092)	0.39 (± 0.16)
8/9/2010	Sediment-Water Interface	Pipette	LD	0.028 (± 0.031)	2.8 (± 0.47)	0.051 (± 0.028)	9.5 (± 5.1)	0.24 (± 0.055)	0.37 (± 0.22)	5 (± 0.89)	0.51 (± 0.24)
8/9/2010	Sediment-Water Interface	Pipette	UMF	0.042 (± 0.048)	0.86 (± 0.19)	0.048 (± 0.022)	11 (± 14)	0.25 (± 0.055)	0.98 (± 1)	5.1 (± 1.1)	0.84 (± 0.58)
8/9/2010	Sediment-Water Interface	Pipette	LMF	0.0076 (± 0.0015)	0.52 (± 0.1)	0.042 (± 0.0049)	7.7 (± 1.4)	0.2	0.27 (± 0.044)	5.1 (± 0.66)	0.38 (± 0.073)
8/9/2010	Porewater (2.5 cm)	Airstone	H2O	0.14 (± 0.084)	0.77 (± 0.61)	0.16 (± 0.25)	7 (± 3.6)	0.26 (± 0.25)	0.91 (± 0.7)	8.9 (± 3.1)	2.4 (± 2.3)
8/9/2010	Porewater (2.5 cm)	Airstone	CTRL	0.33 (± 0.49)	0.35 (± 0.1)	0.45 (± 0.96)	7.2 (± 7.3)	0.3 (± 0.063)	2.2 (± 3.5)	7 (± 1.4)	2.7 (± 2)
8/9/2010	Porewater (2.5 cm)	Airstone	LALL	0.27 (± 0.38)	1.1 (± 1.9)	0.15 (± 0.075)	12 (± 6.3)	6.3 (± 1.2)	0.71 (± 1.3)	5.6 (± 0.59)	3.6 (± 1.1)
8/9/2010	Porewater (2.5 cm)	Airstone	GE	0.028 (± 0.017)	0.19 (± 0.071)	0.067 (± 0.03)	4.2 (± 2.1)	15 (± 3.1)	1.2 (± 1.4)	11 (± 2.4)	3 (± 0.31)
8/9/2010	Porewater (2.5 cm)	Airstone	DE	0.17 (± 0.008)	32 (± 13)	0.18 (± 0.076)	15 (± 1.7)	3.1 (± 1)	0.077 (± 0.025)	5.5 (± 0.71)	0.89 (± 0.17)
8/9/2010	Porewater (2.5 cm)	Airstone	NP	0.087 (± 0.069)	2.9 (± 0.28)	0.13 (± 0.056)	8.1 (± 0.071)	2.9 (± 0.14)	1.3 (± 1.6)	7.8 (± 0.14)	1.5 (± 0.87)
8/9/2010	Porewater (2.5 cm)	Airstone	LD	0.064 (± 0.025)	22 (± 3.6)	0.13 (± 0.033)	14 (± 4.7)	2.5 (± 0.24)	0.13 (± 0.054)	36 (± 28)	1.4 (± 0.23)
8/9/2010	Porewater (2.5 cm)	Airstone	UMF	0.095 (± 0.06)	12 (± 4.1)	0.41 (± 0.17)	8.6 (± 4)	3.6 (± 0.36)	0.48 (± 0.72)	12 (± 3.1)	2.5 (± 0.53)
8/9/2010	Porewater (2.5 cm)	Airstone	LMF	0.035 (± 0.013)	1.1 (± 0.79)	0.3 (± 0.097)	7.4 (± 3.4)	4.2 (± 0.17)	2 (± 1.2)	6.8 (± 1.1)	2.7 (± 0.26)
8/16/2010	Overlying Water	Pipette	H2O	0.053 (± 0.096)	0.84 (± 0.31)	0.092 (± 0.13)	9.7 (± 5.8)	0.18 (± 0.041)	0.43 (± 0.39)	2.8 (± 1.1)	0.73 (± 0.28)
8/16/2010	Overlying Water	Pipette	CTRL	0.02 (± 0.023)	0.86 (± 0.35)	0.08 (± 0.049)	49 (± 89)	0.22 (± 0.041)	0.31 (± 0.11)	7.1 (± 7.5)	0.77 (± 0.27)
8/16/2010	Overlying Water	Pipette	LALL	0.013 (± 0.0029)	0.86 (± 0.28)	0.047 (± 0.0088)	14 (± 14)	0.22 (± 0.041)	0.25 (± 0.14)	3.3 (± 0.84)	0.61 (± 0.12)
8/16/2010	Overlying Water	Pipette	GE	0.018 (± 0.011)	0.76 (± 0.082)	0.051 (± 0.0094)	3.7 (± 1.6)	0.28 (± 0.096)	0.48 (± 0.47)	2.6 (± 1.2)	0.74 (± 0.18)
8/16/2010	Overlying Water	Pipette	DE	0.073 (± 0.041)	6.2 (± 1.7)	0.29 (± 0.08)	17 (± 9.2)	0.37 (± 0.058)	0.31 (± 0.21)	23 (± 34)	0.75 (± 0.15)
8/16/2010	Overlying Water	Pipette	NP	0.017	1.4 (± 0.21)	0.087 (± 0.027)	28 (± 29)	0.25 (± 0.071)	0.23 (± 0.032)	42 (± 48)	0.65 (± 0.2)
8/16/2010	Overlying Water	Pipette	LD	0.015 (± 0.0033)	3.1 (± 0.83)	0.07 (± 0.021)	150 (± 350)	0.3 (± 0.089)	0.6 (± 0.6)	2.9 (± 1.7)	0.8 (± 0.26)
8/16/2010	Overlying Water	Pipette	UMF	0.023 (± 0.0044)	1.5 (± 0.33)	0.094 (± 0.027)	9 (± 5.8)	0.2 (± 0.063)	0.3 (± 0.15)	2.7 (± 1.5)	0.76 (± 0.15)
8/16/2010	Overlying Water	Pipette	LMF	0.039 (± 0.05)	1.4 (± 1.1)	0.14 (± 0.12)	12 (± 6)	0.23 (± 0.096)	0.55 (± 0.76)	11 (± 14)	0.92 (± 0.79)
8/16/2010	Sediment-Water Interface	Pipette	CTRL	0.0086 (± 0.0034)	3.6 (± 7.7)	0.074 (± 0.098)	4.7 (± 2.4)	0.18 (± 0.075)	0.73 (± 1.3)	19 (± 16)	0.53 (± 0.52)
8/16/2010	Sediment-Water Interface	Pipette	LALL	0.095 (± 0.18)	1.2 (± 0.82)	0.15 (± 0.21)	24 (± 17)	0.25 (± 0.084)	1.4 (± 2.7)	41 (± 62)	1.2 (± 1.7)
8/16/2010	Sediment-Water Interface	Pipette	GE	0.011 (± 0.0037)	0.37 (± 0.048)	0.03 (± 0.0085)	3.3 (± 1.1)	0.33 (± 0.096)	0.19 (± 0.044)	61 (± 110)	0.29 (± 0.03)
8/16/2010	Sediment-Water Interface	Pipette	DE	0.034 (± 0.011)	6.6 (± 1.5)	0.14 (± 0.038)	10 (± 1.4)	0.4 (± 0.1)	0.18 (± 0.043)	84 (± 120)	0.35 (± 0.0029)
8/16/2010	Sediment-Water Interface	Pipette	NP	0.017 (± 0.0092)	0.93 (± 0.39)	0.055 (± 0.0057)	5.4 (± 0.6)	0.15 (± 0.071)	0.22 (± 0.057)	31 (± 22)	0.38 (± 0.011)
8/16/2010	Sediment-Water Interface	Pipette	LD	0.12 (± 0.26)	6.2 (± 5.1)	0.58 (± 1.2)	60 (± 100)	0.35 (± 0.18)	1.5 (± 3.2)	6.2 (± 1.2)	1.5 (± 2.8)
8/16/2010	Sediment-Water Interface	Pipette	UMF	0.076 (± 0.11)	1.8 (± 1.6)	0.16 (± 0.18)	16 (± 14)	0.22 (± 0.075)	0.43 (± 0.32)	10 (± 8.2)	0.47 (± 0.18)

Table 5-5. Summary of Dissolved Metals (Cadmium, Copper, Lead, Zinc, Arsenic, Chromium, Mercury, and Nickel) Data Collected during the Study

Date	Medium	Sampling Method	Treatment	Cadmium µg/L	Copper µg/L	Lead µg/L	Zinc µg/L	Arsenic µg/L	Chromium µg/L	Mercury ng/L	Nickel µg/L
8/16/2010	Sediment-Water Interface	Pipette	LMF	0.012 (± 0.0022)	0.69 (± 0.49)	0.048 (± 0.0089)	14 (± 9.1)	0.14 (± 0.055)	0.3 (± 0.14)	32 (± 41)	0.36 (± 0.052)
8/16/2010	Porewater (2.5 cm)	Airstone	H2O	0.039 (± 0.022)	0.66 (± 0.19)	0.047 (± 0.032)	290 (± 190)	0.2 (± 0.071)	0.17 (± 0.042)	35 (± 20)	0.44 (± 0.1)
8/16/2010	Porewater (2.5 cm)	Airstone	CTRL	0.023 (± 0.014)	0.56 (± 0.34)	0.22 (± 0.19)	120 (± 170)	0.58 (± 0.15)	0.2 (± 0.042)	19 (± 16)	2 (± 0.77)
8/16/2010	Porewater (2.5 cm)	Airstone	LALL	0.23 (± 0.048)	4.1 (± 2.5)	12 (± 3.7)	44 (± 22)	7.5 (± 1.7)	1.5 (± 0.63)	15 (± 17)	2.5 (± 0.4)
8/16/2010	Porewater (2.5 cm)	Airstone	GE	0.05 (± 0.026)	0.21 (± 0.036)	0.088 (± 0.026)	300 (± 440)	17 (± 0.86)	0.25 (± 0.05)	22 (± 13)	0.97 (± 0.081)
8/16/2010	Porewater (2.5 cm)	Airstone	DE	1.5 (± 0.69)	190 (± 94)	88 (± 59)	260 (± 110)	6.8 (± 1.8)	3.6 (± 1.8)	12 (± 6.5)	4.3 (± 1.6)
8/16/2010	Porewater (2.5 cm)	Airstone	NP	0.3 (± 0.37)	2.5 (± 1.1)	0.53 (± 0.55)	340 (± 410)	2.4 (± 0.28)	2.8 (± 3.6)	8.6	2.3 (± 2.4)
8/16/2010	Porewater (2.5 cm)	Airstone	LD	0.069 (± 0.026)	19 (± 1.8)	0.15 (± 0.037)	140 (± 140)	2.3 (± 0.31)	0.13 (± 0.085)	12 (± 5.4)	0.63 (± 0.093)
8/16/2010	Porewater (2.5 cm)	Airstone	UMF	1.3 (± 1.2)	82 (± 83)	61 (± 68)	350 (± 190)	4.6 (± 1.9)	3.7 (± 3.6)	24 (± 17)	3.4 (± 1.5)
8/16/2010	Porewater (2.5 cm)	Airstone	LMF	0.034 (± 0.027)	0.55 (± 0.037)	0.23 (± 0.02)	210 (± 140)	3.7 (± 0.32)	0.44 (± 0.26)	14 (± 1.9)	1.2 (± 0.085)
8/20/2010	Sediment-Water Interface	Peeper	H2O	0.056 (± 0.011)	0.3 (± 0.17)	0.86 (± 0.13)	2.3 (± 0.43)	1	0.72 (± 0.12)	ND	0.6 (± 0.018)
8/20/2010	Sediment-Water Interface	Peeper	CTRL	0.05	0.33 (± 0.11)	1 (± 0.24)	4.5 (± 5.2)	1	0.73 (± 0.21)	ND	0.75 (± 0.35)
8/20/2010	Sediment-Water Interface	Peeper	LALL	0.05	0.5 (± 0.64)	0.87 (± 0.056)	2.6 (± 1.5)	1	0.9 (± 0.14)	ND	0.69 (± 0.18)
8/20/2010	Sediment-Water Interface	Peeper	GE	0.053 (± 0.0035)	0.61 (± 0.36)	0.63 (± 0.4)	1400 (± 2400)	1	1 (± 0.27)	ND	1.5 (± 1)
8/20/2010	Sediment-Water Interface	Peeper	DE	0.052 (± 0.0029)	0.96 (± 0.15)	0.14 (± 0.061)	8.4 (± 0.68)	1	0.96 (± 0.1)	ND	0.7 (± 0.12)
8/20/2010	Sediment-Water Interface	Peeper	LD	0.05	0.69 (± 0.31)	0.099 (± 0.029)	5.4 (± 1.9)	1	1.2 (± 0.28)	ND	0.88 (± 0.5)
8/20/2010	Sediment-Water Interface	Peeper	UMF	0.084 (± 0.038)	1.1 (± 0.54)	2.4 (± 0.43)	8 (± 1.9)	1	0.5 (± 0.16)	ND	1.5 (± 0.29)
8/20/2010	Sediment-Water Interface	Peeper	LMF	0.055 (± 0.0087)	1 (± 0.34)	1.1 (± 0.038)	25 (± 24)	1	0.67 (± 0.025)	ND	1 (± 0.27)
8/20/2010	Sediment-Water Interface	DGT	H2O	0.026 (± 0.0037)	0.28 (± 0.023)	0.0072 (± 0.00058)	2.8 (± 0.21)	0.25	0.093 (± 0.02)	ND	0.27 (± 0.015)
8/20/2010	Sediment-Water Interface	DGT	CTRL	0.03 (± 0.017)	0.25 (± 0.12)	0.093 (± 0.07)	3.2 (± 1.6)	0.25	0.15 (± 0.067)	ND	0.43 (± 0.086)
8/20/2010	Sediment-Water Interface	DGT	LALL	0.016 (± 0.0072)	0.17 (± 0.042)	0.014 (± 0.0058)	4.2 (± 1.4)	0.25	0.083 (± 0.022)	ND	0.32 (± 0.025)
8/20/2010	Sediment-Water Interface	DGT	GE	0.007 (± 0.0041)	0.1 (± 0.0088)	0.039 (± 0.028)	16 (± 25)	0.25	0.37 (± 0.33)	ND	0.44 (± 0.2)
8/20/2010	Sediment-Water Interface	DGT	DE	0.19 (± 0.098)	23 (± 9.7)	0.079 (± 0.047)	33 (± 15)	0.43 (± 0.32)	0.11 (± 0.012)	ND	0.46 (± 0.092)
8/20/2010	Sediment-Water Interface	DGT	LD	0.029 (± 0.013)	3.7 (± 2.5)	0.019 (± 0.0062)	21 (± 16)	0.29 (± 0.1)	0.13 (± 0.082)	ND	0.37 (± 0.035)
8/20/2010	Sediment-Water Interface	DGT	UMF	0.032 (± 0.0065)	0.45 (± 0.15)	0.018 (± 0.004)	7.5 (± 2.8)	0.25	0.086 (± 0.011)	ND	0.46 (± 0.11)
8/20/2010	Sediment-Water Interface	DGT	LMF	0.008 (± 0.00074)	0.15 (± 0.026)	0.037 (± 0.036)	5.9 (± 1.9)	0.25	0.058 (± 0.0012)	ND	0.25 (± 0.02)
8/20/2010	Porewater (1 cm)	Peeper	H2O	0.069 (± 0.033)	0.3 (± 0.052)	0.88 (± 0.013)	3.2 (± 1.1)	1	0.59 (± 0.12)	ND	0.83 (± 0.14)
8/20/2010	Porewater (1 cm)	Peeper	CTRL	0.089 (± 0.095)	0.3 (± 0.21)	1 (± 0.45)	2.6 (± 1.4)	1	1.7 (± 0.36)	ND	1.1 (± 0.36)
8/20/2010	Porewater (1 cm)	Peeper	LALL	0.062 (± 0.029)	0.25 (± 0.062)	0.82 (± 0.069)	2.7 (± 1.1)	1.5 (± 1.3)	1.2 (± 0.41)	ND	1.2 (± 0.4)
8/20/2010	Porewater (1 cm)	Peeper	GE	0.05	0.41 (± 0.28)	0.17 (± 0.0074)	2	2 (± 1.7)	2.6 (± 0.34)	ND	0.84 (± 0.14)
8/20/2010	Porewater (1 cm)	Peeper	DE	0.13 (± 0.087)	20 (± 6.5)	0.092 (± 0.011)	9.1 (± 11)	2.2 (± 1.1)	1.4 (± 0.6)	ND	1.2 (± 0.073)
8/20/2010	Porewater (1 cm)	Peeper	LD	0.34 (± 0.46)	8.9 (± 7.1)	0.13 (± 0.036)	11 (± 12)	2.3 (± 1.5)	2.3 (± 0.74)	ND	2 (± 1.7)
8/20/2010	Porewater (1 cm)	Peeper	UMF	0.16 (± 0.057)	3 (± 1.1)	1.9 (± 0.23)	16 (± 7.8)	1	1.7 (± 0.7)	ND	2.4 (± 0.66)
8/20/2010	Porewater (1 cm)	Peeper	LMF	0.05	0.81 (± 0.62)	0.93 (± 0.1)	6.5 (± 4)	2 (± 0.96)	3.5 (± 0.83)	ND	1 (± 0.23)
8/20/2010	Porewater (1 cm)	DGT	H2O	0.024 (± 0.0031)	0.28 (± 0.074)	0.0074 (± 0.00096)	2.8 (± 0.11)	0.25	0.12 (± 0.063)	ND	0.29 (± 0.029)
8/20/2010	Porewater (1 cm)	DGT	CTRL	0.02 (± 0.0037)	0.18 (± 0.065)	0.02 (± 0.018)	2.4 (± 0.83)	0.25	0.12 (± 0.064)	ND	0.25 (± 0.037)
8/20/2010	Porewater (1 cm)	DGT	LALL	0.025 (± 0.012)	0.19 (± 0.062)	0.28 (± 0.087)	6.1 (± 1.4)	0.25	0.11 (± 0.023)	ND	0.53 (± 0.052)
8/20/2010	Porewater (1 cm)	DGT	GE	0.012 (± 0.0019)	0.19 (± 0.027)	0.0091 (± 0.0039)	3.9 (± 2.5)	0.25	0.19 (± 0.13)	ND	0.38 (± 0.049)
8/20/2010	Porewater (1 cm)	DGT	DE	0.044 (± 0.0063)	2.9 (± 1.9)	0.035 (± 0.02)	11 (± 1.7)	0.25	0.16 (± 0.027)	ND	0.34 (± 0.036)
8/20/2010	Porewater (1 cm)	DGT	LD	0.036 (± 0.0037)	7 (± 7.7)	0.077 (± 0.14)	29 (± 21)	0.31 (± 0.14)	0.43 (± 0.64)	ND	0.41 (± 0.063)
8/20/2010	Porewater (1 cm)	DGT	UMF	0.042 (± 0.015)	2.1 (± 1.9)	0.084 (± 0.027)	23 (± 14)	0.4 (± 0.23)	0.1 (± 0.047)	ND	0.37 (± 0.048)
8/20/2010	Porewater (1 cm)	DGT	LMF	0.019 (± 0.0035)	0.36 (± 0.082)	0.29 (± 0.064)	62 (± 14)	0.7 (± 0.2)	0.18 (± 0.085)	ND	0.43 (± 0.039)
8/23/2010	Overlying Water	Pipette	H2O	0.099 (± 0.19)	0.84 (± 0.29)	0.079 (± 0.12)	18 (± 23)	0.16 (± 0.055)	1 (± 1.3)	21 (± 19)	0.83 (± 0.49)
8/23/2010	Overlying Water	Pipette	CTRL	0.015 (± 0.0073)	0.78 (± 0.41)	0.053 (± 0.029)	170 (± 410)	0.17 (± 0.049)	0.57 (± 0.25)	11 (± 7.1)	0.64 (± 0.16)
8/23/2010	Overlying Water	Pipette	LALL	0.021 (± 0.0099)	0.87 (± 0.28)	0.045 (± 0.028)	230 (± 520)	0.18 (± 0.075)	0.41 (± 0.32)	5 (± 3.5)	0.58 (± 0.076)
8/23/2010	Overlying Water	Pipette	GE	0.019 (± 0.015)	0.87 (± 0.38)	0.08 (± 0.11)	11 (± 7.6)	0.23 (± 0.05)	0.39 (± 0.15)	100 (± 180)	0.59 (± 0.14)
8/23/2010	Overlying Water	Pipette	DE	0.17 (± 0.24)	4.9 (± 2.3)	0.21 (± 0.16)	64 (± 82)	0.3 (± 0.1)	1.2 (± 1.2)	54 (± 87)	1.1 (± 0.91)
8/23/2010	Overlying Water	Pipette	NP	0.017 (± 0.0028)	1.5 (± 0.16)	0.083 (± 0.0014)	10 (± 2.2)	0.15 (± 0.071)	0.31 (± 0.035)	23 (± 20)	0.53 (± 0.0071)

Table 5-5. Summary of Dissolved Metals (Cadmium, Copper, Lead, Zinc, Arsenic, Chromium, Mercury, and Nickel) Data Collected during the Study

Date	Medium	Sampling Method	Treatment	Cadmium µg/L	Copper µg/L	Lead µg/L	Zinc µg/L	Arsenic µg/L	Chromium µg/L	Mercury ng/L	Nickel µg/L
8/23/2010	Overlying Water	Pipette	LD	0.022 (± 0.016)	2.7 (± 0.42)	0.07 (± 0.019)	130 (± 270)	0.22 (± 0.041)	0.39 (± 0.11)	740 (± 1600)	0.6 (± 0.07)
8/23/2010	Overlying Water	Pipette	UMF	0.019 (± 0.01)	1.2 (± 0.85)	0.052 (± 0.037)	16 (± 9.9)	0.15 (± 0.1)	0.31 (± 0.21)	6.9 (± 4.5)	0.55 (± 0.38)
8/23/2010	Overlying Water	Pipette	LMF	0.017 (± 0.0048)	1 (± 0.47)	0.096 (± 0.014)	16 (± 6.9)	0.15 (± 0.058)	0.34 (± 0.13)	19 (± 28)	0.55 (± 0.086)
8/23/2010	Sediment-Water Interface	Pipette	CTRL	0.0072 (± 0.0019)	0.43 (± 0.26)	0.025 (± 0.0052)	4.2 (± 3)	0.17 (± 0.076)	0.21 (± 0.084)	41 (± 83)	0.29 (± 0.026)
8/23/2010	Sediment-Water Interface	Pipette	LALL	0.0074 (± 0.0026)	0.74 (± 0.13)	0.027 (± 0.022)	6.2 (± 4)	0.2 (± 0.063)	0.31 (± 0.28)	5 (± 1.8)	0.59 (± 0.087)
8/23/2010	Sediment-Water Interface	Pipette	GE	0.006 (± 0.00091)	0.84 (± 0.78)	0.018 (± 0.0025)	4.4 (± 2.8)	0.15 (± 0.058)	0.72 (± 0.93)	14 (± 11)	0.41 (± 0.17)
8/23/2010	Sediment-Water Interface	Pipette	DE	0.021 (± 0.0052)	4.3 (± 1.3)	0.14 (± 0.012)	8.2 (± 2.3)	0.27 (± 0.12)	0.16 (± 0.033)	12 (± 7.6)	0.29 (± 0.021)
8/23/2010	Sediment-Water Interface	Pipette	NP	0.0095 (± 0.00071)	1.8 (± 0.0071)	0.094 (± 0.059)	6.5 (± 3.4)	0.2	0.24 (± 0.11)	4.7 (± 3.5)	0.32 (± 0.078)
8/23/2010	Sediment-Water Interface	Pipette	LD	0.0082 (± 0.0015)	3.2 (± 1.4)	0.05 (± 0.031)	18 (± 13)	0.23 (± 0.099)	0.22 (± 0.047)	260 (± 600)	0.46 (± 0.19)
8/23/2010	Sediment-Water Interface	Pipette	UMF	0.011 (± 0.0015)	1.4 (± 0.2)	0.035 (± 0.0069)	8.7 (± 1.9)	0.2 (± 0.063)	0.24 (± 0.12)	16 (± 14)	0.32 (± 0.063)
8/23/2010	Sediment-Water Interface	Pipette	LMF	0.01 (± 0.0027)	1.2 (± 1.3)	0.094 (± 0.072)	13 (± 10)	0.15 (± 0.058)	0.26 (± 0.13)	31 (± 31)	0.31 (± 0.06)
8/23/2010	Porewater (2.5 cm)	Airstone	H2O	0.49 (± 0.23)	0.63 (± 0.16)	0.21 (± 0.25)	530 (± 620)	0.4 (± 0.34)	0.23 (± 0.088)	37 (± 9.5)	0.47 (± 0.11)
8/23/2010	Porewater (2.5 cm)	Airstone	CTRL	0.22 (± 0.29)	2 (± 3.9)	0.49 (± 1)	34 (± 55)	0.3 (± 0.071)	0.22 (± 0.14)	19 (± 8.4)	1.1 (± 0.5)
8/23/2010	Porewater (2.5 cm)	Airstone	LALL	0.14 (± 0.053)	0.67 (± 0.37)	0.22 (± 0.11)	41 (± 49)	6.3 (± 0.87)	0.3 (± 0.19)	6 (± 1.8)	1.3 (± 0.16)
8/23/2010	Porewater (2.5 cm)	Airstone	GE	0.13 (± 0.14)	0.16 (± 0.061)	0.045 (± 0.025)	3.2 (± 1.5)	13 (± 1.6)	0.18 (± 0.081)	8 (± 4.2)	0.68 (± 0.074)
8/23/2010	Porewater (2.5 cm)	Airstone	DE	0.21 (± 0.17)	21 (± 11)	0.29 (± 0.099)	13 (± 4)	3.4 (± 1.2)	0.17 (± 0.085)	22 (± 10)	1.2 (± 0.62)
8/23/2010	Porewater (2.5 cm)	Airstone	NP	0.24 (± 0.011)	3.2 (± 1.9)	0.31 (± 0.047)	90 (± 120)	2.5 (± 0.071)	0.18 (± 0.028)	29 (± 30)	0.87 (± 0.22)
8/23/2010	Porewater (2.5 cm)	Airstone	LD	0.14 (± 0.17)	17 (± 2.3)	0.17 (± 0.048)	94 (± 130)	2.2 (± 0.21)	0.21 (± 0.2)	21 (± 31)	1.2 (± 1.1)
8/23/2010	Porewater (2.5 cm)	Airstone	UMF	0.17 (± 0.076)	6.3 (± 2.2)	0.34 (± 0.17)	11 (± 7.9)	2.9 (± 0.43)	0.37 (± 0.67)	20 (± 18)	1.9 (± 0.63)
8/23/2010	Porewater (2.5 cm)	Airstone	LMF	0.3 (± 0.21)	1.5 (± 1)	0.79 (± 0.39)	310 (± 510)	3.6 (± 0.72)	2.9 (± 3.2)	99	4.6 (± 3.4)
8/30/2010	Overlying Water	Pipette	H2O	0.013 (± 0.0017)	0.69 (± 0.11)	0.027 (± 0.0034)	7.1 (± 2.5)	0.22 (± 0.045)	0.61 (± 0.51)	3.2 (± 1.8)	0.72 (± 0.23)
8/30/2010	Overlying Water	Pipette	CTRL	0.0076 (± 0.0052)	0.62 (± 0.14)	0.04 (± 0.042)	4.6 (± 2.5)	0.17 (± 0.052)	0.23 (± 0.042)	5 (± 6.2)	0.57 (± 0.065)
8/30/2010	Overlying Water	Pipette	LALL	0.01 (± 0.0069)	0.65 (± 0.049)	0.028 (± 0.012)	7.9 (± 2.3)	0.16 (± 0.066)	0.34 (± 0.26)	5.9 (± 6.5)	0.6 (± 0.071)
8/30/2010	Overlying Water	Pipette	GE	0.09 (± 0.12)	0.99 (± 0.41)	0.028 (± 0.00071)	5.6 (± 1.3)	0.2	0.36 (± 0.035)	5.1 (± 4.7)	0.69 (± 0.014)
8/30/2010	Overlying Water	Pipette	DE	0.46 (± 0.76)	4 (± 1.3)	0.12 (± 0.12)	21 (± 22)	0.27 (± 0.058)	1 (± 1.3)	43 (± 69)	1.4 (± 1.4)
8/30/2010	Overlying Water	Pipette	NP	0.0085 (± 0.0021)	1.7 (± 0.085)	0.12 (± 0.098)	14 (± 11)	0.2	0.24 (± 0.028)	17 (± 20)	0.68 (± 0.049)
8/30/2010	Overlying Water	Pipette	LD	0.015 (± 0.0052)	2.8 (± 0.28)	0.065 (± 0.023)	18 (± 20)	0.27 (± 0.049)	0.44 (± 0.59)	3.4 (± 1.7)	0.72 (± 0.2)
8/30/2010	Overlying Water	Pipette	UMF	0.013 (± 0.0059)	1.4 (± 0.22)	0.047 (± 0.015)	10 (± 5.2)	0.22 (± 0.075)	0.21 (± 0.077)	3.9 (± 1.9)	0.58 (± 0.13)
8/30/2010	Overlying Water	Pipette	LMF	0.0078 (± 0.0015)	1.4 (± 0.47)	0.11 (± 0.077)	15 (± 7.2)	0.13 (± 0.05)	0.23 (± 0.058)	3.5 (± 1.6)	0.64 (± 0.11)
8/30/2010	Sediment-Water Interface	Pipette	CTRL	0.0093 (± 0.0068)	0.49 (± 0.19)	0.042 (± 0.041)	7.5 (± 3.3)	0.13 (± 0.075)	0.26 (± 0.068)	6.3 (± 3.9)	0.32 (± 0.081)
8/30/2010	Sediment-Water Interface	Pipette	LALL	0.0097 (± 0.006)	0.31 (± 0.018)	0.029 (± 0.0067)	6.7 (± 1.6)	0.17 (± 0.052)	0.23 (± 0.077)	6.9 (± 4.2)	0.29 (± 0.049)
8/30/2010	Sediment-Water Interface	Pipette	GE	0.006 (± 0.0017)	0.5 (± 0.2)	0.03 (± 0.013)	7.1 (± 1)	0.23 (± 0.05)	0.22 (± 0.075)	4.7 (± 0.71)	0.34 (± 0.055)
8/30/2010	Sediment-Water Interface	Pipette	DE	0.015 (± 0.0064)	2.9 (± 0.53)	0.055 (± 0.019)	8.4 (± 3.8)	0.2 (± 0.1)	0.24 (± 0.051)	5.4 (± 1.2)	0.32 (± 0.085)
8/30/2010	Sediment-Water Interface	Pipette	NP	0.014 (± 0.0071)	1.8 (± 0.0071)	0.091 (± 0.044)	14 (± 9.7)	0.25 (± 0.071)	0.49 (± 0.12)	4.8 (± 2.8)	0.51 (± 0.0071)
8/30/2010	Sediment-Water Interface	Pipette	LD	0.0088 (± 0.0018)	2.4 (± 0.67)	0.043 (± 0.005)	12 (± 1.9)	0.25 (± 0.055)	0.36 (± 0.41)	6.2 (± 1.6)	0.39 (± 0.19)
8/30/2010	Sediment-Water Interface	Pipette	UMF	0.087 (± 0.19)	1.3 (± 0.45)	0.053 (± 0.027)	28 (± 44)	0.18 (± 0.041)	0.25 (± 0.11)	4.1 (± 0.97)	0.35 (± 0.11)
8/30/2010	Sediment-Water Interface	Pipette	LMF	0.011 (± 0.0052)	0.67 (± 0.24)	0.081 (± 0.019)	11 (± 3.5)	0.18 (± 0.045)	0.92 (± 0.9)	6 (± 4.8)	0.44 (± 0.18)
8/30/2010	Porewater (2.5 cm)	Airstone	H2O	0.022 (± 0.0076)	0.37 (± 0.072)	0.02 (± 0.0077)	17 (± 7.3)	0.12 (± 0.076)	0.18 (± 0.049)	ND	0.34 (± 0.046)
8/30/2010	Porewater (2.5 cm)	Airstone	CTRL	0.037 (± 0.044)	0.24 (± 0.063)	0.042 (± 0.012)	9.4 (± 3.1)	0.73 (± 0.27)	0.13 (± 0.058)	ND	1.8 (± 1.2)
8/30/2010	Porewater (2.5 cm)	Airstone	LALL	0.027 (± 0.011)	0.29 (± 0.087)	0.1 (± 0.0091)	27 (± 20)	5.4 (± 0.47)	0.16 (± 0.045)	ND	4.9 (± 7.3)
8/30/2010	Porewater (2.5 cm)	Airstone	GE	0.012 (± 0.0023)	0.22 (± 0.06)	0.063 (± 0.021)	12 (± 2.5)	12 (± 2.7)	0.34 (± 0.25)	ND	0.78 (± 0.086)
8/30/2010	Porewater (2.5 cm)	Airstone	DE	0.094 (± 0.017)	35 (± 28)	0.43 (± 0.44)	15 (± 4.5)	3.7 (± 1.8)	0.083 (± 0.059)	ND	0.63 (± 0.15)
8/30/2010	Porewater (2.5 cm)	Airstone	NP	0.02 (± 0.0071)	0.75 (± 0.028)	0.22 (± 0.11)	17 (± 10)	2.4 (± 0.21)	0.29 (± 0.35)	ND	6.3 (± 8.1)
8/30/2010	Porewater (2.5 cm)	Airstone	LD	0.06 (± 0.045)	18 (± 3.1)	0.5 (± 0.84)	56 (± 88)	2.1 (± 0.31)	0.16 (± 0.11)	ND	1.4 (± 2)
8/30/2010	Porewater (2.5 cm)	Airstone	UMF	0.082 (± 0.033)	2.9 (± 0.92)	0.21 (± 0.048)	16 (± 9.2)	2.6 (± 0.41)	0.21 (± 0.13)	ND	0.86 (± 0.14)
8/30/2010	Porewater (2.5 cm)	Airstone	LMF	0.022 (± 0.019)	0.53 (± 0.097)	0.15 (± 0.031)	17 (± 5.7)	3.8 (± 0.52)	0.73 (± 0.5)	ND	1.1 (± 0.22)
9/6/2010	Overlying Water	Pipette	H2O	0.025 (± 0.045)	0.57 (± 0.18)	0.1 (± 0.18)	4.8 (± 4.2)	0.15 (± 0.071)	0.25 (± 0.029)	11 (± 17)	0.28 (± 0.017)
9/6/2010	Overlying Water	Pipette	CTRL	0.0073 (± 0.0034)	0.56 (± 0.38)	0.028 (± 0.0093)	2 (± 0.49)	0.17 (± 0.052)	0.24 (± 0.064)	1.1 (± 0.28)	0.26 (± 0.014)

Table 5-5. Summary of Dissolved Metals (Cadmium, Copper, Lead, Zinc, Arsenic, Chromium, Mercury, and Nickel) Data Collected during the Study

Date	Medium	Sampling Method	Treatment	Cadmium µg/L	Copper µg/L	Lead µg/L	Zinc µg/L	Arsenic µg/L	Chromium µg/L	Mercury ng/L	Nickel µg/L
9/6/2010	Overlying Water	Pipette	LALL	0.014 (± 0.015)	0.81 (± 0.56)	0.03 (± 0.024)	4.4 (± 3.1)	0.18 (± 0.041)	0.32 (± 0.056)	1.8 (± 0.73)	0.32 (± 0.037)
9/6/2010	Overlying Water	Pipette	GE	0.004 (± 0.001)	0.6 (± 0.48)	0.01 (± 0.0021)	2.3 (± 1.2)	0.17 (± 0.067)	0.31 (± 0.16)	1.9 (± 0.85)	0.29 (± 0.048)
9/6/2010	Overlying Water	Pipette	DE	0.0097 (± 0.0018)	1.5 (± 0.34)	0.034 (± 0.023)	3.9 (± 0.47)	0.17 (± 0.058)	0.3 (± 0.082)	1.3 (± 0.076)	0.31 (± 0.046)
9/6/2010	Overlying Water	Pipette	NP	0.0078 (± 0.0018)	2 (± 1.3)	0.042 (± 0.0092)	4.4 (± 0.25)	0.2	0.26 (± 0.025)	1.4 (± 0.28)	0.32 (± 0.074)
9/6/2010	Overlying Water	Pipette	LD	0.0068 (± 0.0014)	2.2 (± 0.49)	0.043 (± 0.014)	6.4 (± 2)	0.28 (± 0.041)	0.26 (± 0.11)	4.9 (± 9.1)	0.32 (± 0.07)
9/6/2010	Overlying Water	Pipette	UMF	0.011 (± 0.0035)	1.1 (± 0.29)	0.041 (± 0.011)	8 (± 4.4)	0.2	0.22 (± 0.04)	1.9 (± 0.71)	0.28 (± 0.042)
9/6/2010	Overlying Water	Pipette	LMF	0.008 (± 0.0028)	1.1 (± 0.57)	0.051 (± 0.0011)	6.6 (± 0.11)	0.2	0.29 (± 0.092)	0.95	0.3 (± 0.011)
9/6/2010	Sediment-Water Interface	Pipette	CTRL	0.008 (± 0.0056)	0.33 (± 0.13)	0.027 (± 0.023)	3.3 (± 1.5)	0.13 (± 0.061)	0.31 (± 0.084)	2 (± 1.1)	0.29 (± 0.032)
9/6/2010	Sediment-Water Interface	Pipette	LALL	0.011 (± 0.0024)	0.29 (± 0.088)	0.033 (± 0.024)	4.9 (± 2.8)	0.18 (± 0.041)	0.28 (± 0.072)	3.4 (± 1.6)	0.3 (± 0.032)
9/6/2010	Sediment-Water Interface	Pipette	GE	0.012 (± 0.009)	0.25 (± 0.027)	0.029 (± 0.025)	4.2 (± 2.2)	0.12 (± 0.045)	0.36 (± 0.15)	1.6 (± 1.5)	0.31 (± 0.08)
9/6/2010	Sediment-Water Interface	Pipette	DE	0.016 (± 0.0043)	0.76 (± 0.15)	0.048 (± 0.014)	6.5 (± 2.8)	0.15 (± 0.087)	0.27 (± 0.036)	2.4 (± 0.47)	0.27 (± 0.024)
9/6/2010	Sediment-Water Interface	Pipette	NP	0.014 (± 0.00035)	0.71 (± 0.046)	0.052 (± 0.00035)	8 (± 1.9)	0.2	0.3 (± 0.0071)	3.5 (± 4)	0.31 (± 0.035)
9/6/2010	Sediment-Water Interface	Pipette	LD	0.014 (± 0.0093)	14 (± 30)	4 (± 9.8)	130 (± 310)	0.23 (± 0.14)	0.61 (± 0.85)	3.5 (± 4)	0.38 (± 0.11)
9/6/2010	Sediment-Water Interface	Pipette	UMF	0.013 (± 0.0052)	2.1 (± 3.6)	0.19 (± 0.38)	8.5 (± 9.7)	0.13 (± 0.061)	0.28 (± 0.13)	1.3 (± 0.57)	0.28 (± 0.03)
9/6/2010	Sediment-Water Interface	Pipette	LMF	0.012 (± 0.007)	0.32 (± 0.039)	0.053 (± 0.013)	8.2 (± 2.2)	0.13 (± 0.05)	0.24 (± 0.019)	1.3 (± 0.74)	0.25 (± 0.016)
9/6/2010	Porewater (2.5 cm)	Airstone	H2O	0.045 (± 0.05)	0.32 (± 0.11)	0.0058 (± 0.002)	6.9 (± 8.5)	0.1 (± 0.061)	1.1 (± 0.047)	ND	1.1 (± 0.79)
9/6/2010	Porewater (2.5 cm)	Airstone	CTRL	0.016 (± 0.027)	0.19 (± 0.053)	0.024 (± 0.015)	1.6 (± 0.68)	1 (± 0.35)	0.82 (± 1.1)	ND	1.9 (± 0.45)
9/6/2010	Porewater (2.5 cm)	Airstone	LALL	0.013 (± 0.0042)	0.18 (± 0.028)	0.058 (± 0.012)	65 (± 86)	5.9 (± 0.8)	1 (± 0.7)	ND	2 (± 0.15)
9/6/2010	Porewater (2.5 cm)	Airstone	GE	0.0079 (± 0.0017)	0.3 (± 0.32)	0.054 (± 0.045)	2.1 (± 0.65)	13 (± 1.8)	0.14 (± 0.036)	ND	1.2 (± 0.79)
9/6/2010	Porewater (2.5 cm)	Airstone	DE	0.07 (± 0.0095)	37 (± 43)	0.39 (± 0.52)	2.9 (± 0.74)	4.2 (± 2.6)	0.067 (± 0.016)	ND	1.3 (± 0.7)
9/6/2010	Porewater (2.5 cm)	Airstone	NP	0.055 (± 0.049)	0.52 (± 0.025)	0.056 (± 0.013)	2.9 (± 0.035)	2.2	0.17 (± 0.085)	ND	1.2 (± 0.18)
9/6/2010	Porewater (2.5 cm)	Airstone	LD	0.066 (± 0.01)	14 (± 1.9)	0.059 (± 0.021)	25 (± 19)	2 (± 0.15)	0.98 (± 1.3)	ND	1.1 (± 0.3)
9/6/2010	Porewater (2.5 cm)	Airstone	UMF	0.088 (± 0.029)	4.4 (± 1.5)	0.18 (± 0.11)	8.2 (± 4.7)	2.5 (± 0.37)	1.3 (± 1.6)	ND	1.6 (± 0.36)
9/6/2010	Porewater (2.5 cm)	Airstone	LMF	0.055 (± 0.018)	0.77 (± 0.38)	0.18 (± 0.1)	11 (± 6.9)	3.2 (± 0.76)	0.9 (± 1.4)	ND	1.8 (± 0.18)
9/13/2010	Overlying Water	Pipette	H2O	0.0091 (± 0.0051)	0.34 (± 0.24)	0.017 (± 0.0093)	2.4 (± 0.47)	0.17 (± 0.067)	0.21 (± 0.048)	0.76 (± 0.14)	0.26 (± 0.047)
9/13/2010	Overlying Water	Pipette	CTRL	0.011 (± 0.0028)	0.38 (± 0.23)	0.017 (± 0.0072)	11 (± 13)	0.11 (± 0.02)	0.77 (± 0.37)	0.67 (± 0.093)	0.54 (± 0.22)
9/13/2010	Overlying Water	Pipette	LALL	0.045 (± 0.09)	0.65 (± 0.49)	0.12 (± 0.25)	19 (± 41)	0.13 (± 0.052)	0.38 (± 0.18)	0.9 (± 0.75)	0.42 (± 0.2)
9/13/2010	Overlying Water	Pipette	GE	0.01 (± 0.0057)	0.23 (± 0.016)	0.012 (± 0.0033)	10 (± 9.2)	0.18 (± 0.05)	0.6 (± 0.44)	0.69 (± 0.22)	0.4 (± 0.18)
9/13/2010	Overlying Water	Pipette	DE	0.0096 (± 0.0034)	1.6 (± 0.29)	0.027 (± 0.011)	2.9 (± 0.88)	0.13 (± 0.05)	0.46 (± 0.2)	1.3 (± 0.76)	0.34 (± 0.057)
9/13/2010	Overlying Water	Pipette	NP	0.29 (± 0.4)	1.6 (± 0.77)	0.09 (± 0.087)	23 (± 18)	0.15 (± 0.071)	1.8 (± 2.2)	0.75 (± 0.14)	1 (± 1)
9/13/2010	Overlying Water	Pipette	LD	0.0097 (± 0.003)	2 (± 0.36)	0.043 (± 0.035)	5.5 (± 2.9)	0.18 (± 0.075)	0.43 (± 0.21)	3.4 (± 6.3)	0.35 (± 0.083)
9/13/2010	Overlying Water	Pipette	UMF	0.019 (± 0.025)	1 (± 0.089)	0.026 (± 0.0038)	7.8 (± 8.5)	0.15 (± 0.055)	0.4 (± 0.23)	5.9 (± 13)	0.33 (± 0.084)
9/13/2010	Overlying Water	Pipette	LMF	0.014 (± 0.0027)	0.79 (± 0.081)	0.18 (± 0.16)	15 (± 3.6)	0.18 (± 0.05)	0.31 (± 0.13)	0.88 (± 0.53)	0.29 (± 0.04)
9/13/2010	Sediment-Water Interface	Pipette	CTRL	0.0054 (± 0.0022)	0.22 (± 0.033)	0.02 (± 0.013)	2.4 (± 1.2)	0.16 (± 0.066)	1.1 (± 1.4)	2.9 (± 1.2)	0.57 (± 0.54)
9/13/2010	Sediment-Water Interface	Pipette	LALL	0.0093 (± 0.0043)	0.38 (± 0.29)	0.02 (± 0.0042)	8.2 (± 13)	0.15 (± 0.077)	0.62 (± 0.15)	31 (± 68)	0.36 (± 0.068)
9/13/2010	Sediment-Water Interface	Pipette	GE	0.017 (± 0.01)	0.23 (± 0.021)	0.018 (± 0.0015)	3.5 (± 1.4)	0.1 (± 0.071)	0.6 (± 0.26)	8.8 (± 10)	0.42 (± 0.087)
9/13/2010	Sediment-Water Interface	Pipette	DE	0.012 (± 0.0042)	1.5 (± 0.51)	0.029 (± 0.0098)	4.6 (± 0.83)	0.18 (± 0.096)	0.44 (± 0.24)	2.7 (± 0.81)	0.39 (± 0.18)
9/13/2010	Sediment-Water Interface	Pipette	NP	0.016 (± 0.0049)	1 (± 0.2)	0.036 (± 0.0049)	27 (± 33)	0.15 (± 0.071)	1.5 (± 1)	8.4 (± 8.3)	1.1 (± 0.86)
9/13/2010	Sediment-Water Interface	Pipette	LD	0.062 (± 0.097)	1.9 (± 1.3)	0.059 (± 0.028)	6.7 (± 2.5)	0.23 (± 0.052)	1 (± 0.54)	2.8 (± 1.1)	0.51 (± 0.24)
9/13/2010	Sediment-Water Interface	Pipette	UMF	0.019 (± 0.018)	0.53 (± 0.055)	0.035 (± 0.015)	5.5 (± 4.5)	0.17 (± 0.052)	1 (± 0.81)	2 (± 0.97)	0.56 (± 0.43)
9/13/2010	Sediment-Water Interface	Pipette	LMF	0.011 (± 0.0026)	0.4 (± 0.014)	0.05 (± 0.01)	17 (± 18)	0.15 (± 0.058)	0.6 (± 0.26)	6.1 (± 4.7)	0.39 (± 0.12)
9/13/2010	Porewater (2.5 cm)	Airstone	H2O	0.062 (± 0.056)	0.26 (± 0.011)	0.89 (± 0.69)	12 (± 11)	0.13 (± 0.067)	0.2 (± 0.12)	ND	0.3 (± 0.086)
9/13/2010	Porewater (2.5 cm)	Airstone	CTRL	0.044 (± 0.027)	1.3 (± 2.8)	0.96 (± 0.77)	11 (± 5.9)	1 (± 0.38)	0.08 (± 0.034)	ND	1.5 (± 0.35)
9/13/2010	Porewater (2.5 cm)	Airstone	LALL	0.052 (± 0.061)	0.5 (± 0.16)	0.41 (± 0.34)	40 (± 53)	6.7 (± 0.71)	0.39 (± 0.18)	ND	1.9 (± 0.28)
9/13/2010	Porewater (2.5 cm)	Airstone	GE	0.081 (± 0.13)	0.48 (± 0.38)	0.43 (± 0.28)	35 (± 54)	13 (± 2.3)	0.23 (± 0.16)	ND	0.9 (± 0.76)
9/13/2010	Porewater (2.5 cm)	Airstone	DE	0.22 (± 0.087)	53 (± 53)	0.84 (± 0.51)	26 (± 19)	5.5 (± 4.4)	0.18 (± 0.12)	ND	1.3 (± 1.4)
9/13/2010	Porewater (2.5 cm)	Airstone	NP	0.048 (± 0.00071)	1.5 (± 0.15)	0.43 (± 0.21)	9.4 (± 6.1)	2.2 (± 0.071)	0.24 (± 0.032)	ND	0.51 (± 0.064)
9/13/2010	Porewater (2.5 cm)	Airstone	LD	0.068 (± 0.018)	15 (± 1.8)	0.26 (± 0.056)	30 (± 15)	2.1 (± 0.14)	0.16 (± 0.13)	ND	0.44 (± 0.039)

Table 5-5. Summary of Dissolved Metals (Cadmium, Copper, Lead, Zinc, Arsenic, Chromium, Mercury, and Nickel) Data Collected during the Study

Date	Medium	Sampling Method	Treatment	Cadmium µg/L	Copper µg/L	Lead µg/L	Zinc µg/L	Arsenic µg/L	Chromium µg/L	Mercury ng/L	Nickel µg/L
9/13/2010	Porewater (2.5 cm)	Airstone	UMF	0.52 (± 0.86)	5.3 (± 1.6)	0.68 (± 0.23)	41 (± 61)	2.8 (± 0.44)	0.34 (± 0.57)	ND	1.8 (± 0.93)
9/13/2010	Porewater (2.5 cm)	Airstone	LMF	0.0094 (± 0.0031)	0.97 (± 0.18)	0.57 (± 0.42)	42 (± 14)	3.4 (± 0.59)	0.26 (± 0.14)	ND	1 (± 0.54)
9/19/2010	Sediment-Water Interface	Peeper	H2O	0.05	0.27 (± 0.092)	0.15 (± 0.03)	2	1	0.67 (± 0.15)	ND	0.66 (± 0.0071)
9/19/2010	Sediment-Water Interface	Peeper	CTRL	0.051 (± 0.0025)	0.22 (± 0.043)	0.087 (± 0.069)	2	1	0.92 (± 0.046)	ND	0.57 (± 0.2)
9/19/2010	Sediment-Water Interface	Peeper	LALL	0.05	0.2	0.098 (± 0.097)	2	1	0.84 (± 0.17)	ND	0.58 (± 0.23)
9/19/2010	Sediment-Water Interface	Peeper	GE	0.05	0.36 (± 0.17)	0.051 (± 0.0017)	2.4 (± 0.72)	1	0.82 (± 0.035)	ND	0.95 (± 0.46)
9/19/2010	Sediment-Water Interface	Peeper	DE	0.05	3.6 (± 5.5)	0.075 (± 0.0081)	8.3 (± 8.4)	1	3.3 (± 4)	ND	1.3 (± 0.94)
9/19/2010	Sediment-Water Interface	Peeper	LD	0.05	0.51 (± 0.19)	0.084 (± 0.033)	3 (± 0.92)	1	0.94 (± 0.065)	ND	0.63 (± 0.15)
9/19/2010	Sediment-Water Interface	Peeper	UMF	0.05	0.46 (± 0.21)	0.07 (± 0.023)	13 (± 27)	1	0.92 (± 0.21)	ND	0.82 (± 0.21)
9/19/2010	Sediment-Water Interface	Peeper	LMF	0.05	0.24 (± 0.041)	0.07 (± 0.0087)	8.4 (± 0.75)	1	0.9 (± 0.053)	ND	0.67 (± 0.14)
9/19/2010	Sediment-Water Interface	DGT	H2O	0.013 (± 0.0016)	0.56 (± 0.098)	0.0065 (± 0.0011)	5.3 (± 0.82)	0.25	0.12 (± 0.02)	ND	0.28 (± 0.015)
9/19/2010	Sediment-Water Interface	DGT	CTRL	0.014 (± 0.0013)	0.55 (± 0.052)	0.011 (± 0.0025)	5.2 (± 0.3)	0.25	0.17 (± 0.096)	ND	0.3 (± 0.039)
9/19/2010	Sediment-Water Interface	DGT	LALL	0.015 (± 0.0031)	0.6 (± 0.086)	0.02 (± 0.0085)	5.2 (± 0.8)	0.25	0.2 (± 0.08)	ND	0.34 (± 0.16)
9/19/2010	Sediment-Water Interface	DGT	GE	0.015 (± 0.00081)	0.77 (± 0.1)	0.011 (± 0.0013)	8.1 (± 1.9)	0.25	0.12 (± 0.026)	ND	0.39 (± 0.058)
9/19/2010	Sediment-Water Interface	DGT	DE	0.02 (± 0.0039)	1.1 (± 0.15)	0.012 (± 0.0014)	7.4 (± 1.1)	0.25	0.31 (± 0.2)	ND	0.28 (± 0.035)
9/19/2010	Sediment-Water Interface	DGT	LD	0.036 (± 0.029)	1.6 (± 0.97)	0.042 (± 0.042)	15 (± 11)	0.25	0.27 (± 0.2)	ND	0.68 (± 0.55)
9/19/2010	Sediment-Water Interface	DGT	UMF	0.019 (± 0.0022)	0.79 (± 0.1)	0.016 (± 0.0049)	8.3 (± 1.1)	0.25	0.25 (± 0.21)	ND	0.29 (± 0.037)
9/19/2010	Sediment-Water Interface	DGT	LMF	0.015 (± 0.0016)	0.77 (± 0.25)	0.053 (± 0.052)	10 (± 0.31)	0.25	0.087 (± 0.014)	ND	0.33 (± 0.0059)
9/19/2010	Porewater (1 cm)	Peeper	H2O	0.05	0.21 (± 0.011)	0.067 (± 0.0078)	2	1	0.97 (± 0.0071)	ND	0.58 (± 0.19)
9/19/2010	Porewater (1 cm)	Peeper	CTRL	0.05	0.22 (± 0.049)	0.076 (± 0.026)	2 (± 0.053)	1	1.3 (± 0.14)	ND	0.99 (± 0.39)
9/19/2010	Porewater (1 cm)	Peeper	LALL	0.05	0.24 (± 0.092)	0.071 (± 0.019)	2.5 (± 1.3)	1.6 (± 1.5)	1 (± 0.17)	ND	1 (± 0.46)
9/19/2010	Porewater (1 cm)	Peeper	GE	0.05	0.53 (± 0.18)	0.077 (± 0.02)	2	1	0.91 (± 0.17)	ND	2 (± 1.7)
9/19/2010	Porewater (1 cm)	Peeper	DE	0.051 (± 0.0017)	3.9 (± 3.2)	0.1 (± 0.069)	10 (± 7.6)	1	1 (± 0.23)	ND	1 (± 0.12)
9/19/2010	Porewater (1 cm)	Peeper	LD	0.052 (± 0.0057)	3.9 (± 1.3)	0.096 (± 0.044)	30 (± 17)	1	1.1 (± 0.088)	ND	1.3 (± 0.35)
9/19/2010	Porewater (1 cm)	Peeper	UMF	0.054 (± 0.0063)	1.8 (± 1.3)	0.11 (± 0.085)	20 (± 18)	1	0.97 (± 0.16)	ND	0.98 (± 0.53)
9/19/2010	Porewater (1 cm)	Peeper	LMF	0.05	0.42 (± 0.12)	0.15 (± 0.01)	26 (± 22)	1.6 (± 0.98)	3.3 (± 2.6)	ND	1.5 (± 0.35)
9/19/2010	Porewater (1 cm)	DGT	H2O	0.012 (± 0.00091)	0.48 (± 0.029)	0.0056 (± 0.00033)	4.6 (± 0.38)	0.25	0.17 (± 0.1)	ND	0.22 (± 0.026)
9/19/2010	Porewater (1 cm)	DGT	CTRL	0.013 (± 0.0022)	0.54 (± 0.026)	0.038 (± 0.029)	5 (± 0.47)	0.25	0.19 (± 0.21)	ND	0.27 (± 0.039)
9/19/2010	Porewater (1 cm)	DGT	LALL	0.019 (± 0.0027)	0.56 (± 0.058)	0.1 (± 0.011)	5.1 (± 0.41)	0.25	0.81 (± 1.6)	ND	0.29 (± 0.023)
9/19/2010	Porewater (1 cm)	DGT	GE	0.018 (± 0.0011)	0.85 (± 0.34)	0.018 (± 0.003)	6.7 (± 0.69)	0.25	0.11 (± 0.047)	ND	0.33 (± 0.021)
9/19/2010	Porewater (1 cm)	DGT	DE	0.032 (± 0.0022)	4.5 (± 3.9)	0.018 (± 0.00069)	11 (± 0.4)	0.25	0.18 (± 0.026)	ND	0.19 (± 0.0069)
9/19/2010	Porewater (1 cm)	DGT	LD	0.062 (± 0.05)	6.6 (± 4.5)	0.11 (± 0.1)	34 (± 35)	0.25	0.31 (± 0.24)	ND	0.77 (± 0.57)
9/19/2010	Porewater (1 cm)	DGT	UMF	0.032 (± 0.0033)	2.1 (± 1.6)	0.025 (± 0.018)	18 (± 2)	0.25	0.13 (± 0.045)	ND	0.27 (± 0.055)
9/19/2010	Porewater (1 cm)	DGT	LMF	0.028 (± 0.0012)	0.88 (± 0.045)	0.06 (± 0.029)	78 (± 8.1)	0.25	0.12 (± 0.022)	ND	0.28 (± 0.029)
9/20/2010	Overlying Water	Pipette	H2O	0.016 (± 0.015)	0.65 (± 0.17)	0.034 (± 0.029)	4.4 (± 6.5)	0.06 (± 0.022)	0.3 (± 0.27)	2.2 (± 1.4)	0.64 (± 0.18)
9/20/2010	Overlying Water	Pipette	CTRL	0.0063 (± 0.0057)	1.8 (± 3.2)	0.019 (± 0.021)	4 (± 4.4)	0.067 (± 0.026)	0.66 (± 0.54)	2 (± 0.79)	0.77 (± 0.17)
9/20/2010	Overlying Water	Pipette	LALL	0.0082 (± 0.0052)	0.83 (± 0.53)	0.035 (± 0.024)	2.6 (± 2.4)	0.092 (± 0.038)	0.5 (± 0.4)	3.4 (± 2.5)	0.69 (± 0.16)
9/20/2010	Overlying Water	Pipette	GE	0.032 (± 0.049)	1.6 (± 2.3)	0.05 (± 0.07)	6.3 (± 0.57)	0.088 (± 0.075)	0.83 (± 1.1)	8.4 (± 3.2)	0.84 (± 0.44)
9/20/2010	Overlying Water	Pipette	DE	0.023 (± 0.018)	1.8 (± 0.29)	0.072 (± 0.015)	26 (± 25)	0.13 (± 0.029)	1.3 (± 1.8)	3.4 (± 3.1)	1.4 (± 0.66)
9/20/2010	Overlying Water	Pipette	NP	0.023 (± 0.022)	2.2 (± 0.86)	0.064 (± 0.0085)	7.5 (± 0.28)	0.1	0.15	8.1 (± 3.2)	0.56 (± 0.071)
9/20/2010	Overlying Water	Pipette	LD	0.0097 (± 0.0031)	2.2 (± 0.36)	0.065 (± 0.0097)	8.3 (± 1.9)	0.092 (± 0.02)	0.19 (± 0.036)	2.7 (± 3.2)	0.58 (± 0.055)
9/20/2010	Overlying Water	Pipette	UMF	0.012 (± 0.0039)	1.2 (± 0.21)	0.061 (± 0.033)	15 (± 20)	0.11 (± 0.038)	0.31 (± 0.24)	2.5 (± 1.9)	0.58 (± 0.036)
9/20/2010	Overlying Water	Pipette	LMF	0.084 (± 0.14)	3.4 (± 5.2)	0.3 (± 0.36)	68 (± 110)	0.32 (± 0.49)	0.79 (± 1.3)	11 (± 18)	1.6 (± 2.2)
9/20/2010	Sediment-Water Interface	Pipette	CTRL	0.013 (± 0.0061)	0.25 (± 0.049)	0.024 (± 0.0088)	4.3 (± 2.8)	0.13 (± 0.042)	0.15 (± 0.036)	7.7 (± 9.1)	0.27 (± 0.027)
9/20/2010	Sediment-Water Interface	Pipette	LALL	0.015 (± 0.0097)	0.31 (± 0.088)	0.065 (± 0.1)	4.6 (± 3)	0.13 (± 0.052)	0.19 (± 0.043)	7.5 (± 6.4)	0.28 (± 0.035)
9/20/2010	Sediment-Water Interface	Pipette	GE	0.013 (± 0.0089)	0.3 (± 0.11)	0.024 (± 0.012)	3.8 (± 1.2)	0.11 (± 0.063)	0.15 (± 0.031)	4 (± 1.3)	0.27 (± 0.014)
9/20/2010	Sediment-Water Interface	Pipette	DE	0.021 (± 0.0096)	0.92 (± 0.14)	0.04 (± 0.014)	5 (± 2.3)	0.17 (± 0.029)	0.21 (± 0.042)	5.9 (± 0.75)	0.33 (± 0.013)
9/20/2010	Sediment-Water Interface	Pipette	NP	0.011 (± 0.0032)	0.83 (± 0.085)	0.038 (± 0.0057)	5 (± 1.6)	0.1 (± 0.071)	0.19 (± 0.0035)	4.8 (± 0.64)	0.29 (± 0.021)

Table 5-5. Summary of Dissolved Metals (Cadmium, Copper, Lead, Zinc, Arsenic, Chromium, Mercury, and Nickel) Data Collected during the Study

Date	Medium	Sampling Method	Treatment	Cadmium µg/L	Copper µg/L	Lead µg/L	Zinc µg/L	Arsenic µg/L	Chromium µg/L	Mercury ng/L	Nickel µg/L
9/20/2010	Sediment-Water Interface	Pipette	LD	0.0088 (± 0.0063)	1.4 (± 0.6)	0.031 (± 0.014)	5 (± 0.75)	0.12 (± 0.041)	0.18 (± 0.04)	2 (± 1.2)	0.29 (± 0.028)
9/20/2010	Sediment-Water Interface	Pipette	UMF	0.015 (± 0.006)	0.6 (± 0.095)	0.041 (± 0.022)	4.9 (± 1.2)	0.16 (± 0.049)	0.22 (± 0.062)	3.7 (± 0.95)	0.28 (± 0.044)
9/20/2010	Sediment-Water Interface	Pipette	LMF	0.056 (± 0.096)	1.2 (± 1.7)	0.14 (± 0.15)	110 (± 230)	0.17 (± 0.097)	0.29 (± 0.29)	3.6 (± 3.8)	0.49 (± 0.48)
9/20/2010	Porewater (2.5 cm)	Airstone	H2O	0.025 (± 0.011)	0.3 (± 0.044)	0.01 (± 0.0028)	30 (± 61)	0.15 (± 0.071)	0.17 (± 0.078)	ND	0.64 (± 0.58)
9/20/2010	Porewater (2.5 cm)	Airstone	CTRL	0.019 (± 0.015)	0.15 (± 0.028)	0.035 (± 0.017)	2.3 (± 0.54)	0.95 (± 0.28)	0.063 (± 0.039)	ND	1.3 (± 0.25)
9/20/2010	Porewater (2.5 cm)	Airstone	LALL	0.033 (± 0.04)	0.19 (± 0.037)	0.088 (± 0.0099)	39 (± 29)	7 (± 0.87)	0.15 (± 0.024)	ND	2.2 (± 0.65)
9/20/2010	Porewater (2.5 cm)	Airstone	GE	0.011 (± 0.004)	0.19 (± 0.084)	0.038 (± 0.021)	2 (± 0.48)	10 (± 3.3)	0.14 (± 0.045)	ND	1.5 (± 0.24)
9/20/2010	Porewater (2.5 cm)	Airstone	DE	0.053 (± 0.01)	46 (± 49)	0.71 (± 0.81)	3.4 (± 1.2)	6.3 (± 5.2)	0.29 (± 0.4)	ND	2.2 (± 1.6)
9/20/2010	Porewater (2.5 cm)	Airstone	NP	0.077 (± 0.088)	1.2 (± 0.028)	0.069 (± 0.046)	3 (± 0.74)	2.3 (± 0.21)	0.37 (± 0.23)	ND	0.54 (± 0.0071)
9/20/2010	Porewater (2.5 cm)	Airstone	LD	0.07 (± 0.079)	14 (± 1.5)	0.098 (± 0.016)	32 (± 30)	2.2 (± 0.18)	0.044 (± 0.056)	ND	0.85 (± 0.78)
9/20/2010	Porewater (2.5 cm)	Airstone	UMF	0.057 (± 0.049)	4 (± 1.2)	0.37 (± 0.08)	12 (± 18)	2.6 (± 0.33)	0.12 (± 0.19)	ND	1.5 (± 0.58)
9/20/2010	Porewater (2.5 cm)	Airstone	LMF	0.0099 (± 0.0087)	0.42 (± 0.07)	0.15 (± 0.15)	17 (± 19)	3.5 (± 0.63)	1.2 (± 1.3)	ND	1.6 (± 0.098)

Notes:

All water quality data are reported as the mean (± standard deviation).
CTRL - artificial substrate control
DE - substrates as collected above the water line from the gravel bar at DME
DME - Deadman's Eddy
DOC - dissolved organic carbon
GE - Genelle Eddy
H2O - water-only control
LALL - Lower Arrow Lakes
LD - Little Dalles
LMF - Lower Marcus Flats
ND - not determined
NP - Northport
UMF - Upper Marcus Flats

Table 5-6. Summary of Biological Results

Treatment	Starting Number of Organisms	Mortalities	Losses	Survival (Number of Organisms at Termination)	Starting Length (mm)	Starting Weight (g)	Number of Fish in Length Calculations	Mean Length at Termination (mm)	Standard Deviation of Length at Termination (mm)	Minimum Length at Termination (mm)	Maximum Length at Termination (mm)	Number of Fish in Weight Calculations	Mean Weight at Termination (g)	Standard Deviation of Weight at Termination (g)	Minimum Weight at Termination (g)	Maximum Weight at Termination (g)
UMF	553	154	12	387	16.4	0.034	389	46.7	5.5	25.9	61.2	389	0.491	0.145	0.126	0.956
GE	459	73	8	378			378	48.1	5.5	32.7	64.9	378	0.531	0.165	0.172	1.147
LMF	352	73	11	268			268	50.1	5.1	36.8	61.6	268	0.603	0.159	0.241	1.088
NP	193	16	0	177			178	47.4	4.7	32.3	58.2	178	0.529	0.127	0.179	0.808
LD	526	97	38	391			391	50.2	5.2	30.5	65.9	391	0.608	0.172	0.173	1.334
LALL	620	119	21	480			480	49.6	5.0	33.5	63.1	480	0.582	0.147	0.236	1.082
DE	267	43	8	216			216	49.6	5.0	30.0	64.9	216	0.578	0.153	0.157	1.124
CTRL	485	149	26	310			309	50.2	4.9	36.0	73.5	309	0.599	0.177	0.256	1.717
H2O	751	139	62	550			554	46.3	4.7	25.7	59.1	554	0.478	0.121	0.151	0.856

Notes:

All exposure chambers have the same starting lengths and weights of organisms at test initiation because those were determined from a representative sample of 100 fish.

Study termination occurred over a roughly 2-day period. Mortalities that occurred over the period during which experiments were terminated are included in the count of mortalities and were also included in the set of fish on which length and weight measurements were performed. In five cases (GE, LMF, LD, LALL, and DE) the numbers of fish surviving and the number for which lengths and weights were reported are equal. In three cases (UMF, NP, and H2O), length and weight measurements were performed on fish that died on the last day of the experiment along with all other fish that survived until the end of the study. In those cases, the number of fish for which weights and lengths were reported exceed the number of fish surviving until the end of the study. In one case (CTRL), length and weight measurements were not reported for one of the 310 surviving fish.

CTRL - artificial substrate control

DE - substrates as collected above the water line from the gravel bar at DME

DME - Deadman's Eddy

GE - Genelle Eddy

H2O - water-only control

LALL - Lower Arrow Lakes

LD - Little Dalles

LMF - Lower Marcus Flats

NP - Northport

UMF - Upper Marcus Flats

Table 5-7. Summary of Survival Stratified by Fish Age

Treatment	Initiation to 14 DPH					15 DPH to 24 DPH					25 DPH to Termination				
	Starting Number of Organisms	Mortalities	Losses	Survival (Number of Organisms at end of exposure period)	Percent Survival (From Kaplan-Meier Analysis)	Starting Number of Organisms	Mortalities	Losses	Survival (Number of Organisms at end of exposure period)	Percent Survival (From Kaplan-Meier Analysis)	Starting Number of Organisms	Mortalities	Losses	Survival (Number of Organisms at end of exposure period)	Percent Survival (From Kaplan-Meier Analysis)
UMF	553	2	11	540	99.6	540	114	0	426	78.9	426	38	1	387	90.2
GE	459	1	7	451	99.8	451	57	1	393	87.4	393	15	0	378	96.0
LMF	352	12	11	329	96.5	329	48	0	281	85.4	281	13	0	268	92.1
NP	193	0	0	193	100.0	193	11	0	182	94.3	182	5	0	177	96.8
LD	526	3	8	515	99.4	515	80	30	405	84.3	405	14	0	391	96.0
LALL	620	3	21	596	99.5	596	99	0	497	83.4	497	17	0	480	96.1
DE	267	0	8	259	100.0	259	35	0	224	86.5	224	8	0	216	96.4
CTRL	485	3	3	479	99.4	479	134	20	325	71.7	325	12	3	310	95.7
H2O	751	7	59	685	99.0	685	96	2	587	86.0	587	36	1	550	92.7

Notes:

CTRL - artificial substrate control
DE - substrates as collected above the water line from the gravel bar at DME
DME - Deadman's Eddy
DPH - days post hatch
GE - Genelle Eddy
H2O - water-only control
LALL - Lower Arrow Lakes
LD - Little Dalles
LMF - Lower Marcus Flats
NP - Northport
UMF - Upper Marcus Flats

Table 5-8. Summary of Statistical Tests Conducted with the End-of-Test survival Data

Statistical Test Number	End-of-Test Survival Data Evaluated	ANOVA (p-value)	Kruskal-Wallis (p-value)
1	LALL, NP, LD, DE, UMF, LMF	0.1549	0.1373
2	GE, NP, LD, DE, UMF, LMF	0.0995	0.0562
3	LALL, NP, LD, DE, UMF (no extreme low value), LMF	0.2573	0.2179
4	GE, NP, LD, DE, UMF (no extreme low value), LMF	0.108	0.0909

Notes:

The null hypothesis tested was that there was no difference in end-of-test survival among the treatments.

DE - substrates as collected above the water line from the gravel bar at DME

DME - Deadman's Eddy

GE - Genelle Eddy

LALL - Lower Arrow Lakes

LD - Little Dalles

LMF - Lower Marcus Flats

NP - Northport

UMF - Upper Marcus Flats

Table 5-9. Summary of Weight, Biomass, and Loading Rate at Test Termination for Exposure Tanks

Treatment	Tank	Starting Number of Organisms	Mortalities	Losses	Survival (Number of Organisms at Termination)	Mean Weight at Termination (g)	Standard Deviation of Weight at Termination (g)	Biomass at Termination (g)	Biomass at Termination Corrected for Fish Losses (g)	Fish Loading Rate at 250 L/day Flow-Through Rate (g/L/day)	Fish Loading Rate at 300 L/day Flow-Through Rate (g/L/day)	Fish Loading Rate at 300 L/day Flow-Through Rate (g/L/day)
UMF	A	134	24	6	104	0.492	0.130	0.382	0.400	0.205	0.171	0.136
UMF	B	81	23	0	58	0.566	0.137	0.405	0.405	0.131	0.109	0.088
UMF	C	100	15	1	84	0.490	0.143	0.412	0.416	0.165	0.137	0.110
UMF	E	140	38	5	97	0.394	0.105	0.273	0.283	0.153	0.127	0.102
UMF	F	98	54	0	44	0.613	0.126	0.275	0.275	0.108	0.090	0.072
GE	A	83	10	0	73	0.552	0.157	0.485	0.485	0.161	0.134	0.107
GE	B	165	41	0	124	0.433	0.114	0.326	0.326	0.215	0.179	0.143
GE	C	121	14	2	105	0.500	0.107	0.434	0.441	0.210	0.175	0.140
GE	D	90	8	6	76	0.713	0.158	0.602	0.646	0.217	0.181	0.145
LMF	A	107	27	4	76	0.562	0.147	0.399	0.414	0.171	0.142	0.114
LMF	B	61	7	3	51	0.703	0.177	0.588	0.618	0.143	0.119	0.096
LMF	C	96	20	3	73	0.531	0.136	0.404	0.417	0.155	0.129	0.103
LMF	D	88	19	1	68	0.652	0.125	0.504	0.510	0.177	0.148	0.118
NP	A	100	9	0	91	0.567	0.110	0.516	0.516	0.207	0.172	0.138
NP	B	93	7	0	86	0.489	0.131	0.452	0.452	0.168	0.140	0.112
LD	A	96	24	0	72	0.575	0.127	0.431	0.431	0.166	0.138	0.110
LD	B	94	17	0	77	0.504	0.105	0.413	0.413	0.155	0.129	0.104
LD	C	77	12	12	53	0.642	0.138	0.442	0.524	0.136	0.113	0.091
LD	D	73	9	8	56	0.753	0.251	0.577	0.649	0.169	0.141	0.112
LD	E	96	20	18	58	0.680	0.135	0.411	0.506	0.158	0.132	0.105
LD	F	90	15	0	75	0.558	0.137	0.465	0.465	0.167	0.139	0.112
LALL	A	104	20	0	84	0.583	0.135	0.471	0.471	0.196	0.163	0.131
LALL	B	99	10	6	83	0.582	0.141	0.488	0.519	0.193	0.161	0.129
LALL	C	110	36	0	74	0.609	0.164	0.410	0.410	0.180	0.150	0.120
LALL	D	105	28	0	77	0.589	0.158	0.432	0.432	0.181	0.151	0.121
LALL	E	86	11	0	75	0.572	0.155	0.499	0.499	0.172	0.143	0.114
LALL	F	116	14	15	87	0.564	0.130	0.423	0.485	0.196	0.163	0.131
DE	A	93	11	7	75	0.616	0.142	0.497	0.537	0.185	0.154	0.123
DE	B	100	15	0	85	0.479	0.114	0.407	0.407	0.163	0.136	0.109
DE	C	74	17	1	56	0.677	0.131	0.512	0.519	0.152	0.126	0.101
CTRL	A	79	66	1	12	1.097	0.371	0.167	0.169	0.053	0.044	0.035
CTRL	B	87	20	0	67	0.552	0.112	0.425	0.425	0.148	0.123	0.099
CTRL	C	88	17	0	71	0.588	0.110	0.474	0.474	0.167	0.139	0.111
CTRL	E	84	19	0	65	0.630	0.165	0.487	0.487	0.164	0.136	0.109
CTRL	F	147	27	25	95	0.559	0.120	0.361	0.435	0.212	0.177	0.141
H2O	A	159	29	29	101	0.522	0.120	0.331	0.405	0.211	0.176	0.141
H2O	B	131	19	7	105	0.476	0.110	0.381	0.403	0.200	0.167	0.133
H2O	C	170	31	12	127	0.442	0.102	0.330	0.355	0.225	0.187	0.150
H2O	D	149	39	10	100	0.509	0.138	0.342	0.366	0.204	0.170	0.136
H2O	E	142	21	4	117	0.453	0.116	0.373	0.384	0.212	0.177	0.141

Notes:

Biomass at test termination was calculated two ways: 1. using starting number of organisms; 2. using starting number of organisms minus the number of fish lost after 48 hours.

CTRL - artificial substrate control
DE - substrates as collected above the water line from the gravel bar at DME
DME - Deadman's Eddy
GE - Genelle Eddy
H2O - water-only control
LALL - Lower Arrow Lakes
LD - Little Dalles
LMF - Lower Marcus Flats
NP - Northport
UMF - Upper Marcus Flats

Table 5-10. Summary of Statistical Tests Conducted with the End-of-Test Biomass Data

Statistical Test Number	End-of-Test Survival Data Evaluated	ANOVA (p-value)	Dunnett's (p-value)	Kruskal-Wallis (p-value)
1	LALL, NP, LD, DE, UMF, LMF	0.0446	0.033 (UMF less than LALL)	0.0858
2	GE, NP, LD, DE, UMF, LMF	0.163		0.1466

Notes:

The null hypothesis tested with analysis of variance (ANOVA) and Kruskal-Wallis was that there was no difference in end-of-test biomass among the treatments.
The null hypothesis tested with the Dunnett's muliple comparison was that there was no biomass was not lower in test sediments compared with the reference.
If there was a difference in the Dunnett's test, the difference was specified.
DE - substrates as collected above the water line from the gravel bar at DME
DME - Deadman's Eddy
GE - Genelle Eddy
LALL - Lower Arrow Lakes
LD - Little Dalles
LMF - Lower Marcus Flats
NP - Northport
UMF - Upper Marcus Flats

APPENDIX A

QUALITY ASSURANCE PROJECT PLAN FOR THE ASSESSMENT OF SEDIMENT TOXICITY TO WHITE STURGEON (*ACIPENSER TRANSMONTANUS)* AND ITS AMENDMENTS

APPENDIX A-1

QUALITY ASSURANCE PROJECT PLAN FOR THE ASSESSMENT OF SEDIMENT TOXICITY TO WHITE STURGEON (*ACIPENSER TRANSMONTANUS)* (TAI, MAY 2010)

UPPER COLUMBIA RIVER

REMEDIAL INVESTIGATION AND FEASIBILITY STUDY

Quality Assurance Project Plan for the

Assessment of Sediment Toxicity to White Sturgeon (*Acipenser transmontanus*)

Prepared for

Teck American Incorporated

P.O. Box 3087

Spokane, Washington 99220, USA

Prepared by

Saskatoon, SK S7N 3B5, Canada

and

Environmental Toxicology Laboratory
Toxicology Centre
University of Saskatchewan
44 Campus Drive
Saskatoon, SK S7N 3B5, Canada

in consultation with

Exponent **Parametrix** **HydroQual**

May 2010

SECTION A: PROJECT MANAGEMENT

A1 TITLE AND APPROVAL SHEET

QUALITY ASSURANCE PROJECT PLAN FOR THE "ASSESSMENT OF SEDIMENT TOXICITY TO WHITE STURGEON (*Acipenser transmontanus*)"

Quality Assurance Project Plan Approvals

EPA Project Coordinator:	Helen Bottcher	Helen H. Bottcher	Date: 05-07-10
EPA Quality Assurance (QA) Manager:	for Gina Grepo-Grove	Maija Th	Date: 5/14/10
Teck Project Coordinator:	Marko Adzic		Date: 05-07-10
Teck Technical Team Coordinator & Task Manager:	Markus Hecker		Date: 5/17/10
U of S Principal Investigator:	John Giesy	John P. Giesy	Date: 5/18/10
Task QA Coordinator:	Shaun Roark	Shaun A Roark	Date: 5/18/10
Database Manager:	Randy O'Boyle		Date: 5/24/10
Analytical Chemistry Lab Coordinator:	Kris McCaig	Kris McCaig	Date: 5/7/10
Chemical Laboratory Project Manager:	Jeff Christian		Date: 5/27/10
Chemical Laboratory QA Manager:	Julie Gish	Julie Gish	Date: 5/24/10

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ACRONYMS AND ABBREVIATIONS

Agreement	June 2, 2006, Settlement Agreement
ASTM	American Society for Testing and Materials
AVS	acid volatile sulfides
BERA	baseline ecological risk assessment
BLM	biotic ligand model
$CaCO_3$	calcium carbonate
CAS	Columbia Analytical Services
COC	chain-of-custody
COPC	contaminant of potential concern
CUR	condition-upon-receipt
DBMS	database management system
DGT	diffusive gradient thin-film
DHSE	University of Saskatchewan Department of Health, Safety, and Environment
DO	dissolved oxygen
DOC	dissolved organic carbon
dph	days post hatch
DQO	data quality objective
Ecology	Washington State Department of Ecology
EDD	electronic data deliverable
ELS	early life stages
ENTRIX	ENTRIX, Inc.
EPA	U.S. Environmental Protection Agency
ERB	equipment rinsate blank
ESI	Environmental Services, Inc.
FSP	field sampling plan

ID	identification
ICP/MS	inductively coupled plasma/mass spectrometry
LC20	lethal concentration for 20 percent of the test population
LC50	lethal concentration for 50 percent of the test population
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LOAEC	lowest-observed-adverse-effect concentration
MDL	method detection limit
MRL	method reporting limit
MS/MSD	matrix spike/matrix spike duplicate
NOAEC	no-observed-adverse-effect concentration
PARCCS	precision, accuracy, representativeness, comparability, completeness, and sensitivity
PDA	personal digital assistant
QA	quality assurance
QA/QC	quality assurance and quality control
QAPP	quality assurance project plan
RI/FS	remedial investigation and feasibility study
RM	river mile
RPD	relative percent difference
SEM	simultaneously extracted metals
Site	Upper Columbia River site
SLERA	screening level ecological risk assessment
SM	Standard Methods for the Examination of Water and Wastewater
SOP	standard operating procedure
SRM	standard reference material
SRMD	standard reference material duplicate

TAL	target analyte list
TDS	total dissolved solids
Teck	Teck American Incorporated
TOC	total organic carbon
U of S	University of Saskatchewan
UCR	Upper Columbia River
USGS	U.S. Geological Survey

UNITS OF MEASURE

°C	degrees Celsius
L	liter(s)
mg	milligram(s)
mL	milliliter(s)
µg	microgram(s)

A3 DISTRIBUTION LIST

EPA Project Coordinator:	Helen Bottcher
EPA QA Manager:	Gina Grepo-Grove
Teck Project Coordinator:	Marko Adzic
Teck Technical Team Coordinator & Task Manager:	Markus Hecker
U of S Principal Investigator:	John Giesy
Task QA Coordinator:	Shaun Roark
Study Team Leader:	David Vardy
Database Manager:	Randy O'Boyle
Data Validator:	Rock Vitale
Analytical Chemistry Lab Coordinator:	Kris McCaig
Chemical Laboratory Project Manager:	Jeff Christian
Chemical Laboratory QA Manager:	Julie Gish

A4 INTRODUCTION AND TASK ORGANIZATION

A4.1 Introduction

This Quality Assurance Project Plan (QAPP) presents the approach and rationale for conducting a study to assess the toxicity of contaminants of potential concern (COPCs) associated with granulated slag from sediments in the Upper Columbia River (UCR) site (Site)[1] to early life stages (ELS), including the hiding stage, of white sturgeon (*Acipenser transmontanus*). Data obtained during this work will be used in the baseline ecological risk assessment (BERA) and overall Remedial Investigation/Feasibility Study (RI/FS). Primary objectives of the RI/FS are to investigate the nature and extent of unacceptable risk at the Site, to provide information to support baseline risk assessments for human health (to be completed by the U.S. Environmental Protection Agency [EPA]) and the environment (to be completed by Teck American Incorporated [Teck]), and to develop and evaluate potential remedial alternatives for the Site.

Sediment toxicity to white sturgeon ELS will be evaluated using field-collected sediments from areas previously hypothesized as suitable white sturgeon habitat, and containing a range of slag-related COPC concentrations. Based on work completed by others, suitable habitat for white sturgeon within the Site is limited to areas north of Kettle Falls and including Marcus Flats (Golder 2007; Howell and McLellan 2006).

In addition to the above-mentioned sediment toxicity tests, a limited number of water exposure acute toxicity tests using copper will be completed to supplement work being conducted by the U.S. Geological Survey (USGS).

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. ENTRIX, Inc. (ENTRIX), and the Environmental Toxicology Group at the

[1] The UCR site as defined within the June 2, 2006, Settlement Agreement is the areal extent of hazardous substances contamination within the United States in or adjacent to the Upper Columbia River, including the Franklin D. Roosevelt Lake, from the U.S.-Canadian border to the Grand Coulee Dam, and those areas in proximity to the contamination which are suitable and necessary for implementation of response actions (USEPA 2006a).

University of Saskatchewan (U of S) are conducting this work with oversight from EPA and with consultation from the Teck technical team.

A4.2.1 EPA Organization and Responsibilities

EPA will oversee Teck's activities associated with the work, 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 regarding review of technical documents submitted by Teck. The project coordinator for EPA is Helen Bottcher. Ms. Bottcher will be responsible for ensuring that the work performed is consistent with all applicable EPA guidance. The EPA quality assurance (QA) manager assigned by EPA is Gina Grepo-Grove, or designee.

A4.2.2 Teck Organization and Responsibilities

Marko Adzic will serve as Teck's project coordinator and will have the primary responsibility for ensuring that Teck meets all the requirements and associated deliverables specified within the June 2, 2006, Settlement Agreement (Agreement) (USEPA 2006a). Dr. Markus Hecker will be responsible for overseeing all technical aspects of this task, and managing the overall task schedule.

A4.2.3 Key Task Personnel

Task Manager—Dr. Markus Hecker (ENTRIX; U of S) will oversee all task activities, review quality assurance reports, approve final project quality assurance needs, and communicate status of the work to the technical team and the Teck project manager. Dr. Hecker will be responsible for compiling summary results and project final reports. He will also be responsible for statistical analysis and data interpretation.

U of S Principal Investigator—Professor John P. Giesy (U of S) will advise the task manager in overseeing and approving all project activities, review quality assurance reports, approve final project quality assurance needs, and authorize necessary actions and adjustments related to U of S activities to accomplish program quality assurance objectives.

Study Team Leader—David Vardy (U of S), under the supervision of Dr. Hecker, will oversee research activities and supervise study crews. The study team leader will ensure that proper sample collection, preservation, storage, transport, and chain-of-custody (COC) procedures are followed; will inform the project quality assurance manager when problems occur; and will communicate and document corrective actions taken. As study team leader, Mr. Vardy will discuss study activities with the task manager.

Analytical Chemistry Laboratory Coordinator—Kris McCaig (Teck) is responsible for coordinating with the testing laboratory and tracking the laboratory's progress; verifying that the laboratory has implemented the requirements of this QAPP; addressing quality assurance 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. As chemistry laboratory coordinator, Ms. McCaig will report directly to the project manager and will work closely with the study team leader and the quality assurance manager.

Quality Assurance Coordinator—Dr. Shaun Roark (ENTRIX) is responsible for providing overall QA support for the work and ensuring that the QAPP and FSP contain all components necessary to meet EPA guidelines (USEPA 2002a). As quality assurance manager, Dr. Roark will review program quality assurance activities, quality problems, and quality-related requests. In response to experimental and bioanalytical findings, he will approve corrective actions. Dr. Roark will also report quality non-conformances to the Teck project coordinator and review all pertinent portions of the U of S and ENTRIX deliverables before they are transmitted to ensure conformance with quality assurance and quality control (QA/QC) procedures and quality work products.

Data Manager—Randy O'Boyle (Exponent) is the database administrator and will have primary responsibility for incorporating the results of the work into the project database, including establishment of storage formats and standards for coding of data. Dr. Hecker will coordinate data acquisition and storage during the execution of the studies, and will coordinate with Mr. O'Boyle on the establishment of formats for storage and uploading of information to the project database.

Data Validator—Rock Vitale (Environmental Services, Inc. [ESI]) is responsible for coordinating the validation of analytical laboratory data; communicating data quality issues to the data users; and working with data users to address any data limitations. Mr. Vitale will report to the analytical laboratory coordinator, and will work closely with the task manager and the database manager to ensure that the objectives of the QAPP are met.

A4.2.4 Analytical Contract Laboratory

The following responsibilities apply to the project manager and quality assurance manager at the analytical laboratory used for the analysis of samples collected during the work. The analytical laboratory will be Columbia Analytical Services (CAS).

Laboratory Project Manager—Jeff Christian (CAS) is responsible for the successful and timely completion of sample analyses, as well as the following actions:

- Ensure that samples are received and logged correctly, that the correct methods and modifications are used, and that data are reported within specified turnaround times
- Review analytical data to ensure that procedures were followed as required in this QAPP, the cited methods, and laboratory standard operating procedures (SOPs)
- Apprise the analytical chemistry laboratory coordinator of the schedule and status of sample analyses and data package preparation
- Notify the chemical laboratory coordinator if problems occur in sample receiving, analysis, or scheduling, or if control limits cannot be met
- Take appropriate corrective action as necessary
- Report data and supporting quality assurance information as specified in this QAPP.

Laboratory Quality Assurance Manager—Julie Gish (CAS) is responsible for overseeing the quality assurance 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 quality assurance program
- Maintain quality assurance 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 issues that affect this task with the laboratory project manager.

A4.3 Problem Definition and Background

Poor recruitment of white sturgeon in the Columbia River between Grand Coulee Dam and Hugh L. Keenleyside Dam in Canada has been documented since the 1970s. While adult spawning and occurrence of embryos and larvae have frequently been reported, limited numbers of embryos and larvae have been captured in this stretch of the river (Howell and McLellan 2006). Furthermore, juveniles (9 to 10 months old) that have been released as part of the White Sturgeon Recovery Program appear to have good survival,

growth rates, and body condition (Howell and McLellan 2006). However, survival of one or more stages during the early development of larval and juvenile sturgeon appears to be limiting recovery of the population (Howell and McLellan 2006).

Given the epibenthic nature of white sturgeon, there is the potential for increased exposure to contaminated sediments within the UCR. Specifically, there are concerns about the potential toxicity of COPCs associated with granulated slag to white sturgeon ELS, including the early hiding stage where fry are in proximity to sediments. Exposure pathways may include pore- and surface water at the sediment-water interface. Water may move through the sediments either from upwelling from deeper sediments, downward movement from surface water, or lateral fluvial flow.

In addition to the above-mentioned factors and based on unpublished data, it would appear that there is a critical stage (15 to 50 days post hatch [dph]) where white sturgeon experience relatively high mortalities, and may be particularly sensitive to water-borne contaminants such as copper. As a result, to supplement work being conducted by the USGS, a limited number of water exposure acute toxicity tests using copper will be completed during this critical life-stage.

A5 EXISTING DATA

There are no data that evaluate sediment toxicity to white sturgeon ELS. A limited number of static acute fish toxicity tests using rainbow trout (*Oncorhynchus mykiss*) exposed to granulated slag were identified and are provided in Appendix A. A number of environmental investigations have, however, identified elevated slag-related COPC sediment concentrations within the Site (Johnson et al. 1988; Bortleson et al. 2001; Era and Serdar 2001; Majewski et al. 2003; Cox et al. 2005; USEPA 2003, 2006b; Paulson et al. 2006). As noted in the site-specific Screening Level Ecological Risk Assessment (SLERA) (Teck 2010a), these COPCs indicate the potential for adverse ecological effects and warrant further investigation.

In addition to studies identifying elevated COPC sediment concentrations, unpublished data are available regarding the location of spawning grounds, nursing grounds, and movements of white sturgeon within the UCR. Based on these data, researchers have identified that the greatest abundance of white sturgeon larvae are located upstream of Marcus Flats (Howell and McLellan 2006; see Map A-1) with Marcus Flats representing a likely habitat for fry and juveniles (Golder 2007). As illustrated in Maps A-2 and A-3, slag-related COPC sediment concentrations within these white sturgeon habitats cover a wide range of concentration gradients and are at concentrations that warrant further

investigation (Johnson et al. 1988; Bortleson et al. 2001; Era and Serdar 2001; Majewski et al. 2003; Cox et al. 2005; USEPA 2003,2006a; Paulson et al. 2006). To assess the risk to white sturgeon ELS from exposure to COPCs through sediments in the UCR, toxicological information specific to this matrix must be collected and evaluated.

A6 DATA GAPS

Although numerous independent studies have been conducted to assess COPC concentrations in sediments and the distribution of white sturgeon ELS within the UCR, there are no data that evaluate the potential toxicity of these sediments to white sturgeon ELS. Given the epibenthic nature of white sturgeon, the potential exists for exposure of ELS of this species to contaminated sediments within the UCR. Specifically, there is concern that white sturgeon ELS (including the hiding stage) can be affected by the potential toxicity of COPCs associated with sediments containing granulated slag. In addition, potential uncertainties associated with the relative sensitivity of white sturgeon during the 15 to 50 dph critical life-stages remain and must be addressed.

A7 DATA QUALITY OBJECTIVES, CRITERIA, AND DESIGN RATIONALE

EPA's seven-step data quality objective (DQO) process (USEPA 2006b) was used to guide the design rationale for the 2010 sturgeon ELS studies. The DQO process is a tool to determine the type, quantity, and quality of data that are needed to address specified risk questions. This process establishes performance and acceptance criteria for the data to promote achievement of study goals.

A7.1 Step 1—State the Problem

White sturgeon is a species of special interest in the UCR ecological risk assessment because of three factors: 1) its poor recruitment over the past decades; 2) it may be sensitive to metals; and 3) its epibenthic habit potentially increases the likelihood of exposure to metals through contact with sediments. The third factor may be especially true during the early hiding stage of white sturgeon fry where they live in close proximity to sediments.

Poor recruitment of white sturgeon in the Columbia River between Grand Coulee Dam and Hugh L. Keenlyside Dam in Canada has been documented since the 1970s. While both spawning of adults and occurrence of embryos and larvae have been reported frequently during the past years, limited embryos and larvae have been captured in nets set from the U.S.-Canadian border to Evans, Washington (Howell and McLellan 2006).

Furthermore, juveniles (9 to 10 months old) that have been released as part of the White Sturgeon Recovery Plan appear to have good survival, growth rates, and body condition (Howell and McLellan 2006). Therefore, survival of one or more stages during the early development of larval and juvenile sturgeon appears to be limiting recovery of the population (Howell and McLellan 2006).

This study seeks to evaluate if COPCs associated with granulated slag in sediments in the UCR Site present an unacceptable risk to the survival and growth of white sturgeon during the first 2 months of life. This QAPP focuses on the sediment pathway; however, a limited number of acute water-only laboratory exposure studies will be conducted during certain life-stages (15 to 50 dph) before and after the transition to feeding as described in Appendix B.

A7.1.1 Team Members and Roles

One of the goals of Step 1 of the DQO process is to establish a planning team and identify decision makers. The planning team will consist of personnel from ENTRIX and U of S, and will be supported by the Teck technical team. A detailed overview of the specific personnel and their roles is provided in Section A4.2.

A7.1.2 Resources and Timelines

To conduct the work identified in this QAPP, toxicity testing will be conducted at the Aquatic Toxicology Research Facility of the Toxicology Centre at the U of S. Details are provided in Section B1.

Timing of toxicity tests will be dictated by the spawning season of white sturgeon in the Columbia River, which is expected to take place sometime between June and July (the only window when embryos are available for testing). Controlled laboratory studies to be conducted at the Aquatic Toxicology Research Facility will include ~60 day subchronic toxicity testing of sturgeon fry with sediments collected in the vicinity of Deadman's Eddy, China Bend, and Marcus Flats in Washington; and at a reference site (e.g. Birchbank[2]) and a laboratory control sediment.

[2] At the time of writing, the exact reference sediment has not yet been confirmed (i.e. neither the reference site nor the laboratory control sediment) as it is dependent on observations and findings outlined within the draft QAPP entitled *Methods Development for Sediment Sampling and White Sturgeon Sediment Toxicity Studies* as submitted on March 3, 2010 (Teck 2010b). For the purposes of this document however, the upstream reference location will be assumed to be Birchbank, as it has historically served as a sediment bioassay reference.

In addition, a limited number of focused 96-hour acute copper toxicity tests with white sturgeon ELS and rainbow trout will be conducted to provide a level of replication based on work being completed by the USGS at their Columbia, Missouri, laboratory.

A7.1.3 Pilot Studies to Inform Work Described in this QAPP

At the time this document was written, some of the information required to make definite decisions regarding the study design were not available. This information is being developed under a separate QAPP entitled *Methods Development for the White Sturgeon Sediment Toxicity Study* as approved on April 26, 2010 (Teck 2010b). Test conditions that are being evaluated as part of the methods development work are listed in Table A-1. Results from the method development work will be presented to EPA in a technical memorandum. Agreement on the study design changes, if any, will be documented in an amendment to this QAPP.

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

There are two goals associated with this work. The primary goal of the study is to determine if COPCs associated with granulated slag in UCR sediments are chronically toxic to white sturgeon ELS (including the hiding stage). A secondary goal is to refine our understanding of acute toxicity of copper at critical life-stages relative to a standard test organism (rainbow trout) in water. The latter will be accomplished in the form of 96h acute toxicity tests at two critical life-stages with white sturgeon and rainbow trout. The water and sediment studies are both part of an ongoing multiple lines-of-evidence approach for assessing the potential toxicity of granulated slag COPCs in UCR matrices to white sturgeon ELS. Specific risk-related questions that will be addressed during the studies are:

- Are there significant differences in acute and/or subchronic effects on survival, growth, and biomass on white sturgeon ELS raised on Site and reference sediments? If significant differences occur
  - What is the magnitude of these effects?
  - Are these effects due to slag-associated COPCs as measured in sediments, porewater, and overlying water?
- What is the relative sensitivity of white sturgeon ELS compared to rainbow trout as determined in acute toxicity tests with copper at 15 and 45 dph? (Additional details presented in Appendix B).

A7.2.1 Testable Null Hypotheses

Null hypotheses to be evaluated in independent studies will provide the following conclusions on white sturgeon ELS at the UCR Site.

1. There are no statistically significant differences in survival, and growth of white sturgeon ELS reared on Site and reference sediments.
2. There are no dose-dependent differences in survival, and growth of white sturgeon ELS as a function of COPC concentrations in sediments from the Site and at the point of exposure.
3. There are no life-stage specific and dose-dependent toxicities after acute exposure to copper under controlled laboratory conditions; moreover, the sensitivity to acute exposure of white sturgeon ELS is no different than that of rainbow trout. (Additional details are presented in Appendix B).

A7.3 Step 3—Identify Information Inputs

Step 3 of the DQO process (USEPA 2006b) requires consideration of the following:

- The 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 analytical methods.

The decision process regarding the white sturgeon toxicity assessment will be supported by analytical measurements detailed in Table A-2.

In addition to the analytical measurements, determination of biological endpoints in white sturgeon ELS during the sediment exposure studies will include:

- Fry/juvenile mortality—NOAECs and LOAECs
- Growth (length and mass)—NOAECs and LOAECs.

Determination of biological endpoints in white sturgeon ELS during the acute exposure studies with copper will include:

- Fry/juvenile mortality—NOAECs, LOAECs, and LC50s
- Growth (length and mass).

Developmental and behavioral abnormalities will also be observed daily during the sediment toxicity and the acute copper toxicity tests.

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 interest for risk evaluation are white sturgeon ELS from the parent population living in the Columbia River between Hugh Keenleyside Dam in Canada and Grand Coulee Dam in the U.S.

A7.4.2 Geographic Boundary of the Site

The Site encompasses the UCR from the U.S.-Canadian border (River Mile [RM] 745) to the Grand Coulee Dam (approximately RM 596). However, with the distribution and occurrence of white sturgeon limited to areas upstream and including Marcus Flats (Howell and McLellan 2006), sediment toxicity tests using white sturgeon ELS will be limited to sediments collected upstream of RM 700 (Marcus Flats). In addition and based on sediment data collected to date (Johnson et al. 1988; Bortleson et al. 2001; Era and Serdar 2001; Majewski et al. 2003; Cox et al. 2005; USEPA 2003,2006a; Paulson et al. 2006), elevated sediment COPC concentrations associated with granulated slag have been identified within this portion of the Site.

A7.4.3 Temporal Considerations

The temporal boundaries of the studies are defined by the reproductive cycle of white sturgeon. Typically, spawning of white sturgeon in the UCR occurs sometime in June or July depending on temperature and hydraulic conditions. Thus, it is anticipated that exposure chambers will be operational at the end of the first two weeks of June, so that the test can be initiated as soon as fertilized sturgeon eggs are available in June/July.

A7.5 Step 5—Develop the Analytical Approach

Risks of exposure of white sturgeon ELS to UCR sediments will be assessed in a deterministic fashion using a multiple lines-of-evidence approach: 1) exposure of white sturgeon ELS to sediments collected in the Site and reference samples, and 2) comparison of metal concentrations measured in porewater and overlying water to chronic ambient water quality criteria.

The first line of evidence will be derived from a controlled study with sediments collected in the UCR and reference sediments. Long-term (> 60 days overall exposure time), exposures of white sturgeon larvae, fry, and juveniles to these sediments will be tested in fluvial flow-through systems. The tests will begin with newly hatched fry and

continue to 60 dph. Effects on survival, growth, and development (external morphology) will be measured and recorded. Details on the experimental design are provided in Section B1.4[3]. If the testing reveals significant effects from exposure to sediments collected downstream of the U.S.-Canadian border vs. reference samples, then the data will be reviewed to determine if the results can be explained by the presence of COPCs in porewater or water overlying sediments. This will be determined by the presence of a relative response, the statistical vigor of that response, and the correlation of exposure to the response (i.e., dose response curve).

All data generated from the herein described toxicity tests will be submitted to the EPA for review (see Section C-2).

A7.6 Step 6—Specify Performance and Acceptance Criteria

Specifying limits on decision errors involves defining the possible decision errors and the consequences of making these errors. Typically, this is done by describing the decisions in terms of hypothesis tests or other objective decision criteria and by specifying the hypotheses to be tested using an appropriate statistical model. Limits can also be specified by identifying the decision errors as false-positive and false-negative errors. In this study, the target value for the type I error (the false positive decision error; α) will be set at 0.05. The target value for the type II error (the false negative decision error; β) will be set at 0.2.

Sediment collection, transport, and storage conditions will meet or exceed requirements listed in:

- ASTM (American Society for Testing and Materials). 2009. *Standard guide for collection, storage, characterization, and manipulation of sediments for toxicology testing and for selection of samples used to collect benthic invertebrates.* E1391-03 (2008). Annual Book of ASTM Standards, Volume 11.06, ASTM International, West Conshohocken, PA.

Detailed descriptions regarding the collection, transport, storing and processing of sediments are provided in SOPs 4 and 8. Details on performance criteria for the sediment exposure assessed in the subchronic studies are provided in Section B1.4 In

[3] At the time of writing, the experimental design has not been finalized as it is dependent on observations and findings outlined within the draft QAPP entitled *Methods Development for Sediment Sampling and White Sturgeon Sediment Toxicity Studies* as submitted on March 3, 2010 (Teck 2010b).

brief, these criteria include acceptable ranges for mortalities in the control sediment treatments, which are not to exceed 20 percent during a specific life-stage with the exception of the transition-to-feed life-stage, during which mortalities up to 50 percent can naturally occur (target value for mortality during this life-stage is not to exceed the upper 95 percent confidential interval of mortality reported for the same batch of fish cultured at the Kootenay Trout Hatchery, Fort Steele, British Columbia, Canada). Overall, mortality in the control sediment treatments should not exceed 36% for the duration of the exposure (i.e., survival should be at least 64%). Initial seeding densities for all treatment chambers will ensure that fish density will not confound overall survival rates. Coefficients of variation for mortalities among replicate chambers of the same treatment group are not to exceed 20 percent.

A7.6.1 Optimized Study Design

Details concerning how data will be collected for assessing the potential toxicity of COPCs present in sediments to white sturgeon are provided in Section B and the SOPs associated with this QAPP (Appendix C). These methods will be tailored to the physical and logistical constraints associated with obtaining the most effective endpoint measurements. The remainder of this section describes the methods that will be used to determine sample sizes needed to meet the objectives of the sediment exposure study.

The method that will be used to calculate statistical power of the studies to be conducted is the hypothesis testing method. This method uses estimates of variance (S^2) to determine the optimal sample size (n). One of the key parameters in determining the required sample size is the relative difference to be demonstrated. The relative difference (relative to the mean) is the property that affects sample size. To demonstrate differences with the same power, a larger sample size would be required to demonstrate a relative difference of 5 percent of the mean than to demonstrate a 20 percent difference. Furthermore, the ability to demonstrate a particular difference relative to the mean is dependent on the variance of the population. As an example, a greater sample size would be required to demonstrate the difference between two means when the coefficient of variation is 40 percent than when it is 20 percent.

Statistical power of the proposed study design was calculated using the "Means Routine" of the PASS software of NTCC (NTCC, Kaysville, Utah). This method allows the specification of the level of type II error (β). It determines the required number of samples (replicates of the basic experimental unit, which in this study is the replicate exposure system) necessary to achieve adequate statistical power in testing the null hypothesis, H_0, using a fixed significance level α (i.e., the type I or false-positive error)

and a fixed, specific alternative hypothesis, H_1. This fixed alternative may be for hypothesis tests involving a single mean (e.g., comparing the mean number of mortalities for one sample to COPC concentrations) or for problems involving two means (e.g., comparing the mean mortality between two treatment groups). The key to this method is determining the relative magnitude of difference to be demonstrated, relative to the variance of the mean or means. Thus, it is the relative magnitude that is important, not the absolute difference between means. To effectively use this method, in addition to selecting values for the probability of committing type I and type II errors, the method requires estimates of the variance of each population as well as the magnitude of difference to be demonstrated for a particular mean value.

Based on the above method and the information collected during previous unpublished surface water toxicity studies (means and variance), the number of replicate groups required to detect significant differences among sites for α values of 0.05 and 0.1 and β values of 0.2 and 0.1 were calculated (Table A-3). Based on these calculations, three or more replicate groups provide sufficient power to detect 10 percent or greater increases in overall mortality among treatment groups. Given the logistical constraints of the studies proposed herein, it was decided to use three true replicate groups, which should permit detection of a 10 percent increase in mortality with a power of greater than 80 percent and an α value of 0.05. However, it should be noted that the above calculations of power are based on variances and other information obtained during studies with aqueous exposure media, and thus, may not completely apply to the tests with natural sediments proposed here.

Based on previous experience with the culture and exposure of white sturgeon ELS (Tompsett et al., submitted for publication), it is expected that there will be naturally elevated mortalities during the transition to exogenous feeding. Therefore, several statistical approaches will be used to evaluate the data and to determine dose-response relationships (if any), with associated LCx [4] (survival) and ECx [5] (growth and development). Data will be aggregated for the entire exposure period of > 60 days and also will be stratified by key life-stages, yolk sac larvae, transition to feeding, and juvenile. Thus, separate LC/ECx endpoints can be calculated for life-stage periods of interest such as 0 to 21 dph, 29 to 50 dph, and for the entire exposure period.

[4] Lethal concentration for "x" percent of the test population.

[5] Effective concentration for "x" percent of the test population.

Additionally, comparisons among treatment and control groups (e.g., using analysis of variance) will compensate for transition-phase mortality because all groups are assumed to have at least as much mortality as the control groups; therefore, data can be statistically adjusted to account for this period of decreased survival. However, over the entire course of the continuous exposure, control survival should be greater than or equal to 64% (in accordance with the sturgeon Level of Effort document) and control survival should be greater than or equal to 80% in each of the 0-21 and 28-56 day posthatch exposure periods. The 0-21 and 28-56 day posthatch periods are meant to represent the endogenous and exogenous feeding stages; actual days are approximate.

A7.7 Step 7—Develop the Study Plan

Detailed discussions of the various study components are presented in Section B1 of this QAPP.

A8 SPECIAL TRAINING/CERTIFICATES

The project manager is responsible for assembling a project team with the necessary experience and technical skills. Part of the process is to identify special training requirements or certifications necessary to execute the project successfully. Project-specific requirements include training specific to the analytical methods to be conducted, handling, and health assessment methods for white sturgeon larvae, usage of the flow-through exposure systems, and health and safety training for personnel engaged in on-site and laboratory activities.

All project personnel will receive training before commencing work to ensure they are familiar with the required SOPs (Appendix C) and safety and emergency procedures and are adequately skilled at collecting data and operating and maintaining the exposure system. Personnel training records will be maintained by the laboratory manager.

In addition, all personnel working at the Site should have the appropriate health and safety training identified in the General Site Health and Safety Plan (Teck 2009a) and U of S laboratory personnel will follow the laboratory safety guide (Appendix D). Field sampling will follow the approved Cultural Resource Plan (Appendix E).

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.

A9.1 Required Records

Critical records required for this project are identified below with descriptive or supporting information as appropriate. The records will include documents and electronic deliverables related to field sampling (field notebook, sample logs, COC, etc.), toxicity testing and chemistry lab documentation (lab records, data packages, project reports, electronic deliverables, etc.), data validation, and data reports and other applicable project reports.

A9.1.1 Field Sampling

Documentation is described in SOPs 2 and 6 and summarized here.

- Field notebooks (hardcopy).
- Field sampling forms.
- Photographs.
- COC records.
- Corrective action reports.

A9.1.2 Toxicity Testing

Documentation is described in SOPs 4 and 12 and summarized here.

- Sample receipt dates.
- Exposure system maintenance logs.
- Equipment maintenance and QA logs.
- Laboratory notebooks.
- Photographs.
- Raw data sheet.

A9.1.3 Chemistry Laboratory

Documentation is described in Appendix F and will include in the electronic data documentation package, at a minimum, the following items.

- Sample receipt and analysis dates.

- Final analyte concentration including reporting limit, laboratory qualifiers, and reanalyses.
- Percent recovery of each compound in the matrix spike sample.
- Matrix spike recovery control limits.
- Relative percent difference (RPD) for all matrix spike/matrix spike duplicate (MS/MSD) and/or laboratory control sample (LCS)/LCS duplicate (LCSD) results.
- RPD control limits for MS/MSD and/or LCS/LCSD reports.
- Laboratory control sample 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.

A9.1.4 Data Validation

For data validation, the following additional data will be reported:

- Calibration information, including initial calibration, concentration response data of the calibration check standards, continuing calibration check data, instrument tunes, and associated samples.

All raw data and logs will include the following information:

- Analyst's initials and date
- Initial and final sample and extract volumes or weights and/or dilutions
- Condition of instrument
- Documentation linking sample analysis to instrument calibration (where appropriate)
- Analysis start time of all experimental and quality control samples
- Instrument run log showing analytical sequence
- Dilutions performed and amount of sample analyzed
- Experimental samples, quality control samples, and blanks clearly labeled
- Quantification reports
- Sample preservation (where applicable).

Paper copies of all these records will be retained. In addition, data will provided as: 1) an electronic deliverable in Microsoft Excel format for all test results, and 2) an electronic backup for all on-site and laboratory data generated.

Procedures for project control, archiving, and storage of laboratory records are described in Section B10 of this QAPP.

A9.2 Project Reports

The task manager will prepare summary reports for investigations described herein as required under the terms of the Agreement.

A9.3 Record Maintenance and Storage

All documents relating to the project will be controlled to ensure proper distribution, filing, and retrieval, and to ensure that revisions are properly recorded, distributed, and filed.

Project records will be stored and maintained by ENTRIX. The task manager and office staff are responsible for organizing, storing, and cataloging all project information and for collecting records and supporting data from project team members. Once project records are cataloged, ENTRIX will ensure that the project records are appropriately filed by category in the correct project file. Filed documents will be available to U of S and ENTRIX staff through checkout procedures developed to ensure the integrity of the project file. Individual project team members may maintain separate files or notebooks for individual tasks. These files or notebooks will be transferred to the task manager as part of project closeout. The archived files will be stored and maintained by ENTRIX. Newly created documents will be transmitted to Teck quarterly in accordance with its document retention policy. Additional information on record management can be found in Section B9 of this QAPP.

SECTION B: DATA GENERATION AND ACQUISITION

This section describes all aspects of measurement, design, and implementation and discusses the methods that will be used for sampling, analysis, data handling, and quality control in support of the studies that will be conducted in 2010 to assess the potential toxicity of sediments from the UCR to white sturgeon ELS. These studies will include the following experiments:

- Chronic sediment exposure studies with field-collected sediments from a reference location in Canada (e.g., Birchbank) and three locations in the UCR (i.e., Deadman's Eddy, China Bend, and Marcus Flats)
- Water-only acute copper toxicity studies (96-hour exposures) at 15 to 45 dph (refer to Appendix B for additional details).

The approach is designed to collect data that supports characterization of the nature and extent of potential sediment-related toxicity to white sturgeon ELS from hatch through 60 dph, as well as to augment the database on acute toxicity from water-only exposures.

The following specific aspects of measurement and data acquisition are discussed in this section:

- Sampling process design and rationale
- Sampling method requirements
- Sample handling and custody requirements
- Analytical method requirements
- Quality control requirements
- Instrument/equipment inspection and maintenance requirements
- Instrument calibration and frequency
- Acceptance requirements for supplies and consumables
- Data management.

B1 SAMPLING PROCESS DESIGN AND RATIONALE

B1.1 Test Species—Numbers, Source, Strain, and Life-Stages

Species: White sturgeon (*Acipenser transmontanus*)

Strain: Offspring from wild sturgeon caught in the Columbia River

Age: Fry, and juveniles

Number: 25,000 eggs from 2 to 4 breeding pairs

Source: Kootenay Trout Hatchery, Fort Steele, British Columbia, Canada

Freshly fertilized white sturgeon eggs from at least two breeding pairs from the Columbia River will be obtained from the Kootenay Trout Hatchery in British Columbia. Fertilization of eggs will be harmonized in the hatchery by injecting adult riverine sturgeon with a gonadotropin analog on 2 subsequent days. Eggs will be transported to the exposure facilities between 4 and 12 hours after fertilization. Arrangements with the Kootenay Trout Hatchery will be made to retain a contingent of fish from the same fertilization event at the hatchery (~3,000 fry) as a backup if mortality rates in the controls are too great to be able to reinitiate studies at a later life-stage.

B1.2 Sampling Locations and Rationale

Four locations between the trans-boundary reach and Kettle Falls (upstream of RM 700) will be sampled (see Maps A-2 and A-3), representing a sediment exposure gradient for slag-associated COPCs such as cadmium (Cd), copper (Cu), lead (Pb), and zinc (Zn). Specifically, these locations include: 1) Deadman's Eddy (RM 737), 2) China Bend (RM 723), and 3 & 4) Upper and Lower Marcus Flats (RM 706 and 704) (Table B-1). In the event that sediment samples cannot be retrieved from the aforementioned areas, due to unspecified reasons, alternative sampling locations have been identified. These include Northport and the Little Dalles (Table B-1). As illustrated in the above-referenced maps, the proposed locations not only represent a gradient of slag-associated COPCs between locations but also within locations.

In addition to a gradient of slag-associated COPC sediment concentrations within the proposed locations, the greatest abundance of white sturgeon ELS (larvae) has been reported in the vicinity of Little Dalles and China Bend downstream of Northport, which represent an important nursing ground for sturgeon. The reference location (Birchbank) is located approximately 12 km upstream of the city of Trail and Teck's Trail smelter (Table B-1).

Within each of the four primary sampling areas (Deadman's Eddy, China Bend, Upper and Lower Marcus Flats) there will be three sites to capture potential local gradients of COPC concentrations.

The rationale for the selected locations is as follows:

1. Reference site—It is located upstream of the Trail smelter facility and has historically been used as a reference for a wide range of environmental studies (e.g., sediment bioassays and surface water quality).
2. Deadman's Eddy (RM 737)—This site is located downstream of a known spawning site within the Columbia River (Waneta, British Columbia, Canada) and, as such, there is the potential that white sturgeon ELS would be exposed to these sediments. In addition, preliminary toxicity tests on white sturgeon ELS (i.e., 30 dph) have been performed by the USGS (2009) using sediment from this area.
3. China Bend (RM 723)—Early larvae abundances appear to be greatest upstream and at this location (MacLellan and Howell 2006). Thus, it is assumed that later life-stages such as fry during the hiding stage will be present at and downstream of this site.
4. Marcus Flats (RM 706)—Marcus Flats has been hypothesized to serve as the farthest downstream sink for slag-containing sediments and as a nursing ground for white sturgeon.

B1.3 Support Facilities for Chemical Analysis

The primary laboratory for analysis of samples for COPCs will be Columbia Analytical Services, Kelso, Washington, USA. Non-COPC measurements (e.g., dissolved oxygen, ammonia, pH) will be monitored by the Aquatic Toxicology Research Facility of the Toxicology Centre at the U of S during the course of the work to maintain appropriate biological conditions in the exposure chambers.

B1.4 Experimental Setup and Sampling Strategy

The following sections describe the experimental set-up and design anticipated during the work. It is important to note however, that specific details presented below are subject to change based on observations and findings outlined within the draft *Methods Development for Sediment Sampling and White Sturgeon Sediment Toxicity Studies* QAPP (Teck 2010b). Observations recorded during the methods development work will be summarized in a technical memorandum submitted to EPA for review and concurrence; and will serve as an addendum to this QAPP.

B1.4.1 Sediment Sampling, Transport, and Storage

A total of approximately 50 gallons of sediment per sediment sampling site (or less, depending upon final fluvial system design as determined during methods development) will be needed for the exposure studies (Table B-2). Samples will be collected in accordance with protocols described in Appendix C. After collection, sediments will be stored and transported immediately to the test facilities using decontaminated 5-gallon resealable polyethylene buckets. Transport will occur at approximately 4°C, and samples will be stored at the same temperature until use in experiments.

B1.4.2 Chronic Sediment Toxicity Studies (U of S)[6]

Exposures to UCR sediments will be conducted in specifically designed flow-through fluvial simulation systems at the Aquatic Exposure Laboratory at the U of S (Figures B-1 and B-2). Prior to adding sediments to the exposure chambers, sediments from each sampling site that were stored separately in 5-gallon buckets will be mixed and homogenized in a commercial grade concrete mixer (SOP-8) or a >50-gallon polyethylene barrel by means of thorough mixing/tumbling (SOP-8). Homogenization of a sediment will be assessed by visual observations, including uniformity of color and consistency (as determined in methods development work). Sediments then will be evenly layered in exposure chambers at a thickness of 5.08 cm (2 inches), or as otherwise determined during the methods development work. A sample for bulk sediment chemistry analysis as specified in Tables B-3 and B-4 will be taken from each replicate exposure chamber. Eight to 12 suction devices (e.g., airstones) that span the entire width of the exposure chambers will be distributed at 4- to 3-inch intervals throughout each chamber to enable porewater sampling during the experiments without disturbing the sediment (number and exact placement to be determined during the methods development work). Diffusive membrane devices (such as "peepers", diffusive gradient thin-film (DGT) probes, or other similar diffusive devices) may also be deployed for collection of porewater and/or sediment-water interface water, depending upon the results of methods development work. After addition of sediments to each chamber,

[6] The procedures described herein and design elements are "envisioned" based on the current state of knowledge, and may not represent the final conditions and design under which the tests will be conducted. Definite conditions will be established based on the current pilot activities as described in the draft QAPP entitled *Methods Development for Sediment Sampling and White Sturgeon Sediment Toxicity Studies* as submitted on March 3, 2010 (Teck 2010b).

test systems will be slowly filled with artificial river water (laboratory water that was adjusted for hardness, pH, dissolved organic carbon [DOC] and alkalinity similar to that observed in the UCR [Teck 2009b]; SOP-13). On top of the sediment layer collected from the river and placed into exposure chambers, medium size gravel (1 to 2 cm diameter) will be placed at a density of ~5 to 7 stones per 100 cm^2 to improve habitat in accordance with earlier observations (Little et al. pers. comm.), with size and distribution optimized during methods development. Water flows and velocities will be determined during methods development, but will be less than those occurring at some of the upstream locations in the river to ensure proper sturgeon culture. Prior to initiation of exposure studies, all systems will be equilibrated for a minimum of 4 weeks, or as otherwise determined during methods development, although timing of sediment collection will ultimately dictate the available timeframe. Although water in the UCR may move through the sediments either from upwelling from deeper sediments, downward movement from surface water, or lateral fluvial flow, it is not possible to recreate these conditions within the laboratory exposure chambers.

Exposures of white sturgeon will begin immediately after hatching at the Aquatic Exposure Laboratory at the Toxicology Centre at the U of S; and will continue through approximately day 60 post-hatch. Eggs will be incubated in McDonald-type incubation jars in artificial river water. After hatching, larvae from the different breeding pairs will be combined and randomly assigned to treatment chambers. Sturgeon will be sampled at day 1 and at termination of the 60-day exposure period (Figure B-2). Number of individuals per treatment and replicate group and general test design are provided in Table B-5.

Exposure of sturgeon fry and juveniles will be conducted in a facility that allows control of light and temperature regimes. Each sediment sample group and the controls/reference will be tested in three replicate exposure systems (Figure B-1). Each exposure system is temperature controlled. All criteria meet or exceed requirements listed in ASTM guidelines for testing fish ELS (Table B-6; ASTM 2005). Summaries of test conditions for conducting the work, the general activity schedule, and the test acceptability requirements are provided in Tables B-7 through B-9, respectively. Fish densities for specific life-stages during the exposure period were calculated based on optimum seeding densities for this species under fluvial conditions (Tompsett et al., submitted for publication).

B1.5 Sample Types

Samples to be collected during the duration of this work are listed in Table B-10 and sample analytical methods are listed in Table B-11. In general, two types of samples will be taken during the studies described herein:

1. Samples for exposure assessment. Three different matrices will be sampled for assessment of exposure

    a. Overlying water—Water samples will be collected at weekly intervals during the course of the exposure studies. Water will be taken initially (for the first two weeks) at the inflow and outflow of the test chambers, and will be tested at the U of S for DOC, alkalinity, hardness, total suspended solids (TSS), pH, dissolved oxygen (DO), conductivity and temperature. If no significant differences between the initial samples taken from inflow and outflow occur, only outflow samples will be taken during the remainder of the study.

    b. Porewater—Porewater will be collected at the same intervals as overlying water using suction devices (see Section B1.4.2). Samples will be taken at multiple locations within each treatment chamber, and will be preserved for dissolved metal analysis, cation, anion, DOC, and other parameters listed in Table B-10 using the methods listed in Table B-11, as appropriate for application of the biotic ligand model (BLM) to the data.

    c. Sediment-water interface water – Water at the interface of the sediment surface and overlying water will be collected by either suction, by means of a "peeper" or a similar sampling device, as determined during the methods development studies. Sampling will occur at the same intervals as pore- and overlying water, and samples will be subjected to the same analysis as porewater.

    d. Sediment—Prior to initiation of the studies, COPC concentrations in whole sediments will be measured, and sediment samples will be characterized for grain size, organic carbon content, acid volatile sulfides (AVS), simultaneously extracted metals (SEM), target analyte list (TAL) metals, and other parameters as appropriate (e.g., pH).

2. Samples for biological analysis. Following measurements of length and biomass (weight), all sturgeon will be preserved at intervals/life-stages specified above to

ensure, if necessary, later analysis of gross and histological morphological alterations (fixation in 10 percent buffered formalin).

B1.6 Study Contingencies

The study design is intended to meet the DQOs and satisfy the data needs of the RI/FS and ecological risk assessment specific to white sturgeon. It is possible that complications may arise due to mortalities in the controls (> 50 percent during transition to feeding). The following is a description of possible contingencies or alternative approaches to be followed in the event control mortalities are unacceptably high (i.e., exceed 25 percent for yolksack larvae or 50 percent for post-swim-up stage). Use of contingency plans will be approved by EPA prior to implementation.

Contingency #1—Maintain backup batch of fish at hatchery

Arrangements with the Kootenay Trout Hatchery will be made to retain a contingent of fish from the same fertilization event at the hatchery (~3,000 fry) as a backup if mortality rates in the controls are too great to be able to reinitiate studies at a later life-stage.

Contingency #2—Obtain fertilized eggs/fry from possible second spawning event

In past years, there often has been more than one spawning event at Waneta, and in such occasions ripe females and males were collected and transported to the Kootenay Trout Hatchery at different time points for stripping and fertilization of eggs. In case there would be a second later spawning event at the hatchery in 2010, a potential second batch of eggs could be obtained for reinitiation of the experiments.

B2 SAMPLING METHOD REQUIREMENTS

B2.1 Sample Processing and Laboratory Analyses

For water quality and COPC analyses conducted at CAS, current EPA analytical methods for analysis of dissolved TAL metals, conventional parameters, and major ions will be used, in addition to *Standard Methods for the Examination of Water and Wastewater* (SM) (APHA 1998), as indicated in Table B-11. All sample processing procedures will be entered into the appropriate forms, and dated and initialed by the person who took the sample.

Water Quality Analysis for Fish Culture. Overlying and porewater quality will be measured a the U of S Aquatic Toxicology Research Facility as part of the daily/weekly

laboratory routine to ensure that water quality is appropriate for culture of fish (e.g., temperature, pH, dissolved oxygen, conductivity, hardness, alkalinity, ammonia; Table B-10)

Sediment Characterization. Sediment samples will be analyzed by CAS for TAL metals, pH, total organic carbon (TOC), AVS, SEM, and grain size at the initiation and end[7] of the study. All sediments will be stored appropriately after termination of the experiments to enable later analyses for additional COPCs if this should be deemed necessary.

Water Samples for COPC Analysis. Overlying and porewater samples for analysis of major cations and anions, dissolved TAL metal, and general water quality parameters (alkalinity, hardness, DOC, TDS) will be taken weekly and preserved as specified in Tables B-8 and B-9 for shipment to CAS. All procedures, including transport of samples to the analytical laboratory for analysis, will be recorded on the COC forms that will accompany the samples at all times. All methods for sample preparation and fixation will be in accordance with EPA methods on a performance basis.

Biological Samples. Subsets of white sturgeon ELS will be sampled throughout the course of the studies (Figure B-2). All samples will be measured and weighed immediately after collection, and observations of any behavioral and morphological abnormalities will be recorded on the appropriate forms (Table B-12). Behavioral observations will follow ASTM E1711-95 (2008). Also, sturgeon of an age >50 dph will be dissected and morphological anomalies (e.g., tissue color, liver size, gut/stomach filling) will be recorded. After 24 to 48 hours, depending on the size of the individual, the sample will be transferred into ethanol, and stored at room temperature. All sturgeon that die prior to termination of the experiments will be subjected to the same procedures as described in this paragraph.

B2.2 Sampling Documentation

Study team members at the Aquatic Toxicology Research Facility will maintain bound logbooks to provide a daily record of significant events, observations, and measurements during sampling and routine experimental maintenance procedures. Each data book will have a unique identifier and each page and carbon copy will include

[7] Grain size will not be determined at the end of the experiment.

this data book identifier. All information pertinent to sampling will be recorded in the logbooks. Each day's logbook entries will be signed and dated and will include:

- Name and title of author, date and time of entry, and experimental conditions during the activity (e.g., water quality parameters, health status of test organisms)
- Activities performed (e.g., water renewal, feeding of larvae)
- Sampled matrix
- Sample collection method
- Number of samples taken.

When activity-specific data forms are used, they will also include:

- Project name and number
- Treatment identifier
- Initials
- Analysis and sample collection method.

The following information will be recorded either in the logbook or on the activity-specific data forms:

- Date and time of collection
- Sample identification number(s)
- Sample destination (e.g., laboratory)
- Laboratory observations
- Experimental measurements
- Experimental handling (preservation).

All original data recorded in experimental logbooks, data forms, sample labels, and COC forms must be written with waterproof, indelible ink. None of these accountable, serialized documents are to be destroyed or discarded, even if one is illegible or contains inaccuracies requiring document replacement. If an error is made on an accountable document assigned to one individual, that individual will make all corrections simply by crossing a line through the error, initialing and dating the correction, and entering the correct information. The erroneous information will not be obliterated. The person who made the entry will correct any subsequent error discovered on an accountable document. All personnel will be trained in the proper use of notebooks prior to the start of the studies.

B2.3 Sample Identification

The analysis and sample identity information will be recorded in bound logbooks or recorded on data sheets while in the custody of the sampling team.

A sample label will be completed and attached to each sample container for every individual or composite sample collected. Labels consist of a waterproof material backed with a water-resistant adhesive. Labels are to be filled out using waterproof ink, and are to contain at least the following information:

- Sampling date and time
- Sample identification number
- Sampler's initials
- Sample matrix or matrix identifier.

Each sample to be analyzed for residues (COPCs) will be assigned a unique number consisting of an alphanumeric code that identifies the treatment group and sample type. These numbers will be tracked electronically, from collection through laboratory analysis and into the final reports.

The sample number will be cross-referenced with the treatment group name on the COC. Additional sample volume will be collected for samples identified for laboratory QC purposes (i.e., MS, MSD, DUP) and identified as "For Lab QC Use." Information to be included on COCs is specified in SOP-8 (Appendix C), titled "Sample Management: Receiving, Preservation, Storage, Documentation, Decontamination, and Disposal."

B2.3.1 Tissue Sample Handling Procedures

Appropriate sample containers will be sealed and labeled. In cases where tissue samples will be archived, samples will be placed on wet or blue ice in an insulated container for no longer than 30 minutes, and then stored appropriately (e.g., buffered formalin). Appropriate COC documentation will accompany the samples as required by the QAPP. Specific sample volumes, sample containers, preservatives, and replication of samples are detailed in the following sections. Any sampling equipment that will be reused will be decontaminated by rinsing with deionized water followed by dilute acid (e.g., nitric acid) between sampling.

B2.3.2 Decontamination Procedures and Materials

All equipment used during investigation activities that could come into contact with chemically affected materials will be thoroughly cleaned, before and after each use, by

washing with Liquinox® (a laboratory-grade detergent) and rinsing with deionized water followed by dilute acid (generally, nitric acid). Decontamination procedures may be modified and/or revised based upon the data obtained or the equipment used.

Decontamination waste is expected to consist of dilute acid. Decontamination solutions will be properly disposed through the Department of Health, Safety and Environment (DHSE) of the U of S.

B2.4 Sampling/Measurement Failure Response

If quality control surveillance and/or experimental audits result in detection of unacceptable conditions, procedures, or data, the task manager, in conjunction with the quality assurance manager, will be responsible for developing and directing implementation of corrective actions. Corrective actions will include one or more of the following:

- Identifying the root cause of the problem and implementing systems to prevent future occurrences
- Identifying the source of the violation
- Evaluating and amending sampling and/or analytical procedures
- Accepting data and flagging the data to indicate the level of uncertainty associated with failure to meet the specified quality control performance criteria.
- If necessary, studies will be restarted at a selected life-stage, by agreement with EPA.

Any finding requiring corrective action must be documented by the task manager on a corrective action form (Figure B-3). The project quality assurance manager will check to ensure that corrective actions have been implemented and that the problem has been resolved. Problems will be addressed and the corrective action noted in the appropriate notebook.

If an error is made on an accountable document assigned to one individual, that individual will make all corrections simply by crossing a line through the error, initialing and dating the correction, and entering the correct information. The erroneous information will not be obliterated. The person who made the entry will correct any subsequent error discovered on an accountable document.

B2.5 Sample Preservation and Holding Time Requirements

The sample containers, preservative requirements, and maximum holding times for analytical methods for this project are provided in Tables B-8 and B-9. All containers for samples submitted for chemical analyses will have screw-type lids to ensure adequate sealing. Pre-cleaned bottles will be provided by the analytical chemistry laboratory.

B3 SAMPLE HANDLING AND CHAIN-OF-CUSTODY REQUIREMENTS

Proper sample handling, shipment, and maintenance of COC are key components of building the documentation and support for data that can be used to make project decisions. It is essential that all sample handling and sample COC requirements be performed in a complete, accurate, and consistent manner. Sample handling and custody requirements must be followed for all samples collected as part of this project.

B3.1 Sample Custody

Sample custody and documentation procedures described herein must be followed throughout all sample collection activities. Components of sample custody procedures include the use of experimental logbooks, sample labels, custody seals, and COC forms. The COC form must accompany the samples during shipment from the collection sites to the Aquatic Toxicology Research Facility at the U of S (SOP-6 in Appendix C) and from the Aquatic Toxicology Research Facility at the U of S to the contract laboratory (CAS) (SOP- 7 through SOP-9 in Appendix C).

Samples will be delivered to the designated laboratories by the experiment personnel, laboratory courier, or by commercial shipping services (such as UPS or Federal Express). The method of sample shipment will be noted on the COC. During the experimental effort, the experiment team leader or a designee will inform the laboratory daily of planned shipments. Hard plastic ice chests or coolers with similar durability will be used for shipping samples. The coolers must be able to withstand a 4-ft drop onto solid concrete in the position most likely to cause damage. The samples will be packed to prevent the least amount of damage if such a fall were to occur.

A sample is under custody under the following conditions:

- It is in one's actual possession
- It is in one's view, after being in his or her physical possession

- It was in one's physical possession and that person then locked it up to prevent tampering
- It is in a designated and identified secure area.

The following procedures must be used to document, establish, and maintain custody of samples:

- A sample label will be completed and attached to each sample container for every sample collected. Labels consist of a waterproof material backed with a water-resistant adhesive. Labels are to be filled out using waterproof ink, making sure that the labels are legible and affixed firmly on the sample container. Sample labels are to contain at least the following information: sampling date and time; sample identification number; treatment group identifier; and sampler's initials.
- All sample-related information must be recorded in the project logbook or on activity-specific data forms.
- The sampler must retain custody of samples until they are transferred or properly dispatched.

To simplify the COC record and minimize potential problems, as few people as possible should handle the samples or other physical evidence. For this reason, one individual from the experiment crew should be designated as the responsible individual for all sample transfer activities. This investigator will be responsible for the care and custody of the samples until they are properly transferred to another person or facility.

A COC record will accompany all samples. This record documents the transfer of custody of samples from the investigator to another person, to the laboratory, or other organizational entities; a signature for relinquishment and receipt of the samples must accompany each change of possession. The COC record will be prepared for groups of samples collected at a given location on a given day.

The COC form makes provision for documenting sample integrity and the identity of any persons involved in sample transfer. Information entered on the COC will consist of the following:

- Project name and number
- Logbook number
- COC serial number
- Treatment group

- Sample numbers
- Sampler/recorder's signature
- Date and time of collection of each sample
- Sample type
- Analyses requested
- Inclusive dates of possession
- Name of person receiving the sample
- Date of receipt of sample
- Name, address, and telephone number of laboratory
- Name, address, and telephone number of person to whom laboratory report will be sent
- Method of delivery and courier.

Completed COC forms will be inserted into a resealable plastic bag, sealed, and taped to the inside cover of the shipping container used for sample transport from the experimental site to the laboratory, or from the laboratory to the analytical laboratory, when a courier or shipping company is used. The shipping company will not sign for custody of the samples.

When samples are relinquished to a courier for transport, the tracking number from the shipping bill or receipt must be recorded on the COC form or in the site logbook.

The recipient for the samples must be notified of the date of shipment and anticipated time of arrival. The shipping bill number must also be provided to the recipient to enable tracking of samples. It must be clearly established prior to shipment who will be responsible for ensuring that timely sample delivery occurs and who will track the samples in case of shipping delays. The recipient of the samples must inform the sender when the samples are delivered. Custody seals must be affixed on shipping containers or individual sample containers[8] when samples are shipped to the laboratory to prevent sample tampering during transportation. In cases of delivery delay or packing damage,

[8] Samples that are shipped to Canada from the United States, or from Canada to the United States, are subject to custom inspection which may break the seal on the shipping container. Therefore, sample containers must be sealed individually.

all details of damage and sample condition must be recorded and, if necessary, photographed for documentation.

B3.1.1 Laboratory Sample Handling and Custody

This section is applicable to all samples sent to the U of S laboratory or to CAS. The task manager or field team leader will notify the laboratory project manager of upcoming sampling activities and the subsequent transfer of samples to the laboratory. This notification will include information concerning the number and type of samples to be shipped, analyses requested, and the expected date of arrival. The laboratory project manager will notify appropriate laboratory personnel about the expected shipment including the sample custodian.

Upon arrival at the laboratory, the samples will be received and logged in by a trained sample custodian in accordance with the laboratory's sample handling program. A description of the laboratory's general program is provided in SOP-7 through SOP-9 and is summarized below.

Upon sample receipt, the sample custodian is responsible for performing the following activities during sample receipt where appropriate:

- Examining the shipping containers to verify custody seals, if used, are intact
- Examining all sample containers for damage
- Taking digital photographs of any custody seals used, before opening, and of any damage to the shipping container or individual sample containers
- Comparing samples received against those listed on the COC
- Verifying sample holding times have not been exceeded
- Determining sample temperature (from the temperature blank vial) and documenting variations from the acceptable range on the COC
- Verifying that all samples listed on the COC are present or accounted for
- Immediately signing and dating the COC after shipment is accepted
- Noting any sample receipt problems on the COC, initiating a condition-upon-receipt (CUR) report, and notifying the laboratory project manager
- Attaching laboratory sample container labels with laboratory identification number and test
- Placing the samples in proper laboratory storage.

The laboratory project manager is responsible for contacting the project liaison as soon as possible if any problems are identified during sample receipt. All identified sample receiving problems will be resolved before sample preparation and analysis.

Following sample receipt, the sample custodian is responsible for logging the samples in the laboratory sample log-in book, and/or the Laboratory Information Management System with the following information:

- Laboratory project number
- Sample numbers
- Type of samples
- Required tests
- Date collected
- Date received.

The sample custodian is also responsible for notifying the laboratory project manager and appropriate group/team leader(s) of sample arrival and placing completed COCs, waybills, and any additional documentation in the project file.

Samples will be stored appropriately within the laboratory to maintain any prescribed temperature, to protect against contamination, and to maintain the security of the samples.

B4 ANALYTICAL METHOD REQUIREMENTS

This subsection presents the analytical method requirements for chemical analyses that will be performed during the study including preparation/extraction procedures, where appropriate, and method performance requirements.

Analysis of samples for COPCs will be conducted by CAS according to the methods indicated in Table B-11. The laboratory's quality assurance protocols are in Appendix F and contain summary information about the analytical methods used, including the following (see also Tables B-3, B-4, and B-13 of this QAPP):

- Holding times
- Sample containers and preservatives
- Calibration requirements and acceptance criteria

- Laboratory quality control samples including acceptance criteria and corrective action
- Limits of detection.

More detailed information on the laboratory's analytical methods is presented in laboratory-specific SOPs, to be provided in Appendix F.

B4.1 Analytical Methods

B4.1.1 Biological Assessments

Prior to initiation of the exposure experiments, hatchability will be assessed by dividing the number of successfully hatched eggs by the total number of eggs seeded in each egg incubation jar. Results will be presented as percent hatchable eggs and used to evaluate test acceptability (see Tables B-7 and B-9). The following endpoints will be measured in the chronic sediment exposure test at the U of S Aquatic Toxicology Research Facility:

Mortality. Mortality data will be reported as the percentage of dead fry/juveniles compared to original seeding density. In addition, life-stage specific mortality will be calculated by dividing the number of fish at the end of a specific life-stage period by the number of fish present at the beginning of the same life-stage. Dead fish will be discerned from live ones by immobility (e.g., in response to gentle prodding) and absence of respiratory movement in older individuals.

Growth. Growth will be determined by measuring length and weight of the fish. All dead fish will be measured when removed from the tanks. A sample of newly hatched fry will be taken from the hatching tank and weighed (in groups of ten) and measured (individually) to document size at start of the test. Photo documentation will be used to measure length of live fish throughout the duration of the experiment, measuring the fish to the nearest 0.5 mm if permitted by resolution of photograph. At the end of the test, all fish will be weighted to the nearest 0.01 g and measured to the nearest 0.5 mm; individuals will be blotted dry prior to determining weight. Growth will be reported as weight and length gain over time.

Other observations. Throughout the experiment, fish will be monitored for alterations in behavior (Table B-12; ASTM E1711-95 (2008)). Furthermore, animals will be inspected for gross morphological alterations (e.g., fin aberrations, skeletal deformities) at the time of sampling. All of the individuals removed from the experiments will be fixed in formalin.

B4.1.2 Chemical Analysis

A summary of the chemical analyses to be performed during this work is presented in Table B-10. As indicated within the table, routine water quality measurements to ensure proper fish culture will be conducted by the U of S Aquatic Toxicology Research Facility; while COPC measurements and associated measure of metal bioavailability (e.g., BLM parameters) will be determined by CAS. To determine the reporting limit goals, available water and sediment guidelines and benchmarks were compiled and compared to the expected reporting limit (Table A-2). For aquatic ecological receptors, reporting limit goals were developed using the EPA national aquatic life chronic criteria (USEPA 2006c).

Screening values and required method reporting limits (MRLs) for samples collected during the 2010 sturgeon ELS studies are provided in Table A-2. The goal is for MRLs to be equal to or below one-fifth of the EPA national aquatic life chronic criteria (USEPA 2006c) for each analyte. MRLs are generally equivalent to the concentration of the lowest calibration standard (i.e., the practical quantification limit) and represent the low end of the calibration range. Analytes that are detected at concentrations below the reporting limit but above the detection limit will be reported, but will be qualified as estimated (i.e., a "J" qualifier will be applied to the result by the laboratory).

Laboratory methods for sample preparation and analysis are summarized in Table B-11. Sample containers, preservation, and holding times are provided in Tables B-8 and B-9.

B4.2 Laboratory Corrective Action

Laboratories have formal corrective action systems in place to ensure that prompt action is taken when an unplanned deviation from a procedure or plan occurs and that, whenever possible, corrective actions include measures to prevent the reoccurrence of deviations. Specific corrective actions will be taken and documented when a quality control sample does not meet acceptance criteria. Following is a description of how information from the laboratory's corrective action system is communicated to the project team.

Corrective action procedures include prompt notification of the project contact (quality assurance manager) for any significant problems or discrepancies. The laboratory project manager is responsible for reporting any significant problems or discrepancies that occur as analyses are conducted to the project liaison or other identified project contact. The laboratory project manager is also responsible for ensuring that corrective action is taken, where appropriate, to prevent the reoccurrence of similar problems or

discrepancies. In addition, each analytical data report will include a case narrative that discusses any problems or discrepancies, and sufficient calibration and quality control information to verify that the method was within control limits at the time that the samples were analyzed. The case narrative will also include a discussion of any corrective action taken by the laboratory to prevent the reoccurrence of similar problems or discrepancies.

B5 EXPERIMENTAL QUALITY CONTROL REQUIREMENTS

This section presents the quality control checks that will be performed by the analytical (chemistry) laboratory during investigations including a discussion of quality control samples with frequency and acceptance criteria and corrective action procedures.

B5.1 Quality Control Samples

Quality control samples for equipment and field blanks will be prepared at CAS and shipped with the sample containers to the U of S exposure facility and the field crew, respectively, for monitoring the bias and precision of the sample collection and analysis procedures. The type and frequency of quality control samples to be collected during investigations are summarized in Table B-13 and are described below.

B5.1.1 Equipment Rinsate Blank Samples

Equipment rinsate blanks (ERBs) are samples of weak acid (e.g., 1 percent nitric acid) passed through and over the surface of decontaminated sampling equipment. The rinsate is collected in sample bottles, preserved, and handled in the same manner as the samples. ERBs are used to monitor the effectiveness of the decontamination process. The planned frequency for ERBs is one per week per equipment type. If more than one type of equipment is used to collect samples for a particular matrix, then an ERB is collected and submitted for each representative group of equipment. Typically, ERBs are analyzed for the same analytes as the corresponding samples collected that day.

B5.1.2 Blanks

Two types of field blanks will be used: 1) sample containers filled with DI water that are transported to and returned from the experimental location unopened and 2) sample containers that are opened at the experimental location, filled with DI water, and then closed. Typically, at least one blank per lot number of collected samples will be analyzed.

B5.1.3 Duplicate (Blind) Samples

"Blind" duplicate samples are collected to monitor the precision of the sampling process. The use of replicates to assess precision is discussed in Section B5.2.1. Experimental duplicates of overlying water in the exposure chambers will be collected weekly and submitted to the laboratory for analysis. However, given the limits in volume that can be taken for porewater and sediment-water interface water analysis, no duplicate samples will be collected during porewater sampling events in the laboratory.

B5.1.4 Certified Reference Materials

Certified reference materials are purchased by the analytical laboratory from nationally recognized, reputable vendors that have fulfilled the requirements of ISO 9001 certification and/or are accredited by A_2LA. These standards ensure the accuracy of the analytical measurements. Further details are provided in Appendix F *Quality Assurance Manual of Columbia Analytical Services*.

B5.1.5 Reference Toxicant

Sensitivity of the fish from the Kooteney hatchery will be assessed through the use of a reference toxicant in water-only exposures (see Appendix B).

B5.2 Method Performance Objectives

Method performance requirements for analytical laboratory methods are expressed in terms of precision, accuracy, representativeness, comparability, completeness, and sensitivity (PARCCS). Summarized below are brief definitions for each PARCCS parameter, with calculation equations as appropriate.

B5.2.1 Precision

Precision is an estimate of the variability between individual measurements of the same physical or chemical property under prescribed similar conditions.

Experimental Precision

Experimental precision is usually assessed through the collection and measurement of duplicate samples from each treatment. The duplicate sample is submitted "blind" to the laboratory, and sample results are compared to check for the overall variability introduced by sampling and analytical procedures. The experimental duplicate approach is generally not applicable to systems where the experimental unit is the single organism because each individual represents a sampling replicate. Similarly, when a

single test solution sample is collected and divided into additional blind samples, these replicate samples represent analytical replicates.

Analytical Precision

Precision in the laboratory is assessed through the calculation of the RPD for two replicate samples. The precision of the analysis can be inferred through the use of one of the following: 1) standard reference materials (SRMs) and duplicate SRM (SRMD) samples; 2) MS/MSD samples, which are project samples spiked with known analyte concentrations; or 3) duplicate analyses of unspiked project samples. The laboratory analyzes one or more of the aforementioned types of duplicate samples at a rate of one per batch of 20 or fewer investigative samples per matrix.

The MS/MSD samples provide information about the effect of the sample matrix on extraction and measurement methodology. An MS/MSD pair will be analyzed at a rate of one per 20 per analytical batch or fewer investigative samples per matrix.

Calculating the RPD for each pair of duplicate analyses (e.g., MS/MSD, LCS spike duplicates, unspiked duplicate samples) and the RPD for experimental duplicate sets using the following formula will assess the precision of laboratory analyses:

$$RPD = \frac{S - D}{(S + D)/2} x100 \qquad \text{(Eq. B5-1)}$$

Where:

RPD	=	Relative percent difference
S	=	First sample value (original or MS value or larger of the duplicate)
D	=	Second sample value (duplicate or MSD value or smaller of the duplicate)

B5.2.2 Accuracy

Accuracy is the degree of agreement between a measurement or observation and an accepted value.

Experimental Accuracy

Experimental accuracy is assessed through the collection and analysis of appropriate experimental blanks, and achieved through adherence to all sample handling, preservation, and holding time requirements. Experimental blank samples are analyzed to check for procedural contamination that may cause sample contamination. Equipment rinse blanks are used to assess the adequacy of decontamination of sampling

equipment between collections of individual samples. Accuracy of instruments will be assessed by using weekly instrument calibration and calibration checks. Experimental blank and equipment rinsate blank analysis frequencies are given in Table B-13.

Analytical Accuracy

Laboratory accuracy is assessed by the analysis of method blanks and matrix spikes, LCS, and/or SRM or certified reference materials. The results are expressed as percent recovery. Method blank samples are generated within the laboratory and used to assess contamination resulting from laboratory procedures. Surrogate compounds are used in analyses for inorganic contaminants and are specified in the analytical methods described in the 2008/2009 surface water study QAPP (Teck 2009b).

Method blanks, matrix spike, LCS, and/or SRM samples will be analyzed at a rate of one per analytical batch of 20 or fewer investigative samples/matrix.

The percent recovery (percent R) of spike samples will be calculated using the formula:

$$R = \frac{A - B}{C} x100 \qquad \text{(Eq. B5-2)}$$

Where:

R	=	Recovery (percent)
A	=	The analyte concentration determined experimentally from the spiked sample, units
B	=	The background level determined by a separate analysis of the un-spiked sample, units
C	=	The amount of the spike added, units.

B5.2.3 Representativeness

Representativeness is a qualitative measure of the degree to which sample data accurately and precisely represent a characteristic experimental condition. Representativeness is a subjective parameter and is used to evaluate the efficacy of the study plan design. Representativeness is demonstrated by providing full descriptions of the sampling design and its rationale in the project planning documents.

There cannot be a target numerical goal for a qualitative parameter such as representativeness or comparability. Therefore, this criterion is completed and evaluated subjectively rather than quantitatively. The measure for representativeness is answered during the preparation of the sampling and analysis approach and rationale, and then reassessed during the data usability process. For example, an integral part of developing

the sampling and analysis approach and rationale is to answer the question "How many samples are needed to fully evaluate x?" Then, during the data usability process, the question "Were enough data collected to answer the original question?" must be answered. Thus, it is not possible to construct a table with numerical goals that can be used to evaluate these subjective measures. The criteria to make these decisions can be based on power analysis conducted after initial information has been collected or during data interpretation to determine if additional samples are necessary to fully describe the nature and extent.

B5.2.4 Comparability

Comparability expresses the confidence with which one data set can be compared with another data set obtained during parallel or previous investigations. Comparability can be related to precision and accuracy because these parameters are measures of data reliability.

Results are generally considered comparable if the same procedures for collecting and analyzing the samples are employed, if the samples comply with the same QA/QC procedures, and if the units of measurements are the same.

The study protocols for the determination of biological effects for this study were designed such that the data obtained during these studies are comparable with data collected during previous studies as outlined in Section A5 where applicable. Furthermore, comparability will be assessed by the parallel assessment of three true replicates for each sediment in the experiments.

The quality objective for data from the study's exposure experiments and analytical tasks is to achieve a level of comparability that allows for the comparison of data collected within and among all experiments. To accomplish this goal, all data generated during the tasks included in this investigation will be subject to strict QA/QC procedures as specified in this QAPP. Furthermore, comparability will be assessed by including a separate control using laboratory water in the field. Key water quality parameters known to influence availability and toxicity of metals and/or that are of importance for larval development and growth will be adjusted in the acute toxicity studies for comparability reasons. These parameters include temperature, pH, hardness, and dissolved oxygen.

B5.2.5 Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that was planned to be obtained under normal conditions. Data completeness will be calculated by using Equation B5-3.

$$\%\,\text{Completeness} = \frac{\text{Valid Data Obtained}}{\text{Total Data Planned}} \text{x}100 \qquad \text{(Eq. B5-3)}$$

Experience on similar projects has shown a reasonable goal considering combined historical field and laboratory performance is 90 percent completeness. All valid data will be used. During the data validation process, an assessment will be made of whether the valid data are sufficient to meet project objectives. If sufficient valid data are not obtained, the project manager will initiate corrective action. Where invalid data are generated, all documentation and the reasons for the invalidation of the data will be provided.

B5.2.6 Sensitivity

Sensitivity is the measure of the concentration at which an analytical method can positively identify and report analytical results. The sensitivity of a given method is commonly referred to as the detection limit. Although there is no single definition of this term, the following terms and definitions of detection limits will be used for this project:

- **Instrument Detection Limit.** Defined as the minimum mass of analyte that can be measured above instrument background noise under ideal conditions.
- **Analytical Detection Limit.** Method detection limits (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 laboratory conducting the analysis will determine a method detection limit for each analyte, as required by USEPA (2004). 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, reflect the typical sensitivity obtained by the analytical system, and represent the level of analyte above which concentrations are accurately quantified. Analyte concentrations for this study will be reported to the MDL. Analytes detected at concentrations between the MRL and the MDL will be reported with a "J" qualifier to indicate that the value is an estimate (i.e., the analyte concentration is below the calibration range). Nondetected

values will be reported at the MRL and will be adjusted by the laboratory as necessary to reflect sample dilution or matrix interference.

B6 EQUIPMENT INSPECTION AND MAINTENANCE REQUIREMENTS

Maintenance and inspection of both experimental and analytical equipment are described in the following sections.

B6.1 Experimental Instruments/Equipment

Preventive maintenance of instrumentation and equipment will be performed according to manufacturer's instructions. The laboratory staff is responsible for ensuring that all instrumentation is operating properly prior to use. If problems are encountered, they will be documented in a bound notebook. The faulty instrumentation/equipment will be scheduled for repair and sequestered and tagged until repaired and qualified for reuse.

B6.2 Analytical Instrument/Equipment

Analytical instrument/equipment testing, inspection, and maintenance will be conducted in accordance with the procedures specified in the manufacturers' directions. The quality assurance manual discusses the schedule, procedures, criteria, and documentation in place at the laboratory to prevent instrument and equipment failure and to minimize downtime. For each instrument or piece of equipment, the laboratory maintains the following:

- Instrument/equipment inventory list
- Instrument/equipment major spare parts list or inventory
- External vendor service agreements (if applicable)
- Instrument-specific preventive maintenance logbook or file.

The laboratory documents all preventive maintenance and repair for each instrument or piece of equipment in dedicated logbooks or files.

B7 INSTRUMENT CALIBRATION AND FREQUENCY

Calibration and frequency of calibration of both experimental and analytical equipment are described in the following sections.

B7.1 Experimental Instruments

The experimental equipment that will need calibration is listed below:

- Water quality meters
- Balance
- Pipettes
- Pumps
- Flow meters.

Proper maintenance, calibration, and operation of each instrument will be the responsibility of experiment personnel assigned to a particular activity. All instruments and equipment used during the investigations will be maintained, calibrated, and operated according to the manufacturer's guidelines and recommendations. If an individual suspects an equipment malfunction, the device must be removed from service and tagged so that it is not inadvertently used, and the appropriate personnel notified so that a recalibration can be performed or a substitute piece of equipment can be obtained. An extra or backup meter will be available at all times to replace the inoperable unit.

Results of measurements performed using equipment that has failed recalibration will be evaluated. If the measurement results are adversely affected, the results of the evaluation will be documented, the data qualified appropriately, and the data users notified.

B7.2 Analytical Equipment and Instrumentation

All laboratory equipment and instruments used for quantitative measurements are calibrated in accordance with the laboratory's formal calibration program as described in the quality assurance manual. A summary of the laboratory instrument/equipment calibration program is presented in that manual. Detailed calibration procedures specific to each analysis are included in method-specific SOPs, which can be obtained from the laboratory.

Whenever possible, the laboratory uses recognized procedures for calibration such as those published by EPA or ASTM. If established procedures are not available, the laboratory develops a calibration procedure based on the type of equipment, stability, characteristics of the equipment, required accuracy, and the effect of operation error on the quantities measured. Equipment requiring only periodic calibration such as pumps,

balances, thermometers, and micropipettes are listed along with their respective calibration requirements in the quality assurance manual. Whenever possible, physical reference standards are used, which are associated with periodic calibrations such as weights or certified thermometers with known relationships to nationally recognized standards. Where national reference standards are not available, the basis for the reference standard is documented.

Other instruments that require initial and/or continuing calibration as a part of instrument usage are listed along with their respective calibration requirements in the quality assurance manual. Initial calibrations are verified and documented for each constituent by analysis of laboratory-prepared certified independent standard solutions.

All calibration standards will be obtained from either the EPA repository or a commercial vendor, and the laboratory will maintain traceability back to the National Institute of Standards and Technology. 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 quality assurance manual.

B8 ACCEPTANCE REQUIREMENTS FOR SUPPLIES AND CONSUMABLES

Supplies and consumables that may be used during the investigations include sample bottles, petri dishes for filter storage, hoses, filters, nitric acid, formalin, ethanol, materials for decontamination activities, potable water, deionized water, ASTM Type II water, MS 222, *Artemia salina* eggs, marine salts, worms, and water quality test kits. Project team members obtaining supplies and consumables are responsible for assuring that the materials obtained meet the required specifications, are intact and in good condition, are available in adequate supply, and are stored appropriately until use. Project team members will direct any questions or identification of any problems regarding supplies and consumables to the experiment team leader for resolution.

B9 DATA MANAGEMENT

Data management procedures will be established and applied during the investigations to record, document, track, and compile investigative data into an overall project database. Data generated during the investigations, as well as historical data, will be used to form the basis for conclusions and recommendations. Efficient utilization and comprehensive consideration of available data require that the data be properly organized for review. Organization of the data shall be planned prior to actual collection to ensure the generation of identifiable and usable data. This section contains procedures necessary to ensure the collection of sufficient data for accurate validation of raw data and transfer of validated data to the project data management system. This section also describes the operating practices to be followed by personnel during the collection and reporting of data.

B9.1 Purpose and Background

Data collected during the investigations will include analytical chemistry data from aqueous and sediment samples; data on survival, and growth; and observations of development and behavior of white sturgeon ELS in each treatment group. The data will be used to analyze sediment-related toxicity in the UCR stretch of interest to these life-stages, and the potential contribution of slag-related COPCs to any potentially occurring toxicity. Data will be collected, managed, and stored in a way that models the inherent structure of the data and facilitates its usage for the RI/FS.

B9.2 Data Recording

Observations made and measurements taken during toxicity testing experiments will be recorded using appropriate hard copy (e.g., data sheets or logbooks) or electronic formats (e.g., laboratory electronic deliverables). Data recorded in hard copy will be transcribed into electronic forms and proofed before use or integration with other data.

For the chemical analytical portions of the study, a variety of manually entered and electronic instrument data will be generated. Data will be manually entered into:

- Standard logbooks
- Storage temperature logs
- Balance calibration logs
- Instrument logs
- Sample preparation and analysis worksheets

- Maintenance logs
- Individual laboratory notebooks
- Results tables for conventional analyses (e.g., grain-size distribution, percent moisture).

All data manually entered into the laboratory information management system will be proofed at each laboratory prior to being released. All 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, data review, and verification is provided in the laboratory quality assurance plans.

Both chemical analytical and biological laboratory data will be entered directly into the project database from the electronic data deliverable (EDD). EDDs for chemical analytical data will be checked against the hard copy with 10 percent QA/QC for all detected analytes and other data where appropriate. For all data collected at the U of S, ENTRIX will perform a comparison of electronic data with the hard copy report prior to submittal to ensure that the EDD and hard copy data are identical. The EDDs will be uploaded to the project database as Microsoft Excel and pdf files.

Toxicity testing and analytical chemistry data will be entered into the project database management system (DBMS). This database will facilitate the following processes:

- Tracking COC and sample identification data
- Reviewing and evaluating analytical data against project-specific QAPP criteria
- Producing data tables.

Data will be tabulated for evaluation and presentation in the investigation report. Copies of the original data records will be attached to the report as appendices.

B9.3 Data Validation

Data validation is an integral part of the quality assurance program and consists of reviewing and assessing the quality of data. Data validation provides assurance that the data are of acceptable quality as reported. Data usability is the determination of whether or not a data set is sufficiently complete and of sufficient quality to support a decision or action in terms of the specific DQOs.

Chemical Analytical Data. For validity of these types of data, the characteristics of importance are precision, accuracy, representativeness, comparability, and completeness.

The data validation process includes:

- Evaluating against blank criteria
- Evaluating against accuracy criteria such as holding times, surrogates, LCS, and matrix spikes
- Evaluating against precision criteria such as MS/MSDs, and experimental and analytical duplicates
- Confirming that data qualifiers are assigned appropriately
- Uploading sample data only to the central database.

Biological Data. Any data generated from biological measurements will be validated based on test acceptability criteria, precision, representativeness, comparability, and completeness.

The data validation process includes:

- Evaluating against reference values specific to this species of batch of fish (e.g., hatchery average values and confidence intervals for survival, and growth at specific temperature)
- Evaluating against test acceptability criteria such as temperature, DO, pH, etc.
- Evaluating against precision criteria such as measurement duplicates (e.g., dependent and/or independent confirmation of weight, length, etc.)
- Confirming that data qualifiers are assigned appropriately
- Uploading sample data only to the central database.

The data validation process is described more fully in Section D.

B9.4 Data Transformation

If data transformation is performed for this study, then conversion procedures will be described in detail in the associated technical report.

B9.5 Data Transmittal

Laboratory data will be uploaded to the project database in Microsoft Excel format. Laboratory log sheets will be provided in *.pdf format and uploaded into the project database. The electronic data will be reviewed for completeness and accuracy by the project liaison before uploading to the project DBMS.

B9.6 Data Analysis

Data analysis (e.g., computation of summary statistics, standard errors, confidence intervals) will be conducted for this project. Percent survival will be calculated based on number of fry/juveniles at the start of each exposure period of interest (i.e., at 0 dph or 21 dph or 29 dph, depending upon which day represents the start of an exposure period of interest). Specifically, data will be analyzed by both analysis of variance and regression approaches. After assessing the distribution of data and homogeneity of variance, data will be tested for statistically significant differences among treatment groups using parametric or non-parametric tests, as appropriate, to determine NOAECs and LOAECs. Statistical comparisons will be made among treatment groups and relative to the controls and reference sediments. Where appropriate, effects on mortality and growth parameters will be assessed using regression approaches such as Probit or Logit analyses (e.g., calculation of LCs). To separate potential effects and interferences due to increased mortalities during the transition to feeding life-stage, the data will be evaluated by considering the entire exposure period of >60 days stratified by key life-stages, namely yolk sac larvae, transition to feeding, and juvenile.

B9.7 Data Tracking

The project manager is ultimately responsible for all activities conducted during experimental activities, including data management with the exception of data generated by the external analytical laboratory CAS. The project manager has the authority to enforce proper procedures as outlined in this plan and to implement corrective procedures to assure the accurate and timely flow and transfer of data. The project manager will review the final data reports.

Data will be generated from the measurements made during the course of the experiments and during sampling and analysis activities. The generators of data will be responsible for accurate and complete documentation of data required under the task, and for ensuring that these data are presented to their supervisor in a timely manner.

The study team leader or his designees will be responsible for the day-to-day monitoring of data during the conduct of the experiments. They will ensure that data are collected in the format specified in this QAPP and then routed to ENTRIX to be placed in the project files at the end of the experimental activities. Original documents will be maintained in the ENTRIX central project file.

The study team leader will also be responsible for evaluating biological data. The study team leader or his designees will review biological data for accuracy and completeness.

The project manager will assure that representations of current experimental conditions are accurate and complete for each component of the study.

The analytical chemistry lab coordinator (Kris McCaig) will be responsible for the day-to-day monitoring of activities related to the generation and reporting of chemical data. Ms. McCaig ensures that samples are analyzed according to the specified procedures; that data are validated; and that the data are properly coded, checked for accuracy, and entered into the project data management system.

B9.8 Data Storage and Retrieval

A project file will be established for the storage of original data, historical data, written documents, and data collected or generated during the experiments. The format for the file will follow the central filing system procedure list, which consists of the following categories:

- Correspondence
- Budgets
- Contracts
- Experimental data
- General data
- Notes/comments
- Raw data
- Figures and maps
- Permits
- Paper and electronic copies of data collected—both paper and personal digital assistant (PDA) data
- Laboratory data and QA/QC documents
- Chains of custody
- Photographs
- Reports
- Schedules
- Background.

All materials will be dated, carry the initials of the person responsible for the preparation of the document, and bear the project number. The file copies will include

peer review sign-off on the calculation sheets and editing review sheets where applicable.

Access to the project files will be limited to those personnel assigned to this project. The project manager will maintain overall responsibility for the project files and will ensure that appropriate documents are filed. All documents relating to the project shall be controlled to ensure proper distribution, filing, and retrieval. The project manager will also ensure that revisions are properly recorded, distributed, and filed. ENTRIX staff will maintain the project files.

ENTRIX staff will handle all documents submitted to the project file and will ensure that the documents are appropriately filed by category and placed in the correct project file. Once filed, documents are available to ENTRIX staff and may be removed from the file for use by signing out the material.

SECTION C: ASSESSMENT AND OVERSIGHT

This section presents the internal and external checks (assessments) that have been built into this project to ensure that

- Elements of this QAPP have been correctly implemented as prescribed for all investigations conducted
- The quality of the data generated is adequate and satisfies the DQOs that have been identified in this QAPP
- Corrective actions, when needed, are implemented in a timely manner and their effectiveness is confirmed.

Assessment activities may include surveillance, inspection, peer review, management systems review, readiness review, technical systems audit, performance evaluation, and data quality assessment.

C1 ASSESSMENT ACTIVITIES

The following subsections identify the planned assessment and oversight activities to ensure the objectives identified above are attained for experimental and analytical operations. The quality assurance manager and/or the project manager may also identify additional assessment activities to be performed during the course of the project based upon findings of the planned assessment activities described below.

C1.1 Assessment of Experimental Operations

The quality assurance manager and/or other designated members of the Aquatic Toxicology Research Facility project team will conduct internal assessments of experimental operations, where appropriate, at least once during the in-life portion of the test. The assessment activities will evaluate performance issues related to the experimental operations such as:

- Are sampling and monitoring operations being conducted in accordance with the QAPP?
- Are the sample labels being filled out completely and accurately?
- Are the COC records complete and accurate?
- Are the experimental notebooks being filled out completely and accurately?

- Are the sampling and monitoring activities being conducted in accordance with the SOPs?

Planned assessment activities to evaluate these and other performance issues include surveillance (frequent review) of sample collection documentation, sample handling records (COC forms), experiment notebooks, and study measurements, as well as the performance of unannounced experimental operations audits.

The team member conducting the assessment activity will report the results of any assessment activities to the project manager. Assessment activity reports will include the findings and identification of any corrective actions taken or planned.

C1.2 Assessment of Analytical Operations

The Chemical Laboratory Project Manager (Jeff Christian) will be in contact with the Analytical Chemistry Laboratory Coordinator (Kris McCaig) on a weekly basis while samples collected during this investigation are being analyzed. This will allow assessment of progress in meeting DQOs and the identification of any problems requiring corrective actions early in the investigative process. The Chemical Laboratory Project Manager will promptly report problems identified, corrective actions taken, and recommendations as appropriate for additional corrective action to the Analytical Chemistry Laboratory Coordinator who will review the problem and provide for the swift implementation of any outstanding corrective actions. In addition, contact between the Chemical Laboratory Quality Assurance Manager and the independent data auditor could result in the need for a laboratory audit. The Chemical Laboratory Quality Assurance Manager will report the audit findings and any recommendations for corrective action to the Analytical Chemistry Laboratory Coordinator, and the laboratory. The Analytical Chemistry Laboratory Coordinator will be responsible for working directly with the laboratory to ensure the prompt resolution of any problems identified.

C2 REPORTS TO EPA

As required by the Agreement, validated data will be provided electronically to EPA within 90 calendar days of completion of the study. This includes analytical chemistry results (sediment, porewater, overlying water) and biological observations (survival and growth), with a draft data summary report to follow shortly thereafter.

SECTION D: DATA VALIDATION AND USABILITY

Data generated 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. Implementation of this section will determine whether the data conform to the specified criteria, thus satisfying the project objectives.

D1 DATA REVIEW, VERIFICATION, AND VALIDATION

Data validation is the process of reviewing data and accepting, qualifying, or rejecting data on the basis of sound criteria using established EPA guidelines. The laboratory will report laboratory data generated during the investigations in the form of data packages. All of these data will be subjected to full data validation conducted by an independent data validator as discussed below in Section D1.1.

D1.1 Independent Data Validation Protocols

All data generated for decisional purposes (i.e., to address the question of toxicity of sediments to sturgeon ELS) will be independently reviewed for completeness and accuracy as specified within this QAPP. Daily or weekly monitoring of water quality for maintenance of the exposure chambers will not be subjected to similar scrutiny as these measurements are intended only to keep the system within the specified limits.

D1.1.1 Aquatic Toxicology Research Facility

Biological data collected at the Aquatic Toxicology Research Facility at the U of S during the course of the study will be validated by Dr. Shaun Roark, ENTRIX QA Coordinator, or his designee. While the actual procedures used will be determined by the validator, the validation approach will consist of a systematic review of the analytical results, associated quality control methods and results, supporting data, and biological observations and measurements. Specific data package review procedures can be found in SOP-17, "Data Package Review," included in Appendix C. Best professional judgment will be used, as necessary, in any area not specifically addressed by EPA guidelines and described in the usability assessment portion of the data validation report.

D1.1.2 Columbia Analytical Services (CAS)

Mr. Rock Vitale and associates at ESI will be responsible for validating analytical data generated by CAS. Where applicable and/or appropriate, data will be validated

according to guidelines set forth in the following sources and guidelines to ensure compliance with the Federal Information Quality Act:

- SOP-17 Data package review (ETL-SOP#4039). Environmental Toxicology Laboratory, Toxicology Centre, University of Saskatchewan, Saskatoon, SK S7N 5B3
- USEPA. 1992. *Guidance for data usability in risk assessment (Part A)*
- USEPA. 2002b. *Guidelines for ensuring and maximizing the quality, objectivity, utility, and integrity of information disseminated by the Environmental Protection Agency*
- Federal Register, 67, No. 36, pp8451-8460. *Guidelines for ensuring and maximizing the quality, objectivity, utility, and integrity of information disseminated by Federal Agencies*, February 22, 2002
- USEPA. 2002c. *Guidance on environmental data verification and validation*.
- USEPA. 2004. *USEPA contract laboratory program national functional guidelines for inorganic data review*.

Data validations will include a data completeness check of each data package, a transcription check for sample results, and a thorough review of all laboratory reporting forms and the associated raw data for QA/QC issues. Specifically, this review will include:

- Review of data package completeness
- Review of the required reporting summary forms and all associated raw data to determine if the quality control requirements were met and to determine the effect of exceeded quality control requirements on the precision, accuracy, and sensitivity of the data
- Review of the overall data package to determine if contractual requirements were met
- Review of raw data and all calculations associated between 1 and a minimum of 10 percent of all samples to determine if the sample results and quantification limits were correctly calculated and reported
- Review of additional QA/QC parameters, such as blank contamination, to determine technical usability of the data
- Application of standard data quality qualifiers to the data.

In addition, each data validation will include a comprehensive review of the following QA/QC parameters:

- Holding times (to assess potential for degradation that will affect accuracy)
- Inductively coupled plasma/mass spectrometry (ICP/MS) instrument check (to assess accuracy and sensitivity of method)
- Initial calibration (to assess method sensitivity)
- Continuing calibration (to assess method sensitivity)
- Blanks (to assess contamination for all compounds)
- System monitoring compounds (to assess method accuracy)
- MS/MSD or laboratory fortified blanks (to assess accuracy of the methods and precision of the method relative to the specific sample matrix)
- Internal standards (to assess method accuracy and sensitivity)
- Target compound identification
- Compound reporting limit and MDL (to assess sensitivity as compared to project-specific requirements)
- System performance (to assess accuracy and precision).

D2 VERIFICATION AND VALIDATION METHODS

The data validation process is conducted to assess the effect of the overall experiment, sampling, and analysis process on the usability of the data. There are three areas of review: assessment of validity of biological measurements conducted, laboratory performance evaluation, and the effect of matrix interferences.

Biological measurements will be conducted in accordance with the procedures specified in the study protocols, and will be verified by means of randomized and blind (unknown sample ID) measurements. During sampling events, a randomly selected subset of fish (1 percent) will be measured twice by the analyst and the validator without either knowing the identity of the sample or the data recorded by the other. The results of these validation efforts will be recorded and reported in a data package and report. The Task QA Coordinator is responsible for ensuring that all required measurements are complete and valid (e.g., correct instruments were used to conduct the measurements, all instrumentation was properly calibrated, and test performance is within required guidelines).

Evaluation of laboratory performance is a check for compliance with the method requirements and is a straightforward examination. This evaluation will determine if the laboratory did or did not analyze the samples within the quality control limits of the analytical method and according to protocol requirements. The assessment of potential matrix effects consists of a quality control evaluation of the analytical results and also the results of testing blank, duplicate, and matrix spike samples, and then assessing how, if at all, the matrix effect will affect the usability of the data.

All bioanalytical data will be supported by a data package. The data package contains the supporting quality control data for the associated samples. The data validation report deliverables will include the following information:

- A comprehensive narrative detailing all quality control exceedances and explaining qualifications of data results. In cases where data are qualified due to quantifiable quality control exceedances, the bias (high or low) will be identified.
- Data summary tables in Microsoft® Excel format reporting all data results with the qualifiers that were added during the data validation review. These tables will include sample ID, laboratory ID, date sampled, sample type (e.g., experimental duplicate, experimental blank), units, concentration of analytes or biological measurements, and validation qualifiers. These tables may be modified to report other information as needed (such as date analyzed, dilution factor).
- Resubmittal requests sent to the laboratory indicating missing information and verification of analytical information, etc.
- EDDs compatible with the project database. These electronic deliverables will contain the validated results and qualifications as presented in the data summary tables of the validation reports. In addition, the validation reports can be submitted in electronic format for inclusion in interim remedial investigation data deliverables.

Before the laboratory releases each data package, the laboratory must carefully review the sample and laboratory performance quality control data to verify sample identity and also the completeness and accuracy of the sample and quality control data. This evaluation is performed through three levels of laboratory data review starting with 100 percent verification performed by the laboratory analyst, followed by a second-level review performed by a peer, supervisor, or designee. The laboratory project manager

performs the third and final laboratory review to assure that project requirements are met for the analyses performed.

Data validation is at times based on best professional judgment. In order to achieve consistent data validation, data worksheets will be completed for each data validation effort. A data review worksheet is a summary form on which the data validator records data validation notes and conclusions specific to each analytical method. The worksheets will help the validator to track and summarize the overall quality of the data. Sample results will then be qualified, as appropriate, following EPA protocols (EPA 2010). Samples that do not meet the acceptance limit criteria will be indicated with a qualifying flag, which is a one-letter or two-letter abbreviation that indicates a problem with the data (Table D-1).

The data verification process begins once the data packages for each project have been validated. During verification, the entire data set will be verified for overall trends in data quality and usability. Information summarized as part of the data quality verification will include percent variation between replicate biological measurements, frequencies of detection, dilution factors that might affect data usability, and patterns of target compound distribution. The data set also will be evaluated to identify potential data limitations or uncertainties in the laboratory. The trend analysis results will be included in the validation summary report, which will be submitted to the project manager at the end of the study efforts. The validation report and notes will be archived with the analytical data.

D3 RECONCILIATION WITH USER REQUIREMENTS

An assessment of the usability of the validated data compared to the data validation criteria and DQOs will be provided. The usability assessment will be performed in accordance with USEPA (1992) and best professional judgment. The data auditor will delineate major and minor deficiencies in the data, their effects on the reported results, and determination of usability for each compound reported in each sample included in the data package. The usability assessment will provide an overall summary of data quality. It will define acceptability or problems with accuracy, precision, sensitivity, and representativeness of the results and will provide clear guidance regarding uncertainties in the data that have been qualified as estimated (J) and a quantification of these uncertainties (e.g., bias high by a maximum of 80 percent), wherever possible. The data auditor may determine specific results to be unusable because of cumulative effects of quality control exceedances (i.e., an "R" qualifier will be applied to the result).

Alternatively, based upon the EPA guidelines and best professional judgment, the data auditor may determine specific results to be usable for DQOs when they are not significantly outside the quality control criteria.

The final activity of the data validation process is to assess whether the data meet the DQOs. The final results, as adjusted for the findings of any data validation/data evaluation, will be checked against the DQOs and an assessment will be made as to whether the data are of sufficient quality to support the DQOs. The decision as to data sufficiency may be affected by the overall precision, accuracy, and completeness of the data as demonstrated by the data validation process. If the data are sufficient to achieve project objectives, the project manager will release the data and work can proceed. If the data are insufficient, corrective action will be required.

SECTION E: REFERENCES

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FIGURES

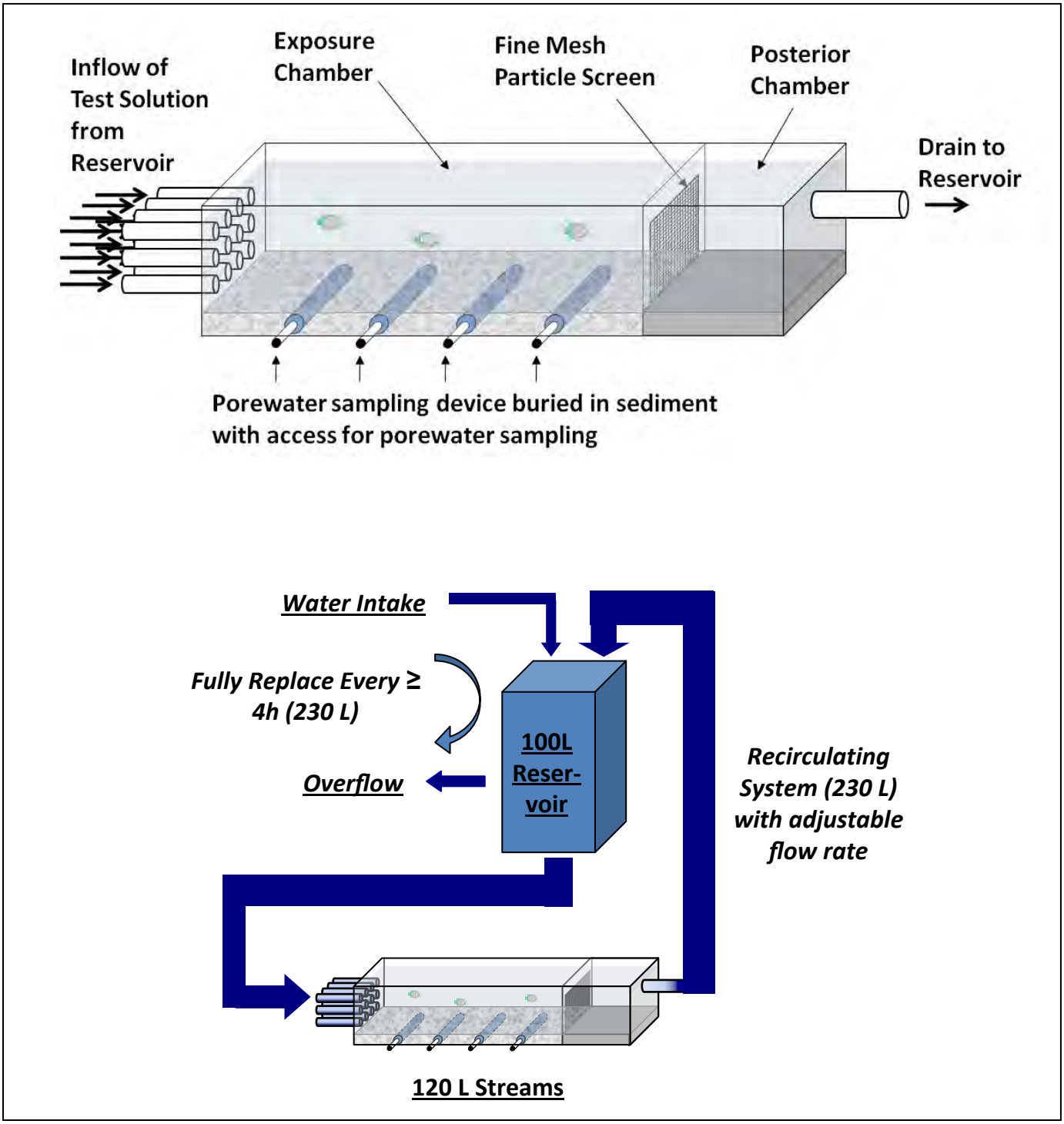


Figure B-1. Test chamber design for the conduct of chronic sediment exposure studies with ELS white sturgeon.

Note:
Inflow of water from reservoir is disributed over 12 evenly spaced horizontally oriented pipes to insure constant flow distributed over the diameter of the test chamber. The posterior chamber enables consistent flow over sediments even at the posterior portion of the sediment layer so no dead spaces with standing or lower flow water can form. The effluent drains into the test solution reservoir, and water from the same reservoir is recirculated to the 12 inflow pipes by a high-flow pumping system allowing for adjusting flow rates through the exposure chamber.

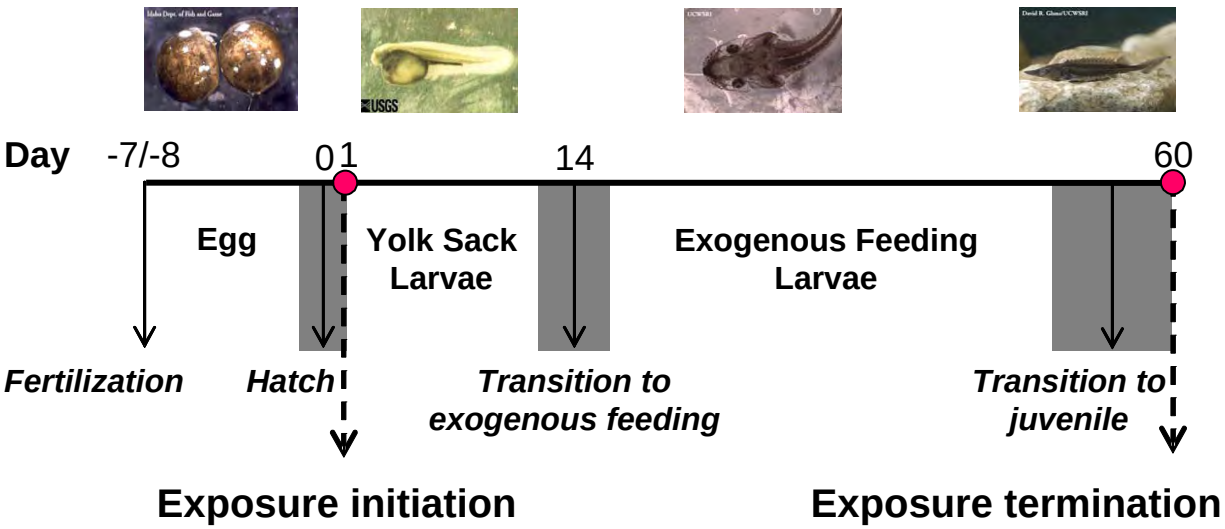


Figure B-2. Sampling Frequency of White Sturgeon Life-stages During the Duration of the Exposure Experiments.

Corrective Action Report

Sturgeon Early Life Stage Sediment Toxicity Test

Date: _____ Change Number: _____

CHANGE REQUEST

Applicable Reference: 2010 Quality Assurance Project Plan for the Assessment of Sediment Toxicity to White Sturgeon (*Acipenser transmontanus*)

Description of Change:

_____

_____

_____

Reason for Change:

_____

_____

_____

_____

_____

Impact on Present and Completed Work:

_____

_____

_____

_____

Requested by: _____ Date: _____

Acknowledged By: _____ Date: _____

APPROVAL

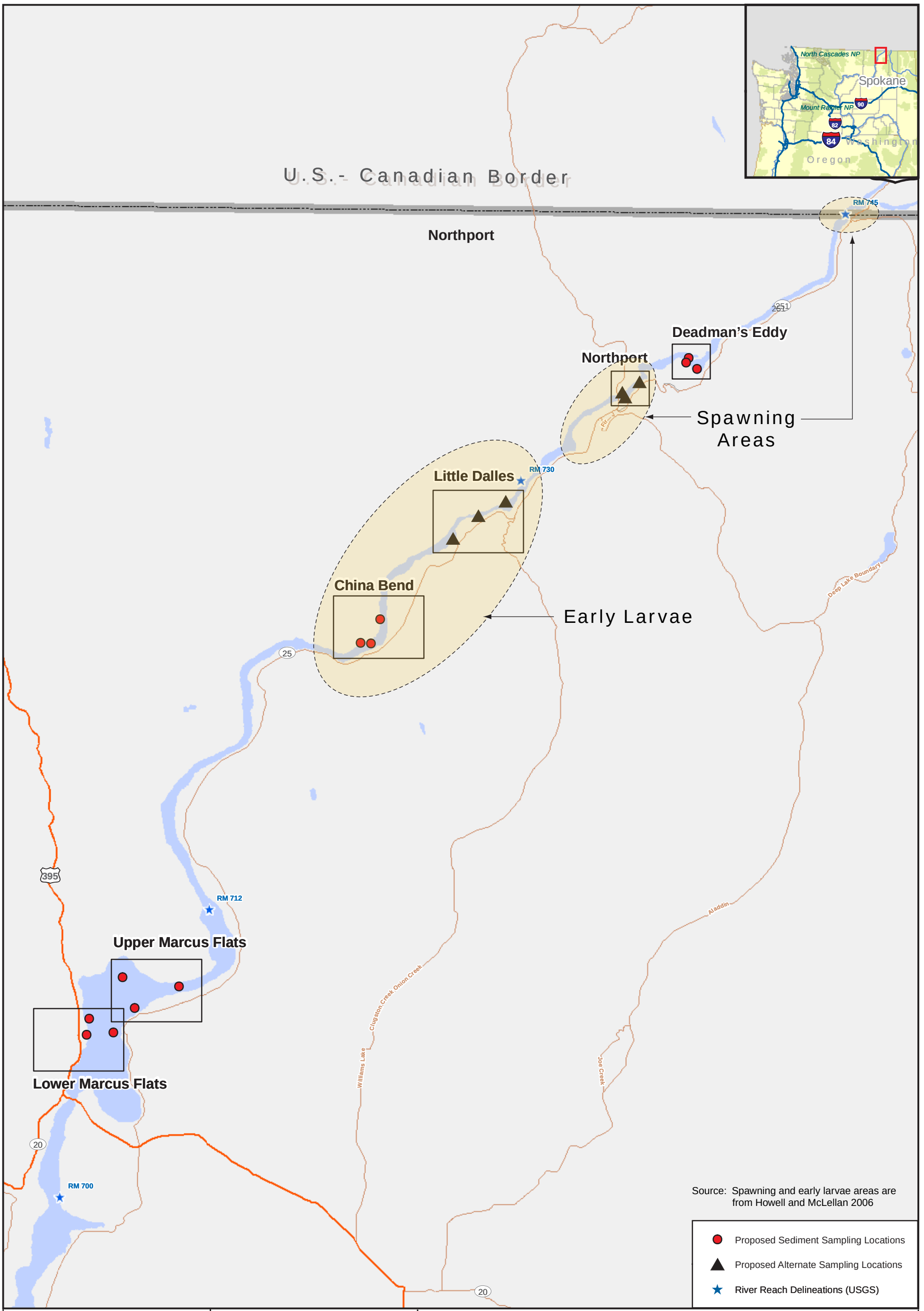
Task Manager: _____ Date: _____

TAI Project Coordinator: _____ Date: _____

EPA Project Coordinator: _____ Date: _____

Figure B-3. Corrective Action Form

Maps



Map A-1. Sturgeon Spawning and Early Life-stages

Upper Columbia River, WA

0900083.014 0101 03/23/2010 WA

U.S.- Canadian Border

RM 745

Spokane

North Cascades NP

Mount Rainier NP

Washington

Oregon

Northport

Deadman's Eddy

Little Dalles

RM 730

China Bend

Upper Marcus Flats

Lower Marcus Flats

RM 712

RM 700

Cd
0.0 2.0 4.0 6.0 8.0

Cu
0 1,000 2,000 3,000 4,000

Pb
0 1,000 2,000 3,000

Zn
0 10,000 20,000 30,000

mg/kg

Proposed Sediment Sampling Locations

Proposed Alternate Sampling Locations

River Reach Delineations (USGS)

Entrix Parametrix Exponent

Km 0 2.5 5

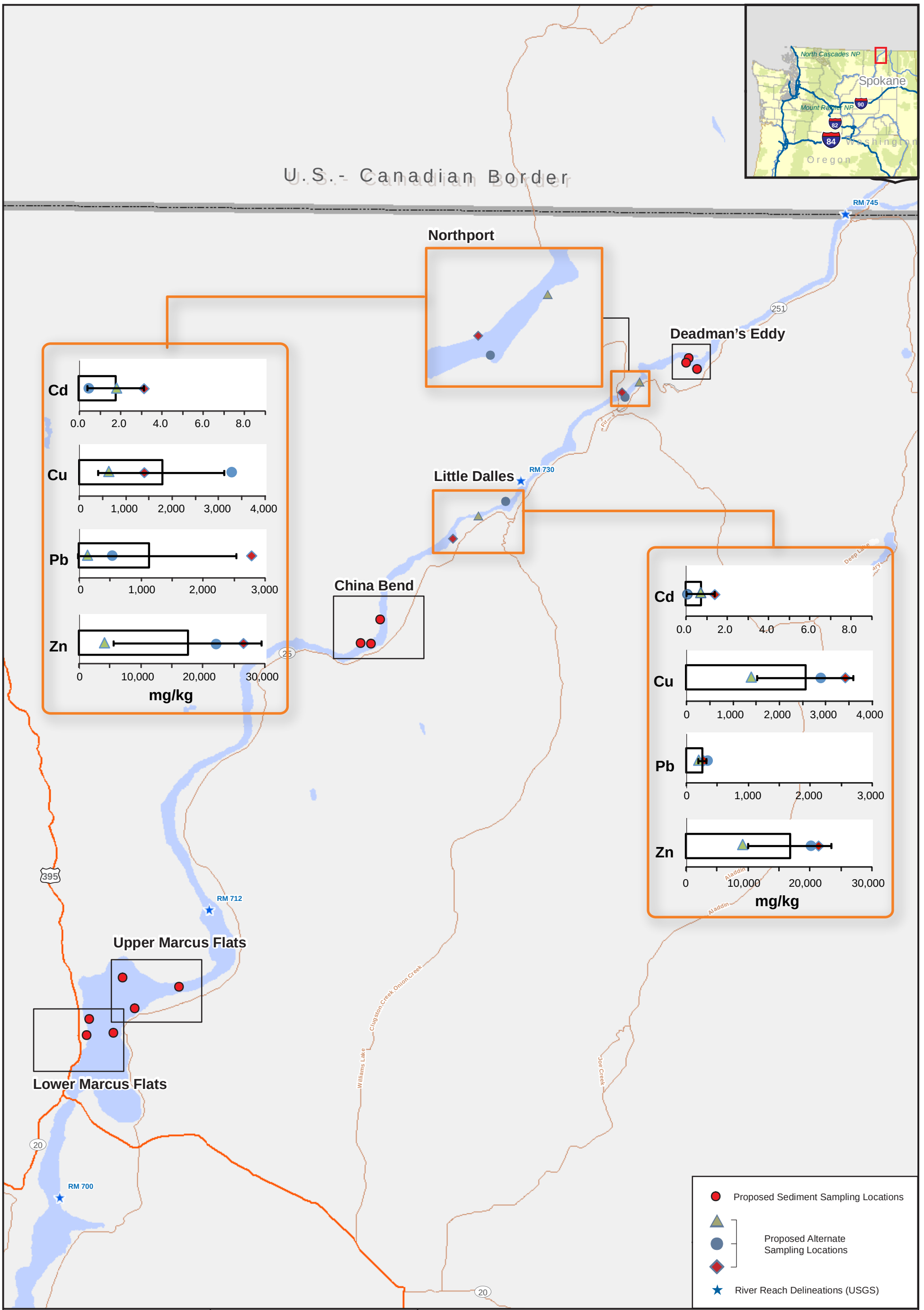
Miles 0 1.5 3

N

Map A-2. Proposed Sediment Sampling Locations

Upper Columbia River, WA

0900083.014 0101 03/23/2010 WA


U.S.- Canadian Border
North Cascades NP
Spokane
Mount Rainier NP
90
82
84
Washington
Oregon
RM 745
Northport
Deadman's Eddy
251
Cd
0.0 2.0 4.0 6.0 8.0
Cu
0 1,000 2,000 3,000 4,000
Pb
0 1,000 2,000 3,000
Zn
0 10,000 20,000 30,000
mg/kg
Little Dalles
RM 730
China Bend
25
Deep Lake
Aladdin
395
RM 712
Upper Marcus Flats
Lower Marcus Flats
Clugston Creek
Onion Creek
Williams Lake
Joe Creek
20
RM 700
Proposed Sediment Sampling Locations
Proposed Alternate Sampling Locations
River Reach Delineations (USGS)
Entrix Parametrix Exponent
Km
0 2.5 5
Miles
0 1.5 3
N
Map A-3. Proposed Alternate Sampling Locations
Upper Columbia River, WA
0900083.014 0101 03/23/2010 WA

TABLES

Table A-1. Parameters, Methods, Measurements and Decision Criteria that will Inform the Design of the Exposure Systems and Test Conditions for the 2010 Studies with White Sturgeon ELS to Investigate Sediment Related Toxicity (listed here in order of operation).

Order	Parameter	Goal	Test Conditions	Measurement	Acceptance Criteria
1	Flow condition	Establish parameters and operational conditions that enable the maintenance of homogenous flow conditions in the test system.	Initial flow rate of 19 L/min, with incremental changes of +/- 2 L/min to achieve desired end state	Video record of fluorescein dye movement	Minimal dead spaces or low flow areas. Flow appropriate for ELS sturgeon, assumed to be: 1. Hatch through 14 dph: 8 to 12 L/min; 2. >14 dph: 16 to 24 L/min.
2	Gravel volume and distributions	Establish optimum density of gravel to create pseudo-hyporheic zone	Gravel: 0, 3, 7, 10 and 13 stones per 100 cm^2	Conductivity measurements	Minimum density of gravel that provides sufficient habitat for white sturgeon ELS without introducing excessive variation in water quality as determined by conductivity (target value: < 30% variation among samples taken in the 1 cm water layer overlying the sediment surface across the exposure chamber).
3	Porewater /surface-water interface water sampling	Establish porewater /surface-water interface water sampling methods	Suction devices (e.g., airstone, pipette) and diffusive devices (e.g., peepers, DGT) in different depths of sediment. Using variable strengths and duration of suction (via manual use of syringe) for suction devices and depths, time, and configurations for diffusive samplers.	Only porewater /surface-water interface water is collected with no overlying water in the sample • Dye, conductivity, and metal measurements, as appropriate	Suction devices -- Extract only porewater /surface-water interface water and not overlying water in sufficient volume (target > 30 mL). Diffusive devices – to be determined
4	Sediment depth	Establish optimum depth of sediment for ELS sturgeon and to maximize porewater collection	Initial depth at 2 inches, with trials of 3 and 4 inches	Porewater sampling at 0.5 and 1 inch and overlying water sampling within the 1 cm of water overlying the sediment • Dye concentration measurements.	Optimal depth for maintaining flow conditions, surface-to-porewater gradients, and porewater collection.

(continued on next page)

Table A-1. Parameters, Methods, Measurements and Decision Criteria that will Inform the Design of the Exposure Systems and Test Conditions for the 2010 Studies with White Sturgeon ELS to Investigate Sediment Related Toxicity (listed here in order of operation) (continued).

Order	Parameter	Goal	Test Conditions	Measurement	Acceptance Criteria
5	Gradients between pore- and overlying water	Establish operational conditions that minimize gradients in water quality parameters between pore- and overlying water.	Each flow/sediment depth combination that is tested.	Time-resolved measurements of: • Dye concentration • Conductivity • DOC • pH	Minimize gradient under optimal flow conditions.
6	Time to steady-state	Establish operational conditions that minimize time to steady-state.	Characterize time to steady-state between pore- and overlying water after establishing optimal flow and gravel conditions.	Time-resolved measurements of: • Alkalinity • Ammonia • Conductivity • DO • DOC • Hardness • pH	Steady-state is attained when changes over the entire exposure period in the definitive test are not projected to exceed 20% for conductivity.
7	Cleaning methods	Establish most efficient method for cleaning	Introduce food 3X daily and scrape tanks at days 2, 3, 4 and 5.	Measure turbidity of samples using light scattering methods	Least turbidity per unit effort.
8	Laboratory control sediment	Define clean sediment with characteristics similar to UCR sediments	Research lab controls used in other bioassays Create sediment from clean silica sand and/or granite with grain size 0.5 to 2 mm and preference to dark color	Measure grain size and color	Grain size and color similar to UCR sediments.

Table A-2. 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				Proposed		Sediment	
Analyte/Parameter	Chronic EPA AWQC (µg/L)	Ecology Chronic WQS (µg/L)	CCT Aquatic Life Chronic Criteria (µg/L)	STI Aquatic Life Chronic Criteria (µg/L)	MDL (µg/L) [c]	MRL (µg/L) [c]	Toxicity Benchmark Values (mg/kg dw)[b]	Required Method Reporting Limits[a] (mg/kg dw)[c]
Conventional Parameters								
Alkalinity	NA	NA	NA	NA	1000	2000	NA	NA
DOC	NA	NA	NA	NA	NA	NA	NA	NA
TOC	NA	NA	NA	NA	NA	NA	NA	NA
Hardness	NA	NA	NA	NA	700	2000	NA	NA
TDS	NA	NA	NA	NA	NA	NA	NA	NA
TSS	NA	NA	NA	NA	NA	NA	NA	NA
pH	NA	NA	NA	NA	NA	NA	NA	NA
Cations/Anions								
Calcium	NA	NA	NA	NA	30	50	NA	500
Chloride	230,000	230,000	230,000	230,000	9.0	200	NA	NA
Fluoride	NA	NA	NA	NA	6.0	200	NA	NA
Magnesium	NA	NA	NA	NA	0.70	20	NA	500
Potassium	NA	NA	NA	NA	1.3	4	NA	NA
Sodium	NA	NA	NA	NA	50	100	NA	NA
Sulfate	NA	NA	NA	NA	7.0	200	NA	NA
Nutrients								
Ammonia	NA	NA	NA	NA	20	50	NA	NA
Nitrate-Nitrite	NA	NA	NA	NA	3	100	NA	NA
Common Metals and Metalloids								
Aluminum	87	NA	87	87	0.30	2.0	NA	20
Antimony	NA	NA	NA	NA	0.030	0.050	0.4	0.08
Arsenic	150	190	150	150	0.080	0.50	9.79	2
Barium	NA	NA	NA	NA	0.020	0.050	NA	20
Beryllium	NA	NA	NA	NA	0.0080	0.020	0.46	0.09
Cadmium	0.25	0.77 [d]	0.19 [d]	0.77 [d]	0.0080	0.020	0.99	0.2
Chromium	74	128 [d]	53 [d]	53	0.070	0.20	NA	500
Cobalt	NA	NA	NA	NA	0.0050	0.020	43.3	8.7

(continued on next page)

Table A-2. Derivation of Analytical Concentration Goals and Proposed Laboratory Reporting and Detection Limits Based on Ecological Screening Criteria and Available Data for the Site (continued).

	Ecological Screening Criteria				Proposed		Sediment	
Analyte/Parameter	Chronic EPA AWQC (µg/L)	Ecology Chronic WQS (µg/L)	CCT Aquatic Life Chronic Criteria (µg/L)	STI Aquatic Life Chronic Criteria (µg/L)	MDL (µg/L) [c]	MRL (µg/L) [c]	Toxicity Benchmark Values (mg/kg dw)[b]	Required Method Reporting Limits[a] (mg/kg dw)[c]
Common Metals and Metalloids (continued)								
Copper	9.0	8.1 [d]	6.4 [d]	6.4	0.020	0.10	NA	5
Iron	1,000	NA	1,000	1,000	3	20	31.6	6.3
Lead	2.5	1.6 [d]	1.6 [d]	1.6	0.0090	0.020	NA	10
Manganese	NA	NA	NA	NA	0.020	0.050	35.8	7.2
Mercury	0.80	0.012	0.80	0.012	0.0001	0.00025	NA	1.5
Molybdenum	NA	NA	NA	NA	0.030	0.050	0.018	0.0036 [e]
Nickel	52	112 [d]	37 [d]	37 [d]	0.070	0.20	22.7	4.5
Selenium	5.0	20	5.0	5.0	0.40	1.0	10	2
Silver	1.6 [d, f]	1.7 [d, f]	1.6	1.7 [d, f]	0.0090	0.020	0.545	0.1
Thallium	NA	NA	NA	NA	0.0030	0.020	NA	2.5
Vanadium	NA	NA	NA	NA	0.080	0.20	NA	5
Zinc	120	74[e]	84 [e]	74	0.10	0.50	121	24.2

Notes:

[a] Water samples were analyzed for dissolved metals and sediment samples were analyzed for total metals.

[b] Based on chronic threshold exposure concentrations (TECs) - Source: MacDonald et al. (2000)

[c] For HRGS/MS methods non-detects will be reported to the sample-specific detection limit (SDL). For all other methods non-detects will be reported to the method reporting limit (MRL).

For all methods, values between SDL/MDL and the MRL will be estimated (i.e., "J" qualified).

[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,

Mean pH = 8.11 s.u., Mean temperature = 9.5°C.

[e] EPA Method 6020 can only achieve a MDL of 0.02 mg/kg and MRL of 0.05 mg/kg.

[f] Value represents the acute criterion because no chronic criterion exists for this analyte.

DOC = dissolved organic carbon

TOC = total organic carbon

TDS = total dissolved solids

TSS = total suspended solids

NA = not applicable

Table A-3. Number of Replicate Groups Required (n) to Detect Significant Differences among Sites

	α=0.05; β=0.2		α=0.05; β=0.1		α=0.1; β=0.2		α=0.1; β=0.1	
Difference	n	Power	n	Power	n	Power	n	Power
5%	7	85%	8	90%	6	87%	7	92%
10%	3	90%	3	90%	3	97%	3	97%
20%	2	96%	2	96%	2	100%	3	100%

Notes:
Calculations were conducted under consideration of the means and variances for mortalities observed in the different treatment groups during unpublished surface water toxicity studies with early life stages of white sturgeon.

Table B-1. UTM Coordinates of Proposed Sampling Sites in the UCR between the U.S.-Canadian Border and Kettle Falls (on-site samples), and the Reference Site at Birchbank, BC, Canada (off-site sample).

	UTM Coordinates	
Sampling Area Description	Easting	Northing
On-site Samples		
Deadman's Eddy	446405.316	5420949.545
	446795.613	5420448.714
	446288.597	5420740.789
China Bend	432020.704	5408773.751
	431604.246	5407646.304
	431112.592	5407674.889
Marcus Flats - Upper Portion	422651.955	5391668.047
	420593.484	5390655.659
	420027.511	5392090.602
Marcus Flats - Lower Portion	419596.598	5389522.361
	418470.318	5390165.566
	418354.187	5389414.844
Northport (Alternative)	443442.45	5419135.82
	444108.47	5419838.75
	443302.5	5419361.44
Little Dalles (Alternative)	435417.18	5412544.52
	437874.45	5414280.9
	436606.68	5413599.7
Off-site Samples		
Birchbank	447251.03	5445720.5

Table B-2 Anticipated Sediment Volumes and Alternative Volume Requirements from Each Site for the Sediment Toxicity Studies with White Sturgeon.

Scenario	Amount Needed per Chamber	# of Replicates	Total Volume	Total required volume [a]
Sediment seeded at 2 inch thickness	25L	3	75L	100L
Sediment seeded at 3 inch thickness	38L	3	114L	130L
Sediment seeded at 4 inch thickness	50L	3	150L	200L

Notes:
[a] Accounts for additional volumes of sediment for analysis of TEM and oversampling to insure sufficient volumes are available for successful conduct of studies.

Table B-3. Required Sample Containers, Preservation, and Holding Times for Overlying Water, Sediment-Water Interface Water, and Porewater Samples.

	Container [a]		Preservation	Holding Time	Proposed Minimum Laboratory Sample Size [b]
	Type	Size			
Conventional Parameters					
Alkalinity as $CaCO_3$	HDPE	1000 mL	4±2ºC	28 days	25 mL
Dissolved organic carbon	HDPE	250 mL	H_2SO_4 to pH <2; 4±2ºC	28 days	10 mL
Hardness as $CaCO_3$	HDPE	with metals	4±2ºC	6 months	with metals[e]
Total dissolved solids	HDPE	with alkalinity	4±2ºC	7 days	200 mL
Total suspended solids	HDPE	with alkalinity	4±2ºC	7 days	200 mL
Major Ions					
Calcium, magnesium, potassium, sodium	HDPE	with metals	HNO_3 to pH <2; 4±2ºC	6 months	with metals[e]
Chloride, fluoride, sulfate	HDPE	250 mL	4±2ºC	6 months	5 mL
Nutrients					
Ammonia	HPDE	250 mL	H_2SO_4 to pH <2; 4±2ºC	28 days	5 mL
Nitrate + nitrite	HDPE	250 mL	4±2ºC	28 days	5 mL
Common metals and metalloids [c]	HDPE	250 mL	5 mL of 1:1 HNO_3; 4±2ºC	6 months	15 to 20 mL
Mercury [d]	FP or G with FP-lined lids	500 mL	BrCl in lab within 28 days of collection; 4±2ºC	90 days	100 mL

Notes:
BrCl = bromine chloride
FP = fluoropolymer
G = glass
HDPE = high density polyethylene bottle
H_2SO_4 = sulfuric acid
HNO_3 = nitric acid
[a] Sample container sizes may be modified to meet laboratory requirements
[b] Extra sample volume will be collected at a frequency of 5 percent of samples to accommodate requirements for laboratory quality control samples.
[c] Surface water samples will be collected and analyzed for dissolved metals and metalloids. A total of 1 L of water will be collected for the common metals/metalloids analyses (dissolved), and 500 mL will be collected for analysis of mercury.
[d] Due to volume limitations mercury analyses will not be performed on porewater samples.
[e] These analyses will be conducted from the same sample collected for metals analysis; therefore, no additional volume is required.

Table B-4. Required Sample Containers, Preservation, and Holding Times for Sediment Samples.

Container [a]					
Type	Size	Analysis	Preservation	Holding Time	Sample Size
G/P	8 oz [b,c]	Grain size	4±2ºC	6 months	100 g [b,c]
G/P	8 oz [b]	pH	4±2ºC	7 days	20 g [b]
		TOC		14 days	1 g
		Mercury		28 days	5 g
		Metals/metalloids, and percent moisture		6 months	10 g
WMG	2 oz	AVS / SEM	No headspace; 4±2ºC (do not freeze)	14 days	5 g
G/P	16 oz	Archive	Freeze	1 year	40 g +

Notes:
AVS = acid-volatile sulfides
G/P = glass or plastic
TOC = total organic carbon
WMG = wide mouth glass
[a] The size and number of containers may be modified by analytical laboratory
[b] Collection of two times the indicated sample size will be necessary for five percent of samples to allow for laboratory QA procedures.
[c] A larger sample size will be needed for coarse-grained sediment.

Table B-5. Study design (locations, sites, replicates) and initial seeding densities of fish at specific life stages.

		Location						Total
		Deadman's Eddy	China Bend	Upper Marcus Flats	Lower Marcus Flats	Reference	Lab Control	6
Sites		3	3	3	3	1	1	14
Replicates per site		3	3	3	3	3	3	42
Number of organisms per replicate	Eggs	15,000						15,000
	Fry	100	100	100	100	100	100	4,200
	Post swim-up	<90	<90	<90	<90	<90	<90	<3,780
	End of test	>40	>40	>40	>40	>40	>40	>1,680

Table B-6. Sampling Design for the 2010 Sediment Toxicity Studies with White Sturgeon Early Life-Stages and ASTM (2005) Target Values for Conducting Early Life-Stage Fish Toxicity Studies.

Parameter	Sturgeon Sediment Study	ASTM 2005
Time of exposure initiation	Post hatch	Salmonids: ≤ 96 hours; All other species: ≤ 48 hours
Exposure duration	60 days (> 40 days post-swim-up)	Salmonids: ≥ 30-day post-swim-up; Pike: 32 days; Fathead minnow: ≥ 28 days; White sucker: 32 days; Channel catfish: 32 days; Bluegill: 32 days
Loading density/rate	≤ 0.1 g/L/24 hours	≤ 0.5 g/L/24 hours
Number of true replicates per site/treatment/dose	3	≥ 2
Number of fish per replicate (controls) at end of study	≥ 64% of start	varies by species
Observations	≥ 2 times per day	≥ 1 time per day
Feeding	≥ 3 times per day	≥ 1 time per day

Table B-7. Test Conditions for Conducting a 60-Day Early Life-Stage Toxicity Test with White Sturgeon (*A. transmontanus*)[a].

Parameter	Conditions
Test Type	Whole-sediment toxicity test
Temperature	15 ± 1°C
Light Quality	Wide spectrum fluorescent lights
Photoperiod	16 hours light; 8 hours dark
Test System	230 L recirculating flow-through system each with two 40 L exposure chambers.
Water Volume	230 L
Sediment Depth	5.08 to 10.16 cm
Renewal Frequency of Water	Complete replacement of water (230 L) every 12 to 24 hours.
Age of Organisms	Day of hatch through ~60-day post-hatch
Number of Organisms per Replicate Group	Larvae will be added to exposure chambers at ~100 fish per replicate treatment group (chamber) after they hatched; Total number of fish tested per sample @ ~300 (Table B-5).
Number of Replicate Groups	Three replicate recirculating systems per sample (site)
Feeding	Live diet: brine shrimp (*Artemia*), oligochaetes, and frozen blood worms 3 to 4 times per day *ad libidum.* Feeding will be initiated 2 to 3 days post-swim-up to acclimate fry to food. Nutritional analysis (crude protein, percent lipids, ash, coloric content) will be done on feed batch at start/end of exposure period.
Aeration	None; recirculation of water provides sufficient aeration
Water Source	Artificial river water (de-chlorinated lab water adjusted to river water for pH, DOC, and hardness)
Volume of Sediment per system	24 – 48L per exposure chamber
Density of gravel added	0, 3, 7, 10 or 13 stones per 100 cm^2
Test System Cleaning	Gently scrape tanks and brush screens if these should become overgrown with organic matter; in-line coarse particle filter at exposure chamber outflow to reduce particle/organic matter build-up.
Water Quality	Daily: DO, pH, temperature, and conductivity One to three times per week: Ammonia, alkalinity, chlorine, hardness, nitrate + nitrite, TSS, and DOC. Frequency will be increased if marked changes in readings occur between measurements.
Test Duration	~60 days

 (continued on next page)

Table B-7. Test Conditions for Conducting a 60-Day Early Life-Stage Toxicity Test with White Sturgeon (*A. transmontanus*) (continued).

Parameter	Conditions
Endpoints / observations	Survival, growth / observations of gross morphology, development, and behavior
Test Acceptability	Minimum hatching rate in the controls/reference should be 60% or within 90% confidence interval of that observed at the hatchery for the same fish Minimum survival of fry until swim-up in the controls/reference should be 80% Minimum average survival of fish in the controls/reference post hatch (initiation of experiment) until test termination should be ≥64%.

Notes:
DOC = dissolved organic carbon
DO = dissolved oxygen
TSS = total suspended solids
[a] To be finalized during methods development work.

Table B-8. General Activity Schedule for Conducting a 60-Day Early Life-Stage Toxicity Test with White Sturgeon (*A. transmontanus*).

Day [b]	Conditions
-75 to -45	• Collection of sediments at selected sampling sites in the UCR • Transport of sediments to the U of S at 4°C • Storage of sediments at U of S at 4°C
-45 to -15	• Set up of re-circulating exposure systems in the Aquatic Exposure Facility at the University of Saskatchewan • Homogenize sediments from each sampling site immediately prior to placing sediments into exposure systems • Add sediments to each exposure chamber • Adjust exposure system flow through and equilibrate exposure systems with sediments and test water (>4 weeks) • Measure water quality in porewater and overlying water at 0, 12, 24, 48, 96 every 48 hrs thereafter after filling systems with water and initiation of flow-through conditions [a]
Test Set Up	
-7	• Test water quality in each exposure system (see Table B-7) • Acclimate freshly fertilized eggs to water temperature in water-only tank • Transfer eggs to egg hatching jars (1000 – 4000 eggs per jar) • Adjust flow through egg hatching jars so that the top layer of eggs rolls very gently but do not get pushed up in the water column
-7 to -1	• Observe systems with hatching jars 2- to 3-times per day • Measure DO, Temperature, pH and conductivity daily
-4	• Ensure that neurolation has been completed • Increase water flow to hatching jars such that eggs are vigorously circulated throughout the jar • Sample sediments and analyze per Table B-10
-1 to 1	• Count and transfer hatched larvae to main exposure chambers • Count and remove dead larvae during first 24 hrs post transfer and replace with live larvae
Pre-Swim-Up Test	
0 to 13	• Observe larvae 2- to 3-times per day • Measure DO, Temperature, pH and conductivity daily and all other water quality parameters at least every 7 days • Count, weigh, measure length, and remove dead fry and preserve dead fish in formalin • Observe and record any behavioral abnormalities • Observe and record swim up and presence/rejection of black yolk sac plugs • Run water-only exposure reference toxicant test
11	• Begin adding diet to the chambers to condition fry to food
Transition Phase	
14 to 18	• Record swim-up and feeding behavior of fry

 (continued on next page)

Table B-8. General Activity Schedule for Conducting a 60-Day Early Life-Stage Toxicity Test with White Sturgeon (*A. transmontanus*) (continued).

Day [b]	Conditions
Post-Swim-Up Test	
14 to 58	• Feed fish 4-times per day • Clean systems daily • Record and remove mortalities daily, and measure, weigh and fix dead fish in formalin • Measure DO, Temperature, pH and conductivity daily and all other water quality parameters at least every 7 days (see Table B-7)
59	• Terminate study • Measure complete water quality suite including metals • Sample sediments and analyze per Table B-10 • Euthanize fish in MS222 • Measure and weigh fish • Fix fish in formalin and archive • Archive sediment sub-sample

Notes:
AVS = acid volatile sulfides COPC = contaminants of potential concern DOC = dissolved organic carbon
(cont. next page)
DO = dissolved oxygen SEM = simultaneously extracted metals TAL = target analyte list
TOC = total organic carbon
[a] To be finalized during methods development work.
[b] Actual days listed here are approximate; posthatch periods and are meant to represent endogenous and exogenous feeding stages.

Table B-9. Test Acceptability Requirements of a 60-Day Early Life-Stage Sediment Toxicity Test with White Sturgeon (*A. transmontanus*).

Acceptance Criteria	
1	Freshly fertilized eggs from at least 2 to 4 different females and males are to be used (time between hatching and initiation of study must not exceed 24 hours)
2	Average hatching rate of eggs in the lab water controls should not be less than 60%, or within 90% confidence interval of that observed at the hatchery for the same fish
3	Average survival of fry until swim-up in the lab water controls should be greater or equal to 80%, or within 90% confidence interval of that observed at the hatchery for the same fish
4	Average survival of fry from the start to finish of exposure in the lab water controls should be greater or equal to 64%
5	All water quality parameters with the exception of DO and temperature should not vary by more than 50% during the exposure
6	Dissolved oxygen should be maintained above 70% saturation
7	Average daily temperature should be maintained at 15 ± 1°C; the instantaneous temperature must always be within ± 3°C of 15°C
Additional Acceptance Criteria	
1	All organisms must be from the same source
2	Hatchability in the lab water controls should be comparable to those observed at the Kootenay Trout Hatchery for the fish from the same fertilization event
3	All test systems and chambers should be identical and should be run under the same recirculating conditions for each study, except if otherwise stated in the protocols
4	Natural physico-chemical conditions of the control lab water should be within the tolerance limit for white sturgeon early life-stages
5	Food should be obtained and tested for possible comparability with white sturgeon early life-stages prior to initiation of the studies
6	Reference toxicant (copper) will be tested in acute toxicity (96hr) water-only exposure, using a life stage previously tested at U of S and fish from the same batch of fish used in the sediment study

Notes:
DO = dissolved oxygen

Table B-10. Parameters Measured in Sturgeon Exposure Chambers.

	Sediment [a]		Pore/SWI/Overlying Water	
Analyte/Parameter	CAS	U of S	CAS	U of S
Conventional Parameters				
Alkalinity			W	start[b] W
Hardness			W	start[b],D
TDS			W	
TOC / DOC	start, end			start[b] D
pH	start, end			start[b] D
DO				D
Temperature				D
Conductivity				D
Cations/Anions				
Calcium			W	
Chloride			W	
Fluoride			W	
Magnesium			W	
Potassium			W	
Sodium			W	
Sulfate			W	
Nutrients				
Ammonia				W
Nitrate+Nitrite				W
Common Metals and Metalloids				
Aluminum	start, end		W	
Antimony	start, end		W	
Arsenic	start, end		W	
Barium	start, end		W	
Beryllium	start, end		W	
Cadmium	start, end		W	
Chromium	start, end		W	
Cobalt	start, end		W	
Copper	start, end		W	
Iron	start, end		W	
Lead	start, end		W	
Manganese	start, end		W	
Mercury	start, end		W	
Molybdenum	start, end		W	
Nickel	start, end		W	
Selenium	start, end		W	
Silver	start, end		W	
Thallium	start, end		W	
Vanadium	start, end		W	
Zinc	start, end		W	

(continued on next page)

Table B-10. Parameters Measured in Sturgeon Exposure Chambers (continued).

	Sediment [a]		Pore/SWI/Overlying Water	
Analyte/Parameter	CAS	U of S	CAS	U of S
Other				
AVS	start, end			
SEM	start, end			
Grain Size	start			
Biological Measurements				
Length				Measure Day 0, end of test, and all dead fish; Photo document periodically
Weight				Measure Day 0 and end of test; all dead fish
Survival				D

Notes:

D Daily measurements conducted by the U of S to control for appropriate water quality required for successful sturgeon culture

W Weekly measurements will be conducted by the U of S to assess changes in exposure conditions that require immediate corrective action. During the beginning of the exposure these parameters will be measured more frequently (e.g. every 3 to 5 days).

AVS = acid volatile sulfides
DO = dissolved oxygen
SEM = simultaneously extracted metals
TDS = total dissolved solids
TOC = total organic carbon

[a] samples will also be archived per Table B-4

[b] parameters to be analyzed / adjusted in artificial river water

Table B-11. Recommended Laboratory Methods for Analysis of Samples.

	Sample Preparation		Quantitative Analysis	
Analytes	Protocol	Procedure	Protocol	Procedure
Pore-, Interface, and Surface Water Samples				
Conventional Parameters				
Alkalinity as $CaCO_3$	--	--	SM 2320B	Titrimetric
DOC	SM 5310C	Filtration, chemical oxidation	SM 5310C	Infrared detector
Hardness as $CaCO_3$	--	--	SM 2340C	Titrimetric
TDS	--	--	SM 2540	Gravimetric
TSS	--	--	SM 2540	Gravimetric
pH	EPA 150.1/SM 4500 H^+ B	--	EPA 150.1/SM 4500 H^+ B	Electrometric
Major Ions				
Calcium, magnesium, potassium, sodium	EPA 3005	Acid digestion	EPA 6010B	ICP/AES
Chloride, fluoride, sulfate	--	--	EPA 300.0	Ion chromatography
Nutrients				
Ammonia	SM 4500-NH3 G	Buffered to pH 9.5	SM 4500-NH3 G	Colorimetric
Nitrate + nitrite	--	--	EPA 300.0	Ion chromatography
Common Metals and Metalloids [a]				
Aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, manganese, nickel, selenium, silver, thallium, vanadium, zinc	EPA 3005	Acid digestion	EPA 6020	ICP/MS
Iron	EPA 3005	Acid digestion	EPA 6010B	ICP/AES
Mercury	EPA 1631E	BrCl oxidation	EPA 1631E	AFS
Sediment Samples				
TAL Metals	NA	NA	EPA 6020	ICP/AES
TOC	NA	NA	ASTM D 4129-82	oxidation and coulometry
pH	NA	NA	EPA 9045C	
AVS/SEM	NA	NA	EPA 821-R-91-100	
Grain Size	NA	NA	ASTM D422	

Notes:

AFS = atomic fluorescence spectroscopy
AVS/SEM = acid volatile sulfides/ simultaneously extracted metals
BrCl = bromine chloride
$CaCo_3$ = calcium carbonate
DOC = dissolved organic carbon
EPA = U.S. Environmental Protection Agency
ICP/AES = inductively coupled plasma/atomic emission spectrometry
ICP/MS = inductively coupled plasma/mass spectrometry
SM = Standard Methods for the Examination of Water and Wastewater
TAL = target analyte list
TDS = total dissolved solids
TOC = total organic carbon
TSS = total suspended solids
NA = not applicable

[a] Water samples will be collected and analyzed for dissolved metals and metalloids.

Table B-12. Behavioral observations to be made during the course of the definite sediment toxicity studies with white sturgeon ELS (from ASTM E1711-95).

Observation	Behavior	Frequency of Observation [/d]	Life-Stage [dph]	Response
Feeding	Active searching, grazing, ingestion	3	> Swim Up	Absence, presence
Level of activity	Hiding, schooling	3	Yolksack	Absence, presence
	Active swimming, lethargy, hyperactivity, hiding	3	Swim Up	Absence, presence
	Active swimming, lethargy, hyperactivity, hiding	3	Transition to feed	Absence, presence
Movements or postures	Swimming patterns, loss of equilibrium	3	All	Absence, presence
Response to stimuli	Lack of response, hyperreactivity	3	All	Absence, presence

Table B-13. Experimental Quality Control Samples for Precision and Accuracy.

Type of QC Sample	Frequency	Acceptance Criteria
Equipment rinsate blank	1 per sampling event	No analyte should be detected
Matrix spike/matrix spike duplicate (MS/MSD)	1 per 20 samples	RPD should be ≤ 30 percent for each analyte.
Duplicate blind sample	1 per sampling event	± 30% of original sample
Experimental blank	1 per sampling event	No analyte should be detected

Note:
MS/MSD samples are included as experimental quality control samples for planning purposes to ensure sufficient sample volume is collected for the analyses.

Table D-1. Data Validation Qualifiers.

Qualifier	Explanation of Qualifier
U	The compound was analyzed for, but was not detected above the reported method detection limit.
J	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
R	The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.
UJ	The analyte was not detected above the reported method detection limit. However, the reported limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
B	The analyte was positively identified; the reported concentration is greater than the instrument detection limit, but less than the QAPP-specified reporting limit.

APPENDIX A

DANGEROUS WASTE CHARACTERIZATION

Nautilus Environmental, LLC

RECEIVED
MAR 28 2008
DEPARTMENT OF ECOLOGY
EASTERN REGIONAL OFFICE

Dangerous Waste Characterization

Sample IDs: North Comp. A; North Comp. A (ground); North 2B; North 3A; South Comp. A; South Comp. B; South 2A; South 2C

Report date: March 24, 2008

Submitted to:

Washington State Department of Ecology
4601 N. Monroe St.
Spokane, WA 99205

Washington Laboratory
5009 Pacific Hwy East
Suite 2
Tacoma, WA 98424

1.0 INTRODUCTION

A dangerous waste characterization using the test organism *Oncorhynchus mykiss* (rainbow trout) was conducted on eight samples submitted by Washington State Department of Ecology (WDOE) to Nautilus Environmental. Testing was conducted following the Washington State Department of Ecology Publication 80-12.

2.0 METHODS

The samples, identified as North Comp. A, North Comp. A (ground), North 2B, North 3A, South Comp. A, South Comp. B, South 2A, and South 2C, were received in the laboratory on March 11, 2008. Sample North Comp. A (ground) was ground in the laboratory using a coffee grinder cleaned to EPA specifications. The test procedure is outlined in Table 1.

Table 1. Summary of Dangerous Waste Characterization Test Conditions

Parameter	Standard Fish Toxicity Test	Standard Fish Toxicity Test
Test number	0803-T035	0803-T050
Samples tested	North Comp. A, North Comp. A (ground), North 2B, North 3A	South Comp. A, South Comp. B, South 2A, South 2C
Test initiation date; time	3/15/2008; 1100h	3/20/2008; 1240h
Test termination date; time	3/19/2008; 1115h	3/24/2008; 1140h
Endpoint	Mortality at 96-hours	
Test chamber	10-L glass tank	
Test temperature	12 ± 1°C	
Dilution water	Carbon filtered water	
Test solution volume	8 L	
Test concentrations (mg/L)	100, 10, 0	
Number of organisms/ chamber	10	
Number of replicates	3	
Test organism	*Oncorhynchus mykiss* (rainbow trout)	
Feeding	No feeding during test	
Photoperiod	16 hours light/ 8 hours dark	
Extraction	Rotary agitation (30 +/- 2 rpm) for 18 hours	
Reference Toxicant	Copper sulfate	
Deviations	See Quality Assurance Section	

The test organisms used in the test are outlined in Table 2. Both sets of samples were tested using fish from the same batch received on March 12, 2008.

Table 2. Test organisms (*Oncorhynchus mykiss*)

Test number	0803-T035	0803-T050
Test organism age	40 days post swim-up (hatch date 1/14/08)	45 days post swim-up (hatch date 1/14/08)
Mean weight	0.37 g	0.39 g
Mean length	31 mm	32 mm
Ratio of longest to shortest	1.1	1.1
Loading	0.47 g/L	0.48 g/L
Test organism source	Trout Lodge; Sumner, WA	Trout Lodge; Sumner, WA

3.0 RESULTS

A summary of results for the dangerous waste characterization conducted on samples North Comp A, North Comp. A (ground), North 2B, North 3A, South Comp. A, South Comp. B, South 2A, and South 2C is contained in Table 3.

There was 3 percent mortality in the 100 mg/L concentration and no mortality in the 10 mg/L concentration of sample South 2C during the test. There was no mortality in any other sample during the test. Based on these results, North Comp. A, North Comp. A (ground), North 2B, South Comp. A, South Comp. B, South 2A, and South 2C do not designate as either dangerous or extremely hazardous wastes.

Table 3. Summary of Results

Sample ID	Concentration (mg/L)	Survival (# fish, N=30)	Percent Mortality	Dangerous Waste Designation
Control	0	30	0	NA
North Comp. A	10	30	0	None
	100	30	0	
North Comp. A	10	30	0	None
	100	30	0	
North 2B	10	30	0	None
	100	30	0	
North 3A	10	30	0	None
	100	25[1]	0	
Control	0	30	0	NA
South Comp. A	10	30	0	None
	100	30	0	
South Comp. B	10	30	0	None
	100	30	0	
South 2A	10	30	0	None
	100	30	0	
South 2C	10	29[2]	0	None
	100	29	3	

[1] Initial count was 25, see Quality Assurance section for further explanation.

[2] Initial count was 29, see Quality Assurance section for further explanation.

4.0 QUALITY ASSURANCE

One replicate of the 100 mg/L concentration of sample North 3A had 5 fish added instead of 10 at test initiation. As there was no mortality in this sample, this deviation is not expected to have affected the results.

One replicate of the 10 mg/L concentration of sample South 2C had 9 fish added instead of 10 at test initiation. As there was no mortality in the 10 mg/L concentration and only 3 percent mortality in the 100 mg/L concentration of this sample, this deviation is not expected to have affected the results.

Three replicates of the 10 mg/L concentration of sample North Comp. A had super-saturated dissolved oxygen levels at test initiation. As there was no mortality in this sample, this deviation is not expected to have affected the results.

The most recently completed reference toxicant test was initiated March 11, 2008. The LC_{50} of 85.07 µg/L copper was acceptable based on control charting for this laboratory. The coefficient of variation (CV) for the last 20 tests was 39.1 percent, which is considered good by the Biomonitoring Science Advisory Board.

References

Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria. Washington State Department of Ecology Publication # WQ-R-95-80 Revised June 2005.

Biological Testing Methods 80-12 for the Designation of Dangerous Waste. Washington State Department of Ecology Publication #80-12. Revised June 1999.

Appendix A
Test Data

Dangerous Waste Toxicity Test
Toxicity Test Data Sheet - Washington Laboratory

Client: WDOE
Sample ID: North Comp. A; North Comp. A (ground); North 2B
Test # 0803-T035

Start Date & Time: 3/15/08 1100
End Date & Time: 3/19/08 1115
Test Organism: *Oncorhynchus mykiss*
Test Protocol: **Washington State Department of Ecology Publ. 80-12**

Rep	Conc.	Cont #	Number of Live Organisms					Dissolved Oxygen (mg/L)					pH (units)					Conductivity (umhos/cm)					Temperature (°C)					Percent Survival
			0	24	48	72	96	0	24	48	72	96	0	24	48	72	96	0	24	48	72	96	0	24	48	72	96	
1	Ø	21	10	10	10	10	10	10.1	9.1	8.4	9.1	7.9	7.39	7.30	7.18	7.06	7.05	49				46	12.3	12.6	12.9	12.0	12.6	100%
2		20	10	10	10	10	10	10.1	9.2	8.8	9.2	8.5	7.48	7.34	7.22	7.20	7.21	48				50						
3		23	10	10	10	10	10	10.2	9.1	8.6	9.0	8.8	7.45	7.22	7.15	7.20	7.11	42				44						
1	10ppm	24	10	10	10	10	10	11.0	8.9	8.4	8.8	7.9	7.44	7.18	7.14	7.12	7.06	41				44	11.6	11.7	11.9	11.6	12.1	100%
2	TD8-043	16	10	10	10	10	10	11.8	9.1	8.2	8.9	8.2	7.43	7.13	7.12	7.08	7.08	49				46						
3	North Comp A	13	10	10	10	10	10	11.8	9.2	8.5	8.9	8.5	7.44	7.17	7.15	7.13	7.13	44				46						
1	100ppm	9	10	10	10	10	10	9.6	8.8	8.4	9.0	8.3	7.46	7.21	7.20	7.22	7.18	51				53	11.8	11.8	12.1	11.7	11.6	100%
2	TD8-043	4	10	10	10	10	10	9.5	8.9	8.4	9.0	8.6	7.45	7.19	7.18	7.20	7.20	48				50						
3	North Comp. A	17	10	10	10	10	10	9.7	8.9	8.4	8.8	8.3	7.46	7.17	7.18	7.15	7.20	46				48						
1	10ppm	27	10	10	10	10	10	10.1	8.9	8.1	8.4	7.9	7.42	7.13	7.07	7.04	7.07	42				44	12.2	12.0	12.2	11.9	11.9	100%
2	TD8-042	6	10	10	10	10	10	9.7	9.0	8.1	8.4	7.6	7.43	7.13	7.09	7.07	7.08	48				50						
3	No. Co. A (Grnd)	5	10	10	10	10	10	9.7	8.5	8.1	8.5	8.0	7.43	7.12	7.10	7.13	7.12	48				50						
1	100ppm	7	10	10	10	10	10	9.7	8.7	8.4	8.5	8.2	7.44	7.17	7.16	7.21	7.14	50				52	12.5	12.3	12.8	12.1	11.9	100%
2	TD8-042	12	10	10	10	10	10	9.8	8.7	8.1	8.3	7.5	7.43	7.13	7.06	7.05	7.06	43				45						
3	No. Co. (Ground)	11	10	10	10	10	10	9.8	8.6	8.1	8.2	7.3	7.43	7.12	7.04	7.09	7.03	44				46						
1	10ppm	18	10	10	10	10	10	9.6	8.5	8.0	8.4	8.3	7.45	7.13	7.09	7.10	7.08	47				49	12.6	12.4	12.9	12.5	12.0	100%
2	TD8-044	19	10	10	10	10	10	9.6	8.5	8.0	8.4	8.2	7.44	7.15	7.12	7.13	7.12	49				50						
3	North 2B	15	10	10	10	10	10	9.6	8.7	8.1	8.7	7.5	7.47	7.15	7.09	7.12	7.09	45				47						
1	100ppm	8	10	10	10	10	10	9.7	8.7	8.4	8.6	7.8	7.47	7.16	7.19	7.15	7.14	50				54	11.7	11.2	11.9	11.1	12.1	100%
2	TD8-044	3	10	10	10	10	10	9.5	8.7	8.2	8.6	7.9	7.46	7.17	7.13	7.16	7.14	49				52						
3	North 2B	1	10	10	10	10	10	9.6	8.6	8.3	8.5	8.1	7.46	7.16	7.14	7.13	7.14	47				52						
Technician Initials			JS	(N)	BP	BP	BP	(N)	(N)	BP	BP	MM																

Sample	Alk. (init.)	Hard. (init.)	Alk. (fin.)	Hard. (fin.)
	(mg/L as CaCO3)			
Control	20	20	24	28
TD8-042 (N) ~~TD8-043~~ 100ppm	28	32	28	32
TD8-043 (N) ~~TD8-044~~ 10ppm	20	(N) ~~20~~ 24	20	24
TD8-044 (N) ~~TD8-045~~ 100ppm	28	20	28	20

Animal Source: Trout Lodge
Date of Hatch: 1/14/08
Test Volume: 8-1
Date Received: 3/12/08
Date of Swim-up: 2/4/08

Weights (g): 33* 33 46 34 37 30 40 41 45 31 $\mu = 37.4$
Lengths(mm): 30 33 33 31 31 30 32 32 33 29 $\mu = 31.4$
Length max/min: 1.1
Loading: .4675 g/L

Sample Description: * See Corrective Action Log, 08-009,

Nautilus Environmental
Washington Laboratory
5009 Pacific Hwy. E., Suite 2
Tacoma, WA 98424
253-922-4296

Dangerous Waste Toxicity Test
Toxicity Test Data Sheet - Washington Laboratory

Client: WDOE
Sample ID: North 3A
Test # 0803 - T035

Start Date & Time: 3/15/08 1100
End Date & Time: 3/19/08 1115
Test Organism: *Oncorhynchus mykiss*
Test Protocol: **Washington State Department of Ecology Publ. 80-12**

Rep	Conc.	Cont #	Number of Live Organisms					Dissolved Oxygen (mg/L)					pH (units)					Conductivity (umhos/cm)					Temperature (°C)					Percent Survival
			0	24	48	72	96	0	24	48	72	96	0	24	48	72	96	0	24	48	72	96	0	24	48	72	96	
1	10ppm	26	10	10	10	10	10	9.9	8.7	8.4	8.7	7.9	7.47	7.13	7.18	7.13	7.05	41				45	11.6	11.4	11.4	11.3	12.4	100%
2	TO8-045	14	10	10	10	10	10	9.9	8.7	8.3	8.5	8.0	7.45	7.11	7.11	7.11	7.07	43				47						
3	North 3A	10	10	10	10	10	10	9.7	8.6	8.3	8.4	8.0	7.42	7.19	7.12	7.30	7.11	52				54						
1	100ppm	22	10	10	10	10	10	9.7	8.6	8.4	8.4	7.9	7.47	7.19	7.20	7.13	7.14	44				47	11.8	11.6	11.9	11.8	12.0	100%
2	TO8-045	25	10	10	10	10	10	9.5	8.7	8.1	8.3	7.5	7.43	7.10	7.13	7.12	7.03	43				46						
3	North 3A	2*	10 5	10 5 (R)	5	5	5	9.7	9.0	8.6	8.6	8.3	7.43	7.30	7.11	7.23	7.19	49				53						
1																												
2																												
3																												
1																												
2																												
3																												
1																												
2																												
3																												
1																												
2																												
3																												
1																												
2																												
3																												
Technician Initials			D	(R)	BP	BP	BP	(R)	(R)	BP	BP	MM																

Sample	Alk. (init.)	Hard. (init.)	Alk. (fin.)	Hard. (fin.)
	(mg/L as CaCO3)			
Control	20	20	24	28
TO8-045	28	20	28	20

Animal Source: TROUT LODGE
Date of Hatch: 1/14/08

Test Volume: 8-L
Date Received: 3/12/08
Date of Swim-up: 2/4/08

Weights (g): .33 .33 .46 .38 .37 .30 .40 .41 .45 .31
Lengths(mm): 30 33 33 31 31 30 32 32 33 29
Length max/min: 1.1

μ = .374
μ = 31.4

Loading: .4675 g/L

Nautilus Environmental
Washington Laboratory
5009 Pacific Hwy. E., Suite 2
Tacoma, WA 98424
253-922-4296

Sample Description: *Tank 2 started with only 5 fish. See CA# Corrective Action Log # 08-010

Dangerous Waste Toxicity Test
Toxicity Test Data Sheet - Washington Laboratory

Client: WDOE
Sample ID: South Comp A, South Comp B, South 2A, South 2C
Test #: 0803-TD5D

Start Date & Time: 3/20/08 1240
End Date & Time: 3/24/08 1140
Test Organism: *Oncorhynchus mykiss*
Test Protocol: **Washington State Department of Ecology Publ. 80-12**

Rep	Conc.	Cont #	Number of Live Organisms					Dissolved Oxygen (mg/L)					pH (units)					Conductivity (umhos/cm)					Temperature (°C)					Percent Survival
			0	24	48	72	96	0	24	48	72	96	0	24	48	72	96	0	24	48	72	96	0	24	48	72	96	
1	CON	27	10	10	10	10	10	10.5	8.4	8.7	8.2	8.3	7.30	7.12	7.07	7.26	7.13	39				41	11.6	12.8	12.3	12.6	11.6	100%
2		9	10	10	10	10	10	10.2	8.3	8.8	8.7	8.7	7.32	7.16	7.14	7.24	7.21	42				46						
3		1	10	10	10	10	10	10.3	8.4	8.5	8.6	8.6	7.34	7.20	7.13	7.22	7.17	42				45						
1	TD8-046	2	10	10	10	10	10	10.1	8.5	9.0	8.5	8.8	7.36	7.20	7.11	7.22	7.20	41				44	11.7	12.5	11.5	11.6	11.5	100%
2	10ppm	18	10	10	10	10	10	10.4	8.4	8.7	8.8	9.1	7.37	7.18	7.13	7.20	7.21	40				44						
3	South compA	15	10	10	10	10	10	10.5	8.5	8.4	8.3	8.3	7.39	7.21	7.14	7.19	7.18	39				42						
1	TD8-046	11	10	10	10	10	10	10.1	8.3	8.5	9.1	8.9	7.36	7.19	7.14	7.19	7.17	42				45	11.6	12.5	11.7	11.3	11.4	100%
2	100ppm	25	10	10	10	10	10	10.5	8.9	8.4	8.4	8.8	7.37	7.18	7.12	7.16	7.16	39				41						
3	SouthCompA	21	10	10	10	10	10	10.3	8.5	8.5	8.4	8.6	7.36	7.19	7.13	7.17	7.18	41				45						
1	TD8-047	12	10	10	10	10	10	10.5	8.7	8.7	8.4	8.9	7.40	7.21	7.15	7.15	7.16	39				42	11.6	12.9	11.8	11.4	11.6	100%
2	10ppm	13	10	10	10	10	10	10.5	8.5	8.5	8.9	8.5	7.40	7.20	7.13	7.16	7.18	39				42						
3	SouthCompB	4	10	10	10	10	10	10.4	8.3	8.8	8.2	8.5	7.37	7.16	7.15	7.16	7.15	41				44						
1	TD8-048	5	10	10	10	10	10	10.4	8.8	8.5	8.8	8.6	7.38	7.21	7.16	7.22	7.21	41				44	11.8	13.0	12.3	11.8	12.0	100%
2	100ppm	19	10	10	10	10	10	10.3	8.7	8.8	8.5	8.9	7.38	7.20	7.14	7.22	7.21	41				45						
3	SouthCompB	23	10	10	10	10	10	10.5	8.5	8.1	8.7	8.4	7.39	7.15	7.12	7.14	7.13	39				42						
1	TD8-048	24	10	10	10	10	10	10.2	8.5	8.5	8.2	8.0	7.31	7.10	7.03	7.15	7.11	38				42	11.4	11.5	12.2	11.3	12.5	100%
2	10ppm	6	10	10	10	10	10	10.4	8.4	8.7	8.1	8.4	7.34	7.15	7.12	7.15	7.14	42				46						
3	South 2A	10	10	10	10	10	10	10.0	8.4	8.4	8.3	7.7	7.36	7.19	7.15	7.15	7.16	42				46						
1	TD8-048	3	10	10	10	10	10	10.0	8.8	8.3	8.2	8.3	7.37	7.21	7.14	7.18	7.20	41				45	11.6	11.5	11.6	11.2	12.6	100%
2	100ppm	22	10	10	10	10	10	10.2	9.0	8.3	8.4	8.3	7.36	7.23	7.17	7.19	7.21	42				46						
3	South 2A	16	10	10	10	10	10	10.4	8.9	8.6	8.7	8.4	7.39	7.20	7.16	7.18	7.20	40				44						
Technician Initials			JS	BP	AT	AT	JS	JS	BP	BP	AT	JS																

Sample	Alk. (init.)	Hard. (init.)	Alk. (fin.)	Hard. (fin.)
	(mg/L as CaCO3)			
Control	24	20	20	16
TD8-046	20	24	24	20
TD8-047	28	20	24	20
TD8-048	24	40	24	40

Animal Source: Trout Lodge
Date of Hatch: 1/4/08
Test Volume: 8L
Date Received: 3/12/08
Date of Swim-up: 2/4/08

Weights (g): 0.31 0.36 0.39 0.42 0.49 0.44 0.40 0.36 0.32 0.38
Lengths(mm): 31 31 32 31 33 33 32 31 30 32
Length max/min: 1.1
Loading: .48 g/L

μ = 3.87 Nautilus Environmental
μ = 31.6 Washington Laboratory

5009 Pacific Hwy. E., Suite 2
Tacoma, WA 98424
253-922-4296

Sample Description:

Dangerous Waste Toxicity Test
Toxicity Test Data Sheet - Washington Laboratory

Client: WDOE
Sample ID: South Comp A, South Comp B, South 2A, South 2C
Test #: 0803-T050

Start Date & Time: 3/20/08 1240
End Date & Time: 3/24/08 1140
Test Organism: *Oncorhynchus mykiss*
Test Protocol: **Washington State Department of Ecology Publ. 80-12**

Rep	Conc.	Cont #	Number of Live Organisms					Dissolved Oxygen (mg/L)					pH (units)					Conductivity (umhos/cm)					Temperature (°C)					Percent Survival
			0	24	48	72	96	0	24	48	72	96	0	24	48	72	96	0	24	48	72	96	0	24	48	72	96	
1	T08-049	17	10	9	9	9	9	10.5	9.2	8.5	8.8	8.4	7.38	7.23	7.21	7.21	7.23	40				44	11.4	11.8	11.7	11.3	12.2	100%
2	10 ppm	8	10	10	10	10	10	10.2	8.7	8.1	8.0	8.3	7.37	7.22	7.13	7.14	7.16	42				47						
3	South 2C	7	10	10	10	10	10	10.2	8.8	8.4	8.3	8.0	7.37	7.22	7.16	7.15	7.16	42				46						
1	T08-049	26	10	10	10	10	10	10.4	8.8	9.2	8.4	8.4	7.41	7.21	7.18	7.14	7.18	39				43	11.8	12.3	12.0	11.6	12.8	97%
2	100 ppm	20	10	10	10	10	10	10.4	8.4	8.5	8.8	8.3	7.37	7.21	7.16	7.16	7.21	41				46						
3	South 2C	14	10	10	9	9	9	10.6	8.7	8.5	8.0	8.0	7.41	7.21	7.14	7.15	7.14	40				46						
1																												
2																												
3																												
1																												
2																												
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1																												
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3																												
1																												
2																												
3																												
1																												
2																												
3																												
Technician Initials			BP	BP	PT	TT	BP	BP	BP	BP	PT	BP																

Sample	Alk. (init.)	Hard. (init.)	Alk. (fin.)	Hard. (fin.)
	(mg/L as CaCO3)			
Control	24	20	20	16
T08-049	24	20	20	16

Animal Source: Troutlodge
Date of Hatch: 1/4/08
Test Volume: 8L
Date Received: 3/12/08
Date of Swim-up: 2/4/08

Weights (g): .31 .36 .39 .42 .49 .44 .40 .36 .32 .38
Lengths(mm): 31 31 32 31 33 33 32 31 30 32
Length max/min: 1.1
Loading: 48g/L

μ = .387 Nautilus Environmental
μ = 31.6 Washington Laboratory

5009 Pacific Hwy. E., Suite 2
Tacoma, WA 98424
253-922-4296

Sample Description: * Replicate 17 only has 9 fish -

Nautilus Environmental

Corrective Action Log - 2008

Entry No.: 08-009

Date Identified: 3/17/08 **By Whom:** Marie

Problem Description:
NOTE: Please be very specific (i.e. if temperature is out of range, which way and by how much?)!

D.O.'s too high on 3 of the 80-12 tanks at start-up.
D.O. over saturated by 0.5 ~~mg/L~~ in tank #24, & 1.3 ~~ppt~~ mg/L in tanks #16 + 13

Analysis & Resolution:
NOTE: Key points here are: 1) How can the problem be avoided in the future? 2) What action was taken?

1) Meter should be allowed to settle completely or possibly be re-calibrated. If D.O. is still high, tank can be stirred to de-saturate.

Affected Test IDs: WDOE 80-12 3/15/08
TDS-043 Tanks 24, 16, 13

Further action required? Y (N) **Verified By:** Andrea Santiago
(Supervisor)

If yes, provide the following information (minimum):

Correction/Action Needed: _____

Date/Time Performed: _____

Performed by: _____

Date all action completed: _____ **Verified By:** _____
(QA Officer)

Nautilus Environmental

Corrective Action Log - 2007 8 ies

Entry No.: ~~07~~ 08 -010 (ies)

Date Identified: 3/16/08 **By Whom:** Maria

Problem Description:
NOTE: Please be very specific (i.e. if temperature is out of range, which way and by how much?)!

One tank of an 80-12 tank contained only five fish instead of the required ten.

Analysis & Resolution:
NOTE: Key points here are: 1) How can the problem be avoided in the future? 2) What action was taken?

I, Laura Shanks, who added the fish, will double check that 10 fish are added to each test chamber. The paperwork for this test reflects the test chamber was initiated with only 6 fish.

Affected Test IDs: WDOE 80-12 test, initiated 3/15/08

Further action required? Y N **Verified By:** Andrea Santiago
(Supervisor)

If yes, provide the following information (minimum):

Correction/Action Needed: _____

Date/Time Performed: _____

Performed by: _____

Date all action completed: _____ **Verified By:** _____
(QA Officer)

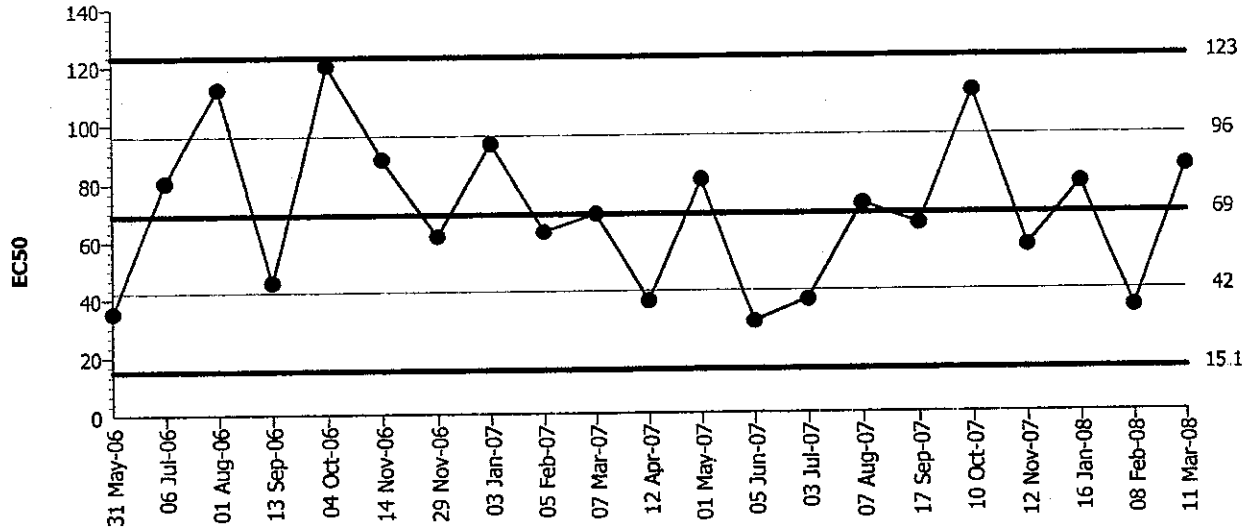
Appendix B
Reference Toxicant Test
Control Chart and Statistical Summary

CETIS QC Plot

Acute Fish Survival Test — Nautilus Environmental WA

Test Type: Survival (96h) **Organism:** Oncorhynchus mykiss (Rainbow Tro **Material:** Copper sulfate
Protocol: EPA/821/R-02-012 (2002) **Endpoint:** 96h Survival Rate **Source:** Reference Toxicant-REF

Acute Fish Survival Test



Mean:	69.02	**Count:**	20	**-1s Warning Limit:**	42.04	**-2s Action Limit:**	15.06
Sigma:	26.98	**CV:**	39.10%	**+1s Warning Limit:**	96	**+2s Action Limit:**	123

Quality Control Data

Point	Year	Month	Day	QC Data	Delta	Sigma	Warning	Action	Link No	Analysis No
1	2006	May	31	35.36	-33.66	-1.248	(-)		19-3457-2633	02-9683-8993
2		Jul	6	80.47	11.45	0.4242			08-0196-2782	16-9690-6989
3		Aug	1	112.2	43.23	1.602	(+)		08-6267-8343	09-7746-6681
4		Sep	13	45.65	-23.37	-0.8663			14-1862-0699	14-4190-4111
5		Oct	4	120.3	51.28	1.901	(+)		05-1640-1733	20-2095-2651
6		Nov	14	88.07	19.05	0.706			11-2573-0594	06-3342-6879
7			29	61.56	-7.463	-0.2766			07-2713-6445	10-5454-1996
8	2007	Jan	3	93.3	24.28	0.9			16-1383-8186	09-5460-8069
9		Feb	5	63	-6.024	-0.2233			02-4511-2417	08-3345-6600
10		Mar	7	69.1	0.07564	0.002804			15-2742-2430	14-0632-0126
11		Apr	12	38.65	-30.37	-1.126	(-)		05-2221-9409	06-5376-8430
12		May	1	80.81	11.79	0.437			07-8440-9066	16-2412-3916
13		Jun	5	31.5	-37.52	-1.391	(-)		04-7226-1595	13-4878-0526
14		Jul	3	38.97	-30.05	-1.114	(-)		09-2201-9419	09-6463-0833
15		Aug	7	72.36	3.343	0.1239			00-2704-2087	10-0764-4900
16		Sep	17	65.31	-3.708	-0.1374			09-6049-9537	19-0516-9479
17		Oct	10	110.9	41.87	1.552	(+)		07-7267-2112	10-4144-5232
18		Nov	12	57.43	-11.59	-0.4294			01-5405-3561	12-3986-4906
19	2008	Jan	16	79.37	10.35	0.3836			04-2972-7948	18-3406-5324
20		Feb	8	36.13	-32.89	-1.219	(-)		18-0745-0448	10-2659-0509
21		Mar	11	85.07	16.05	0.5948			01-5589-5982	15-0144-3175

CETIS Summary Report

Acute Fish Survival Test — **Nautilus Environmental WA**

Test Run No:	15-7154-5566	**Test Type:**	Survival (96h)	**Analyst:**	Meghan Murphy
Start Date:	11 Mar-08 10:45	**Protocol:**	EPA/821/R-02-012 (2002)	**Diluent:**	Dechlorinated Tap Water
Ending Date:	15 Mar-08 10:15	**Species:**	Oncorhynchus mykiss	**Brine:**	
Duration:	96h	**Source:**	Trout Lodge Fish Farm	**Age:**	57d

Sample No:	16-4358-6736	**Code:**	RA031108OM	**Client:**	Reference Toxicant Test
Sample Date:	11 Mar-08 10:45	**Material:**	Copper sulfate	**Project:**	
Receive Date:	15 Mar-08 10:15	**Source:**	Reference Toxicant		
Sample Age:	N/A	**Station:**			

Point Estimate Summary

Analysis No	Endpoint	Effect-%	Conc-µg/L	95% LCL	95% UCL	Method
15-0144-3175	96h Survival Rate	50	85.1	73.7	98.2	Trimmed Spearman-Kärber

Test Acceptability

Analysis No	Endpoint	Attribute	Test Stat	Acceptability Limits	Overlap	Decision
15-0144-3175	96h Survival Rate	Control Resp	1	0.9 - NL	Yes	Passes acceptability criteria

96h Survival Rate Summary

Conc-µg/L	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	Diff%
0	Dilution Water	3	1	1	1	1	1	0	0	0.0%	0.0%
25		3	1	1	1	1	1	0	0	0.0%	0.0%
50		3	0.9	0.863	0.937	0.8	1	0.0183	0.1	11.1%	10.0%
100		3	0.367	0.345	0.388	0.3	0.4	0.0105	0.0577	15.7%	63.3%
200		3	0	0	0	0	0	0	0		100.0%
400		3	0	0	0	0	0	0	0		100.0%

96h Survival Rate Detail

Conc-µg/L	Control Type	Rep 1	Rep 2	Rep 3
0	Dilution Water	1	1	1
25		1	1	1
50		1	0.9	0.8
100		0.4	0.3	0.4
200		0	0	0
400		0	0	0

Appendix C
Chain-of-Custody Form

Chain of Custody

Nautilus Environmental

TESTING LOCATION (Please Circle)

California
5550 Morehouse Drive, Suite 150
San Diego, CA 92121
Phone 858.587.7333
Fax 858.587.3961

Washington
5009 Pacific Highway East, Suite 2
Tacoma, WA 98424
Phone 253.922.4296
Fax 253.922.5814

British Columbia
8664 Commerce Court
Burnaby, British Columbia, Canada V5A 4N3
Phone 604.420.8773
Fax 604.357.1361

Date 3/7/08 Page 1 of 1

Sample Collection By:

Report to:

Company	WA State Dept. of Ecology
Address	4601 N. Monroe St.
City/State/Zip	Spokane, WA 99205
Contact	Brendan Dowling
Phone	509/ 329-3611
Email	bdow461@ecy.wa.gov

Invoice To:

Company	WA State Dept. of Ecology
Address	4601 N. Monroe St.
City/State/Zip	Spokane, WA 99205
Contact	Brendan Dowling
Phone	509/ 329-3611
Email	bdow461@ecy.wa.gov

	SAMPLE ID	DATE	TIME	MATRIX	CONTAINER TYPE	NO. OF CONTAINERS	COMMENTS	ANALYSES REQUIRED: WDOE 80-12 Hazardous Waste Characterization using Rainbow Trout only	Receipt Temperature (°C)
1	North Comp. A	3/7/2008		Sediment	8 oz. glass jar	1	# T08-043	X	
2	North Comp. A	3/7/2008		Sediment	8 oz. glass jar	1	THIS SAMPLE ONLY: grind partially prior to toxicity analysis (sample is labeled) # T08-042	X	
3	North 2B	3/7/2008		Sediment	8 oz. glass jar	1	T08-044	X	
4	North 3A	3/7/2008		Sediment	8 oz. glass jar	1	T08-045	X	
5	South Comp. A	3/7/2008		Sediment	8 oz. glass jar	1	T08-046	X	
6	South Comp. B	3/7/2008		Sediment	8 oz. glass jar	1	T08-047	X	
7	South 2A	3/7/2008		Sediment	8 oz. glass jar	1	T08-048	X	
8	South 2C	3/7/2008		Sediment	8 oz. glass jar	1	T08-049	X	
9									
10									

PROJECT INFORMATION

Client:	WA Dept of Ecology
PO No.:	ER-08-0112
Shipped Via:	UPS Ground

SAMPLE RECEIPT

Total No. of Containers	8
Received Good Condition?	Y
Matches Test Schedule?	Y

SPECIAL INSTRUCTIONS/COMMENTS:

RELINQUISHED BY (CLIENT)

(Signature) [signature] (Time) 1500

(Printed Name) ZACHARY T. HEDGPETH (Date) 3/7/08

(Company) DEPT OF ECOLOGY

RECEIVED BY (COURIER)

(Signature) (Time)

(Printed Name) (Date)

(Company)

RELINQUISHED BY (COURIER)

(Signature) (Time)

(Printed Name) (Date)

(Company)

RECEIVED BY (LABORATORY)

(Signature) [signature] (Time) 1515

(Printed Name) Elizabeth Tobin (Date) 3/11/08

(Company) Nautilus Environmental

Additional costs may be required for sample disposal or storage. Payment net 30 unless otherwise contracted.

APPENDIX !

ACUTE WATER-ONLY
EXPOSURES TO ELS
WHITE STURGEON

APPENDIX B
ACUTE WATER-ONLY EXPOSURES TO WHITE STURGEON ELS

Rationale

To assess the potential life-stage-specific sensitivity of white sturgeon to metals, two 96-hour LC50 studies will be conducted by the University of Saskatchewan (U of S) in parallel to studies being completed by the U.S. Geological Survey (USGS) laboratory in Columbia, Missouri. All studies will follow requirements listed in American Society for Testing and Materials (ASTM) guidelines for early life stage (ELS) testing of fish (ASTM 2009: E1241-05 and ASTM 2007: E729-96).

Approach

USGS-Columbia will use white sturgeon from the Columbia River as provided by Washington State Hatchery and will provide fish from the same source to the U of S. Both laboratories will conduct parallel studies with rainbow trout. Concentrations to be tested will be 0, 2, 4, 8, 16, 32, and 64 µg/L for copper. Selection of exposure concentrations was based on discussions with USGS (Little et al. pers. comm.) and concentrations cover the range of NOAECs[1], LOAECs[2], and LC50s[3] established during previous unpublished studies. U of S will assess the acute toxicity of copper at days 15 and 43 post-hatch.

The test conditions, general activity schedule, and summaries of the test acceptability requirements for conducting the studies are provided in Tables B1 through B3, respectively.

Measurements

Two types of samples will be taken during the studies described herein:

1. Samples for biological analysis. Sturgeon will be preserved in the event that later analysis of the following parameter is necessary:
    a. Gross and histopathological alterations (fixation in 10 percent buffered formalin)
2. Samples for exposure assessment. Test solutions will be collected at hour 0 and hour 96 and preserved for analysis of chemical of interest, cation, anion, and dissolved organic carbon.

[1] no-observed-adverse-effect concentrations

[2] lowest-observed-adverse-effect concentrations

[3] lethal concentration for 50 percent of the test populations

3. Sturgeon will be observed for survival and behavior changes at 6, 12, 24, 48, 72, and 96 hours.

Mortality data will be reported as the percentage of dead fry/juveniles compared to original number of fish in each chamber. Mortality will be assessed as follows: Dead fish will be discerned from live ones by immobility (e.g., in response to gentle prodding) and absence of respiratory movement in older individuals.

Quality Assurance

Testing will meet the quality criteria and quality assurance (QA) criteria defined in ASTM 2005 and 2007. All other QA requirements identified in Sections A and B of this Quality Assurance Project Plan (QAPP) for the Assessment of Sediment Toxicity to White Sturgeon are incorporated herein by reference and will be followed during acute toxicity testing of the white sturgeon ELS.

References

ASTM (American Society for Testing and Materials). 2009. Standard guide for conducting early life-stage toxicity tests with fishes. ASTM E 1241 – 05. American Society for Testing and Materials, West Conshohocken, PA, USA.

ASTM. 2007. Standard guide for conducting acute toxicity tests on test materials with fishes, macroinvertebrates, and amphibians. ASTM E 729 – 96. American Society for Testing and Materials, West Conshohocken, PA, USA.

Little, E. and others. 2010. Personal communication (technical team conference call on February 24, 2010). U.S. Geological Survey, Tacoma, WA.

TABLES

Table B-1. Test Conditions for Conducting a 96-Hour Acute Toxicity Test with White Sturgeon (*A. transmontanus*) Using Lab Water.

Parameter	Conditions
Test Type	Static renewal whole-water toxicity test with filtered laboratory water
Temperature	16 ± 1°C
Light Quality	Wide spectrum fluorescent lights
Photoperiod	16 hours light; 8 hours dark
Test System	Static renewal system (50% test solution replacement every 12 hours)
Water Volume	1 L (15 dph); 5 L (43 dph)
Renewal Frequency of Water	50% test solution renewal every 12 hours; pre-equilibration of test solutions ≥ 48 hours prior to water change
Age of Organisms	15 to 17 and 36 to 43 dph
Number of Organisms per Replicate Group	10
Number of Replicate Groups	Four replicates per treatment (dilution)
Feeding	No
Aeration	No
Water Source	Dechlorinated and filtered city water adjusted to a hardness of 60 mg/L $CaCO_3$ and a DOC between 2 and 3 mg/L
Water Quality	COPCs, dissolved oxygen, pH, temperature, and conductivity; ammonia, alkalinity, chlorine, hardness, and major cations (Ca, Mg, Na, K), nitrate + nitrite, sulfate, DOC
Test Duration	96 hours
Endpoints	Survival
Frequency of observations	Observations will be made after 0, 6, 12, and 24 hours, and every 24 hours thereafter
Test Acceptability	See Table B-3

Notes:
dph = days post hatch
DOC = dissolved organic carbon
$CaCO_3$ = calcium carbonate
COPC = contaminant of potential concern

Table B-2. General Activity Schedule for Conducting a 96-Hour Acute Toxicity Test with White Sturgeon (*A. transmontanus*).

Hour	Conditions
–48	• Prepare test solutions and allow to completely equilibrate for 48 hours • Set up exposure systems
–24 to –1	• Acclimate sturgeon to exposure system containing only reference/control water
0	• Initiate exposure by adding appropriate concentrations of test solutions to all treatment chambers • Test water quality in each exposure system (DO, pH, temperature, ammonia, nitrate, nitrite, hardness, alkalinity, phosphate, chlorine, sulfate) • Take and preserve samples for COPC analysis
6	• Observe all exposure groups and record changes in behavior (e.g., lethargy, hyperactivity) and mortalities
12	• Observe all exposure groups and record changes in behavior (e.g., lethargy, hyperactivity) and mortalities • Replace 50% of test solutions
24	• Test water quality in each exposure system (DO, pH, temperature) • Observe all exposure groups and record changes in behavior (e.g., lethargy, hyperactivity) and mortalities • Replace 50% of test solutions
36	• Replace 50% of test solutions
48	• Test water quality in each exposure system (DO, pH, temperature) • Observe all exposure groups and record changes in behavior (e.g., lethargy, hyperactivity) and mortalities • Replace 50% of test solutions
60	• Replace 50% of test solutions
72	• Test water quality in each exposure system (DO, pH, temperature) • Observe all exposure groups and record changes in behavior (e.g., lethargy, hyperactivity) and mortalities • Replace 50% of test solutions
84	• Replace 50% of test solutions
96	• Observe all exposure groups and record changes in behavior (e.g., lethargy, hyperactivity) and mortalities • Terminate study • Measure complete water quality suite and preserve samples for COPC analyses • Euthanize surviving fish in MS222

Notes:
DO = dissolved oxygen
COPC = contaminant of potential concern

Table B-3. Test Acceptability Requirements for a 96-Hour Acute Toxicity Test with White Sturgeon (*A. transmontanus*).

Acceptance Criteria	
1	Fish used for test should be from at least 2 to 4 different parent females and males
2	Average hatching rate of eggs in the lab water controls should not be less than 60%
3	Average survival in controls should be greater or equal to 80%
4	All water quality parameters with the exception of DO and temperature should not vary by more than 50% during the exposure
5	DO should be maintained above 70% saturation
6	Average daily temperature should be maintained at 16 ± 1°C; the instantaneous temperature must always be within ± 3°C of 16°C
Additional Acceptance Criteria	
1	All organisms must be from the same source

Notes:
DO = dissolved oxygen

APPENDIX C

STANDARD OPERATING PROCEDURES

LIST OF STANDARD OPERATING PROCEDURES

SOP-1 Positioning at Below-Water Stations

SOP-2 Field Documentation

SOP-3 Digital Camera Use and Documentation Procedures

SOP-4 Below-Water Grab Sampling Procedures

SOP-5 Sample Labeling

SOP-6 Chain of Custody – Field Samples

SOP-7 Chain of Custody – Laboratory

SOP-8 Sample Management: Receiving, Preservation, Storage, Documentation, Decontamination, and Disposal

SOP-9 Maintenance of Sample Chain-of-Custody

SOP-10 Maintenance of Sample Integrity, and Proper Usage of Refrigerators, Freezers, and Liquid Nitrogen Dewar Flasks

SOP-11 Standard Operating Procedure for Weighing Using Analytical Balances

SOP-12 Equipment Maintenance and Calibration

SOP-13 Experimental Exposure Systems for Field- and Laboratory-Based Studies of Aquatic Organisms Under Fluvial Conditions

SOP-14 Care and Maintenance of Early White Sturgeon (*Acipenser transmontanus*) Life-Stages under Laboratory Conditions

SOP-15 Preparation and Preservation of White Sturgeon (*Acipenser transmontanus*) Eggs, Fry and Juveniles for Histology, Molecular Biology Endpoints, Metal Analysis, and Evaluation of Nutritional State

SOP-16 Measurement of Water Quality and Processing of Water Samples During White Sturgeon (*Acipenser transmontanus*) Exposures

SOP-17 Data Package Review

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 the water surface.

Scope and Applicability

This SOP is applicable for determining the horizontal and vertical location of below-water surface 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 global positioning system (GPS) instrument with 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.

Vertical positioning will be done 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 surface stations will be accomplished using differential GPS (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 meters (3.3 to 9.8 feet). The following

requirements apply to the GPS instrument and will be verified initially by the Field Team Leader (FTL) 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 four satellites will be used for computing all positions.

The GPS antenna will be mounted on the swing davit or top centerline of the A-frame. This will avoid the need for computing distance offsets for the antenna location.

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. The vessel will be navigated until it is within a within a circle of 40 meters (131 feet) or less around the station location. A buoy will be deployed to mark the position. This buoy will have a short mooring line slope of about 1.1 to 1 so as to minimize the lateral excursion of the buoy on the surface of the water. The vessel will be maneuvered so that the buoy is no more than 10 meters (33 feet) from the vessel at the time the sampler or corer contacts the bottom. A radar and/or laser rangefinder fix will be taken at the time of the grab or core.

The sampling vessel must locate and remain fixed on the general sampling location before sampling can begin. The vessel operator (VO) will be responsible for navigating the boat to each sample location. For submerged sediment sampling, the boat will be positioned so that it is within a circle of 20 meters (66 feet) or less around the planned position at the time that the sediment sampler or corer contacts the bottom. The FTL will verify that the sample location is within the allowable position circle. If the actual sample position is outside the 20-meter radius, the vessel will be re-positioned. If conditions are such that the vessel's position cannot be maintained within the 20-meter radius, the sample will not be taken.

All submerged sediment samples will be taken without anchoring the vessel except when current or wind conditions preclude holding the vessel on station within the 20-meter position circle. The VO and FTL will determine whether anchoring is required for taking the sediment sample.

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 meters

deep) with drift rates exceeding about 0.5 meter per second (m/sec) (1.6 feet per second [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 kept to approximately 5 degrees or less for all sampling activities, if possible, and will be measured using a wire angle indicator. 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.

The VO is responsible at all times for the safe and prudent operation of the boat and the conditions under which any operation will be performed. This is particularly important for operations under stormy conditions, in shallow water, in strong currents, or any situation that affects the maneuverability and stability of the boat. Although the FTL is responsible for all scientific operations, it is the VO who will be responsible for any actions concerning operation of the boat.

Vertical Positioning

The vertical position of below-water surface stations will be determined using a fathometer. In areas where the depth is too shallow, a lead line or survey rod 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

FIELD DOCUMENTATION

Purpose

The purpose of this standard operating procedure (SOP) is to describe procedures used to properly document sample collection information to ensure transparency (and reproducibility) of methods and procedures.

Scope and Applicability

The integrity of each sample from the time of collection to the point of data reporting must be maintained throughout the study. 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. Several types of field documents will be used for this purpose by field personnel.

Field Logbooks

During field sampling events, field logbooks are used to record all daily field activities on each vessel used for sediment collection. The purpose of the field logbook is to document events that occur during field activities and to record data measured in the field to ensure transparency and reproducibility.

The field logbook is the responsibility of, and maintained by the Field Team Leader (FTL) for each vessel. The site logbook will be placed in the project files at the conclusion of field activities.

The field logbook will be bound and waterproof with consecutively numbered pages. All entries will be made using indelible ink and no erasures will be made. Any necessary corrections in the logbook should consist of a single line-out deletion, followed by the author's initials and the date. The author will initial and date each page of the field logbook, sign and date the last page at the end of each day, and draw a line through the remainder (unused portion) of that page.

- The project name, dates of the field work, site name, and location (city and state) should be written on the cover of the field logbook. If more than one logbook is used during a single sampling event, then the upper right hand corner of the logbook will be annotated (e.g., Volume 1 of 2, 2 of 2) to indicate the number of logbooks used during the field event. Field logbooks will be stored in a secure manner when not in use in the field. At a minimum, the following information will be recorded in the field logbook:
- Project name and location.
- Purpose and description of the field task.
- Project start date and end date.
- Date and time of entry (24-hour clock).
- Time and duration of daily sampling activities.
- Weather conditions at the beginning of the field work and any changes that occur throughout the day, including the approximate time of the change (e.g., wind speed and direction, rain, thunder, wave action, vessel traffic, temperature of both the air and water).
- Name and affiliation of person making entries and other field personnel and their duties, including the times that they are present.
- The location and description of the work area, including sketches, map references, and photograph log, if appropriate.
- Level of personal protection being used.
- Onsite visitors (names and affiliations), if any, including the times that they are present (e.g., cultural resource personnel, agency observers, etc.).
- The name, affiliation, and telephone number(s) of any key field contacts.
- Notation of the coordinate system used to determine the station location information.
- The sample identifier and analysis code for each sample to be submitted for laboratory analysis, if not included on separate field data sheets.
- All field measurements made (or reference to specific field data sheets used for this purpose), including the time that the measurement was collected and the date of calibration, if appropriate.
- The sampling location name, date, gear, water depth (if applicable), and sampling location coordinates, if not included on separate field data sheets.
- The type of vessel used (e.g., size, power, type of engine) (for aquatic sampling only).
- Specific information on each type of sampling activity.
- The sample type (e.g., surface sediment), sample number, sample tag number, and preservatives used (if any), if not included on separate field data sheets.
- Sample storage methods.
- Cross-references of numbers for duplicate samples.

- A description of the sample.
- Photographs (uniquely identified) taken at the sampling location, if any.
- Details of the work performed.
- Variations, if any, from the project-specific Quality Assurance Project Plan (QAPP) or standard operating protocols and reasons for deviation.
- Details pertaining to unusual events which might have occurred during sample collection (e.g., possible sources of sample contamination, equipment failure, unusual appearance of sample integrity).
- References to other logbooks or field forms used to record information (e.g., field data sheets, health and safety log).
- Sample shipment information (e.g., shipping manifests, COC form numbers, carrier, air bill numbers, time addresses).
- A record of quantity of investigation derived wastes (if any) and storage and handling procedures.

During the field day, as listed above, a summary of all site activities should be recorded in the logbook. The information need not duplicate anything recorded in other field logbooks or field forms (e.g., Site Health and Safety Officer's logbook, calibration logbook, field data sheets), but should summarize the contents of the other logbooks and refer to the page locations in these logbooks for detailed information.

If measurements are made at any location, the measurements and equipment used must either be recorded in the field logbook or reference must be made to the logbook and page number(s) on which they are recorded. All maintenance and calibration records for equipment should be traceable through field records to the person using the instrument and to the specific piece of instrumentation itself.

Upon completion of the field sampling event, the FTL will be responsible for submitting all field logbooks to be copied. A discussion of copy distribution is provided below.

Sample Processing and Field Data Forms

Sample processing and field data forms will be generated during this field sampling event to record the relevant sample information collected during a sampling event. Upon completion of the field sampling event, the FTL will be responsible for submitting all field data forms to be copied. A discussion of copy distribution is provided below.

Equipment Calibration Records

Equipment calibration records, including instrument type and serial number, calibration supplies used, calibration methods and calibration results, date, time, and personnel performing

the calibration, should be recorded in the field logbook. At a minimum, equipment used during the investigation should be calibrated daily in accordance with the manufacturers' recommendations.

Distribution of Copies

Two copies of all field logbooks and additional field data forms will be made at completion of the field event. The first copy will be stamped with a "COPY" stamp. This copy will be placed in the project file and will be available for general staff use. The second copy will be stamped with a "FILE" stamp. This copy will be placed in the data management file with the laboratory data packages and will be used by the data management and quality assurance staff only. The original field logbooks and forms will be placed in a locked file cabinet at the Project Manager's location.

STANDARD OPERATING PROCEDURE SOP-3

DIGITAL CAMERA USE AND DOCUMENTATION PROCEDURES

Purpose

The purpose of this standard of practice (SOP) is to describe the use of digital cameras and procedures for digital camera data management.

Scope and Applicability

This SOP is applicable to taking digital photographs and placing the digital data in a database. Digital photographs may be taken to document field activities, site conditions and features, and sampling locations.

Equipment and Materials

- Digital camera
- Spare batteries
- 12-volt charger
- Digital camera carrying case and manual
- Digital Photograph Data Form
- Permanent marker
- Personal computer.

Typical Camera Features

- Save pictures (in standard mode) directly to a memory stick or comparable
- Auto focus; manual focus available if required
- Zoom
- Brightness control
- Playback of photos on camera screen
- Display of photograph number, date, and time
- Flash
- Timer

- Display showing time remaining on battery and remaining disk capacity
- Ability to protect and delete images that have been taken.

Camera Use

Digital cameras will be used by the field team to document field activities. Each field team will be directly responsible for the camera and ensure that it is not exposed to excessive heat/cold or moisture. The field team leader (FTL) will be responsible for digital photograph documentation or for assigning documentation duties to a team member.

Digital photographs will be taken to document field activities and locations. Examples of field activities for which photo documentation will be useful include: 1) sample collected in bowls, van Veen, or other collection device along with station and sample identifiers, 2) station vicinity with associated river mile and compass directions noted, and 3) field sampling techniques utilized, such as equipment use/operation.

Digital photographs will be collected at a high-pixel setting such that enlargements can be made with minimal degradation in picture quality.

Photograph Documentation

Field Team Responsibilities

Each field team will keep a daily hard copy log of all photographs. The following digital photograph data will be collected:

- Camera identifier (type, model, equipment number).
- Project and event ID—this information is obtained from the FTL.
- Team members—list each team member.
- Photograph number—record the number of the photograph and the photograph file name (as coded below).
- Date and time—as provided by the camera display .
- Description—the target of the photograph.
- Station—identify a station ID (such as sample location ID), if applicable.
- Northing and easting—list the coordinates of the subject of the photograph and the compass direction in which the picture is being taken. Coordinates can be acquired from a global positioning system (GPS) or from the GIS system if the location has been surveyed. Coordinates do not need to be recorded for a station if the location was surveyed prior to photograph collection.
- Notes—record any other pertinent information (including coordinates of location where picture was taken [see above]).

Digital Photograph File Name

At the end of each field day, the member of the field team who is responsible for the camera will transfer the electronic data from the camera to the field operations computer. The folder structure will be as follows:

\\DATA\PHOTOS\VESSEL_xx\YYYYMMDD\LOCATION\file [1, 2, 3, ...N]

The third structure level shown above (e.g., VESSEL xx, VESSEL yy) continues for all sampling teams. The notation YYYYMMDD represents the year, month, day. The LOCATION is general area in the river (e.g., Marcus Flats, China Bend). The individual files for the day (e.g., file1, file 2, file N) will be placed within this folder using the default file identifier provided by the camera.

Transfer of Information and Archive

After the photograph disks have been uploaded, the original hard copy of the photograph log will be initialed and dated by the team member who downloaded the photographs, then archived by the FTL.

Sample Processing Coordinator Responsibilities

The FTL will be responsible for: 1) reviewing electronic photographs and the logs as they are made available to ensure consistency and completeness of annotations; 2) collecting and archiving the hard copies of the photograph logs; 3) reviewing electronic photographs and the logs as they are made available to ensure consistency and completeness of annotations; and 4) notifying the sampling team leader of apparent inconsistencies and making recommendations for corrective action.

Key Checks/Items

- Make sure the camera's battery is fully charged on a daily basis
- Keep extra memory sticks available
- To save battery life, use flash only when necessary
- Make sure the camera quality level is set at "best" or equivalent (high pixel)
- Review photograph records periodically to ensure that the electronic photographs and the data log agree
- Leave enough time at the end of the field day to transfer the data.

STANDARD OPERATING PROCEDURE SOP-4

BELOW-WATER GRAB SAMPLING PROCEDURES

Purpose

The purpose of this SOP is to describe sample collection and processing procedures for sediment samples collected using below-water grab sampling equipment.

Scope and Applicability

This sediment sampling SOP is divided into two procedures: the first procedure is applicable to sample locations that can be accessed by boat without disruption of bottom sediment or damage to the vessel, and the second procedure is applicable to below-water sample locations that are in shallow water or in areas that cannot be accessed by boat. Below-water sample locations include transect samples, focus area samples, tributary mouth samples, and bioassay and reference area samples (including samples from which pore water will be isolated). Under certain conditions (e.g., high water), beach samples may also be obtained from sediment that is submerged at the time of sampling. Vessel and sample positioning required prior to below-water sediment sampling is described in SOP-4, Positioning at Below-Water Stations.

Below-Water Sampling From Vessel

This procedure is applicable to below-water samples collected using a van Veen grab sampler operated from a vessel.

Equipment and Materials

The equipment and materials required for below-water grab sampling from a vessel are listed in Table 1.

Sample Collection Procedures

Vessels equipped with a van Veen grab sampler will be used to collect below-water sediment samples. A backup van Veen grab will also be available in the event that the primary grab is damaged, malfunctions, or is lost. Sampling locations will be approached at slow boat speeds with minimal wake to minimize disturbance of bottom sediments prior to sampling, particularly in shallow sampling locations. Sediment samples will be handled carefully to minimize disturbance during collection and transportation to the analytical laboratory.

Preparation for Sampling

After all sampling equipment and supplies have been transported to the work vessel, the van Veen grab can be assembled on deck. Because of the depth of water and the weight of the sampler, a hydraulic winching system will be used to control the rate of the sampler ascent and descent. When not in use, the sampler will always be secured when the vessel is underway.

The hydrowire will be attached to the sampler using a ball-bearing swivel (or similar hardware) to minimize any twisting forces during deployment and recovery. The hydrowire, swivel, and shackles will all have a working load capacity at least three times the weight of a full sampler (e.g., approximately 250 kilograms [kg] or 550 pounds [lb]).

At the direction of the field team leader (FTL), the vessel will move to the sampling station and, depending on surface wind and wave conditions, will be held or anchored onstation using the differential global positioning system (DGPS) (or GPS if the DGPS cannot be received) and navigation system (see SOP-4, Positioning at Below-Water Stations). At this time, relevant information on sampling date, time, station location and coordinates, local water depth, and weather observations will be recorded in the field notebook in accordance with sample documentation requirements identified in the main body of the FSP.

Sampling Procedure

A decontaminated van Veen sampler (see SOP-8) will be used to collect the sediment samples. Once the sampler is ready for deployment, the sampler will be locked open with the safety pin. The sampler will be deployed using the hydraulic winch and an overhead davit or boom. While the winch operator slowly picks up the sampler with the hydrowire, another team member will be responsible for safely guiding the sampler over the side of the boat and into position over the intended sampling location. The safety pin will be removed while keeping hands and fingers outside the sampler. The deckhand will indicate to the winch operator when the sampler is at the surface and ready for sampling. At this time, the FTL will notify the vessel operator (VO) that sampling will commence and that the VO should prepare to collect a DGPS/GPS fix.

The position of the sampler relative to the riverbed can be shown by configuring the display of the vessel's depth sounder. Alternatively, the sampler may be lowered at a controlled rate of speed approximately equal to 30 centimeters per second (cm/sec) (1 foot per second [ft/sec]). The location of the sampler as it is lowered through the water column would then be determined either by rigging the hydrowire to a meter wheel or using pre-marked meter lengths on the cable itself.

Under no circumstances should the sampler be allowed to "free fall" to the bottom. Doing so may result in premature triggering of the sampler, or an excessive bow wake around the sampler, or improper orientation of the sampler. When the sampler reaches the mudline, the

cable will be drawn taut and DGPS/GPS coordinates recorded. **Note: 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).** After the sample is collected, the sampling device will be lifted slowly off the bottom, then steadily raised to the surface at a speed of about 30 cm/sec (1 ft/sec). Care will be used to avoid swinging or tipping the sampler during retrieval.

Once aboard the vessel, the sampler will be gently lowered onto a sampling table or stand. This waist-high stand may be constructed of wood and should be large enough to hold the sampler and allow for at least two team members to retrieve the sample. Ideally, the stand will be approximately 1 meter wide by 1.5 meters long (3 feet by 4 feet), one end of which will extend over the transom or gunwale of the work vessel.

The access doors on the top of the sampler, which consist of wire mesh screens and rubber flaps, allow visual characterization of the sediment surface and aid in assessing sample acceptability. Each surface grab sample will be retrieved aboard the vessel and evaluated for the following acceptance criteria, which are illustrated generally in Figure 1:

- Overlying water is present and has low turbidity.
- Adequate penetration depth is achieved.
- The sampler is not overfilled (no contact with doors).
- The sediment surface is undisturbed.
- There are no signs of winnowing or leaking from the sampling device.

Grab samples not meeting these criteria will be rejected near the location of sample collection and steps repeated until the criteria have been met or until three attempts at a location have failed. Deployments will be repeated within a 20-meter (66-foot) radius of the proposed sample location, or other suitable location based on observed conditions, as determined by FTL. If adequate penetration is not achieved after multiple attempts, less volume will be accepted and noted in the field notebook. Chemical replicate samples will be a split sample. All samples will be collected to a depth of approximately 10 cm. The following are minimum penetration depths based on sample grain size:

- Coarse to medium sand: 4 to 5 cm
- Fine sand: 6 to 7 cm
- Silt and clay: 10 cm

Before sample processing commences, the material in the sampler will be photographed and the photograph labeled with station location, date, and time of sample. The overlying water will

then be siphoned off near one corner of the sampler. Next, a decontaminated stainless steel trowel or spoon may be used to collect only the upper 10 to 15 cm (4 to 6 inches) of sediment from inside the sampler, without touching the sidewalls. The sampler and sampling table will be decontaminated between stations and rinsed with site water between grabs in accordance with the equipment decontamination procedures described in SOP-8.

Sample Processing Procedures

After an acceptable grab sample is retrieved, the following processing steps will be completed on the vessel for all discrete grab samples (the procedures for processing of composite samples are in SOP-8):

1. Physical characterization will be performed in general accordance with the American Society for Testing and Materials (ASTM) D2488-00 visual-manual description procedure. The following information will be recorded on the Sediment Sample Data Sheet and signed by the FTL:
    - Date, type, and name of person logging the sample
    - Weather conditions
    - Sample location number and coordinates
    - Project designation
    - Depth of water at the location and surface elevation
    - Equipment used
    - Whether an examination was made by the cultural resources observer and whether the observer established the presence of any historical or cultural resources requiring this target sampling station to be abandoned, in accordance with the process described in the main body of the FSP
    - Sediment texture
    - Sediment color
    - Presence, type, and strength of odors
    - Grab penetration depth (nearest centimeter)
    - Degree of leakage or sediment surface disturbance
    - Any obvious abnormalities such as wood/shell fragments or large organisms
    - Estimation of sample recovery volume (e.g., percent full)

2 The sediment will be transferred to an aluminum-foil-lined stainless steel bowl for homogenization with disposable hand tools. Sediment that is in direct contact with the sides of the grab sampler should not be included with the sediment placed in the bowl to avoid potential contamination from the device. Team members conducting the sample processing will don a clean pair of disposable nitrile gloves and collect the upper 10 centimeters of sediment using disposable hand tools.

3 Any obvious abnormalities present (e.g., wood/shell fragments or large organisms) and coarser grained sediment (e.g., pebbles and gravel) will be removed from the sample by hand or using disposable hand tools.

4 In the event that one grab sample does not have an adequate volume for the sample aliquot, repeat the sampling procedure at the same station and combine and thoroughly homogenize the samples.

5 The homogenized sample will be distributed into the appropriate pre-labeled sample containers, filled to capacity, and stored in a cooler with a maximum temperature of 4 degrees Celsius (°C).

6 The sampling equipment will be decontaminated according to the procedures described in SOP-8.

7 Any excess sediment remaining after processing will be returned to the water, and the deck will be rinsed clean after all grab samples are collected and before moving to the next station.

8 The sampler will be secured and moved to the next sample location.

Below-Water Sampling in Shallow Water

This procedure is applicable to below-water samples collected in shallow water using hand-operated equipment.

Equipment and Materials

The equipment and materials required for below-water grab sampling by hand in shallow water are listed in Table 2.

Sample Collection Procedures

Shallow-water sampling locations may be accessed by vessel or by land. The sampling team will be equipped with a petite ponar grab sampler and disposable hand tools, with backups available in the event of equipment failure. Sediment samples will be handled carefully to minimize disturbance during collection and transportation to the analytical laboratory.

Preparation for Sampling

All sampling equipment and supplies will be transported to the sampling station by water vessel or land vehicle. For approach by water, the vessel will maneuver as close to shore as possible, to water depths of 2 feet or less, near the sampling station at the direction of the FTL; the field team will disembark with the necessary field equipment. Approach via land vehicle will use the best available path.

At the direction of the FTL, personnel will identify the sampling station using the DGPS (or GPS if the DGPS cannot be received) and navigation system (see SOP -1, Positioning at Below-Water Stations). The sampler will observe the general hydrologic and geologic conditions present at the proposed location and determine whether the location is suitable for sampling of fine-grained sediment. If the materials present are primarily gravel, cobbles, or rocks, an alternative sample location in the vicinity will be identified and the DGPS or GPS coordinates will be determined and recorded in the field notebook. All relevant information on sampling date, time, station location and coordinates, local water depth, and weather observations will be recorded in the field notebook in accordance with sample documentation requirements identified in the main body of the FSP.

Sampling Procedure

The petite ponar grab sampler is the preferred equipment for collection of sediment samples in shallow water areas. The petite ponar will be operated by hand. Under no circumstances should the sampler be allowed to "free fall" to the bottom. Doing so may result in premature triggering of the sampler, or an excessive bow wake around the sampler, or improper orientation of the sampler. After the sample is collected, the sampling device will be lifted slowly off the bottom, then steadily raised to the surface.

The access doors on the top of the sampler, which consist of wire mesh screens and rubber flaps, allow visual characterization of the sediment surface and aid in assessing sample acceptability. Each surface grab sample will be evaluated for the following acceptance criteria, which are illustrated generally in Figure 1:

- Overlying water is present and has low turbidity.
- Adequate penetration depth is achieved.
- The sampler is not overfilled (no contact with doors).
- The sediment surface is undisturbed.
- There are no signs of winnowing or leaking from the sampling device.

Grab samples not meeting these criteria will be rejected near the location of sample collection and steps repeated until the criteria have been met or until three attempts at a location have

failed. If adequate penetration is not achieved after multiple attempts or the sample is too coarsely grained, multiple grabs of lesser volume will be accepted and noted in the field notebook. If all attempts at use of the petite ponar fail, disposable hand tools may be used to gather the sediment sample. At such locations, the reasons for using hand tools will be thoroughly detailed in the field notebook.

Before sample processing commences, the material in the sampler will be photographed and the photograph labeled with station location, date, and time of sample. The overlying water will then be siphoned off near one corner of the sampler. Next, a decontaminated stainless steel trowel or spoon may be used to collect only the upper 10 (4 inches) of sediment from inside the sampler, without touching the sidewalls. The sampler will be decontaminated between stations and rinsed with site water between grabs in accordance with the equipment decontamination procedures described in SOP-8.

Sample Processing Procedures

After an acceptable grab sample is retrieved, the following processing steps will be completed for all discrete grab samples (the procedures for processing of composite samples are in SOP -8):

1. Physical characterization will be performed in general accordance with the American Society for Testing and Materials (ASTM) D2488-00 visual-manual description procedure. The following information will be recorded on the Sediment Sample Data Sheet and signed by the FTL:
    - Date, type, and name of person logging the sample
    - Weather conditions
    - Sample location number and coordinates
    - Project designation
    - Depth of water at the location and surface elevation
    - Equipment used
    - Whether an examination was made by the cultural resources observer and whether the observer established the presence of any historical or cultural resources requiring this target sampling station to be abandoned, in accordance with the process described in the main body of the FSP
    - Sediment texture
    - Sediment color
    - Presence, type, and strength of odors

- Grab penetration depth (nearest centimeter)
- Degree of leakage or sediment surface disturbance
- Any obvious abnormalities such as wood/shell fragments or large organisms
- Estimation of sample recovery volume (e.g., percent full)

2 The sediment will be transferred to an aluminum-foil-lined stainless steel bowl for homogenization with disposable hand tools. Sediment that is in direct contact with the sides of the grab sampler should not be included with the sediment placed in the bowl to avoid potential contamination from the device. Team members conducting the sample processing will don a clean pair of disposable nitrile gloves and collect the upper 10 to 15 centimeters of sediment using disposable hand tools.

3 Any obvious abnormalities present (e.g., wood/shell fragments or large organisms) and coarser-grained sediment (e.g., pebbles and gravel) will be removed from the sample by gloved hand or by disposable hand tools.

4 In the event that one grab sample does not have an adequate volume for the sample aliquot, repeat the sampling procedure at the same station and combine and thoroughly homogenize the samples.

5 The homogenized sample will be distributed into the appropriate pre-labeled sample containers, filled to capacity, and stored in a cooler with a maximum temperature of 4 °C.

6 Any reusable sampling equipment will be decontaminated according to the procedures described in SOP-8.

7 Any excess sediment remaining after processing will be returned to the water, and the deck will be rinsed clean after all grab samples are collected and before moving to the next station.

8 The sampler will be secured and moved to the next sample location.

Table 1. Equipment List for van Veen Grab Sampling Operations

Description	Quantity
van Veen grab—0.11 m^2 area (20-L capacity), stainless steel	1 ea
Lead weights for van Veen grab—3.4 kg (7.5 lb)	2 ea
Lead weights for van Veen grab—5.0 kg (11 lb)	2 ea
Plastic floats for van Veen Grab	2 ea
Spare parts and tool kit for van Veen grab	1 ea
Field Sampling Plan	1 copy
Daily sampling schedule	2 copies
Health and Safety Plan	1 copy
Personal protection equipment as required by the Health and Safety Plan	as needed for day[a]
Field notebook	1 ea
Camera—35 mm with flash unit (or digital with flash unit)	1 ea
For 35 mm camera—Film, 400/36, color print	2 rolls
For digital camera— memory cards	2 ea
Camera kit (batteries, charger, instructions, lens cleaner, and wipes)	1 ea
Pens—ballpoint, black ink	4 ea
Duct tape	2 rolls
Measuring tape	1 ea
Stainless steel ruler	1 ea
Decontamination equipment as listed in SOP-8	as needed for day[a]
Disposable tubing to siphon off water in sampler	as needed for day[a]
Disposable stainless steel spoons, scoops, or spatula for sediment sample transfer	as needed for day[a]
Aluminum-foil-lined stainless steel bowls for sediment homogenization	as needed for day[a]
Sample bottles as specified in the sample matrix table	as needed for day[a]
Coolers with ice for sample storage	as needed for day[a]
Field data sheets, chain-of-custody forms, sample labels, custody seals, and related materials	as needed for day[a]
Nitrile gloves	as needed for day[a]
Paper towels or Kimwipes	as needed for day[a]

[a] To be determined for each day's sampling and stocked before vessel departs.
ea = each; kg = kilogram; L = liter; lb = pound; m^2 = square meter; mm = millimeter

Table 2. Equipment List for Petite Ponar Grab Sampling Operations

Description	Quantity
Petite ponar grab sampler (2.5-L capacity), stainless steel	1 ea
Spare parts and tool kit for petite ponar grab	1 ea
Field Sampling Plan	1 copy
Daily sampling schedule	2 copies
Health and Safety Plan	1 copy
Personal protection equipment as required by the Health and Safety Plan	as needed for day[a]
Field notebook	1 ea
Camera—35 mm with flash unit (or digital with flash unit)	1 ea
For 35 mm camera—Film, 400/36, color print	2 rolls
For digital camera— memory cards	2 ea
Camera kit (batteries, charger, instructions, lens cleaner, and wipes)	1 ea
Pens—ballpoint, black ink	4 ea
Duct tape	2 rolls
Measuring tape	1 ea
Stainless steel ruler	1 ea
Decontamination equipment as listed in SOP-8	as needed for day[a]
Disposable tubing to siphon off water in sampler	as needed for day[a]
Disposable stainless steel spoons, scoops, or spatula for sediment sample transfer (and for last resort sample collection)	as needed for day[a]
Aluminum-foil-lined stainless steel bowls for sediment homogenization	as needed for day[a]
Sample bottles as specified in the sample matrix table	as needed for day[a]
Coolers with ice for sample storage	as needed for day[a]
Field data sheets, chain-of-custody forms, sample labels, custody seals, and related materials	as needed for day[a]
Nitrile gloves	as needed for day[a]
Paper towels or Kimwipes	as needed for day[a]

[a] To be determined for each day's sampling and stocked before vessel departs.
ea = each
L = liter
mm = millimeter

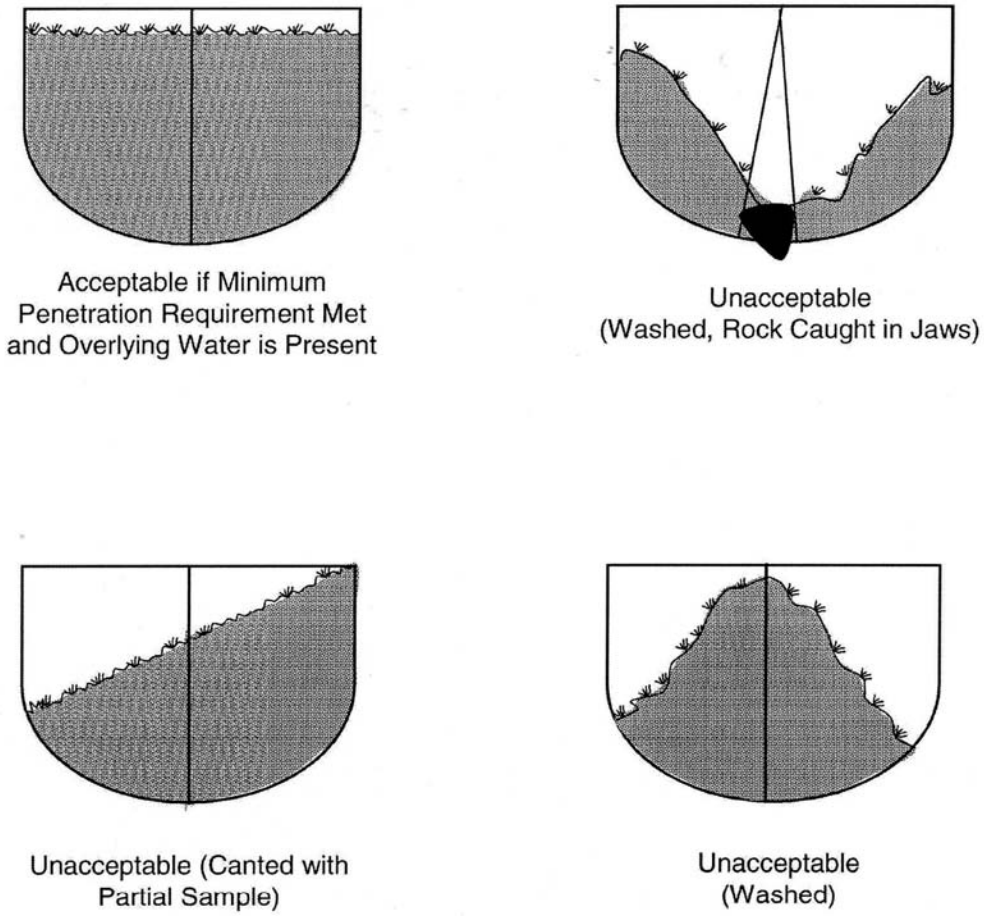


Figure 1. Examples of Acceptable and Unacceptable Grab Samples

STANDARD OPERATING PROCEDURE SOP-5

SAMPLE LABELING

Scope and Application

This SOP describes the general procedures for sample labeling and the three different kinds of labels that could be used on a project (i.e., sample labels, sample tags, and internal sample labels). The project-specific sampling and analysis plan (SAP) should be consulted to determine the exact sample identifiers and sample labels required for a given project. If they are not specified in the SAP, the designations listed below should be followed.

Sample Identifiers

Sample identifiers will be established before field sampling begins and assigned 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. To accomplish these purposes, each container may have three different codes associated with it: the sample identifier, the sample number, and the sample tag number. These codes and their uses are described as follows:

- Sample Identifier—The sample identifier is a unique designation that identifies where and how the sample was collected. The sample identifier is recorded in the field logbook *only* and is not provided on the sample label or chain-of-custody form. The sample identifier is a multiple-part code. The first component will begin with the letter abbreviation; for example, "DME" to designate the sample was collected at Deadman's Eddy. The second part could identify the specific location; for example, "1" to designate Location 1 at Deadman's Eddy. The station number would be the final component and complete the sample identifier. Leading zeros will be used for stations with numbers below 100 for ease of data management and correct data sorting.

  If appropriate, a supplemental component will be added to the sample identifier to code field duplicate samples and splits. A single letter (i.e., a suffix of "A" and "B") will be used to indicate field duplicates or splits in the final component of the sample

identifiers. For equipment decontamination blanks, sequential numbers starting at 900 will be assigned instead of station numbers. The sample type code will correspond to the sample type for which the decontamination blank was collected. Additional codes may be adopted, if necessary, to reflect sampling equipment requirements (see project-specific SAP).

- Sample Number—The sample number is an arbitrary number assigned to each distinct sample or split that is shipped to the laboratory for separate analysis. The sample number appears on the sample containers and the COC forms. Each sample will be assigned a unique sample number. All aliquots of a composited field sample will have the same sample number. Note that in cases where samples consist of multiple buckets from the same location, each bucket will be assigned the same sample number and time. Replicates from the same location, however, will be assigned a different sample number and time, and the sample numbers of related field replicates will not necessarily have any shared content. Each field split of a single sample will also have a different sample number and time.

  The sample number is a unique number that is generally assigned six digits, including a two-digit media code and a four-digit number. The media code may be site-specific, but the default codes are as follows:

  - SS – Surface soil
  - BH – Subsurface soil or rock (typically from borehole)
  - GW – Groundwater
  - SW – Surface water
  - PW – Pore water
  - SD – Sediment
  - BT – Biota or biological tissue

  The exact sample numbering scheme may vary from project to project. Variances in the sample numbering scheme will be described in the project-specific SAP for the field event.

  Example sample numbers would be: PW0001, PW0002, PW0003, etc.

- **Tag Number**—A different tag number is attached to each sample container. If the amount of material (i.e., everything associated with a single sample number) is too large for a single container, each container will have the same sample number and a different

sample tag. A sample will also be split between containers if a different preservation technique is used for each container (i.e., because different analyses will be conducted).

The sample tag number is a unique five-or six-digit number assigned to each sample label (or "tag") for multiple bottles per sample. Sample labels come with a pre-printed sample tag number. The purpose of the tag number is to provide a unique tracking number to a specific sample bottle. This allows for greater flexibility in tracking sample bottles and assists in field quality control when filling out documentation and shipping. Sample tags are not used by many other consultants, and there may be resistance from such firms during teaming situations. However, experience has shown that tags can be very valuable, both in the field and while processing data from field efforts.

The tag number will appear on the COC forms. Tag numbers are used by laboratories only to confirm that they have received all of the containers that were filled and shipped. Data are reported by sample number.

Sample numbers will be assigned sequentially in the field; sample labels will be preprinted with sequential tag numbers.

Sample Labels

Sample labels are designed to uniquely identify each individual sample container that is collected during a sampling event. Field sampling teams will be provided with preprinted sample labels, which must be affixed to each sample container used. The labels should be filled out at the time the samples are collected and should consist of the following information:

1 Sample number

2 Site name or project number

3 Date and time sample is collected

4 Initials of the samplers

5 Preservatives used, if any

6 A unique number (commonly referred to as the "Tag Number") that is preprinted on the label consisting of five or six digits; used to identify individual containers.

Sample Tags

Sample tags are designed to be affixed to each container that is used for a sample. Sample tags are only required for environmental samples collected in certain U.S. Environmental Protection Agency (EPA) regions (i.e., EPA Region 5). Field crews will be provided with preprinted sample

tags. Sample tags must be attached to each individual sample container with a rubber band or wire through a reinforced hole in the tag. All sample tag entries will be made with indelible ink. The tags should be filled out at the time the samples are collected and should consist of the following information:

1 Sample number

2 Site name or project number

3 Date and time sample is collected

4 Initials of the samplers

5 Preservatives used, if any

6 Type of analysis.

A space for the laboratory sample number (provided by the laboratory at log-in) will also be provided on the sample tag.

STANDARD OPERATING PROCEDURE SOP-6

CHAIN-OF-CUSTODY – FIELD SAMPLES

Scope and Application

This SOP describes procedures for custody management of sediment samples collected for sturgeon sediment bioassays.

A stringent, established program of sample chain-of-custody will be followed during sample storage and shipping activities to account for each sample. 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 of project personnel's custody unless the samples have been transferred to a secure area (i.e., locked up). If the samples cannot be placed in a secure area, then a field team member must physically remain with the samples (e.g., at lunch time one team member must remain with the samples).

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. 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.

The COC forms each consist of 3-part carbon-less paper with white, yellow, and pink copies. The pink copy is kept by the sampling team leader. The white sheet and the yellow sheet will be placed into a plastic sealable bag and secured to the inside top of each transfer container (e.g., cooler). The pink sheet will be retained by the field staff for filing at the Project Manager's location. Each COC form has a unique 4-digit number. This number and the samples on the form shall be recorded in the field logbook. If computer-generated forms are used, then the forms must be printed in triplicate and all three sheets signed so that two sheets can accompany the shipment to the laboratory and one sheet can be retained on file at the Project Manager's location. Alternatively, if sufficient lead time is available, the computer-generated forms will be printed on 3-part carbon-less paper.

The project-assigned sample number and the unique tag number at the bottom of each sample label 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. In addition, the COC form provides information on the preservative or other sample pretreatment applied in the field and the analyses to be conducted by referencing a list of specific analyses or the statement of work for the laboratory. The COC form will be sent to the laboratory along with the sample(s).

Procedures

The following guidelines will be followed to ensure the integrity of the samples:

1 Each COC form must be appropriately signed and dated by the sampling personnel. The person who relinquishes custody of the samples must also sign this form.

2 At the end of each sampling day and prior to shipping or storage, chain-of-custody entries will be made for all samples. Information on the labels and tags will be checked against field logbook entries.

3 The COC form should not be signed until the information has been checked for inaccuracies by the sampling team leader. All changes should be made by drawing a single line through the incorrect entry and initialing and dating it. 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.

4 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.

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 also should be entered on the COC form. The time of transfer should be as close to the actual drop-off time as possible. After the COC forms are signed and the "pink" copy has been removed, they should be sealed inside the transfer container.

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 Samples that are archived internally must be accompanied by a COC form and an Archive Record form.

8 Upon completion of the field sampling event, the sampling team leader will be responsible for submitting all COC forms to be copied.

Custody Seal

As security against unauthorized handling of the samples during shipping, custody seals will be affixed to each sample cooler. The custody seals will be placed across the opening of the cooler (front right and back left) 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.

Acknowledgement of Sample Receipt Forms

In most cases, when samples are sent to a testing laboratory, an Acknowledgment of Sample Receipt form is faxed to the project QA/QC coordinator the day the samples are received by the laboratory. It is the responsibility of the person receiving this form to review the form and make sure that all the samples that were sent to the laboratory were received by the laboratory and that the correct analyses were requested. If an error is found, the laboratory must be called immediately. Decisions made during the telephone conversation should be documented in writing on the Acknowledgment of Sample Receipt Form. In addition, corrections should be made to the COC form and the corrected version of the COC form should be faxed to the laboratory.

The Acknowledgment of Sample Receipt form (and any modified COC forms) will then be submitted to be copied.

STANDARD OPERATING PROCEDURE SOP-7

CHAIN-OF-CUSTODY – LABORATORY

Scope and Applicability

This standard operating procedure (SOP) describes procedures for custody management of environmental samples. 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 of project personnel's custody unless the samples have been transferred to a secure area (i.e., locked up and custody sealed). If the samples cannot be placed in a secure area, then a field team member must physically remain with the samples (e.g., at lunch time one team member must remain with the samples).

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. 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. The COC forms each consist of three-part carbonless paper with white, yellow, and pink copies. The white sheet and the yellow sheet will be placed into a plastic sealable bag and secured to the inside top of each transfer container (e.g., cooler). The pink sheet will be retained by the field staff for filing at the Project Manager's location. Each COC form has a unique number. This number and the samples on the form shall be recorded in

the field logbook. Computer-generated COC forms may be used instead of the hard copy forms. If computer-generated forms are used, then the forms will be printed in triplicate, sequentially numbered, and all three sheets signed so that two sheets can accompany the shipment to the laboratory and one sheet can be retained on file at the Project Manager's location.

The individual sample labels 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. In addition, the COC form provides information on the preservative or other sample pretreatment applied in the field and the analyses to be conducted by referencing a list of specific analyses or the statement of work for the laboratory. The COC form will be sent to the laboratory along with the sample(s).

Procedures

The following guidelines will be followed to ensure the integrity of the samples:

1. At the end of each sampling day and prior to shipping or storage, COC entries will be made for all samples and COCs will be filled out for all samples. 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. Usually the Field Team Leader (FTL) will relinquish the samples. The time that the samples were relinquished should match. Each COC form must be appropriately signed and dated by the sampling personnel. The person who relinquishes custody of the samples must also sign this form.
3. The COC form should not be signed until the information has been checked for inaccuracies by the FTL. All changes should be made by drawing a single line through the incorrect entry and initialing and dating it. 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.
4. 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.
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 the COC forms are signed and the "pink" copy has been removed, they should be sealed inside the transfer container.

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. Samples that are archived internally at Parametrix or a Parametrix authorized laboratory must be accompanied by a COC form and an Archive Record form.
8. Upon completion of the field sampling event, the FS will be responsible for submitting all COC forms to be copied.

Custody Seal

As security against unauthorized handling of the samples during shipping, two custody seals will be affixed to each sample cooler. The custody seals will be placed across the opening of the cooler (front right and back left) 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.

Shipping Air Bills

When samples are shipped from the field to the testing laboratory via a commercial carrier (e.g., Federal Express, UPS), an air bill or receipt is provided by the shipper. Upon completion of the field sampling event, the FS will be responsible for submitting the sender's copy of all shipping air bills to be copied. The air bill number (or tracking number) should be noted on the applicable COC forms or alternatively the applicable COC form number should be noted on the air bill to enable the tracking of samples if a cooler becomes lost.

Acknowledgement of Sample Receipt Forms

In most cases, when samples are sent to a testing laboratory, an Acknowledgment of Sample Receipt form is faxed to the project QA/QC coordinator the day the samples are received by the laboratory. It is the responsibility of the person receiving this form (designated by Project Manager) to review the form and make sure that all the samples that were sent to the laboratory were received by the laboratory and that the correct analyses were requested. If an error is found, the laboratory must be called immediately. Decisions made during the telephone conversation should be documented in writing on the Acknowledgment of Sample Receipt Form. In addition, corrections should be made to the COC form and the corrected version of the COC form should be faxed to the laboratory.

The Acknowledgment of Sample Receipt form (and any modified COC forms) will then be submitted to be copied.

Archive Record Forms

On occasion, samples are archived at an authorized laboratory. If samples are to be archived, it is the responsibility of the project manager or analytical laboratory manager to complete an Archive Record form. This form is to be accompanied by a copy of the COC form for the samples, and will be placed in a locked file cabinet. The original COC form will remain with the samples in a resealable plastic bag.

STANDARD OPERATING PROCEDURE SOP-8

SAMPLE MANAGEMENT: RECEIVING, PRESERVATION, STORAGE, DOCUMENTATION, DECONTAMINATION, AND DISPOSAL

Purpose

This standard operating procedure (SOP) specifies the requirements for sample receipt, control, record keeping, decontamination, and disposal at the Environmental Toxicology Laboratory (ETL) at the University of Saskatchewan (U of S).

Scope and Applicability

This SOP applies to the ETL for samples supplied from the Upper Columbia River white sturgeon studies.

Safety Considerations

Safety training and medical monitoring requirements are described in the Health and Safety Plan for the Upper Columbia River Remedial Investigation and Feasibility Study (TCAI 2007).

In addition, there are various safety concerns regarding the receipt, storage, and disposal of sample containers at the ETL. Upon receipt, the sample containers will be monitored for breakage. If sample containers are broken, the appropriate personnel will be immediately notified and the Department of Health, Safety and Environment (DHSE) will be called in order to assess the hazard. DHSE will also be contacted in the case of chemical spills and will be responsible for the disposal of hazardous wastes.

Personal Protective Equipment

Personnel protective equipment (PPE), consisting of lab coats, safety glasses, and latex gloves will be worn at all times when handling samples.

Waste Management

All waste will be managed and disposed of in accordance with U of S DHSE regulations. Waste management practices will include the control of all standards and solutions. This means that if required expired or used standards, associated solvents and other chemicals used for

preservation and biological or element analysis will be disposed of in labeled waste containers and DHSE will be notified for waste pick up.

Spill Decontamination

If a spill occurs in the laboratory, DHSE will be notified immediately. The area where the spill occurred will be evacuated and marked.

Equipment, Materials, and Reagents

The sample storage area is equipped with a locked freezer, refrigerator and a liquid nitrogen Dewar flask in which samples are stored as appropriate. Access to these storage areas is limited to laboratory personnel with appropriate authorization that work at the Toxicology Centre (lockable walk-in cold room and freezer, and liquid nitrogen storage room), or only to the white sturgeon UofS study team (separate lockable fridge and freezer units). A list of personnel with access to refrigerators, freezers and dewars and other storage areas will be established once the hiring and training portion of the studies is completed. Sediments and archived samples will be sealed with a breakable seal that is dated and initialed. The freezer and Dewar flask are connected to phone and audible alarm systems that monitor temperature and notify laboratory personnel in cases of temperature and/or power related issues. A calibrated balance is also kept in the sample storage area and is used to weigh sub-samples. Sample storage at 4°C will occur in a lockable walk-in refrigerator that is connected to a phone alarm system. Temperature in the walk-in refrigerator is monitored continuously by an automated temperature logging system, and checked manually every morning during weekdays. In case of a building power outage, an auxiliary generator automatically provides power to freezers and the walk-in refrigerator and an alarm is sent to U of S Public Safety office.

No materials or reagents are used in sample receipt.

METHOD, PROCEDURES, AND REQUIREMENTS

Sample Receipt

The physical condition of coolers or other containers used for transportation, and each individual sample container will be inspected upon arrival at the ETL. The following objectives have been established for sample receiving:

A. Inspect sample coolers and samples for signs of damage upon receipt at the laboratory.

B. Attach air bill or shipping receipt to the chain-of-custody (COC) form.

C. Examine individual samples and record their status (frozen/ not frozen; immersed in preservation liquid, etc.) on a sample receipt form.

D. Verify that a COC form is submitted with samples, and that the COC contains all information required for analysis and reporting. Maintain custody of samples by ensuring that all dates, times, and signatures are provided on the COC forms.

E. Identify and reconcile any discrepancies between the COC and sample labels.

F. Verify that sample containers, labeling, or other requirements are correct. Assign a unique lab identification number to each sample and log samples into the sample tracking sheet (STS) (see attached STS.) Identify any hazards or special precautions associated with the incoming samples.

G. Notify appropriate laboratory and field study personnel when samples have arrived. These individuals are to be identified in either a Work Plan or Sampling and Analysis Plan (SAP).

H. Track and document the handling of samples from receipt through data reporting to final disposal. This will be accomplished by keeping all of the log forms in a binder kept in the laboratory.

Sample Documentation

Upon arrival, the shipping receipts will be collected from the cooler and be stapled to the COC form. Samples submitted to the ETL will be accounted for by documenting their arrival and condition on COC and sample tracking sheets. Within the ETL, the STS will be used to monitor the samples whereabouts at all times. Aliquots removed will be recorded on the STS. While handling samples, any anomalies or problems will be noted in bound laboratory notebooks.

Sample Storage and Preservation

Samples will be stored in liquid nitrogen, freezer, refrigerator or locked storage room at room temperature (formalin preserved sturgeon samples) in the laboratory. This room is accessible only to lab personnel. The freezer and (walk-in) refrigerators will be set at -20°C and +4°C, respectively, and the temperature will be monitored daily. If for any reason there is a power outage or an increase in temperature, the facility manager on call and/or other lab personnel will be immediately notified by the automated phone alarm system that will automatically call the cell phone of the person on duty. Also, the walk-in refrigerator for the storage of sediments is connected to a backup generator that insures continuous operation in case of a power outage. The necessary action will then be taken to ensure that sample integrity is not compromised. If samples are removed from any of the storage compartments/units for any reason, this activity will be documented on the STS form. Copies of the forms will be placed in the records archive. When samples are removed for preparation and analysis, a sample extraction form will be completed.

Storage Container and Compositing Equipment Decontamination

All equipment used for storage (e.g. HPDE buckets, instruments to move samples) as well as all other equipment that could come into contact with chemically affected materials will be thoroughly cleaned, before and after each use, by washing with Liquinox® (a laboratory-grade detergent) and rinsing with deionized water followed by dilute nitric acid and another wash of deionized water. Decontamination procedures may be modified and/or revised based upon the data obtained or the equipment used (e.g. no acid will be used if the equipment or parts of the equipment consist of non-coated metal). Sub-samples of final deionized water rinses after acid washing will be collected for metal analysis to insure successful decontamination of equipment.

Decontamination waste is expected to consist of dilute nitric acid. Decontamination solutions will be properly disposed through the Department of Health, Safety and Environment (DHSE) of the U of S.

Sediment Sample Transport and Storage [1]

Freshly collected sediment will be placed in 5 gallon HDPE buckets from Columbia Analytical Services (CAS). Buckets will be cleaned and shipped to the field site in a protective covering to ensure they are contamination free. Buckets will be completely filled with sediment except for a small layer of river water above the sediment. The container will be filled to the brim to reduce oxygen exposure. The container will be purged with an inert gas (for example, nitrogen) before filling and then again before capping tightly. Sediment samples will never be frozen. All sediment containers will be properly labeled with a waterproof marker before sampling. Each label will include: the study title, station location or sample identification, date and time of collection, sample type, and name of collector. Labeled containers will be stabilized in an upright position in the transport/storage container. Following collection from each location the sediment samples will be immediately transferred to a refrigerated truck and stored upright at 4°C until placed in refrigerated room (walk-in refrigerator) at the ETL.

Sediment Sample Compositing[2]

Compositing will be accomplished in the laboratory in the following manner:

1. Overlying water will be siphoned off, not decanted, prior to compositing.

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[1] These procedures follow ASTM guidelines 1391-03 (2008) Standard Guide for Collection, Storage, Characterization, and Manipulation of Sediments for Toxicological Testing and for Selection of Samplers Used to Collect Benthic Invertebrates.

[2] These procedures follow ASTM guidelines 1391-03 (2008) Standard Guide for Collection, Storage, Characterization, and Manipulation of Sediments for Toxicological Testing and for Selection of Samplers Used to Collect Benthic Invertebrates.

2. All utensils that are used to process samples will be made of inert materials such as high quality stainless steel, or high density polyethylene (HDPE).
3. Unrepresentative materials (for example, twigs, shells, leaves, large stones, wood chips etc.) will be removed and documented before homogenization.
4. A high-grade stainless steel concrete mixer (or similar industrial mixing device made out of stainless steel or HDPE) will be used to thoroughly homogenize samples (homogenization will occur at medium to low mixing speed for a minimum of 30 minutes).
5. Reference sediments will be mixed first.
6. The sediment mixer will be cleaned thoroughly between uses (low percent nitric acid bath followed by thorough rinsing with ultraclean water, as appropriate).

Partitioning sediments for biological testing will be accomplished by removing small portions from random locations in the sediment mixer and distributing them randomly in all corresponding exposure chambers until the appropriate volume of sediment is contained in each. During distribution, the sediment will be periodically mixed to minimize stratification effects due to differential settling. Remaining sediments will be placed into 5 gallon HDPE buckets, overlaid with water, and stored at 4°C under a nitrogen atmosphere.

Scheduled Monitoring

All Dewar flasks, refrigerators, and freezers used in the ETL will be examined frequently due to constant use and will be monitored at a minimum daily. Freezer temperatures are maintained at a nominal -20°C. If the freezer temperature rises to equal or greater than -15°C, if the liquid nitrogen levels decrease such that it triggers the alarm, or if the refrigerator temperature rises over +7°C, corrective action must be taken. Actions include adjusting the thermostats, refilling liquid nitrogen, having the unit serviced, or moving the samples to another unit.

Sample Accountability

To ensure that all samples will be accounted for, the following guidelines will be followed:

A. The person obtaining the sample or submitting the sample to the laboratory for analysis must establish sample identity.
B. Integrity of sample must be maintained from collection to delivery.
C. Composition of sample must remain the same during handling and storage before analysis.
D. Evidence must exist of sample's receipt and COC record filled out, and appropriate personnel notified of the sample arrival.

E. Person preparing sample must not allow composition of sample to change or integrity to be questioned.

F. Analyst must ensure correct sample is analyzed.

G. Analyst must record all data contributing to the analysis.

H. Records must be kept to trace sample from retrieval through data reporting.

I. Special storage conditions must be documented.

Label and COC Discrepancies

Discrepancies between the sample labels and COC will be noted on the COC or Sample Receipt Form. The sample manager will resolve any documentation discrepancies by contacting the personnel that submitted the samples. For discrepancies impacting sample viability (i.e., improper sample temperature) where a Corrective Action Report (CAR) is required to be completed, the sample manager will coordinate with the sample submitter, quality assurance (QA), and Project Study Group representatives to determine the appropriate corrective action.

RECORDS, DOCUMENTATION, AND QUALITY CONTROL (QC) REQUIREMENTS

The primary analyst shall document any anomalies and/or deviation from the specified method in a bound, serially numbered, laboratory notebook with tear-out carbon copies. All electronic files and hardcopies will be kept at the participating laboratory.

The carbon copies from data notebooks will be removed and archived in a separate building. Copies of the COC forms, the STS, and laboratory notes will be kept in three-ring binders in separate places at all times in case of fire or other disaster.

RESPONSIBILITIES

Project Manager. Dr. Markus Hecker will oversee and approve all project activities, authorize necessary actions and adjustments, and act as liaison between the principle investigator and other U of S personnel, Teck American personnel, and the sponsor Project Manager.

Principle Investigator. Prof. John P. Giesy will advise the Project Manager in overseeing and approving all project activities, authorize necessary actions and adjustments related to U of S activities to accomplish program QA objectives; and act as liaison between agencies, staff, and the sponsor Project Manager.

Study Team Leaders (STLs). David Vardy and Jonathon Doering, under the supervision of Markus Hecker, will oversee all research activities and supervise all personnel involved with the assemblage of the experimental exposure systems. The STLs will ensure that proper sample

collection, preservation, storage, transport, and COC QC procedures are followed and will inform the Project QA Manager when problems occur, and will communicate and document corrective actions taken. The STLs will discuss study activities with the Project Manager.

Quality Assurance (QA) Manager. Dr. Shaun Roark will initiate audits on work completed by project personnel. The manager will review program QA activities, quality problems, and quality-related requests. In response to experimental findings, the QA manager will approve corrective actions. The QA manager will report quality non-conformances to the Project Manager.

QUESTIONS OR COMMENTS

Please feel free to contact the following persons with any questions, comments, etc., you may regarding the procedures outlined in this SOP.

Markus Hecker
mhecker@entrix.com
(306) 966-5233

Paul D. Jones, Ph.D.
paul.jones@usask.ca
(306) 966-5062

John P. Giesy, Ph.D.
john.giesy@usask.ca
(306) 966-2096

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STANDARD OPERATING PROCEDURE SOP-9

MAINTENANCE OF SAMPLE CHAIN-OF-CUSTODY

Purpose

This SOP specifies sample chain-of-custody procedures that must be followed by the members of the Environmental Toxicology Laboratory (ETL).

Scope and Applicability

This SOP applies to the ETL for samples supplied from the Upper Columbia River white sturgeon studies

Chain of Sample Custody

To maintain the chain of custody, samples must be treated in the manner described below.

1. Samples are inspected upon arrival to see if they are in agreement with any accompanying inventory of samples. The sample condition should be noted and compared to expected condition.
2. Samples are assigned laboratory identification and custodian. Documents of shipment or transfer from incoming person (e.g., bill of lading number or mail receipt) will be obtained.
3. Chain-of-custody (COC) record should be maintained throughout the project. The custodian has the responsibility to maintain the integrity of the sample. The custodian must maintain the original COC. A copy may be obtained for the relinquishing party, if so desired.
4. Samples should be stored in refrigerators or freezers to maintain stability. The refrigerators and freezers are located in Rooms 261 and 181. The walk-in refrigerator and freezer are located in Room 118 and 116, respectively. All rooms are located in the Toxicology Centre at the University of Saskatchewan, Saskatoon, Canada.

Sample Security

Sample Storage Locations

1. Samples for analysis are stored in various refrigerators or Dewar flasks within the Wet Chemistry or Biochemistry Laboratories in the Toxicology Centre at the University of Saskatchewan (U of S) (Room 181).

2. Post-analysis storage is in walk-in freezer (Room 116 of the Toxicology Centre).

Sample Access

1. The Wet Chemistry and Biochemistry Laboratories are locked areas within a locked building and are considered secure during working and non-working hours. All Environmental Toxicology Laboratory (ETL) employees have access to the Dewar flasks, freezers and refrigerators.

2. Access to the walk-in freezer in Room 116 is limited to authorized personnel.

Scheduled Monitoring

All refrigerators and freezers used by the ETL are examined frequently due to constant use and monitored weekly by reading and recording the temperature on the Freezer/Refrigerator Temperature Record Sheet from a thermometer located in each unit. Freezer temperatures are maintained at a nominal -20°C if not indicated otherwise. If the temperature rises to -15°C, corrective action must be taken. Refrigerator temperatures are maintained at +4°C. If the temperature rises to +7°C or above, corrective action has to be taken. Actions include adjusting the thermostats, refilling liquid nitrogen, having the unit serviced, or moving the samples to another unit.

The walk-in freezer, walk-in refrigerator, Fisher Scientific Ultra Freezer and liquid nitrogen Dewar flasks are protected by temperature and power failure phone alarm systems. Instructions for these systems are posted with each unit and an additional emergency phone list is provided at the door of each laboratory/room. In case of a building power outage the freezers are all connected to the emergency generator. Be sure that the cause of the power outage is identified and corrected.

FREEZER ALARM

If the above alarms are triggered, it means that this freezer/refrigeration/Dewar flask unit has a serious problem. Please take one of the actions listed below to save valuable research materials.

1. Consult the Laboratory On-Call List posted on the wall by the nearest telephone and call the responsible person.

2. Contact one of the following people:
    a. Dr. Paul D. Jones at 966-5062 (office) of at 517-281-5666 (cell)
    b. Dr. Markus Hecker at 966-5233 (office) or 517-899-0594 (cell)
    c. Dr. John Giesy at 966-2096 (office) or at 517-614-6123 (cell))
    d. Any member of the ETL Management team at 966-4680
3. During evenings and weekends, if it isn't simply a matter of a freezer door being left open, call the campus operator and request physical plant emergency service for a freezer malfunction and call Dr. Paul D. Jones at 517-281-5666.
4. Report electrical and freezer malfunctions to the ETL laboratory manager Dr. Wan Yi, Toxicology Building, Room 134, or Anne St. Yves, Toxicology Building, Room 125

Any Environmental Toxicology personnel who respond to an alarm will visually inspect the unit that gave the alarm and comment in the Maintenance Log binder. An estimate of the amount of time the unit was not functioning properly should be entered under Comments. If there is not enough space on the log sheet for a thorough description of the incident, refer the reader to the Additional Notes section and place a full report there. All electrical and freezer malfunctions should be reported to the ETL laboratory manager.

Sample Accountability

Sample accountability will be insured by the following measures:

1. Identity of sample must be established by person obtaining sample or submitting the sample to the laboratory for analysis.
2. Integrity of sample must be maintained from collection to delivery.
3. Composition and integrity of sample must remain the same during handling and storage before analysis.
4. Evidence must exist of sample's receipt and a COC filled out and appropriate personnel notified of the sample arrival.
5. Person preparing sample must not allow composition of sample to change or integrity to be questioned.
6. Analyst must ensure the correct sample is analyzed.
7. Analyst must record all data contributing to analysis.

8. Records must be kept to trace sample from time obtained through reporting, including storage.

9. Special storage conditions must be documented.

STANDARD OPERATING PROCEDURE SOP-10

MAINTENANCE OF SAMPLE INTEGRITY, AND PROPER USAGE OF REFRIGERATORS, FREEZERS, AND LIQUID NITROGEN DEWAR FLASKS

Purpose

This SOP outlines proper usage of refrigerators and freezers by the members of the Environmental Toxicology Laboratory (ETL), as well as sample logging and treating procedures.

Scope and Applicability

This procedure describes guidelines for safe storage of samples and standards, sample storage locations, restrictions on the types of materials that may be stored in certain units, sample access, temperature monitoring, protection of sample integrity and alarm systems.

This SOP applies to the ETL for samples supplied from the Upper Columbia River white sturgeon studies

Safety Considerations

Safety training and medical monitoring requirements are described in the Health and Safety Plan for the Upper Columbia River Remedial Investigation and Feasibility Study (TCAI 2007).

Method, Procedures, and Requirements

Sample Storage Locations

A. Water samples are sometimes kept in short-term storage (24 to 48 hours) in the walk-in refrigerator, Room 118, Toxicology Building, University of Saskatchewan (U of S).

B. Feed, ingredients for feed, and substratum for invertebrate (*Artemia*) culture are stored in the small Danby refrigerator located in Room 57, Toxicology Centre, U of S.

C. The walk-in freezer in Room 116 and the walk-in refrigerator in Room 118, Toxicology Building, U of S, are used to store tissue, sediment, and whole organism samples from field and laboratory studies. The walk-in freezer is maintained at -20°C and the walk-in cooler is maintained at 4°C. These rooms are accessible only to lab personnel.

D. The Baxter Cryo-Fridge upright refrigerator/freezer unit in Room 181, Toxicology Building, U of S (Serial # Z19D-193854-ZD) is used for storage of samples to be analyzed. The refrigerated areas are maintained at 4°C, and the freezer areas at -20°C.

E. The Thermo Scientific Forma -86C Ultra Freezer (Serial # 812712-2490) in Room 261, Toxicology Building, U of S, is used to store biological samples for analysis. It is maintained at -80°C.

F. Samples for biochemical and molecular analyses are stored in the MVE Cryosystem 2000 liquid nitrogen Dewar flask in Room 261, Toxicology Building, U of S.

Sample Access

All rooms and laboratories are locked at all times and are considered very secure. Each employee authorized to work there has a key to enter the rooms. The walk-in freezer and refrigerator are locked and access to these rooms is limited to ETL personnel.

Scheduled Monitoring

All refrigerators and freezers used by the Environmental Toxicology research group are examined frequently due to constant use and monitored weekly by reading the temperature from a thermometer located in each unit and recording the temperature in the Maintenance Log for Refrigerators, Freezers, and liquid nitrogen Dewar flasks. Freezer temperatures are maintained at -20°C. If the freezer temperature rises to equal or greater than -15°C, if the liquid nitrogen levels decrease such that it triggers the alarm, or if the refrigerator temperature rises over +7°C corrective action must be taken. Actions include adjusting the thermostats, refilling liquid nitrogen, having the unit serviced, or moving the samples to another unit.

Any incidents requiring corrective action are recorded in the Maintenance Log, a three-ring binder in the Biochemistry Lab, Toxicology Building, Room 261.

Temperatures in the walk-in refrigerator and walk-in freezer are monitored continuously by an automated temperature logging system, and checked manually every morning during weekdays. Maximum-minimum thermometers are located inside the walk-in refrigerator and inside the walk-in freezer. These thermometers are checked weekly and reset, and the maximum temperature for each unit is recorded in the logbook. Directions for use of the maximum-minimum thermometers are located in the Additional Notes section of the Maintenance Log binder.

Alarm System

The walk-in freezer and walk-in refrigerator can tolerate brief power outages or malfunctions without compromise of the samples they contain because of their large volume and large stored mass. However, it is important that any such malfunctions or power outages are recognized

promptly; therefore, the walk-in freezer, walk-in refrigerator, Fisher Scientific Ultra Freezer and liquid nitrogen Dewar flasks are protected by temperature and power failure phone alarm systems. Instructions for these systems are posted with each unit and an additional emergency phone list is provided at the door of each laboratory/room. In case of a building power outage the freezers are all connected to the emergency generator. Be sure that the cause of the power outage is identified and corrected.

FREEZER ALARM

If the above alarms are triggered, it means that this freezer/refrigeration/Dewar flask unit has a serious problem. Please take one of the actions listed below to save valuable research materials.

1. Consult the Laboratory On-Call List posted on the wall by the nearest telephone and call the responsible person.
2. Contact one of the following people:
    a. Dr. Paul D. Jones at 966-5062 (office) of at 517-281-5666 (cell)
    b. Dr. Markus Hecker at 966-5233 (office) or 517-899-0594 (cell)
    c. Dr. John Giesy at 966-2096 (office) or at 517-614-6123 (cell))
    d. Any member of the ETL Management team at 966-4680
3. During evenings and weekends, if it isn't simply a matter of a freezer door being left open, call the campus operator and request physical plant emergency service for a freezer malfunction and call Dr. Paul D. Jones at 517-281-5666.
4. Report electrical and freezer malfunctions to the ETL laboratory manager Dr. Wan Yi, Toxicology Building, Room 134, or Anne St. Yves, Toxicology Building, Room 125

Any Environmental Toxicology personnel who respond to an alarm will visually inspect the unit that gave the alarm and comment in the Maintenance Log binder. An estimate of the amount of time the unit was not functioning properly should be entered under Comments. If there is not enough space on the log sheet for a thorough description of the incident, refer the reader to the Additional Notes section and place a full report there. All electrical and freezer malfunctions should be reported to the ETL laboratory manager.

The walk-in freezer and walk-in refrigerator are connected to an audible alarm, phone alarm system and an auxiliary generator. If power from the main power grid is lost, the auxiliary generator automatically provides power and an alarm is sent to U of S Public Safety office. The alarm is then transferred to "on call" ETL personnel. There are two individuals on call at all

times. These individuals can be contacted by telephone and carry pagers at all times. The Thermo Scientific Forma -86C Ultra Freezer in Room 261 is also attached to the auxiliary power system and has an phone alarm system that in case of a power outage and/or temperature increase automatically calls the cell phones of ETL personnel on duty (a minimum of two persons are on duty at any time). Otherwise, the procedures for this freezer are the same as those for the walk-in freezer, and records for its maintenance will be kept in the Maintenance Log in the Toxicology Building Room 261.

The -196°C liquid nitrogen Dewar flasks are also equipped with audible alarms. If an alarm is registered, check the liquid nitrogen (N2; liquid nitrogen) level. If it is low, add liquid nitrogen from the upright liquid nitrogen tank in room 159 (chemistry laboratory) in the Toxicology Building. Then reset the alarm and record corrective actions in the Liquid Nitrogen section of the Maintenance Logbook in the Toxicology Building Room 261. The liquid nitrogen Dewars will also be checked weekly for sufficient liquid nitrogen levels. See the section on procedures for and safe use of liquid nitrogen.

Guidelines for Proper use of Refrigerators / Freezers

A. All samples, standards, and reagents should be properly labeled with the identification of the substance in the container and the date. If appropriate, hazard warnings, concentration, and an expiration date should be added. All incoming chemicals should be labeled with the full name of the receiver and the date of receipt and should be logged into either a logbook or a database. Note: It is not acceptable to label only the rack holding many small tubes or vials.

B. All stored samples should be given new labels within 13 months past the date on the label. All samples must be in labeled sample boxes with a closing lid- preferably ECONSTOR 704 (Available from Fellowes Manufacturing Co., Perma Products, Atlanta, GA). Each individual sample in the box should be labeled with the following:

   Project name:

   Date collected:

   Date placed in freezer/ cooler:

   Sample type: (e.g., rainbow trout carcass)

   Client name:

   Client's sample ID:

   Sample tracking # (chain-of-custody):

Samples should be labeled on the outside of the container or package as well as on a piece of waterproof paper placed inside the sample container. Labels should be written with pencil on paper. Do not use felt tip pens to write on glass or plastic. Use only permanent, waterproof markers to write on glass or plastic. For samples to be stored in liquid nitrogen see the Materials portion of the Liquid Nitrogen section.

C. Labels: Samples should be grouped by project and/or sample type and placed in the storage boxes. Boxes should be labeled with the following information:

Project name:

Sample type:

Date placed in freezer:

Name of person who collected sample:

Client Name:

Location where sample was collected:

List of sample #s in box:

A sample log sheet should be filled out and a copy placed in both the sample box and the sample log binder. Note that there are numbers on the shelves in the walk-in freezer and cooler and that there is a map of the -80°C freezer in the sample log showing numbered storage areas. These numbers are the sample box location numbers. When a sample box is logged, the number corresponding to the area where it is stored should be recorded on the appropriate line in the logbook. This system makes the task of finding a sample box much simpler and minimizes the amount of time that the freezer door is open. An entry should be made in the Maintenance Log every time the freezer is entered so that in case of a malfunction, it can be determined when the unit was last known to be functioning properly.

D. Samples and analytical standards should be kept in separate refrigerators or freezers.

E. Food or beverages for human consumption should never be stored in a refrigerator or freezer where standards, samples, or reagents are stored.

F. Buffers such as Tris(hydroxymethyl)aminomethane (TRIS), N-2-Hydroxyethylpiperazine-N'-2-ethanesulfonic Acid (HEPES), and phosphate buffers should be kept for no longer than 1 month. The pH of a buffer should be checked regularly at the temperature at which the buffer is intended to function. Buffers with sucrose should be filtered before storage; filtering will increase the storage life to no

longer than 2 weeks. Buffers should be marked with an expiration date and disposed of after that date.

G. Samples and standards should be kept in containers that will prevent them from spilling or otherwise contaminating other stored materials. Items easily tipped or without tight lids should be placed inside other containers to prevent spilling. For example, a flask with a Parafilm cover might be placed inside a wide beaker.

H. Each person using storage space in a refrigerator or freezer should check routinely (once a month) for old buffers, glassware, etc., that he/she has left behind and should remove unneeded items.

I. For reasons of cleanliness, safety, and limited space, each person using storage space in a refrigerator or freezer may remove any items not in compliance with the above guidelines to a designated area in another refrigerator or freezer. Every reasonable effort must then be made to contact the person responsible, including contact by mail and telephone, and a note describing the item(s) removed and the new storage location should be posted on the refrigerator or freezer in which the items were found. If the items are not claimed and dealt with properly, they will be destroyed 1 month after removal.

Safety and Usage of Liquid Nitrogen Dewars

(Taken from the CRC Handbook of Laboratory Safety, Steere 1967)

A. Flammability. Liquid nitrogen, liquid helium, and metal surfaces made very cold by liquefied gases can condense oxygen from the atmosphere, causing oxygen to build up or become entrapped in enclosed spaces. This greatly increases the risk of fire, and may cause even non-combustible materials like carbon steel to burn under the right conditions. Make sure that the area where liquid nitrogen Dewars are stored is well ventilated.

B. High Pressure. Liquefied nitrogen is stored at or near its boiling point, so that some gas is always present in the container that holds it. Be aware that liquid nitrogen expands rapidly when allowed to warm up, so make certain that containers that hold it include an allowance for the gaseous phase.

C. Materials. Materials that are otherwise pliable or tough may become brittle and shatter under the extreme cold temperatures of liquid nitrogen. Materials suitable for cryogenic temperatures include Dacron, Teflon, Kel-F, asbestos impregnated with Teflon, mylar, nylon, stainless steel (300 series), copper, bronze, aluminum, and brass. **Important:** Do not use glass vials to store samples in a liquid nitrogen Dewar. The glass will shatter.

Use only plastic Cryovials with tamper-proof vinyl stick-on labels. Also, do not use wooden materials with liquid nitrogen, since wood (or asphalt) saturated with oxygen might explode when subjected to mechanical shock. If in doubt, consult a materials manual or call Department of Health, Safety and Environment (DHSE) to make certain that liquid nitrogen will not cause a problem with the materials with which it is to be used.

D. Personnel.

1. Avoid hazards of fire, high pressure, and material failures listed above.
2. Even very brief contact of body parts with fluids or materials at cryogenic temperatures can cause burns similar to thermal burns. Prolonged contact will cause exposed parts to freeze and become brittle. The eyes are particularly sensitive to this type of trauma, so always wear eye protection while working with liquid nitrogen.
3. While liquid nitrogen is not itself toxic, it can cause asphyxiation by displacing air, so store and use liquid nitrogen only in well-ventilated areas.
4. Equipment should be kept very clean to avoid dangerous contamination of liquid nitrogen stores.
5. When there is a possibility of personal contact with liquid nitrogen, wear full-face protection, an impervious apron or lab coat, cuff-less trousers, and closed shoes (no sandals). Do not wear jewelry. Gloves may or may not be worn. If worn, gloves should be impervious and loose fitting so that they can be easily thrown off the hand if liquid nitrogen is spilled inside them. Potholder type protection for the hands is probably best. Do not touch the interior of the Dewar or anything that has been recently removed from it without protection for the hands.
6. Do not tilt a Dewar flask to pour out the liquid, as this may damage the container.

E. Contamination. Oxygen can build up in liquid nitrogen containers if the cap is not kept on or if the entire volume of liquid in the container is not occasionally replaced (i.e., the Dewar is continually refilled from larger containers without ever allowing it to become totally empty) increasing the chances of contamination with oxygen. If the liquid takes on a bluish color, it is contaminated with oxygen and should be treated as a dangerous, potentially explosive material.

Responsibilties

Project Manager. Dr. Markus Hecker will oversee and approve all project activities, authorize necessary actions and adjustments, and act as liaison between the principle investigator and other U of S personnel, Teck American personnel, and the sponsor Project Manager.

Principle Investigator. Prof. John P. Giesy will advise the Project Manager in overseeing and approving all project activities, authorize necessary actions and adjustments related to U of S activities to accomplish program quality assurance (QA) objectives; and act as liaison between agencies, staff, and the sponsor Project Manager.

Study Team Leaders (STLs). David Vardy and Jonathon Doering, under the supervision of Markus Hecker, will oversee all research activities and supervise all personnel involved with the assemblage of the experimental exposure systems. The STLs will ensure that proper sample collection, preservation, storage, transport, and chain-of-custody quality control procedures are followed and will inform the Project QA Manager when problems occur, and will communicate and document corrective actions taken. The STLs will discuss study activities with the Project Manager.

Quality Assurance (QA) Manager. Dr. Shaun Roark will initiate audits on work completed by project personnel. The manager will review program QA activities, quality problems, and quality-related requests. In response to experimental findings, the QA manager will approve corrective actions. The QA manager will report quality non-conformances to the Project Manager.

Questions or Comments

Please feel free to contact the following persons with any questions, comments, etc., you may regarding the procedures outlined in this SOP.

Markus Hecker
mhecker@entrix.com
(306) 966-5233

Paul D. Jones, Ph.D.
paul.jones@usask.ca
(306) 966-5062

John P. Giesy, Ph.D.
john.giesy@usask.ca
(306) 966-2096

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STANDARD OPERATING PROCEDURE SOP-11

STANDARD OPERATING PROCEDURE FOR WEIGHING USING ANALYTICAL BALANCES

Purpose

This SOP specifies sample weighing procedures for the members of the Environmental Toxicology Laboratory (ETL).

Scope and Applicability

This SOP applies to the ETL for samples supplied from the Upper Columbia River white sturgeon studies

Procedures for Weighing Samples

When weighing samples or chemicals the following procedures are to be followed:

1. Check level and cleanliness of balance.
2. Balances must not be affected by room drafts; close balance doors.
3. Always weigh into containers or use weigh papers. Under no circumstances should excess standard or reagent be returned to its original container.
4. Weigh quickly. It is better to accurately weigh close to a desired weight in one or two steps than to repeatedly manipulate a sample to obtain a round number. For example 10.02 and 9.81 are just as good weights as 10.00.
5. Objects weighed must be at room temperature.
6. Choose a balance appropriate for the mass to be weighed. For example, a 4 decimal place balance is need for a 0.0100 g standard whereas a 40.00 g soil sample requires only a 2 place balance.
7. At the beginning of each phase of the study the balance must be checked using standard reference weights and the results recorded on the Analytical Balance Maintenance Calibration Record form.
8. Routine and preventative maintenance is purchased from the balance manufacturer at recommended intervals, nominally once in 2 years.

STANDARD OPERATING PROCEDURE SOP-12

EQUIPMENT MAINTENANCE AND CALIBRATION

Purpose

The purpose of this SOP is to provide guidelines for the maintenance and calibration of equipment used in the Upper Columbia River (UCR) white sturgeon studies conducted by the University of Saskatchewan (U of S) Environmental Toxicology Laboratory (ETL).

Scope and Application

This SOP will be applied to all equipment used in the UCR white sturgeon studies including multi-parameter meters, pipettors, and balances.

Safety Considerations

There are no safety issues for this SOP.

Equipment, Materials, and Reagents

The equipment used in UCR white sturgeon studies will be:

- Sartorius balance (Mettler Toledo, Inc, serial number 37030129)
- Ohaus Adventurer Pro balances (VWR, Cat. #11379-144)
- Certified balance weights (Troemner Inc., serial number 13637)
- VWR sympHony Multiparameter Research meters (VWR, Cat #11388-328)
- Pipetman pipettors (P100, P200, P1000, P5000).

Method, Procedures, and Requirements

This SOP will provide details on the methods used to calibrate and maintain equipment used in the UCR white sturgeon experiments. In cases where the calibration procedures are identical to the manufacturer's descriptions, it will refer to these and the according document will be included with this SOP as an attachment.

Equipment Calibration

Balances (Sartorius, Mettler, and Ohaus)

The balances will be calibrated before each use. They will be calibrated using check weights provided by the manufacturer. The weight of the check weights will be recorded in a balance log along with the date of use, user's name, and whether the balance recorded the check weights within 10 percent (Attachment 1a through 1c).

VWR sympHony Multiparameter Research Meters

pH probe

The pH meter will undergo a two point calibration before each use. Two standard buffer solutions are recommended for precise calibration. The first, near the electrode isopotential point (pH 7.0) and the second near the expected sample pH (pH 4.0 or 10.0). Calibration will be recorded on a data sheet once it is performed (Attachment 2a).

Conductivity probe

The conductivity meter will undergo a two point calibration before each use. Standard buffer solutions will be used. Calibration will be recorded on a data sheet once it is performed (Attachment 2b).

Dissolved oxygen (DO) probe

No user calibration is required (Attachment 2c).

Temperature probe

No user calibration is required.

Note that a similar research meter of another brand or model may be selected instead of the VWR symphony Multiparameter Research Meter. A single research meter will be used from the beginning to the end of each study to ensure consistent results.

Pipetman pipettors

Pipettors will be calibrated on a weekly basis. Each pipettor will be used to draw up a volume of liquid that will then be weighed to confirm that the volume is correct. The serial number of each pipettor will be recorded along with the date, presumed volume, weight of the liquid, calibrator's name and whether the pipettor was adjusted will be recorded on a log sheet (Attachments 3a and 3b).

Equipment Maintenance

Balances

The balances will be brushed off after each use, and kept covered between uses.

VWR sympHony Multiparameter Research Meters

Between measurements, the probes will be rinsed with distilled water. The filling hole cover will be removed when taking measurements, but will be put back in place during storage. The pH probe will be kept in buffer solution of 3M KCl in between uses. All other probes will be stored according to manufacturer's protocol (Attachments 2a through 2c).

Records, Documentation, and Quality Control Requirements

All maintenance and calibration procedures shall be entered in the appropriate notebooks and instrument logs. Instrument logs are kept with each piece of equipment, and a copy of all files is kept with Shanda Sedgwick in Room 125 at the Toxicology Building.

Responsibilities

Project Manager. Dr. Markus Hecker will oversee and approve all project activities, authorize necessary actions and adjustments, and act as liaison between the principle investigator and other U of S personnel, Teck American personnel, and the sponsor Project Manager.

Principle Investigator. Prof. John P. Giesy will advise the Project Manager in overseeing and approving all project activities, authorize necessary actions and adjustments related to U of S activities to accomplish program quality assurance (QA) objectives; and act as liaison between agencies, staff, and the sponsor Project Manager.

Study Team Leaders (STLs). David Vardy and Jonathon Doering, under the supervision of Markus Hecker, will oversee all research activities and supervise all personnel involved with the assemblage of the experimental exposure systems. The STLs will ensure that proper sample collection, preservation, storage, transport, and COC quality control (QC) procedures are followed and will inform the Project QA Manager when problems occur, and will communicate and document corrective actions taken. The STLs will discuss study activities with the Project Manager.

Quality Assurance (QA) Manager. Dr. Shaun Roark will initiate audits on work completed by project personnel. The manager will review program QA activities, quality problems, and quality-related requests. In response to experimental findings, the QA manager will approve corrective actions. The QA manager will report quality non-conformances to the Project Manager.

Questions or Comments

Please feel free to contact the following persons with any questions, comments, etc., you may regarding the procedures outlined in this SOP.

Markus Hecker
mhecker@entrix.com
(306) 966-5233

Paul D. Jones, Ph.D.
paul.jones@usask.ca
(306) 966-5062

John P. Giesy, Ph.D.
john.giesy@usask.ca
(306) 966-2096

GWP®
Good Weighing Practice™

Good Weighing Practice™

Recommendation for your weighing system

GWP® Recommendation:	MTCDN-101-20091130-11
Company:	University of Saskatchewan
Contact:	Howard Zhang
Department / Position:	Toxicology Centre
Street:	44 Campus Dr
Zip Code / City:	Saskatoon, S7N 5B3
State / Country:	Saskatchewan
Phone:	(306) 966-1204
Email:	xiao.wei.zhang@usask.ca

Characterization of your weighing process

- Accuracy of weighing process: 2 %
- Smallest net weight: 10 mg
- Maximum weighing load: 200 g
- Safety factor: 1
- Impact of wrong measuring results on the business process: low
- Impact of wrong measuring results on humans, animals and the environment: low
- Wrong measuring results can be discovered very easily: yes
- Applicable standards and regulations: none

METTLER TOLEDO

GWP® Recommendation: MTCDN-101-20091130-11

Balance

AB265-S

Weighing Parameters

Minimum weight according to the specifications for 2 % accuracy
(Expansion factor k = 2, without safety factor)

Specified:	3 mg[1)]	Required:	10 mg
Safety factor			
Achieved:	3.3	Required:	1

For the determination of the actual minimum weight the issuing of a minimum weight certificate is recommended.

Installation, qualification and training

Starter Pac

Service contract

Maintenance

Tests[2)]

Calibration (by service)	yearly
Repeatability (by user)	monthly
Sensitivity (by user)	quarterly

Weights

Weight 1:	200 g	Class:	F2, F1 or E2
Weight 2:	10 g	Class:	F1 or E2

For correct handling of weights we recommend the use of appropriate tweezers and/or gloves.

Recalibration interval of weights:[3)]	every three years

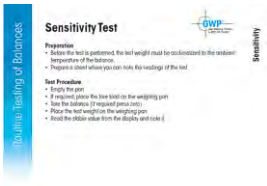
Test tolerances[4)]

Sensitivity

Weight 1:		Control limit:	2 g
Weight 2:		Control limit:	100 mg

Repeatability

Weight 2:		Control limit:	0.1 mg



Remarks

1) The minimum weight depends on the settings of the balance, the tare weight as well as the balance's environment. The minimum weight of your instrument in situ can be smaller than the specified value given in the Operating Instructions. A precise determination of the minimum weight on site is documented in the METTLER TOLEDO Minimum Weight Certificate.

2) Original recommendation for Repeatability (by user): none
Reason for the change: Required for the verification of the pipettes.

3) If country specific regulations apply, they have to be considered.

4) Various weighing parameters can contribute to the measurement uncertainty of a weighing result. While repeatability is the dominant uncertainty factor when weighing small net amounts, parameters such as sensitivity have a greater influence with larger net weights. With the exception of the repeatability test, all control limits are set to 1/2 of the weighing accuracy in order to have a security reserve accounting for any other influences on the result (control limit = test weight * weighing accuracy / 2).
For repeatability tests however, the influence of the other parameters are negligible for small test weights, thus a security reserve is not necessary for the control limit (control limit = weighing accuracy * smallest net weight / k).
If a safety factor >1 is defined, then the warning limits of the appropriate parameters are calculated by the control limits divided by the safety factor.

General remarks

Used in the toxicology environment and for the verification of pipettes.

GWP® Recommendation: MTCDN-101-20091130-11

Disclaimer
These general recommendations are for information only and are not binding in any way. To reach utmost weighing accuracy, and to allow an optimal use of the weighing instruments, it is necessary to conduct calibration and test procedures in a regular and timely manner. This document is offered as a recommendation to improve weighing accuracy and to optimize the use of the weighing instruments. It is based on specifically selected parameters like risk and process tolerance. Other factors, which might also have an influence, like installation location, history of the instrument, experience of laboratory staff, safety management system of user etc., have not been taken into account. Therefore these intervals are to be considered as recommendations. Depending on the circumstances the use of modified / other time schedules might be appropriate. The final responsibility for the test procedures is with the user of the equipment. This recommendation does not extend our warranty in any way.

GWP® Recommendation V 2.4, Tables V 2.44

Created on Monday, November 30, 2009 by

Michael Birtzu
Email michael.birtzu@mt.com

www.mt.com/GWP
For more information

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Mettler-Toledo Inc.
Laboratory Division
2915 Argentia Road, Uuni 6
Mississauga, Ontario L5N 8G6
Phone (416) 888-8537
Fax (614) 781-3906

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SOP for Periodic Repeatability Tests (Routine Tests)

Title:	SOP for Periodic Repeatability Tests
Document No.:	
Author:	METTLER TOLEDO Laboratory & Weighing Technologies
Number of Pages:	4
Controls	
Replacement Document:	N/A
Reason for Revision:	N/A
Release Date:	17. Oct. 2007
Release for Routine Operation	
Reviewed by:	
Date:	
Signature:	
Approved by:	
Date:	
Signature:	

METTLER TOLEDO

General

Basic Rules for Handling Balances

- Before using a balance, make sure the balance was left on power for a sufficient period of time (mentioned in the balance operating instructions).
- Make sure the balance is leveled.
- Minimize environmental influences, e.g. open windows, direct sunlight or strong drafts.
- Do not enter the draft shield with hands. Use gloves or long tweezers.
- Place objects gently and in the center of the pan.

Basic Rules for Handling Weights

Test Weights

- Only an external test weight with calibration certificate can make a balance a "traceable" piece of equipment.
- Test weights should always be placed gently on a clean weighing pan and put back immediately in their storage place after use.
- Test weights (since they are also part of measuring equipment) need to be re-calibrated at specified intervals (ISO 9001).
- Any incident, which might have affected the value of the test weight, should trigger an immediate re-calibration. METTLER TOLEDO's calibration services will give advice on this.

How to Store Test Weights

- Test weights should be stored in their original box.
- Test weights should be stored in the same room as the balance they are used with, since temperature differences between test weights and their surrounding lead to measurement errors.
- Test weights that have not been stored at the same temperature need acclimatization, which can take several hours.

How to Move Weights

- Test weights should only be handled with appropriate tools such as tweezers, forks, handles or gloves (see METTLER TOLEDO's accessories for weights).
- These tools should be exclusively used for transferring test weights, to avoid possible contamination.

Repeatability Test

Preparation

- Before performing the test, the test weight must be acclimatized to the ambient temperature of the balance.
- Prepare a sheet where you can note the readings of the repeatability test points. Prepare 3 columns titled "w/o Test Wght", "With Test Wght." and "Differences".

Test Procedure

- Empty the pan
- If required, place tare load on the weighing pan
- Tare the balance (if required press zero)
- Read the stable value from the display and note it in the column "w/o Test Wght."
- Place the test weight in the center of the weighing pan
- Read the stable value from the display and note it in the column "With Test Wght."
- Remove the test weight
- Repeat the measurements from "tare the balance" to "remove test weight" until the customer defined number of "w/o Test Wght." and "With Test Wght." readings is performed

Evaluation

- Subtract each "w/o Test Wght." from the corresponding "With Test Wght." to calculate the difference.
- Calculate the standard deviation of the differences.
- Evaluate whether standard deviation exceeds the defined "Control Limit" [1)].

Deviation

Control Limit [1)]

- If the control limit is exceeded, report the problem to the laboratory supervisor or the person responsible of the balance.
- Mark the balance as "out of control limits".
- Contact METTLER TOLEDO service organization for advice.

1) – Values within the control limit: no action is necessary.
   - Values beyond the control limit show that weighing process is no longer under control and immediate action is therefore required.

Mettler-Toledo AG
Laboratory & Weighing Technologies
Im Langacher
P.O. Box LabTec
CH-8606 Greifensee
Switzerland

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Routine Testing of Balances

SOP for Periodic Sensitivity Tests (Routine Tests)

Title:	SOP for Periodic Sensitivity Tests
Document No.:	
Author:	METTLER TOLEDO Laboratory & Weighing Technologies
Number of Pages:	4
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Replacement Document:	N/A
Reason for Revision:	N/A
Release Date:	17. Oct. 2007
Release for Routine Operation	
Reviewed by:	
Date:	
Signature:	
Approved by:	
Date:	
Signature:	

METTLER TOLEDO

General

To test the sensitivity of a balance, a large test weight is more suitable than a small one.

Basic Rules for Handling Balances

- Before using a balance, make sure the balance was left on power for a sufficient period of time (mentioned in the balance operating instructions).
- Make sure the balance is leveled.
- Minimize environmental influences, e.g. open windows, direct sunlight or strong drafts.
- Do not enter the draft shield with hands. Use gloves or long tweezers.
- Place objects gently and in the center of the pan.

Basic Rules for Handling Weights

Test Weights

- Only an external test weight with calibration certificate can make a balance a "traceable" piece of equipment.
- Test weights should always be placed gently on a clean weighing pan and put back immediately in their storage place after use.
- Test weights (since they are also part of measuring equipment) need to be re-calibrated at specified intervals (ISO 9001).
- Any incident, which might have affected the value of the test weight, should trigger an immediate re-calibration. METTLER TOLEDO's calibration services will give advice on this.

How to Store Test Weights

- Test weights should be stored in their original box.
- Test weights should be stored in the same room as the balance they are used with, since temperature differences between test weights and their surrounding lead to measurement errors.
- Test weights that have not been stored at the same temperature need acclimatization, which can take several hours.

How to Move Weights

- Test weights should only be handled with appropriate tools such as tweezers, forks, handles or gloves (see METTLER TOLEDO's accessories for weights).
- These tools should be exclusively used for transferring test weights, to avoid possible contamination.

Sensitivity Test

Preparation

- Before the test is performed, the test weight must be acclimatized to the ambient temperature of the balance.
- Prepare a sheet where you can note the readings of the sensitivity test.

Test Procedure

- Empty the pan
- If required, place the tare load on the weighing pan
- Tare the balance (if required press zero)
- Place the test weight on the weighing pan
- Read the stable value from the display and note it

Evaluation

- Evaluate whether the noted value exceeds the defined "Warning Limit" [1].
- Evaluate whether the noted value exceeds the defined "Control Limit" [2].

Deviation

Warning Limit [1] (where defined)

- If the warning limit is exceeded, repeat the test.
- If the warning limit is exceeded again, report that the warning limit was not met to the laboratory supervisor or the person responsible for the balance.
- Level the balance, perform adjustment with built-in or external adjustment weight and repeat the test.
- If the warning limit is still exceeded, report the problem to the laboratory supervisor or the person responsible of the balance. Optionally, contact METTLER TOLEDO's service organization for advice.

Control Limit [2]

- If the control limit is exceeded, report the problem to the laboratory supervisor or the person responsible of the balance.
- Mark the balance as "out of control limits".
- Contact METTLER TOLEDO service organization for advice.

[1] – Values within the warning limit: no action is necessary.
– Values between the warning and control limit are within the tolerance but must be kept under surveillance. Corrective action may be appropriate, depending on the direction in which the values are changing.

[2] – Values within the control limit, see [1]
– Values beyond the control limit show that weighing process is no longer under control and immediate action is therefore required.

Mettler-Toledo AG
Laboratory & Weighing Technologies
Im Langacher
P.O. Box LabTec
CH-8606 Greifensee
Switzerland

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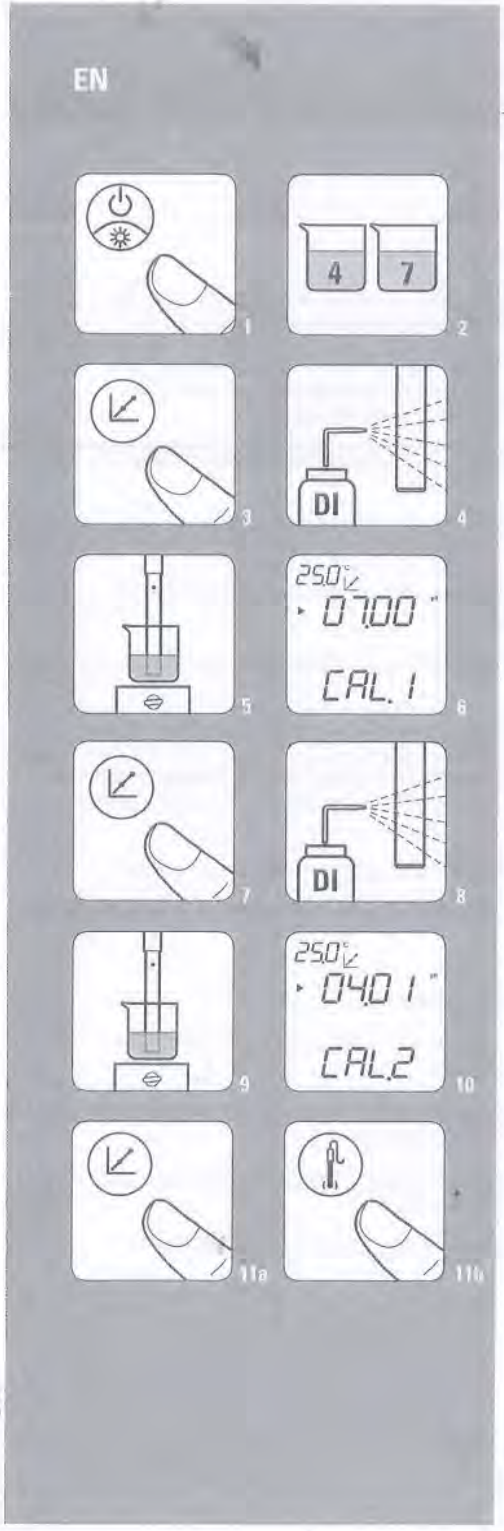
Attachment 2a

EN



pH Meter

Quick Start Guide

pH Autocalibration with Two Buffers

1. Press the **power** key to turn on the meter. **See 1**.
2. Select two buffers that bracket the expected sample pH and are one to four pH units apart. **See 2**. See **Autocalibration Buffer Selection** section.
3. Press the **calibrate** key. **See 3**.
4. Rinse the electrode with deionized water and blot dry with a lint-free tissue. **See 4**.

   NOTE: *Do not wipe or rub the electrode, as static buildup will occur.*
5. Insert the electrode into the first buffer and gently stir – if a stir probe is being used press the **stir** key to start and stop stirring (benchtop models only). **See 5**.
6. Wait for the **pH** icon to stop flashing and the ▶ icon to start flashing. The meter should display the temperature corrected pH buffer value. **See 6**.

   If the displayed buffer value is incorrect or a customer buffer is being used manually enter the value by pressing the **up/down arrow** keys to adjust each digit and the **digits** key to move to the next digit.
7. Press the **calibrate** key. **See 7**.
8. Rinse the electrode with deionized water and blot dry with a lint-free tissue. **See 8**.

   NOTE: *Do not wipe or rub the electrode, as static buildup will occur.*
9. Insert the electrode into the second buffer and gently stir – if a stir probe is being used press the **stir** key to start and stop stirring (benchtop models only). **See 9**.
10. Wait for the **pH** icon to stop flashing and the ▶ icon to start flashing. The meter should display the temperature corrected pH buffer value. **See 10**.
11. Press the **calibrate** key and then press the **measure** key to save and end the calibration. The slope will be displayed and then the meter will proceed to the measurement mode. **See 11a & 11b**.

Autocalibration Buffer Selection

1. Press the **setup** key.
2. Press the **up arrow** key until PH is displayed on the top line.
3. Press the **line select** key to move the ▶ icon to the middle line. Press the **up arrow** key until bUF is displayed.
4. Press the **line select** key to move the ▶ icon to the bottom line. Press the **up arrow** key to select the buffer set. USA is default setting.

   USA = 1.68, 4.01, 7.00, 10.01, and 12.46
   EUr0 = 1.68, 4.01, 6.86, and 9.18
5. Press the **line select** key to move the ▶ icon to the top line. Press the **measure** key to return to the measurement mode.

Measurement Mode Selection

1. Press the **setup** key.
2. Press the **up arrow** key until rEAd is displayed on the top line.
3. Press the **line select** key to move the ▶ icon to the middle line. Press the **up arrow** key until tYPE is displayed.
4. Press the **line select** key to move the ▶ icon to the bottom line. Press the **up arrow** key to select the measurement mode. AUtO is default setting.

   COnt = Continuous measurement mode
   AUtO = AUTO-READ™ measurement mode
   tImE = Timed measurement mode
5. Press the **line select** key to move the ▶ icon to the top line. Press the **measure** key to return to the measurement mode.

pH Measurements

1. Rinse the electrode with deionized water, blot dry with a lint-free tissue, and insert the electrode into the sample.
2. If the meter is in AUTO-READ mode, press the **measure** key to take a measurement. Once the reading stabilizes the **AR** icon will stop flashing and the display will freeze. Press the **measure** key again to take a new measurement.

   If a stir probe is connected it will start stirring when the **measure** key is pressed and stop stirring when the **AR** icon stops flashing (benchtop meters only).
3. If the meter is in the continuous or timed measurement modes, the meter will continuously take measurements and update the display. Once the reading stabilizes the **pH** icon will stop flashing.

   If a stir probe is connected press the **stir** key to start stirring and press the **stir** key again to stop stirring (benchtop meters only).

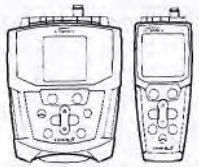
Printing Data

In the AUTO-READ and continuous measurement modes, every time the **measure** key is pressed the meter logs the data on the display. In the timed measurement mode, the meter logs the data at the predetermined time interval.

1. Press the **view log** key.
2. Use the **up arrow** key to scroll between CALO (print the calibration log) and SEnd (print the measurement log).
3. Press the **line select** key to print the data.

VWR

sympHony™



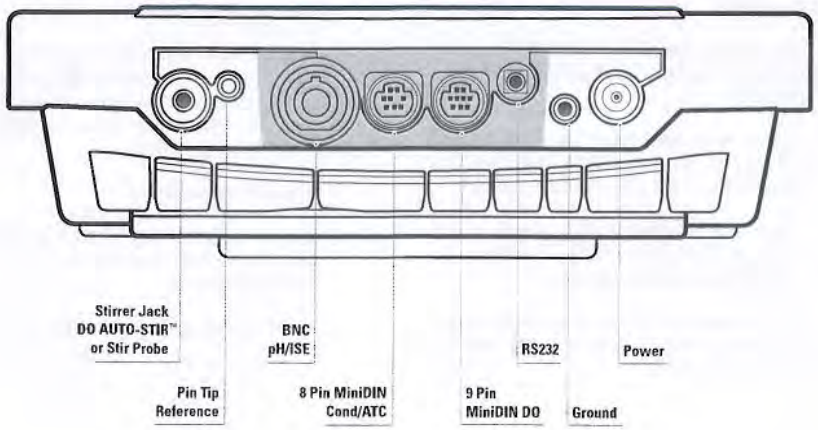
Key Description

power		up arrow		line select		view log	
calibrate		down arrow		setup		stir	
measure		digits					

All connectors on the sympHony™ SB90M5 benchtop meter are depicted below. All connectors on the SP90M5 portable meter are highlighted in gray.

The SB70P, SP70P, SB80PI, SP80PI, SB80PD, SP80PD, SB80PC, and SP80PC meters will have fewer connectors. For example, the SP70P portable pH meter will only have BNC, 8 pin miniDIN (ATC), and RS232 connectors.

Meter Connections



For the most current contact information, visit www.vwr.com

253833-001 RevA
QS-SYMPPH-E 0407

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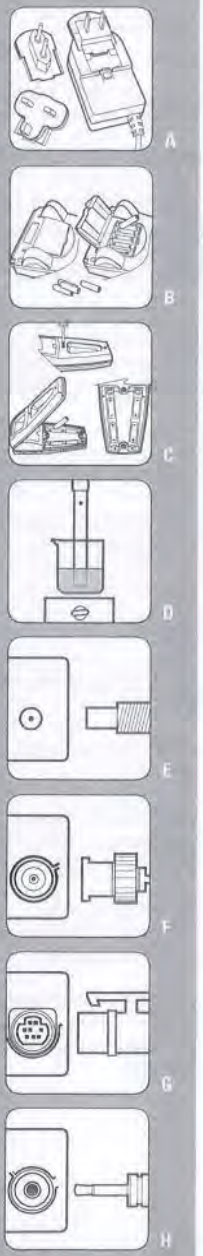


pH Meter

Preparation

1. Power adapter (benchtop models only) - Select the appropriate wall socket plug and slide the plug plate into the groove on the back of the adapter. **See A.**

   Batteries - Select four AA Alkaline batteries. Confirm that the meter is off and remove the battery cover. Orient and insert the batteries as depicted in the battery compartment housing. Replace the cover. **See B & C.**

2. Prepare the electrode according to the directions in the electrode instruction manual. In general, these steps include:

   - Gently remove the protective cap/sleeve from the sensing element and save for storage.
   - If the electrode is refillable, remove the fill hole cover and fill the electrode with the appropriate fill solution.
   - Soak the electrode in pH electrode storage solution, VWR® Cat. No. 14002-828. **See D.**

3. Meter connections - Connect the power adapter to the meter and then to the wall socket (benchtop meters only). **See E.** Connect the pH electrode to the BNC input on the meter. **See F.** Connect the ATC probe to the 8 pin miniDIN input on the meter. **See G.** Connect the stir probe to the stir jack input on the meter (benchtop meters only). **See H.**

   NOTE: *Make sure that all unused inputs on the meter are covered with the black caps.* ▲

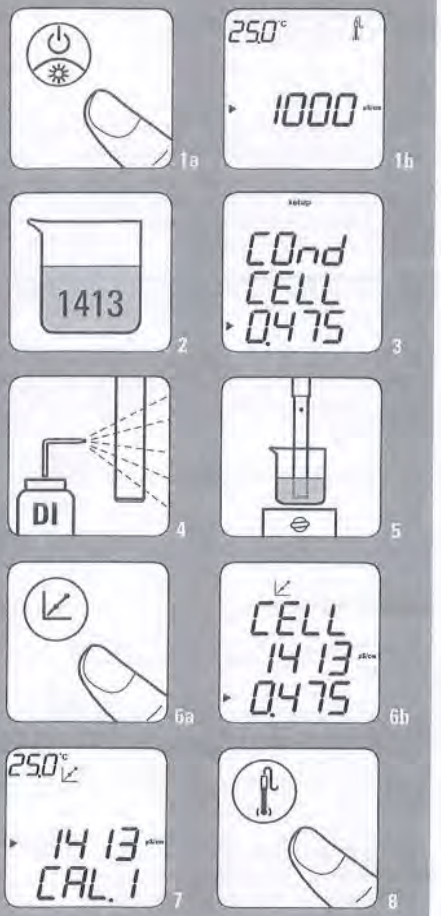
Meter Overview

1. To power on the meter press the **power** key.
2. Press the **line select** key to choose the top, middle, or bottom display line. The ▶ icon will point to the selected line.
3. In the measurement screen press the **up arrow** key to change the value on the top display line to pH, RmV, mV, or a blank line.
4. To escape out of any meter function, press and hold the **measure** key until the meter returns to the measurement mode.
5. The sympHony™ pH meters can be calibrated using up to five pH buffers.

VWR sympHony™

Attachment 2b

EN



Conductivity Meter

Quick Start Guide

Conductivity Autocalibration with One Standard

1. Press the **power** key to turn on the meter. **See 1a**. Use the **line select** key to move the ▶ icon to the conductivity measurement line. **See 1b**.
2. Select the VWR® conductivity standard (100 µS/cm, 1413 µS/cm, or 12.9 mS/cm) that has the closest conductivity to your expected sample value. **See 2**.
3. In the setup mode enter the nominal cell constant value for the conductivity probe. **See 3**. The meter will use the nominal cell constant value to recognize the conductivity standard during autocalibration. See **Nominal Cell Constant Selection** section.
4. Rinse the conductivity probe with deionized water and blot dry with a lint-free tissue. **See 4**.
5. Insert the conductivity probe into the conductivity standard and gently stir – if a stir probe is being used press the **stir** key to start and stop stirring (benchtop models only). **See 5**.
6. Press the **calibrate** key. **See 6a**. The meter will show the manual calibration display for about five seconds. **See 6b**. Do not press any keys.
7. After about five seconds the meter will proceed to the direct and autocalibration display. Wait for the **µS/cm** or **mS/cm** icon to stop flashing and the ▶ icon to start flashing. The meter should display the conductivity standard value at 25 °C. **See 7**.
8. Press the **measure** key to save and end the calibration. **See 8**. The calculated cell constant will be displayed and then the meter will proceed to the measurement mode.

Nominal Cell Constant Selection

1. Press the **setup** key.
2. Press the **up arrow** key until COnd is displayed on the top line.
3. Press the **line select** key to move the ▶ icon to the middle line. Press the **up arrow** key until CELL is displayed.
4. Press the **line select** key to move the ▶ icon to the bottom line. Enter the nominal cell constant by pressing the **up/down arrow** keys to adjust each digit and the **digits** key to move to the next digit. 0.475 cm^{-1} is default setting.
5. Press the **line select** key to move the ▶ icon to the top line. Press the **measure** key to return to the measurement mode.

Reference Temperature Selection

1. Press the **setup** key.
2. Press the **up arrow** key until COnd is displayed on the top line.
3. Press the **line select** key to move the ▶ icon to the middle line. Press the **up arrow** key until trEF is displayed.
4. Press the **line select** key to move the ▶ icon to the bottom line. Press the **up arrow** key to select 15 °C, 20 °C, or 25 °C as the reference temperature. 25 °C is default setting.
5. Press the **line select** key to move the ▶ icon to the top line. Press the **measure** key to return to the measurement mode.

Conductivity Measurements

1. Rinse the conductivity probe with deionized water, blot dry with a lint-free tissue, and insert the probe into the sample.
2. If the meter is in AUTO-READ™ mode, press the **measure** key to take a measurement. Once the reading stabilizes the **AR** icon will stop flashing and the display will freeze. Press the **measure** key again to take a new measurement.

   If a stir probe is connected it will start stirring when the **measure** key is pressed and stop stirring when the **AR** icon stops flashing (benchtop meters only).
3. If the meter is in the continuous or timed measurement modes, the meter will continuously take measurements and update the display. Once the reading stabilizes the **µS/cm** or **mS/cm** icon will stop flashing.

   If a stir probe is connected press the **stir** key to start stirring and press the **stir** key again to stop stirring (benchtop meters only).

Printing Data

In the AUTO-READ and continuous measurement modes, every time the **measure** key is pressed the meter logs the data on the display. In the timed measurement mode, the meter logs the data at the predetermined time interval.

1. Press the **view log** key.
2. Use the **up arrow** key to scroll between CALO (print the calibration log) and SEnd (print the measurement log).
3. Press the **line select** key to print the data.

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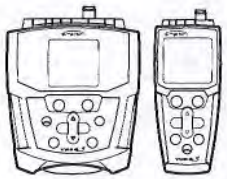


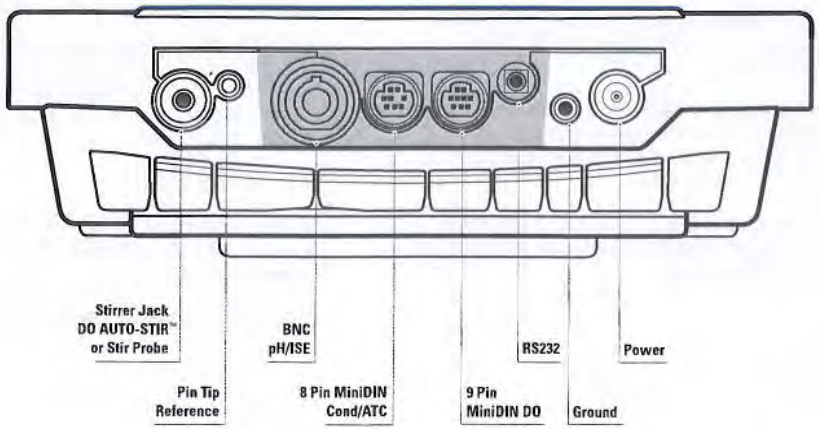
Key Description

power	up arrow	line select	view log
calibrate	down arrow	setup	stir
measure	digits		

All connectors on the sympHony™ SB90M5 meter are depicted below. All connectors on the SP90M5 portable meter are highlighted in gray.

The SB70C, SP70C, SB80PC, and SP80PC meters will have fewer connectors. For example, the SP70C portable conductivity meter will only have 8 pin miniDIN and RS232 connectors.

Meter Connections



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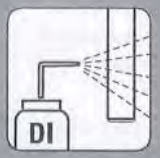
A

B

C



D

E

F

G

Conductivity Meter

Preparation

1. Power adapter (benchtop models only) - Select the appropriate wall socket plug and slide the plug plate into the groove on the back of the adapter. **See A.**

   Batteries - Select four AA Alkaline batteries. Confirm that the meter is off and remove the battery cover. Orient and insert the batteries as depicted in the battery compartment housing. Replace the cover. **See B & C.**

2. Prepare the conductivity probe according to the directions in the probe instruction manual. In general, this includes rinsing the probe with deionized water. **See D.**

3. Meter connections - Connect the power adapter to the meter and then to the wall socket (benchtop meters only). **See E.** Connect the conductivity probe to the 8 pin miniDIN input on the meter. **See F.** Connect the stir probe to the stir jack input on the meter (benchtop meters only). **See G.**

   NOTE: *Make sure that all unused inputs on the meter are covered with the black caps.* ▲

Meter Overview

1. To power on the meter press the **power** key.
2. Press the **line select** key to choose the top, middle, or bottom display line. The ▶ icon will point to the selected line.
3. In the measurement screen press the **up arrow** key to change the value on the middle display line to µS/cm or mS/cm, mg/L, ppt, MΩ-cm, or a blank line.
4. To escape out of any meter function, press and hold the **measure** key until the meter returns to the measurement mode.
5. The sympHony™ conductivity meters can perform a one point manual calibration, up to a three point autocalibration, or up to a five point direct calibration.

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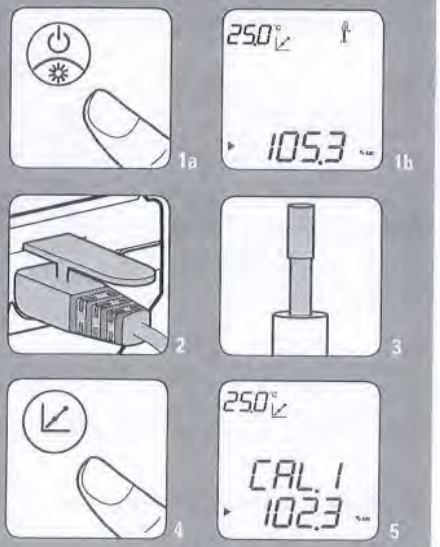
DO Meter

Quick Start Guide



Meter Overview

1. To power on the meter press the **power** key.
2. Press the **line select** key to choose the top, middle, or bottom display line. The ▶ icon will point to the selected line.
3. In the measurement screen press the **up arrow** key to change the value on the bottom display line to % saturation, mg/L, barometric pressure (no icon), or a blank line.
4. To escape out of any meter function, press and hold the **measure** key until the meter returns to the measurement mode.
5. The sympHony™ DO meters can perform an air calibration using water saturated air, water calibration using air saturated water, manual calibration (Winkler titration), or zero point calibration.

Air Calibration

1. Press the **power** key to turn on the meter. **See 1a**. Use the **line select** key to move the ▶ icon to the DO measurement line. **See 1b**.
2. Make sure the DO probe is connected to the meter and fully polarized. **See 2**.

   Allow the probe to polarize for 30 to 60 minutes when the probe is first connected to the meter, the membrane cap is changed, or the electrolyte solution is changed.
3. Insert the probe into the prepared calibration sleeve or BOD bottle and allow five minutes for the probe to equilibrate. **See 3**.
4. Press the **calibrate** key. **See 4**.
5. When the reading stabilizes the meter will display 102.3% saturation and then proceed to the measurement mode. **See 5**.

DO Calibration Type Selection

1. Press the **setup** key.
2. Press the **up arrow** key until dO is displayed on the top line.
3. Press the **line select** key to move the ▶ icon to the middle line. Press the **up arrow** key until CALt is displayed.
4. Press the **line select** key to move the ▶ icon to the bottom line. Press the **up arrow** key to select the calibration type. Air is default setting.

   Air = Water Saturated Air Calibration
   H2O = Air Saturated Water Calibration
   mAn = Manual Calibration (Winkler titration)
   SEt0 = Zero Point Calibration
5. Press the **line select** key to move the ▶ icon to the top line.
6. Press the **measurement** key to return to the measurement mode.

Measurement Mode Selection

1. Press the **setup** key.
2. Press the **up arrow** key until rEAd is displayed on the top line.
3. Press the **line select** key to move the ▶ icon to the middle line. Press the **up arrow** key until tYPE is displayed.
4. Press the **line select** key to move the ▶ icon to the bottom line. Press the **up arrow** key to select the measurement mode. AUtO is default setting.

   COnt = Continuous measurement mode
   AUtO = AUTO-READ™ measurement mode
   tImE = Timed measurement mode
5. Press the **line select** key to move the ▶ icon to the top line.
6. Press the **measure** key to return to the measurement mode

DO Measurements

1. Rinse the DO probe with deionized water, blot dry with a lint-free tissue, and insert the probe into the sample.
2. If the meter is in AUTO-READ mode, press the **measure** key to take a measurement. Once the reading stabilizes the **AR** icon will stop flashing and the display will freeze. Press the **measure** key again to take a new measurement.

   If a stir probe is connected it will start stirring when the **measure** key is pressed and stop stirring when the **AR** icon stops flashing. If an AUTO-STIR™ BOD probe is connected, the stir button on the probe can be pressed to take a new measurement and begin stirring. (Benchtop meters only)
3. If the meter is in the continuous or timed measurement modes the meter will continuously take measurements and update the display. Once the reading stabilizes the **mg/L** or **%sat** icon will stop flashing.

   If a stir probe or AUTO-STIR BOD probe is connected, press the **stir** key on the meter to start stirring and press the **stir** key again to stop stirring (Benchtop meters only).

Printing Data

In the AUTO-READ and continuous measurement modes, every time the **measure** key is pressed the meter logs the data on the display. In the timed measurement mode the meter logs the data at the predetermined time interval.

1. Press the **view log** key.
2. Use the **up arrow** key to scroll between CALO (print the calibration log) and SEnd (print the measurement log).
3. Press the **line select** key to print the data.

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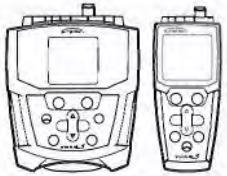


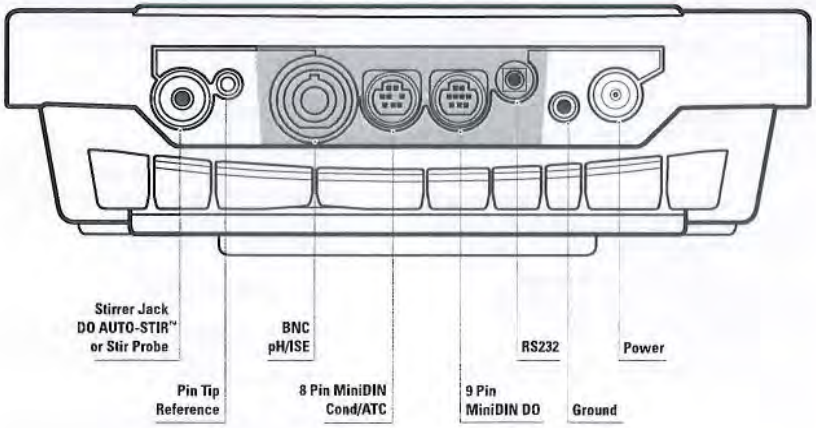
Key Description

power	up arrow	line select	view log
calibrate	down arrow	setup	stir
measure	digits		

All connectors on the sympHony™ SB90M5 meter are depicted below. All connectors on the SP90M5 portable meter are highlighted in gray.

The SB70D, SP70D, SB80PD, and SP80PD meters will have fewer connectors. For example, the SP70D portable DO meter will only have 9 pin miniDIN, 8 pin miniDIN (ATC), and RS232 connectors.

Meter Connections



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DO Meter

Preparation

1. Power adapter (benchtop models only) - Select the appropriate wall socket plug and slide the plug plate into the groove on the back of the adapter. **See A.**

   Batteries - Select four AA Alkaline batteries. Confirm that the meter is off and remove the battery cover. Orient and insert the batteries as depicted in the battery compartment housing. Replace the cover. **See B & C.**

2. Prepare the DO probe according to the directions in the probe instruction manual. In general, these steps include:

   - Unscrew the membrane cap from the DO probe, fill the membrane cap about ¾ full with DO probe electrolyte solution, and screw the membrane cap onto the DO probe.
   - Connect the DO probe to the meter and allow the probe to polarize for about 30-60 minutes.

   NOTE: *A DO reading of zero and no change in temperature indicates that the DO probe is not connected. Firmly reconnect the DO probe to the meter.* ▲

3. Calibration sleeve or BOD bottle.

   - To prepare the calibration sleeve remove the cap from the sleeve and remove the sponge from the cap. Saturate the sponge with distilled water and then squeeze all the excess water out of the sponge. Reassemble the calibration sleeve and insert the DO probe.
   - To prepare a BOD bottle fill the bottle with about 50 mL of distilled water. Insert the probe into the BOD bottle (Use a BOD bottle adapter if the DO probe does not fit directly into the bottle). Make sure the probe is suspended about half an inch above the distilled water and there is no water on the surface of the DO probe.

4. Meter connections - Connect the power adapter to the meter and then to the wall socket (benchtop meters only). **See D.** Connect the DO probe to the 9 pin miniDIN input on the meter. **See E.** Connect the stir probe or the stir connector on the AUTO-STIR™ BOD probe to the stir jack input on the meter (benchtop meters only). **See F.**

   NOTE: *Make sure that all unused inputs on the meter are covered with the black caps.* ▲

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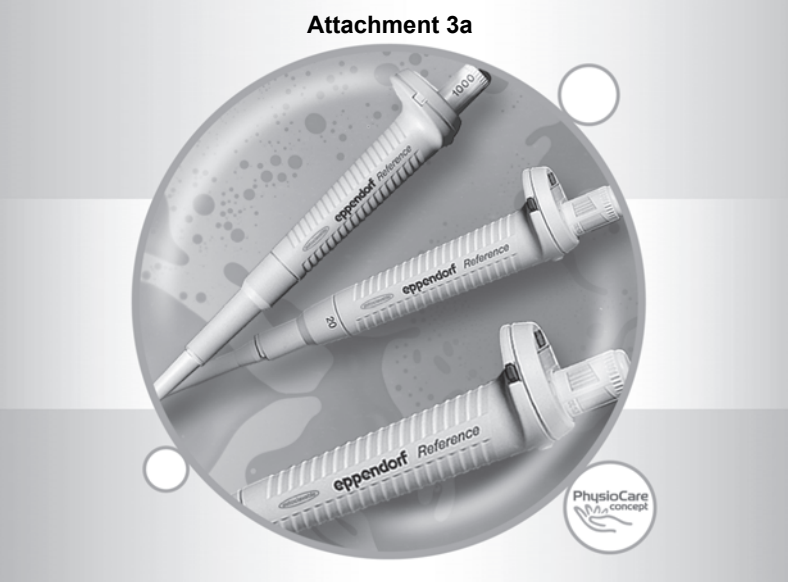
Attachment 3a



Eppendorf Reference®

Operating Manual

eppendorf

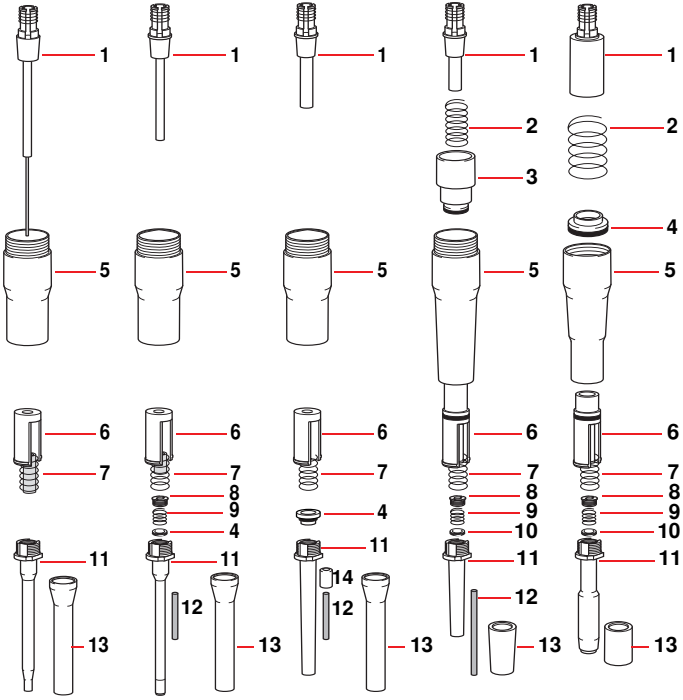
1 Fig. / Abb. 1

Reference variabel / Reference adjustable

0.1 – 2.5 µL 10 – 100 µL 20 – 200 µL 100 – 1000 µL 500 – 2500 µL
0.5 – 10 µL
2 – 20 µL

Reference fix

1 – 50 µL 100 µL 200 – 250 µL 500 – 2500 µL



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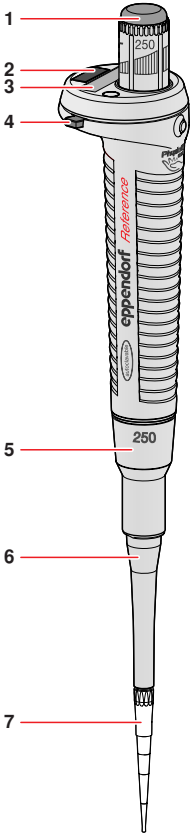
1 Main Illustration



1 Control button

The control button is for setting the volume, dispensing and ejecting the pipette tip.

2 Volume display

Displays the preset volume.

3 Labeling area

The provided autoclavable, blank labels can be labeled with a waterproof pen and affixed at this location.

4 Catch

Hold down the catch when you set the volume using the control button.

5 Lower part

6 Ejector sleeve

7 Pipette tip

2 Warning signs and hazard icons

2.1 Hazard icons

Biological hazard	**Health hazard**
General hazard	**Material damage**
Notice	

2.2 Danger levels

The danger level is part of a safety note and defines the potential consequences if the information contained therein is not observed.

DANGER	*Will* lead to serious injuries or death.
WARNING	*May* lead to serious injuries or death.
CAUTION	May lead to minor or moderate injuries.
NOTICE	May lead to material damage.
Notice	Provides useful information.

3 General safety notes

WARNING! Damage to health due to handling infectious liquids and pathogenic germs.

- Observe the national regulations for handling these substances, the biological security level of your laboratory, the material safety data sheets and the manufacturer's application notes.
- Wear your personal protective equipment (PPE).
- Follow the instructions regarding hygiene, cleaning and decontamination.
- For complete instructions regarding the handling of germs or biological material of risk group II or higher, please refer to the "Laboratory Biosafety Manual" (Source: World Health Organization, current edition of the Laboratory Biosafety Manual).

WARNING! Damage to health due to toxic, radioactive or aggressive chemicals.

- Observe the national regulations for handling these substances as well as the material safety data sheets and manufacturer's application notes.
- Wear your personal protective equipment (PPE).

CAUTION! Danger to persons from improper handling.

- Never aim the opening of a Reference equipped with pipette tip at yourself or other persons.
- Only initiate dispensing if it is safe to do so.
- For all dispensing tasks, make sure that you are not endangering yourself or anyone else.

CAUTION! Poor safety due to incorrect accessories and spare parts.
The use of accessories and spare parts other than those recommended by Eppendorf may impair the safety, functioning and precision of the device. Eppendorf cannot be held liable or accept any liability for damage resulting from the use of incorrect or non-recommended accessories and spare parts or from the improper use of such equipment.

- Only use accessories and original spare parts recommended by Eppendorf.

NOTICE! Damage to device from missing pipette tips.
- Only use the Reference with attached pipette tips.

NOTICE! Carry-over, contamination and incorrect dispensing results due to the repeated use of pipette tips.
The pipette tips are for single use only. Prolonged use can have a negative impact on dispensing tasks.
- Use the pipette tips only once.
- Do not autoclave the epDualfilter T.I.P.S.

NOTICE! Incorrect dispensing volume with special liquids and due to temperature differences.
Solutions which differ greatly from water in terms of their physical data, or temperature differences between the pipette, pipette tip and liquid can result in incorrect dispensing volumes.
- Avoid temperature differences between pipette, pipette tip and liquid.
- Ensure that the temperature remains constant between 20 and 25 °C, ±0,5 °C.
- Check the dispensing volume and readjust the pipette in case of deviations.

NOTICE! Damage to device due to penetration of liquids.
- Do not deposit the Reference with filled pipette tip.
- Only use pipettes in the Reference-Serie when a pipette tip has been attached.
- Do not allow any liquids to penetrate the inside of the housing.

4 Intended use

The Reference is a lab device intended for dispensing liquids in the volume range from 0.1 µL to 2.5 mL, in combination with matching pipette tips. In vivo applications (applications in or on the human body) are not permitted.

The Reference may only be operated by trained specialist staff. All users must have read the operating manual carefully and familiarized themselves with the device's mode of operation.

5 Technical data

5.1 Reference fix

Model / Volume µL	Color code	epT.I.P.S. µL	Systematic error %	Systematic error µL	Random error %	Random error µL
1	light gray	0.5– 20	± 2.5	± 0.025	± 1.8	± 0.018
2	light gray	0.5– 20	± 2.0	± 0.04	± 1.2	± 0.024
5	light gray	0.5– 20	± 1.5	± 0.075	± 0.8	± 0.04
10	light gray	0.5– 20	± 1.0	± 0.1	± 0.5	± 0.05
10	yellow	2– 200	± 1.0	± 0.1	± 0.5	± 0.05
20	yellow	2– 200	± 0.8	± 0.16	± 0.3	± 0.06
25	yellow	2– 200	± 0.8	± 0.2	± 0.3	± 0.075
50	yellow	2– 200	± 0.7	± 0.35	± 0.3	± 0.15
100	yellow	2– 200	± 0.6	± 0.6	± 0.2	± 0.2
200	blue	50–1,000	± 0.6	± 1.2	± 0.2	± 0.4
250	blue	50–1,000	± 0.6	± 1.5	± 0.2	± 0.5
500	blue	50–1,000	± 0.6	± 3	± 0.2	± 1
1,000	blue	50–1,000	± 0.6	± 6	± 0.2	± 2
1,500	red	500–2,500	± 0.6	± 9	± 0.2	± 3
2,000	red	500–2,500	± 0.6	± 12	± 0.2	± 4
2,500	red	500–2,500	± 0.6	± 15	± 0.2	± 5

5.2 Reference variable

Model µL	Color code	epT.I.P.S. µL	Volume µL	Systematic error %	Systematic error µL	Random error %	Random error µL
0.1– 2.5	dark gray	0.1– 10	0.25	± 12.0	± 0.030	± 6.0	± 0.015
			1.25	± 2.5	± 0.031	± 1.5	± 0.019
			2.5	± 1.4	± 0.035	± 0.7	± 0.018
0.5– 10	light gray	0.5– 20	1	± 2.5	± 0.025	± 1.8	± 0.018
			5	± 1.5	± 0.075	± 0.8	± 0.04
			10	± 1.0	± 0.1	± 0.4	± 0.04
2– 20	light gray	0.5– 20	2	± 3.0	± 0.06	± 2.0	± 0.04
			10	± 1.0	± 0.1	± 0.5	± 0.05
			20	± 0.8	± 0.16	± 0.3	± 0.06
2– 20	yellow	2– 200	2	± 5.0	± 0.1	± 1.5	± 0.03
			10	± 1.2	± 0.12	± 0.6	± 0.06
			20	± 1.0	± 0.2	± 0.3	± 0.06
10– 100	yellow	2– 200	10	± 3.0	± 0.3	± 0.7	± 0.07
			50	± 1.0	± 0.5	± 0.3	± 0.15
			100	± 0.8	± 0.8	± 0.15	± 0.15
50– 200	yellow	2– 200	50	± 1.0	± 0.5	± 0.3	± 0.15
			100	± 0.9	± 0.9	± 0.3	± 0.3
			200	± 0.6	± 1.2	± 0.2	± 0.4
50– 250	blue	50–1,000	50	± 1.4	± 0.7	± 0.3	± 0.15
			100	± 1.1	± 1.1	± 0.3	± 0.3
			250	± 0.6	± 1.5	± 0.2	± 0.5
100–1,000	blue	50–1,000	100	± 3	± 3	± 0.3	± 0.3
			500	± 1	± 5	± 0.2	± 1
			1,000	± 0.6	± 6	± 0.2	± 2
500–2,500	red	500–2,500	500	± 1.5	± 7.5	± 0.3	± 1.5
			1,250	± 0.8	± 8	± 0.2	± 2
			2,500	± 0.6	± 15	± 0.2	± 5

The technical data is only valid when the quoted **eppendorf** pipette tips are used. Tests carried out in accordance with ISO 8655 for piston-stroke pipettes with an air cushion using a precision balance with evaporation trap approved by the standardization authorities.
Number of determinations:
10; degassed, bidistilled water, 20 °C – 25 °C, constant to ± 0.5 °C; with pre-wetted pipette tip; dispensing carried out on inner wall of vessel. If the place where the pipette is used is at extremely high altitude, an adjustment must be made in line with the ambient air pressure.

6 Function principle

The pipettes in the Reference-Serie are piston-stroke pipettes that operate according to the air-cushion principle.
The Reference-Serie consists of fixed-volume pipettes and pipettes with an adjustable volume setting.
The control button is multi-functional. The function executed by the pipette depends on how far its control button is pressed down.

Ex
20 °C

Three steps are necessary to operate the pipette:

1. Measuring stroke
   Press the control button down until the first stop. The desired volume of liquid is dispensed or, when the button is released, aspirated.
2. Blow-out
   Press the button down a little more until the next stop.
   Any liquid remaining in the pipette tip is emptied.
3. Ejection
   Press the button all the way down.
   The pipette tip is ejected.

7 Operation

The pipette can be individually labelled. The autoclavable blank adhesive label provided can be marked with a permanent marker and fits onto the identification area on the top of the housing.

7.1 Volume setting

The volume is adjusted by pressing down the lateral catch and turning the control button at the same time.

It is advisable to carry out volume setting from the higher down to the lower value. i.e. first go above the desired volume and then return to the lower value.

7.2 Pipette tips

The pipette can function only when a pipette tip is attached into which the liquid is aspirated.

To facilitate the search for a suitable tip, the color of the control buttons corresponds to the color of the **eppendorf** tip racks.

When pipetting liquids with wetting properties different to those of water, please observe the recommendations contained in Chapter 7.5.

7.3 Aspirating liquid

– The liquid which is to be aspirated is taken from a suitable vessel.
– Attach suitable pipette tip to the pipette firmly (observe the color coding).
– Press down the control button to the first stop (measuring stroke).
– Immerse the pipette tip vertically approx. 3 mm into the liquid.
– Allow the control button to slide back **slowly**.
– Pull the tip out of the liquid **slowly**.
– To remove any remaining droplets, dab with non-fibrous cellulose material. When doing so, ensure that no liquid comes out of the tip.

7.4 Dispensing liquid

– Hold the tip at an angle against the inside wall of the tube.
– Press down the control button slowly to the first stop (measuring stroke) and wait until the liquid stops flowing.
– Press down the control button to the second stop (blow-out) until the tip is completely empty.
– Hold down the control button and pull the tip up the inner wall of the tube.
– Tip is ejected by pressing the control button to the final stop.

7.5 Special notes

To guarantee the highest degree of precision and accuracy, we recommend pre-wetting all new tips by aspirating and dispensing liquid two or three times before pipetting.
Finally, with the tip not in contact with the liquid, empty it completely on the inner wall of the tube (via blow-out).

Explanation: Why does the pipette tip have to be **pre-wetted**?
To compensate for the properties of the liquid.
Wetting liquids (serum, detergent) form a thin film on the inner wall of the pipette tip. When the first pipetting is carried out, the volume dispensed would thus be too low.
When pipetting serum or high-viscosity solutions, wait a few seconds when aspirating and dispensing liquid.

8 Testing / Alignment

The serial number of the pipette is located on its control button.

8.1 Testing

Distilled water is dispensed from a pre-wetted tip into a tube and is then weighed.

Volumes 0.1 – 10 µL:
The test is performed with a highly sensitive analytic balance (resolution balance: 0.001 mg) by releasing the volume.

The bidistilled water, weighing vessel, pipette and pipette tip must all be the same temperature!

To calculate the volume, divide the weight by the density of the water (at 20 °C: 0.9982 mg/µL; mg/µL = g/mL).

Volumes > 10 – 2.500 µL:
For a volume of more than 10 µL, a balance with a resolution of 0.01 mg is sufficient.

8.2 Alignment

8.2.1 When should alignment be carried out?

The pipettes in the Reference-Serie were tested during production in accordance with the measurement conditions for water listed in Chapter 2.

In the case of doubts arising about the accuracy of the pipetted volume, the following points should first be checked:

– Is the pipette leaking? (This is one possible reason for dispensed volumes being too low; troubleshooting and solutions are contained in Chapter 7)
– What is the temperature of the sample? (In open tubes, water at room temperature cools down due to evaporation.)
– What is the temperature of the pipette?
– What is the temperature of the air?
– Has mg been converted into µL?
– Does the sample have a different density to that of water?
– Is the pipetting speed too high?

If the place where the pipette is used is at extremely high altitude, an adjustment must be made in line with the ambient air pressure. At 1,000 m above sea level, there is a volume error of approx. –0.4 %.

Assistance with these questions is contained in **eppendorf's** SOP (**S**tandard **O**perating **P**rocedure). An SOP can be called up from our home page *www.eppendorf.com*

If these checks prove to be unsuccessful, it is safe to assume that the alignment of the pipette has altered (e.g. due to several components having been replaced).

8.2.2 Follow-up alignment in the case of error

From a technical point of view, this is a zero-point shift. The value by which the setting of the pipette is shifted remains constant across the entire measuring range. If, for example, in the case of a 10 – 100 µL pipette, follow-up alignment of 1 µL is carried out at 100 µL (=1 %), the pipette is also adjusted by 1 µL at 10 µL (= 10 %!)

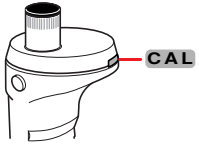
Alignment Reference fix:

To assist you in finding the basic setting again, round adhesive labels with an arrow are provided as an alignment aid.

– Stick the alignment aid onto the control button.

Determine the volume by weighing and calculation
(see point a – c "Alignment Reference variable").

d



Pierce the calibration seal attached to the opening for adjustments with Side B of the key provided. This destroys the seal which should be removed. Undo the screw inside a little until the control button can be turned.

e Adjust control button by the volume determined.
One revolution of the control button corresponds to the following values for water:

Reference fix	Vol./revol.
1, 2, 5, 10 µL	approx. 0.5 µL
10, 20 µL	approx. 1 µL
25, 50 µL	approx. 2.4 µL
100 µL	approx. 5 µL
200, 250 µL	approx. 12 µL
500, 1000 µL	approx. 46 µL
1500, 2000, 2500 µL	approx. 118 µL

Clockwise rotation: decrease in volume.
Counterclockwise rotation: increase in volume.

f Tighten the screw until the control button can no longer be turned.

Then continue as described in steps f and g of the Alignment Reference variable.

If the nominal volume does not correspond with the measuring result, repeat steps d – g.
Then reseal the adjustment opening using one of the calibration seals supplied.

Alignment Reference variable:

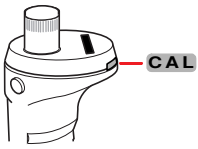
a The pipette, tip and water must all be the same temperature (20 – 25 °C, constant to ± 0.5 °C).

b Set the Reference variable to the desired nominal volume.

c With a pipette tip attached to the pipette, the desired volume is pipetted and weighed 10 times. The average of this weighing is converted into µL using the following formula:

$$\text{Volume} = \frac{\text{Weight}}{\text{Density of liquid (at the temperature specified)}}$$

The value obtained is the actual setting
(density of water at 20 °C: 0.9982 mg/µL; mg/µL = g/mL).

d 

Pierce the calibration seal attached to the opening for adjustments with Side B of the key provided. This destroys the seal which should be removed. Carefully attach the key to the adjusting sleeve inside.

e Turn the wrench to adjust the volume display of the pipette (with piston stroke unchanged) to the actual volume (measurement under step c).

f Remove the wrench.

g Repeat step c). The readings must be within the tolerances specified in the technical data.

If the nominal value still does not agree with the measuring result, repeat steps d – g.

Since this adjustment affects the entire measuring range, it is imperative to check the other volumes of this pipette specified in the technical data.
Then reseal the adjustment opening using one of the calibration seals supplied.

8.2.3 Adjustment for liquids with a density different to that of water

It is possible to adjust the pipette for **one specific volume of liquid** with a density different to that of water in such a way that the volume displayed corresponds to the volume pipetted.

All other values for the adjustable pipettes are now out of alignment, i.e. an adjustable-volume pipette has been converted into a fixed-volume pipette!

Proceed as described in Chapter 8.2.2.

A pipette set in this way delivers a pipetting value that correlates with that in the display **only for the liquid used and for the volume tested**! For this reason, we very strongly recommend labeling the converted pipette **as a fixed-volume pipette** for "Solution y"!
The error for liquids with a higher vapor pressure (e.g. organic solvents) cannot be aligned in this way. In this case, we recommend using an **eppendorf** positive-displacement pipette.

9 Care / Sterilization

9.1 Care

Depending on the frequency of use, all parts of the pipette should be cleaned from time to time in a soap solution or should be carefully wiped clean using isopropanol. They should then be rinsed in distilled water and dried.
The seals are maintenance-free and the pistons should be lubricated lightly (using the grease for pipettes provided) when cleaned or replaced.

Severe contamination caused by the liquid entering the pipette can be removed after the pipette has been disassembled (see Part B, Maintenance).

For information about replacing defective parts, please see Part B, Maintenance.

9.2 Sterilization

The Reference-Serie including the blank label provided (marked with a permanent marker) is fully autoclavable at 121 °C for 20 minutes.
Before autoclaving, unscrew the pipette at the central junction by rotating about one revolution. This enables steam to penetrate more easily into the pipette during autoclaving.
After autoclaving, the pipette may have to be dried at room temperature. Retighten the central junction only after the pipette has completely cooled.
The tip cone may have to be tightened again with the wrench (see part B, Maintenance).

The Reference pipettes may be temporarily subjected to the UV light of a sterile bench ($\propto$ 254 nm).

9.3 Decontamination prior to dispatch

If the Reference pipette is to be checked, repaired or calibrated by Eppendorf AG or another service partner, it must be free of hazardous substances and clean!

A form called "Decontamination certificate for return of goods" and general notes about decontamination are available on our home page:
www.eppendorf.com
A signed decontamination certificate must be enclosed with the pipette when it is returned. The serial number of the Reference must be entered on the decontamination certificate.
The Reference can be decontaminated of potentially infectious substances by being steam-autoclaved (see Sec. 9.2).
The surfaces of the pipette can be disinfected with alcohol (ethanol, propanol) or with a disinfectant containing alcohol.

10 Troubleshooting

Error	Cause	Solution
Droplets on the inner wall of the pipette tip.	– Uneven wetting of the plastic wall.	– Attach a new pipette tip.
	– A pipette tip with poor wetting properties has been used.	– Use an original **eppendorf** tip.
Pipette is dripping and/or the volume pipetted is incorrect.	– The tip is loose.	– Press the tip firmly in place.
	– A poorly fitting pipette tip has been used.	– Use an original **eppendorf** tip.
	– Liquid with a high vapor pressure has been pipetted.	– In this case, we recommend pipetting using a positive-displacement pipette.
	– Tip has been taken out of the liquid too quickly.	– Remove the tip slowly from the liquid.
	The pipette is dripping because:	
	– Piston is contaminated.	– Clean and lightly lubricate the piston.
	– Piston is damaged.	– Replace the piston and seal (see Part B, Maintenance).
	– Seals are damaged.	– Replace all seals (see Part B, Maintenance).
	– Tip cone loose.	– Lightly tighten tip cone with wrench (see Part B, Maintenance). Exchange, where necessary.

Error	Cause	Solution
Control button jams, moves erratically.	– Piston contaminated.	– Clean piston and lubricate lightly.
	– Seals contaminated.	– Disassemble pipette. Clean all seals and exchange where necessary (see Part B, Maintenance).
	– Penetration of solvent vapors.	– Unscrew pipette at the central junction and ventilate. Clean piston and lubricate lightly.
Pipette blocked, too little liquid is aspirated.	– Liquid has penetrated the tip cone and dried.	– Unscrew pipette at the central junction, rinse lower part first with warm water, then with distilled water and allow to dry. Or: – Disassemble pipette. Replace ejector seal in the tip cone (see Part B, Maintenance).
	For 25 to 500 µL pipettes: – The filling tube in the nose cone is blocked.	For 25 to 50 µL: – Replace tip cone. For 100 to 500 µL: – Replace the filling tube in the tip cone (see Part B, Maintenance).

10.1 If there is doubt that dispensing data are correct

To avoid dispensing errors, the precision and accuracy of the Reference pipettes need to be checked regularly. The PICASO II software program (see ordering information) is available to determine permitted systematic and random measuring deviation (see Chapter 2 "Technical data"). An SOP (**S**tandard **O**perating **P**rocedure) for checking pipettes can be called up from our home page www.eppendorf.com.

For liquids whose physical data deviate significantly from those of water, calibration needs to be changed in accordance with Chapter 8.2.3. Calibration will also need to be changed if the pipette is being used at a very high altitude.

Maintenance

I	**Exchanging the piston**	**95**
II	**Exchanging the seals**	**95**
	Removing the seals	96
	Inserting the seals	101
III	**Exchanging the filling tube**	**101**
IV	**Exchanging the tip cone**	**101**

Ordering information

I	**Reference fixed-volume**	**102**
II	**Reference adjustable-volume**	**106**
III	**Additional accessories**	**109**
IV	**Pipette tips**	**110**

Please only use the accessories recommended by eppendorf. Using spare parts and disposables which we have not recommended can reduce the precision, accuracy and life of the pipette. We do not honor any warranty or accept any responsibility for damage resulting from such action.

Guarantee and warranty

In the case of warranty claims please contact your responsible Eppendorf contractual partner.
Wear-and-tear parts are excluded from the warranty. When returning the pipette to the Eppendorf contractual partner the necessary data for utilization and the performance of decontamination (see Part A section 6.3) should be included.

Servicing must be carried out by the Service of the Eppendorf contractual partner. No warranty shall apply with misuse or opening of the device by unauthorized persons.

For information on replacing pistons and seals as well as on disassembling and assembling the different models in the Reference-Serie please see page 1 at the front of this manual.
The fix and variable pipettes are of identical construction. You should therefore refer to the figure corresponding to the volume of your pipette or the volume range it falls in.

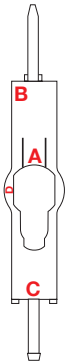
I Exchanging the piston

– Unscrew pipette at the central junction.
– Press control button and hold down. Hold piston at the top of the piston mounting and pull off. If the piston fits too tightly, the spring at the piston mounting can be pressed down slightly with side B of the wrench and the piston then pulled off.
– Attach new piston down to the stop and lubricate lightly.

II Exchanging the seals

The lower parts of the Reference-Serie can be completely disassembled for cleaning and maintenance using the wrench provided.

The wrench has the following functions:



A = Narrow opening: for loosening and tightening the tip cone.
Wide opening (D): For tightening the tip cone (with the lettering facing the pipette tip).
The wrench is designed in such a way that the tip cone cannot be tightened too much.

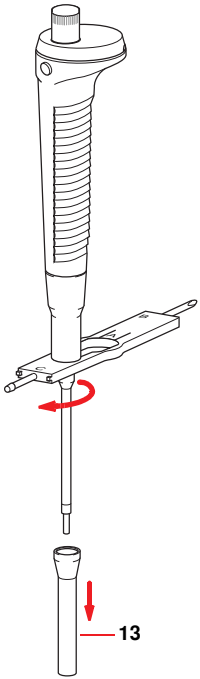
B =For loosening the screw in the tip cone.
During assembly, for mounting the screw, spring and seal and tightening the screw.
During alignment, for adjusting the volume display.

C =For removing the seal in the tip cone.

Removing the seals

Fig. 2 – 6 on the following pages show you how to remove the seals. The numbers shown are identical with the numbers in the Ordering information (page 94) and the numbers of the parts on page 1 of this manual.

0.1 – 2.5 µL, 0.5 – 10 µL and 2 – 20 µL (Fig. 2)

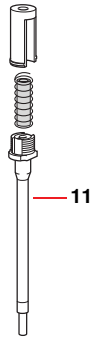


Push the control button all the way down and pull off the ejector sleeve (13).

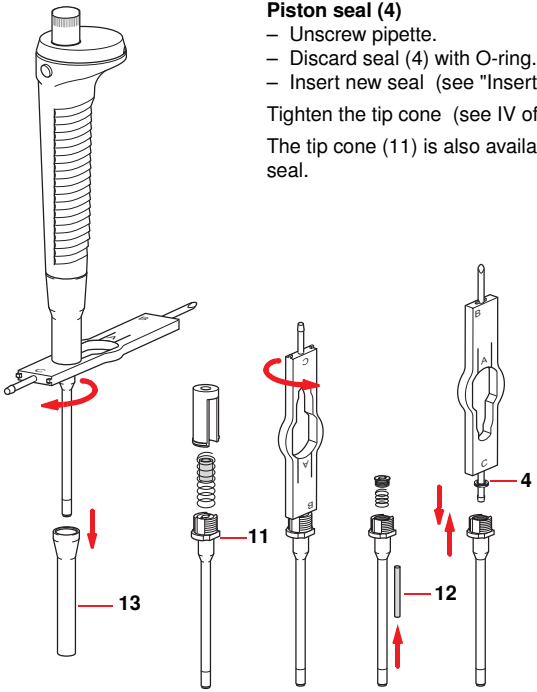
Piston seal

The piston seal in the tip cone is exchanged by replacing the entire tip cone (11).

Tighten the tip cone (see IV of this part).



10 – 100 µL (Fig. 3)



Push the control button all the way down and pull off the ejector sleeve (13).

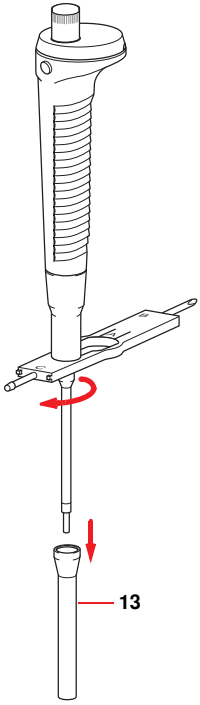
Piston seal (4)

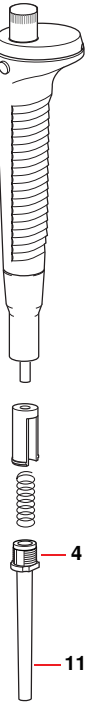
– Unscrew pipette.
– Discard seal (4) with O-ring.
– Insert new seal (see "Inserting the seals").

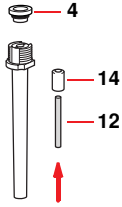
Tighten the tip cone (see IV of this part).

The tip cone (11) is also available complete with seal.

50 – 200 µL (Fig. 4)







Push the control button all the way down and pull off the ejector sleeve (13).

Piston seal (4)

– Unscrew pipette.
– Remove piston seal (4) from tip cone (with the piston in the grip of the pipette) and discard.
– Place new piston seal onto tip cone.

Tighten the tip cone (see IV of this part).

50 – 250 µL (Fig. 5)

Push the control button all the way down and pull off the ejector sleeve (13).

Piston seal (4)

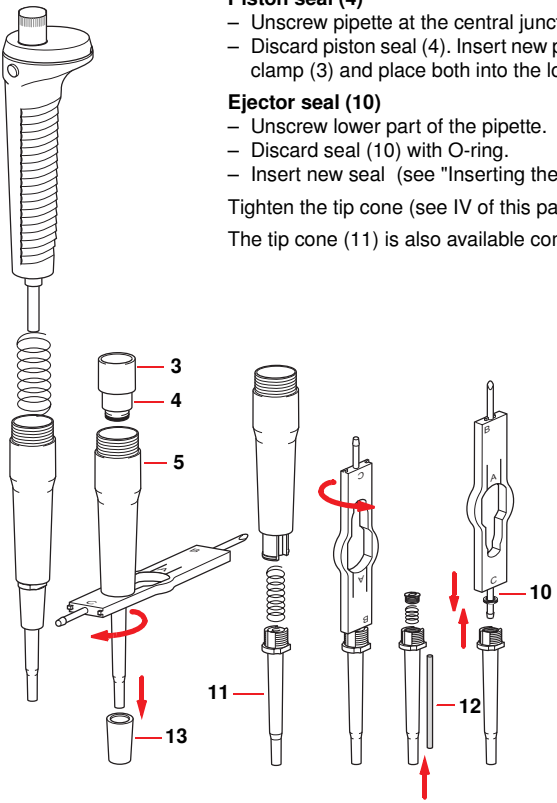
– Unscrew pipette at the central junction.
– Discard piston seal (4). Insert new piston seal into the clamp (3) and place both into the lower part (5).

Ejector seal (10)

– Unscrew lower part of the pipette.
– Discard seal (10) with O-ring.
– Insert new seal (see "Inserting the seals").

Tighten the tip cone (see IV of this part).

The tip cone (11) is also available complete with seal.



100 – 1000 and 500 – 2500 µL (Fig. 6)

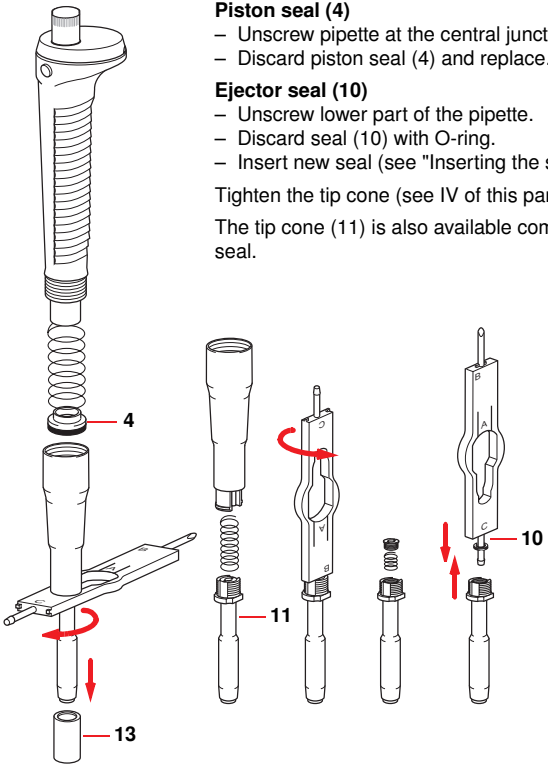
Push the control button all the way down and pull off the ejector sleeve (13).

Piston seal (4)
– Unscrew pipette at the central junction.
– Discard piston seal (4) and replace.

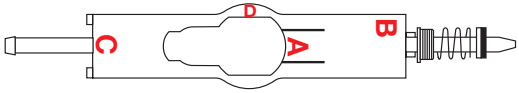
Ejector seal (10)
– Unscrew lower part of the pipette.
– Discard seal (10) with O-ring.
– Insert new seal (see "Inserting the seals").

Tighten the tip cone (see IV of this part).

The tip cone (11) is also available complete with ejector seal.



Inserting the seals



Pull new seal off the pin and push screw, spring, seal (with plastic part first) in that order onto side B of the wrench as shown in the figure and screw lightly into tip cone. Do not tighten too much. Assemble pipette again.

III Exchanging the filling tube

10 – 100 µL, 50 – 200 µL and 50 – 250 µL (Fig. 3, 4, 5)

Filling tube (12)

– Unscrew lower part of the pipette.
– Push filling tube (12) (and damping tube (14) for 50 – 250 µL) out of the tip cone from below with the wire punch. Push in new tube from above.

IV Exchanging the tip cone

After the ejector sleeve has been pulled off, the tip cone together with the seal (11) can be loosened with the wrench (A, narrow opening) and exchanged (together with the seal. See Fig. 2 – 6).

Tighten the tip cone:
Place wrench with the wide opening (A, lettering facing the pipette tip) onto the tip cone and tighten until it locks into position by turning half a revolution.
The wrench is designed in such a way that the tip cone cannot be tightened too much.

Caution
After exchanging parts or completing other maintenance, always check that the pipette functions correctly (see Part A, Section 5 and 7 of this Manual).

If a problem cannot be solved with the aid of the recommendations above, please return the **eppendorf** Reference to your **eppendorf** appointed dealer.

I Reference fixed-volume

(Please see page 1 (Fig. 1) of this manual).
Only parts with order numbers are available separately.

Pipettes / spare parts

Models	Order number International	Order number North America
Gray control button (for 10 µL pipette tips)		
1 µL	4900 000.010	022470400
2 µL	4900 000.028	022470451
5 µL	4900 000.036	022470507
10 µL	4900 000.044	022470558
Yellow control button (for 200 µL pipette tips)		
10 µL	4900 000.109	022470604
20 µL	4900 000.117	022470752
25 µL	4900 000.150	022470809
30 µL		022470850
50 µL	4900 000.125	022470957
75 µL		022471007
80 µL		022471058
90 µL		022471104
100 µL	4900 000.133	022471155
150 µL		022471201
200 µL		022471252
Blue control button (for 1000 µL pipette tips)		
200 µL	4900 000.508	
250 µL	4900 000.540	022471309
300 µL		022471350
500 µL	4900 000.516	022471457
800 µL		022471554
900 µL		022471601
1000 µL	4900 000.524	022471651
Red control button (for 2500 µL pipette tips)		
1500 µL	4900 000.923	022471708
2000 µL	4900 000.907	022471759
2500 µL	4900 000.915	022471805

		Order number International	Order number North America
1 Piston			
1 –	10 µL (gray control button)	4910 810.001	022475088
	20 µL	4910 811.008	
10 –	20 µL (yellow control button)		022475100
25 –	50 µL	4900 810.003	022475118
	100 µL, incl. piston seal (4)	4910 812.004	
75 –	100 µL, incl. piston seal (4)		022475126
150 –	200 µL		022475142
	250 µL		022475169
200 –	250 µL, incl. piston seal (4)	4910 813.000	
300 –	1000 µL, incl. piston seal (4)		022475185
500 –	1000 µL, incl. piston seal (4)	4910 814.007	
500 –	2500 µL, incl. piston seal (4)	4910 815.003	022475207
2 Piston spring			
1 –	250 µL	4910 825.009	
	250 µL		022475223
300 –	1000 µL		022475240
500 –	1000 µL	4910 826.005	
1500 –	2500 µL	4910 827.001	022475266
3 Clamp		not sold separately	
4 Piston seal			
75 –	100 µL, incl. screw (8), spring (9)		022475282
	100 µL, incl. screw (8), spring (9)	4910 820.007	
150 –	200 µL, incl. screw (8), spring (9)		022475304
200 –	250 µL, incl. screw (8), spring (9), ejector seal (10)	4910 821.003	
	250 µL, incl. screw (8), spring (9), ejector seal (10)		022475321
300 –	1000 µL, incl. screw (8), spring (9), ejector seal (10)		022475347
500 –	1000 µL, incl. screw (8), spring (9), ejector seal (10)	4910 822.000	
500 –	2500 µL, incl. screw (8), spring (9), ejector seal (10)	4910 823.006	022475363

	Order number International	Order number North America
5 Lower housing	not sold separately	
6 Ejector, includes ejector spring (7)		
1 – 20 µL, incl. ejector tube	4910 839.000	022475380
25 – 100 µL, incl. ejector tube	4910 840.008	022475401
150 – 200 µL		022475428
200 – 250 µL	4910 841.004	
250 µL		022475461
300 – 1000 µL		022475487
500 – 1000 µL	4910 842.000	
1500 – 2500 µL	4910 843.007	022475509
7 Ejector spring (1 – 100 µL includes ejector tube)	not sold separately	
8 Screw for tip cone	not sold separately	
9 Tip cone spring	not sold separately	
10 Ejector seal	not sold separately	
11 Tip cone, complete		
1 – 10 µL gray, incl. seal	4910 830.002	022475541
10 – 20 µL yellow, incl. seal	4910 832.005	022475584
25 – 50 µL, incl. (8), (9), (4), (12)	4900 830.004	022475606
75 – 100 µL, incl. (8), (9), (4), (12)		022475622
100 µL, incl. (8), (9), (4), (12)	4910 833.001	
150 – 200 µL, incl. (12), (14)		022475649
200 – 250 µL, incl. (8), (9), (10), (12)	4910 834.008	
250 µL, incl. (8), (9), (10), (12)		022475665
300 – 500 µL, incl. (8), (9), (10), (12)		022475681
500 µL, incl. (8), (9), (10), (12)	4900 831.000	
800 – 1000 µL, incl. (8), (9), (10)		022475703
1000 µL, incl. (8), (9), (10)	4910 835.004	
500 – 2500 µL, incl. (8), (9), (10)	4910 836.000	022475720
12 Filling tube (5 pieces, 1 wire punch)		
75 – 100 µL		022475746
100 µL	4910 837.007	
150 – 200 µL		022475762
200 – 250 µL	4910 838.003	
250 µL		022475789
300 – 500 µL		022475801
500 µL	4900 837.009	

	Order number International	Order number North America
13 Ejector sleeve		
1 – 100 µL	4910 845.000	022475827
150 – 200 µL		022475843
200 – 1000 µL	4910 846.006	
250 – 1000 µL		022475860
500 – 2500 µL	4910 847.002	022475886
14 Damping tube	not sold separately	
Lower part complete, incl. piston and (3) – (13)		
1 – 10 µL	4910 890.005	
10 µL (gray button)		022475924
10 – 20 µL (yellow button)	4910 892.008	022475967
25 – 50 µL	4900 890.007	022475983
75 – 100 µL		022476009
100 µL	4910 893.004	
150 – 200 µL		022476025
200 – 250 µL	4910 894.000	
250 µL		022476041
300 – 500 µL		022476068
500 µL	4900 891.003	
800 – 1000 µL		022476084
1000 µL	4910 895.007	
500 – 2500 µL	4910 896.003	022476106
Reference repair set (tube of grease for pipettes, 1 wrench, 6 blank labels, 1 wire punch, 1 filling tube each for 75 – 100 µL, 150 – 200 µL, 250 µL and 300 – 500 µL, 1 damping tube for 50 – 200 µL)	4910 805.008	022475045
Calibration aid labels (5 pieces)	4900 805.000	022475002
Grease for pipettes	0013 063.010	022458507
Wrench	4910 092.001	022475029
Calibration seal, red (5 pieces)	4910 601.003	

II Reference adjustable-volume

(Please see page 1 (Fig. 1) of this manual).
Only parts with order numbers are available separately.

Pipettes / spare parts

Models	Order number International	Order number North America
Dark gray control button (for 10 µL pipette tips)		
0.1 – 2.5 µL	4910 000.085	022470001
Light gray control button (for 20 µL pipette tips)		
0.5 – 10 µL	4910 000.018	022470051
2 – 20 µL	4910 000.026	022470108
Yellow control button (for 200 µL pipette tips)		
2 – 20 µL	4910 000.034	022470159
10 – 100 µL	4910 000.042	022470205
50 – 200 µL	4910 000.093	022470256
Blue control button (for 1000 µL pipette tips)		
50 – 250 µL	4910 000.050	
100 – 1000 µL	4910 000.069	022470302
Red control button (for 2500 µL pipette tips)		
500 – 2500 µL	4910 000.077	022470353
1 Piston		
0.1 – 2.5 µL	4910 809.003	022475061
0.5 – 10 µL	4910 810.001	022475088
2 – 20 µL	4910 811.008	022475100
10 – 100 µL, incl. piston seal (4)	4910 812.004	022475126
50 – 200 µL, incl. piston seal (4)	4910 816.000	022475142
50 – 250 µL, incl. piston seal (4)	4910 813.000	
100 – 1000 µL, incl. piston seal (4)	4910 814.007	022475185
500 – 2500 µL, incl. piston seal (4)	4910 815.003	022475207
2 Piston spring		
50 – 250 µL	4910 825.009	
100 – 1000 µL	4910 826.005	022475240
500 – 2500 µL	4910 827.001	022475266
3 Clamp	not sold separately	

	Order number International	Order number North America
4 Piston seal		
10 – 100 µL, incl. screw (8), spring (9)	4910 820.007	022475282
50 – 200 µL, with 2 O-rings	4910 824.002	022475304
50 – 250 µL, incl. screw (8), spring (9), ejector seal (10)	4910 821.003	
100 – 1000 µL, incl. screw (8), spring (9), ejector seal (10)	4910 822.000	022475347
500 – 2500 µL, incl. screw (8), spring (9), ejector seal (10)	4910 823.006	022475363
5 Lower housing	not sold separately	
6 Ejector, includes ejector spring (7)		
0.1 – 2.5 µL, incl. ejector tube	4910 839.000	022475380
0.5 – 10 µL, incl. ejector tube	4910 839.000	022475380
2 – 20 µL	4910 839.000	022475380
10 – 100 µL	4910 840.008	022475401
50 – 200 µL	4910 844.003	022475444
50 – 250 µL	4910 841.004	
100 – 1000 µL	4910 842.000	022475487
500 – 2500 µL	4910 843.007	022475509
7 Ejector spring (0.1–2.5, 0.5–10, 2–20, 10–100 µL incl. ejector tube)	not sold separately	
8 Screw for tip cone	not sold separately	
9 Tip cone spring	not sold separately	
10 Ejector seal	not sold separately	
11 Tip cone, complete		
0.1 – 2.5 µL, incl. seal	4910 829.004	022475525
0.5 – 10 µL, incl. seal	4910 830.002	022475541
2 – 20 µL, light gray, incl. seal	4910 831.009	022475568
2 – 20 µL, yellow, incl. seal	4910 832.005	022475584
10 – 100 µL, incl. (8), (9), (4), (12)	4910 833.001	022475622
50 – 200 µL, incl. (12), (14)	4910 851.000	022475649
50 – 250 µL, incl. (8), (9), (10), (12)	4910 834.008	
100 – 1000 µL, incl. (8), (9), (10)	4910 835.004	022475703
500 – 2500 µL, incl. (8), (9), (10)	4910 836.000	022475720

	Order number International	Order number North America
12 Filling tube, (5 pieces, 1 wire punch)		
10 – 100 µL	4910 837.007	022475746
50 – 200 µL, incl. 2 pieces of (14)	4910 853.002	022475762
50 – 250 µL	4910 838.003	
13 Ejector sleeve		
0.1 – 2.5 µL	4910 845.000	022475827
0.5 – 10 µL	4910 845.000	022475827
2 – 20 µL	4910 845.000	022475827
10 – 100 µL	4910 845.000	022475827
50 – 200 µL	4910 852.006	022475843
50 – 250 µL	4910 846.006	
100 – 1000 µL	4910 846.006	022475860
500 – 2500 µL	4910 847.002	022475886
14 Damping tube	not sold separately	
Lower part, complete, incl. piston and (3) – (14)		
0.1 – 2.5 µL	4910 889.007	022475908
0.5 – 10 µL	4910 890.005	022475924
2 – 20 µL, light gray	4910 891.001	022475941
2 – 20 µL, yellow	4910 892.008	022475967
10 – 100 µL	4910 893.004	022476009
50 – 200 µL	4910 897.000	022476025
50 – 250 µL	4910 894.000	
100 – 1000 µL	4910 895.007	022476084
500 – 2500 µL	4910 896.003	022476108
Reference repair set (tube of grease for pipettes, 1 wrench, 6 blank labels, 1 wire punch, 1 filling tube each for 75 – 100 µL, 150 – 200 µL, 250 µL and 300 – 500 µL, 1 damping tube for 50 – 200 µL)	4910 805.008	022475045
Calibration aid labels (5 pieces)	4900 805.000	022475002
Grease for pipettes	0013 063.010	022458507
Calibration seal, red (5 pieces)	4910 601.003	
Wrench	4910 092.001	022475029

III Additional accessories

	Order number International	Order number North America
Pipette carousel, incl. 6 pipette supports	3115 000.003	022444905
Pipette holder (replacement for stand)	3115 600.019	022260588
Pipette wall mount (with adhesive surface for attachment to lab benches and wall)	3115 000.020	022444913
PICASO II (Pipette Calibration Software)	3113 004.001	
PICASO accessories	see eppendorf catalog	
Operating manual	4910 900.132	

IV Pipette tips

epT.I.P.S.
(The packaging units stated represent the minimum ordering quantity).

	Length	Color code	Order number International	Order number North America
Standard, in bags, 2x 500 = 1000 tips				
0.1 – 10 µL	34 mm	dark gray	0030 000.811	022492004
0.1 – 20 µL	40 mm	medium gray	0030 000.838	022492012
0.5 – 20 µL L	46 mm	light gray	0030 000.854	022492021
2 – 200 µL	53 mm	yellow	0030 000.870	022492039
50 – 1000 µL	71 mm	blue	0030 000.919	022492055
500 tips				
500 – 2500 µL	115 mm	red	0030 000.951	022492071
Set, 1 Box, incl. 5x 96 tips				
0.1 – 10 µL	34 mm	dark gray	0030 073.207	022491407
0.1 – 20 µL	40 mm	medium gray	0030 073.223	022491415
0.5 – 20 µL L	46 mm	light gray	0030 073.240	022491423
2 – 200 µL	53 mm	yellow	0030 073.266	022491431
50 – 1000 µL	71 mm	blue	0030 073.304	022491458
5x 48 tips				
500 – 2500 µL	115 mm	red	0030 073.347	022491474
Reloads, 10x 96 = 960 tips				
0.1 – 10 µL (in stacks)	34 mm	dark gray	0030 073.363	022491504
0.1 – 20 µL	40 mm	medium gray	0030 073.380	022491512
0.5 – 20 µL L	46 mm	light gray	0030 073.401	022491521
2 – 200 µL (in stacks)	53 mm	yellow	0030 073.428	022491539
50 – 1000 µL	71 mm	blue	0030 073.460	022491555
10x 48 = 480 tips				
500 – 2500 µL	115 mm	red	0030 073.509	022491571
Reloads PCR-clean, 10x 96 = 960 tips				
0.1 – 10 µL (in stacks)	34 mm	dark gray	0030 073.746	022491709
0.1 – 20 µL	40 mm	medium gray	0030 073.762	022491717
0.5 – 20 µL L	46 mm	light gray	0030 073.789	022491725
2 – 200 µL (in stacks)	53 mm	yellow	0030 073.800	022491733
50 – 1000 µL	71 mm	blue	0030 073.843	022491750
10x 48 = 480 tips				
500 – 2500 µL	115 mm	red	0030 073.886	022491776

	Length	Color code	Order number International	Order number North America
Box, 1 box plus 96 tips				
0.1 – 10 µL	34 mm	dark gray	0030 073.002	022491300
0.1 – 20 µL	40 mm	medium gray	0030 073.029	022491318
0.5 – 20 µL L	46 mm	light gray	0030 073.045	022491326
2 – 200 µL	53 mm	yellow	0030 073.061	022491334
50 – 1000 µL	71 mm	blue	0030 073.100	022491351
48 tips				
500 – 2500 µL	115 mm	red	0030 073.142	022491377
Racks, plus 10x96=960 tips				
0.1 – 10 µL	34 mm	dark gray		022491903
0.1 – 20 µL	40 mm	medium gray		022491911
0.5 – 20 µL L	46 mm	light gray		022491920
2 – 200 µL	53 mm	yellow		022491938
50 – 1000 µL	71 mm	blue		022491954
480 tips				
500 – 2500 µL	115 mm	red		022491971
Racks PCR-clean, plus 10x96=960 tips				
0.1 – 10 µL	34 mm	dark gray		022491806
0.1 – 20 µL	40 mm	medium gray		022491814
0.5 – 20 µL L	46 mm	light gray		022491822
2 – 200 µL	53 mm	yellow		022491831
50 – 1000 µL	71 mm	blue		022491857
240 tips				
500 – 2500 µL	115 mm	red		022491873
Racks, sterile, plus 10x96=960 tips				
0.1 – 20 µL	40 mm	medium gray		022492250
2 – 200 µL	53 mm	yellow		022492276
50 – 1000 µL	71 mm	blue		022492292
Racks Eppendorf Biopur, colorless, pyrogen-free, DNA-free, RNase-free, ATP-free				
5x 96 = 480 tips				
0.1 – 20 µL	40 mm	medium gray	0030 075.005	022491067
2 – 200 µL	53 mm	yellow	0030 075.021	022491083
50 – 1000 µL	71 mm	blue	0030 075.064	022491105
240 tips				
500 – 2500 µL	115 mm	red	0030 075.102	022491121

		Length	Color code	Order number International	Order number North America
Singles (Eppendorf Biopur), colorless, pyrogen-free, DNA-free, RNase-free, ATP-free, individually wrapped, 100 tips					
0.1 – 20 µL		40 mm	medium gray	0030 010.019	022491130
2 – 200 µL		53 mm	yellow	0030 010.035	022491148
50 – 1000 µL		71 mm	blue	0030 010.051	022491156
ep Dualfilter T.I.P.S., PCR-clean, sterile, in racks, 10x 96 = 960 tips					
0.1 – 10 µL	S	34 mm	dark gray	0030 077.504	022491202
0.1 – 10 µL	M	40 mm	medium gray	0030 077.512	022491211
0.5 – 20 µL	L	46 mm	light gray	0030 077.520	022491229
2 – 20 µL		53 mm	yellow	0030 077.539	022491270
2 – 100 µL		53 mm	yellow	0030 077.547	022491237
2 – 200 µL		55 mm	yellow	0030 077.555	022491296
20 – 300 µL		55 mm	orange	0030 077.563	022491245
50 – 1000 µL		76 mm	blue	0030 077.571	022491253
GELoader® tips (f. 0.5 – 10 µL)					
1 set = 200 tips		62 mm	light gray	0030 001.222	022351656

	Length	Color code	Order number International	Order number North America
Reloads, LoRetention PCR clean,				
10 x 96 = 960 tips				
0.1 – 10 µL	34 mm	dark gray	0030 072.006	022493010
0.5 – 20 µL L	46 mm	light gray	0030 072.014	022493012
2 – 200 µL	53 mm	yellow	0030 072.022	022493014
50 – 1000 µL	71 mm	blue	0030 072.030	022493016
Reloads, LoRetention, autoclavable,				
10 x 96 = 960 tips				
0.1 – 10 µL	34 mm	dark gray	0030 072.049	022493018
0.5 – 20 µL L	46 mm	light gray	0030 072.057	022493020
2 – 200 µL	53 mm	yellow	0030 072.065	022493022
50 – 1000 µL	71 mm	blue	0030 072.073	022493024
Racks, LoRetention PCR clean,				
10 x 96 = 960 tips				
0.1 – 10 µL	34 mm	dark gray		022493026
0.5 – 20 µL L	46 mm	light gray		022493028
2 – 200 µL	53 mm	yellow		022493030
50 – 1000 µL	71 mm	blue		022493032
Racks, LoRetention Dualfilter, PCR clean, sterile and pyrogen free				
10 x 96 = 960 tips				
0.1 – 10 µL S	34 mm	dark gray	0030 077.610	022493000
0.5 – 20 µL L	46 mm	light gray	0030 077.628	022493002
2 – 100 µL	53 mm	yellow	0030 077.644	022493006
20 – 300 µL	55 mm	orange	0030 077.636	022493004
50 – 1000 µL	76 mm	blue	0030 077.652	022493008

Eppendorf Offices

AUSTRALIA / NEW ZEALAND
Eppendorf South Pacific Pty. Ltd.
Tel. +61 2 98 89 50 00
Fax +61 2 98 89 51 11
E-Mail: Info@eppendorf.com.au
Internet: www.eppendorf.com.au

AUSTRIA
Eppendorf Austria GmbH
Tel. +43 (0) 1 890 13 64 - 0
Fax +43 (0) 1 890 13 64 - 20
E-Mail: office@eppendorf.at
Internet: www.eppendorf.at

BRAZIL
Eppendorf do Brasil Ltda.
Tel. +55 11 3095 9344
Fax +55 11 3095 9340
E-Mail: eppendorf@eppendorf.com.br
Internet: www.eppendorf.com.br

CANADA
Eppendorf Canada Ltd.
Tel. +1 905 826 5525
Fax +1 905 826 5424
E-Mail: canada@eppendorf.com
Internet: www.eppendorfna.com

CHINA
Eppendorf China Ltd.
Tel. +86 21 68760880
Fax +86 21 50815371
E-Mail: market.info@eppendorf.cn
Internet: www.eppendorf.cn

FRANCE
EPPENDORF FRANCE S.A.R.L.
Tel. +33 1 30 15 67 40
Fax +33 1 30 15 67 45
E-Mail: eppendorf@eppendorf.fr
Internet: www.eppendorf.fr

GERMANY
Eppendorf Vertrieb
Deutschland GmbH
Tel. +49 2232 418-0
Fax +49 2232 418-155
E-Mail: vertrieb@eppendorf.de
Internet: www.eppendorf.de

INDIA
Eppendorf India Limited
Tel. +91 44 42 11 13 14
Fax +91 44 42 18 74 05
E-Mail: info@eppendorf.co.in
Internet: www.eppendorf.co.in

ITALY
Eppendorf s.r.l.
Tel. +390 2 55 404 1
Fax +390 2 58 013 438
E-Mail: eppendorf@eppendorf.it
Internet: www.eppendorf.it

JAPAN
Eppendorf Co. Ltd.
Tel. +81 3 5825 2363
Fax +81 3 5825 2365
E-Mail: info@eppendorf.jp
Internet: www.eppendorf.jp

NORDIC
Eppendorf Nordic Aps
Tel. +45 70 22 29 70
Fax +45 45 76 73 70
E-Mail: nordic@eppendorf.dk
Internet: www.eppendorf.dk

SOUTH & SOUTHEAST ASIA
Eppendorf Asia Pacific Sdn. Bhd.
Tel. +60 3 8023 2769
Fax +60 3 8023 3720
E-Mail: asiapacifichq@eppendorf.com.my
Internet: www.eppendorf.com.my

SPAIN
Eppendorf Ibérica S.L.U.
Tel. +34 91 651 76 94
Fax +34 91 651 81 44
E-Mail: iberica@eppendorf.es
Internet: www.eppendorf.es

SWITZERLAND
Vaudaux-Eppendorf AG
Tel. +41 61 482 1414
Fax +41 61 482 1419
E-Mail: vaudaux@vaudaux.ch
Internet: www.eppendorf.ch

UNITED KINGDOM
Eppendorf UK Limited
Tel. +44 1223 200 440
Fax +44 1223 200 441
E-Mail: sales@eppendorf.co.uk
Internet: www.eppendorf.co.uk

USA
Eppendorf North America
Tel. +1 516 334 7500
Fax +1 516 334 7506
E-Mail: info@eppendorf.com
Internet: www.eppendorfna.com

OTHER COUNTRIES
Internet:
www.eppendorf.com/worldwide

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Your local distributor: www.eppendorf.com/worldwide

Eppendorf AG · 22331 Hamburg · Germany · Tel: +49 40 538 01-0 · Fax: +49 40 538 01-556
E-Mail: eppendorf@eppendorf.com

Eppendorf North America, Inc. · 102 Motor Parkway, Suite 410 · Hauppauge, NY 11788-5178 · USA
Tel: +1 516 334 7500 · Toll free phone: +1 800 645 3050 · Fax: +1 516 334 7506
E-Mail: info@eppendorf.com

Application Support

Europe, International: Tel: +49 1803 666 789 · E-Mail: support@eppendorf.com
North America: Tel: +1 800 645 3050 ext. 2258 · E-Mail: support_na@eppendorf.com
Asia, Pacific: Tel: +60 3 8023 2769 · E-Mail: support_asiapacific@eppendorf.com

Attachment 3b

Eppendorf SOP

Standard Operating Procedure for Pipettes

eppendorf

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eppendorf®, Eppendorf Reference®, Eppendorf Research®, Eppendorf Research® plus, Multipette® plus, Multipette® stream/Xstream, Varipette®, Varispenser®, Biomaster®, Combitips® and PICASO® are registered trademarks of Eppendorf AG, Hamburg, Germany.

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1 Test and pipette conditions

These test and pipetting conditions are valid for all Eppendorf pipettes and dispensers. Follow EN ISO 8655 "Volume-measuring equipment with pistons".

For the calibration or adjustment of pipettes, the scales and measuring station should fulfill the following requirements:

1.1 Balances

1.1.1 Balance type

Use semi-microbalances and microbalances to calibrate pipettes.

Some companies offer balances that are specially designed to meet the requirements of pipette calibration, e.g. Sartorius and Mettler.

1.1.2 Accuracy

When selecting the balances, ensure that they are suitable for the accuracy of the pipette. This helps to ensure that deviations within a measuring series are recorded exactly for the assessment of the systematic and random measurement deviations in accordance with EN ISO 8655.

For a pipette volume of less than or equal to 10 µL, balances with a 6-digit display must be used. With larger volumes, balances with a 5-digit display are sufficient.

1.1.3 Minimum requirements for balances

Selected volume* of the pipette to be tested	Display resolution (mg)
1 µL to 10 µL	0.001
>10 µL to 100 µL	0.01
>100 µL to 1 000 µL	0.1
>1 mL to 10 mL	0.1
>10 mL to 200 mL	1

* For practical reasons, the nominal volume can be used for the selection of the balances.

1 Test and pipette conditions

1.2 Measuring station

1.2.1 Evaporation

Take evaporation protection into account while carrying out the measurement.

With volumes < 50 µL in particular, errors caused by the evaporation of the test liquid must be taken into consideration.

This can be ensured by using a liquid trap or other equipment to prevent evaporation.

1.2.2 Measuring station

For electronic measurement data processing, we recommend calibration software and accessories for your balance (PICASO, order no. 3113 004.001).

(see also EN ISO 8655, Part 6)

1.2.3 Test room

The tests should be carried out in a draft-free room under constant climatic conditions.

The test room should have a constant temperature between 15 °C and 30 °C and a constant relative humidity above 50 %.

1.2.4 Temperature differences

Before the test, the device to be tested and test liquid must have stood in the test room for a sufficient amount of time, at least 2 hours, in order to reach equilibrium with the storage conditions.

Direct sunlight and other influences which could affect the temperature should be avoided at all costs.

1.2.5 Test liquid

Distilled or deionized water of "Quality 3 in accordance with ISO 3696", degassed or at equilibrium with air. The water must be at room temperature.

1.2.6 Operating Manual

Observe the operating instructions for your pipette.

2 Calibration

2.1 Scope of testing

Note concerning the nominal volume:

The nominal volume of an adjustable-volume pipette is the largest volume to be set by the user and specified by the manufacturer.

When using the Combitip with the Multipette, the nominal volume is the largest possible dispensing volume of the Combitip. For Multipette plus, the nominal volume is 1/5 of the Combitip filling volume. For the Multipette stream / Xstream, the nominal volume is the filling volume of the Combitip.

2.1.1 Adjustable-volume pipettes

For variable pipettes, check **3 different volumes** with 10 measured values each:

- the nominal volume,
- approx. 50 % of the nominal volume,
- 10 % of the nominal volume.

2.1.2 Multi-channel pipettes

For Multi-channel pipettes check **each channel separately** with 3 different volumes, each with 10 measured values:

- the nominal volume,
- approx. 50 % of the nominal volume,
- 10 % of the nominal volume.

2.1.3 Multipette

For

- Multipette,
- Multipette plus,
- Multipette stream,
- Multipette Xstream

check the nominal volume with 10 measured values with the Eppendorf Combitip used.

2.1.4 Bottle-top dispenser and Top Buret

For bottle-top dispensers and the Top Buret, check the nominal volume with 10 measured values.

2 Calibration

2.2 Measurement

2.2.1 Work method

1. Place the selected pipette tip on the tip cone of the pipette or on the corresponding Combitip in the Multipette.
2. Implement the following settings:
   - Adjustable-volume piston-stroke pipettes: the smallest volume to be tested
   - Multipettes: the nominal volume
   - Bottle-top dispenser and Top Buret: the nominal volume
3. For all Multipettes with fully drawn up Combitip plus, first discard the first dispensing step.
4. Fill test liquid up to a height of min. 3 mm in the weighing vessel.
5. For piston-stroke pipettes fill the pipette tip 5x with test liquid and empty it (pre-wet), in order to create a moisture balance in the dead air volume.
6. Replace the single-use tip.
7. Pre-wet the tip 1x.

2.2.2 Removing the test volume from the reservoir

1. Hold the pipette vertically.
2. Dip the pipette tip into the test liquid by a few millimeters.
3. Draw in the volume to be tested slowly and evenly. The waiting time of 1 to 3 seconds, for Research 1 to 10 mL 5 seconds must be observed.
   (the waiting time corresponds to the size of the tip, see operating instructions.)
4. Pull the pipette tip slowly out of the liquid, wiping it on the vessel wall.

2.2.3 Dispensing the test volume into the weighing vessel

1. Rest the filled tip up against the wall of the weighing vessel at an angle.
2. Dispense the test liquid slowly until the first stop (measuring stroke).
3. Press the control button to the second stop (blow-out) and dispense the remaining liquid in the tip (does not apply for dispensers and burets).
4. Hold down the control button and pull the tip up the vessel wall.
5. Let the control button slide back into position.
6. Determine the weight.
7. Complete all measurements of a measuring series as described and calculate the systematic and random error (see p. 9).
8. In case of adjustable-volume pipettes, determine the measurement with the nominal volume, 50 % and 10 % of the nominal volume. Always begin the test with 10 % of the nominal volume.

3 Evaluation

3.1 Calculating the systematic error

Mean value of the dispensed volume:

$$\bar{x} = \frac{\sum \text{All measured values}}{n} \cdot Z$$

n = Number of measured values

To convert the measured values into volume values, use correction factor Z for the dependency of the test liquid on temperature and air pressure for each individual value (see *Factor Z for distilled water* on p. 29).

Systematic error e_s in micro liter:

$$e_s = \bar{x} - x_{nominal}$$

Systematic error e_s in percent:

$$e_s = 100 \frac{(\bar{x} - x_{nominal})}{x_{nominal}}$$

3.2 Calculating the random error

Random error as repeat standard s:

$$s = \sqrt{\frac{\sum (x_i \cdot z - \bar{x})^2}{n-1}}$$

Random error as coefficient of variation CV:

$$CV\ (\%) = \frac{s}{\bar{x}} \cdot 100$$

The specifications of the tested pipette can be found in the relevant operating instructions or technical specifications (see *Technical specifications* on p. 30).

4 Sterilization and cleaning

Further notes on cleaning and sterilization can found in the relevant operating manual.

4.1 Sterilization

Parameter for autoclaving

- 121 °C
- 20 minutes
- 1 bar overpressure

4.1.1 Reference and Biomaster

The Reference pipettes and the Biomaster are fully autoclavable.

1. Prior to autoclaving, unscrew the upper and lower part of the pipette apart by approx. one turn to enable the vapor to enter more easily.
2. After autoclaving, allow the pipette to cool down to room temperature and to dry completely and then screw together.

4.1.2 Research plus

The Research plus pipettes are completely autoclavable.

1. You can put the Research plus into the autoclave as a whole unit or with the lower part removed. Do not disassemble the lower part.
2. For 5 mL and 10 mL pipettes: remove the old protection filter. Add a new protection filter and install it after autoclaving. Autoclave the protection filter only once.

   After autoclaving:
3. Cool the pipette down to room temperature and leave to dry.
4. For 5 mL / 10 mL pipettes: the protection filter swells during autoclaving. Slightly squeeze the protection filter when installing it into the cone tip.

4.1.3 Research and Research pro

With the Research and Research pro pipettes, the lower section is autoclavable.

With single-channel models prior to autoclaving

1. Pull off the ejector sleeve with depressed ejector.
2. Unscrew the lower part of the pipette.

With the multi-channel versions, you can autoclave the entire lower section.

After autoclaving, assemble the parts only after room temperature has been reached and the parts have been dried.

4.1.4 Top Buret

The Top Buret can not be autoclaved.

4 Sterilization and cleaning

4.1.5 Varipette and Multipette

The

- Varipette,
- Multipette,
- Multipette plus,
- Multipette stream and
- Multipette Xstream

are not autoclavable.

4.1.6 Varispenser

The Varispenser and Varispenser plus are only autoclavable when fully assembled.
With theVarispenser plus

1. Set the discharge valve toggle to the dispensing position (–>).
2. Release the volume setting knob, move to the middle position and leave released.
3. Place the dispenser on a cloth and autoclave, avoiding contact with hot surfaces.
4. Only use the dispenser again when it has cooled down to room temperature.

4.1.7 Xplorer

The lower part on the Xplorer pipettes can be autoclaved.

1. Pull off the ejector sleeve with depressed ejector.
2. On the lower part of the pipette, push the ring labeled **PUSH UP TO RELEASE** upward until the lower part is released.

After autoclaving, assemble the parts only after room temperature has been reached and the parts have been dried.

4.2 Cleaning

All areas of the underside of the pipette can be cleaned in a soap solution or isopropanol 60 % provided that no differing instructions are given in the operating manual.

1. Clean the parts in soap solution or isopropanol.
2. Rinse the parts in distilled water.
3. Allow the parts to dry completely and then assemble.
4. Lightly lubricate the piston of the pipette (Eppendorf special grease

5 Leakage check

5.1 Pipette leakage check

In order to carry out a leakage check on a pipette, follow the procedure outlined below:

1. For adjustable-volume pipettes: set the nominal volume.
2. For volumes <20 µL pre-wet the tip several times.
3. Hold the pipette vertically with a full tip for approx. 30 sec. Do not touch the pipette tip.
4. Observe the meniscus of the liquid on the tip opening. If there is a leak in the pipette, a drip will form on the tip opening.

6 Troubleshooting

6.1 Possible error causes and elimination of errors

Observe the error descriptions in the operating instructions.

Error	Cause	Elimination
Droplets on the inner wall of the pipette tip.	Uneven wetting of the plastic wall.	▸ Attach a new pipette tip.
Pipette is dripping, pipetted volume is incorrect.	• Tip loose.	▸ Press the tip on firmly.
	• Incorrect pipette tip.	▸ Use original Eppendorf tip.
	Pipette is leaking because:	
	• The piston is contaminated.	▸ Clean the piston and lubricate slightly.
	• The piston is damaged.	▸ Replace the piston and piston sealing and lubricate slightly.
	• The seal is damaged.	▸ Replace the seal.
Liquid cannot be aspirated correctly or dripping occurs.	• Leakage in the Combitip plus.	▸ Replace the Combitip plus with a new Combitip plus.
	• Combitip plus has heated up.	▸ Ensure that the temperature is uniform as the liquid expands when heated.
The control button is jammed, runs jerky.	• The piston is contaminated.	▸ Clean the piston and lubricate slightly.
	• The seal is contaminated.	▸ Disassemble the pipette, clean all seals, replace if necessary.
	• The piston is damaged.	▸ Replace the piston and piston seal and lubricate slightly.
	• Penetration of solvent vapors	▸ Unscrew the lower part of the pipette and aerate the lower part. ▸ Clean the piston and lubricate slightly.

7 Adjustment

7.1 General information

Prior to delivery, all pipettes are adjusted with distilled or de-ionized, degassed water under the conditions described in Chapters 1 to 3 and according to ISO 3696 (see *Calibration* on p. 7).

If you have doubts regarding the accuracy of the volume entered, please check the following points first:

- Is there a leak in the device (see *Leakage check* on p. 12)?
  Exception: Biomaster
- Does the temperature of the pipetted liquid correspond to:
  - the temperature of the device?
  - the ambient air temperature?
- Is the set volume correct?
- Has the liquid density and air pressure been taken into consideration?
- Does the density of the pipetted liquid deviate from the double-distilled, degassed water?
- Was the work completed correctly, as described in the "Calibration" chapter (see p. 7) and "Evaluation" chapter (see p. 9)?
- Were original Eppendorf pipette tips used?

Volume errors can also occur when pipetting liquids with high vapor pressure, where the density or viscosity deviates considerably from the values of water.

Adjustments should only be carried out on the device after these conditions have been taken into consideration.

7.2 Adjusting adjustable-volume pipettes

Observe the operating instructions for your pipette. There you will find detailed descriptions on adjustment.

The adjustment of the adjustable-volume pipettes:

- Research
- Reference
- Biomaster

refers to a zero point shift.

7 Adjustment

7.2.1 Procedure

Requirements

Device, original Eppendorf tip, test liquid and ambient air must have the same temperature (15 – 30 °C) at a constant temperature of ±0.5 °C during the test (according to EN ISO 8655, Part 6).

If your Research or Reference has an adjustment seal, removing it prior to adjusting. After adjusting, lock the adjustment opening with a new adjustment seal. Adjustment seals can be reordered (see operating manual).

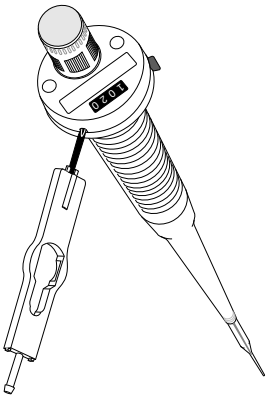
---

1. Set the pipette to the smallest volume to be tested.
2. Use a matching original Eppendorf tip for single-channel pipettes. For Multi-channel pipettes, use any channel.
3. Pipette the set volume 10 times.
4. Conduct a weighing after every volume dispensing.
5. Calculate the mean value after 10 measurements (see *Evaluation* on p. 9).
   The calculated mean value of these weighings (observe conversion factor Z = mg to µL) yields the actual volume.
6. For adjusting, introduce the suitable tool into the opening intended for this purpose, or place it on the designated location, and adjust the actual volume (see the following figures or operating manual).
7. Check the set volume by measuring again. If the target volume does not match the result of the measurement, repeat steps 2 to 6.
8. After the adjustment, check the measured values for accuracy at 50% of the nominal volume and check the nominal volume for accuracy.

7.2.2 Biomaster

Auxiliary equipment

- Supplied pipette wrench (order no. 4910 092.001)



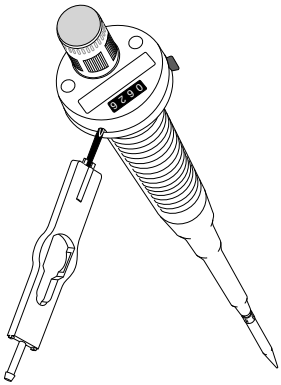
1. Using the pipette wrench, set the digital display of the pipette, with unaltered piston stroke, to the actual volume value of the measurement.
2. Pull off the pipette wrench.
3. Set the pipette to the target volume in the usual manner.
4. Mark the adjustment on the pipette.

7 Adjustment

7.2.3 Reference adjustable-volume

Auxiliary equipment

- Supplied pipette wrench (order no. 4910 092.001)
- Supplied red ADJ seal



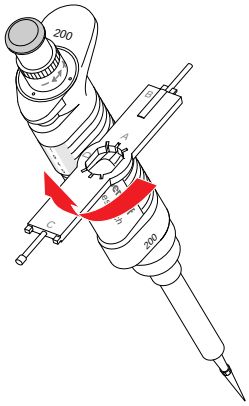
1. Insert side B of the pipette wrench into the adjustment opening in the lid.
2. Using the pipette wrench, set the digital display of the pipette, with unaltered piston stroke, to the actual volume value of the measurement.
3. Pull off the pipette wrench.
4. Set the pipette to the target volume in the usual manner.
5. After the adjustment has been successfully completed, lock the adjustment opening with a red ADJ seal.

7 Adjustment

7.2.4 Research adjustable-volume

Auxiliary equipment

- Supplied pipette wrench (order no. 3111 501.016)
- Supplied red ADJ seal



1. Insert side D of the pipette wrench vertically into the lateral adjustment opening of the pipette grip.
2. Tilt the pipette wrench to the vertical position.
3. Turn the volume setting ring toward – or +. This adjusts the piston stoke of the pipette. The digital display does not change in the process. A revolution corresponds to:

Volume range	Vol. / revolution
0.1 – 2.5 µL	approx. 0.1 µL
0.5 - 10 µL	approx. 0.5 µL
2 - 20 µL	approx. 1 µL
10 - 100 µL	approx. 5 µL
20 - 200 µL	approx. 10 µL
100 - 1 000 µL	approx. 50 µL
500 - 5 000 µL	approx. 250 µL
1 -10 mL	approx. 510 µL

4. Pull off the pipette wrench.
5. Move the volume setting ring back and forth a bit until the digital indicator and stroke system engage with each other again.
6. After the adjustment has been successfully completed, lock the adjustment opening with a red ADJ seal.

7 Adjustment

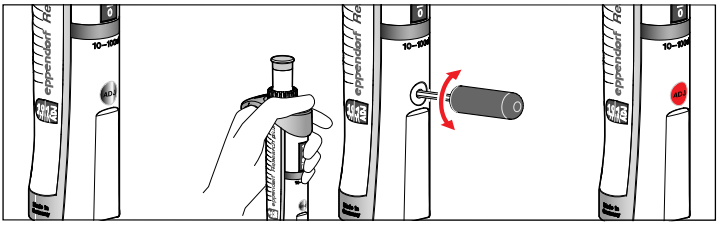
7.2.5 Research plus adjustable-volume - adjustment to environmental parameters

Adjustment change for specific liquid densities, changed altitudes or pipette tips that are not used to calculate the random and systematic error.

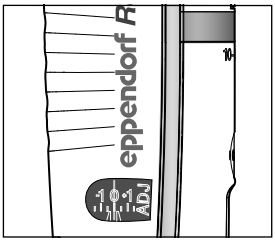
The Research plus was adjusted, tested and fitted with a gray adjustment seal with the abbreviation "ADJ" before delivery. The adjustment display on the side reads "0". If the adjustment is changed, the volume changes by a certain value. Strictly speaking, the change only applies to the testing volume.

Auxiliary equipment

- Supplied adjustment tool (order no. 3120 633.006)
- Supplied red adjustment seal (ADJ)



1. Remove the gray adjustment seal.
2. Keep the ejector pressed.
3. Insert the adjustment tool (from the delivery package).
4. Turn the adjustment tool until the adjustment display shows the desired value.
5. Place the Research plus on a horizontal surface (table). When completing the adjustment, look absolutely vertically at the window and read the set value via the backsight in the viewing window.



6. Carry out weighings to verify accuracy and precision.
7. After the tests, close the opening with the red adjustment seal (from the delivery package).

If the adjustment is meant for a specific liquid, mark the pipette accordingly. Use the labeling area on the pipette for this purpose and write down the liquid and the volume.

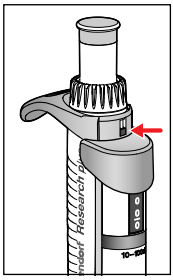
7 Adjustment

7.2.6 Research plus adjustable-volume - change to the factory adjustment

Auxiliary equipment

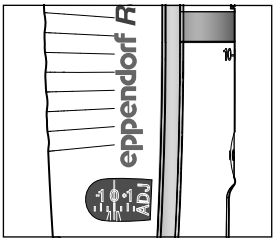
- Supplied safety plug tool
- Supplied pin to loosen the safety plug

It is possible to change the factory adjustment with the corresponding accessories for a Research plus with adjustable volume setting. If the factory adjustment of the Research plus has been changed by a user, this can be recognized by a red safety plug behind the ejector. If the Research plus has been adjusted and calibrated by Eppendorf AG, this is indicated by a gray safety plug.

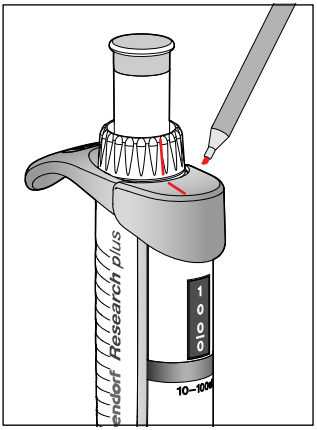


1. Check whether the adjustment display on the side is set to "0".

   If the adjustment display is not set to "0", you will first need to set it to "0" with the adjustment tool. In this case, instead of continuing with the factory adjustment modification, carry out a gravimetric test of the Research plus with the adjustment display set to "0".

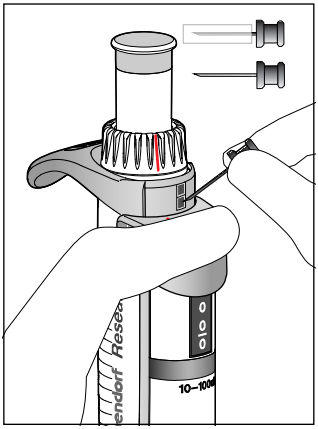


2. Provide the volume setting ring and the ejector with a common mark with a pen. This mark serves as an orientation for factory adjustment changes. When changing the factory adjustment, you can turn the volume setting ring, without the volume display changing. The mark on the volume setting ring and the ejector informs you how far you have moved from the factory setting.

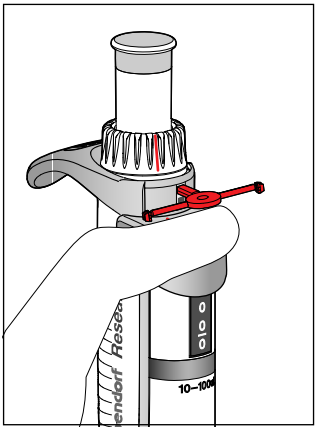


7 Adjustment

3. Keep the ejector pressed and remove the safety plug with the pin.

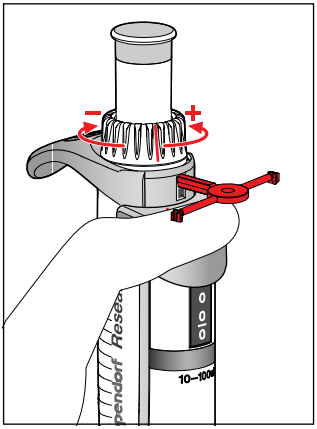


4. Continue to keep the ejector pressed. Insert the safety plug tool such that the counter locking mechanism is pushed down.



7 Adjustment

5. Turn the volume setting ring slightly to change the volume. Proceed as shown in the figure.



7 Adjustment

This results in the following approximate volume changes:

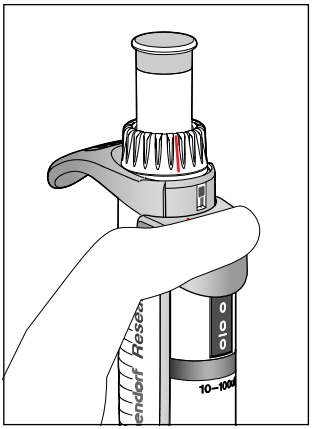
Single-channel				
Nominal volume Color code	**+½ revolution**	**+¼ revolution**	**–¼ revolution**	**–½ revolution**
2.5 µL dark gray	0.106 µL	0.053 µL	–0.053 µL	–0.106 µL
10 µL medium gray	0.53 µL	0.27 µL	–0.27 µL	–0.53 µL
20 µL light gray	1.06 µL	0.53 µL	–0.53 µL	–1.06 µL
20 µL yellow	1.07 µL	0.54 µL	–0.54 µL	–1.07 µL
100 µL yellow	5.4 µL	2.7 µL	–2.7 µL	–5.4 µL
200 µL yellow	10.8 µL	5.4 µL	–5.4 µL	–10.8 µL
300 µL orange	10.7 µL	5.4 µL	–5.4 µL	–10.7 µL
1 000 µL blue	54 µL	27 µL	–27 µL	–54 µL
5 mL purple	271 µL	135 µL	–135 µL	–271 µL
10 mL turquoise	542 µL	271 µL	–271 µL	–542 µL

Multi-channel				
Nominal volume Color code	**+½ revolution**	**+¼ revolution**	**–¼ revolution**	**–½ revolution**
10 µL medium gray	0.53 µL	0.27 µL	–0.27 µL	–0.53 µL
100 µL yellow	5.4 µL	2.7 µL	–2.7 µL	–5.4 µL
300 µL orange	10.7 µL	5.4 µL	–5.4 µL	–10.7 µL

The values mentioned are theoretical values and are for orientation purposes only. The volume changes mentioned apply to each volume setting.

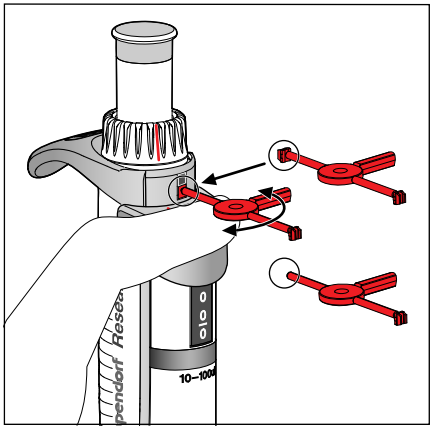
7 Adjustment

6. Slide the locking mechanism up and carry out a gravimetric test of the changes which have been made.



7. If the measured gravimetric values meet your requirements: insert the red safety plug on the tool into the opening of the Research plus and break it off from the tool.

   The red safety plug on the pipette indicates that the Research plus has been adjusted by the user. If the adjustment display had also been set to "0" before, you must close the opening with a new, red adjustment seal at the position for the adjustment seal.



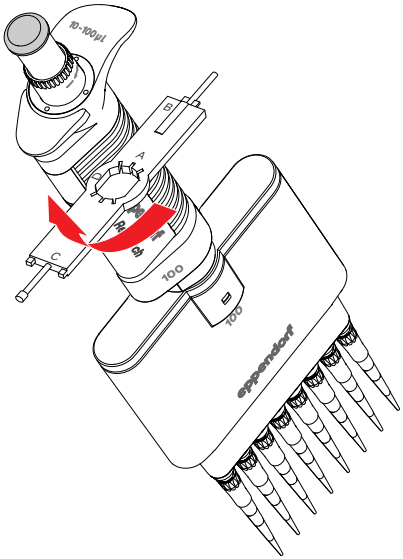
8. Document the changes made and the measurements conducted. Remove the mark on the volume setting ring and the ejector. The red safety plug on the pipette indicates that the Research plus has been adjusted and calibrated by the user.

7 Adjustment

7.2.7 Research multi-channel

Auxiliary equipment

- Supplied pipette wrench (order no. 3111 501.016)
- Supplied red ADJ seal



1. Insert side D of the pipette wrench vertically into the lateral adjustment opening of the pipette grip.
2. Tilt the pipette wrench to the vertical position.
3. Turn the volume setting ring toward – or +. This adjusts the piston stoke of the pipette. The digital display does not change in the process. A revolution corresponds to:

Volume range	Vol. / revolution
0.5 - 10 µL	approx. 0.5 µL
10 - 300 µL	approx. 5 µL
30 µL	approx. 10 µL

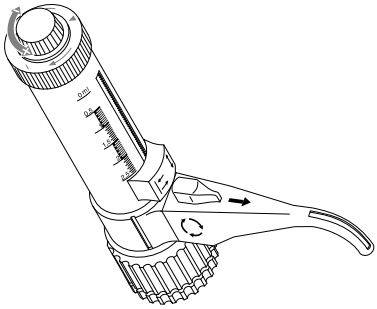
4. Pull off the pipette wrench.
5. Move the volume setting ring back and forth a bit until the digital indicator and stroke system engage with each other again.
6. After the adjustment has been successfully completed, lock the adjustment opening with a red ADJ seal.

7 Adjustment

7.2.8 Research plus multi-channel

Conduct the adjustment as described for the Research plus single-channel pipette(see p. 18).

7.2.9 Varispenser plus



- Turn the fine adjustment toward + or –. A revolution corresponds to the smallest dispensing step:

Reduce volume:

- Turn toward -.

Increase volume:

- Turn toward +.

The factory adjustment is carried out at 20 °C with double distilled, vented water.

7.2.10 Xplorer

The adjustment of the Xplorer pipette is described on the CD enclosed with the pipette.

If a different adjustment was selected in the options for the Xplorer pipette, a wrench symbol will appear in the display header.

Another symbol showing the selected adjustment is displayed to the right of the wrench symbol. If you switch back to the factory adjustment later, the previously selected adjustment is deleted, and both symbols disappear from the header.

7 Adjustment

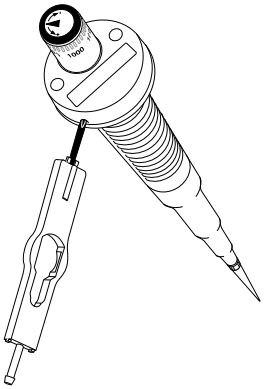
7.3 Adjusting fixed-volume pipettes

The adjustment process for fixed-volume pipettes is the same as for adjustable-volume pipettes (see *Adjusting adjustable-volume pipettes* on p. 14). For fixed-volume pipettes, 10 measured values of the nominal volume are tested.

7.3.1 Reference fixed

Auxiliary equipment

- Adhesive label as an adjusting aid for the basic setting
- Supplied pipette wrench (order no. 4910 092.001)



1. In order to simplify relocating the basic setting, attach the adhesive label supplied as an adjusting aid to the control button.
2. Using the B side of the pipette wrench, loosen the inside screw until the control button can be turned.
3. Set the control button to the calculated actual volume value of the measurement (see *Adjusting adjustable-volume pipettes* on p. 14). One revolution of the control button corresponds to the following (based on water):

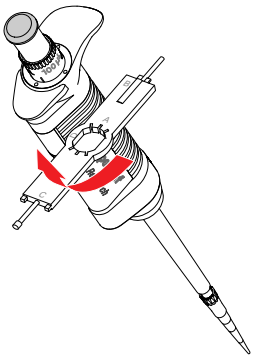
Reference fixed-volume	Vol. / revolution
1, 2, 5, 10 µL	approx. 0.5 µL
10, 20 µL	approx. 1 µL
25, 50 µL	approx. 2.4 µL
100 µL	approx. 5 µL
200, 250 µL	approx. 12 µL
500, 1 000 µL	approx. 46 µL
1 500, 2 000, 2 500 µL	approx. 118 µL

7 Adjustment

7.3.2 Research fixed

Auxiliary equipment

- Supplied pipette wrench (order no. 3111 501.016)



1. Insert side D of the pipette wrench vertically into the lateral adjustment opening of the pipette grip.
2. Move the tool into the vertical position.
3. Turn the volume setting ring toward – or +. This adjusts the piston stoke of the pipette. With reference to water, one revolution of the volume setting ring corresponds to:

Volume range	Vol. / revolution
10	approx. 0.8 µL
20	approx. 0.8 µL
25	approx. 0.8 µL
50	approx. 0.8 µL
100	approx. 0.8 µL
200	approx. 38 µL
250	approx. 38 µL
500	approx. 38 µL
1 000	approx. 38 µL

7.3.3 Research plus fixed

Adjustment is carried out as described for the Research plus adjustable-volume (see p. 18).

7 Adjustment

7.4 Physical influences of liquids

It is possible to adjust the previously described devices for a volume of a liquid with a different density than water so that the displayed volume value corresponds to the pipetted volume.

With adjustable-volume pipettes, all other values are then readjusted, as the adjustable-volume pipette then becomes a fix-volume pipette.

The adjustment process is comparable to the described procedure (see p. 15). The difference is that the mean value of the weighings is converted to microliters according to the formula:

$$\text{Pipetting volume} = \frac{\text{Mean value of weighings}}{\text{Density of liquid weighed}}$$

1. Determine the mean value and convert it to microliters.
   The calculated value is the nominal value.
2. The digital display of variable pipettes, or the volume of fix-volume pipettes, must be set to the calculated actual value.
3. Check the value set for the liquid gravimetrically. The accordingly set device only delivers a dispensing value, which corresponds to the digital display, for the used liquid and set volume.
4. If necessary correct and check the setting.
5. Label the measuring device following adjustment with the measured value and the name of the liquid which was used for the adjustment.

Following adjustment, the certificate accompanying the pipette becomes invalid.

8 Factor Z for distilled water

8.1 Factor Z overview table

Factor Z (µL/mg) in accordance with EN ISO 8655 for distilled water depending on test temperature and air pressure:

Temperature	Air pressure (kPa)						
(°C)	80	85	90	95	100	101.3	105
15	1.0017	1.0018	1.0019	1.0019	1.0020	1.0020	1.0020
15.5	1.0018	1.0019	1.0019	1.0020	1.0020	1.0020	1.0021
16	1.0019	1.0020	1.0020	1.0021	1.0021	1.0021	1.0022
16.5	1.0020	1.0020	1.0021	1.0021	1.0022	1.0022	1.0022
17	1.0021	1.0021	1.0022	1.0022	1.0023	1.0023	1.0023
17.5	1.0022	1.0022	1.0023	1.0023	1.0024	1.0024	1.0024
18	1.0022	1.0023	1.0023	1.0024	1.0025	1.0025	1.0025
18.5	1.0023	1.0024	1.0024	1.0025	1.0025	1.0026	1.0026
19	1.0024	1.0025	1.0025	1.0026	1.0026	1.0027	1.0027
19.5	1.0025	1.0026	1.0026	1.0027	1.0027	1.0028	1.0028
20	1.0026	1.0027	1.0027	1.0028	1.0028	1.0029	1.0029
20.5	1.0027	1.0028	1.0028	1.0029	1.0029	1.0030	1.0030
21	1.0028	1.0029	1.0029	1.0030	1.0031	1.0031	1.0031
21.5	1.0030	1.0030	1.0031	1.0031	1.0032	1.0032	1.0032
22	1.0031	1.0031	1.0032	1.0032	1.0033	1.0033	1.0033
22.5	1.0032	1.0032	1.0033	1.0033	1.0034	1.0034	1.0034
23	1.0033	1.0033	1.0034	1.0034	1.0035	1.0035	1.0036
23.5	1.0034	1.0035	1.0035	1.0036	1.0036	1.0036	1.0037
24	1.0035	1.0036	1.0036	1.0037	1.0037	1.0038	1.0038
24.5	1.0037	1.0037	1.0038	1.0038	1.0039	1.0039	1.0039
25	1.0038	1.0038	1.0039	1.0039	1.0040	1.0040	1.0040
25.5	1.0039	1.0040	1.0040	1.0041	1.0041	1.0041	1.0042
26	1.0040	1.0041	1.0041	1.0042	1.0042	1.0043	1.0043
26.5	1.0042	1.0042	1.0043	1.0043	1.0044	1.0044	1.0044
27	1.0043	1.0044	1.0044	1.0045	1.0045	1.0045	1.0046
27.5	1.0045	1.0045	1.0046	1.0046	1.0047	1.0047	1.0047
28	1.0046	1.0046	1.0047	1.0047	1.0048	1.0048	1.0048
28.5	1.0047	1.0048	1.0048	1.0049	1.0049	1.0050	1.0050
29	1.0049	1.0049	1.0050	1.0050	1.0051	1.0051	1.0051
29.5	1.0050	1.0051	1.0051	1.0052	1.0052	1.0052	1.0053
30	1.0052	1.0052	1.0053	1.0053	1.0054	1.0054	1.0054

9 Technical specifications

The following specifications are valid for the following conditions:

Liquid: Distilled or deionized water

Reference temperature: 20 °C to 25 °C ±0.5 °C

Number of determinations: 10, in accordance with EN ISO 8655 with original Eppendorf pipette tips

Technical specifications subject to change!

9.1 Fix-volume pipettes

9.1.1 Reference fix

Model	Test tip epT.I.P.S. Color code Volume range Length	Error limits			
		Error			
		Systematic		Random	
		± %	± µL	± %	± µL
1 µL	light gray 0.5 - 20 µL L 46 mm	± 2.5	± 0.025	± 1.8	± 0.018
2 µL		± 2.0	± 0.04	± 1.2	± 0.024
5 µL		± 1.5	± 0.075	± 0.8	± 0.04
10 µL		± 1.0	± 0.1	± 0.5	± 0.05
10 µL	yellow 2 - 200 µL 53 mm	± 1.0	± 0.1	± 0.5	± 0.05
20 µL		± 0.8	± 0.16	± 0.3	± 0.06
25 µL		± 0.8	± 0.2	± 0.3	± 0.075
50 µL		± 0.7	± 0.35	± 0.3	± 0.15
100 µL		± 0.6	± 0.6	± 0.2	± 0.2
200 µL	blue 50 - 1 000 µL 71 mm	± 0.6	± 1.2	± 0.2	± 0.4
250 µL		± 0.6	± 1.5	± 0.2	± 0.5
500 µL		± 0.6	± 3	± 0.2	± 1
1 000 µL		± 0.6	± 6	± 0.2	± 2
1 500 µL	red 500 - 2 500 µL 115 mm	± 0.6	± 9	± 0.2	± 3
2 000 µL		± 0.6	± 12	± 0.2	± 4
2 500 µL		± 0.6	± 15	± 0.2	± 5

9 Technical specifications

9.1.2 Research fix

Model	Test tip epT.I.P.S. Color code Volume range Length	Error limits			
		Error			
		Systematic		Random	
		± %	± µL	± %	± µL
10 µL	yellow 2 - 200 µL 53 mm	± 1.2	± 0.12	± 0.6	± 0.06
20 µL		± 1.0	± 0.2	± 0.3	± 0.06
25 µL		± 1.0	± 0.25	± 0.3	± 0.075
50 µL		± 0.7	± 0.35	± 0.3	± 0.15
100 µL		± 0.6	± 0.6	± 0.2	± 0.2
200 µL	blue 0.05 - 1 mL 71 mm	± 0.6	± 1.2	± 0.2	± 0.4
250 µL		± 0.6	± 1.5	± 0.2	± 0.5
500 µL		± 0.6	± 3	± 0.2	± 1
1 000 µL		± 0.6	± 6	± 0.2	± 2

9 Technical specifications

9.1.3 Research plus fix

Research plus fixed volume					
Model	**Test tip** **epT.I.P.S. Color code** **Volume range** **Length**	**Error limits**			
		Error			
		Systematic		**Random**	
		± %	**± µL**	**± %**	**± µL**
10 µL	medium gray 0.1 - 20 µL 40 mm	± 1.2	± 0.12	± 0.6	± 0.06
20 µL	light gray 0.5 - 20 µL L 46 mm	± 0.8	± 0.16	± 0.3	± 0.06
10 µL	yellow 2 - 200 µL 53 mm	± 1.2	± 0.12	± 0.6	± 0.06
20 µL		± 1.0	± 0.2	± 0.3	± 0.06
25 µL		± 1.0	± 0.25	± 0.3	± 0.08
50 µL		± 0.7	± 0.35	± 0.3	± 0.15
100 µL		± 0.6	± 0.6	± 0.2	± 0.2
200 µL		± 0.6	± 1.2	± 0.2	± 0.4
200 µL	blue 50 - 1 000 µL 71 mm	± 0.6	± 1.2	± 0.2	± 0.4
250 µL		± 0.6	± 1.5	± 0.2	± 0.5
500 µL		± 0.6	± 3	± 0.2	± 1
1 000 µL		± 0.6	± 6	± 0.2	± 2

9 Technical specifications

9.2 Adjustable volume pipettes

9.2.1 Reference variable

Model	Test tip# epT.I.P.S. Color code# Volume range# Length	Testing volume	Error limits			
			Error			
			Systematic		Random	
			± %	± µL	± %	± µL
0.1 - 2.5 µL	dark gray 0.1 - 10 µL 34 mm	0.25 µL	± 12.0	± 0.03	± 6.0	± 0.015
		1.25 µL	± 2.5	± 0.031	± 1.5	± 0.019
		2.5 µL	± 1.4	± 0.035	± 0.7	± 0.018
0.5 - 10 µL	light gray 0.5 - 20 µL 46 mm	1 µL	± 2.5	± 0.025	± 1.8	± 0.018
		5 µL	± 1.5	± 0.075	± 0.8	± 0.04
		10 µL	± 1.0	± 0.1	± 0.4	± 0.04
2 - 20 µL	light gray 0.5 - 20 µL 46 mm	2 µL	± 3.0	± 0.06	± 2.0	± 0.04
		10 µL	± 1.0	± 0.1	± 0.5	± 0.05
		20 µL	± 0.8	± 0.16	± 0.3	± 0.06
2 - 20 µL	yellow 2 - 200 µL 53 mm	2 µL	± 5.0	± 0.1	± 1.5	± 0.03
		10 µL	± 1.2	± 0.12	± 0.6	± 0.06
		20 µL	± 1.0	± 0.2	± 0.3	± 0.06
10 - 100 µL	yellow 2 - 200 µL 53 mm	10 µL	± 3.0	± 0.3	± 0.7	± 0.07
		50 µL	± 1.0	± 0.5	± 0.3	± 0.15
		100 µL	± 0.8	± 0.8	± 0.15	± 0.15
50 - 200 µL	yellow 2 - 200 µL 53 mm	50 µL	± 1.0	± 0.5	± 0.3	± 0.15
		100 µL	± 0.9	± 0.9	± 0.3	± 0.3
		200 µL	± 0.6	± 1.2	± 0.2	± 0.4
50 - 250 µL	blue 50 - 1 000 µL 71 mm	50 µL	± 1.4	± 0.7	± 0.3	± 0.15
		100 µL	± 1.1	± 1.1	± 0.3	± 0.3
		250 µL	± 0.6	± 1.5	± 0.2	± 0.5
100 - 1 000 µL	blue 50 - 1 000 µL 71 mm	100 µL	± 3.0	± 3	± 0.3	± 0.3
		500 µL	± 1.0	± 5	± 0.2	± 1
		1 000 µL	± 0.6	± 6	± 0.2	± 2
500 - 2 500 µL	red 500 - 2 500 µL 115 mm	0.5 mL	± 1.5	± 7.5	± 0.3	± 1.5
		1.0 mL	± 0.8	± 8	± 0.2	± 2
		2.5 mL	± 0.6	± 15	± 0.2	± 5

9 Technical specifications

9.2.2 Research variable

Model	Test tip epT.I.P.S. Color code Volume range Length	Testing volume	Error limits			
			Error			
			Systematic		Random	
			± %	± µL	± %	± µL
0.1 - 2.5 µL	dark gray 0.1 - 10 µL 34 mm	0.25 µL	± 12.0	± 0.03	± 6.0	± 0.015
		1.25 µL	± 2.5	± 0.031	± 1.5	± 0.019
		2.5 µL	± 1.4	± 0.035	± 0.7	± 0.018
0.5 - 10 µL	light gray 0.5 - 20 µL L 46 mm	1 µL	± 2.5	± 0.025	± 1.8	± 0.018
		5 µL	± 1.5	± 0.075	± 0.8	± 0.04
		10 µL	± 1.0	± 0.1	± 0.4	± 0.04
2 - 20 µL	yellow 2 - 200 µL 53 mm	2 µL	± 5.0	± 0.1	± 1.5	± 0.03
		10 µL	± 1.2	± 0.12	± 0.6	± 0.06
		20 µL	± 1.0	± 0.2	± 0.3	± 0.06
10 - 100 µL	yellow 2 - 200 µL 53 mm	10 µL	± 3.0	± 0.3	± 1.0	± 0.1
		50 µL	± 1.0	± 0.5	± 0.3	± 0.15
		100 µL	± 0.8	± 0.8	± 0.2	± 0.20
20 - 200 µL	yellow 2 - 200 µL 53 mm	20 µL	± 2.5	± 0.5	± 0.7	± 0.14
		100 µL	± 1.0	± 1	± 0.3	± 0.3
		200 µL	± 0.6	± 1.2	± 0.2	± 0.4
100 - 1 000 µL	blue 0.05 - 1 mL 71 mm	100 µL	± 3.0	± 3	± 0.6	± 0.6
		500 µL	± 1.0	± 5	± 0.2	± 1
		1 000 µL	± 0.6	± 6	± 0.2	± 2
0.5 - 5 mL	purple 0.1 - 5 mL 120 mm	0.5 mL	± 2.4	± 12	± 0.6	± 3
		2.5 mL	± 1.2	± 30	± 0.25	± 6.25
		5.0 mL	± 0.6	± 30	± 0.15	± 7.5
1 - 10 mL	turquoise 1 – 10 mL 165 mm	1.0 mL	± 3.0	± 30	± 0.6	± 6
		5.0 mL	± 0.8	± 40	± 0.2	± 10
		10.0 mL	± 0.6	± 60	± 0.15	± 15

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9.2.3 Research pro

Model	Test tip epT.I.P.S. Color code Volume range Length	Testing volume	Error limits			
			Error			
			Systematic		Random	
			± %	± µL	± %	± µL
0.5 - 10 µL	light gray 0.5 - 20 µL L 46 mm	1 µL	± 2.5	± 0.025	± 1.8	± 0.018
		5 µL	± 1.5	± 0.075	± 0.8	± 0.04
		10 µL	± 1.0	± 0.1	± 0.4	± 0.04
5 - 100 µL	yellow 2 - 200 µL 53 mm	10 µL	± 2.0	± 0.2	± 1.0	± 0.1
		50 µL	± 1.0	± 0.5	± 0.3	± 0.15
		100 µL	± 0.8	± 0.8	± 0.2	± 0.2
20 - 300 µL	orange 20 - 300 µL 55 mm	30 µL	± 2.5	± 0.75	± 0.7	± 0.21
		150 µL	± 1.0	± 1.5	± 0.3	± 0.45
		300 µL	± 0.6	± 1.8	± 0.2	± 0.6
50 - 1 000 µL	blue 50 - 1 000 µL 71 mm	100 µL	± 3.0	± 3	± 0.6	± 0.6
		500 µL	± 1.0	± 5	± 0.2	± 1
		1 000 µL	± 0.6	± 6	± 0.2	± 2
500 - 5 000 µL	purple 0.1 - 5 mL 120 mm	0.5 mL	± 3.0	± 15	± 0.6	± 3
		2.5 mL	± 1.2	± 30	± 0.25	± 6.25
		5.0 mL	± 0.6	± 30	± 0.15	± 7.5

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9.2.4 Research plus variable

Research plus adjustable single-channel						
Model	**Test tip** **epT.I.P.S. Color code** **Volume range** **Length**	**Testing volume**	**Error limits**			
			Error			
			Systematic		**Random**	
			± %	**± µL**	**± %**	**± µL**
0.1 - 2.5 µL Increment: 0.002 µL	dark gray 0.1 - 10 µL 34 mm	0.1 µL	± 48	± 0.048	± 12	± 0.012
		0.25 µL	± 12	± 0.03	± 6	± 0.015
		1.25 µL	± 2.5	± 0.031	± 1.5	± 0.019
		2.5 µL	± 1.4	± 0.035	± 0.7	± 0.018
0.5 - 10 µL Increment: 0.01 µL	medium gray 0.1 - 20 µL 40 mm	0.5 µL	± 8	± 0.04	± 5	± 0.025
		1 µL	± 2.5	± 0.025	± 1.8	± 0.018
		5 µL	± 1.5	± 0.075	± 0.8	± 0.04
		10 µL	± 1.0	± 0.1	± 0.4	± 0.04
2 - 20 µL Increment: 0.02 µL	light gray 0.5 - 20 µL L 46 mm	2 µL	± 5	± 0.1	± 1.5	± 0.03
		10 µL	± 1.2	± 0.12	± 0.6	± 0.06
		20 µL	± 1.0	± 0.2	± 0.3	± 0.06
2 - 20 µL Increment: 0.02 µL	yellow 2 - 200 µL 53 mm	2 µL	± 5	± 0.1	± 1.5	± 0.03
		10 µL	± 1.2	± 0.12	± 0.6	± 0.06
		20 µL	± 1.0	± 0.2	± 0.3	± 0.06
10 - 100 µL Increment: 0.1 µL	yellow 2 - 200 µL 53 mm	10 µL	± 3	± 0.3	± 1	± 0.1
		50 µL	± 1	± 0.5	± 0.3	± 0.15
		100 µL	± 0.8	± 0.8	± 0.2	± 0.2
20 - 200 µL Increment: 0.2 µL	yellow 2 - 200 µL 53 mm	20 µL	± 2.5	± 0.5	± 0.7	± 0.14
		100 µL	± 1	± 1	± 0.3	± 0.3
		200 µL	± 0.6	± 1.2	± 0.2	± 0.4
30 - 300 µL Increment: 0.2 µL	orange 20 - 300 µL 55 mm	30 µL	± 2.5	± 0.75	± 0.7	± 0.21
		150 µL	± 1	± 1.5	± 0.3	± 0.45
		300 µL	± 0.6	± 1.8	± 0.2	± 0.6
100 - 1 000 µL Increment: 1 µL	blue 50 - 1 000 µL 71 mm	100 µL	± 3	± 3	± 0.6	± 0.6
		500 µL	± 1	± 5	± 0.2	± 1
		1 000 µL	± 0.6	± 6	± 0.2	± 2

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Research plus adjustable single-channel						
Model	**Test tip** **epT.I.P.S. Color code** **Volume range** **Length**	**Testing volume**	**Error limits**			
			Error			
			Systematic		**Random**	
			± %	**± µL**	**± %**	**± µL**
0.5 - 5 mL Increment: 0.005 mL	purple 0.1 - 5 mL 120 mm	0.5 mL	± 2.4	± 12	± 0.6	± 3
		2.5 mL	± 1.2	± 30	± 0.25	± 6
		5.0 mL	± 0.6	± 30	± 0.15	± 8
1 - 10 mL Increment: 0.01 mL	turquoise 1 – 10 mL 165 mm	1.0 mL	± 3	± 30	± 0.6	± 6
		5.0 mL	± 0.8	± 40	± 0.2	± 10
		10.0 mL	± 0.6	± 60	± 0.15	± 15

9.2.5 Biomaster

Model	**Pipette tip**	**Testing volume**	**Error limits**			
			Error			
			Systematic		**Random**	
			± %	**± µL**	**± %**	**± µL**
Biomaster 4830	Mastertip	2 µL	± 6.0	± 0.12	± 4.0	± 0.08
		3 µL	± 5.0	± 0.15	± 3.0	± 0.09
		5 µL	± 4.0	± 0.2	± 2.0	± 0.1
		10 µL	± 3.0	± 0.3	± 1.5	± 0.15
		20 µL	± 2.5	± 0.5	± 0.8	± 0.16

9.2.6 Varipette

Model	**Pipette tip**	**Testing volume**	**Error limits**			
			Error			
			Systematic		**Random**	
			± %	**± µL**	**± %**	**± µL**
Varipette 4720	Varitip S	2.5 µL	± 1.0	± 0.025	± 0.2	± 0.005
		5 µL	± 0.4	± 0.02	± 0.2	± 0.01
		10 µL	± 0.3	± 0.03	± 0.2	± 0.02
Varipette 4720	Varitip P	1 µL	± 0.6	± 0.006	± 0.2	± 0.002
		5 µL	± 0.5	± 0.025	± 0.1	± 0.005
		10 µL	± 0.3	± 0.03	± 0.1	± 0.01

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9.2.7 Xplorer

Model Increment	Test tip epT.I.P.S. Color code Volume range Length	Testing volume	Error limits			
			Error			
			Systematic		Random	
			± %	± µL	± %	± µL
0.5 - 10 µL Increment: 0.01 µL	medium gray 0.1 - 20 µL 40 mm	1 µL	± 2.5	± 0.025	± 1.8	± 0.018
		5 µL	± 1.5	± 0.075	± 0.8	± 0.04
		10 µL	± 1.0	± 0.1	± 0.4	± 0.04
5 - 100 µL Increment: 0.1 µL	yellow 2 - 200 µL 53 mm	10 µL	± 2.0	± 0.2	± 1.0	± 0.1
		50 µL	± 1.0	± 0.5	± 0.3	± 0.15
		100 µL	± 0.8	± 0.8	± 0.2	± 0.2
15 - 300 µL Increment: 0.1 µL	orange 15 - 300 µL 55 mm	30 µL	± 2.5	± 0.75	± 0.7	± 0.21
		150 µL	± 1.0	± 1.5	± 0.3	± 0.45
		300 µL	± 0.6	± 1.8	± 0.2	± 0.6
50 - 1 000 µL Increment: 1 µL	blue 50 - 1 000 µL 71 mm	100 µL	± 3.0	± 3.0	± 0.6	± 0.6
		500 µL	± 1.0	± 5.0	± 0.2	± 1
		1 000 µL	± 0.6	± 6.0	± 0.2	± 2
0.25 - 5 mL Increment: 0.005 mL	purple 0.1 - 5 mL 120 mm	0.5 mL	± 3.0	± 15.0	± 0.6	± 3
		2.5 mL	± 1.2	± 30.0	± 0.25	± 6.25
		5 mL	± 0.6	± 30.0	± 0.15	± 7.5
0.5 - 10 mL Increment: 0.01 mL	turquoise 1 – 10 mL 165 mm	1 mL	± 3.0	± 30.0	± 0.60	± 6.0
		5 mL	± 0.8	± 40.0	± 0.20	± 10.0
		10 mL	± 0.6	± 60.0	± 0.15	± 15.0

9 Technical specifications

9.3 Multi-channel pipettes

9.3.1 Research

Model	Test tip epT.I.P.S. Color code Volume range Length	Volume in µL	Error limits			
			Error			
			Systematic		Random	
			± %	± µL	± %	± µL
Research 8-channel 0.5 – 10 µL	light gray 0.5 - 20 µL L 46 mm	1	± 8.0	± 0.08	± 5.0	± 0.05
		5	± 4.0	± 0.2	± 2.0	± 0.1
		10	± 2.0	± 0.2	± 1.0	± 0.1
Research 12-channel 0.5 – 10 µL		see 8-channel				
Research 8-channel 10 – 100 µL	yellow 2 - 200 µL 53 mm	10	± 3.0	± 0.3	± 2.0	± 0.2
		50	± 1.0	± 0.5	± 0.8	± 0.4
		100	± 0.8	± 0.8	± 0.3	± 0.3
Research 12-channel 10 – 100 µL		see 8-channel				
Research 8-channel 30 – 300 µL	orange 20 - 300 µL 55 mm	30	± 3.0	± 0.9	± 1.0	± 0.3
		150	± 1.0	± 1.5	± 0.5	± 0.75
		300	± 0.6	± 1.8	± 0.3	± 0.9
Research 12-channel 30 – 300 µL		see 8-channel				

9 Technical specifications

9.3.2 Research pro

Model	Test tip epT.I.P.S. Color code Volume range Length	Testing volume	Error limits			
			Error			
			Systematic		Random	
			± %	± µL	± %	± µL
Research pro 8-channel / 12-channel 0.5 – 10 µL	light gray 0.5 - 20 µL L 46 mm	1 µL	± 5.0	± 0.05	± 3.0	± 0.03
		5 µL	± 3.0	± 0.15	± 1.5	± 0.075
		10 µL	± 2.0	± 0.2	± 0.8	± 0.08
Research pro 8-channel / 12-channel 5 – 100 µL	yellow 2 - 200 µL 53 mm	10 µL	± 2.0	± 0.2	± 2.0	± 0.2
		50 µL	± 1.0	± 0.5	± 0.8	± 0.4
		100 µL	± 0.8	± 0.8	± 0.25	± 0.25
Research pro 8-channel / 12-channel 20 – 300 µL	orange 20 - 300 µL 55 mm	30 µL	± 2.5	± 0.75	± 1.0	± 0.3
		150 µL	± 1.0	± 1.5	± 0.5	± 0.75
		300 µL	± 0.6	± 1.8	± 0.25	± 0.75
Research pro 8-channel / 12-channel 50 - 1 250 µL	green 50 - 1 250 µL 76 mm	120 µL	± 6.0	± 7.2	± 0.9	± 1.08
		600 µL	± 2.7	± 16.2	± 0.4	± 2.4
		1 200 µL	± 1.2	± 14.4	± 0.3	± 3.6

9.3.3 Research plus

Research plus adjustable multi-channel						
Model	Test tip epT.I.P.S. Color code Volume range Length	Testing volume	Error limits			
			Error			
			Systematic		Random	
			± %	± µL	± %	± µL
0.5 – 10 µL Increment: 0.01 µL	medium gray 0.1 - 20 µL 40 mm	0.5 µL	± 12	± 0.06	± 8.0	± 0.04
		1 µL	± 8.0	± 0.08	± 5.0	± 0.05
		5 µL	± 4.0	± 0.2	± 2.0	± 0.1
		10 µL	± 2.0	± 0.2	± 1.0	± 0.1
10 – 100 µL Increment: 0.1 µL	yellow 2 - 200 µL 53 mm	10 µL	± 3.0	± 0.3	± 2.0	± 0.2
		50 µL	± 1.0	± 0.5	± 0.8	± 0.4
		100 µL	± 0.8	± 0.8	± 0.3	± 0.3
30 – 300 µL Increment: 0.2 µL	orange 20 - 300 µL 55 mm	30 µL	± 3.0	± 0.9	± 1.0	± 0.3
		150 µL	± 1.0	± 1.5	± 0.5	± 0.75
		300 µL	± 0.6	± 1.8	± 0.3	± 0.9

9 Technical specifications

9.3.4 Xplorer

Model Increment	Test tip epT.I.P.S. Color code Volume range Length	Testing volume	Error limits			
			Error			
			Systematic		Random	
			± %	± µL	± %	± µL
0.5 - 10 µL Increment: 0.01 µL	medium gray 0.1 - 20 µL 40 mm	1 µL	± 5.0	± 0.05	± 3.0	± 0.03
		5 µL	± 3.0	± 0.15	± 1.5	± 0.075
		10 µL	± 2.0	± 0.2	± 0.8	± 0.08
5 - 100 µL Increment: 0.1 µL	yellow 2 - 200 µL 53 mm	10 µL	± 2.0	± 0.2	± 2.0	± 0.2
		50 µL	± 1.0	± 0.5	± 0.8	± 0.4
		100 µL	± 0.8	± 0.8	± 0.25	± 0.25
15 - 300 µL Increment: 0.1 µL	orange 15 - 300 µL 55 mm	30 µL	± 2.5	± 0.75	± 1.0	± 0.3
		150 µL	± 1.0	± 1.5	± 0.5	± 0.75
		300 µL	± 0.6	± 1.8	± 0.25	± 0.75
50 - 1 200 µL (only 8-channel) Increment: 1 µL	green 50 - 1 250 µL 76 mm	120 µL	± 6.0	± 7.2	± 0.9	± 1.08
		600 µL	± 2.7	± 16.2	± 0.4	± 2.4
		1 200 µL	± 1.2	± 14.2	± 0.3	± 3.6

9 Technical specifications

9.4 Multipette

The following specifications for the Multipette plus, Multipette stream / Multipette Xstream apply for the following conditions:

- Using the Combitips plus
- Liquid: Distilled or deionized water
- Reference temperature: 20 to 25 °C, ±0.5 °C
- Number of determinations: 10 according to EN ISO 8655, with original Eppendorf Combitip plus

Multipette stream / Multipette Xstream:

- Volume test in "DIS" mode
- Set speed level: 7

9.4.1 Multipette plus

Combitip plus	Testing volume	Error limits			
		Error			
		Systematic		Random	
		± %	± µL	± %	± µL
0.1 mL	2 µL	± 1.6	± 0.032	± 3.0	± 0.06
	20 µL	± 1.0	± 0.2	± 2.0	± 0.4
0.2 mL	4 µL	± 1.3	± 0.052	± 2.0	± 0.08
	40 µL	± 0.8	± 0.32	± 1.5	± 0.6
0.5 mL	10 µL	± 0.9	± 0.09	± 1.5	± 0.15
	100 µL	± 0.8	± 0.8	± 0.6	± 0.6
1 mL	20 µL	± 0.9	± 0.18	± 0.9	± 0.18
	200 µL	± 0.6	± 1.2	± 0.4	± 0.8
2.5 mL	50 µL	± 0.8	± 0.4	± 0.8	± 0.4
	500 µL	± 0.5	± 2.5	± 0.3	± 1.5
5 mL	100 µL	± 0.6	± 0.6	± 0.6	± 0.6
	1 000 µL	± 0.5	± 5	± 0.25	± 2.5
10 mL	200 µL	± 0.5	± 1	± 0.6	± 1.2
	2 000 µL	± 0.5	± 10	± 0.25	± 5
25 mL	500 µL	± 0.4	± 2	± 0.6	± 3
	5 000 µL	± 0.3	± 15	± 0.25	± 12.5
50 mL	1 000 µL	± 0.3	± 3	± 0.5	± 5
	10 000 µL	± 0.3	± 30	± 0.3	± 30

9 Technical specifications

9.4.2 Multipette stream / Multipette Xstream

Combitip plus	Dispensing range (min./max.)	Testing volume	Error limits			
			Error			
			Systematic		Random	
			± %	± µL	± %	± µL
0.1 mL (white piston) Increment: 0.1 µL	1 - 100 µL	10 µL	± 1.6	± 0.16	± 2.5	± 0.25
		50 µL	± 1.0	± 0.5	± 1.5	± 0.75
		100 µL	± 1.0	± 1	± 0.5	± 0.5
0.2 mL (blue piston) Increment: 0.2 µL	2 - 200 µL	20 µL	± 1.3	± 0.26	± 1.5	± 0.3
		100 µL	± 1.0	± 1	± 1.0	± 1
		200 µL	± 1.0	± 2	± 0.5	± 1
0.5 mL Increment: 0.5 µL	5 - 500 µL	50 µL	± 0.9	± 0.45	± 0.8	± 0.4
		250 µL	± 0.9	± 2.25	± 0.5	± 1.25
		500 µL	± 0.9	± 4.5	± 0.3	± 1.5
1 mL Increment: 1 µL	10 - 1 000 µL	100 µL	± 0.9	± 0.9	± 0.55	± 0.55
		500 µL	± 0.6	± 3	± 0.3	± 1.5
		1 000 µL	± 0.6	± 6	± 0.2	± 2
2.5 mL Increment: 2.5 µL	25 - 2 500 µL	250 µL	± 0.8	± 2	± 0.45	± 1.125
		1 250 µL	± 0.5	± 6.25	± 0.3	± 3.75
		2 500 µL	± 0.5	± 12.5	± 0.15	± 3.75
5 mL Increment: 5 µL	50 - 5 000 µL	0.5 mL	± 0.8	± 4	± 0.35	± 1.75
		2.5 mL	± 0.5	± 12.5	± 0.25	± 6.25
		5.0 mL	± 0.5	± 25	± 0.15	± 7.5
10 mL Increment: 10 µL	0.1 - 10 mL	1.0 mL	± 0.5	± 5	± 0.25	± 3
		5.0 mL	± 0.4	± 20	± 0.25	± 13
		10.0 mL	± 0.4	± 40	± 0.15	± 15
25 mL (blue adapter) Increment: 25 µL	0.25 - 25 mL	2.5 mL	± 0.3	± 8	± 0.35	± 8.8
		12.5 mL	± 0.3	± 38	± 0.25	± 31
		25.0 mL	± 0.3	± 75	± 0.15	± 38
50 mL (dark gray adapter) Increment: 50 µL	0.5 - 50 mL	5.0 mL	± 0.3	± 15	± 0.50	± 25
		25.0 mL	± 0.3	± 75	± 0.20	± 50
		50.0 mL	± 0.3	± 150	± 0.15	± 75

9 Technical specifications

9.5 Varispenser / Top Buret

The following specifications for Varispenser and Top Buret are valid for the following conditions:

Liquid:	Distilled or deionized water
Reference temperature:	20 to 25 °C, ±0.5 °C unchanging
Number of determinations:	10, in accordance with EN ISO 8655

9.5.1 Varispenser and Varispenser plus

Setting range	Tested volume	Systematic error (inaccuracy)	Random error (imprecision)
0.5 – 2.50 mL	2.5 mL	± 0.6 %	∞0.1 %
1.00 – 5.00 mL	5.0 mL	±0.5 %	∞0.1 %
2.00 – 10.0 mL	10.0 mL	±0.5 %	∞0.1 %
5.00 – 25.0 mL	25.0 mL	±0.5 %	∞0.1 %
10.0 – 50.0 mL	50.0 mL	±0.5 %	∞0.1 %
20.0 – 100.0 mL	100.0 mL	±0.5 %	∞0.1 %

9.5.2 Top Buret

Size	Setting range	Systematic error (inaccuracy)	Random error (imprecision)
C	25 mL	±0.2 %	∞0.1 %
H	50 mL	±0.2 %	∞0.1 %

9 Technical specifications

9.6 Error limits in accordance with EN ISO 8655

The error limits always refer to the overall system: pipette and tip. If the nominal volume of the pipette lies between two entries in the table, the absolute error values for the next largest nominal volume apply.

The absolute error limits in µL referring to the nominal volume apply to each volume which can be set on the piston stroke pipette. The list below includes the absolute and relative error limits in relation to the volume.

9.6.1 Air-cushion pipettes, fixed and adjustable volume

Nominal volume	Error limits			
	Measurement errors			
	Systematic		Random	
	± %	± µL	± %	± µL
1 µL	±5.0 %	±0.05 µL	±5.0 %	±0.05 µL
2 µL	±4.0 %	±0.08 µL	±2.0 %	±0.04 µL
5 µL	±2.5 %	±0,125 µL	±1.5 %	±0.075 µL
10 µL	±1.2 %	±0,12 µL	± 0.8 %	±0.08 µL
20 µL	±1.0 %	±0.2 µL	±0.5 %	±0.1 µL
50 µL	±1.0 %	±0.5 µL	±0.4 %	±0.2 µL
100 µL	± 0.8 %	±0.8 µL	±0.3 %	±0.3 µL
200 µL	± 0.8 %	±1,6 µL	±0.3 %	±0.6 µL
500 µL	± 0.8 %	±4,0 µL	±0.3 %	±1.5 µL
1 000 µL	± 0.8 %	±8,0 µL	±0.3 %	±3,0 µL
2 000 µL	± 0.8 %	±16,0 µL	±0.3 %	±6,0 µL
5 000 µL	± 0.8 %	±40,0 µL	±0.3 %	±15,0 µL
10 000 µL	±0.6 %	±60,0 µL	±0.3 %	±30,0 µL

For Multi-channel pipettes, the error values are two times the values specified for single-channel pipettes.

9 Technical specifications

9.6.2 Positive displacement pipettes (Biomaster)

Nominal volume	Error limits			
	Measurement errors			
	Systematic		Random	
	± %	± µL	± %	± µL
5 µL	±2.5 %	±0,13 µL	±1.5 %	±0.08 µL
10 µL	±2.0 %	±0.2 µL	±1.0 %	±0.1 µL
20 µL	±2.0 %	±0.4 µL	± 0.8 %	±0,16 µL
50 µL	±1.4 %	±0,7 µL	±0.6 %	±0.3 µL
100 µL	±1.5 %	±1.5 µL	±0.6 %	±0.6 µL
200 µL	±1.5 %	±3.0 µL	±0.4 %	±0.8 µL
500 µL	±1.2 %	±6.0 µL	±0.4 %	±2.0 µL
1 000 µL	±1.2 %	±12.0 µL	±0.4 %	±4.0 µL

9 Technical specifications

9.6.3 Dispenser (Multipette)

Nominal volume	Error limits			
	Measurement errors			
	Systematic		Random	
	± %	± µL	± %	± µL
0.001 mL	±5.0 %	±0.05 µL	±5.0 %	±0.05 µL
0,002 mL	±5.0 %	±0.1 µL	±5.0 %	±0.1 µL
0,003 mL	±2.5 %	±0.075 µL	±3.5 %	±0,11 µL
0,01 mL	±2.0 %	±0.2 µL	±2.5 %	±0.25 µL
0,02 mL	±1.5 %	±0.3 µL	±2.0 %	±0.4 µL
0,05 mL	±1.0 %	±0.5 µL	±1.5 %	±0.75 µL
0,1 mL	±1.0 %	±1,0 µL	±1.0 %	±1,0 µL
0.2 mL	±1.0 %	±2,0 µL	±1.0 %	±2,0 µL
0.5 mL	±1.0 %	±5,0 µL	±0.6 %	±3,0 µL
1 mL	±1.0 %	±10,0 µL	±0.4 %	±4,0 µL
2 mL	± 0.8 %	±16,0 µL	±0.4 %	±8,0 µL
5 mL	±0.6 %	±30,0 µL	±0.3 %	±15,0 µL
10 mL	±0.5 %	±50,0 µL	±0.3 %	±30,0 µL
25 mL	±0.5 %	±125,0 µL	±0.3 %	±75,0 µL
50 mL	±0.5 %	±250 µL	±0.25 %	±125.0 µL
100 mL	±0.5 %	±500 µL	±0.25 %	±250.0 µL
200 mL	±0.5 %	±1 000 µL	±0.25 %	±500,0 µL

9 Technical specifications

9.6.4 Single-stroke dispenser (Varispenser)

Nominal volume	Error limits			
	Measurement errors			
	Systematic		Random	
	± %	± µL	± %	± µL
0.01 mL	±2.0 %	±0.2 µL	±1.0 %	±0.1 µL
0.02 mL	±2.0 %	±0.4 µL	±0.5 %	±0.1 µL
0.05 mL	±1.5 %	±0.75 µL	±0.4 %	±0.2 µL
0.1 mL	±1.5 %	±1.5 µL	±0.3 %	±0.3 µL
0.2 mL	±1.0 %	±2.0 µL	±0.3 %	±0.6 µL
0.5 mL	±1.0 %	±5.0 µL	±0.2 %	±1.0 µL
1 mL	±0.6 %	±6.0 µL	±0.2 %	±2.0 µL
2 mL	±0.6 %	±12.0 µL	±0.2 %	±4.0 µL
5 mL	±0.6 %	±30.0 µL	±0.2 %	±10.0 µL
10 mL	±0.6 %	±60.0 µL	±0.2 %	±20.0 µL
25 mL	±0.6 %	±150.0 µL	±0.2 %	±50.0 µL
50 mL	±0.6 %	±300.0 µL	±0.2 %	±100.0 µL
100 mL	±0.6 %	±600.0 µL	±0.2 %	±200.0 µL
200 mL	±0.6 %	±1 200 µL	±0.2 %	±400,0 µL

9 Technical specifications

9.6.5 Piston stroke burets

Nominal volume	Error limits			
	Measurement errors			
	Systematic		Random	
	± %	± µL	± %	± µL
<1 mL	±0.6 %	±6,0 µL	±0.1 %	±1,0 µL
2 mL	±0.5 %	±10,0 µL	±0.1 %	±2,0 µL
5 mL	±0.3 %	±15,0 µL	±0.1 %	±5,0 µL
10 mL	±0.3 %	±30,0 µL	±0.1 %	±10,0 µL
20 mL	±0.2 %	±40,0 µL	±0.1 %	±20,0 µL
25 mL	±0.2 %	±50,0 µL	±0.1 %	±25,0 µL
50 mL	±0.2 %	±100,0 µL	±0.1 %	±50,0 µL
100 mL	±0.2 %	±200 µL	±0.1 %	±100,0 µL

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Eppendorf offices

AUSTRALIA & NEW ZEALAND

Eppendorf South Pacific Pty. Ltd.
Phone: +61 2 9889 5000
Fax: +61 2 9889 5111
E-mail: Info@eppendorf.com.au
Internet: www.eppendorf.com.au

AUSTRIA

Eppendorf Austria GmbH
Phone: +43 (0) 1 890 13 64 - 0
Fax: +43 (0) 1 890 13 64 - 20
E-mail: office@eppendorf.at
Internet: www.eppendorf.at

BRAZIL

Eppendorf do Brasil Ltda.
Phone: +55 11 30 95 93 44
Fax: +55 11 30 95 93 40
E-mail:
eppendorf@eppendorf.com.br
Internet: www.eppendorf.com.br

CANADA

Eppendorf Canada Ltd.
Phone: +1 905 826 5525
Fax: +1 905 826 5424
E-mail: canada@eppendorf.com
Internet: www.eppendorfna.com

CHINA

Eppendorf China Ltd.
Phone: +86 21 38560500
Fax: +86 21 38560555
E-mail: market.info@eppendorf.cn
Internet: www.eppendorf.cn

CZECH REP. & SLOVAKIA

Eppendorf Czech & Slovakia s.r.o.
Phone: +420 323 605 454
Fax: +420 323 605 454
E-mail: eppendorf@eppendorf.cz
Internet: www.eppendorf.cz /
www.eppendorf.sk

FRANCE

Eppendorf France S.A.R.L.
Phone: +33 1 30 15 67 40
Fax: +33 1 30 15 67 45
E-mail: eppendorf@eppendorf.fr
Internet: www.eppendorf.fr

GERMANY

Eppendorf Vertrieb
Deutschland GmbH
Phone: +49 2232 418-0
Fax: +49 2232 418-155
E-mail: vertrieb@eppendorf.de
Internet: www.eppendorf.de

INDIA

Eppendorf India Limited
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Fax: +91 44 42 18 74 05
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Internet: www.eppendorf.co.in

ITALY

Eppendorf s.r.l.
Phone: +390 2 55 404 1
Fax: +390 2 58 013 438
E-mail: eppendorf@eppendorf.it
Internet: www.eppendorf.it

JAPAN

Eppendorf Co. Ltd.
Phone: +81 3 5825 2363
Fax: +81 3 5825 2365
E-mail: info@eppendorf.jp
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NORDIC

Eppendorf Nordic Aps
Phone: +45 70 22 2970
Fax: +45 45 76 7370
E-mail: nordic@eppendorf.dk
Internet: www.eppendorf.dk

SOUTH & SOUTHEAST ASIA

Eppendorf Asia Pacific Sdn. Bhd.
Phone: +60 3 8023 2769
Fax: +60 3 8023 3720
E-mail:
eppendorf@eppendorf.com.my
Internet: www.eppendorf.com.my

SPAIN

Eppendorf Ibérica S.L.U.
Phone: +34 91 651 76 94
Fax: +34 91 651 81 44
E-mail: iberica@eppendorf.es
Internet: www.eppendorf.es

SWITZERLAND

Vaudaux-Eppendorf AG
Phone: +41 61 482 1414
Fax: +41 61 482 1419
E-mail: vaudaux@vaudaux.ch
Internet: www.eppendorf.ch

UNITED KINGDOM

Eppendorf UK Limited
Phone: +44 1223 200 440
Fax: +44 1223 200 441
E-mail: sales@eppendorf.co.uk
Internet: www.eppendorf.co.uk

USA

Eppendorf North America, Inc.
Phone: +1 516 334 7500
Fax: +1 516 334 7506
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E-Mail: eppendorf@eppendorf.com
Eppendorf North America, Inc. · 102 Motor Parkway, Suite 410 · Hauppauge, NY 11788-5178 · USA
Tel: +1 516 334 7500 · Toll free phone: +1 800 645 3050 · Fax: +1 516 334 7506 · E-Mail: info@eppendorf.com

Application Support

Europe, International: Tel: +49 1803 666 789 · E-Mail: support@eppendorf.com
North America: Tel: +1 800 645 3050 ext. 2258 · E-Mail: techserv@eppendorf.com
Asia Pacific: Tel: +60 3 8023 6869 · E-Mail: support_asiapacific@eppendorf.com

STANDARD OPERATING PROCEDURE SOP-13

EXPERIMENTAL EXPOSURE SYSTEMS FOR LABORATORY STUDIES OF AQUATIC ORGANISMS UNDER FLUVIAL CONDITIONS

Purpose

The purpose of this SOP is to describe the methods to assemble exposure system structures, where to obtain the parts, and how to arrange the experimental setup for laboratory studies under simulated fluvial conditions.

Scope and Applicability

This SOP describes the design, construction, maintenance and utilization of artificial flow-through exposure systems. The flow regime in the recirculating exposure units can be adjusted such that it simulates fluvial conditions of interest (e.g., the flow regime can be adjusted such that it accommodates the specific requirements for different life-stages or riverine fish such as sturgeon).

Summary of Method

The method described herein covers the initial construction and assemblage of all materials required for a fully functioning exposure system as well as considerations to be taken when choosing an experimental layout. Details of all building materials and suppliers are provided. A list of supplier contact information is included at the end of the SOP.

Safety Considerations

All safety considerations will be in accordance with University of Saskatchewan (U of S) Department of Health, Safety and Environment (DHSE) procedures and with the requirements of the U of S Environmental Toxicology Laboratory (ETL) Safety Manual. These requirements include:

1. All persons involved in research at the ETL shall complete basic laboratory safety, new employee orientation, bio-safety, and radiation safety courses offered by the DHSE (summer student orientation will suffice for summer students);

2. All persons involved in research using vertebrate subjects must have taken proper training through the Animal Use and Care Committee.

Other job-specific safety training will be provided by qualified members of the ETL.

Specific safety concerns are:

1. Personnel will be working in close proximity to water and electricity, such that electrocution is an imminent danger. For this reason, it is important to assure that all equipment is certified for this use and to always wire equipment and use ground fault interruption (GFI) circuits at all times. Do not stand in water while touching wiring, extension chords, or electrically powered equipment.
2. The exposure system frames and wet tables are heavy structures and care should be taken when lifting and assembling.
3. All chemicals and flammable liquids that are to be used should be disposed of in properly labeled waste containers and stored in appropriate storage bins.

Equipment and Materials

Flow-through Exposure Chambers

Artificial flow-through exposure chambers and screen dividers are constructed from ¼-inch plexi-glass or ¼-inch high density polyethylene (HDPE). The material and structures are supplied and fabricated by WD Plastics (Saskatoon, SK) and QMP plastics (Saskatoon, SK), respectively. Each exposure chamber contains removable screen dividers for controlling flow regime.

¼-inch puck board reservoir baffles and exposure chamber dividers are also supplied and fabricated by WD Plastics.

Incubation/hatching Jars

6L McDonald-type egg hatching jars are supplied by Aquatic Ecosystems
(Apopka,. FL; Cat. #J30).

Wet Table

The fiberglass wet tables are open 4-foot by 4-foot boxes that are 8 inches deep. A 2-inch female thread by female thread bulkhead fitting is installed at the bottom of one end for a stand pipe. The wet table, with installed bulkhead, is fabricated by Progressive Yard Works Ltd (Saskatoon, SK).

Exposure System Table Frame

The steel table frame is supplied and fabricated by Elance, steel fabricating Co. Ltd (Saskatoon, SK). Each exposure system table frame consist of a 4-foot ¼-inch by x 4-foot ¼-inch welded L-bracket top frame, four 30-inch removable steel legs, four 4-inch steel bolts and four steel nuts.

Reservoir and Mixing Tank

100L polyethylene reservoir tanks (part # 70394-0) and 1000L polyethylene oval vertical mixing tanks with 8-inch lids and 1-inch female thread by female thread bulkheads (part # 60014-1) are supplied by Quality Molded Plastics Ltd (Saskatoon, SK).

Pumps

Pulsafeeder pulsatron diaphragm metering pumps (model # LEH7SAPHC3-XXX) are supplied by Viking Pump of Canada Inc. and magnetic drive march pumps (part # W30HD) are supplied by Aquatic Eco-systems Inc, Saskatoon, SK.

Chillers

Water chillers are supplied by Aqua Logic Inc (Apopka, FL).

Plumbing Equipment

Bulkhead fittings are supplied by Western/Westlund. Ball valves, adapters, bushings, tees, PVC piping, and clamps are supplied by Aquifer Distribution Ltd (Saskatoon, SK). Some plumbing equipment can also be found at Home Depot. Quick coupler cam locks are supplied by Green Line Hose and Fittings (Saskatoon, SK), and hose/tubing is supplied by Goodall Rubber Company of Canada (Saskatoon, SK).

Tools and Miscellaneous Equipment

Tools such as drills, drill bits, Teflon tape, and saws can be found at Home Depot. Miscellaneous equipment such as PVC/ABS cement, silicon, fiberglass mosquito netting, etc., can also be found at Home Depot or Canadian Tire.

Methods and Procedures

Overview

A holding tank contains the reverse osmosis and dechlorinated lab water mixture supplied to the experimental exposure systems. The water is delivered from the tank to the 100L exposure system reservoir via a metering pump. The water then travels from the reservoir to the exposure system treatment chambers via a re-circulating march pump. The water flows from one end of the treatment chamber to the other and exits through a drain hole, which in turn is connected back to the 100L reservoir. There is an overflow drain out the back of each reservoir

to discard wastewater and a baffle to prevent short-circuiting of the inflow to the overflow drain (Figure 1). The water may be cooled to the desired temperature by either placing a chiller unit inside the 100L reservoir or by re-circulating chilled water through the wet table.

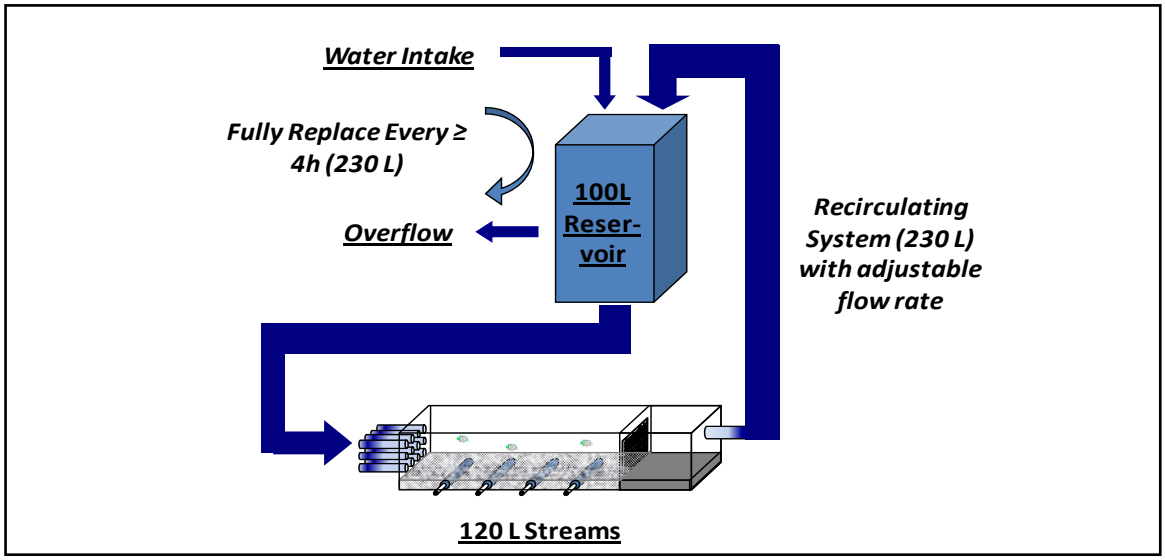

Figure 1. Experimental exposure system. Each true replicate exposure system consists of one 100L reservoir and one 120L chambers. Each chamber can hold up to 24,000 cm^3 of sediment.

Experimental Setup

- All piping threads should be wrapped in Teflon tape prior to attachment.
- All PVC/ABS piping joints should be glued with the appropriate cement.

Exposure system table frames

- Arrange the experimental exposure systems in such a fashion that enables easy access, preferably from all sides.
- Assemble the steel table frame. Attach four steel legs to the steel top frame by sliding each leg into a sleeve on the frame and secure with a bold and nut.

Wet table

- A fiberglass wet table is placed inside the table frame.
- If using a water bath to cool the treatment chambers
  - Fabricate a 6-inch standpipe from 2-inch diameter PVC piping
  - Attach the wet table standpipes into the bulkhead fitting of the wet table using a 2-inch socket by male adapter.

- Attach a drain hose to the bulkhead fitting on the underside of the wet table using a 2-inch PVC male adapter and run the drain hose back to the chilled water supply.
- Attach a delivery hose from the chilled water supply to the wet table frame using PVC piping and a clamp. Attach a ball valve at the end so that the water flow can be adjusted.

Treatment chambers and incubation/hatching jars

- Each wet table can hold up to six 40L plexiglass treatment chambers, or three 120L HDPE treatment chambers, side by side.
- Attach a 1-inch female thread by female thread bulkhead to the 2-inch hole at the end part of each chamber.
- Each treatment chamber has removable screen inserts to control the flow regime. Silicon fiberglass mosquito netting is placed over the rectangular holes on the inserts in order to reduce water flow and to prevent the fish from passing through.
- Egg hatching jars are placed at the end of the exposure chambers. The test solution is pumped through the top of the standpipe of the hatching jar (from the exposure chamber) when the experiment is initiated and flows into the reservoir and is re-circulated (Figure 2.).[1]

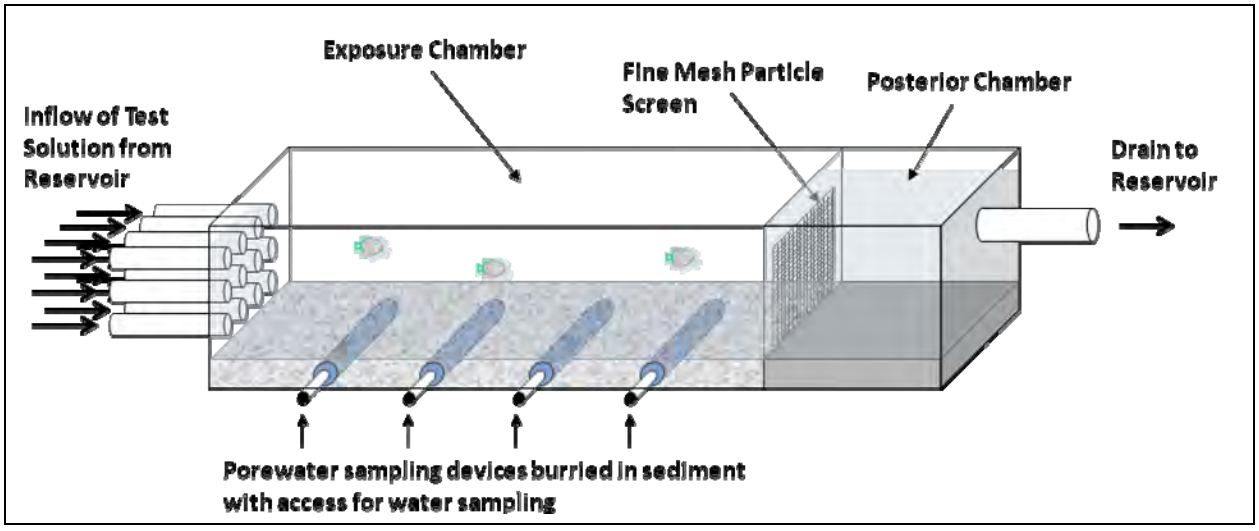

Figure 2. Exposure Chamber. This schematic represents one exposure chamber. Gravel (Hagen, GeoSystems Substrate) will be placed on top of the sediment at densities in the range of 0, 3, 7, 10 or 13 stones per 100 cm^2 (gravel not shown in schematic) [1]

[1] Final exposure chamber design may vary, and will be adjusted in accordance with the methods established during the 2010 pilot studies.

- A right angle 1-inch male PVC adapter is attached to the exterior side of the bulkhead fitting at the end of the exposure chambers.
- Tubing is attached to the adapters.
- Depending on the number of replicates per table, combine the drain pipe tubing from common doses into one hose with an appropriate splitter.
- Run one drain hose (per true replicate) from each splitter back into the appropriate reservoir.
- Place a 48-inch by 24-inch by ¼-inch puck board divider between each true replicate on the table.
- Each chamber is capable of holding up to 24,000 cubic cm of sediment given a depth of 7.6 cm.
- Cylindrical, ceramic airstones are placed horizontally 1.5 inches below sediment surface at 3-inch intervals. Airstones are inserted into a grommet built into the side of the exposure chamber to allow water to be pulled through the airstone into a 2.5 mL syringe for collection. A valve is placed onto the grommet to regulate flow[1].

Reservoirs

- Reservoirs and lids must be cut to the appropriate size to fit under the table frame.
- Drill a 2-inch output hole in the center of one face of the reservoir near the bottom so that it will align with the march pumps. Attach a 1-inch female thread by female thread bulkhead. Attach a 1-inch ball valve and a male cam lock to the bulkhead.
- Drill a 2-inch intake hole in the center of the reservoir on the same face as the previous hole near the top (about 3 inches below the lid). Attach a 1-inch female thread by female thread bulkhead. Attach a male cam lock to the bulkhead.
- Drill a 2-inch overflow hole to the far side, near the top, in the reservoir face directly opposite the face in which the two previous holes were drilled. Make sure the center of this hole is at least 1-inch lower then the previously drilled intake hole. This hole is the overflow hole and must be lower than the previously drilled intake hole. Attach a 1-inch female thread by female thread bulkhead.
- Drill a 4-inch hole in the center of the bottom of the 23-inch by 8-inch by ¼-inch puck board baffle. Silicon this baffle, with the hole on the bottom, to the inside corner nearest the overflow hole of the reservoir. Make sure the baffle will separate the intake water from the overflow water.

- Drill a 2-inch hole in the corner of the reservoir lid opposite the reservoir overflow hole. Attach a 1-inch female thread by female thread bulkhead and a 1-inch male PVC adapter.
- Place the reservoirs under the exposure system frame and wet table.
- Attach black flexible sump-pump hose to the overflow drain at the back of the reservoir to discard of the wastewater.
- Attach the drain hose from each splitter of the exposure chambers to the 1-inch male PVC adapter in the lid of the appropriate reservoir.

March pump and manifold[1]

- Attach a female cam lock to the intake of the march pump. Connect the march pump intake to the male cam lock at the bottom output of the reservoir.
- Attach a 4-way or 3-way splitter, depending on the number of pseudo-replicate exposure chambers per true replicate being used, to the output of the march pump. This is the initial piece of the manifold that will allow for water flow regulation to each exposure chamber.
- Attach two ball valves in series to each output arm of the splitter (this will allow the water flow to be shut off without disrupting the flow settings).
- Attach male PVC adapters and tubing to the second ball valve of each of the manifold arms and run the tubing to the right angle ½-inch PVC nozzle that was previously attached to the front of each treatment chamber.
- The PVC nozzle will be attached to a spray-bar assembly. The spray-bar assembly will consist of four vertical spray bars, each regulated by a ball valve. Water will enter from either end of the spray-bar assembly to deliver an even flow[2].

Metering pumps

- Place the metering pumps next to their corresponding reservoirs.
- Attach a 3/8-inch inner diameter hose barb to a female cam lock and attach to the male intake cam lock at the top of the reservoir.
- Attach 3/8-inch inner diameter tubing from the hose barb to the output of the corresponding metering pump.

[1] Final manifold design may vary depending on number of chambers per table.

[2]Final spray-bar assembly design may vary.

Mixing/holding tanks and receiving tanks

- Position the mixing/holding tanks or the receiving tank (used in continuous delivery of test solution from river or lake source) in such a way that they are easily accessible and so that they are as close as possible to their corresponding exposure systems.
- Attach a 3-way splitter to the 1-inch bulkhead of the tank.
- Attach ball valves to each of the output arms of the splitter.
- Attach a 3/8-inch inner diameter hose barb to the ball valves on the splitter.
- Attach 3/8-inch inner diameter tubing from the intake of the metering pumps to the 3/8-inch inner diameter hose barb on the splitter on the corresponding tank.

Pump Settings and Flow Rate

Metering pump

Using the current pumping system the turnover rate of the water/mixture in the 205L re-circulating system can be varied from one to four times per 24-hour period. This is controlled by the settings on the metering pump.

Metering pump settings and adjustments:

- Disconnect the cam lock on the reservoir intake at the top of the reservoir.
- Position the hose so that it is discharging into a graduated cylinder.
- Time the discharge for 60 seconds using a stopwatch and a measuring cylinder (or for 15 seconds and multiply by 4).
- Regulate the discharge rate (ml/min) by adjusting the frequency and stroke knobs on the metering pump and repeat timing of discharge until the desired flow is achieved:
  - Set stroke rate to nearest value of flow (Table 1.). Use stroke length to calibrate fine adjustment to achieve desired rate. Stroke length should be kept as close to 100 percent as possible for maximum efficiency.

Table 1. Stroke rate adjustments for metering pump.

Stroke rate	10	15	20	30	40	50	60	70	80	90	100
mL/min	110	140	210	330	400	480	580	695	755	800	900
L/day	160	200	300	475	575	690	835	1000	1090	1150	1300

- Ensure that the hose is reconnected once the flow rate is achieved.

March pump and manifold

The recirculation rate of the water/mixture from the reservoir to the treatment chambers can be varied from approximately 2L/min to 15L/min by adjusting the ball valves on the manifold attached to the march pump. Never completely shut off the ball valves on the manifold as the back pressure may damage the pump.

Manifold settings:

- Place a beaker under the right angle ½-inch PVC nozzle in the front of each treatment chamber corresponding to the manifold of interest.
- Fully open the ball valves on the manifold.
- Start the march pump and measure the flow rate into the beakers. Adjust the second ball valves on the manifold arms until the flow into each exposure chamber is at the desired rate.
- If the flow ever needs to be shut off for an exposure chamber, adjust the first ball valves on the manifold so that the set flow rate remains the same once normal flow is restored. This is will prevent having to re-calibrate the manifold.

Take-Down of Exposure System

Ideally, all cleaning and acid washing should be done as soon as possible once the experiment is terminated. All tanks, streams and wet tables must be scrubbed clean before algae hardens and dries. Aquarium/ wet lab appropriate soap should be used for cleaning.

- Mixing tanks should be scrubbed using soap and water to remove any algal/fungal buildup and then acid washed (5percent hydrochloric acid [HCl]) for a minimum of 8 hours.
- Exposure chambers can be cleaned first by scrubbing with water and soap and then with an acid bath (5 percent HCl). The plexiglass should be subjected to the acid bath for a minimum of 8 hours, and then well rinsed with clean water.
- Reservoirs can be cleaned first by scrubbing with water and soap and then with an acid bath (5 percent HCl). The plastic should be subjected to the acid bath for a minimum of 8 hours, and then well rinsed with clean water.
- To clean the March pump, run clean water through it to dilute any contaminants. Note: Do not use acid as it will corrode the metal parts of the pump.
- To clean the metering pump, run clean water through it to dilute any contaminants. If needed, remove the four screws to disassemble the head assembly. Check the injection valve assembly, the discharge valve cartridge and the suction valve cartridge - these

may have lime or other substances blocking them or preventing the ball from functioning properly. Note: Do not use acid as it will corrode the metal parts of the pump.

- Clean the area of concern with a small brush, being careful not to scratch or damage the apparatus.

Manufacturers' Contact Information

WD Plastics
826- 56th St. East
Saskatoon, SK, S7K 5Y8
(PH) 306-934-6844 (FAX) 306-934-6842

Elance Steel Fabricating Company Ltd.
40 Unger St. North Corman Park
Site 404, Box 3, RR #4
Saskatoon, SK, S7K 3J7
(PH) 306-931-4412 (FAX) 306-931-7683

Progressive Yard Works Ltd.
3423 Millar Ave.
Saskatoon, SK, S7K 6J4
(PH) 306-244-6911 (FAX) 306-244-6913

Aquatic Eco-Systems, Inc.
2395 Apopka Blvd.
Apopka, FL, 32703
Orders and General Inquiries: 877-347-4788
Free Tech Support: 407-598-1401
Fax: 407-886-6787

Aquifer Distribution Ltd.
227A Venture Crescent
Saskatoon, SK, S7K 6N8
(PH) 306-242-1567 (FAX) 306-665-2115

Quality Molded Plastics Ltd. (QMP)
Site 412, Box 280, RR#4
71st. St. Rd. & Highway 16W
Saskatoon, SK, S7K 3J7
(PH) 306-242-4494 (FAX) 306-242-4122

Goodall Rubber Co. of Canada
2902 Miners Ave
Saskatoon, SK, S7K 4Z7
(PH) 306-652-3791 (FAX) 306-652-5848

Green Line Hose and Fittings
2520 Millar Ave.
Saskatoon, SK, S7K 4K2
(PH) 306-653-5001 (FAX) 306-653-5008

Marine Aquaria
2854 Calgary Trail
Edmonton, AB
(PH) 780-761-1101 (FAX) 780-761-1102

Viking Pump of Canada.
8912-60 Avenue
Edmonton, AB T6E 6A6
1-888-VIK-PUMP (845-7867)
(FAX) 780-466-9131
For parts ordering 519-256-5438

Kootenay Trout Hatchery
4522 Fenwick Road
Fort Steel, BC, V0B 1N0
(PH) 250-429-3214 (FAX) 250-429-3202

Records, Documentation and Quality Control Requirements

All procedures, activities, anomalies and/or deviation from the specified method shall be recorded in a bound, serially numbered, laboratory notebook. In case of routine procedures that are identical to those conducted at an earlier time, the earlier description can be referred to without writing the complete procedures down again by indicating procedure, notebook page, date and initial.

Responsibilities

Project Manager. Dr. Markus Hecker will oversee and approve all project activities, authorize necessary actions and adjustments, and act as liaison between the principle investigator and other U of S personnel, Teck American personnel, and the sponsor Project Manager.

Principle Investigator. Prof. John P. Giesy will advise the Project Manager in overseeing and approving all project activities, authorize necessary actions and adjustments related to U of S activities to accomplish program quality assurance (QA) objectives; and act as liaison between agencies, staff, and the sponsor Project Manager.

Study Team Leaders (STL). David Vardy and Jonathon Doering, under the supervision of Markus Hecker, will oversee all research activities and supervise all personnel involved with the assemblage of the experimental exposure systems. The STLs will ensure that proper sample collection, preservation, storage, transport, and chain-of-custody quality control procedures are followed and will inform the Project QA Manager when problems occur, and will communicate and document corrective actions taken. The STLs will discuss study activities with the Project Manager.

Quality Assurance (QA) Manager. Dr. Shaun Roark will initiate audits on work completed by project personnel. The manager will review program QA activities, quality problems, and quality-related requests. In response to experimental findings, the QA manager will approve corrective actions. The QA manager will report quality non-conformances to the Project Manager.

Questions or Comments

Please feel free to contact the following persons with any questions, comments, etc., you may regarding the procedures outlined in this SOP.

Markus Hecker
mhecker@entrix.com
(306) 966-5233

Paul D. Jones, Ph.D.
paul.jones@usask.ca
(306) 966-5062

John P. Giesy, Ph.D.
john.giesy@usask.ca
(306) 966-2096

STANDARD OPERATING PROCEDURE SOP-14

CARE AND MAINTENANCE OF EARLY WHITE STURGEON (*ACIPENSER TRANSMONTANUS*) LIFE-STAGES UNDER LABORATORY CONDITIONS

Purpose

The purpose of this SOP is to describe methods necessary to culture and maintain white sturgeon from fertilized eggs obtained from wild adult fish in the laboratory, including maintenance of cultures in field-based mobile laboratories.

Scope and Applicability

This document describes culture requirements for white sturgeon eggs (2 to -3 days post-fertilization) through larvae up to 90-day post-hatch.

Summary of Method

The method described herein covers the maintenance of proper conditions for early life-stage white sturgeon cultures. This includes instructions for feeding the fish, cleaning tanks, maintaining water quality, and routine monitoring procedures to ensure health and growth of larvae and juveniles.

Safety Considerations

All safety considerations will be in accordance with University of Saskatchewan (U of S) Department of Health, Safety and Environment (DHSE) procedures and with the requirements of the U of S Environmental Toxicology Laboratory (ETL) Safety Manual. These requirements include: all persons involved in research at the ETL shall complete basic laboratory safety, new employee orientation, bio-safety, and radiation safety courses offered by the DHSE (summer student orientation will suffice for summer students); and all persons involved in research using vertebrate subjects must have taken proper training through the Animal Use and Care Committee. Other job-specific safety training will be provided by qualified members of the ETL.

Specific safety concerns are:

Personnel will be working in close proximity to water and electricity, such that electrocution is an imminent danger. For this reason, it is important to assure that all equipment is certified for this

use and to always wire equipment and use ground fault interruption (GFI) circuits at all times. Do not stand in water while touching wiring, extension chords, or electrically powered equipment.

Equipment, Materials, and Reagents

Flow-through chamber set up

Artificial flow-through chamber system (set up as described in SOP-ETL6032, [SOP-13 in this document]) or similar flow-through system fed by suitable water source

Daily maintenance of fertilized white sturgeon eggs

Egg hatching jars (Aquatic Ecosystems, Cat. #J32)

Daily maintenance of larval white sturgeon

- Bloodworms; Species: *Chironomus plumosus* (Hagen, Cat #A-9558)
- Mortar and pestle
- Artemia Cysts; Species: *Artemia salina* (Aquatic Ecosystems, Cat #BS90)
- Marine salt (Aquatic Ecosystems, Cat #SC1431)
- Separatory funnel (VWR, Cat #4300-1000)
- Air pumps and hoses
- Terrestrial, Oligochaete worms; Species: *Enchytraeus buchholzi, E. albidus* (ETL Culture)
- Plastic culture container, culture medium (Canadian Tire)
- Terrestrial worm feed (local grocery store)
- Bio Diet semi-moist or similar food (Kootenay Trout Hatchery)
- Grasslin Rondomatic Feeder (Marine Aquaria)
- Nets (Aquatic Ecosystems, Cat #AN4 & AN6)
- Net soak (Aquatic Ecosystems, Cat #NS8)
- Iodine (Aquatic Ecosystems, Cat #ID10)
- Buckets (Canadian Tire).

Methods, Procedures, and Requirements

Flow-through chamber set up

- Flow-through chamber systems should be fabricated as outlined in SOP-ETL6032 (SOP-13 in this document).
- Flow-through chambers are fed by a suitable water source (i.e., laboratory water, river water, exposure water). In the laboratory a combination of reverse-osmosis and dechlorinated lab water will be used to simulate water parameters found in the Columbia River (i.e., dissolved organic carbon, alkalinity, hardness, and pH).
- Flow-through chambers should be allowed to run for a minimum of 1 month before test organisms are added to the chambers.
- If the experiment will begin from the egg stage, an egg hatching jar should be attached to one exposure chamber in each treatment group when flow-through chambers are set up.

Daily maintenance of fertilized white sturgeon eggs

1. Eggs are obtained approximately 4 hours post-fertilization from the Kootenay Trout Hatchery in late June/early July.
2. Eggs are transported to the appropriate location (i.e., ETL at U of S, Upper Columbia River field sites) via motor vehicle or airplane in plastic bags filled with pure oxygen. Bags are to be sealed after filling with oxygen. Transport time should not exceed 12 hours.
3. When bags are opened, they should be aerated and kept at a constant temperature to avoid mass mortality.
4. Eggs are then randomly divided into the egg hatching jars in the mesocosms. Each jar should hold approximately ≥ 900 eggs.
5. The flow of water through the flow-through chambers should be adjusted to properly circulate and suspend the white sturgeon eggs in the hatching jars.
6. The eggs should be kept in suspension until hatch (approximately 7 days post-fertilization).
7. Water quality measurements should be performed daily and water samples taken as outlined in SOP-ETL2096 (SOP-16 in this document).
8. Cleaning of the exposure chambers and egg hatching jars should be performed as needed with designated brushes soaked in net soak or iodine solution.
9. Dead eggs should be removed at least twice a day and processed as outlined in SOP-ETL4071 (SOP-15 in this document).

Daily maintenance of larval white sturgeon

1. When white sturgeon eggs hatch, they should be removed from the egg hatching jars and 100 larvae randomly allocated into each of the corresponding treatment's exposure systems. Egg hatching jars should then be thoroughly cleaned, disinfected in iodine, and stored.

2. Sturgeon larvae should be observed daily. Once the first individuals reject their "yolk-plugs" (black plug that can be observed at the rear of yolk sack) as observable by black plugs laying on the bottom of the exposure chambers, the sturgeon should be fed as listed below. Small amounts of feed will be supplied in the days previous to the rejection of the "yolk plugs" to acclimate the fish to the presence of the feed.

3. Small (up to 5 cm) white sturgeon larvae should be fed at least 5 times daily as follows:[1]

    - Terrestrial worms will be offered at 8 AM. Feeders will be refilled as required over the course of the day.
    - 8 to 9AM—each stream should be fed 5 mL bloodworms that have been crushed with a mortar and pestle to a smooth puree. Bloodworms are spread on the feeding strips and placed into the streams.
    - 12 PM—each stream is fed freshly hatched *Artemia*[2]. Evenly split the *Artemia* hatched from 1L of culture.
    - 4 to 5 PM—feed each stream 5 mL bloodworms (as above).
    - 8 to 9 PM—feed each stream 5 mL bloodworms (as above).
    - 9 PM—Terrestrial worm feeders filled for nighttime feeding.
    - Overnight feeding of Bio Diet semi-moist or similar food[3].

4. Larger (more than 5 cm) white sturgeon should be fed 3 to 4 times daily as follows:[1]

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[1] The frozen, semi-moist, and live *Artemia* diets will be supplemented (or replaced as appropriate) by live, terrestrial oligochaete worms of suitable size. Worms will be applied to a submersible, passive feeder so fish can feed at their leisure. Worms will be cultured by the ETL. Exact culture method will depend upon species chosen.

[2] To culture *Artemia*, mix 1L of fresh water with 1 tablespoon of marine salts and 1 tablespoon of *Artemia* cysts in a plastic separatory funnel. Aerate with an air hose and small aquarium pump and incubate in a 25 to 30°C water bath for 12 to 24 hours.

[3] Overnight feeding of Bio Diet semi-moist feed will be supplied by automatic feeders, at 2-hour intervals. Crumble size #0 will be offered initially, followed by crumble size #1 after 30 days post-hatch.

- Terrestrial worms will be offered at 8 AM. Feeders will be refilled as required over the course of the day.
- 8 to 9AM—feed each stream 10 mL crushed bloodworms.
- 12 PM—feed each stream 10 mL crushed bloodworms.
- 4 to 5PM—feed each stream 10 mL crushed bloodworms.
- 8 to 9PM—feed each stream 10 mL crushed bloodworms.
- 9 PM—Terrestrial worm feeders filled for nighttime feeding
- Overnight feeding of Bio Diet semi-moist or similar food.

5. Water quality measurements should be taken and water samples preserved as outlined in SOP-ETL2096 (SOP-15 in this document).
6. Flow-through chambers should be cleaned as needed with designated brushes disinfected in net soak or iodine.
7. Dead white sturgeon should be removed and processed as outlined in SOP-ETL4071 (SOP-15 in this document).
8. Each exposure system will be culled down to approximately 60 fish after 10 days post-hatch. Exposure systems with fewer than 60 remaining fish will not be culled.

Records, Documentation and QC Requirements

All procedures, activities, anomalies and/or deviation from the specified method shall be recorded in a bound, serially numbered, laboratory notebook. In case of routine procedures that are identical to those conducted at an earlier time, the earlier description can be referred to without writing the complete procedures down again by indicating procedure, notebook page, date and initial.

Responsibilities

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Study Team Leaders (STLs). David Vardy and Jonathon Doering under the supervision of Markus Hecker will oversee all research activities and supervise all personnel involved with the culture and maintenance of early white sturgeon life-stages. The STLs will ensure that proper sample collection, preservation, storage, transport, and chain-of-custody quality control procedures are followed will inform the Project QA Manager when problems occur, and will communicate and document corrective actions taken. The STLs will discuss study activities with the Project Manager.

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Questions or Comments

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Markus Hecker
mhecker@entrix.com
(306) 966-5233

Paul D. Jones, Ph.D.
paul.jones@usask.ca
(306) 966-5062

John P. Giesy, Ph.D.
john.giesy@usask.ca
(306) 966-2096

STANDARD OPERATING PROCEDURE SOP-15

PREPARATION AND PRESERVATION OF WHITE STURGEON (*ACIPENSER TRANSMONTANUS*) EGGS, FRY AND JUVENILES

Purpose

The purpose of this SOP is to describe procedures for preserving white sturgeon eggs and fry/juveniles.

Scope and Applicability

Methods are described for preparing daily mortalities, samples taken at points during the course of the experiment, and samples taken at exposure termination.

Summary of Method

The information provided herein is intended to provide the information required to properly prepare and preserve white sturgeon samples for various forms of subsequent laboratory analysis.

Safety Considerations

All safety considerations will be in accordance with University of Saskatchewan (U of S) Department of Health, Safety and Environment (DHSE) procedures and with the requirements of the U of S Environmental Toxicology Laboratory (ETL) Safety Manual. These requirements include: all persons involved in research at the ETL shall complete basic laboratory safety, new employee orientation, bio-safety, and radiation safety courses offered by the DHSE (summer student orientation will suffice for summer students); all persons involved in research using vertebrate subjects must have taken proper training through the Animal Use and Care Committee. Other job specific safety training will be provided by qualified members of the ETL.

Specific safety warnings are:

- Formalin is a dangerous chemical. It is a human carcinogen and can cause damage to skin and eyes. Contact with formalin should be avoided at all times. Because

formalin is volatile, avoid breathing the fumes. Always wear gloves and use in a well ventilated area, outside or in a hood when working in the laboratory.

Equipment, Materials, and Reagents

Preparation and preservation of daily mortalities

- Nets (Aquatic Ecosystems, Cat #AN4 & AN6)
- Net soak (Aquatic Ecosystems, Cat #NS8)
- Iodine (Aquatic Ecosystems, Cat #ID10)
- Buckets (Canadian Tire)
- Paper towel
- Calipers (Canadian Tire)
- Forceps (VWR, Cat #25715-043)
- Balance (VWR, Cat #11379-144)
- 20 mL sample vials (VWR, Cat #66021-679)
- 10 percent formalin (VWR, Cat #VW3239-7)
- 70 percent ethanol.

Preparation and preservation of time point samples

- Nets (Aquatic Ecosystems, Cat #AN4 & AN6)
- Net soak (Aquatic Ecosystems, Cat #NS8)
- Iodine (Aquatic Ecosystems, Cat #ID10)
- Buckets (Canadian Tire)
- MS-222 (Sigma, Cat #A5040)
- Paper towel
- Calipers (Canadian Tire)
- Forceps (VWR, Cat #25715-043)
- Balance (VWR, Cat #11379-144)
- Scissors (VWR, Cat #25870-002)
- 7 mL sample vials (VWR, Cat #66022-387)
- 10 percent formalin (VWR, Cat #VW3239-7)

- 70 percent ethanol

Preparation and preservation of samples at exposure termination

- Same supplies needed as for time point samples

Methods, Procedures, and Requirements

Preparation and preservation of daily mortalities (performed twice daily)

1. Remove dead eggs or fry/juveniles from a single exposure chamber with a disinfected and rinsed net.
2. Place samples on a piece of paper towel to blot excess water.
3. Egg samples can be pooled and weighed on the balance down to the nearest 0.001 g, then preserved in 10 percent formalin for 24 hours in a properly labeled 20 mL sample vial.
4. Fry/juveniles samples are individually measured with the calipers down to the nearest 0.01 mm.
5. Fry/juveniles samples are then pooled and weighed on the balance, then preserved in 10 percent formalin for 24 hours in a properly labeled 20 mL sample vial.
6. Very large fry/juveniles can be individually weighed and placed into an individual properly labeled 7 mL sample vial.
7. All weight and length values should be recorded on the appropriate data sheets.
8. After 24 hours the formalin in the vials is replaced with 70 percent ethanol for long-term storage until histological analysis can be completed. **CAUTION**: Ethanol is extremely flammable!
9. Samples can be stored at room temperature.
10. Sample transfers must be completed using proper chain-of-custody (COC) procedures (see SOP-ETL4006; SOP-9 in this document).

Preparation and preservation of time point samples

1. White sturgeon fry/juveniles will be sampled from each exposure chamber at multiple points during the course of experiments.
2. WS fry/juveniles should be removed from chambers with cleaned and rinsed nets.
3. WS fry/juveniles are then placed into a 1 g/L solution of MS-222 until euthanized.
4. WS fry/juveniles are removed from MS-222 and blotted dry on paper towels.

5. All samples should be individually weighed on the balance and measured with calipers.
6. Weight and length data is recorded on the appropriate data sheets.
7. Sample transfers must be completed using proper COC procedures (see SOP-ETL4006; SOP-9 in this document).

Preparation and preservation of samples at exposure termination

1. At exposure terminations, all white sturgeon fry/juveniles in all streams will be sampled.
2. Procedures and methods for processing and preserving samples for histology, molecular biology, metals analysis, and nutritional analysis are identical to those outlined in the previous section.

Records, Documentation and Quality Control Requirements

All procedures, activities, anomalies and/or deviation from the specified method shall be recorded in a bound, serially numbered, laboratory notebook. In case of routine procedures that are identical to those conducted at an earlier time, the earlier description can be referred to without writing the complete procedures down again by indicating procedure, notebook page, date and initial.

Responsibilities

Project Manager. Dr. Markus Hecker will oversee and approve all project activities, authorize necessary actions and adjustments, and act as liaison between the principle investigator and other U of S personnel, Teck American personnel, and the sponsor Project Manager.

Principle Investigator. Prof. John P. Giesy will advise the Project Manager in overseeing and approving all project activities, authorize necessary actions and adjustments related to U of S activities to accomplish program quality assurance (QA) objectives; and act as liaison between agencies, staff, and the sponsor Project Manager.

Study Team Leaders (STLs). David Vardy and Jonathon Doering under the supervision of Dr. Markus Hecker will oversee all research activities and supervise all personnel involved with the culture and maintenance of early white sturgeon life-stages. The STLs will ensure that proper sample collection, preservation, storage, transport, and COC QC procedures are followed will inform the Project QA Manager when problems occur, and will communicate and document corrective actions taken. The STLs will discuss study activities with the Project Manager.

Quality Assurance (QA) Manager. Dr. Shaun Roark. The QA Manager will initiate audits on work completed by project personnel. The manager will review program QA activities, quality problems, and quality-related requests. In response to experimental findings, the QA manager

will approve corrective actions. The QA manager will report quality non-conformances to the Project Manager.

Questions or Comments

Please feel free to contact the following persons with any questions, comments, etc., you may regarding the procedures outlined in this SOP.

Markus Hecker
mhecker@entrix.com
(306) 966-5233

Paul D. Jones, Ph.D.
paul.jones@usask.ca
(306) 966-5062

John P. Giesy, Ph.D.
john.giesy@usask.ca
(306) 966-2096

STANDARD OPERATING PROCEDURE SOP-16

MEASUREMENT OF WATER QUALITY AND PROCESSING OF WATER SAMPLES DURING WHITE STURGEON (*ACIPENSER TRANSMONTANUS*) EXPOSURES

Purpose

The purpose of this SOP is to describe methods necessary to make water quality (WQ) measurements on exposure chambers and process water samples during white sturgeon exposures in the University of Saskatchewan (U of S) laboratory.

Scope and Application

This SOP applies to the ETL for samples supplied from the Upper Columbia River white sturgeon studies.

Summary of Method

The method described herein describes the appropriate methods for taking daily WQ measurements from exposure chambers during white sturgeon exposures. In addition, methods for processing periodic water samples for extended analysis are described.

Safety Considerations

All safety considerations will be in accordance with U of S Department of Health, Safety and Environment (DHSE) procedures and with the requirements of the U of S Environmental Toxicology Laboratory (ETL) Safety Manual. These requirements include: all persons involved in research at the ETL shall complete basic laboratory safety, new employee orientation, bio-safety, and radiation safety courses offered by the DHSE (summer student orientation will suffice for summer students); all persons involved in research using vertebrate subjects must have taken proper training through the Animal Use and Care Committee. Other job-specific safety training will be provided by qualified members of the ETL.

Specific safety concerns are:

Personnel will be working in close proximity to water and electricity, such that electrocution is an imminent danger. For this reason, it is important to assure that all equipment is certified for this use and to always wire equipment and use ground fault interruption (GFI) circuits at all

times. Do not stand in water while touching wiring, extension chords, or electrically powered equipment.

Equipment, Materials, and Reagents

Daily WQ measurements

- Ammonia nitrogen kit (LaMotte, Cat #7674)
- Nitrate nitrogen kit (LaMotte, Cat #7418-01)
- Hardness kit (LaMotte, Cat #4482-DR-LI)
- Multi-function meter for pH, temperature, dissolved oxygen, and conductivity (VWR, Cat #11388-328)

Periodic WQ measurements

- Chlorine kit (VWR, Cat #66170-136)
- Sulfate kit (VWR, Cat #66121-530)

Preparation of water samples for metal analysis and detailed WQ analysis

- Water filtration apparatus (VWR, Cat #28199-406)
- 0.45 μm water filters (VWR, Cat #28157-960)
- Plastic forceps (VWR, Cat #83009-010)
- Ultrapure nitric acid (VWR, Cat #CANX0408-7)
- Water sample bottles (VWR, Cat #EP156-125WMN)
- 1 mL pipetter
- 1 mL pipette tips
- Water bath (plastic tote will work)
- Ultra-pure water
- Hydrochloric acid (HCl)
- Small Petri dishes (VWR, Cat #25384-332)
- -20°C freezer

Preparation of water samples for total organic carbon (TOC) and dissolved organic carbon (DOC) analysis

- Water filtration apparatus (VWR, Cat #28199-406)
- 0.45 μm water filters (VWR, Cat #28157-960)
- Water sample bottles (VWR, Cat #EP156-125WMN)
- HCl

- Small Petri dishes (VWR, Cat #25384-332)
- -20°C freezer

Methods, Procedures, and Requirements

Daily water quality measurements[1]

1. Selected WQ measurements (temperature, oxygen, pH, conductivity) should be made from one exposure chamber in each recirculating system every day. Chambers should be alternated so that WQ measurements are made on each different chamber over 2 to -3 days.
2. Using the multi-parameter WQ monitor, make measurements for temperature, pH, dissolved oxygen and conductivity.
3. Record all WQ measurements on the appropriate data sheet(s) following quality assurance/quality control (QA/QC) requirements.
4. Any abnormal WQ measurements, especially high temperatures should be immediately reported to a team leader.

Periodic WQ measurements[1]

1. WQ kits to make measurements for nitrite, nitrate, ammonia, chlorine, phosphate, and sulfate are available to be used at important time points or when needed (at least once per week per exposure system).
2. Make kit measurements for those parameters that are not performed by the Liber lab (see subsequent Section). Copies of kit instructions are available in SOP notebooks and as electronic copies from Upper Columbia River (UCR) team members.
3. These measurements should be made in one exposure chamber per recirculating system the first day water is supplied to the mesocosms, before eggs/larvae are added to chambers, after eggs/larvae are added to chambers, once per week during the exposures in the field, at exposure termination, and whenever UCR team members deem necessary.
4. Record all WQ measurements on the appropriate data sheet(s) following QA/QC requirements.
5. Any abnormal WQ measurements, especially high ammonia levels, should be immediately reported to a team leader.

[1]1 Any samples sent to CAS laboratory will be collected, stored and shipped according to CAS protocols.

Preparation of water samples for metal analysis and detailed water quality analysis[1]

1. Water samples should be prepared as outlined in the sampling plan provided by the UCR team leaders.
2. Place water filtration units, water filters, water sample transfer bottles and plastic tweezers into a 5 percent HCl bath 12 to 24 hours before the samples will be taken.
3. Rinse the water filtration units, filters, bottles, and tweezers in an Ultrapure water bath.
4. Remove a 150 mL water sample from one exposure chamber in each exposure treatment (i.e., each river water treatment, each metal dose, controls) with a water sample transfer bottle.
5. Assemble the water filtration units with water filters in place.
6. Place the water samples into the filtration units.
7. Allow samples an appropriate amount of time to pass through filters.
8. Disassemble filtration units and decant filtered water samples into properly labeled 60 or 125 mL sample bottles. Discard excess filtered sample.
9. Acidify filtered samples with 1 percent of total sample volume of Ultrapure nitric acid.
10. Cap bottles.
11. Place filters into properly labeled individual Petri dishes.
12. Store filtered water at 4°C or lower until analysis by Columbia Analytical Services.
13. Record samples taken on the proper data sheet(s) and in the laboratory notebook.
14. All sample transfers, both between laboratories and from the field, should be performed with proper chain-of-custody (COC) documentation (see SOP-ETL4006; SOP-9 in this document for COC details).

Preparation of water samples for DOC analysis[1]

1. Place water filtration units, water filters, water sample transfer bottles and plastic tweezers into a 5 percent hydrochloric acid bath 12 to -24 hours before the samples will be taken.
2. Rinse the water filtration units, filters, bottles, and tweezers in an Ultrapure water bath.
3. Remove a 150 mL water sample from one exposure chamber in each exposure treatment (i.e., each river water treatment, each metal dose, controls) with a water sample transfer bottle.
4. Assemble the water filtration units with water filters in place.
5. Place the water samples into the filtration units.
6. Allow samples an appropriate amount of time to pass through filters.

7. Disassemble filtration units and decant filtered water samples into properly labeled 125 mL sample bottles. Fill bottles to approximately 1 inch from top and cap. Discard excess filtered sample. The filtered sample contains the DOC content.
8. Preserve the water samples for analysis by acidifying the samples with 1 mL of HCl.
9. Store water samples at 4°C, or lower.
10. Carbon analysis will be performed using a TOC analyzer (TOC-5050A, Shimadzu, Mandel Scientific, Guelph, Ontario).
11. Record samples taken on the proper data sheet(s) and in the laboratory notebook.
12. All sample transfers, both between laboratories and from the field, should be performed with proper COC documentation (see SOP-ETL4006; SOP-9 in this document) for COC details.

Preparation of Porewater Samples for Metal Analysis[1]

1. Porewater samples should be prepared as outlined in the sampling plan provided by the UCR team leaders.
2. Place water filtration units, water filters, water sample bottles, and plastic tweezers into a 5 percent hydrochloric acid bath 12 to 24 hours before the samples will be taken.
3. Attach 2.5 mL syringe to the grommet of the exposure chamber using airline tubing.
4. Open valve and pull 2.5 mL of water into syringe and properly discard. Pull another 2.5 mL of porewater into the syringe and transfer into clean, sample bottle.
5. Repeat steps 1 through 4 for the remaining airstones using one sample bottle per exposure chamber.
6. Process porewater samples following procedure detailed in the "Preparation of water samples for metal analysis and detailed water quality analysis" section above.

Records, Documentation and QC Requirements

All procedures, activities, anomalies and/or deviation from the specified method shall be recorded in a bound, serially numbered, laboratory notebook. In case of routine procedures that are identical to those conducted at an earlier time, the earlier description can be referred to without writing the complete procedures down again by indicating procedure, notebook page, date and initial.

Responsibilities

Project Manager. Dr. Markus Hecker will oversee and approve all project activities, authorize necessary actions and adjustments, and act as liaison between the principle investigator and other U of S personnel, Teck American personnel, and the sponsor Project Manager.

Principle Investigator. Prof. John P. Giesy will advise the Project Manager in overseeing and approving all project activities, authorize necessary actions and adjustments related to U of S activities to accomplish program QA objectives; and act as liaison between agencies, staff, and the sponsor Project Manager.

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Please feel free to contact the following persons with any questions, comments, etc., you may regarding the procedures outlined in this SOP.

Markus Hecker
mhecker@entrix.com
(306) 966-5233

Paul D. Jones, Ph.D.
paul.jones@usask.ca
(306) 966-5062

John P. Giesy, Ph.D.
john.giesy@usask.ca
(306) 966-2096

STANDARD OPERATING PROCEDURE SOP-17

DATA PACKAGE REVIEW

Purpose

The purpose for data package review is to ensure that final results reported are an accurate representation of the raw data generated during analysis. Data packages must function as stand-alone units. They must contain all information necessary to verify the reported results and to completely document the quality control (QC) procedures utilized during the analysis. Any deviations from the written protocol and/or quality control procedures which do not meet the documented limits must be clearly noted in the data package.

Scope and Applicability

Data package review is applicable to all data packages generated by the Environmental Toxicology Laboratory (ETL) at University of Saskatchewan (U of S). Two levels of review will be performed on each data package prior to submission of the data package to the Quality Assurance (QA) Coordinator. The first level of review will be performed by the primary analyst (analyst who performed the analysis or his/her designee). The second level of review is to be performed by the lead supervisor or their designee. Both levels of data package review must be documented utilizing the appropriate checklist. A QC review will be performed at a frequency of 20 percent of samples.

Safety Considerations

All personnel shall adhere to prudent safety practices as specified in the project Health and Safety Plan (HASP) (TCAI 2007).

Equipment, Materials, and Reagents

The data package reviewers will require basic office equipment including, at a minimum, pens, a calculator and a computer. The computer must be loaded with Reflections for access to the LIMS software and should have the ability to review raw analytical data when required.

Method, Procedures, and Requirements

Three levels of data review will routinely be performed:

Analyst review

Technical review

QA review.

Primary Analyst Review

Once the data package has been generated, in accordance with ETL standard operating procedures (SOPs), the analyst, or their designee, will perform the first level of review. This review, detailed below, will verify the completeness of the data package prior to submission for technical review.

A. Review the Lot Folder Tracking Form. Verify that the header information is correct. Verify that the collection and analysis dates for samples are correct.

B. Each package will contain a data package checklist appropriate for the method performed. Verify that the data package includes all required forms as listed on the appropriate data package checklist. Verify that the data package is assembled in the order detailed on the appropriate data package checklist. Verify that the review of the contents have been performed by checking off each specific item on the appropriate data package checklist.

C. The primary analyst must verify each item on the appropriate Review Checklist. The review of each item must be noted by checking the appropriate item on the checklist.

D. Review the LIMS Worklist printout and the client and internal chains-of-custody (COCs). Verify that all samples on the client and internal COCs match the samples on the worklist and that there are no transcription errors or omissions.

E. Verify that there are no transcription errors on the LIMS worklist printout by checking the results against the raw data.

F. Check all QC sample results. Ensure that all quality control samples met acceptance criteria specified in the appropriate method SOP. If any QC samples do not meet criteria, verify that this is noted in the Case Narrative and also in the Analyst Comments section of the data package checklist. Verify that there is sufficient explanation regarding data acceptability.

G. Verify that all unused lines and entries on all forms have been lined out, dated, and initialed.

H. Verify that the correct calibration standards were used for quantitation.

I. Verify that all raw data for the analyses are included.

J. Verify correct calculation of results by recalculating the reported result on the Example Calculation Form.

K. Verify that all pages in the data package that require analyst signatures have been signed and dated by the analyst.

L. Document all variations from the SOP or problems with the analytical run in the Case Narrative.

M. If applicable, verify that the data package is consecutively paginated and that an electronic data deliverable (EDD) has been generated.

Technical Review

The technical review is the second level review and is performed by the Lead Supervisor or his/her designee. The technical review is performed to confirm the completeness of the package as submitted by the analyst and to verify the technical validity of the reported results, and is detailed below.

A. Review the Lot Folder Tracking Form. Verify that all header information is included and is accurate. Review the items listed in the Case Narrative Form and add pertinent information, as appropriate. Sign and date the Lot Folder Tracking Form for Technical Review.

B. Each package will contain a data package checklist appropriate for the method performed. Verify that the data package includes all required forms as listed on the data package checklist. Verify that the data package is assembled in the order detailed on the appropriate data package checklist. Verify that the primary analyst has checked off all applicable items on the appropriate data package checklist.

C. Each data package will contain the appropriate Method Review Checklists. Verify that the primary analyst has completely and correctly filled out the Review Checklists. Verify that the primary analyst has signed and dated the checklist. Verify that items listed on the form have been included in the data package and that all information is accurate. Sign and date the Review Checklists as the Reviewer.

D. Review the LIMS worklist printout. Verify that there were no transcription errors for the reported results by reviewing the raw data. Verify that all QC sample recoveries are reported correctly. Sign and date the LIMS report as the Reviewer.

E. Review the internal COC to ensure that custody was maintained within the laboratory. Signatures and dates must be present for all exchanges of samples between personnel. Verify that all client COCs are included for all samples contained on the internal COC.

F. Review the Sample Preparation Form, if applicable. This form must include preparation information for all samples present in the analytical run(s). Verify that all header information, sample identification, sample initial and final weights or volumes, units, solvent used with manufacturer's name and lot number, spike volumes and solution identifications have been completed. Ensure that sample preparation steps and holding time requirements have been met. Verify that the spiking solutions are traceable to certified reference materials and the traceability has been clearly documented in the data package. Verify that none of the stock or working standards used for spiking have expired. Verify that the source used for the laboratory control spike (LCS) is different from the source used for the initial calibration standards. The source for the matrix spike (MS) may be from the same source as the LCS or the initial calibration standards. All unused lines must be crossed out, initialed, and dated.

G. Review the Additional Sample Preparation Information Form, if applicable. The steps involved in the preparation process must be clearly defined with all initial and final volumes clearly stated. All unused lines must be crossed out, dated and initialed.

H. Review the Sample Preparation Comments Form, if applicable. Verify that the header information is complete and accurate. Verify that the analyst included any comments regarding the sample preparation process which may affect the results and which deviate from the specified method. If there were no reportable instances which affect the data, verify that the analyst indicates this. All unused lines must be crossed out, dated and initialed by the analyst.

I. Review the Sample Extract Dilution Form, if applicable. Verify that the header information is complete and accurate. Verify that the sample IDs and extract and solvent volumes and units are correct. Verify that the resulting dilution factors are correctly calculated. All unused lines must be crossed out, dated and initialed by the analyst.

J. Review the Solvent Purity Form, if applicable. Verify that the header information is complete and accurate. Verify that any solvents used for the method have had the solvent purity verified. As laboratory deionized water is continuously monitored, documentation using this form is not required.

K. Verify the calibration of the instrument. Documentation of the calibration may consist of the Calibration Form, instrument calibration reports, or the use of a spreadsheet or other

documentation specified in the method SOP. Raw responses must be checked for accurate data transcription and acceptable calibration results. Verify that all calibration information presented on the raw data has been accurately transcribed onto the calibration forms. Verify that all instrument calibration criteria (initial calibration verification [ICV], continuing calibration verification [CCV], instrument drift checks, etc.) meet the requirements detailed in the laboratory quality control plan (LQCP) and/or method SOP. For daily calibration checks, verify that the daily standard is checked against the correct initial calibration. Any manual integrations of calibration standards require clear identification, and an explanation for the use of manual integration.

L. Verify that all calibration and QC standard sources meet the requirements of the LQCP and associated method SOP. Verify that the calibration solutions are traceable to certified reference materials and the traceability has been clearly documented in the data package.

M. Verify that all associated raw data are included in the data package. Review the responses for all sample and QC analyses. Raw responses must be checked for accurate data transcription, if applicable. If a spreadsheet is used for interpretation of raw data, check for accurate data transcription. Confirm analysis holding time is within requirements. Verify that final concentrations have been calculated correctly by checking 10 percent of reported results. Check raw data for obvious problems, this may include elevated baselines, peak tailing, retention-time shifts, interfering ions, etc.

N. Verify that the analysis was in control by evaluating the recoveries observed for the QC samples. The method blank result should be below the method specific limits (method detection limits, practical quantification limit, method reporting limit, etc). If there are concentrations present in the method blank at levels above the method specific limits, then professional judgment must be used to determine if the data are acceptable. This must be noted on the Case Narrative.

O. Verify that a matrix spike was performed and is included in the Data Package. Verify that the matrix spike recoveries are acceptable.

P. Verify that all standards used for the sample preparation and analysis have not expired. Verify that all required stock and working standards logbook pages are included. Verify that all standards can be traced back to a certified standard reference material and that all Certificates of Analysis are included.

Q. Verify that the report is consecutively paginated and that the EDD has been generated. If the report is not paginated and/or the EDD is not generated, perform these functions.

R. Although each data package is a stand-alone entity assessment of results particularly for laboratory control samples and certified reference materials should be compared to those of preceding data packages to detect possible trending of data with time. Should any trending be detected the data in all packages should be examined closely to determine the cause of any trends observed.

QC Review

A. A QC review will be performed at a frequency of 20 percent of samples. The QC review will be performed utilizing the QC Lot Folder Review Checklist. For each portion of the data package to be reviewed, check each item listed on the QC Lot Folder Review Form to ensure completeness and accuracy.

B. If QC or technical discrepancies are identified in the 20 percent data package review, the QC reviewer should use their professional judgment in determining whether more than 20 percent of the data packages should be reviewed.

C. Verify that anomalies, variations, or problems are stated in the Case Narrative Section.

D. Verify that all necessary forms are included in the data package.

E. Verify that the field COC, Lab COC, LIMS worklist and COC information is complete and accurate.

F. Verify that all sample preparation information is complete and accurate, and that sample prep and analytical holding time requirements have been met.

G. Verify that the calibration information is complete and accurate.

H. Verify that the sample response information is complete and accurate.

I. Verify that method blank, LCS, and MS samples were performed and accurately reported. Verify that the QC samples meet the method specific criteria.

J. Sample integrity and traceability will be assessed in two samples per data package by performing a full audit trail analysis. The audit trail will track the sample documentation from field collection through final reporting and will include verification of sample documentation, sample container labeling and all COC and analytical procedures.

K. Sign and date the QC Review Checklist.

L. Upon completion of the QC review, any discrepancies in the data package should be brought to the attention of the Lead Supervisor for resolution.

Records, Documentation, and QC Requirements

A. The primary analyst shall document any anomalies and/or deviations from the specified method in the appropriate sections of the data package and list them in the Case Narrative Form. The primary analyst will sign and date any forms as the analyst.

B. The technical reviewer will record any problems noted during the technical review. The technical reviewer will return the data package to the analyst for corrections prior to submission of the data package. The technical reviewer must sign and date all forms as the reviewer.

C. The technical reviewer, or his/her designee, will paginate the report.

D. Generation of EDDs will be performed by the technical reviewer or by a designee of the technical reviewer or lead supervisor. As the nature of the EDD will vary considerably for each sample type and analytical procedure it is not possible to provide a definitive description of specific EDDs. EDDs will take the format of summary tables which may be directly extracted from the data package but may also consist of scanned documents in electronic format suitable for electronic storage, transmission and retrieval. QC procedures for summary tables will be determined based on the method of generation. EDDs will be provided in a format that will allow them to be suitably protected from electronic manipulation of the data.

E. The QC reviewer will document any findings on the QC Lot Folder Review Checklist and notify the Lead Supervisor(s) and primary analyst.

Responsibilities

Individuals and their project responsibilities are identified in a work plan or quality assurance project plan (QAPP) for each project. Any changes in personnel or their responsibilities will be noted in a protocol amendment and place on file with other project records.

References

Field and Laboratory Policies and Procedures Manual, 1996, Department of Fisheries and Wildlife, Michigan State University, East Lansing, MI 48824.

Data Quality Objectives Process for Superfund, Office of Emergency and Remedial Response, EPA 540-R-93-071, September 1993, United States Environmental Protection Agency, Washington DC 20460.

TCAI (Teck Cominco American, Inc.). 2007. Upper Columbia River: Draft general health and safety plan for the remedial investigation and feasibility study. Prepared for Teck Cominco American Incorporated, December 27, 2007. Integral Consulting Inc., Mercer Island, Washington, and Parametrix, Bellevue, Washington.

Teck American Incorporated
501 N Riverpoint Blvd., Suite 300
Spokane, WA 99202
PO Box 3087
Spokane, WA 99220-3087

+1 509 747-6111 Tel
+1 509 922-8767 Fax
www.teck.com

Teck

July 21, 2010

File No.: 1-773180-000

Ms. Helen Bottcher
Project Coordinator, Office of Environmental Cleanup
U.S. Environmental Protection Agency, Region 10
1200 6th Avenue, Suite 900 (ECL-111)
Seattle, WA 98101-3140

Subject: Upper Columbia River Remedial Investigation and Feasibility Study (UCR RI/FS) – White Sturgeon Sediment Toxicity Study; Standard Operating Procedure for the Decontamination, Deployment and Retrieval of Diffusive Sampling Devices

Dear Ms. Bottcher:

Further to your July 16th correspondence and as requested, we are pleased to submit for your review and information the above referenced Standard Operating Procedure (SOP) as part of the Assessment of Sediment Toxicity to White Sturgeon (*Acipenser transmontanus*) Quality Assurance Project Plan (QAPP) and its amendments.

We would like to thank you in advance for your continued assistance and cooperation on this matter, and look forward to a successful study. Should you have any questions or require any additional information at this time, please do not hesitate to contact me directly at (509) 892-2585.

Sincerely,
Teck American Incorporated

Marko E. Adzic, P.E.
Manager, Environmental Engineering

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Teck

Attachment (1) – Standard Operating Procedure No. 18 - *Decontamination, Deployment and Retrieval of Diffusive Sampling Devices*

cc: Dr. Anne Fairbrother – Exponent, Inc., Bellevue, WA (w/o attachment)
Dr. Markus Hecker – ENTRIX, Inc. c/o University of Saskatchewan, Aquatic Toxicology Centre, Saskatoon, SK (attachment)
Randall Connolly - Spokane Tribe of Indians; Wellpinit, WA (attachment)
Daniel Audet - U.S. Department of Interior; Spokane, WA (attachment)
Patti Bailey - Confederated Tribes of the Colville Reservation; Nespelem, WA (attachment)
John Roland - Washington Department of Ecology; Spokane, WA (attachment)

STANDARD OPERATING PROCEDURE SOP-18

DECONTAMINATION, DEPLOYMENT AND RETRIEVAL OF DIFFUSIVE SAMPLING DEVICES

Purpose

The purpose of this standard operating procedure (SOP) is to describe procedures used to decontaminate, deploy, and retrieve peepers and Diffusive Gradient Thin-Films (DGTs) (i.e., diffusive sampling devices) within fluvial exposure chambers designed by the Environmental Toxicology Laboratory (ETL) at the University of Saskatchewan (U of S).

Scope and Applicability

This SOP applies to the ETL for activities completed for the upper Columbia River white sturgeon sediment toxicity study.

DECONTAMINATION/PREPARATION[1]

Peepers

The peeper design to be used as part of this study is a modified version of the mini-peeper described by Doig and Liber (2000). Peepers are cleaned by soaking overnight in a high density polyethylene (HDPE) or polypropylene (PP) container of appropriate size containing a 4% HNO_3, 1% HCl solution. After cleaning, peepers are triple rinsed with de-ionized (DI) water and are either stored in DI water until further preparation or processed immediately. Prior to assembling peepers, DI water should be de-oxygenated by bubbling with an inert gas (e.g., nitrogen [N_2]) for 12-24 hours (hrs). Clean peeper chambers are filled completely with de-oxygenated (DO), DI water (DODI water) until a convex meniscus forms above the chamber openings. A Supor®-450 (Pall Corporation, Anne Arbor, USA) 0.45 micron (μm) filter membrane is then placed over the peeper openings, and the cover plate screwed on, to affix and seal the membrane in place. Excess membrane material on the outside is cut away and discarded. Once seated, the membrane is inspected for rupture and the peeper 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. The finished

[1] Always wear clean gloves (powder-free; e.g. nitrile) to avoid contamination of the sampling device!

peepers are transferred to an acid-cleaned HDPE or PP storage container (approximately 10 peepers per liter [L]) containing DODI water and 0.5-1.0 gram (g) of metal-chelating resin per L (e.g., Chelex-100™; Note: Make sure that the peepers do not come in direct contact with the resin). The storage container is "topped off" with DODI water, capped tightly and placed in a refrigerator maintained at approximately 4°C (degrees Celsius). Peepers can be stored in this manner for several weeks before use. Prior to deployment of peepers into sediments, they must be de-oxygenated for a minimum of 60 hrs by bubbling with an inert gas to minimize oxygen content in the peeper chambers. Peepers are to be deployed immediately after degassing.

Diffusive Gradient Thin-Films (DGTs)

DGT sediment probes (loaded DGT sediment probes for metals; Chelex gel, 0.78 millimeter [mm] open-pore diffusive gel; 1.8x15 cm^2 window) as obtained from DGT Research Ltd. (Lancaster, UK) will be employed. They can be stored at 4°C in a tightly sealed clean plastic bag with a few drops of 0.01 Molar (M) NaCl, until the expiration date listed by DGT Research Ltd. for each batch. Prior to deployment, DGT probes need to be de-oxygenated for approximately 24 to 48 hrs.

Prepare an acid cleaned, 1 or 2 L HDPE or PP container, sufficiently tall to submerse the entire DGT probe including the handle. Fill the container with 0.01 M NaCl and add a 0.5-1.0 g of metal-chelating resin per L of water (e.g., Chelex-100™). Place the DGT probes into the solution (approximately 6 DGTs per L; Note: Make sure that DGTs do not come in direct contact with the resin), and de-oxygenate by bubbling with an inert gas for 24 to 48 hrs. Deploy DGTs immediately after degassing.

To control for potential cross-contamination of DGT probes during the degassing process, a DGT solution monitoring unit (i.e., loaded DGT solution monitoring unit for metals [Chelex gel, 0.78 mm open-pore diffusive gel 3.14 cm^2 window]) is introduced during the degassing procedure serving as a procedural blank. Sampling and processing of this blank are identical to the methods described below (Retrieval of Diffusive Gradient Thin-Films).

DEPLOYMENT AND RETRIEVAL[2]

Peepers

Deployment

Carefully remove the peeper from the storage/de-oxygenation solution by means of plastic forceps. Gently and smoothly push the peeper into the sediment such that the surface covered by the membrane window is parallel to the direction of water flow in the chamber and until one

[2] Always wear clean gloves (powder-free; e.g. nitrile) to avoid contamination of the sampling device!

chamber is submerged into the sediment; while the second chamber remains above the sediment/water interface line (see Figure 1). Keep the peeper as close to a vertical position as possible during this process. Record the water temperature in the test chamber where peepers are deployed, and the time of deployment.

Retrieval

After 7 days (d) of exposure, carefully remove the peeper from the sediment by avoiding re-suspension of substrate to the extent possible and practical. Rinse the peeper with DI water, and insure that there are no particles left on the surface of the device, especially the window area. Record the time and water temperature in test chamber upon retrieval. Following retrieval, the solution in the peeper chamber is extracted using a pipette and plastic pipette tip by penetrating the membrane of each chamber (using a new clean tip per chamber), and transferring the solution into a pre-cleaned HDPE or PP vial (as provided by the analytical laboratory [Columbia Analytical Services]; with a 1% HNO_3 [90%] and hydrofluoric acid [10%] solution).

Two sets of blanks (2 peepers each) are to be included in addition to those that are exposed in the test systems. The first set serves as a procedural blank and will be only subjected to the cleaning and preparation procedures to control for potential contamination due to these processes. The second set represents experimental blanks, and will be exposed to DI water only. These blank exposures are to be conducted in the same room where and during the same time when the peeper sediment exposure experiments occur. Sampling and processing of peepers will be identical to the above described methods.

Diffusive Gradient Thin-Films (DGTs)

Deployment

Use a permanent marker to draw a mark on the plastic frame of the DGT probe to indicate the depth to which the probe will be inserted into the sediment (Note: Do not draw on the membrane [window] portion of the DGT) (Figure 1). Gently and smoothly push the long edge of the DGT probe into the sediment until the marks are in line with the sediment/water interface (Figure 1). The face of the probe should remain perpendicular to the sediment/water interface and the long axis of the probe should be oriented such that it is parallel to the long axis of the chamber, and the direction of flow through the chamber. Keep the probe as straight as possible during this process. Record the water temperature in test chamber and time of deployment.

Retrieval

After 24 to 48 hrs of exposure carefully remove the DGT probe from the sediment and avoid re-suspension of substrate to the extent possible and practical. Rinse the DGT with DI water, and insure that there are no particles left on the surface of the probe, especially the window area. Record the time and water temperature in test chamber upon retrieval. After retrieval, the DGT

can be cut into segments of desired size using a Teflon coated blade. Each DGT fragment is then transferred to a 15 mL HDPP centrifuge tube (e.g., BD Falcon High Clarity Polypropylene Conical Centrifuge Tube) containing 5 mL of 1M HNO_3 (make sure to completely cover gel). Leave at least 24 hrs prior to analysis.

QUESTIONS OR COMMENTS

Please feel free to contact the following persons with any questions, comments, etc., you may regarding the procedures outlined in this SOP.

Markus Hecker, Ph.D.
mhecker@entrix.com
(306) 966-5233

John P. Giesy, Ph.D.
john.giesy@usask.ca
(306) 966-2096

REFERENCES

Doig, L. and Liber, K. 2000. DIALYSIS MINIPEEPER FOR MEASURING PORE-WATER METAL CONCENTRATIONS IN LABORATORY SEDIMENT TOXICITY AND BIOAVAILABILITY TESTS. Environ Toxicol Chem 19(12): 2882-2889.

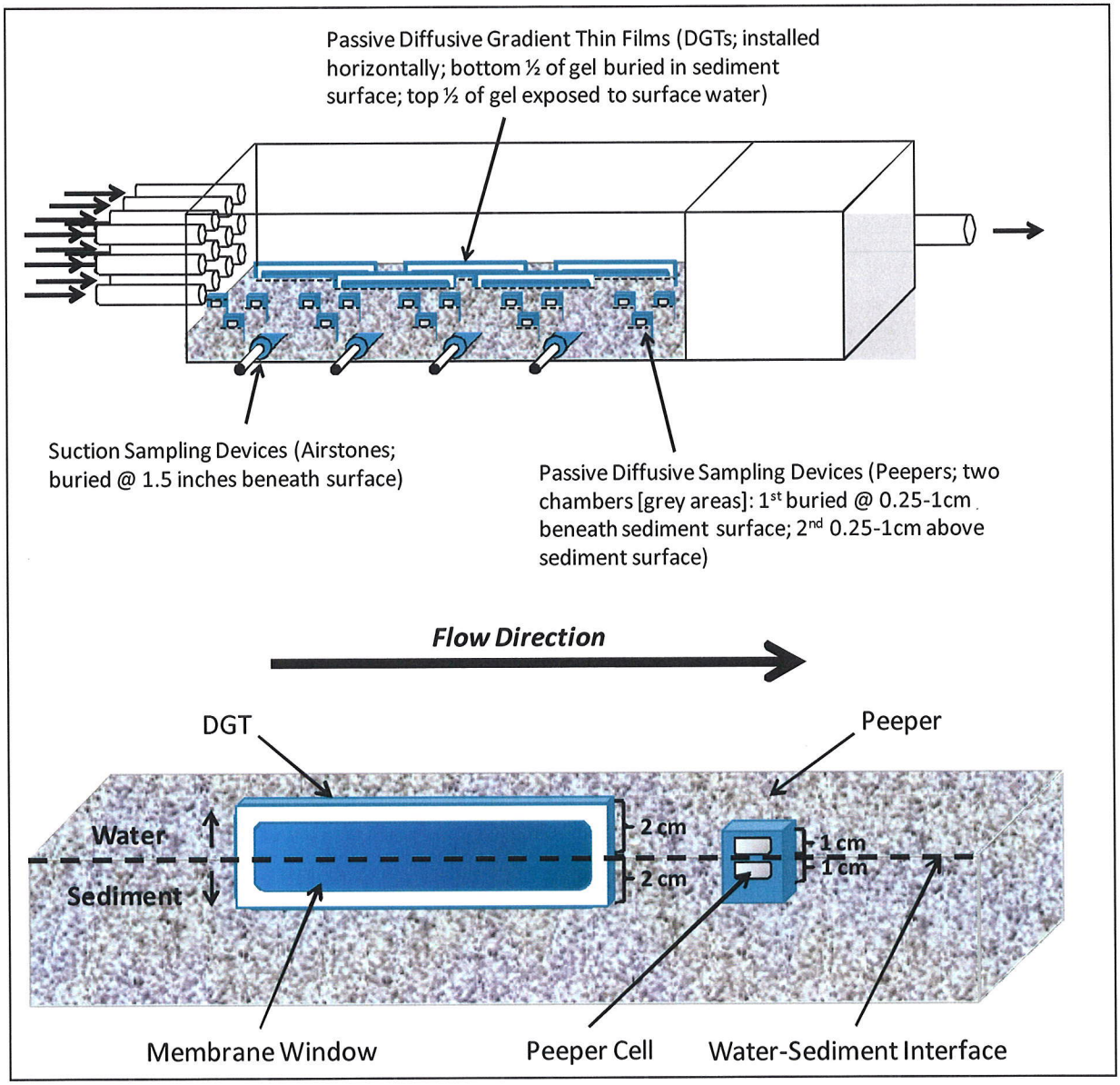


Figure 1: Deployment schematic for peepers and DGT probes. Note: Drawings are not to scale and definite design may deviate from the here shown illustrations.

APPENDIX D

U OF S ETL
LABORTORY SAFETY GUIDE

Environmental Toxicology Laboratory

UNIVERSITY OF SASKATCHEWAN

Laboratory Safety Guide

January 2008

Environmental Toxicology Laboratory
Toxicology Centre
University of Saskatchewan

LABORATORY SAFETY GUIDE

Version 1, Jan 2008

John P. Giesy, Ph.D., Jong Seong Khim, Ph.D., and Paul D. Jones, Ph.D.

Supported through:
Toxicology Centre and
Department of Veterinary Biomedical Sciences

Correspondence to:
Environmental Toxicology Laboratory
Toxicology Centre
44 Campus Drive,
Saskatoon, Saskatchewan, S7N 5B3
Canada

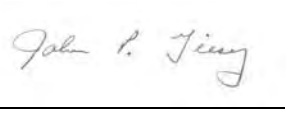
Phone: (306) 966-2096; 5206; 5062
Facsimile: (306) 966-4796

APPROVAL PAGE

Revisions to an existing SOP, addition of a SOP change form, or preparation of a new SOP must be reviewed, approved, and signed by the following:

Authored By: John P. Giesy
Jong Seong Khim
Paul D. Jones

Date: February 19, 2008



Supervisor Review By: John P. Giesy, Ph.D.

Date: February 20, 2008

DEFINITIONS AND ACRONYMS

ATRF Aquatic Toxicology Research Facility

DHSE Department of Health Safety and Environment

ERP Emergency Response Plan

ETL Environmental Toxicology Laboratory

PPE Personal Protective Equipment

SOP Standard Operating Procedure

U of S University of Saskatchewan

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- Laboratory Worker Safety Agreement, ETL, U of S, Sep 2007
- University Safety Manual, DHSE, University of Saskatchewan, 2004-2006
  - LabSafety, BioSafety, Radiation Safety, and Hazardous Waste Disposal

1 LABORATORY SAFETY PLAN

1.1 Laboratory Safety Policy

Work conducted in the laboratory and field can be hazardous, but if all of the safety protocols are followed a person can minimize the potential for injury to themselves and others. None of the work that is conducted by the Environmental Toxicology Laboratory (ETL) is more important than the health and safety of our people. While the laboratory directors, Prof. John Giesy and Prof. Paul Jones, have the ultimate responsibility for providing a safe and comfortable work environment, the daily overall supervision and assurance of safety in the laboratory and field is delegated to the laboratory manager and individual team leaders in charge of the individual studies.

Safety is the responsibility of both the management and workers. We have put procedures in place to insure the safety of all workers. These procedures are outlined in the University of Saskatchewan (U of S) safety manuals for general, biological, chemical and radiation safety and waste management and sample transportation, shipping and receiving. More specific information on safety procedures can be obtained in the individual ETL-standard operating procedures (SOPs) provided for each procedure and/or in the Health and Safety Plan (HASP) for each project.

This safety manual is not meant to be a complete compendium of all policies and procedures and does not replace or supplant any of the policies and procedures put in place by the U of S. In fact, this document builds upon and augments those policies and procedures. The relevant manuals and policy statements of the U of S are appended to this Safety Plan. In addition, more complete guidance can be obtained from the Department of Safety Health and Environment (DHSE) web site: www.usask.ca\DHSE. Furthermore, there are national and provincial laws in place that govern the workplace and these policies and procedures must be followed at all times. It is the responsibility of each employee to know the rules that apply to their situation and to follow the proscribed procedures at all times. Failure to do so will result in a warning and if the policies and procedures set forth in this document are not followed, it can lead to dismissal from the ETL.

Furthermore, each project conducted through the auspices of the ETL of the University of Saskatchewan Toxicology Centre is required to have a safety plan. In addition, each standard operating procedure (SOP) developed for ETL projects is required to have a project and procedure specific identification of potential hazards and a section on safety procedures.

1.2 Laboratory Safety Training

All laboratory personnel, including principle investigators, technicians, post doctoral fellows, graduate students, undergraduate assistants and visiting scientists are required to have the necessary and appropriate safety training. This training can be obtained in several ways. In addition to the laboratory and project specific training, each member of the ETL is required to take all of the appropriate safety classes listed below (provided from U of S, DHSE, http://www.usask.ca/dhse/trainingcourses) and in the appropriate HASPs and SOPs for the laboratories in which they work or the projects on which they work. When a class is taken, a certificate of training will be issued by DHSE. The employee is to retain the original and provide a copy to the ETL management team to be kept on file in the ETL. It is also the responsability of all personnel to ensure appropriate refresher courses are taken to keep their safety training current.

1.2.1 Basic Required Safety Training

1) Safety Orientation for New Employees: This course is offered to new employees for the purpose of helping prevent job related injury and illness and to provide general training required under Saskatchewan Occupational Health and Safety Regulations (mandatory as per Sec. 18 & 19). The course provides generic health and safety information and will introduce attendees to safety processes on campus. Site-specific training is the responsibility of the supervisor.

2) Safety Orientation for Supervisors: Individuals who have employees report to them are supervisors. Incumbents with supervisory roles or functions are responsible for the health and safety of workers and for workplaces in their areas of jurisdiction. This course covers legal aspects including Bill C-45, University policy on Health, Safety and Environmental Protection and supervisor responsibilities. Supervisory faculty and staff will be provided with some tools to help them integrate and manage health, safety and environment business into their planning and operations processes.

3) Laboratory Safety: This course is mandatory for all employees, including faculty and graduate students, who work in a laboratory and handle chemicals and/or other hazardous substances. (Employees working with other hazards such as electricity, heavy equipment, etc. should contact DHSE for guidance). The course will include training in: WHMIS, accident response procedures, emergency response plans, the safe use, storage and disposal of a range of hazardous chemicals, the proper use of personal protective equipment, and laboratory safety requirements. This course is supplementary to the Biosafety and Radiation Safety Courses. Participants must attend both days.

4) Biosafety: This course is mandatory for all employees, including faculty and graduate students, who work with biological materials. This course provides training in: Biosafety regulations, University policies and procedures pertaining to Biosafety, exposure routes, selection and use of PPE, biosafety cabinets, laboratory acquired infections and prevention,

biosafety considerations when working with animals or plants, importation of pathogens or animal by-products, and the safe use, storage and disposal of biological materials.

5) Radiation Safety: This course is mandatory for all employees, including faculty and graduate students who work with radioactive nuclear substances. This course will include training in: University policies and procedures, handling procedures, physics of radiation, contamination control, monitoring, disposal, local emergency procedures pertaining to nuclear substances, and the responsibilities and duties of permit holders and nuclear energy workers. Participants must attend all 3 days.

1.2.2 Optional Safety Training

6) Hazardous Waste Management: Hazardous Waste Management is an essential supporting element of the biological, chemical, radiological and environmental safety programs. Centrally-funded hazardous waste disposal helps our University community meet its legal and ethical obligations by providing a comprehensive and convenient waste disposal system to support research and teaching. Please refer to the Hazardous Waste Disposal Manual for essential technical and contact information.

7) Transportation of Dangerous Goods: DHSE offers training in the safe transport and receipt of dangerous goods. Anyone who ships, transports or receives dangerous goods must be trained and certified to do so. Different courses are offered to suit the needs of the campus community.

8) Fire Safety: This course is designed to instruct employees on the BASICS of Fire Science, the different classes of fires and fire extinguishing methods. Employees will be instructed in the proper use of a fire extinguisher and the topics of Flight or Fight and Life Safety.

1.2.3 Safety Information and ETL-SOP

In addition to the basic safety training courses offered by the U of S-DHSE, there is additional safety information provided in any and all HASPs and SOPs appropriate to your particular studies. It is required that all workers obtain and read all appropriate safety materials. In addition to reading the written materials, each worker will receive personal instruction before being asked to undertake any task. If the worker does not understand the instruction, or has concerns about the safety of any procedure, it is the joint responsibility of the supervisor and the employee to assure that the procedures and appropriate safety procedures are understood.

ETL-SOPs are written in response to a requirement to document and standardize routine activities, procedures, or schemes used to accomplish the task. The objective of an SOP is to provide a systematic, usable, and efficient method of accomplishing a routine laboratory task and individual SOP always includes ‘Safety Considerations’ section to

provide all safety information required when applying procedures. Appropriate SOPs will be provided to all individuals working in the ETL. All laboratory and field workers need to read and understand the SOPs given and/or related with his/her task before and during their work. All individuals in the ETL need to strictly follow the procedures, particularly for safety guide, to protect their and others' health and safety. Refer to ETL-SOP #1000, entitled 'Requirements for the Preparation, Review, Approval, and Implementation of Standard Operating Procedures (SOPs)', for the detailed guideline for SOPs

1.2.4 Certificates of Training

When an employee completes the training courses, they will be issued certificate of completion. They should keep the original for their records and provide a copy to be maintained by the ETL management. These records will be available to anyone who wishes to determine whom has had what formal training. In some cases ETL employees will take additional training not offered by the U of S. In such cases, this training will not substitute for or replace the required U of S training, but the employee should provide a record of all such training to the ETL management.

1.3 Laboratory Safety Responsibilities

Safety is the responsibility of all members of the ETL team. Regulations and guidelines, however well conceived or communicated are not sufficient to assure a completely safe working environment. It is the skill, knowledge, vigilance, diligence, communication and basic common sense of the individual workers that are essential to maintaining a safe working environment. Do not undertake any operations that you have not been trained for or if you are uncertain of how to conduct the operation. When in doubt ask. Furthermore, if you observe any of your colleagues conducting an unsafe operation bring it to their attention immediately. If you see an unsafe situation in the laboratory, correct it immediately and inform appropriate supervisory personnel. If you can not do so bring the situation to the attention of laboratory management immediately. No issue is too small to bring to the attention of others. If information on safety is lacking in HASPs or SOPs, bring it to the attention of the laboratory management so that the necessary safety information can be added to the appropriate documents.

If you are not satisfied with the response received from laboratory management to any safety issue it can be raised with the U of S Local Safety Committee #21 (LSC #21). This committee is responsible for all safety matters relating to the ETL and the Toxicology Centre as a whole. ETL management supports and encourages the use of LSC #21 to resolve any contentious safety issues after all possible internal avenues to resolution have been exhausted.

1.3.1 Safety Management in ETL

The laboratory management will do its part to assure the safety of the working condition of the laboratory and field campaigns. **It is the responsibility of the workers to:**

1) Attend safety training courses and to read all appropriate safety materials issued to him/her (such as instrument manuals, hazard alerts etc.).

2) If new hazards come to his/her attention, these should be corrected immediately and the issue and corrective action taken communicated immediately to the principal investigator (Prof. John Giesy or Prof. Paul Jones) and or the unity Safety Officer (Dr. Jong Seong Khim).

3) Be aware of all of the policies, regulations and practices of the Federal Government, Provincial government, U of S and the ETL.

4) Comply fully with all of the established safety regulations and practices and to consult the principle investigator or designated representative for advice in circumstances where safe practices or the appropriate measures are in doubt.

5) Limit laboratory and field work to projects authorized by the principal investigator.

6) Advise coworkers if unsafe activities are observed and to report such instances to the principal investigator so that corrective actions can be put into place.

7) Advise visitors to the existing hazards and when necessary (when others are using equipment in the laboratory or field) to inform them of the ETL, U of S and any other pertinent regulations or safety procedures. Assure that others making use of equipment have the necessary safety training.

8) Be sure that all required monitoring is conducted and reports generated.

9) Assure that laboratories are secured by locking and monitoring who comes and goes so that unauthorized persons are not allowed access.

Individual workers need to understand and agree his/her responsibilities before they start working in the ETL

1.3.2 Work Approval in ETL

To work in the ETL laboratories or take part in field studies, requires the permission of the laboratory director (Prof. Giesy). This permission is granted by the employee signing the achknowledgement and approval form stating that they have taken all of the required training and received all of the supplemental trainig required to do their tasks in a safe manner both to themselves and those around them. Unauthorized personnel (those not explicitly approved by Prof. Giesy) are not allowed to enter the laboratory portions of the ETL or take part in field expeditions. Signed, approval authorization forms will be maintained for all employees in the ETL main office. An example of the authorization form is attached as an appendix to this document (see appendix, **LABORATORY WORKER SAFETY AGREEMENT**).

2 WORK ENVIRONMENT

The **Environmental Toxicology Laboratory (ETL)** is part of the ca. 38,600 sq-ft Toxicology Centre at the University of Saskatchewan (U of S) in Saskatoon, SK, Canada. The 15,600 sq-ft ETL consists of a 2,260 sq-ft biochemistry/molecular biology lab, a 2,720 sq-ft wet chemistry and analytical lab (a separate 320 sq-ft high resolution (HR) GC-MS for dioxin analysis), and 3,560 sq-ft office and lounge spaces to accommodate room for up to 50 graduate students, post-docs, visiting scientists and professors. ETL also manages the 7,100 sq-ft Aquatic Toxicology Research Facility (ATRF) for the maintenance, culture, and exposure of aquatic organisms. The ATRF is a facility for the use of all investigators in the Toxicology Centre as well as for investigators from outside the U of S.

The facility allows U of S researchers to conduct long-term studies of the accumulation, metabolism, and effects of toxic substances and therapeutic agents on aquatic organisms under controlled laboratory conditions. Aquaculture drug studies can also be conducted. The facility was built to assist researchers from academic institutions, provincial and federal agencies and businesses and industries as well as non-government institutions in conducting research into the fates and effects of trace substances in aquatic environments. The facility is specifically designed to assist the aquaculture, commercial and sport-commercial fishing and chemical industries by providing a safe and efficient facility in which to conduct studies without danger to researchers or releases to the ambient environment. The containment laboratories also minimize contamination from normal urban and agricultural environments so that controlled studies can be conducted. In addition to the culturing and rearing capabilities and exposure capabilities, the facility contains the following specialized areas: storage areas rearing and exposure tanks and coolers, food, chemicals, solvents and drugs. There are also freezers and walk-in chambers to permit experiments to be run in a constant temperature controlled environment.

The ETL laboratories were designed to allow researchers to conduct all of the steps in a study from rearing organisms, preparing chemicals, diet preparation, exposure, sample collection and both biochemical and instrumental residue analyses of compounds and their metabolites in a single completely contained and regulated facility. The specific types of studies that can be conducted include setting water quality standards for the protection of aquatic life and determining the kinetics of accumulation of trace contaminants from water, food and sediments by aquatic biota. This information can then be used to assist regulators in setting safe environmental concentrations of these compounds or determining the degree of remediation required at contaminated sites. The flexible facility can also be used to determine the accumulation, metabolism, and safety of veterinary pharmaceuticals used in fish culture and of industrial chemicals. In addition to the applied aspects, the facility can also be used to study the basic mechanisms of effects of contaminants such as mutagens and carcinogens, in animal models.

More information can be found at our ETL web-site: http://www.usask.ca/toxicology/jgiesy

2.1 Occupational and Environmental Safety

The ETL was designed so that all aspects of research into toxic substances can be conducted under one roof without the need to transport toxic or radio-active materials from one building to another. The building has special treatment facilities for water entering and leaving the building to guard against releases, to maintain the integrity of experiments and to protect the health and safety of its workers.

2.2 Work Area and Laboratory Facilities

The facility in the ETL is designed so that all phases of studies can be conducted under one roof, without the need to transport samples among buildings. These specialty areas include the Aquatics lab (Fig. 1), Chemistry lab (Fig. 2), and Biochemistry and Molecular Biology lab (Fig. 3), respectively.

	Room	***Ext.***
• Aquatics lab (ATRF Culture room)	55	4169
• Aquatics lab (ATRF Exposure room)	57	4942
• Chemistry lab (Wet & Instrumental lab)	158-159	4935
• Biochemistry and Molecular Biology lab	261	4940

2.2.1 Aquatic Toxicology Research Facility (ATRF)

The 4,600 sq-ft rearing laboratory is divided by moveable plastic curtains so that research areas can be configured in a variety of ways to accommodate and separate various experiments. The area can be set up as one large area or divided into several separate research areas. Lighting in each region of the laboratory is controlled by individual timers so that the duration of lighting can be regulated in each area separately. The culture room is equipped with a range of containers for rearing aquatic organisms including aquariums, large round and rectangular fiberglass tanks speciality rearing systems for small tropical fish. The facilities are designed and equipped to allow both static- and continuous flow through exposures with organisms ranging from phytoplankton, and zooplankton to benthic invertebrates, including insects and clams, fish and amphibians. Adult salmon as large as 10 kg can be accommodated.

The exposure area is similar in most respects to the culture area. The exposure rooms are equipped with HEPA filters in the influent and effluent air to maintain clean air in the laboratory while minimizing the chance that any toxicants would escape the containment room. In addition, the biochemistry/microbiology and chemistry labs contain laminar flow hoods and fume hoods so that studies can be conducted with toxic chemicals, radioisotopes and genetically engineered organisms.

Influent water treatment: The source of water for the facility is Saskatoon city water with a maximum potential flow rate of 100,000 L per day. The incoming city water is treated with activated carbon and biological filtration before it is stored in 2 50,000 L cement storage tanks. The treated fresh water (FW) then passes through ultraviolet light banks to kill any possible pathogens, including spores. Portions of the water can be diverted to a reverse osmosis (RO) system to decrease hardness and to a chiller/heater system to provide temperatures ranging from 4 to 45°C. Each tank or research area is plumbed with three water lines that deliver normal water, heated/cooled water and RO water. In addition to these three types of water, there are several additional larger capacity lines carrying treated freshwater. The water can be mixed at the tank to make any combination of hardness from 0 to 235 mg $CaCO_3$/L and temperature from 6 to 45 °C. The rearing and containment rooms each contain a 108 sq-ft controlled temperature room that researchers can use to maintain temperatures from 4 to 30 °C within 0.2 °C.

Effluent water treatment: The effluent water can be sent directly to the sanitary sewer if it does not require any special treatment. Inorganic and organic contaminants can be removed from water before it is released to the sewer. The treatment system is a series of closed cartridge filters that can be filled with different materials, depending on what contaminant needs to be removed from the system. These are closed systems so that workers are never exposed to the contaminants. In addition to the sanitary line, there are two separate lines to receive effluent water so that two different types of treatment can be used simultaneously. All of the effluents are removed from the tanks by gravity flow through piping enclosed in trenches in the floor. Before treatment effluent water is stored in two 50,000 L storage tanks.

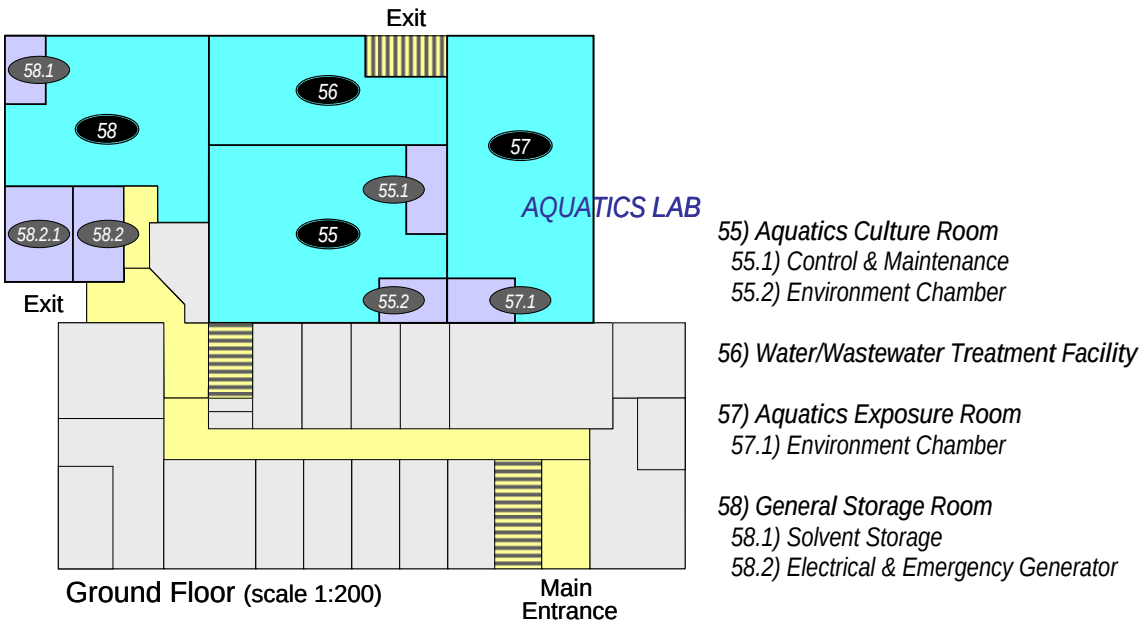

Fig. 1. Map of Aquatics Lab in ETL, Toxicology Centre, U of S

2.2.2 Chemistry Facilities

The chemistry lab at the ETL is designed to handle all aspects of sample processing from extraction to cleanup. The lab has a glassware washing station with nano-pure water, 4 chemical hoods, 6 lab benches, and a gas cylinder rack for safe and convenient storage of gas cylinders. The lab is set up so that everything from glassware washing to sample cleanup can take place in one room to maximize efficiency and minimize possible contamination to other parts of the facility.

The analytical lab is connected to the wet chemistry lab to maximize efficiency and communication between all aspects of the research. The analytical lab contains instruments including a Agilent 5975 GS-MSD including G1942N 6890 GC and 5973N MSD, an Applied Biosystems/SCIEX API 3000 Triple Quadrupole Mass Spectrometer, a Micromass Q-Tof II/Ultima (housed at Environment Canada), 2 Agilent 5975 GC/MSD systems, 2 Micromass Platform II LC/MS systems, a Mitsubishi AQF-100 for combustion ion chromatography, and two Dionex DX-500 Ion Chromatography system. There is a also a separate room which houses a Micromass AutoSpec-S High Resolution Mass spectrometer used for the analysis of dioxins and similar semi-volatile organic contaminants.

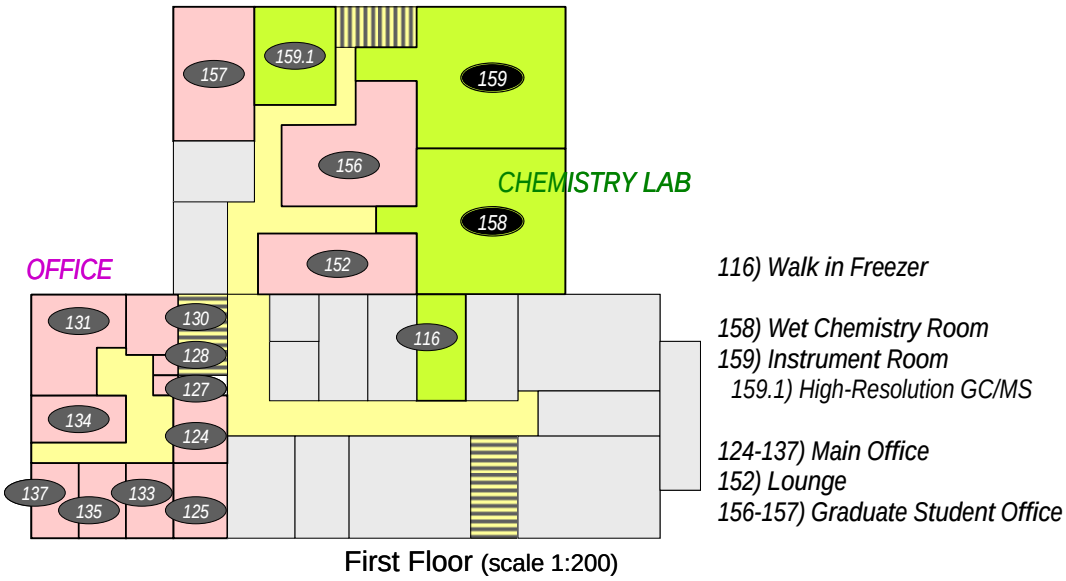

Fig. 2. Map of Chemistry Lab in ETL, Toxicology Centre, U of S

2.2.3 Biochemistry and Molecular Facilities

This facility is capable of doing just about any type of biochemistry and molecular work used on the toxicology field. New equipment includes Polarstar Optima which can read fluorescence intensity, fluorescence polarization, time resolved fluorescence, luminescence and absorbance. The 7300 Real time PCR system, which runs 96 well plates, for the analysis of gene expression. Also, a new micro injector, Injectman NI 2, that can micro inject small specimens including fish eggs, cells, and bird eggs. These facilities have the equipment (centrifuges, water baths, incubators, etc.) and capacity to run anything from gel electrophoresis and western blotting to ELISA's and enzyme activity (EROD, MROD and Aromatase). Three rooms adjacent to this facility are a dish washing room with an autoclave and nanopure system for washing and sterilizing dishware. ETL also includes a chemical storage room for all the chemicals used in the facilities and a separate room for micro and analytical balances. Within the biochemical and molecular rooms are a -80 degree freezer, liquid nitrogen dewars and many -20 and 4 degree freezers and fridges for preserving all samples and reagents. Worker safety is a big concern and will be the number one priority for these labs. There are eye wash and emergency shower stations throughout the facilities for anyone accidentally exposed to any toxic chemicals, All experiments using volatile compounds or solvents are carried out in fume hoods.

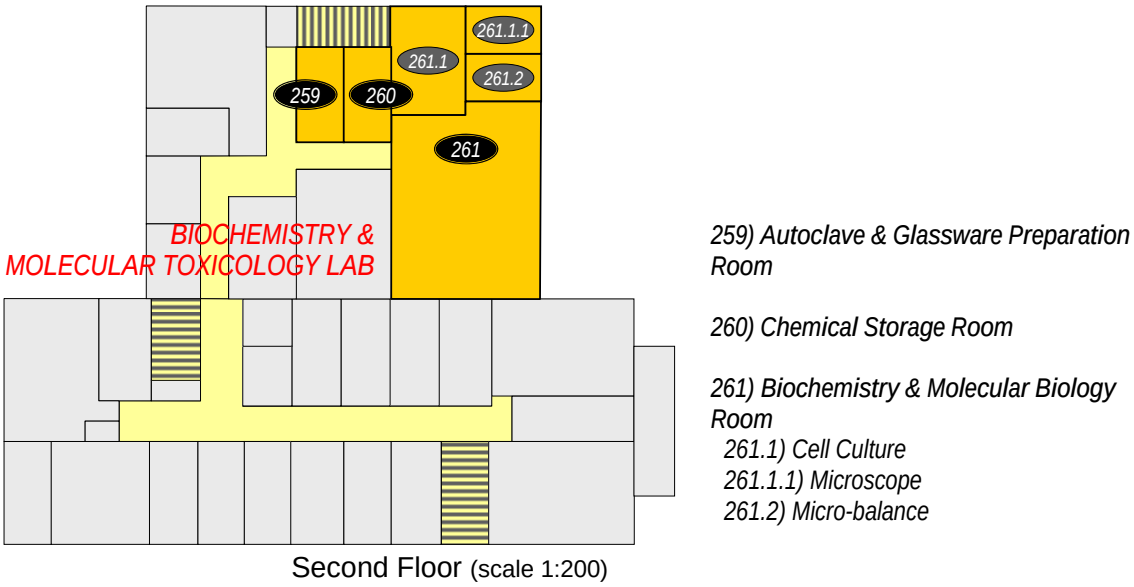

Fig. 3. Map of Biochemistry and Molecular Toxicology Lab in ETL, Toxicology Centre, U of S

Cell Culture Facilities: The cell culture facility in the biochemistry lab contains two large Microzone biosafety cabinets used in the safe cell culturing of many environmentally relevant cell lines (H295R, MVLN, H4IIE, MDA). The lab has two water jacketed CO_2 incubators and 2 other Hotpack incubators for more than one cell line can be in culture at any one time. The cell culture facilities are attached to the biochemistry main room for easy analysis of all the cell samples. Also attached to the cell culture lab is a microscope room equipped with an Olympus fluorescence microscope and many other monocular and stereo light microscopes.

2.3 Support Facilities

- Autoclave and dishwasher room
- Equipment and tank storage
- Field equipment storage and staging area
- Food storage
- Drug storage
- Chemical storage (special explosion proof room)
- Chemical storage
- Controlled Environment Chambers (4-30 ^{o}C)
- Walk-in freezer (-20 ^{o}C)
- Lunch and Conference Room
- Auxiliary power generator to supply 65% of peak power for critical areas

3 EMERGENCY RESPONSE PLAN (ERP)

3.1 Fire Evacuation Procedures

The fire alarm is tested for periods of less than ten seconds on the first Monday of each month in the Toxicology Centre.

On any occasion, the sounding of the alarm for more than ten seconds means immediate evacuation of the building is mandatory.

The following procedures must be followed in case of emergency evacuation of the ETL and/or Toxicology Centre.

• **When the Fire Alarm Sounds:**

Step 1: Everyone in the building must immediately evacuate the building in as orderly a fashion as possible using the pre-determined exit route**.**

Step 2: Each floor will have wardens and door guards who will direct the evacuation as quickly as possible in a safe and controlled manner.

a) Duties of the fire wardens and door guards are listed in Appendix I.

b) Exit routes, fire wardens and door guards are shown in Appendix II.

Step 3: Every instructor is responsible for his or her own classroom. Students must exit the building from the predetermined exit route. (An overhead of the predetermined exit route should be prepared by the instructor and available in all classrooms.)

Step 4: If a disabled person cannot easily be guided out of the building, 1 or 2 people (preferably 2) should be assigned to stay with them in a safe place until the Fire Department arrives to evacuate them. Someone must be sent to notify the Chief Fire Warden or the Fire Department of the situation and location. They should never be left to wait alone. If it developed that the situation could not wait, or if the person refuses to wait, the monitor (s) would assist her/him to evacuate the building (carry if necessary).

Step 5: The elevator must not be used during the evacuation of the building.

Step 6: In the event that one of the exit routes cannot be used due to the emergency, fire wardens will direct evacuees to the nearest clear exit route, and filter them into the stream of evacuees allotted those exit routes.

Step 7: All building personnel and visitors will follow the instructions of the fire wardens when asked to evacuate the building.

Step 8: No one shall re-enter the building following a fire or fire drill until permission has been given by the Fire Department in attendance, the Chief Fire Warden, the Assistant Chief Fire Warden or a representative from the campus DHSE.

• **After hours**

The senior person (supervisor) working after hours is responsible for all evacuation procedures.

Contact DSS (5555) for assistance if building alarm has not been activated.

APPENDIX I

NOTE: ALL WARDENS MUST MAKE THEMSELVES AWARE OF THEIR DUTIES

Duties of Chief Fire Warden:

- Will go immediately to the annunciator panel to determine the location of the emergency.
- Will go to the area, assess the situation, assist in first aid if required and notify fire fighter of special hazards in the area.
- After the emergency is over will notify wardens and door guards that it is safe to re-enter the building. The campus DHSE representative will arrive and will have a radio to assist in re-entry by calling Security and announcing an all clear when given that information by the Fire Department.

Duties of Deputy Fire Warden:

- Will go immediately to the annunciator panel to determine the location of the emergency.
- Will remain at the Service Area Door, meet with firefighters and direct them to the location of the emergency.
- Will act as Chief Fire Warden in his/her absence.

Duties of Floor Wardens:

- To see the complete and immediate withdrawal of everyone from his or her area through a pre-determined route to the nearest exit.
- If the emergency has occurred in the Warden's area, then he/she should assess the situation and take appropriate action to ensure everyone's safety. They should notify the Chief Warden (or firefighter) of any special hazards in the immediate area of the emergency or about anyone who did not or could not leave the area.

Duties of Door Guards:

- Will go directly to the exit door to be guarded.
- Insist that everyone move a safe distance away from the exit door so that others can get out.
- Guard exit door to prevent premature re-entry during an emergency.
- Ensure that everyone stay a safe distance away from the building during the emergency.
- Notify everyone that they may re-enter the building when permission has been given by the Fire Department, the Chief Fire Warden or the Deputy Fire Warden or Security.
- Inform people evacuating to the assigned exit.

APPENDIX II

Chief Fire Warden: (1)	Adriana Brown
Deputy Fire Warden: (1)	Mark Wickstrom
Ground Floor Wardens: (3)	Fiona Price = south front door Michael Pollock = west door (side)
1st Floor Wardens: (2)	Shanda Sedgwick = south door (front) Paul Jones = west door (side)
2nd Floor Wardens: (2)	Brian Saraurer = south door (front) Steve Wiseman = west door (side)
Front Entrance Door Guard:	Adriana Brown = south door (front)
Back Entrance Door Guard:	Michael Pollock = west door (side)

3.2 Chemical Spills

- Chemical spill procedures are dependent on the type chemicals involved.
- Ensure that the procedures are specific for the type of chemicals.

The following procedures must be followed in case of chemical spills in the ETL.

• **Minor Spill**

Step 1: ***Assessment***
Are you capable of dealing with this on your own based on training, equipment and circumstances?

Step 2: ***Containment***
Alert all people in the area that there has been a spill. Keep the material from contaminating a other areas.

Step 3: ***Cleaning***
Gather the spilled material and absorbent and place it in an appropriate container.

Step 4: ***Decontamination***
Complete the final cleanup of the area and yourself.

Step 5: ***Reporting***
Report the incident to your supervisor and fill out an Incident Report Form.

• **Major Spill (larger than you or your colleagues can handle)**

Step 1: Cordon off area with caution tape from the chemical spill kit and/or use appropriate signage.
Step 2: Alert everyone in the area that there has been a chemical spill.
Step 3: Call the Waste Management Facility (WMF) @ 8497 (after hours 5555).
Step 4: Report spill to supervisor or lab manager.
Step 5: Fill out an Incident Report Form.

***Note: Chemical Use:** Chemicals purchased or brought to the laboratory will be covered under a specific chemical use SOP. All chemicals brought into the ETL will be logged into the chemical registry and a materials safety data sheet (MSD) procured. The MSD will be provided to ETL management and kept electronically on the ETL server. A hard copy of the MSD will be placed into the MSD binder that will be kept in the chemical storage area. Each chemical will be stored appropriately based on the MSD. Specifically, when not being used, all chemicals will be stored in the chemical storage room and the room will be locked at all times. Access to the room will be to only authorized ETL workers. When chemicals are used the use and amount used will be logged into the chemical use log which is kept in the chemical storage room.

3.3 Biological Spills

- Biological spill procedures are dependent on the type biological agent involved.
- Ensure that the procedures are specific for the type of agent.

The following procedures must be followed in case of biological spills in the ETL.

• **Minor Spill**

Step 1: Wear protective and appropriate PPEs, i.e. lab coats, gloves, and masks etc.
Step 2: Allow aerosols to settle.
Step 3: Alert everyone in the area that there has been a biological spill.
Step 4: Gently cover spill with paper towels.
Step 5: Apply the appropriate disinfectant to the paper towels starting at perimeter and working saturation towards centre of spill.
Step 6: Allow contact time appropriately before cleaning up.
Step 7: Seal waste in appropriate Biohazard autoclave bag or container.
Step 8: Decontaminate area appropriately.
Step 9: Report spill to supervisor or lab manager.
Step 10: Fill out an Incident Report Form.

• **Major Spill (Larger than you or your colleagues can handle)**

Step 1: Cordon off area with caution tape out from a chemical spill kit and/or use appropriate signage.
Step 2: Alert everyone in the area that there has been a biological spill.
Step 3: Call the Biosafety Office @ 8496 and WMF @ 8497 (after hours 5555).
Step 4: Report spill to supervisor or lab manager.
Step 5: Fill out an Incident Report Form.

3.4 Radiation Spills

- All clean ups should be carried out according to a prearranged plan.
- Only persons properly trained shall clean a radiation spill.
- Detailed steps can be found in the Radiation Safety training manual.

The following procedures must be followed in case of biological spills in the ETL.

• **Minor Spill**

Step 1: ***Assess the situation***
Take your time to assess the situation for any potential hazards and then determine your plan of action. The protection of personnel and the containment of the nuclear substance should be given primary consideration.

Step 2: ***Alert everyone in the area***
Ensure that everyone in the vicinity of the accident has been alerted. Be sure to make an effective warning, especially in large laboratories or areas.

Step 3: ***Confine the spill***
Restrict access to the area. Confine the problem (contain the nuclear substance) to minimize the exposure to personnel or release to the environment.

Step 4: ***Clear the area***
Evacuate all persons from the immediate vicinity of the contaminated area. Ensure a sufficient separation such that persons near the spill cannot become exposed to the hazard.

Step 5: ***Summon aid***
In any emergency situation, it is vital to notify the appropriate personnel (Security, Ambulance, and/or Fire Department). Do not delay medical attention for seriously injured people due to concerns relating to radiation contamination.

Step 6: ***Cleaning***
Wear a lab coat and two pair of gloves; outline the location of the spill and probable extent of the contamination. Collect the spilled substance by blotting the area.

Step 7: ***Decontamination***
Apply appropriate cleansing agent to contaminated area. Working from the outside of the spill area towards the centre wipe the spilled area. Repeat 3-4 times. Dispose of all cleaning material into an appropriate container.

Step 8: ***Monitoring***
Monitor for contamination. Ensure no access to area while results are pending.

Step 9: ***Reporting***
Report the incident to your Permit Holder and the Radiation Safety Manager. Fill out an Incident Report form.

• **<u>Major Spill</u> (Activity spilled is greater than 100 uCi)**

Step 1: Cordon off and clear the area.
Step 2: Alert everyone in the area.
Step 3: Confine the spill, if required.
Step 4: Call the Radiation Safety Manager @ 8494 (after hours 5555).
Step 5: Fill out an Incident Report form.

3.5 Waste Disposal

During the normal course of conducting studies, waste will be generated. This will include normal paper waste, chemical wastes and biological wastes and radiological wastes. It is important that wastes be stored, labeled, transported, and disposed of properly. Detailed instructions for all of these are given in the U of S DHSE manual on waste management. A copy of this manual is attached to this safety manual. Please consult this manual for specifics for handling wastes safely and legally.

3.6 Medical Emergencies

The following procedures must be followed in case of medial emergencies in the ETL.

Step 1: **Dial 9-911** for all medical emergencies. Be prepared to provide the nature of the emergency, exact location (including building, room number and closest entrance), your name and the phone number at which you can be reached. Follow the 911 operator's instructions.
Step 2: Dial 5555 for Security Services.
Step 3: When responding directly to a first aid emergency, first ensure that there is no further danger to yourself or the victim before commencing first aid techniques.
Step 4: Provide first aid for any life-threatening conditions. **DO NOT** transport victim yourself.
Step 5: Fill out an Incident Report Form.

3.7 Incident reporting

It is important that incidents be reported immediately to your supervisor and ETL management. There are several reasons for this. The first and most important reason is so that the laboratory management is aware of the situation, and so that it can be managed properly in a timely and efficient manner. Second, because it is important to identify these situations so that corrective actions can be put into place to avoid the situation in the future. It is thus, important to report situations that you feel are impending issues and those that were "near misses". Even in these cases where injury was avoided, it is important to report the situation immediately.

Safety is everyone's responsibility. We are responsible for the safety, health, well being and security of ourselves as well as those around us. So if you see an unsafe act, bring it to the attention of the offending person immediately and also report it to the ETL management. We are all busy so it is important to make a written record of the situation and then follow up so that everyone knows about it and it can be avoided in the future. Be proactive. If you see an unsafe situation, and you are properly trained to do so, remedy it immediate. This includes things so minor as a wet spot on the floor or a paper clip on which someone could slip. There is a formal U of S process for incident reporting. Please see the detailed information below and in the attached appendices for the policies and the necessary forms to be filed.

4 EMERGENCY CONTACT

Please contact person immediately and appropriately among listed for the safety issue(s) and/or emergency in the ETL

4.1 ETL-Emergency Contact

	Home	***Cell***	***Office (Ext.)***
Prof. John Giesy	955-3819	517-614-6123	2096
Prof. Paul Jones	242-8957	517-281-5666	5062
Dr. Jong Seong Khim	955-0405	306-281-6204	5206

4.2 University-Emergency Contact

	Extension
SECURITY SERVICES (24 hours)	5555
Ambulance (if using a pay phone)	9 911 911
Fire (Pull an alarm and call) (if using a pay phone)	9 911 911
Safety Related Incidents (Mon – Fri: 8:30 to 4:30)	8493
Spills (Mon – Fri: 8:30 to 4:30)	8497

4.3 DHSE-General Contact

	Ext. (Fax)
General Inquiries	8493 (8394)
Hazardous Waste Disposal	8497 (6146)
Safety Training Inquiries	8492
Biosafety	8496
Biosafety Cabinet Testing Inquiries	8510
Chemical/Environmental Safety	8512
Safety Inspections Inquiries	8738
Environmental Program Inquiries	2379
Community Safety	1957
Fire Safety	8838
Contractor Safety Inquiries	6076
Occupational Hygiene / Injury Prevention	8511
Radiation Safety	8494
Radiological Inquiries	8491
Health, Safety and Environment Management System Coordinator	2370
Director	8463

REFERENCES

1. *LabSafety Manual, DHSE, University of Saskatchewan, February 2006*

2. *BioSafety Manual, DHSE, University of Saskatchewan, January 2005*

3. *Radiation Safety Manual, DHSE, University of Saskatchewan, June 2004*

4. *Hazardous Waste Disposal Manual, DHSE, University of Saskatchewan, Aug 2007*

5. *DHSE, University of Saskatchewan: http://www.usask.ca/dhse/*

APPENDICIES

- Laboratory Worker Safety Agreement, ETL, University of Saskatchewan, Sep 2007

- University Safety Manual, DHSE, University of Saskatchewan, 2004-2006
  - *LabSafety, Feb 2006*
  - *BioSafety, Jan 2005*
  - *Radiation Safety, Jun 2004*
  - *Hazardous Waste Disposal, Aug 2007*

ENVIRONMENTAL TOXICOLOGY LABORATORY
TOXICOLOGY CENTRE
UNIVERSITY OF SASKATCHEWAN
LABORATORY WORKER SAFETY AGREEMENT

Work conducted in the laboratory and field can be hazardous, but if all of the safety protocols are followed a person can minimize the potential for injury to themselves and others. None of the work that is conducted by the Environmental Toxicology Laboratory (ETL) is more important than the health and safety of our people. While the laboratory directors, Prof. Giesy and Prof. Paul Jones, have the ultimate responsibility for providing a safe and comfortable work environment, the daily overall supervision and assurance of safety in the laboratory and field is delegated to the laboratory manager and individual team leaders in charge of the individual studies. Safety is the responsibility of both the management and workers. We have put procedures in place to insure the safety of all workers. These procedures are outlined in the University of Saskatchewan (U of S) safety manuals for general, biological, chemical and radiation safety and waste management and sample transportation, shipping and receiving. In addition, specific safety instructions are contained in the ETL safety manual, or Toxicology Centre (TC) manuals or directives, which give specific safety procedures for individual laboratories and procedures. Also, more specific information on safety procedures can be obtained in the standard operating procedures (SOPs) provided for each procedure and in the Health and Safety Plan (HASP) for each project. All laboratory personnel, including principle investigators, technicians, post doctoral fellows, graduate students, undergraduate assistants and visiting scientists are required to have take all of the appropriate safety classes listed below and in the appropriate HASPs and SOPs for the laboratories in which they work or the projects on which they work.

The basic required safety training includes the following U of S courses:

1) Basic safety orientation for employees
2) Safety training for supervisors
   (for anyone who has supervisory responsibilities, this can include anyone in the laboratory)
3) Basic Laboratory safety
3) Biological Safety
4) Chemical Safety
5) Radiation Safety
   (required even if you will not be using isotopes because others in the laboratory do use these materials and workers need to be aware of the issues and safety precautions)

Optional training includes:
1) Waste management
2) Transportation and shipping of hazardous materials
3) Fire safety

In addition to these courses offered by the U of S there is additional safety information provided in the Laboratory Safety plan and any and all HASPs and SOPs appropriate to your particular studies. It is required that all workers obtain and read all appropriate safety materials. In addition to reading the written materials, each worker will receive personal instruction before asked to undertake any task. If the worker does not understand the instruction, or has concerns about the safety of any procedure, it is the joint responsibility of the supervisor and the employee to assure that the procedures and appropriate safety procedures are understood.

Safety is the responsibility of all members of the ETL team. Regulations and guidelines, however well conceived or communicated are not sufficient to assure a completely safe working environment. It is the skill, knowledge, vigilance, diligence, communication and basic common sense of the individual workers that are essential to maintaining a safe working environment. Do not undertake any operations that you have not been trained for or if you are uncertain of how to conduct the operation. When in doubt ask. Furthermore, if you observe any of your colleagues conducting an unsafe operation bring it to their attention immediately. If you see an unsafe situation in the laboratory, correct it immediately and inform appropriate supervisory personnel.

If you can not do so bring the situation to the attention of laboratory management immediately. No issue is too small to bring to the attention of others. If information on safety is lacking in HASPs or SOPs, bring it to the attention of the laboratory management so that the necessary safety information can be added to the appropriate documents.

The laboratory management will do its part to assure the safety of the working condition of the laboratory and field campaigns. It is the responsibility of the workers to:

1) Attend safety training courses and to read all appropriate safety materials issued to him/her (such as instrument manuals, hazard alerts etc.).
2) If new hazards come to his/her attention, these should be corrected immediately and the issue and corrective action taken communicated immediately to the principal investigator (Prof. Giesy or Prof. Jones) and or the unity Safety Officer (Dr. Khim).
3) Be aware of all of the policies, regulations and practices of the Federal Government, Provincial government, U of S and the ETL.
4) Comply fully with all of the established safety regulations and practices and to consult the principle investigator or designated representative for advice in circumstances where safe practices or the appropriate measures are in doubt.
5) Limit laboratory and field work to projects authorized by the principal investigator.
6) Advise coworkers if unsafe activities are observed and to report such instances to the principal investigator so that corrective actions can be put into place.
7) Advise visitors to the existing hazards and when necessary (when others are using equipment in the laboratory or field) to inform them of the ETL, U of S and any other pertinent regulations or safety procedures. Assure that others making use of equipment have the necessary safety training.
8) Be sure that all required monitoring is conducted and reports generated.
9) Assure that laboratories are secured by locking and monitoring who comes and goes so that unauthorized persons are not allowed access.

I have read and understand the above responsibilities and agree to observe them for all of my laboratory and field work with the ETL. I recognize that I may be conducting procedures or using materials that may be hazardous and will make every effort to conduct these operations such that I maintain my personal safety and those around me. I consent to work with these potentially hazardous procedures and materials. If I am not confident in my training or understanding of the regulations and or safety precautions, I will inform my supervisor of any deficiencies I perceive in my training.

Signing of this Worker Safety Agreement is not a waiver of individual rights or redress in case of injury.

_____ _____
Signature Worker Date

_____
Printed Name

Permission is herby granted to _____ to participate in studies of the ETL under our supervision. We have discussed the identified hazards of the proposed work with the above-signed worker and he/she has been given copies of all of the relevant unit safety regulations and procedures.

_____ _____
John P. Giesy, PI Date

_____ _____
Paul D. Jones, co-PI Date

DHSE
DEPARTMENT OF HEALTH
SAFETY & ENVIRONMENT

LabSafety Manual

University of Saskatchewan

February 2006

Emergency Numbers

SECURITY SERVICES (24 hours) **5555**

Ambulance **9 911**
(if using a pay phone) **911**

Fire (Pull an alarm and call) **9 911**
(if using a pay phone) **911**

Safety Related Incidents (Mon – Fri: 8:30 to 4:30) **8493**

Spills (Mon – Fri: 8:30 to 4:30) **8497**

Department of Health, Safety and Environment

General Inquiries **8493**
Fax **8394**

Hazardous Waste Disposal **8497**
Fax **6146**

Safety Training Inquiries **8492**

Biosafety **8496**
Biosafety Cabinet Testing Inquiries **8510**

Chemical/Environmental Safety **8512**
Safety Inspections Inquiries **8738**
Environmental Program Inquiries **2379**

Community Safety **1957**

Fire Safety **8838**
Contractor Safety Inquiries **6076**

Occupational Hygiene / Injury Prevention **8511**

Radiation Safety **8494**
Radiological Inquiries **8491**

Health, Safety and Environment Management System Coordinator **2370**

Director **8463**

Other Essential Services

Bloodborne Pathogen Exposures (Sharps Puncture)
Department of Immunology and Infectious Disease **655-1777**
Public Health Consultation **655-4620**

Employee Assistance Program **4300**

Facilities Management Work Control (Mon – Fri: 8:00 to 4:30) **4496**

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Disclaimer

The information included in this manual has come from a variety of reliable sources and is believed to be accurate. It is intended for the use of persons at the University of Saskatchewan and those who have taken the LabSafety Course. While every effort has been made to ensure its accuracy, there is no guarantee that it is free of errors and omissions. If, through your use or review of this document, you discover errors or omissions, please report them to us at 966-8493 or hse.dept@usask.ca

1. Introduction

Significant legislation exists that governs activities in work places across Canada. Through the Saskatchewan Occupational Health & Safety Act and applicable regulations and standards, every employer has both a moral and legal responsibility to ensure that all the necessary information, instruction, training and supervision are provided to protect the health and safety of employees, students and the campus public. It is the duty of workers to conduct themselves in a safe and responsible manner by incorporating safety as an integral part of their training and laboratory work. Information is provided here on health and safety policies, procedures and guidelines to be used by University employees and students so that risks will be reduced to **a**s **l**ow **a**s is **r**easonably **a**chievable (**ALARA**) and that accidents can be avoided.

Regulations regarding the storage, use and disposal of hazardous materials are not so prevalent. The Saskatchewan Occupational Health and Safety Regulations (encompassing WHMIS) and the National Fire Code are the two significant pieces of legislation that specify the rules for us to follow with respect to laboratory work with hazardous materials. In this sparse legislative environment, the University has developed and implemented its own policies, procedures and guidelines with respect to hazardous materials management. Thus, the requirements presented in this manual have been adapted from many sources in an effort to achieve a safe environment for all, while allowing each person as much freedom as possible to conduct their work. A combination of published best practices, University history, and experiences of the members of DHSE and research and teaching persons on campus have gone into the development of this manual.

Through the **Health, Safety and Environment Protection Policy**, DHSE is empowered and directed to work to establish exemplary and proactive risk reduction practices. These are the objectives of this manual and the LabSafety training course which it accompanies.

It is not the intent of this manual, nor the Department of Health, Safety and Environment (DHSE), to in any way impede any work activities at this University, but rather to remain sensitive to the needs of all of the members of the University community and to assist individuals in meeting health, safety and environmental compliance to set standards wherever applicable.

2. Objectives

The objectives of this manual and the accompanying training are to:

1) Provide a guideline for setting safety procedures in all laboratories.
2) Promote compliance with the Saskatchewan Occupational Health & Safety Act and Regulations and other applicable Provincial and Federal legislation.
3) Identify the responsibility of persons who acquire, use or store potentially hazardous substances and assist them to meet compliance and implement good laboratory safety practices.
4) Promote the University's safety policies, codes and safety procedures, as well as those associated with the research granting agency's safety conditions for working with hazardous substances.
5) Assist the campus community in the area of health, safety and environmental issues that involve hazardous substance use, transport, storage, release or disposal.
6) Ensure that all workers and students know the safety and compliance requirements of the legislation and are aware of their rights under Canadian and Saskatchewan Health & Safety legislation.

7) Ensure that all workers and students have access to hazard information on the substances they use, transport, store or dispose of.

8) Ensure that all workers and students have the proper engineered and procedural safety controls and personal protective equipment (PPE) in place in order to work safely with their hazardous substances and to also ensure that they know how to use and maintain them.

9) Ensure that all substances used, transported or stored are known and are WHMIS labeled.

10) Ensure that all areas are inspected for safety and compliance on a routine basis.

11) Ensure that **ALL** accidents and incidents are investigated and recorded with DHSE (See Appendix).

3. General Duties and Responsibilities

3.1. President's Safety Committee

The President, through the Vice President of Research, appoints committee members to serve on the President's Chemical, Biosafety or Radiation Safety Advisory Committees. The membership is made up of researchers and technical support employees from campus that are knowledgeable in health, safety and environmental aspects and can assist in setting or reviewing campus safety policies and procedures.

Their Duties and Responsibilities are to:

1) Advise the President of the University of Saskatchewan, through the Vice-President of Research, on compliance with health, safety and environmental regulations that are related to the safe acquisition, use, storage, handling, and disposal of hazardous substances on the campus.

2) Act as a liaison between researchers or units utilizing hazardous substances and the applicable DHSE Managers if and when there is a difference of opinion on matters related to health, safety and environmental compliance, safety policy, and/or hazardous substance use.

3) Review proposals and make recommendations on safety policies and procedures developed by DHSE.

4) Provide technical advice and review the operations of the applicable DHSE program.

5) Review and approve Operating Permits for research activities involving the use of hazardous materials, agents in Risk Group Level 2 and greater, Notifiable Substances, genetically modified microorganisms (GMMOs) and nuclear substances.

3.2. DHSE Managers

DHSE Managers have the rights and responsibilities to conduct the following activities:

1) Facilitate the implementation of the policies and procedures represented by University Codes and Statutes.

2) Conduct and promote safety training courses.

3) Investigate and assist in the prevention of accidents, incidents, spills, and exposures which involve hazardous substances.

4) Assist in the resolution of any employee's unresolved health and safety concerns by reporting them to the Statutory Occupational Health Committee.

5) Ensure that regular safety and compliance inspections are carried out in all areas using or storing hazardous substances. Consult with individuals who work with hazardous substances on health, safety and environmental or compliance related issues.

6) Act in an advisory capacity to supervisors to assist them in developing their written procedures related to; use and maintenance of PPE, immunization, substance storage, waste disposal, safety policies, Standard Operating Procedures (SOPs) and others.

7) Ensure that areas which have been issued Permits or have been registered by the Supervisor or Principal Investigator as High Risk Areas comply with all health, safety and environmental regulations and granting agency's requirements.

8) Suspend any operation that is considered to be unsafe until corrective action is taken. The applicable President's Safety Committee may be asked to review the matter if necessary. The ***Non-Compliance Enforcement Policy*** can be initiated when life safety issues have not been addressed in a timely manner.

9) Submit reports to the chair of the applicable President's Safety Committee.

3.3. Statutory Occupational Health Committee

Provides a mechanism for employees to address unresolved health and safety concerns if they have not been resolved by i) the Supervisor, ii) the Department Head, or iii) DHSE.

1) Cooperates with DHSE to ensure that workers' unresolved health and safety concerns are addressed.

2) Promotes and reviews health and safety training courses given by DHSE.

3) Maintains and posts the minutes of their meetings and sends a copy to the Department of Labour and DHSE.

4) Investigates any work refusals and maintains the applicable health and safety records.

5) Conducts or directs workplace inspections.

6) Reviews unsafe conditions, accidents, incidents and spills.

3.4. Supervisors and Principal Investigators

The Principal Investigator or Supervisor (Professors, Scientists, and Laboratory Supervisors) must ensure that their work areas are in safety compliance with both Federal and Provincial health, safety and environmental regulations and also with any requirements of their respective granting agencies, where applicable. DHSE will inspect areas on campus to assist in identification of any deficiencies so that they may be rectified.

The Supervisor must ensure that their workers are aware of their rights under the SOHS Act and Regulations by ensuring the worker(s):

1) have received safety orientation courses offered by DHSE and site specific safety training for the jobs assigned along with written Standard Operating Procedures (SOP's) where applicable.

2) are competently supervised and have reviewed their Department's safety policies and procedures.

3) are informed of the potential risks associated with their work and have access to any hazard information on the substances used, transported, stored or disposed of (Right to know & WHMIS).

4) are provided with the appropriate safety equipment, engineering safety controls, and PPE necessary to protect their health and safety and that the worker knows how to use and maintain this equipment.

5) are provided with the proper supervision, guidance and written SOPs which will help prevent hazardous exposures to them or to any people peripheral to the work area.

6) register with or obtain required Permits from DHSE for any activities that use high risk substances, Biohazardous Materials, Notifiable Substances or Nuclear Substances.

Note: Basic Safety and Orientation Courses are provided by the DHSE, while site or task specific training is provided by the Supervisor or Principal Investigator of the projects or their qualified designate. Records must be kept of this training. DHSE will keep the worker's basic orientation and safety training records.

3.5. Waste Generators and Waste Contact Person

Waste Generators are any persons who generate hazardous waste as a result of work conducted. For example, a supervisor, a faculty member, a student, a technician, a research fellow, a postdoctoral fellow, etc. may be waste generators. Each is responsible for:

1) ensuring that waste is properly segregated, identified, and labeled for disposal,

2) conducting experiment in a safe manner,

3) ensuring that processes that generate unusual or novel waste have been identified and that a waste disposal plan has been developed and approved by DHSE prior to work starting,

4) collecting the waste in accordance with the University's waste procedures, and

5) keeping an inventory of the waste deposited into each waste container.

A Waste Contact Person is a person designated by his/her supervisor. The names, department(s), and phone number(s) of the supervisor and the contact person should be registered with the Waste Management Facility (WMF).

A Waste Contact Person is responsible for:

1) maintaining a liaison with the WMF staff,

2) ensuring that hazardous waste is securely packaged in appropriate containers,

3) ensuring that waste is packaged in compatible groups,

4) labeling the containers in accordance is the University's waste procedures, and

5) correctly completing the appropriated waste disposal authorization forms.

3.6. Students or Employees

Students and employees are required to:

1) Know their duties and responsibilities and conduct work in a safe and responsible manner so as to protect their health and safety as well as that of others that may be affected by their acts or lack of action.
2) Comply with the appropriate standards set forth by regulatory agencies and University policies, codes, terms and conditions.
3) Co-operate with their Supervisor or Principal Investigator and DHSE personnel in discharging their responsibilities as well as with any other person exercising a duty entrusted by a regulatory agency or agencies to promote safety.
4) Ensure they have received and understood the safety training, SOP and any other relevant safety information received from their Supervisor or Principal Investigator before commencing work that involves hazardous substances. This training must include the proper use and maintenance of safeguards, safety devices and PPE, so that they may carry out their work in a safe manner.
5) Notify their Supervisor or Principal Investigator when they become aware of any accident, incident, spill or unsafe act or condition.

4. Permits and Registration

The Supervisor or Principal Investigator of the laboratory or area should register every laboratory that uses or stores hazardous substances with DHSE. All laboratories should have the *Biological and Chemical Safety Poster* posted just inside the main door of the laboratory. In special cases when the hazards are high, the laboratory may have to have the doors into the lab appropriately labeled with warning signs.

The Supervisor/Principal Investigator of a project that uses Notifiable Substances must register these areas with DHSE. In turn, DHSE will notify the Occupational Health and Safety Branch of the Saskatchewan Department of Labour to receive any other requirements that are be specified.

4.1 Chemical Substances

Contact the Chemical Safety Manager for more information about or to notify of the intended use of a Notifiable Chemical Substances as defined in Table 19 of the OHS Regulations.

4.2 Biological Substances

Principal Investigators in research and teaching laboratories using or storing biological substances in Risk Groups Level 2 or higher, using Notifiable Biological Substances (GMMOs) or biological materials are required to obtain a Biosafety Operating Permit or Registration. Submit a completed Permit Application Form to the Biosafety Office. DHSE will contact you if more information is needed. If the function of the laboratory or work changes, the onus is on the Supervisor or Principal Investigator to inform DHSE of this change.

4.3 Radioactive Substances

Contact the Radiation Safety Manager in DHSE.

5. General Safety and Compliance Requirements

Each person has an obligation to follow these instructions.

1) Comply with the SOHS Act and Regulations.

2) Follow all University safety policies, codes and procedures.

3) Follow the Research Granting Agency's Condition and the SOHS Act and Regulations for working with Notifiable Chemical or Biological Substances.

4) Keep unauthorized persons out of the laboratory and keep the laboratory locked when unattended.

5) Use Good Laboratory Safety Practices to keep all individuals as safe as possible.

6) Do not eat, drink, store food or smoke in a laboratory. Take the time to keep your laboratory neat and tidy.

7) Do not pipette solutions by mouth.

8) Know how to maintain and use appropriate PPE to limit exposures.

9) Wear gloves where appropriate and a lab coat in the laboratory and remove them when leaving the laboratory area as defined by internal department policies.

10) Wash hands thoroughly before leaving any laboratory area.

11) Minimize your risk of exposures by reviewing the appropriate sections of the MSDS on hazardous substances before they are used, transported, or stored. Know the location of the MSDS and know how to interpret the safety information on it.

12) Periodically review and monitor your procedures for safety and improve procedures wherever possible.

13) Substitute less hazardous substances when possible.

14) Equipment or areas which may contain or have the potential to become contaminated with any High Risk Substances must be kept as clean as possible. These areas should be labeled to identify the hazards. The NFPA *Safety Diamond* or the *WHMIS labeling System* may be used to identify the primary health hazards.

15) Use a fume hood for any work with volatile chemical substances and a Biosafety Cabinet for infectious substance containment and product sterility. Ensure that these units are included in your quality assurance program by having them tested yearly. Wherever possible, any equipment or area that may contain a hazardous residue must be appropriately labeled with warning signs identifying the substance(s) of concern.

16) Wherever appropriate use disposable absorbent liners on trays or surfaces to contain splashes or any spills of hazardous substances and replace when activity is complete.

17) Laboratory equipment used for hazardous substances must not be transferred to lower level labs, sold to the public, or passed to service employees without decontamination / inactivation or neutralization. An "**Equipment & Area Release Form**" must be filled out and attached to any laboratory equipment which is to be serviced, sold or relocated (see Appendix).

18) Written Emergency Response Plans (ERP) should be developed for high possibility emergency situations (eg spill response, fire evacuation, power outage, etc). Employees must have received training, know the location of response materials, and know how to interpret the information on a MSDS so as to respond safely and effectively.

6. Non-Compliance Enforcement Policy

This policy sets forth the actions the University of Saskatchewan is prepared to take in order to enforce compliance with terms and conditions of various licenses issued to the University and with the applicable federal and provincial statutes pertaining to the use, handling, storage, and disposal of hazardous substances[1].

Non-Compliance

Step 1. On the first occurrence of non-compliance; the Department of Health, Safety and Environment (DHSE) will send a written notification to the Supervisor or Principal Investigator with copies to the Dean and Head of the Department outlining the nature of the infraction. Immediate response to and correction of the violation is required within the time frame specified on the notification.

Step 2. On a second occurrence of non-compliance within a twelve-month period or when there is no response to the first infraction within the specified time, DHSE will suspend privileges to obtain and use hazardous substances. The Supervisor or Principal Investigator may have this privilege restored upon written verification from the Dean indicating rectification of the infraction. A copy will be forward to the appropriate Department Head and respective President's Advisory Committee[2].

Step 3. On a third occurrence of non-compliance within a twelve-month period, the permit will be revoked and research activity suspended by DHSE. The Supervisor or Principal Investigator may appeal by requesting a meeting with the representatives of DHSE and the executive members of the appropriate President's Advisory Committee. Written notification of the above actions will be sent to the Dean and the Department Head.

Unacceptable Risk

DHSE shall take appropriate action when determined by the Safety Manager that there is an unacceptable risk to employees, the public, the environment, university property, security, and/or gross disregard to health and safety standards involving the handling of hazardous substances. Action may include the immediate suspension of research activity, prohibited entry to the laboratory, and/or removal of hazardous material from the premises.

[1] Hazardous substance means any substance regulated by the federal or provincial statutes, e.g. radioactive, chemical, and infectious substance, radiation producing equipment.

[2] Radiation Safety Advisory Committee, Biosafety Advisory Committee, Chemical Safety Advisory Committee and Environmental Safety Advisory Committee.

7. Substance Acquisition, Storage, Inventory, Transportation, Waste Disposal and Minimization

Also see Fire Safety Code, National Fire Code, Hazardous Waste Disposal Manual and the Transportation of Dangerous Goods Regulations.

7.1. Acquisition

1) All chemical and other hazardous materials purchases must be made through the University purchasing system. No P-Card purchases of hazardous materials are allowed.

2) Effective May 1, 2005 the purchasing system will require that chemicals be purchased through the use of one of a number of predetermined commodity codes. Some of these codes are associated with special groups of chemicals which we are required to gather statistics about. Statistics such as amount purchased or the mere presence of certain materials on campus must be reported to various branches of the government under international treaty obligations, such as the Chemical Weapons Convention and the Precursor Control Regulations. Purchasing information will only be reported as campus wide statistical data – it is not our intention to identify individual purchasers. The detailed lists of compounds will be kept current on the DHSE website. The website may be accessed at: http://www.usask.ca/dhse/chemicalsafety/index.html . Users are expected to keep themselves abreast of updates by periodically revisiting these data to ensure they are complying with the most recent lists. DHSE will endeavor to keep the University community apprised of changes in information.

7.2. Storage

1) Ensure that all containers of hazardous substances are WHMIS compliance labeled, dated, and are on the required inventory list.

2) Place WHMIS (can also use Transportation of Dangerous Goods) warning symbols or signs on all hazardous bulk storage areas.

3) Label all peroxide forming substances (e.g. ethers) on the outside of the container with the date received, date opened, and the dates and results of every periodic peroxide test. See section on unstable substances for testing frequency.

4) Ensure that procedures are in place to prevent unnecessary storage (accumulation) of substances in the laboratory, especially if the substances become unstable with time (e.g. review inventory yearly).

Store hazardous substances in compatible groups in secure areas. DHSE is available to assist you in developing a storage plan. Follow these guidelines:

- Keep flammable and combustible material away from inorganic acids, oxidizers and reactive substances.
- Keep acids away from alkali materials.
- Keep inorganic acids away from flammable and alkali materials. Separate from inorganic and organic acids (e.g. nitric acid separate from glacial acetic acid).
- Keep oxidizers and organic peroxides away from flammable material, inorganic acids and organic material including wooden bench components.

- Keep health toxins and other especially dangerous items under added security.
- Keep pressurized gases securely strapped to wall, bench or proper cart at all times and their safety caps on while not in use. Toxic and flammable gases have special storage requirements, see DHSE for further information if you are storing or using flammable or toxic gases in any amount.

7.3. Inventory

The SOHS Regulations require that an employer develop and maintain a list of all chemical substances that may be hazardous to the health and safety of worker at the place of employment. This means that each lab must maintain a list available for inspection and use during and emergency of all hazardous materials (ie anything governed under WHMIS).

7.4. Transportation of Dangerous Goods

OFF CAMPUS

Individuals who package and/or complete shippers declarations for TDG on or off campus must have received training and hold a valid training certificate. Training and certificates are obtained through DHSE. Training must be updated every three years with records kept by the individuals' department. With only a few exceptions, all hazardous material transported by motorized carrier must comply with the TDG packaging, training and manifesting requirements. See DHSE for possible exclusions.

ON CAMPUS

All substances being transported out of a laboratory must be in a secondary container that shall be capable of containing all of the substance in the event it is dropped or the primary container leaks for any reason. The container must be WHMIS labeled and the secondary container must have the contact person's name and telephone number printed on the outside. For transportation outside of buildings, we also recommend an Emergency Response Plan be included with the package in case the carrier is unable to respond in the event of a spill.

7.5. Waste Disposal

See the Hazardous Waste Disposal Manual for details on collection, packaging and disposal of hazardous waste.

Chemical waste removed from laboratories is typically bulked prior to shipment for disposal. For the safety of the WMF staff, it is important that your waste information is accurate. If special handling procedures are required for specific items then this information should also be included. The WMF staff often decide the classification and compatibility solely relying on your information. The consequence of misinformation may lead to a major accident. Any extra processing and/or rectification created due to misinformation provided could be dangerous or very expensive.

7.6. Waste Minimization and Pre-planning

Waste generation and disposal should be an integral part of your experiment planning. The following items should be considered at the design stage of any experiment.

1) Minimize the amount of reagents used. Purchase just the enough of the reagent that you would use within a reasonable time frame. Pay close attention to the expiry dates of the reagents you are utilizing. Disposal of 'leftover' material and expired reagents are usually much more expensive than purchasing in smaller batches.

2) It is expensive to dispose of pesticides, cyano compounds and reactive and shock sensitive chemicals. Whenever feasible, use alternative reagents or procedures to avoid or minimize generating costly waste streams. If there are no alternative reagents or procedures available, then the following ideas should be given some consideration:

   - use smaller quantity of reagents at the beginning of the experiment until the procedure is operating,
   - try to reclaim reagents whenever possible for reuse in the experiment,
   - when it is possible and safe, convert very hazardous by-products and reagent waste to less hazardous material before sending them to the WMF for disposal; and
   - know all the by-products of the waste generated during the experiment and their toxicity.

3) Investigate disposal options with DHSE prior to generating any new waste. New types or combinations of waste types may require additional time or resources to find a suitable disposal method. DHSE will work collaboratively with waste producers to meet their needs.

8. Emergencies: Accidents, Incidents, Spills and Exposures

Comply with your written ERP and ensure that you have been properly trained to handle an emergency. Emergency contact information is contained inside the front cover of the LabSafety Manual. Emergency contact is through 9 911 and campus security at 5555.

Accidents

Seek medical aid for all accidents where bodily injury or exposure occurs. Fill out an Incident Report Form and return it to DHSE (see Appendix).

If an employee loses work time or seeks medical aid because of an accident, injury or exposure, contact Human Resources as soon as possible to complete a Workers' Compensation Board (WCB) form.

Incidents (Near Miss)

A near miss incident is an unplanned or unanticipated event where nobody was injured and nothing was spilled or damaged but only by good fortune. These must be investigated to prevent the set of circumstances leading to the incident from arising again. Take immediate steps to contain any further possible danger, inform you supervisor, complete and Incident Report Form and return it to DHSE.

Spills

1) Protect yourself first by leaving the immediate area of a spill or release especially if hazardous materials are volatile and/or toxic. Inform individuals in the affected area(s).

2) Put on PPE and re-enter the area to do the spill inactivation and clean up with the appropriate spill media only if it is safe.

3) Take immediate steps to contain the spill or release of the hazardous substances.

4) If the spill or release gets out of control, is too large or is life or health threatening to you or anyone in the area, consider evacuation and call the spill response team at the WMF for assistance (8497 or 5555).

5) Restrict entry to the area by posting the area with warning signs. Do not allow custodial employees to clean up hazardous substances.

6) Do not allow persons who may be contaminated to leave the area until cleared by DHSE. They must be decontaminated and may need to be monitored for possible effects of the exposure.

7) Complete an Incident Report Form and return it to DHSE.

Exposures

Exposures by individuals or groups of people to chemical, radioactive or biological material that has or could lead to sickness or injury must be reported to DHSE. Contact DHSE immediately and contain the spill and people as well as possible.

Complete an Incident Report Form and return it to DHSE.

9. Laboratory Spill Response Materials

Spill response assistance is required whenever a spill is;

1) Health or life threatening to you or anyone else,

2) There is a lack of proper cleanup equipment or spill absorbent, or

3) You have insufficient training or experience.

It is therefore obvious that equipment availability and spill training are important. Spill kits and suitable sorbent must be available and individuals should be trained. Spill response training is available in the LabSafety Course.

The minimum materials needed are:

1) Hazard information on the substance spilled; MSDS, container label and additional information.

2) Warning signs to ensure others don't inadvertently wander into a contaminated area.

3) Proper PPE to protect hands, feet, eyes, body, and (possibly) respiratory system.

4) Compatible adsorbent or absorbent material; bentonite, diapers, charcoal or vermiculite.

5) Spill clean-up tools; brooms, dust pan, shovel or scoop.

6) Leak-proof waste container with closure; heavy duty plastic bags or 20L pail with a snap lid.

7) Accessories; pH paper, duct tape, long tweezers and plastic scoop.

8) Reporting Forms to DHSE.

10. Your Right-to-Know, Right-to-Refuse and Unresolved Safety Concerns

Right to Know

It is your right under the SOHS Act and Regulations to know about the presence of hazards in the workplace, to know the details of those hazards and how to protect yourself against them. This information is usually supplied to you via a local orientation, access to WHMIS compliance information such as MSDS's and access to proper safety equipment in the form of engineered and procedural safety controls and PPE.

Right to Refuse

You have the right to refuse to do any particular act or series of acts at work that you have reasonable grounds to believe are unusually dangerous to your health or safety or to the health or safety of any other person at the place of employment. The regulation states that you cannot be discriminated against because you have exercised this right conferred to you under the law. You may stop the unsafe work immediately and bring your health and safety concerns to the attention of your Supervisor/Principal Investigator. He/she is obliged to investigate the matter and inform you of his/her decision. If another person is assigned the task, that person must be notified, in writing, that you had previously refused the work, the reason(s) why you refused and the reasons why he/she believes the work is not unusually dangerous.

Unresolved Safety Concerns

If unresolved, you should talk to your Department Head and/or the applicable Local Safety Committee. A Committee representative must be informed of all stop work or unresolved safety concerns. Call DHSE to find out who is the representative, check our website or see your OH&S bulletin board in your building for this information. DHSE Managers are available to consult with anyone who wishes to review their safety procedures in order to minimize their risk of exposure. For work refusals, the Statutory Occupational Health Committee must be notified. For workplace harassment, contact Discrimination and Harassment Prevention Services.

11. Quick Guide to Risk Assessment for Hazardous Chemicals

1. **Identify chemicals to be used and circumstances of use.** Identify the chemicals involved in the proposed experiment and determine the amounts that will be used. Is the experiment to be done once, or will the chemicals be handled repeatedly? Will the experiment be conducted in an open laboratory, in an enclosed apparatus, or in a fume hood? Is it possible that new or unknown substances will be generated? Are any of the workers involved in the experiment pregnant or likely to become pregnant? Do they have any known sensitivities to specific chemicals?

2. **Consult sources of information.** Consult an up-to-date MSDS for each chemical involved in the planned experiment. In cases where substances with significant or unusual potential hazards are involved, it may also be advisable to consult more detailed references. Depending on the worker's level of experience and the degree of potential hazard associated with the proposed experiment, it may also be necessary to obtain the assistance of experts in the field, supervisors and safety professionals before proceeding with risk assessment.

3. **Evaluate the types of toxicity and other dangers.** Are any of the chemicals to be used toxic, corrosive, irritants or sensitizers? Will any carcinogens or possible carcinogens be encountered? How about flammability and environmental toxicity? Are any chemicals involved in the proposed experiment suspected to be reproductive or developmental toxins or neurotoxins? Examine all possible types of toxicity and other danger.

4. **Consider possible routes of exposure.** Determine the potential routes of exposure for each chemical. Are the chemicals gases, or are they volatile enough to present a significant risk of exposure through inhalation? If liquid, can the substances be absorbed through the skin? Is it possible that dusts or aerosols will be formed in the experiment? Does the experiment involve a significant risk of inadvertent ingestion or injection of chemicals? What about environmental impacts.

5. **Evaluate quantitative information on toxicity.** Consult the information sources to determine the LD50 for each chemical via the relevant routes of exposure. Determine the acute toxicity hazard level for each substance, classifying each chemical as highly toxic, moderately toxic, slightly toxic and so forth. For substances that pose inhalation hazards, take note of the threshold limit value time-weighted average (TLV-TWA), short-term exposure limit (STEL) and odour threshold.

6. **Select appropriate procedures to minimize exposure.** Use Good Laboratory Practices for all work with chemical in the laboratory. In addition, determine whether any of the chemicals to be handled in the planned experiment are extremely hazardous. I.e. Deserve a '3' or '4' rating under any of the NFPA categories. If so, pay special attention to the control of these compounds. Consider the total amount of the substance that will be used, the expected frequency of use, the chemical's routes of entry, and the circumstances of its use in the proposed experiment.

7. **Prepare for contingencies.** Note the signs and symptoms of exposure to the chemicals to be used in the proposed experiment. Note appropriate measures to be taken in the event of exposure, accidental release or other unplanned situation involving any of the chemicals.

Adapted from:
Committee on Prudent Practices for Handling, Storage and Disposal of Chemicals in Laboratories. Prudent Practices in the Laboratory: Handling and Disposal of Chemicals. Washington: NATIONAL ACADEMY PRESS, 1995. Page 47

Appendices

A. Notifiable & Designated Substances

Preamble

The Supervisor or Principal Investigator shall ensure that adequate engineering and procedural controls and suitable PPE are provided where workers are required or allowed to handle, use or produce:

1. any substance listed in **Table 19** or **Table 20** of the Regulations, or
2. any substances listed in **Table 21** of the Regulations. These substances must have the safety controls in place to ensure that any exposures are kept below the *contamination limits* as set in the regulations.

A.1 Notifiable Chemical Substances

Identified in Section 305 and 311 and in **Table 19** in the Saskatchewan Occupational Health and Safety Regulations.

Supervisors of projects shall provide written notice to the Department of Health, Safety and Environment of their activity or intention to procure, handle, use, store, produce, distribute or dispose of any of the following chemical substances or any mixture containing more than 1% of any of them. DHSE will then request permission from the Saskatchewan Director of Occupational Health and Safety. The director may issue permits subject to any conditions which, in his/her opinion, are warranted in the particular situation. Please note that there are many other chemical substances that have hazards associated with them and therefore this list is only the minimum of the reportable substances.

To Register

Contact the Department of Health, Safety and Environment if you have any Notifiable Chemical Substances in your area. These compounds are listed below or can be found in **Table 19** of the regulations. No exposure or contact by any route to any of these substances is regarded as acceptable; therefore no contamination limits are stipulated.

4-Aminobiphenyl	Auramine	Benzidine
bis(Chloromethyl) ether	o-Dianisidine	3,3'-Dichlorobenzidine
Methyl chloromethyl ether	Mustard gas	2-Naphthylamine
4-Nitrobiphenyl	Vinyl chloride	

A.2 Biological Substances (Permit or Registration Required)

A Biosafety Permit or Registration may be required for:

a) any research or teaching involving Genetically Modified Microorganisms or

b) any research or teaching involves biological material in Risk Groups 1 (registration) or 2, 3 and 4 (permit).

Contact the Biosafety Office for further information.

A.3 Designated Chemical Substances

Substances listed in **Table 20** of the Saskatchewan Occupation Health and Safety Regulations as well as those containing 1% or less of any substance listed in **Table 19** are classes as Designated Substances. The Supervisor/Principal Investigator shall ensure that adequate engineering and procedural controls and suitable PPE are provided to prevent any significant risk to workers caused by exposure to any of

these substances where workers are required or allowed to produce, handle or use them.

A.4 Contamination Limits

Substances listed in **Table 21** of the Saskatchewan Occupation Health and Safety Regulations have specified occupational exposure limits, commonly referred to as Threshold Limit Values (TLVs). TLVs are maximum concentrations in air in which employees may work for specified periods of time. If your workplace uses or produces any of these substances, ensure that employees are protected.

A.5 Radioactive Substances

All radioisotope users must have an Operating Permit from DHSE.

A.6 Requirements for Use

The use of any Notifiable or Designated chemical or biological substance requires an elevated level of safety awareness and preparedness. The following items are the minimum requirements of areas involved with these substances:

- Written ERP's are in place for a spill or release of any hazardous substances.
- Activities are performed in the appropriately designed containment work areas. Containment level of work area is commensurate with the RGL of the agent. Likewise, fume hoods must be used where appropriate for chemical substances.
- Safety equipment (engineered safety controls) are used properly and maintained. (e.g. fume hoods and Biosafety Cabinets tested yearly and checked daily).
- Procedural controls being used will comply with the safety precautions necessary for the level of containment required for this activity.
- The applicable University Safety Committee has endorsed the work activities where applicable.
- The Supervisor or Principal Investigator is aware that any significant changes in the activities must be reported to the applicable University Safety Committee and to the research granting agency when registration or permitting is in place.
- Authorized workers are aware of any and all hazards (physical, chemical or other) that may be encountered in the course of the work activities.
- Personnel are adequately trained and any safety procedures are enforced, in compliance with the SOHS Act and Regulations.
- The Supervisor or Principal Investigator adheres to both the Federal and Provincial statutes pertaining to the protection of the environment. In addition, projects that may generate significant amounts of waste or waste of an unusual or novel nature will have their waste disposal process reviewed and approved by DHSE prior to generating any waste.

Penalty (as stated in the granting guide): Deliberate failure to comply with the guidelines of a granting agency could lead to termination of support to the investigator, the department or the University. Ignorance will not be an excuse for non-compliance.

B. Standard Operating Procedures

Laboratory supervisors should review their written Standard Operating Procedures (SOPs) with their workers once a year.

Goals:

- ensure consistency of work procedures
- provide training material on experimental protocols and explain the inherent risks associated with the work
- establish engineered and procedural safety controls to reduce the risk or exposure. These safety controls and identification of risks are one of the main parts of the SOP.
- comply with legislative aspects of the Occupational Health & Safety Act and Regulations. It is recommended that an ECP, SOP or equivalent documentation be developed in each laboratory where employees work with or near hazardous biological, chemical or physical substances.

The following topics should be considered when writing an SOP or a Departmental Safety Policies and Procedures manual.

- Identify the hazards, risks and symptoms of exposure associated with the work to the employees.
- Provide instructions on the safe use, handling, storage, transport and disposal of all materials.
- Ensure that ERP's are available to the employees.
- Provide procedures for the corrective action for unsafe acts and unsafe conditions.
- Provide procedure and frequency for routine housekeeping and inspections of all work areas.
- Ensure WHMIS hazard identification labeling and MSDSs are available as required.
- Use "Equipment and Area Release Forms" where applicable.
- Identify and ensure that equipment has the proper engineered safety controls (guards and shields are in place, biosafety cabinets and fume hoods are used and maintained).
- Develop policies for working alone and for unattended operations.
- Ensure that no food and drink is consumed or stored in an area where there are hazardous substances.
- Ensure that the mechanisms to maintain personal hygiene are in place.
- Provide PPE and ensure that employees know how to select, maintain and use it properly.
- Develop policies and procedures to restrict, limit and control access to high risk areas or substances.
- Maintain records on all employee orientation and training and all equipment maintenance.
- Ensure that Incident investigating and reporting takes place.
- Remember to control exposures first by engineering control, then by procedural and use PPE only as a last defense.

C. Handling Procedures for Unstable Substances

All hazardous compounds must be treated with respect. Certain compounds have the ability to become even more dangerous through neglect (dehydration or contamination) or chemical reaction (oxidation). Ethers, picric acid and some other common examples are listed here. There are others – know your chemicals!

Ethers

Ether functional groups can oxidize to unstable peroxide functional groups when exposed to a source of oxygen and given time. Containers of ether which have been opened should be checked for peroxide formation periodically, according to the table below. Unopened containers are not as susceptible, but should still be treated carefully if old. Test strips are the easiest method of measuring peroxide concentration. Any ethers which have developed more than 5 ppm peroxides should be disposed of through the Waste Management Facility. Do not evaporate or distil this ether since this will concentrate the peroxides. Chemical removal methods are available but should be only be attempted by experienced, knowledgeable people.

Do not try to open the cap of old ether containers which have not been opened for a long time in order to test for peroxides. If crystals are visible at the neck of the bottle or if crystals or sludge are noted inside the container, be especially careful. DO NOT OPEN the container and contact DHSE for advice. Friction on the dried peroxides in the cap threads could cause an explosion.

The following table provides some information about the more common compounds that are susceptible to peroxide formation. This list is not exhaustive, but is more representative of the structural groups that are prone to unstable compound formation. You are responsible to ensure your own safety – check first!

Class 1(C)	Class 2(B)		Class 3 (A)
Acrylic acid	Acetal	Cyclohexene	Divinyl ether
Acrylonitrile	Cumene	Dicyclopentadiene	Divinyl acetylene
Butadiene	Cyclopentene	Methyl cyclopentane	Isopropyl ether
Chlorobutadiene	Cyclooctene	Diacetylene	Vinylidene chloride
Chlorotrifluoroethylene	Diethyl ether	diozane (p-dioxane)	Potassium Metal
Methyl methacrylate	Furan	Tetrahydrofuran	Potassium amide
Styrene	Methyl acetylene	Ethylene glycol dimethyl ether	Sodium amide
Tetrafluoroethylene	Tetrahydro naphthalene	Diethylene glycol dimethyl ether	
Vinyl acetate	Vinyl Ethers		
Vinyl acetylene			
Vinyl chloride			
Vinyl pyridine			
Vinylidene chloride			

Class I (C) – Testing at 3 month intervals, with those showing peroxides discarded.
Class II (B) – Test stocks at 6 month intervals; discarded or purify those showing peroxides.
Class III (A) – Contain peroxidizable monomers and the presence of peroxides may initiate exothermic polymerisation. May explode without concentration. Test every 3 months.

The time frames and amounts of peroxide formed are greatly influenced by the amount of air space in the container (therefore the oxygen present), storage temperature and whether inhibitors are present or not.

Picric Acid, Perchloric Acid , 2, 4 DNPH and others

Picric acid is stable when properly hydrated, but if allowed to dry out can become unstable and has the potential to explode like TNT when shocked. 2,4 Dinitrophenylhydrazine, perchloric acid and others have similar characteristics. Treat them similarly. Contamination with metals lowers stability further. Experienced persons have re-hydrated these materials by submerging the container in cold water for a number of days until the dry crystals are rewetted. DHSE does **not** recommend this procedure, but rather that you contact us to remove and disposal of this material.

D. WHMIS

The Federal Hazardous Products Act and Controlled Products Regulations have created the Workplace Hazardous Materials Information System (WHMIS). This Federal legislation is also enforced in Saskatchewan through Part XXII of the OHS Regulation. The WHMIS system is composed of three elements: training, labeling and Material Safety Data Sheets (MSDS's).

Training

Employers are required to train workers who work with or in proximity to hazardous substances. This training must include:

- the content required on a supplier label, a workplace label and an MSDS,
- all necessary procedures for the safe use, storage, handling and disposal of the material, and
- information on how to handle fugitive emissions and how to respond to an emergency involving a controlled product.

Employees are required to attend training when offered and to apply knowledge gained during the training. DHSE offers generic WHMIS training for all University persons required to take it. This training addresses general information regarding the above aspects, but must always be followed up by site specific training at the work area about the specific materials used in that area.

Labeling

Containers holding hazardous materials (controlled products) must be labeled according to the requirements of the legislation. There are two primary labeling situations and one additional one that laboratory employees need to be aware of.

Supplier Labels

By law, the supplier of a hazardous chemical or biological substance must label their product in a specific manner. Any container obtained from a supplier that does not meet the WHMIS labeling requirements should be reported to DHSE. Supplier labels have the following nine components:

1. Hatched border
2. Material identifier
3. Risk phrases
4. Precautionary phrase(s)
5. First Aid measures
6. Supplier identification
7. Symbols
8. Reference to the MSDS
9. Bilingual

Laboratory Supplier Labels

Packages produced and supplied specifically to laboratories have relaxed requirements for labeling. You will likely see many of these types of labels in your work area. They have only 6 requirements:

1. Product identifier
2. Risk phrases
3. Precautionary phrase(s)
4. First Aid measures
5. Reference to MSDS
6. Bilingual

Workplace Labels

For occasions where a material has been transferred to another container, the original label has been defaced or the material has been produced in the work area (and therefore there is no supplier label) a workplace label shall be used. Workplace labels are generated by knowledgeable people using the substance based on information from the supplier label and/or the MSDS. These labels have three requirements:

1. Product identifier
2. Precautionary phrase(s)
3. Reference to MSDS

Assistance in generating workplace labels can be obtained from DHSE.

WHMIS Symbols

As is clear from the above lists, symbols form an important element of some labels. These symbols assist in the identification of hazardous substances. A table of classes, divisions and symbols appears at the end of this section.

The Class of a WHMIS substance is dictated by the nature of its hazard. There are six WHMIS Classes: A through F. Two of these classes have differentiation within them referred to as Divisions:

Class B has six divisions further detailing the nature of the flammability danger. All six divisions within class B have the same symbol.

Class D has three divisions within it:

Division 1 is the familiar skull and cross bones indicating a material with immediate and serious effects.

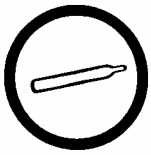
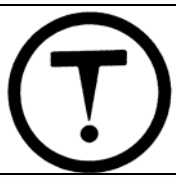
Division 2 is the chronic toxic category indicating a material which may require multiple exposures or may have serious effects that may not appear for a significant time.

Division 3 is biohazardous or infectious material which has different protection and decontamination requirements and can have very serious health consequences.

Each gets its own symbol.

MSDS

MSDS's for all the hazardous products used or stored in a work area must be available to all workers. Suppliers must provide MSDSs with the first shipment of a compound and periodically after that with new orders. Contact the supplier of the product to obtain updates since these documents must be renewed every three years. Visit our web page at http:www.usask.ca/dhse for access to MSDS information.

WHMIS Class	Division	Symbol
A **Compressed Gas**	(Often requires another symbol if not inert) - Toxic - Oxidizer - Corrosive - Inert - Flammable - Reactive	
B **Flammable and Combustible**	Division 1: Flammable Gases Division 2: Flammable Liquids (Fp < 37C) Division 3 Combustible Liquids (Fp > 37C) Division 4: Flammable Solids Division 5: Flammable Aerosols Division 6: Flammable Reactive Materials	
C **Oxidizing Material**		
D **Poisonous or Infectious Material**	DIVISION 1: Material Causing Immediate and Serious Toxic Effects	
	DIVISION 2: Material Causing Other Toxic Effects	
	DIVISION 3: Biohazardous Infectious Material	
E **Corrosive Material**		
F **Reactive Material**		

E. MSDS Information for 9 Section (Canadian) Form

Category/Section	Information	Item
1. Product Information	• Product identifier • Manufacturer's name, street address, city, province/state, postal/zip code, emergency phone number	• Product use • Product identification number (PIN) • Supplier identifier, street address, city, province/state, postal/zip code, emergency phone number
2. Hazardous Ingredients	• Information required by the Hazardous Products Act	• CAS number • LD_{50} (species and route) • LC_{50} (species and route)
3. Physical Data	• Physical state (gas, liquid or solid) • Odour and appearance • Vapour pressure • Evaporation rate • Specific gravity	• Odour threshold • Vapour density • Boiling point • Freezing point • PH • Coefficient of water/oil distribution
4. Fire or Explosion Hazard	• Conditions of flammability • Flashpoint and method of determination • Auto-ignition temperature • Hazardous combustion products	• Means of extinction • Upper flammable limit (% by volume) • Lower flammable limit (% by volume) • Explosion data - sensitivity to impact • Explosion data sensitivity to static
5. Reactivity Data	• Conditions under which the product is chemically unstable • Name of any substance or class of substance with which the product is incompatible	• Conditions of reactivity • Hazardous decomposition products
6. Toxicological Properties	• Route of entry, including: skin contact, skin absorption, eye contact, inhalation and ingestion • Effects of acute exposure to product • Effects of chronic exposure to product	• Irritancy of product • Sensitization to product • Carcinogenicity • Teratogenicity • Reproductive toxicity • Mutagenicity • Name of toxicologically synergistic products
7. Preventive Measures	• Personal protective equipment to be used • Procedures to be followed in case of leak or spill • Waste disposal	• Specific engineering controls to be used • Handling procedures and equipment • Storage requirements • Special shipping information
8. First Aid Measures	• Specific first aid measures	
9. Preparation Information	• Name and phone number of group department or party responsible for MSDS preparation.	• Date of preparation

F. MSDS Sample for 16 Section (ILO version) Form

MATERIAL SAFETY DATA SHEET

SECTION 1 CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

a. Product identifier: Chemical class, Synonym
b. Name of supplier, address and emergency telephone number:
c. Name of manufacturer, address and emergency telephone number:
d. Product use:
e. Date of MSDS preparation:
f. Name and telephone number of party responsible for MSDS preparation:

SECTION 2 COMPOSITION/INFORMATION ON INGREDIENTS

a. Chemical identity and CAS registry no. of hazardous ingredients (WHMIS Controlled Products) present at 1.0%, or 0.1% as appropriate, by weight.
b. Ingredients present which are on the WHMIS Ingredient Disclosure List at, or above, the minimum concentration specified on the List.
c. Ingredients with unknown toxicological properties:
d. Ingredients the supplier believes may be harmful:
e. Generic chemical identity, registry number, and date of claim for trade secret ingredients:
f. Ingredient concentration in units of wt./wt., vol./vol. or wt./vol. expressed as: i) actual concentration, or ii) a range as specified in the Controlled Product Regulations.
g. LD50s and/or LC50s for ingredients.
h. Exposure limits for ingredients:

SECTION 3 HAZARDS IDENTIFICATION

Potential Health Effects:
a. Relevant routes of exposure:
b. Adverse health effects from exposure to product or ingredients of product:
i) Length of exposure
ii) Severity of effect
iii) Target organ
iv) Type of effect
v) Signs and symptoms

SECTION 4 FIRST AID MEASURES

If accidental overexposure is suspected
Eyes:
Skin:
Inhalation:
Ingestion:
Note to physician:
Medical conditions likely to be aggravated by exposure:

SECTION 5 FIRE FIGHTING MEASURES

1. Flash point and method:
2. Upper and lower flammable (explosive) limits in air:
3. Autoignition temperature:
4. Hazardous combustion products:
5. Conditions under which flammability could occur:
6. Extinguishing media:
7. Sensitivity to explosion by mechanical impact or static discharge:
8. Fire fighting procedures:

SECTION 6 ACCIDENTAL RELEASE MEASURES

a. Procedures for dealing with a release or spill:

SECTION 7 HANDLING AND STORAGE

a. Handling practices and equipment:
b. Appropriate storage practices/requirements:

SECTION 8 EXPOSURE CONTROLS/PERSONAL PROTECTION

a. Applicable control measures, including engineering controls:
b. Personal protective equipment for each exposure route:

SECTION 9 PHYSICAL AND CHEMICAL PROPERTIES

a. Appearance:
b. Odour:
c. Physical state:
d. pH:
e. Vapour pressure and reference temperature:
f. Vapour density:
g. Boiling point:
h. Freezing/melting point:
i. Specific gravity or density:
j. Evaporation rate:
k. Partition coefficient:
l. Odour threshold:
m. Viscosity:
n. Solubility in water:

SECTION 10 STABILITY AND REACTIVITY

a. Chemical stability:
b. Conditions to avoid:
c. Incompatibility with other materials:
d. Hazardous decomposition products:
e. Hazardous polymerization:

SECTION 11 TOXICOLOGICAL INFORMATION

a. Effects of short-term exposure:
b. Effects of long-term exposure:
c. Irritancy:
d. Sensitization:
e. Carcinogenicity:
f. Reproductive toxicity:
g. Teratogenicity:
h. Mutagenicity:
i. Name of toxicologically synergistic products:

SECTION 12 ECOLOGICAL INFORMATION

SECTION 13 DISPOSAL CONSIDERATIONS

a. Waste disposal information:

SECTION 14 TRANSPORT INFORMATION

a. Shipping information such as shipping classification:
PIN (Transport Canada - Product Identification Number) for the entire product.

SECTION 15 REGULATORY INFORMATION

a. WHMIS classification for product:
b. A statement that the MSDS has been prepared to meet the requirements of the Canadian Controlled Products Regulation:

SECTION 16 OTHER INFORMATION

G. MSDS Definitions

Reproduced from CCOHS Website, January 3, 2003 (http://ccinfoweb.ccohs.ca/help/msds/msdstermse.html)

ACGIH
ACGIH stands for American Conference of Governmental Industrial Hygienists. The ACGIH is an association of occupational health professionals employed by government and educational institutions. The Threshold Limit Value (TLV) Committee and Ventilation Committee of the ACGIH publish guidelines which are used worldwide.

ACID, ACIDIC
See pH.

ACTIVE INGREDIENT
An active ingredient is the part of a product which actually does what the product is designed to do. It is not necessarily the largest or most hazardous part of the product. For example, an insecticidal spray may contain less than 1% pyrethrin, the ingredient which actually kills insects. The remaining ingredients are often called inert ingredients.

ACUTE
Acute means sudden or brief. Acute can be used to describe either an exposure or a health effect. An acute exposure is a short-term exposure. Short-term means lasting for minutes, hours or days. An acute health effect is an effect that develops either immediately or a short time after an exposure. Acute health effects may appear minutes, hours or even days after an exposure. (See also Chronic.)

AEROSOL
An aerosol is a collection of very small particles suspended in air. The particles can be liquid (mist) or solid (dust or fume). The term aerosol is also commonly used for a pressurized container (aerosol can) which is designed to release a fine spray of a material such as paint.
Inhalation of aerosols is a common route of exposure to many chemicals. Also, aerosols may be fire hazards.

AIHA
AIHA stands for American Industrial Hygiene Association.

ALKALI, ALKALINE
See pH.

ANSI
ANSI stands for the American National Standards Institute.

AUTO-IGNITION TEMPERATURE
The auto-ignition temperature is the lowest temperature at which a material begins to burn in air in the absence of a spark or flame. Many chemicals will decompose (break down) when heated. The autoignition temperature is the temperature at which the chemicals formed by decomposition begin to burn. Auto-ignition temperatures for a specific material can vary by one hundred degrees Celsius or more, depending on the test method used. Therefore, values listed on the MSDS may be rough estimates. To avoid the risk of fire or explosion, materials must be stored and handled at temperatures well below the auto-ignition temperature.

BASE, BASIC
See pH.

BIOHAZARDOUS INFECTIOUS MATERIAL
Under the Canadian Controlled Products Regulations, a biohazardous infectious material is a material that contains organisms which can cause disease in humans or animals. For example, a person exposed to a blood sample from someone with hepatitis B may contract the disease. Some jurisdictions require MSDSs for products which contain biohazardous infectious materials.

BOD
BOD stands for biological oxygen demand.

BOILING POINT
The boiling point is the temperature at which the material changes from a liquid to a gas. Below the boiling point, the liquid can evaporate to form a vapour. As the material approaches the boiling point, the change from liquid to vapour is rapid and vapour concentrations in the air can be extremely high. Airborne gases and vapours may pose fire, explosion and health hazards. Sometimes, the boiling point of a mixture is given as a range of temperatures. This is because the different ingredients in a mixture can boil at different temperatures.
If the material decomposes (breaks down) without boiling, the temperature at which it decomposes may be given with the abbreviation "dec." Some of the decomposition chemicals may be hazardous. (See also Thermal Decomposition Products.)

CANUTEC
CANUTEC stands for Canadian Transport Emergency Centre, which is part of the Transport Dangerous Goods Directorate of Transport Canada. CANUTEC provides information and communications assistance in case of transportation emergencies involving dangerous goods. It is accessible in Canada by telephone, 24 hours a day, year round at (613) 996-6666 (collect).

CARCINOGEN, CARCINOGENIC, CARCINOGENICITY

A carcinogen is a substance which can cause cancer. Carcinogenic means able to cause cancer. Carcinogenicity is the ability of a substance to cause cancer.

Under the Canadian Controlled Products Regulations, materials are identified as carcinogens if they are recognized as carcinogens by the American Conference of Governmental Industrial Hygienists (ACGIH), or the International Agency for Research on Cancer (IARC).

Under the US OSHA Hazard Communication (Hazcom) Standard, materials are identified as carcinogens on MSDSs if they are listed as either carcinogens or potential carcinogens by IARC or the US National Toxicology Program (NTP), if they are regulated as carcinogens by OSHA, or if there is valid scientific evidence in man or animals demonstrating a cancer causing potential.

The lists of carcinogens published by the IARC, ACGIH and NTP include known human carcinogens and some materials which cause cancer in animal experiments. Certain chemicals may be listed as suspect or possible carcinogens if the evidence is limited or so variable that a definite conclusion cannot be made.

CAS REGISTRY NUMBER

The CAS Registry Number is a number assigned to a material by the Chemical Abstracts Service (CAS) of the American Chemical Society (ACS). The CAS number provides a single unique identifier. A unique identifier is necessary because the same material can have many different names. For example, the name given to a specific chemical may vary from one language or country to another. The CAS Registry Number is similar to a telephone number and has no significance in terms of the chemical nature or hazards of the material. The CAS Registry Number can be used to locate additional information on the material.

CC

Depending on the context, CC can stand for closed cup, cubic centimeters or ceiling concentration.

CCC

CCC stands for Cleveland closed cup, a standard method of determining flash points.

CCOHS

CCOHS stands for the Canadian Centre for Occupational Health and Safety. CCOHS provides an occupational health and safety information service through answers to inquiries, publications and a computerized information service. The computerized information is available both online (CCINFOWeb) and on CD-ROM (CCINFOdisc).

CEILING (C)

See Exposure Limits for a general explanation.

CHEMICAL FAMILY

The chemical family describes the general nature of the chemical. Chemicals belonging to the same family often share certain physical and chemical properties and toxic effects. However, there may also be important differences. For example, toluene and benzene both belong to the aromatic hydrocarbon family. However, benzene is a carcinogen, but toluene is not.

CHEMICAL FORMULA

The chemical formula, sometimes called the molecular formula, tells which elements (carbon, hydrogen, oxygen, and so on) make up a chemical. It also gives the number of atoms of each element in one unit or molecule of the chemical. The chemical formula can be used to confirm the identity of ingredients or to indicate the presence of a potentially hazardous element.

For example, zinc yellow has the chemical formula ZnCrO4, which shows that it contains not only zinc (Zn) but also chromium (Cr).

CHEMICAL NAME

The chemical name is a proper scientific name for an ingredient of a product. For example, the chemical name of the herbicide 2,4-D is 2,4-dichlorophenoxyacetic acid. The chemical name can be used to obtain additional information.

CHEMICAL REACTIVITY

Chemical reactivity is the ability of a material to undergo a chemical change. A chemical reaction may occur under conditions such as heating, burning, contact with other chemicals, or exposure to light. Undesirable effects such as pressure buildup, temperature increase or formation of other hazardous chemicals may result. (See also Dangerously Reactive Material and Reactive Flammable Material.)

CHEMTREC

CHEMTREC stands for the Chemical Transportation Emergency Centre. It is a U. S. national center established by the Chemical Manufacturers Association (CMA) to relay pertinent emergency information concerning specific chemicals on requests from individuals. CHEMTREC has a 24-hour toll-free telephone number to help respond to chemical transportation emergencies for companies who have registered with them for this service.

CHRONIC

Chronic means long-term or prolonged. It can describe either an exposure or a health effect. A chronic exposure is a long-term exposure. Long-term means lasting for months or years. A chronic health effect is an adverse health effect resulting from long-term exposure or a persistent adverse health effect resulting from a short-term exposure. The Canadian Controlled Products Regulations describe technical criteria for identifying materials which cause chronic health effects. (See also Acute.)

CNS
CNS stands for central nervous system.
COC
COC stands for Cleveland open cup, a standard method of determining flash points.
COD
COD stands for chemical oxygen demand.
COEFFICIENT OF OIL/WATER DISTRIBUTION
The coefficient of oil/water distribution, also called the partition coefficient (abbreviated as P), is the ratio of the solubility of a chemical in an oil to its solubility in water. The P value is typically presented as a logarithm of P (log P). It indicates how easily a chemical can be absorbed into or stored in the body. The P value is also used to help determine the effects of the chemical on the environment.
COMBUSTIBLE
Combustible means able to burn. Broadly speaking, a material is combustible if it can catch fire and burn. However, in many jurisdictions, the term combustible is given a specific regulatory meaning. (See Combustible Liquid.)
The terms combustible and flammable both describe the ability of a material to burn. Commonly, combustible materials are less easily ignited than flammable materials.
COMBUSTIBLE LIQUID
Under the Canadian Controlled Products Regulations, a combustible liquid has a flash point from 37.8 to 93.3 degrees C (100 to 200 degrees F) using a closed cup test. The US OSHA Hazcom Standard uses a similar definition.
This range of flash points is well above normal room temperature. Combustible liquids are, therefore, less of a fire hazard than flammable liquids. If there is a possibility that a combustible liquid will be heated to a temperature near its flash point, appropriate precautions must be taken to prevent a fire or explosion.
COMPRESSED GAS
A compressed gas is a material which is a gas at normal room temperature and pressure but is packaged as a pressurized gas, pressurized liquid or refrigerated liquid. The Canadian Controlled Products Regulations and the U.S. Hazcom standard describe technical criteria for identifying materials which are classified as compressed gases.
Regardless of whether a compressed gas is packaged in an aerosol can, a pressurized cylinder or a refrigerated container, it must be stored and handled very carefully. Puncturing or damaging the container or allowing the container to become hot may result in an explosion.
CONTROLLED PRODUCTS
Under the Canadian Controlled Products Regulations, a controlled product is defined as a material, product or substance which is imported or sold in Canada and meets the criteria for one or more of the following classes:
Class A - Compressed Gas
Class B - Flammable and Combustible Material:
Class C - Oxidizing Material
Class D - Poisonous and Infectious Material:
Division 1 - Material Causing Immediate and Serious Toxic Effects:
Subdivision A - Very Toxic Material
Subdivision B - Toxic Material
Division 2 - Material Causing Other Toxic Effects:
Subdivision A - Very Toxic Material
Subdivision B - Toxic Material
Division 3 - Biohazardous Infectious Material
Class E - Corrosive Material
Class F - Dangerously Reactive Material
CONTROLLED PRODUCTS REGULATIONS (CPR)
The Controlled Products Regulations are Canadian federal regulations developed under the Hazardous Products Act. They are part of the national Workplace Hazardous Materials Information System (WHMIS).
The regulations apply to all suppliers (importers or sellers) in Canada of controlled products intended for use in Canadian workplaces. The regulations specify the criteria for identification of controlled products. They also specify what information must be included on labels and MSDSs.
CORROSIVE MATERIAL
A corrosive material can attack (corrode) metals or human tissues such as the skin or eyes. Corrosive materials may cause metal containers or structural materials to become weak and eventually to leak or collapse. Corrosive materials can burn or destroy human tissues on contact and can cause effects such as permanent scarring or blindness.
The Canadian Controlled Products Regulations and the US OSHA Hazcom Standard, specify technical criteria for identifying materials which are classified as corrosive materials for the purposes of each regulation. (See also pH.)
CU M or CU.M
This stands for cubic meter
DANGEROUSLY REACTIVE MATERIAL
The Canadian Controlled Products Regulations describes technical criteria for identifying materials which are classified as dangerously reactive. A dangerously reactive material can react vigorously:

- with water to produce a very toxic gas;
- on its own by polymerization or decomposition; or
- under conditions of shock, or an increase in pressure or temperature.

ANSI defines a dangerously reactive material as one that is able to undergo a violent self-accelerating exothermic chemical reaction with common materials, or by itself.

A dangerously reactive material may cause a fire, explosion or other hazardous condition. It is very important to know which conditions (such as shock, heating or contact with water) may set off the dangerous reaction so that appropriate preventive measures can be taken.

DENSITY

The density of a material is its weight for a given volume. Density is usually given in units of grams per millilitre (g/mL) or grams per cubic centimetre (g/cc). Density is closely related to specific gravity (relative density). The volume of a material in a container can be calculated from its density and weight.

DOT

DOT stands for the U.S. Department of Transportation.

EMBRYO

An embryo is an organism in the early stages of its development prior to birth. In humans, the embryo is the developing child from conception to the end of the second month of pregnancy. (See also Fetus/Foetus.)

EMBRYOTOXIC, EMBRYOTOXICITY

Embryotoxic means harmful to the embryo. Embryotoxicity is the ability of a substance to cause harm to the embryo. The Canadian Controlled Products Regulations describe technical criteria for identifying materials which have teratogenicity and embryotoxicity. (See also Fetotoxicity and Reproductive Effects.) Under the U.S. OSHA HAZCOM standard, embryotoxic effects are included as Target Organ Effects.

ENGINEERING CONTROLS

Engineering controls help reduce exposure to potential hazards either by isolating the hazard or by removing it from the work environment. Engineering controls include mechanical ventilation and process enclosure. They are important because they are built into the work process.

Engineering controls are usually preferred to other control measures such as the use of personal protective equipment.

EPA

EPA stands for the U.S. Environmental Protection Agency.

EU

EU stands for the European Union, formerly known as the EEC (European Economic Community) and the EC (European Community).

EVAPORATION RATE

The evaporation rate is a measure of how quickly the material becomes a vapour at normal room temperature. Usually, the evaporation rate is given in comparison to certain chemicals, such as butyl acetate, which evaporate fairly quickly. For example, the rate might be given as "0.5 (butyl acetate=1)." This means that, under specific conditions, 0.5 grams of the material evaporates during the same time that 1 gram of butyl acetate evaporates. Often, the evaporation rate is given only as greater or less than 1, which means the material evaporates faster or slower than the comparison chemical.

In general, a hazardous material with a higher evaporation rate presents a greater hazard than a similar compound with a lower evaporation rate.

EXPLOSION DATA

Explosion data is information on the explosive properties of a material. Quantitative explosion data is seldom available and is usually given in descriptive terms such as low, moderate or high.

The following types of information can be used to describe the explosive hazard of a material:

- Sensitivity to mechanical impact. This information indicates whether or not the material will burn or explode on shock (for example, dropping a package) or friction (for example, scooping up spilled material).
- Sensitivity to static discharge. This information indicates how readily the material can be ignited by an electric spark.

Detailed information is available on the properties of commercial explosives. In Canada, the storage, transportation and handling of commercial explosives are strictly regulated under the Explosives Act and TDG. Commercial explosives are not regulated by the Controlled Products Regulations.

EXPLOSIVE LIMITS

Explosive limits specify the concentration range of a material in air which will burn or explode in the presence of an ignition source (spark or flame). Explosive limits may also be called flammable limits or explosion limits.

The lower explosive limit (LEL), or lower flammable limit (LFL), is the lowest concentration of gas or vapour which will burn or explode if ignited. The upper explosive limit (UEL), or upper flammable limit (UFL), is the highest concentration of gas or vapour which will burn or explode if ignited. From the LEL to the UEL, the mixture is explosive. Below the LEL, the mixture is too lean to burn. Above the UEL, the mixture is too rich to burn. However, concentrations above the UEL are still very dangerous because, if the concentration is lowered (for example, by introducing fresh air), it will enter the explosive range.

In reality, explosive limits for a material vary since they depend on many factors such as air temperature. Therefore, the values given on an MSDS are approximate.

The explosive limits are usually given as the percent by volume of the material in the air. One percent by volume is 10,000 ppm. For example, gasoline has a LEL of 1.4% and a UEL of 7.6%. This means that gasoline vapours at concentrations of 1.4% to 7.6% (14,000 to 76,000 ppm) are flammable or explosive.

EXPOSURE LIMITS (OR OCCUPATIONAL EXPOSURE LIMITS (OELs))

An exposure limit is the concentration of a chemical in the workplace air to which most people can be exposed without experiencing harmful effects. Exposure limits should not be taken as sharp dividing lines between safe and unsafe exposures. It is possible for a chemical to cause health effects, in some people, at concentrations lower than the exposure limit.

Exposure limits have different names and different meanings depending on who developed them and whether or not they are legal limits. For example, Threshold Limit Values (TLVs) are exposure guidelines developed by the American Conference of Governmental Industrial Hygienists (ACGIH). They have been adopted by many Canadian governments as their legal limits. Permissible Exposure Limits (PELs) are legal exposure limits in the United States. Sometimes, a manufacturer will recommend an exposure limit for a material.

Exposure limits have not been set for many chemicals, for many different reasons. For example, there may not be enough information available to set an exposure limit. Therefore, the absence of an exposure limit does not necessarily mean the material is not harmful. There are three different types of exposure limits in common use:

1) Time-weighted average (TWA) exposure limit is the time-weighted average concentration of a chemical in air for a normal 8-hour work day and 40-hour work week to which nearly all workers may be exposed day after day without harmful effects. Time-weighted average means that the average concentration has been calculated using the duration of exposure to different concentrations of the chemical during a specific time period. In this way, higher and lower exposures are averaged over the day or week.

2) Short-term exposure limit (STEL) is the average concentration to which workers can be exposed for a short period (usually 15 minutes) without experiencing irritation, long-term or irreversible tissue damage, or reduced alertness. The number of times the concentration reaches the STEL and the amount of time between these occurrences can also be restricted.

3) Ceiling (C) exposure limit is the concentration which should not be exceeded at any time.

SKIN notation (SKIN) means that contact with the skin, eyes and moist tissues (for example, the mouth) can contribute to the overall exposure. The purpose of this notation is to suggest that measures be used to prevent absorption by these routes; for example, the use of protective gloves. If absorption occurs through the skin, then the airborne exposure limits are not relevant.

EXTINGUISHING MEDIA

Extinguishing media are agents which can put out fires involving the material. Common extinguishing agents are water, carbon dioxide, dry chemical, "alcohol" foam, and halogenated gases (Halons). It is important to know which extinguishers can be used so they can be made available at the worksite. It is also important to know which agents cannot be used since an incorrect extinguisher may not work or may create a more hazardous situation. If several materials are involved in a fire, an extinguisher effective for all of the materials should be used.

FDA

FDA stands for the Food and Drug Administration (U.S.).

FETOTOXIC, FETOTOXICITY

Fetotoxic means the substance is harmful to the fetus/foetus. Fetotoxicity describes the ability of a substance to harm the fetus. (See also Embryotoxicity, Teratogenicity and Reproductive Effects.)

FETUS/FOETUS

A fetus is an organism in the later stages of development prior to birth. In humans, it is the unborn child from the end of the second month of pregnancy to birth. (See also Embryo.)

FIRST AID

First aid is emergency care given immediately to an injured person. The purpose of first aid is to minimize injury and future disability. In serious cases, first aid may be necessary to keep the victim alive.

FLAMMABLE, FLAMMABILITY

Flammable means able to ignite and burn readily. Flammability is the ability of a material to ignite and burn readily. (See also Combustible.) Under the Canadian Controlled Products Regulations and the U.S. HAZCOM Standard, there are specific technical criteria for identifying flammable materials. (See Flammable Aerosol, Flammable Gas, Flammable Liquid, Flammable Solid and Reactive Flammable Material.)

There are closely related criteria for the classification of certain flammable materials under the Canadian Transportation of Dangerous Goods (TDG) Regulations and the U.S. Department of Transportation regulations. (See TDG Flammability Classification.) In Canada, at least, local, provincial and national fire codes also classify and regulate the use of flammable materials in workplaces. (See also Combustible.)

FLAMMABLE AEROSOL

Under the Canadian Controlled Products Regulations, a material is identified as a flammable aerosol if it is packaged in an aerosol container which can release a flammable material. A flammable aerosol is hazardous because it may form a torch (explosive ignition of the spray) or because a fire fueled by the flammable aerosol may flash back.

The U.S. OSHA HAZCOM Standard has a specific definition. Refer to the regulations for detailed information.

FLAMMABLE AND COMBUSTIBLE MATERIAL
Under the Canadian Controlled Products Regulations, a material may be classified as a flammable and combustible material if it meets specific criteria for a flammable gas, flammable liquid, combustible liquid, flammable solid, flammable aerosol or reactive flammable material.
FLAMMABLE GAS
A flammable gas is a gas which can ignite readily and burn rapidly or explosively. Under the Canadian Controlled Products Regulations and under the US Hazard Communication Standard, there are certain technical criteria for the identification of materials as flammable gases for the purposes of each regulation. Flammable gases can be extremely hazardous in the workplace.
FLAMMABLE LIMITS
See Explosive Limits.
FLAMMABLE LIQUID
A flammable liquid gives off a vapour which can be readily ignited at normal working temperatures. Under the Canadian Controlled Products Regulations, a flammable liquid is a liquid with a flash point (using a closed cup test) below 37.8 degrees C (100 degrees F). The US Hazard Communication Standard uses a similar, but not identical, definition.
Flammable liquids can be extremely hazardous in the workplace; for example:
- If there is inadequate ventilation, vapours can travel considerable distances to a source of ignition and flash back to the flammable liquid.
- It may be difficult to extinguish a burning flammable liquid with water because water may not be able to cool the liquid below its flash point.
FLAMMABLE SOLID
A flammable solid is a material which can ignite readily and burn vigorously and persistently. There are certain technical criteria in the Canadian Controlled Products Regulations and in the US OSHA Hazard Communication Standard for the identification of flammable solids for the purposes of each regulation. These criteria are based on ease of ignition and rate of burning. Flammable solids may be hazardous because heat from friction (for example, surfaces rubbing together) or heat from processing may cause a fire. Flammable solids in the form of a dust or powder may be particularly hazardous because they may explode if ignited.
FLASH BACK
Flash back occurs when a trail of flammable gas, vapour or aerosol is ignited by a distant spark, flame or other source of ignition. The flame then travels back along the trail of gas, vapour or aerosol to its source. A serious fire or explosion could result.
FLASH POINT
The flash point is the lowest temperature at which a liquid or solid gives off enough vapour to form a flammable air-vapour mixture near its surface. The lower the flash point, the greater the fire hazard. The flash point is an approximate value and should not be taken as a sharp dividing line between safe and hazardous conditions. The flash point is determined by a variety of test methods which give different results. Two types of methods are abbreviated as OC (open cup) and CC (closed cup).
FREEZING POINT
See Melting Point.
FUMES
Fumes are very small, airborne, solid particles formed by the cooling of a hot vapour. For example, a hot zinc vapour may form when zinc-coated steel is welded. The vapour then condenses to form fine zinc fume as soon as it contacts the cool surrounding air. Fumes are smaller than dusts and are more easily breathed into the lungs.
GAS
A gas is a material without a specific shape or volume. Gases tend to occupy an entire space uniformly at normal room pressure and temperature. The terms vapour and fume are sometimes confused with gas.
GENERAL VENTILATION
As used in an MSDS, general ventilation, also known as dilution ventilation, is the removal of contaminated air from the general area and the bringing in of clean air. This dilutes the amount of contaminant in the work environment. General ventilation is usually suggested for non-hazardous materials. (See also Mechanical Ventilation, Local Exhaust Ventilation and Ventilation.)
GI
GI stands for gastrointestinal (relating to the stomach and intestines).
HAZARD, HAZARDOUS
Hazard is the potential for harmful effects. Hazardous means potentially harmful. The hazards of a material are evaluated by examining the properties of the material, such as toxicity, flammability and chemical reactivity, as well as how the material is used. How a material is used can vary greatly from workplace to workplace and, therefore, so can the hazard.
In Canada and the U.S., the term hazardous is used by many different regulatory agencies. Definitions may vary. For example, OSHA defines a hazardous chemical as any chemical which is a physical hazard or a health hazard according to the OSHA Hazard Communication (Hazcom) criteria.

HAZARDOUS COMBUSTION PRODUCTS
Hazardous combustion products are chemicals which may be formed when a material burns. These chemicals may be toxic, flammable or have other hazards. The chemicals released and their amounts vary, depending upon conditions such as the temperature and the amount of air (or more specifically, oxygen) available. The combustion chemicals may be quite different from those formed by heating the same material during processing (thermal decomposition products). It is important to know which chemicals are formed by hazardous combustion in order to plan the response to a fire involving the material.

HAZARDOUS DECOMPOSITION PRODUCTS
Hazardous decomposition products are formed when a material decomposes (breaks down) because it is unstable, or reacts with common materials such as water or oxygen (in air). This information should be considered when planning storage and handling procedures.

HAZARDOUS INGREDIENT
Under the Canadian Hazardous Products Act, a chemical must be listed in the Hazardous Ingredients Section of an MSDS if:
- it meets the criteria for a controlled product;
- it is on the Ingredient Disclosure List;
- there is no toxicological information available; or
- the supplier has reason to believe it might be hazardous.

Certain chemicals may be exempt from disclosure on an MSDS if they meet specific criteria set out in the Hazardous Materials Information Review Act.

HAZCOM
HAZCOM stands for the Hazard Communication Standard (U.S.) (29CFR1910.1200).

HEPATOTOXIN
Hepatotoxins are agents that can cause toxic effects on the liver.

HIGHLY TOXIC
Under the U.S. OSHA HAZCOM Standard, there are specific criteria for materials which must be identified as toxic. The corresponding term under Canadian WHMIS is "Very Toxic" (criteria are not the same).

HR
HR stands for hour.

IARC
IARC stands for the International Agency for Research on Cancer. IARC evaluates information on the carcinogenicity of chemicals, groups of chemicals and chemicals associated with certain industrial processes. IARC has published lists of chemicals which are generally recognized as human carcinogens, probable human carcinogens or carcinogens in animal tests.

IATA
IATA stands for International Air Transport Association.

IDLH
IDLH stands for Immediately Dangerous to Life or Health. For the purposes of respirator selection, NIOSH defines the IDLH concentration as the airborne concentration that poses a threat of exposure to airborne contaminants when that exposure is likely to cause death or immediate or delayed permanent adverse health effects or prevent escape from such an environment. The purpose of establishing an IDLH exposure concentration is to ensure that the worker can escape from a given contaminated environment in the event of failure of the respiratory protection equipment. In the event of failure of respiratory protective equipment, every effort should be made to exit immediately.

IMPERVIOUS
On an MSDS, impervious is a term used to describe protective gloves and other protective clothing. If a material is impervious to a chemical, then that chemical cannot readily penetrate through the material or damage the material. Different materials are impervious (resistant) to different chemicals. No single material is impervious to all chemicals. If an MSDS recommends wearing impervious gloves, you need to know the type of material from which the gloves should be made. For example, neoprene gloves are impervious to butyl alcohol but not to ethyl alcohol.

INCOMPATIBLE MATERIALS
Incompatible materials can react with the product or with components of the product and may:
- destroy the structure or function of a product;
- cause a fire, explosion or violent reaction; or
- cause the release of hazardous chemicals.

INERT INGREDIENT
An inert ingredient is anything other than the active ingredient of a product. It may be a solvent, colorant, filler or dispersing agent. In some cases, inert ingredients may be hazardous.

INGESTION
Ingestion means taking a material into the body by mouth (swallowing).

INHALATION
Inhalation means taking a material into the body by breathing it in.

IRRITANCY, IRRITATION
Irritancy is the ability of a material to irritate the skin, eyes, nose, throat or any other part of the body that it contacts. Signs and symptoms of irritation include tearing in the eyes and reddening, swelling, itching and pain of the affected part of the body.
Irritancy is often described as mild, moderate or severe, depending on the degree of irritation caused by a specific amount of the material. Irritancy may also be described by a number on a scale of 0 to 4, where 0 indicates no irritation and 4 means severe irritation. Irritancy is usually determined in animal experiments.
The Canadian Controlled Products Regulations and the U.S. OSHA Hazcom Standard describe technical criteria for identifying materials which are skin or eye irritants for the purposes of each regulation.
ISO
ISO stands for the International Standards Organization.
KG
KG stands for kilogram
LC50
LC stands for lethal concentration. LC50 is the concentration of a material in air which causes the death of 50% (one half) of a group of test animals. The material is inhaled over a set period of time, usually 1 or 4 hours. The LC50 helps determine the short-term poisoning potential of a material.
LD50
LD stands for lethal dose. LD50 is the amount of a material, given all at once, which causes the death of 50% (one half) of a group of test animals. The LD50 can be determined for any route of entry, but dermal (applied to skin) and oral (given by mouth) LD50's are most common. The LD50 is one measure of the short-term poisoning potential of a material. (See also LC50.)
LCLO
LCLO stands for lowest lethal airborne concentration tested. (See also LC50 and LD50.)
LDLO
LDLO stands for lowest lethal dose tested. (See also LC50 and LD50.)
LEL
See Explosive Limits.
LFL
See Explosive Limits.
LOCAL EXHAUST VENTILATION
Local exhaust ventilation is the removal of contaminated air directly at its source. This type of ventilation can help reduce worker exposure to airborne materials more effectively than general ventilation. This is because it does not allow the material to enter the work environment. It is usually recommended for hazardous airborne materials. (See also Mechanical Ventilation and Ventilation.)
LOWER EXPLOSION LIMIT
See Explosive Limits.
LOWER EXPLOSIVE LIMIT
See Explosive Limits.
LOWER FLAMMABLE LIMIT
See Explosive Limits.
MATERIAL CAUSING IMMEDIATE AND SERIOUS TOXIC EFFECTS
The Canadian Controlled Products Regulations describe technical criteria for identifying materials which cause immediate and serious toxic effects. These criteria use information such as the LD50 or LC50 for a material. Based on the specific information, a material may be identified as toxic or very toxic in the class Poisonous and Infectious Material.
MATERIAL CAUSING OTHER TOXIC EFFECTS
The Canadian Controlled Products Regulations describe technical criteria for identifying materials which cause toxic effects such as skin or respiratory sensitization, mutagenicity and carcinogenicity. Based on the specific information, a material may be identified as toxic or very toxic in the class Poisonous and Infectious Material.
MEANS OF EXTINCTION
See Extinguishing Media.
MECHANICAL VENTILATION
Mechanical ventilation is the movement of air by mechanical means (for example, a wall fan). There are two kinds of mechanical ventilation: general ventilation and local exhaust ventilation. (See also Ventilation.)
MELTING POINT
The melting point is the temperature at which a solid material becomes a liquid. The freezing point is the temperature at which a liquid material becomes a solid. Usually one value or the other is given on the MSDS.
It is important to know the freezing or melting point for storage and handling purposes. For example, a frozen or melted material may burst a container. As well, a change of physical state could alter the hazards of the material.
mg/m3
The abbreviation mg/m3 stands for milligrams (mg) of a material per cubic metre (m3) of air. It is a unit of metric

measurement for concentration (weight/volume). The concentrations of any airborne chemical can be measured in mg/m3, whether it is a solid, liquid, gas or vapour.

MIN

MIN can stand for minute or minimum.

MISCIBLE

Miscible means able to be mixed. Two liquids are said to be miscible if they are partially or completely soluble in each other. Commonly, the term miscible is understood to mean that the two liquids are completely soluble in each other. (See also Solubility.)

MIST

A mist is a collection of liquid droplets suspended in air. A mist can be formed when spraying or splashing a liquid. It can also be formed when a vapour condenses into liquid droplets in the air. (See also Aerosol.)

ML

ML stands for millilitres (mL).

mm Hg

The abbreviation mm Hg stands for millimeters (mm) of mercury (Hg). It is a common unit of measurement for the pressure exerted by gases such as air. Normal atmospheric pressure is 760 mm Hg.

MOLECULAR FORMULA

See Chemical Formula.

MOLECULAR WEIGHT

The molecular weight of a chemical is a number showing how heavy one molecule (or unit) of the chemical is compared to the lightest element, hydrogen, which has a weight of 1. The molecular weight has various technical uses, such as calculating conversions from parts per million (ppm) to milligrams per cubic metre (mg/m3) in air.

MUTAGEN, MUTAGENIC, MUTAGENICITY

A mutagen is a substance which can cause changes in the DNA of cells (mutations). Mutagenic means able to cause mutations. Mutagenicity is the ability of a substance to cause mutations.

DNA determines the characteristics that children inherit from their parents. DNA also determines how cells in the body divide or reproduce.

A number of mutagenicity tests are used to screen chemicals for possible carcinogenicity or reproductive effects. This is because there is some evidence that mutations may increase the risk of cancer and reproductive problems such as infertility or birth defects. However, mutagenicity test results are not very reliable predictors of these effects. One reason for this is that the human body can repair mutations while most mutagenicity tests cannot.

Mutagenicity is included on MSDSs because it is an early indicator of potential hazard, and often there is very little other evidence available on possible carcinogenic or reproductive effects. The Canadian Controlled Products Regulations describes technical criteria for identifying materials which are mutagenic. The U.S. OSHA HAZCOM Standard includes mutagenic effects as reproductive target organ effects.

NA NUMBER

See UN Number.

NATURAL VENTILATION

Natural ventilation is a type of general ventilation which depends on natural instead of mechanical means for air movement. Natural ventilation can depend on the wind or the difference in temperature from one area to another to move air through a building. Therefore, it is unpredictable and unreliable. (See also Local Exhaust Ventilation, Mechanical Ventilation and Ventilation.)

NEPHROTOXINS

Nephrotoxins are agents that can cause toxic effects on the kidney.

NEUROTOXINS

Neurotoxins are agents that can cause toxic effects on the nervous system.

NFPA

NFPA stands for National Fire Protection Association (U.S.).

NIOSH

NIOSH stands for National Institute for Occupational Safety and Health. NIOSH is a branch of the United States government which undertakes research and develops occupational health and safety standards.

NOEL

NOEL stands for No Observable Effect Level.

NOS

NOS stands for not otherwise specified.

NUISANCE DUST, NUISANCE PARTICULATE (see Particulates Not Otherwise Classified) Nuisance particulate is a term used historically by the ACGIH to describe airborne materials (solids and liquids) which have little harmful effect on the lungs and do not produce significant disease or harmful effects when exposures are kept under reasonable control. Nuisance particulates may also be called nuisance dusts. High levels of nuisance particulates in the air may reduce visibility and can get into the eyes, ears and nose. Removal of this material by washing or rubbing may cause irritation.

OC
OC stands for open cup.
ODOUR THRESHOLD
The odour threshold is the lowest concentration of a chemical in air that is detectable by smell. The odour threshold should only be regarded as an estimate. This is because odour thresholds are commonly determined under controlled laboratory conditions using people trained in odour recognition.
As well, in the workplace, the ability to detect the odour of a chemical varies from person to person and depends on conditions such as the presence of other odorous materials.
Odour cannot be used as a warning of unsafe conditions since workers may become used to the smell (adaptation), or the chemical may numb the sense of smell, a process called olfactory fatigue. However, if the odour threshold for a chemical is well below its exposure limit, odour can be used to warn of a problem with your respirator.
OECD
OECD stands for Organization for Economic Cooperation and Development. The OECD is an international agency which supports programs designed to facilitate trade and development.
The OECD has published "Guidelines for Testing of Chemicals." These guidelines contain recommended procedures for testing chemicals for toxic and environmental effects and for determining physical and chemical properties.
OEL
OEL stands for Occupational Exposure Limit. (See Exposure Limits for a general explanation.)
OSHA
OSHA stands for Occupational Safety and Health Administration. It is the branch of the United States government which sets and enforces occupational health and safety regulations. For example, OSHA sets the legal exposure limits in the United States, which are called Permissible Exposure Limits (PELs). OSHA also specifies what information must be given on labels and Material Safety Data Sheets for materials which have been classified as hazardous using their criteria.
OXIDIZING AGENT, OXIDIZING MATERIAL
An oxidizing agent or material gives up oxygen easily or can readily oxidize other materials. Examples of oxidizing agents are oxygen, chlorine and peroxide compounds. These chemicals will support a fire and are highly reactive. Under the Canadian Controlled Products Regulations and under the U.S. OSHA Hazcom Standard, there are specific criteria for the classification of materials as oxidizing materials.
PARTITION COEFFICIENT
See Coefficient of Oil/Water Distribution.
PEL
PEL stands for Permissible Exposure Limit. PELs are legal limits in the United States set by the Occupational Safety and Health Administration (OSHA). (See Exposure Limits for a general explanation.)
PENSKY-MARTENS CLOSED CUP
Pensky-Martens Closed Cup (PMCC) is a specific method for determining flash points.
PERSONAL PROTECTIVE EQUIPMENT
Personal protective equipment is clothing or devices worn to help isolate a person from direct exposure to a hazardous material or situation. Recommended personal protective equipment is often listed on an MSDS. This can include protective clothing, respiratory protection and eye protection.
The use of personal protective equipment is the least preferred method of protection from hazardous exposures. It can be unreliable and, if it fails, the person can be left completely unprotected. This is why engineering controls are preferred. Sometimes, personal protective equipment may be needed along with engineering controls. For example, a ventilation system (an engineering control) reduces the inhalation hazard of a chemical, while gloves and an apron (personal protective equipment) reduce skin contact. In addition, personal protective equipment can be an important means of protection when engineering controls are not practical: for example, during an emergency or other temporary conditions such as maintenance operations.
pH
The pH is a measure of the acidity or basicity (alkalinity) of a material when dissolved in water. It is expressed on a scale from 0 to 14. Roughly, pH can be divided into the following ranges:

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pH 0 - 2       Strongly acidic
pH 3 - 5       Weakly acidic
pH 6 - 8       Neutral
pH 9 - 11      Weakly basic
pH 12 - 14     Strongly basic
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Under the Canadian Controlled Products Regulations, materials with pH values of 0-2 or 11.5-14 may be classified corrosive. Corrosive materials must be stored and handled with great care.
PIN
See UN Number.
PMCC
See Pensky-Martens Closed Cup

POISONOUS AND INFECTIOUS MATERIAL
Under the Canadian Controlled Products Regulations, a Poisonous and Infectious Material is any material which meets the criteria for a Material Causing Immediate and Serious Toxic Effects, a Material Causing Other Toxic Effects, or a Biohazardous Infectious Material.
POLYMER
A polymer is a natural or man-made material formed by combining units, called monomers, into long chains. The word polymer means many parts. Examples of polymers are starch (which has many sugar units), polyethylene (which has many ethylene units) and polystyrene (which has many styrene units).
Most man-made polymers have low toxicity, low flammability and low chemical reactivity. In these ways, polymers tend to be less hazardous than the chemicals (monomers) from which they are made.
POLYMERIZE, POLYMERIZATION
Polymerization is the process of forming a polymer by combining large numbers of chemical units or monomers into long chains. Polymerization can be used to make some useful materials. However, uncontrolled polymerization can be extremely hazardous. Some polymerization processes can release considerable heat, can generate enough pressure to burst a container or can be explosive. Some chemicals can polymerize on their own without warning. Others can polymerize upon contact with water, air or other common chemicals. Inhibitors are normally added to products to reduce or eliminate the possibility of uncontrolled polymerization. Most MSDSs have a section called "Hazardous Polymerization" which indicates whether hazardous polymerization reactions can occur.
ppb
ppb stands for parts per billion.
ppm
The abbreviation ppm stands for parts per million. It is a common unit of concentration of gases or vapour in air. For example, 1 ppm of a gas means that 1 unit of the gas is present for every 1 million units of air. One ppm is the same as 1 minute in 2 years or 1 cent in $10,000.
PROCESS ENCLOSURE
As used on an MSDS, process enclosure means that the operation in which the material is used is completely enclosed. A physical barrier separates the worker from the potential health or fire hazard. Process enclosure is usually recommended if the material is very toxic or flammable.
PSI
PSI stands for pounds per square inch and is a unit of pressure.
PYROPHORIC
Pyrophoric chemicals are defined in the U.S. OSHA Hazcom Standard as chemicals which will ignite spontaneously in air at a temperature of 130 degrees F (54.4 degrees C) or below. Regulatory definitions in other jurisdictions may differ.
RCRA
RCRA stands for Resource Conservation and Recovery Act (U.S.) It is a statute regulating waste that is administered by the U.S. EPA.
REACTIVE FLAMMABLE MATERIAL
Under the Canadian Controlled Products Regulations, a reactive flammable material is a material which is a dangerous fire risk because it can react readily with air or water. This category includes any material which:
- is spontaneously combustible, that is, a material which can react with air until enough heat builds up that it begins to burn;
- can react vigorously with air under normal conditions without actually catching fire;
- gives off dangerous quantities of flammable gas on reaction with water; or
- becomes spontaneously combustible when it contacts water or water vapour.

Reactive flammable materials must be kept dry and isolated from oxygen (in air) or other oxidizing agents. Therefore, they are often stored and handled in an atmosphere of unreactive gas, such as nitrogen or argon.
RELATIVE DENSITY
See Specific Gravity.
REPRODUCTIVE EFFECTS
Reproductive effects are problems in the reproductive process which may be caused by a substance. Possible reproductive effects include reduced fertility in the male or female, menstrual changes, miscarriage, embryotoxicity, fetotoxicity, teratogenicity, or harmful effects to the nursing infant from chemicals in breast milk.
Most chemicals can cause reproductive effects if there is an extremely high exposure. In these cases, the exposed person would experience other noticeable signs and symptoms caused by the exposure. These signs and symptoms act as a warning of toxicity. Chemicals which cause reproductive effects in the absence of other significant harmful effects are regarded as true reproductive hazards. Very few workplace chemicals are known to be true reproductive hazards.
REPRODUCTIVE TOXICITY
The Canadian Controlled Products Regulations describe technical criteria for identifying materials which have reproductive toxicity. These criteria refer to adverse effects on fertility. (See also Reproductive Effects.) Other jurisdictions likely have corresponding criteria, which may differ.
Under the U.S. OSHA HAZCOM Standard, Reproductive Toxicity is a Target Organ Effect, and includes mutagens, embryotoxins, teratogens and reproductive toxins.

RESPIRATORY SENSITIZATION
See Sensitization.
RTECS
RTECS stands for Registry of Toxic Effects of Chemical Substances.
SARA
SARA stands for Superfund Amendments and Reauthorization Act of 1986 (U.S.).
SEC
SEC stands for second or section.
SENSITIZATION
Sensitization is the development, over time, of an allergic reaction to a chemical. The chemical may cause a mild response on the first few exposures but, as the allergy develops, the response becomes worse with subsequent exposures. Eventually, even short exposures to low concentrations can cause a very severe reaction.
There are two different types of occupational sensitization: skin and respiratory. Typical symptoms of skin sensitivity are swelling, redness, itching, pain, and blistering. Sensitization of the respiratory system may result in symptoms similar to a severe asthmatic attack. These symptoms include wheezing, difficulty in breathing, chest tightness, coughing and shortness of breath.
The Canadian Controlled Products Regulations and the U.S. OSHA HAZCOM Standard describe technical criteria for identifying materials which are respiratory tract sensitizers or skin sensitizers.
SKIN NOTATION
See Exposure Limits for a general explanation.
SOLUBILITY
Solubility is the ability of a material to dissolve in water or another liquid. Solubility may be expressed as a ratio or may be described using words such as insoluble, very soluble or miscible.
Often, on an MSDS, the "Solubility" section describes solubility in water since water is the single most important industrial solvent. Solubility information is useful for planning spill clean-up and fire fighting procedures.
SOLVENT
A solvent is a material, usually a liquid, which is capable of dissolving another chemical. Chemicals commonly called solvents can dissolve many different chemicals. Examples of common solvents are water, ethanol, acetone, hexane and toluene.
SPECIFIC GRAVITY
Specific gravity is the ratio of the density of a material to the density of water. The density of water is about 1 gram per cubic centimetre (g/cc). Materials which are lighter than water (specific gravity less than 1.0) will float. Most materials have specific gravities exceeding 1.0, which means they are heavier than water and so will sink. Knowing the specific gravity is important for planning spill clean-up and fire fighting procedures. For example, a light flammable liquid such as gasoline may spread and, if ignited, burn on top of a water surface.
STABILITY
Stability is the ability of a material to remain unchanged in the presence of heat, moisture or air. An unstable material may decompose, polymerize, burn or explode under normal environmental conditions. Any indication that the material is unstable gives warning that special handling and storage precautions may be necessary.
STEL
STEL stands for Short-Term Exposure Limit. (See Exposure Limits for a general explanation.)
STP
STP stands for Standard Temperature and Pressure (0 degrees Celsius and one atmosphere pressure).
SYNERGISTIC, SYNERGISM
As used on an MSDS, synergism means that exposure to more than one chemical can result in health effects greater than expected when the effects of exposure to each chemical are added together. Very simply, it is like saying 1 + 1 = 3. When chemicals are synergistic, the potential hazards of the chemicals should be re-evaluated, taking their synergistic properties into consideration.
SYNONYMS
Synonyms are alternative names for the same chemical. For example, methanol and methyl hydrate are synonyms for methyl alcohol. Synonyms may help in locating additional information on a chemical.
TARGET ORGAN EFFECTS
Under the U.S. OSHA HAZCOM Standard, chemicals are identified as having target organ effects if there is statistically significant evidence of an acute or chronic health effect determined in a scientifically valid study. The following agents would be included (note, the list is not all- inclusive): hepatotoxins, agents which damage the lungs (including irritants), agents which act on the hematopoietic system, neurotoxins, nephrotoxins, reproductive toxins (mutagens, embryotoxins, teratogens and reproductive toxins), cutaneous hazards (chemicals which affect the dermal layer of the skin) and eye hazards (chemicals which affect the eye or visual capacity). There are no maximum dose criteria for chronic toxicity studies, as specified in the Canadian Controlled Products Regulations.
TCC
TCC stands for Tagliabue closed cup; a standard method of determining flash points. Generally, this appears in abbreviated form as Tag closed cup.

TCLO
TCLO stands for lowest toxic airborne concentration tested (see also LCLO and LC50).
TDG
TDG stands for Transportation of Dangerous Goods. In Canada, the transportation of potentially hazardous materials is regulated under the federal Transportation of Dangerous Goods Act and Regulations which are administered by Transport Canada. The TDG Act and Regulations set out criteria for the classification of materials as dangerous goods and state how these materials must be packaged and shipped.
TDG FLAMMABILITY CLASSIFICATION
Under the Canadian TDG Act and Regulations, chemicals are classified as flammable materials if they have certain properties. Consult the regulation for detailed information.
TDLO
TDLO stands for lowest toxic dose tested (see also LDLO and LD50).
TERATOGEN, TERATOGENIC, TERATOGENICITY
A teratogen is a substance which can cause birth defects. Teratogenic means able to cause birth defects. Teratogenicity is the ability of a chemical to cause birth defects. Teratogenicity results from a harmful effect to the embryo or the fetus/foetus.
The Canadian Controlled Products Regulations describe technical criteria for identifying materials which have teratogenicity and embryotoxicity. (See also Reproductive Effects.) Other jurisdictions may also have defined specific criteria.
Under the U.S. OSHA HAZCOM Standard, materials which have teratogenic effects are included under reproductive Target Organ Effects.
THERMAL DECOMPOSITION PRODUCTS
Thermal decomposition products are chemicals which may be formed when the material is heated but does not burn. These chemicals may be toxic, flammable or have other hazards. The chemicals released and their amounts vary depending upon conditions such as the temperature. The thermal decomposition products may be quite different from the chemicals formed by burning the same material (hazardous combustion products). It is important to know which chemicals are formed by thermal decomposition because this information is used to plan ventilation requirements for processes where a material may be heated.
TLV
TLV stands for Threshold Limit Value. It is the occupational exposure limit established by the American Conference of Governmental Industrial Hygienists (ACGIH). TLV is a registered trademark of ACGIH. TLVs are adopted by some governments as their legal limits. (See Exposure Limits for a general explanation.)
TLV-C
TLV-C stands for the ACGIH Threshold Limit Value-Ceiling. See also TLV.
TOC
TOC stands for Tagliabue open cup; a standard method of determining flash points. Generally, this appears in abbreviated form as Tag open cup.
TOXIC, TOXICITY
Toxic means able to cause harmful health effects. Toxicity is the ability of a substance to cause harmful health effects. Descriptions of toxicity (e.g. low, moderate, severe, etc.) depend on the amount needed to cause an effect or the severity of the effect.
Under the Canadian Controlled Products Regulations and the U.S. OSHA HAZCOM Standard, there are specific technical criteria for identifying a material as toxic for the purpose of each regulation. (See also Very Toxic and Highly Toxic.)
TRADE NAME
A trade name is the name under which a product is commercially known. Some materials are sold under common names, such as Stoddard solvent or degreaser, or internationally recognized trade names, like Varsol. Trade names are sometimes identified by symbols such as (R) or (TM).
TSCA
TSCA stands for Toxic Substances Control Act (U.S.).
TWA
TWA stands for Time-Weighted Average. (See Exposure Limits for a general explanation.)
UEL
See Explosive Limits.
UFL
See Explosive Limits.
uG
uG stands for microgram, a unit of mass.
UN NUMBER
UN number stands for United Nations number. The UN number is a four-digit number assigned to a potentially hazardous material (such as gasoline, UN 1203) or class of materials (such as corrosive liquids, UN 1760). These numbers are used by firefighters and other emergency response personnel for identification of materials during

transportation emergencies. UN (United Nations) numbers are internationally recognized. NA (North American) numbers are used only for shipments within Canada and the United States. PINs (Product Identification Numbers) are used in Canada. UN, NA and PIN numbers have the same uses.

UNSTABLE (REACTIVE)

Under the U.S. OSHA HAZCOM standard, a chemical is identified as unstable (reactive) if in the pure state, or as produced or transported, it will vigorously polymerize, decompose, condense, or will become self-reactive under conditions of shock, pressure or temperature.

UPPER EXPLOSION LIMIT

See Explosive Limits.

UPPER EXPLOSIVE LIMIT

See Explosive Limits.

UPPER FLAMMABLE LIMIT

See Explosive Limits.

USEPA

See EPA.

VAPOUR

A vapour is the gaseous form of a material which is normally solid or liquid at room temperature and pressure. Evaporation is the process by which a liquid is changed into a vapour. Sublimation is the process by which a solid is changed directly into the vapour state.

VAPOUR DENSITY

Vapour density is the weight per unit volume of a pure gas or vapour. On an MSDS, the vapour density is commonly given as the ratio of the density of the gas or vapour to the density of air. The density of air is given a value of 1. Light gases (density less than 1) such as helium rise in air. If there is inadequate ventilation, heavy gases and vapours (density greater than 1) can accumulate in low-lying areas such as pits and along floors.

VAPOUR PRESSURE

Vapour pressure is a measure of the tendency of a material to form a vapour. The higher the vapour pressure, the higher the potential vapour concentration. In general, a material with a high vapour pressure is more likely to be an inhalation or fire hazard than a similar material with a lower vapour pressure.

VENTILATION

Ventilation is the movement of air. One of the main purposes of ventilation is to remove contaminated air from the workplace. There are several different kinds of ventilation. (See General Ventilation, Local Exhaust Ventilation, Mechanical Ventilation and Natural Ventilation.)

More detailed information is available in the CCOHS publication "A Basic Guide to Industrial Ventilation."

VERY TOXIC

Under the Canadian Controlled Products Regulations, there are specific technical criteria for identifying a very toxic material. There are specific criteria for short-term lethality, long-term toxicity, teratogenicity and embryotoxicity, reproductive toxicity, carcinogenicity, respiratory sensitization and mutagenicity. (See also Toxic.)

VOC

VOC stands for volatile organic compound.

VOLATILE, VOLATILITY

Volatile means a material can evaporate. Volatility is the ability of a material to evaporate. The term volatile is commonly understood to mean that a material evaporates easily.

On an MSDS, volatility is commonly expressed as the "% volatile." The percent volatile can vary from 0% (none of the material will evaporate) to 100% (all of the material will evaporate if given enough time).

If a product contains volatile ingredients, there may be a need for ventilation and other precautions to control vapour concentrations.

WATER REACTIVE

Under the U.S. OSHA HAZCOM standard, a chemical is identified as water reactive if it reacts with water to release a gas that is either flammable or presents a health hazard.

WHMIS

WHMIS stands for Workplace Hazardous Materials Information System. It is a Canadian program designed to protect workers by providing them and their employers with vital information about hazardous materials. The following are key features of WHMIS:

- Criteria to identify controlled products and to provide information about them in the workplace;
- A cautionary labelling system for containers of controlled products;
- Requirements for the disclosure of information by the use of material safety data sheets;
- Worker education programs;
- A mechanism to protect trade secrets.

WHMIS is implemented by a series of federal, provincial and territorial acts and regulations.

H. CCOHS INFORMATION GUIDE

INFORMATION PATHFINDER

CCOHS is the path to health and safety with its wealth of worldwide information!

Health & Safety Information on...	CD-ROM Products – Databases & Collections						
	MSDS plus CHEMINFO	CHEMpendium™	FTSS	OSH RESEARCHER	OSHLINE™ with NIOSHTIC®/ NIOSHTIC-2	RTECS®	
Chemicals/ Chemical Safety	CHEMINFO MSDS	CHEMINFO CHEMINDEX CESARS CHRIS DSL/NDSL HSDB® NJ HSFS NPG TRANSP. 49CFR TRANSP. TDG	FTSS (F)	CISILO ♦ HSELINE ♦ CANADIANA INRS- BIBLIO ♦(F)	OSHLINE™ NIOSHTIC® NIOSHTIC-2♦	RTECS®	
Pesticides	CHEMINFO MSDS	CHEMINFO CESARS HSDB®	FTSS (F)		OSHLINE™ NIOSHTIC® NIOSHTIC-2♦	RTECS®	
Emergency Response	CHEMINFO MSDS	CHEMINFO CHRIS HSDB® TRANSP. 49CFR TRANSP. TDG	FTSS (F)				
Environment	MSDS	CESARS HSDB®	FTSS (F)	CISILO ♦ HSELINE ♦ CANADIANA INRS- BIBLIO ♦(F)	OSHLINE™ NIOSHTIC® NIOSHTIC-2♦	RTECS®	
Toxicology	CHEMINFO	CHEMINFO CESARS HSDB® NJ HSFS		HSELINE ♦ CANADIANA	OSHLINE™ NIOSHTIC® NIOSHTIC-2♦	RTECS®	
Occupational Hygiene	CHEMINFO MSDS	CHEMINFO CHRIS HSDB® NJ HSFS NPG *	FTSS (F)	CISILO ♦ HSELINE ♦ CANADIANA	OSHLINE™ NIOSHTIC® NIOSHTIC-2♦	RTECS®	
Transportation Of Dangerous Goods	CHEMINFO MSDS	CHEMINFO HSDB® TRANSP. 49CFR TRANSP. TDG	FTSS (F)			RTECS®	
Regulations/ Legislation	CHEMINFO	CHEMINFO DSL/NDSL HSDB® TRANSP. 49CFR TRANSP. TDG		CISILO ♦ HSELINE ♦		RTECS®	
Physical Hazards/ Safety				CISILO ♦ HSELINE ♦ CANADIANA INRS- BIBLIO ♦(F)	OSHLINE™ NIOSHTIC® NIOSHTIC-2♦		
Ergonomics				CISILO ♦ HSELINE ♦ CANADIANA INRS- BIBLIO ♦(F)	OSHLINE™ NIOSHTIC® NIOSHTIC-2♦		

Detailed information about individual products is provided in the CCOHS Catalogue of Products and Services, database fact sheets, and from the CCOHS Web Site -- www.ccohs.ca.

LEGEND: **Type of information:** direct/full text data, bibliographic (♦), or directory (#). French data (F).

(As of: October 2003)

INFORMATION PATHFINDER

CCOHS is the path to health and safety with its wealth of worldwide information!

Health & Safety Information on...	CD-ROM Products – Databases & Collections				
	Canadian *enviro*OSH Legislation (Also available as regional discs)	Legislation Plus Standards (Also available as regional discs)	IPCS INTOX CD-ROM	IPCS INCHEM CD-ROM	
Chemicals/ Chemical Safety			International data for the prevention of and response to poisoning	Consolidation of international data for the sound management of chemicals	
Pesticides			International data for the prevention of and response to poisoning	Consolidation of international data for the sound management of chemicals	
Emergency Response			International data for the prevention of and response to poisoning	Consolidation of international data for the sound management of chemicals	
Environment	All Canadian (Fed. & Prov.) Health, Safety, & Environmental Legislation	CSA & CGSB Standards All Canadian (Fed. & Prov.) Health, Safety, & Environmental Legislation	International data for the prevention of and response to poisoning	Consolidation of international data for the sound management of chemicals	
Toxicology			International data for the prevention of and response to poisoning	Consolidation of international data for the sound management of chemicals	
Occupational Hygiene			International data for the prevention of and response to poisoning	Consolidation of international data for the sound management of chemicals	
Transportation Of Dangerous Goods	All Canadian (Fed. & Prov.) Health, Safety, & Environmental Legislation	CSA & CGSB Standards All Canadian (Fed. & Prov.) Health, Safety, & Environmental Legislation			
Regulations/ Legislation	All Canadian (Fed. & Prov.) Health, Safety, & Environmental Legislation	CSA & CGSB Standards All Canadian (Fed. & Prov.) Health, Safety, & Environmental Legislation		Consolidation of international data for the sound management of chemicals	
Physical Hazards/ Safety				Consolidation of international data for the sound management of chemicals	

Detailed information about individual products is provided in the CCOHS Catalogue of Products and Services. database fact sheets, and from the CCOHS Web Site -- www.ccohs.ca.

LEGEND: **Type of information:** direct/full text data, bibliographic (♦), or directory (#). French data (F).

(As of: October 2003)

I. Glove Selection Guide

Gloves are probably the most commonly used type of PPE in labs. Selecting the right glove is important. You may find the following information useful in selecting the right kind of glove for your application.

Reuse

- Some gloves are designed for single use. If your lab uses disposable gloves, do not wash and re-use them, they are meant for single use.
- Your lab will have specific requirements that will dictate whether you use disposable or reusable gloves. Follow these requirements when making your choice.

Fit

- Fit is important because a glove that is too big or too small will not be worn as it should.
- Gloves that are too small will cut off circulation and be uncomfortable.
- Gloves that are too big will be cumbersome and contribute to spills and accidents.

Lining

Linings add comfort and durability to a glove; they also however, add cost. Some gloves are manufactured with a lining by necessity; here you will have no choice.

Powdering

Powdering is added to some gloves to allow them to be slipped on and off more easily. Powdering can contribute to latex sensitivity (in latex gloves) and latex protein can leach into the powder. If this powder is released into the air and inhaled by a sensitized person, results can be severe.

Thickness

Thickness of a glove influences its resistance to physical and chemical attack; in general, the thicker the glove the better the protection. Increased thickness, however, leads to decreased sensitivity and dexterity.

Material

Material selection is the most important criteria with respect to chemical resistance. See the table below as a guideline to be used in selecting materials. More information may be obtained from glove manufacturers, see them for final confirmation of material selection. Compatibility, breakthrough times, permeation rates and degradation are some factors to be considered.

Material Of Construction	Good Against	Comments	Price
Viton – Fluoroelastomer	PCBs, benzene, chlorinated and aromatic solvents, gas.	Limited physical strength but very flexible.	Very Expensive
Neoprene – Synthetic rubber	Most organic and inorganic acids, caustic, alcohols, solvents, oils.	Resistance is very dependant on method of manufacture (solvent or water dipped).	Moderately Expensive
Latex – Natural rubber	Acids, alkalis, salts, ketones.	Contain sensitizing proteins. Use only if necessary. Form fitting (elastic).	Inexpensive
Multi-Layer - Silvershield, Norfoil	Vinyl chloride, acetone, ethyl ether, superb resistance against a wide variety of compounds.	Virtually no cut resistance, lightweight, flexible.	Very Expensive
Vinyl (PVC) – Thermoplastic	Excellent resistance to most acids, and petroleum hydrocarbons.	Good abrasion resistance.	Inexpensive
Nitrile – Synthetic rubber	Good general resistance; alcohols, acids.	Good physical strength, good flexibility, form fitting.	Inexpensive

BIOLOGICAL and CHEMICAL SAFETY

Fire Department/Ambulance: 9 911

Security: 966-5555

Spills: 966-8497 or 966-8493 (after hours 966-5555)

Safety Requirements

1. **Comply with Occupational Health & Safety Act & Regulations and follow University Safety Policies and Procedures**
2. **Keep unauthorized persons out of laboratory**
3. **Keep laboratory locked when unattended**
4. **Individuals handling hazardous substances shall be trained**
5. **Follow Research Granting Agency's Condition for working with hazardous biological, chemical and physical substances**
6. **Use good laboratory practices, responsible care, and safety precautions to keep all individuals safe**

Safety Precautions

1. **Do not eat, drink, store food or smoke in laboratory**
2. **Do not pipette solutions by mouth**
3. **Wear gloves or other appropriate protective equipment when working with hazardous substances to limit exposures**
4. **Wash hands thoroughly before leaving any laboratory**
5. **Maintain an up-to-date inventory and disposal records**
6. **Keep laboratory neat and tidy**
7. **Review and monitor procedures and substitute less hazardous substances wherever possible. Minimize exposure risks by reviewing safety information (MSDS)**
8. **Use a fume hood when handling volatile, toxic or flammable chemicals and a biosafety cabinet or proper containment for infectious agents. Ensure all units are tested when new, yearly or when moved**
9. **Clearly identify working areas and equipment used for handling hazardous substances**
10. **Develop written Exposure Control Plan when working with biohazardous materials (infectious materials)**
11. **Where possible use disposable absorbent liners on trays or surfaces to contain any spills of hazardous substances**
12. **Labs using Notifiable Biologicals(GMO's) or Chemical Substances, biohazardous materials in Risk Group Level 2 or higher are to have an operating permit**
13. **"Equipment and Area Release Form" must be filled out by the lab user and attached to equipment that is serviced, sold, or relocated**
14. **Disinfect equipment and work areas after use to minimize spread of contamination**
15. **Develop an Emergency Response Plan (ERP) for spills and medical emergencies. Equipment for spill clean up must be maintained and ready**

Storage and Waste Disposal

1. **WHMIS label and date all containers and place warning signs or symbols on all hazardous storage facilities.**
2. **Handling procedures for waste shall be in accordance with University Waste Disposal Procedures Manuals. Individuals who handle, package & dispose of waste must be trained.**
3. **Ensure that procedures are in place to prevent unnecessary storage (accumulation) of substances in the laboratory, especially if the substances become unstable with time.**
4. **Store hazardous substances in compatible groups, in secure areas and in proper storage containment.**
5. **Do not dispose or release any hazardous waste to the environment (e.g. sewer)**
6. **Needles (sharps) must be put into specific puncture & leak proof waste containers. If this material is contaminated, autoclave or chemically disinfect prior to pickup**
7. **All non-incinerable sharps waste (e.g. glass, metal,) must be decontaminated prior to packaging in secure puncture proof waste containers. These can go to the normal garbage**

Spills/Incidents/Accidents

1. **Comply with your written Emergency Response Plan**
2. **Warn people in the immediate area of the situation**
3. **Take immediate steps to protect your health and safety**
4. **Exit area and obtain assistance. Post the area to restrict entry**
5. **Use proper PPE for spill clean up. If spill gets out of control call Waste Management for assistance (8497or 8493)**
6. **Fill out a Spill or Incident Report Form and/or a WCB form (if loss of work time) and return it to the HSE Department**

Laboratory Spill Response Materials

1. **Compatible absorbent material (e.g. bentonite, pads, etc.)**
2. **Inactivation or neutralizing material and warning Signs**
3. **Waste Containers, pH paper, plastic bags, tape, tweezers**
4. **Personal Protective Equipment (PPE) to protect hands, eyes, body, and respiratory system**
5. **Call Waste Management for assistance (8497 or 8493)**

Right to Know and to Refuse

Under the law, it is your right to take the time to obtain the proper training & knowledge of the substances you work with before you start to work with them. You also have the right to refuse to do hazardous work on reasonable grounds with out being discriminated against.

K. Equipment & Area Release Form

Guidelines for Cleaning Equipment or Area Destined for Release or Service

1. Objective

The objective of the Equipment or Area Release Form and guidelines are to protect the health and safety of all staff and the public at large from being exposed unnecessarily to equipment or areas that may contain hazardous biological, chemical or radioactive substances. It is hoped that the person requesting service in an area or on a piece of equipment will take the time to evaluate the associated risks from the point of view of the service technician who will be completing the work.

2. Biological Substances

The minimum for cleaning any area or equipment contaminated with biological agents is for the technical staff in the laboratory to wipe down the area or equipment with a disinfectant that is effective on that biological substance. Often 70% alcohol or javex bleach diluted 1:9 is effective. There are many other ways to disinfect areas and equipment depending on the extent of the contamination and the biological substance. The Biosafety Office (966-8496) is equipped with a paraformaldehyde gas generator for equipment that can be encapsulated to hold the gas for a period of time. The generator also neutralizes the formaldehyde gas with ammonium carbonate.

3. Chemical Substances

Technical staff is to wipe down areas or equipment to remove any surface contamination. It is costly to do quantitative measurements on any surface for chemical contamination therefore, the removal procedure must be repeated several times (3) to ensure minimum contamination. Personal protective equipment may be required in extreme cases to ensure safety.

4. Radioactive Substances

The minimum for cleaning any area or equipment contaminated with radioactive substances is for the technical staff to decontaminated the area or equipment. Wipe tests must be completed to determine if the area or equipment is free from contamination.

5. Personal Protective Equipment and Precautions

Personal protective equipment and precautions shall be taken in handling equipment or upon entering a certain area. Ask technical staff what you should wear when handling or entering the designated area to work. Always protect your eyes and hands. Wash your hands and tools upon completion of the work.

6. Consultation

The Department of Health, Safety and Environment will provide consultation if there is any unresolved safety concerns – phone 966-8493.

7. Examples

Some types of equipment that may need decontamination and/or cleaning as well as the use of personal protective equipment and good hygiene techniques are as follows. *Note:* The type of department where the equipment is used with often indicate what risks may exist.

biosafety cabinets	water baths	chemical storage cupboards	fume hoods
autoclaves	vacuum pumps	sinks and drains	incubators
pipette washers	homogenizers	cage washers	shaker units
vortexers	toilet snakes	sonicaters	centrifuges
plugged toilets	drinking troughs	washing machines	

Some types of areas that may need decontamination and/or cleaning as well as the use of personal protective equipment and good hygiene techniques are as follows:

roof venting areas	ventilation ducts	plenums	isolation rooms
animal rooms	radioactive work areas	chemical storage rooms	pits
compressor rooms	refrigeration rooms	incinerator	fume hood discharge areas

EQUIPMENT OR AREA RELEASE FORM

Work Order #: _____

Service Technician: _____

Introductory Notes:

Under the Saskatchewan Occupational Health and Safety Act and Regulations, every employer has a duty to conduct his business so as not expose persons to undue risk to their health and safety. Warnings must be given to any persons if there are likely to be any hazardous biological, chemical, or radioactive agents present in/on equipment or devices offered for service, resale or disposal.

Service staff has the right to refuse acceptance of, or service work on, any equipment or devices, which they have, reason to believe may be hazardous to their health and safety until they receive proper safety instructions. The Department of Health, Safety and Environment will provide consultation if there is any unresolved safety concerns - phone 966-8493.

Supervisors or Person-in-Charge releasing areas for service work or equipment for service, resale or disposal which by its' design may contain hazardous residues within or on its' surface shall complete an Equipment/Area Release Form. This form shall be attached to such equipment or given to the service employee.

Failure to complete this form or comply with this procedure may lead to refusal to handle the equipment for service, resale or disposal.

Equipment / Area Details:

Room # :	Building:
Description of Equipment/Area:	Model # :
	Serial # :
	University ID # :

Destination:

( ) Disposal	( ) Relocation	( ) Resale	( ) Service
Comments:			

Safety Details:

Were any hazardous substances used in this equipment or area?
( ) Biological ( ) Chemical ( ) Radioactive ( ) None
Details of any hazardous substances that could be present:

Has this equipment or area been decontaminated or purged of any hazardous substances, which could cause harm to service employees? ( ) Yes ( ) No
If yes, describe procedure:

What personal protective equipment (PPE) or precautions should be taken in handling this equipment or working in this area?
( ) gloves ( ) eye protection ( ) respiratory protection ( ) foot protection ( ) ear protection
( ) disposable coveralls ( ) other: _____

What action should be taken in the event of human contact with the hazardous substance?

Declaration:

I have decontaminated or cleaned this equipment or area specified above so that it does not present any hazard associated with hazardous substances.

Print Name:	Date:
( ) Supervisor ( ) Person-In-Charge ( ) Senior Technician	Telephone # :
Signature:	

L. Incident Report

This report is to be completed by each person involved in an incident or near miss incident while engaged in activities at, or conducting work for, the University of Saskatchewan.

Complete this report and return a copy to the Department of Health, Safety and Environment (Room 150, Research Annex or by fax to 966-8394) within 24 hours of the incident.
Definitions of terms and instructions are available on the DHSE website at: www.usask.ca/dhse.

☐ **Incident** ☐ **Near Miss Incident**

Identifying Information (complete all that apply)

Type of Occurrence	☐ Serious or Major Injury	☐ Minor Injury	☐ Exposure	☐ Spill	☐ No Loss Incident	☐ Property Damage	☐ Construction

Personal Information

Name:		**Ph. #:**	
Department:		**Location of Incident:**	
Occupation:	**Years of Job Experience:**	**Supervisor in Charge (name & ph. #):**	
Incident Date:	**Time of Incident:** **a.m. / p.m.**	**Equipment Involved:**	

Incident Information

Injury or Illness	Spill	Exposure	Other Loss Type
Nature of Illness or Injury:	**Material:**	**Material/Noise Exposed to:**	**Type:**
Object Inflicting Harm:	**Quantity:**	**Quantity:**	**Est. Cost of Loss:**
Part of Body (indicate left, right, upper, etc.):	**Reason for Spill:**	**Reason for Exposure:**	**Nature of Loss:**
Medical Attention Received: Y or N / **Days Lost: Y or N**	**Risk: High Moderate Low**	**Risk: High Moderate Low**	**Object Causing Loss:**
Additional Details Required:		**Signature:** **Date:**	

Immediate Causes (check all that apply)

Identification of Substandard Conditions

☐ **Inadequate Warning System/Alarm**	☐ **Fire or Explosion Hazard**	☐ **Congestion or Restricted Action**
☐ **Inadequate Guards or Barriers**	☐ **Poor Housekeeping**	☐ **Inadequate/Improper PPE**
☐ **Defective Tools/Equipment/Materials**	☐ **Noise**	☐ **Inadequate Ventilation**
☐ **High/Low Temperature (specify)**	☐ **Hazardous Environmental Conditions: gases, dust, smoke, vapours (specify)**	☐ **Inadequate or Excessive Illumination (specify)**
☐ **Failure of PPE**	☐ **Other (explain):**	

Specify/Explain:

Substandard Acts or Practices

☐ **Operating Equipment without Authority/ Training (specify)**	☐ **Removing or Disabling Safety Device**	☐ **Improper Placement**
☐ **Failure to Warn Others**	☐ **Using Defective Equipment**	☐ **Horseplay**
☐ **Failure to Secure**	☐ **Using Equipment Improperly**	☐ **Improper Materials Handling**
☐ **Operating at Improper Speed**	☐ **Improper Loading**	☐ **Improper Position for Task**
☐ **Failure to Follow Procedures**	☐ **Under Influence of Alcohol/Drugs (specify)**	☐ **Servicing Equipment while Operating**
☐ **Failing to Use PPE**	☐ **Other (explain):**	

Specify/Explain:

Identification of Basic Causes (check all that apply)	**Job/System Factors**	☐ Inadequate Work Standards	☐ Inadequate Supervision	☐ Inadequate Equipment	☐ Inadequate Maintenance
		☐ Inadequate Engineering	☐ Inadequate Tools	☐ Wear and Tear	☐ Abuse/Misuse
		☐ Inadequate Purchasing	☐ Other (specify)		
		Specify/Explain:			
	Personal Factors	☐ Inadequate Capability	☐ Lack of Skill	☐ Rushing	☐ Personal Challenge
		☐ Lack of Knowledge/training	☐ Stress	☐ Improper Motivation	☐ Other (specify)
		Specify/Explain:			

Identification of Contact (check all that apply)	**Type of Contact/ Exposure**	☐ Struck By/Against	☐ Poke/Puncture	☐ Caught In	☐ Fall on Same Level
		☐ Caught Between	☐ Slip/Trip	☐ Inhalation Of	☐ Fall to Below
		☐ Cut By	☐ Bit By	☐ Scratched By	☐ Other
	Contact With/ Exposure To	☐ Electricity	☐ Machinery/Equipment	☐ Harmful Substance	☐ Radiation
		☐ Biohazard	☐ Chemical	☐ Heat/Cold	☐ Structure (railing, wall)
		☐ Noise	☐ Material (specify)	☐ Object (specify)	☐ Animal (specify)
		Specify/Explain:			

Description	**Describe How the Event Occurred:**

Action Plan	**Remedial Action (list all actions to control potential future incidents based on causes):**
	Action to Be Taken (completed by Supervisor – ensure changes do not bring about new hazards):
	Immediate:
	Long Term:
	Set Target Date for Action(s): **Supervisor Signature:** **Date:**

Attach if Applicable/Available: Sketch of Site, Photograph, and/or Additional Explanation as required.

Final Review	**Concluding Reviewers Comments (to be completed by DHSE):**		
	Dangerous Occurrence? Y or N	**Date Reported to Sask.Labour:**	**SL File #:**
	Signature of Reviewer:	**Date Reviewed:**	**Follow Up Date:**
	DHSE File #:	**WCB File # (if any):**	**Date Concluded:**

M.

Safety Audit Checklist –Generic Sample

Date:_____ Area: _____

I. **Laboratory Work Practices**		Comments
✓ No smoking, food & beverages rules are observed.	Yes/No	
✓ Food and beverages are not stored in the laboratory areas, refrigerators or in glassware that is also used for laboratory operations.	Yes/No	
✓ Pipetting is performed by mechanical means.	Yes/No	
✓ Laboratory surfaces are cleaned; disinfected or decontaminated after work is performed.	Yes/No	
✓ Required PPE is being worn.	Yes/No	
✓ Used needles are stored in appropriate sharps containers		
✓ Syringes comply with modern requirements.	Yes/No	
✓ No recapping of needles is performed.	Yes/No	
✓ Hoods are not being used for storage.	Yes/No	

II. **Housekeeping**		Comments
✓ Laboratory and storage areas uncluttered and orderly (including benchtops).	Yes/No	
✓ Aisles & exits are free from obstruction.	Yes/No	
✓ Work surfaces are protected from contamination.	Yes/No	
✓ Electrical cords are in good condition and are CSA or ULC listed.	Yes/No	
✓ Tools and equipment are in good repair and electrically grounded.	Yes/No	
✓ Tops of cabinets and shelves are free from inappropriate stored items.	Yes/No	
✓ Heavy objects are confined to lower shelves.	Yes/No	
✓ Glassware is free from cracks, chips, sharp edges and other defects.	Yes/No	
✓ Broken glass containers are available and in use.	Yes/No	

III. **Personal Protective Equipment**		Comments
✓ Protective gloves are available and matched to hazards involved.	Yes/No	
✓ Eye protection is available and in use in all laboratories.	Yes/No	
✓ Lab coats, tyvek garments etc. are available and in use.	Yes/No	
✓ Lab coats are only worn in the laboratory and are removed before entering offices, lunchrooms, rest rooms, conference rooms and other non-laboratory general use areas. (This includes disposable protective clothing).	Yes/No	
✓ Dirty lab coats/uniforms are stored in a covered container until removed for laundering.	Yes/No	
✓ Appropriate protective clothing is available and in use when working with hazardous materials.	Yes/No	
✓ Respirators are provided when necessary, and selected on the basis of hazard present.	Yes/No	
✓ Respirators are used correctly, cleaned after every use and stored in a convenient, clean and sanitary area. Users have been trained.	Yes/No	

IV. **Hazard Communication**		Comments
✓ Primary & secondary transport containers are labeled with identity, appropriate hazard warnings, and expiration dates.	Yes/No	
✓ Signs on storage areas (e.g. Refrigerators) and laboratories are consistent with hazards within.	Yes/No	
✓ MSDSs are available (paper or electronic) for WHMIS agents used and stored.	Yes/No	
✓ Employees know the location of the MSDS binders for their work area.	Yes/No	
✓ Satellite MSDS collections are complete and readily available at all times to labs.	Yes/No	

V. **Chemical Storage**		Comments
✓ Incompatible materials are segregated.	Yes/No	
✓ Corrosives and flammables are stored below eye level.	Yes/No	
✓ Hazardous materials used/stored in the laboratory are limited to small quantities.	Yes/No	
✓ Unnecessary, unused, or outdated materials are removed from laboratories and chemical storage areas.	Yes/No	
✓ Safety carriers are available and in use while transporting chemicals.	Yes/No	
✓ Hazardous materials storage areas include trays, doors or lips on shelves.	Yes/No	
✓ All lab carts have side-rails.	Yes/No	
✓ All containers are properly labeled with: Name, Date, Contents, Lab #	Yes/No	

VI. **Flammable Liquids Storage & Handling**		Comments
✓ Flammable liquids are stored and used away from ignition sources.	Yes/No	
✓ Bulk quantities of flammable liquids are stored in approved storage cabinets.	Yes/No	
✓ Flammable liquid storage cabinets are properly labeled.	Yes/No	
✓ Flammable liquid storage cabinets close properly.	Yes/No	
✓ Flammables stored on open shelves in glass or plastic containers are within permissible quantities (limit =)	Yes/No	
✓ Safety cans used to handle small quantities of flammable liquids are properly labeled.	Yes/No	
✓ Solvent waste cans are labeled properly with Name, Contents, Lab #.	Yes/No	
✓ Nothing flammable is stored on top of flammable cabinets.	Yes/No	

VII. **Compressed Gas Cylinders**		Comments
✓ Gas cylinders are properly secured from falling.	Yes/No	
✓ Cylinder caps are in place when cylinders are not in use or being moved.	Yes/No	
✓ Gas cylinders are secured on carts for any transport.	Yes/No	
✓ Gas cylinders are stored away from excessive heat.	Yes/No	
✓ Flammable and toxic gas cylinders are stored in approved area and not above allowable maximums.	Yes/No	
✓ All gas cylinders are properly marked as to their contents.	Yes/No	
✓ Full and empty cylinders are stored separately.	Yes/No	
✓ Empty gas cylinders are labeled “EMPTY”.	Yes/No	
✓ Gas lines, piping, manifold, etc. are labeled with the identity of their	Yes/No	

contents.		
✓ Hoses, tubing and regulators are in good working condition.	Yes/No	

VIII. **Waste Handling: Hazardous, Non-Hazardous & Biological**		Comments
✓ No liquid waste is disposed of in the sinks or the sewer.	Yes/No	
✓ Hazardous wastes are not accumulated for longer than is necessary in the laboratory.	Yes/No	
✓ Waste streams are separated as necessary: ex. Solid vs. liquid, hazardous vs. non-hazardous, halogenated vs. non-halogenated, etc.	Yes/No	
✓ Waste containers are appropriately tagged before placing in waste room.	Yes/No	
✓ Containers of hazardous waste are labeled properly with the date and name of person discarding waste.	Yes/No	
✓ Biological waste is appropriately marked with a biohazard symbol.	Yes/No	
✓ Syringes and other sharp waste are disposed of into labeled sharps container.	Yes/No	
✓ Waste material is not allowed to accumulate on the floors, in corners or under shelves/tables in laboratories.	Yes/No	
✓ Radioactive waste is properly marked with radiation symbol.	Yes/No	

IX. **Means of Egress and Emergency**		Comments
✓ Exits are clearly marked.	Yes/No	
✓ Exits are free from obstruction.	Yes/No	
✓ All fire doors are self-closing and are kept closed.	Yes/No	
✓ A fire emergency response plan is in place and communicated.	Yes/No	
✓ Fire alarms are provided.	Yes/No	
✓ Telephones are labeled with emergency numbers.	Yes/No	
✓ Emergency evacuation routes are clearly posted.	Yes/No	
✓ Emergency evacuation routes are posted in common hallways.	Yes/No	
✓ Emergency exit lights are working and clear of obstruction.	Yes/No	
✓ Spill Response Materials and Equipment are available.	Yes/No	

X. **Safety Equipment**		Comments
✓ Safety showers and eye wash stations are located within 100' of all laboratories.	Yes/No	
✓ Safety showers and eye wash stations are clearly labeled, and these areas are clear from obstruction.	Yes/No	
✓ All showers and eye wash stations are clean, covers are replaced and they in good working condition.	Yes/No	
✓ Showers and eye washes are checked monthly and recorded. Date of last check: _____	Yes/No	
✓ Fire extinguishers are available.	Yes/No	
✓ Fire extinguishers are the appropriate type for the hazard in the work area.	Yes/No	
✓ Fire extinguishers are checked annually. Date of last check: _____	Yes/No	
✓ Fire detection devices, smoke alarms, sprinkler systems, lighted exit signs are in good working condition.	Yes/No	
✓ First-aid supplies are readily available and clearly visible.	Yes/No	
✓ Spill team list is clearly posted in laboratories.	Yes/No	

✓ Fume Hood sash and inflow checked within year	Yes/No	
✓ Biosafety Cabinet checked within year	Yes/No	
✓ Perchloric Fume Hood wash down done	Yes/No	

XI. **Other Labeling & Posting**		Comments
✓ Warning signs and labels are present whenever required (e.g. carcinogen, mutagen) where chemicals are stored.	Yes/No	
✓ "No Smoking" signs are posted in prohibited areas.	Yes/No	
✓ "Caution- Radioactive Material" signs are posted on doors of all authorized laboratories and on refrigerators/freezers where materials are stored.	Yes/No	
✓ Biohazard symbols are posted on access doors to biohazard laboratories and animal rooms and on potentially contaminated equipment.	Yes/No	

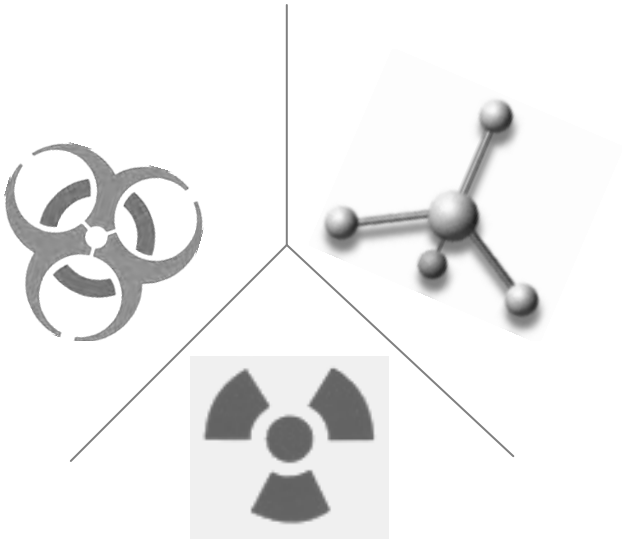
XII. **Miscellaneous & Notes**

There are more styles available at www.usask.ca/dhse

NOTES

NOTES

Hazardous Waste Disposal Manual



August 2007

Emergency Numbers

SECURITY SERVICES (24 hours) ····· 5555

Ambulance ····· 9 - 911
(if using a pay phone) ····· 911

Fire (Pull an alarm and call) ····· 9 - 911
(if using a pay phone) ····· 911

Safety Related Incidents (Mon – Fri: 8:30 to 4:30) ····· 8493

Spills (Mon – Fri: 8:30 to 4:30) ····· 8497

Department of Health, Safety and Environment

General Inquiries 8493
Fax 8394

Hazardous Waste Disposal 8497
Fax 6146

Safety Training Inquiries 8492

Biosafety 8496
Biosafety Cabinet Testing Inquiries 8510

Chemical/Environmental Safety 8512
Safety Inspections Inquiries 8738
Environmental Program Inquiries 2379

Community Safety 1957

Fire Safety 8838
Contractor Safety Inquiries 6076

Occupational Hygiene / Injury Prevention 8511

Radiation Safety 8494
Radiological Inquiries 8491

Director 8463

Health, Safety and Environment Management System Coordinator 2370

Other Essential Services

Bloodborne Pathogen Exposures (Sharps Puncture)
Department of Immunology and Infectious Disease 655-1777
Public Health Consultation 655-4620

Employee Assistance Program ····· 4300

Facilities Management (Mon – Fri: 8:00 to 4:30) ····· 4496

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1. General Information

The objective of this manual is to help you collect, segregate, handle, treat, store, transport, and dispose of all hazardous waste in a safe and efficient manner.

The University of Saskatchewan (U of S) is committed to the proper management of hazardous waste generated by research, educational and business activities. Proper management of waste will minimize the risk to the University community, the general public and the environment, and reduce the financial cost to the University.

The University provides a hazardous waste management service through the Department of Health, Safety and Environment (DHSE). The Waste Management Facility (WMF) personnel collect, process, and package hazardous waste generated at the University. Federal, Provincial, and Municipal Acts and Regulations regulate these activities.

In order to comply with the specific regulations of these acts, it is imperative that the WMF personnel know whether the waste is biological, chemical, radioactive, mixed or unusual waste. They must also have specific details regarding the waste.

All hazardous waste is University of Saskatchewan property; therefore it shall be disposed of according to the procedures outlined in this manual.

Any person (or any waste generator sending hazardous waste to an approved external waste facility, or sending waste to the University from an off campus site must be trained in accordance with the Transportation of Dangerous Goods regulations.

POLICY: Hazardous waste from University laboratories will be removed and disposed of in a safe manner: waste must be identified, segregated into compatible groups, collected in appropriate containers, labelled, and the corresponding forms filled out as per University's waste disposal procedures. DHSE reserves the right to charge a fee or decline services in the event these procedures are not followed.

2 Categories of Hazardous Waste

There are primarily four methods available for the disposal of hazardous waste: incineration, landfill, sewer dilution or shipment to an approved external waste facility. The method of disposal is determined by factors such as:

- the type of waste;
- the nature of the hazard to the public and to the environment;
- the ease of destruction of any hazard if present; and
- the volume reduction and cost of disposal.

Therefore, it is essential that each type of waste be properly segregated according to the categories listed below to ensure safe and environmentally responsible disposal of the hazardous waste.

2.1 Biohazardous Waste

A Biohazard refers to a biological substance that may pose a threat to the health and safety of humans, animals or the environment. Anything that comes in contact with a Biohazard is normally deemed contaminated. Any contaminated items must be disposed of in accordance with the Saskatchewan Biomedical Waste Guidelines. There are different methods of disposal such as: autoclaving, chemical inactivation or incineration. There are also different categories of Biohazardous waste such as: medical waste, animal carcasses, animal husbandry, laboratory waste, sharps, blood soaked towels or gauze, petri dishes, or any contaminated laboratory ware. This waste must be segregated and disposed of according to the information presented in this section.

See Appendix A for the Biological Waste Flow Chart.

2.1.1 Animal waste

Waste that is destined for incineration must not contain highly combustible materials (e.g. culture plates, gloves, test tubes) because they are not allowed to be incinerated under the permit. Therefore, it is important that animal waste be collected separately in properly labelled containers.

Definition:
This type of waste consists of animal tissues, organs, body parts, and carcasses. This waste must be:

- Stored in a freezer/refrigerator until the day of pick up.
- Segregated from other waste (e.g. glass, metals, gloves).
- Treated as radioactive animal waste if contaminated with a nuclear substance.(see section 2.3.1.2)

2.1.1.1 Infectious animal waste

- This type of waste includes animal tissues, organs, body parts, and whole carcasses that contain infectious agents.
- Collect this waste in a lined Biohazard box.
- Keep the weight of the container below 20 kg.
- Label the box according to the specifications in section 3.1.2.
- Store this waste in a secure, refrigerated area until WMF personnel picks it up for incineration.

2.1.1.2 Non infectious animal waste

- This type of waste includes animal tissues, organs, body parts, and whole carcasses that do not contain infectious agents.
- Collect this waste in a heavy-duty cardboard box lined with double plastic bags or a Biohazard box with the biohazard warning symbol defaced.
- Keep the weight of the container below 20 kg.
- Label the box according to the specifications in section 3.1.2.
- Store this waste in a secure, refrigerated area until WMF personnel picks it up for incineration.
- When exceptionally large or heavy animals are involved, contact the Biosafety Manager for more information on disposal arrangements.

2.1.2 Animal husbandry waste

Definition:
This type of waste includes stable or cage bedding, waste feed, litter, etc.

- ***Infectious*:** waste must be autoclaved or inactivated then treated as non-infectious and put into a regular garbage bin.
- ***Non-infectious***: waste that is not contaminated with radioactivity or chemicals can be directly disposed of into a regular garbage bin.

2.1.3 Microbiological laboratory waste

Definition:
This type of waste includes laboratory cultures, weigh boats, gloves, paper towels, absorbent pads, bench top covers, plastic products (tubes, flasks, petri dishes), non penetrable waste (metal pans, blunt objects), etc.

2.1.3.1 Not contaminated

- Do not put in a Biohazard box or Biohazard bag.
- Must be placed into plastic bags and closed by the technical staff before custodial employees handle it.
- Waste can be disposed of into the regular garbage bin(s).

2.1.3.2 Contaminated

- This waste should be autoclaved and then disposed of with general waste provided it is contained in a package that is labelled **decontaminated** and there is no evidence of a recognizable Biohazard sign anywhere.
- Do not send autoclaved waste to the approved external waste facility or to WMF.
- If the waste is not autoclaved, then it should be collected in a Biohazard box or appropriate designated biowaste bin(s).
- This waste should be collected and labelled in accordance with sections 3.1.1 and 3.1.2.
- If contaminated with radioactivity, treat as radioactive waste and see section 2.3.1.
- If contaminated with volatile or extremely toxic material, contact Biosafety Manager for consultation.

2.1.4 Liquid waste

Definition:
This type of waste includes human and/or animal blood and body fluids.

- Small quantities of infectious liquid waste must be decontaminated or inactivated *prior to* diluting them down the drain. Due care must be taken to ensure this waste has truly been inactivated.
- Ensure that all containers with residual blood or body fluids are rinsed prior to disposal.
- If a large amount of infectious liquid is being produced, contact the Biosafety Manager for advice.
- Note that for **prion** contaminated formalin or formic acid waste consult the Biosafety Manager for appropriate disposal procedure.

2.2 Chemical Waste

Chemical waste is divided into several categories, with each type of waste requiring storage, handling, and disposal practices appropriate to the type of chemicals present in the waste. It is the responsibility of the person generating the chemical waste to ensure that all procedures are followed to ensure safe and environmentally responsible disposal of the waste. For each chemical to be disposed of refer to the MSDS to be aware of the safety and environmental considerations.

2.2.1 Unused chemicals and chemical mixtures waste

Definition:
Pure chemicals or mixtures of chemicals that will not be used for their intended purpose or are waste products.

- Refer to the MSDS to recognize all hazards associated with each chemical.
- Waste chemicals must be collected in sealed, leak proof containers that are appropriate for each chemical being disposed of. Containers that do not seal (e.g. pails or containers with bungs or corks), containers that have spigots, or leaking containers will not be accepted.
- Containers must have screw type lids that seal securely.
- **Containers designed to store solid chemicals must not be used to hold liquid chemicals.**
- Chemicals or chemical mixtures with incompatibility must not be packaged in the same package.
- **Use containers of appropriate size for the amount of waste generated. Maximum container size is 10 L (see exceptions in section 3.2.1).**
- **Maximum container size for collecting flammable waste is 5L (flammable waste is waste that has ≥40% flammable content).**
- Ensure that containers are not overfilled. Leave space in the container to allow for expansion and contraction of the contents of the container, as well as to allow the contents to be poured without spilling.
- Label each container according to the specification in section 3.2.2.
- Ensure container lids are secured tightly prior to shipping.
- Packages must be strong enough to bear the aggregate weight of all containers within.
- All tops and bottoms of boxes must be taped shut.
- Liquid chemicals must not be contaminated with debris. Ensure that all pipette tips, tubes, etc are segregated from liquid waste.

10L maximum container capacity allows for hand processing by Waste Management. Only tight sealing original chemical containers or liquid waste jugs supplied by Waste Management are acceptable due to safe transportation and handling requirements.

2.2.2 Lubricating oils waste

Definition:
Lubricating oils include: various automotive oils, pump oils, hydraulic fluid, etc.

- Packaging requirements are the same as for other liquid chemicals.
- In the case of transformer oil, indicate whether or not PCBs are suspected or known (or if the oil is known to be PCB-free from analysis or purchasing information). Consult with WMF personnel for proper handling and labeling of PCB contaminated waste.

2.2.3 Gel waste

Definition:
Gels containing trace amounts of chemicals must be disposed of as hazardous waste.

- Gels must be packaged in wide-mouth, leak-proof, sealable plastic containers that are appropriate for the chemicals present in the gel (consult MSDS).
- Twenty litre pails are acceptable as a container for gels provided that the lid seals water tight and the weight of the container and contents is less than 20 kg.
- Paper, gloves, plastic pipette tips, etc. must not be disposed of with the gels.

2.2.4 Plastics with chemical residue waste

Definition:
Plastics that are contaminated with a hazardous chemical residue.

- These plastics must be disposed of according to the hazard of the chemicals present on the plastics
- Collect dry plastic waste in a plastic lined cardboard box.
- Collect wet plastic waste in a wide-mouthed leak-proof container appropriate for the chemicals present (consult MSDS).
- Plastics contaminated with microorganisms must be disposed of as biological waste according to section 2.1.3.

2.2.5 Equipment containing mercury waste

Definition:
Any equipment containing mercury such as thermometers, barometers, blood pressure gauges, flasks of mercury, etc.

- Equipment containing mercury must be collected separately from other types of waste.
- Collect this equipment in a puncture-proof, sealable container of appropriate size to contain the mercury and equipment. Remember that the container will also be disposed of as hazardous waste, so do not use an oversize container.
- Label the container according to section 3.2.2.

2.2.6 Contaminated debris (including empty chemical containers) waste

Definition:
Contaminated debris refers to any material not otherwise specified in this document that is contaminated with hazardous chemical residues, including plastic bags, paper, gloves, etc, and also includes empty chemical containers.

- Appropriate disposal will depend on the hazards associated with the chemicals and each waste generator should consult the MSDS to determine what the hazards are.

- If the waste generator determines that debris is contaminated with highly toxic or hazardous substance, or if the amount of contamination is great, this waste shall be categorized as hazardous waste and shipped to WMF.
- Contaminated debris that is shipped to WMF may be packaged with contaminated plastics without segregating.
- If it is determined that minute amounts of contamination of low toxicity, corrosivity, flammability or environmental hazardous chemicals are present, this debris can be disposed of in the regular garbage bin after being sealed in a garbage bag.
- Empty chemical containers should be treated the same way as contaminated debris. If the containers contain only trace amounts of low-toxicity, corrosivity, flammability or environmental hazardous chemicals, the containers can be disposed of in the regular garbage bin after the labels are removed or defaced and containers are slashed or broken to prevent reuse. If concentrated contamination is present, triple rinse the containers, collect the rinsate and dispose of the rinsate as hazardous waste. Rinsed clean containers can be disposed of in the regular garbage bin.
- Prior to disposing of any container into the regular garbage bin, deface labels and slash or break the container to prevent reuse.
- Package garbage appropriately to ensure custodial staff are not exposed to any hazards in the laboratory.

2.2.7 Empty pesticide containers

Definition:
This type of waste includes any container contaminated with pesticide residue.

- Triple rinse all empty pesticide containers prior to disposal.
- Rinsate must also be collected and disposed of through WMF.
- Empty pesticide containers must not be disposed of with regular garbage.
- **Send rinsed containers to WMF for disposal.**

2.2.8 Unknown chemicals

Definition:
The chemical composition characteristics of the chemicals are unknown.

- To determine the general characteristics of the chemical a sample of the chemical must be sent to an analytical lab for analysis.
- It is the responsibility of the waste generator to have the chemical properly analyzed so that the chemical can be disposed of in a safe and environmentally responsible manner.
- Contact the Chemical Safety Manager for more information on disposal of this type of waste.

2.2.9 Unstable chemicals

Definition:
Certain chemicals may decompose or dry into potentially unstable compounds that may react or become explosive under certain conditions. Peroxide forming compounds and picric acid are (along with several other compounds) examples of potentially unstable chemicals that require special handling and management.

- Refer to MSDS for precautionary measures with potentially unstable chemicals
- Contact the Chemical Safety Manager for handling and disposal advice.
- Do not handle or disturb potentially unstable compounds until given clearance to do so by the Chemical Safety Manager.

2.2.10 Gas cylinders

Definition:
Any cylinder used to hold a gas or **any** container used to hold a liquefied gas at or above atmospheric pressure.

- Gas cylinders are returned by the waste generator to the manufacturer after being used or if no longer needed.
- Many manufacturers will accept returned cylinders, if the cylinders meet the manufacturer"s return criteria.
- Cylinders that can not be returned to the manufacturer (cylinders older than ten years or not eligible for re-filling) must be disposed of through a hazardous waste contractor. Disposing of cylinders through a contractor is expensive and should therefore be avoided by promptly returning empty cylinders.
- Any costs associated with the disposal of gas cylinders are the responsibility of the waste generator.
- WMF personnel will act in a **consulting** role with individuals on proper disposal procedures for gas cylinders on a case by case basis.

2.3 Radioactive Waste

Radioactive waste is divided into 8 categories with each type of waste requiring storage, handling and disposal practices appropriate for the amount of radioactivity present in the waste. It is the responsibility of the person generating the radioactive waste to ensure that all procedures are followed to ensure safe and environmentally responsible disposal of the waste.

2.3.1 Dry waste

2.3.1.1 Dry (DRY)

Definition:

This type of waste includes laboratory wares (i.e. pipette tips, Petri plates, test tubes, etc.) gloves, absorbent materials, etc. Liquid content must be removed from all containers deemed as dry waste.

- Collect dry waste in a cardboard box lined with a heavy-duty plastic bag. Ensure that the plastic bag is closed prior to sealing the box.
- All tops and bottoms of boxes must be taped shut.
- Remove all radiation warning symbols from material prior to disposing it as waste.
- Specifically describe the physical and chemical nature of the waste on the form.

2.3.1.2 Animal (COM)

Definition:
This type of waste consists of animal tissue, carcasses, body parts, and/or organs.

- The method of disposal of dead animals (whole or parts) is incineration.
- The Radiation Safety Manager will determine the number of animals that can be packaged together to ensure that during incineration the environmental release limit is not exceeded.
- Collect animal waste in a sturdy plastic bag(s).
- Label each bag with the date, name of the radioisotope, and the activity remaining.
- No other objects shall be packed with the animal (i.e. no gloves, scalpels, etc.).
- Animal waste waiting for disposal must be kept in a freezer or designated cold room until removal by WM technicians. Freezers and cold rooms shall be labelled with appropriate radiation signs.
- Animal waste with a substantial amount of activity may have to decay to an acceptable level before it can be incinerated. Therefore, researchers shall ensure that there is adequate space to store the animal waste to allow for decay.
- Animal waste that is infectious and radioactive shall have the biohazard warning label affixed to the bag.

2.3.2 Liquid scintillation vials (LSV) waste

Definition:
Plastic or glass vials containing the radioactive sample and liquid scintillant.

- Collect this waste in either plastic pails (with lids) or cardboard boxes lined with a heavy duty plastic bag.
- All tops and bottoms of boxes must be taped shut.

- Plastic vials and glass vials shall be collected separately.
- Do not separate the scintillant from the vial.
- When describing the *chemical nature* of the scintillant, identify the chemical composition.

2.3.3 Liquid waste

Liquid waste is waste that is purely in liquid form. It does not contain tissue, paper matter, tubes or any other solid material in the liquid. To avoid contaminating the outside of the waste container use a funnel during the transfer of the waste to the waste container.

2.3.3.1 Aqueous (AQU)

Definition:
This category of waste is comprised of all liquids that are water-soluble, non-toxic and contain a nuclear substance.

- Do not mix this waste with any other non-aqueous liquid waste.
- All liquid waste must be collected in plastic containers of suitable size with lids that tighten securely.
- Recycled plastic containers are acceptable provided the container was previously used to contain a liquid and has a securable lid. (Exception is 4 L milk containers).
- Liquid waste generated from the third and fourth washing of cells or equipment may be released directly to the sewer.

2.3.3.2 Non Aqueous (NAQ)

Definition:
This category of waste includes substances such as flammable, toxic, and/or corrosive liquids ($5.5 > pH > 9.5$) that contain a nuclear substance. This type of waste is not water soluble.

- Collect this waste in a container (teflon lined plastic) that is compatible with the waste. Ensure the lid tightens securely.
- All liquid waste must be collected in plastic jugs with lids that tighten securely.
- Indicate the chemical composition on the Radioactive Waste Disposal form.

2.3.4 Unused or Partially Used Radioactive Materials (URM)

Definition:
Any radioisotope partly used or unused that is futile (i.e. chemically broken down, bacteriological contamination, old or no longer required for research).

- Radionuclides with an activity greater than 100 uCi (370 kBq) must remain in its original shipping vials. Record the volume and activity (correct for decay) on the form.
- Radionuclides with an activity less than 101 uCi (370 kBq) must be pipetted from the shipping vials and added to the aqueous waste. The shipping vials shall be triple rinsed (add rinse to aqueous waste). Deface the radiation warning symbol and dispose of container as "dry waste".

2.3.5 Protein Iodination Waste (PRO)

Definition:
This waste is generated during separation of the desired product from the waste using size exclusion chromatography.

- Discard all waste products such as fraction columns, pipette tips, syringes, gloves, liquids, etc. into a sealable plastic container.
- If the column needs to be broken to fit in the plastic container, break it inside a plastic bag.
- The plastic container(s) used to collect the waste must be small enough to fit into a 4 litre can. The dimensions of the can are 15 cm in height and 16.5 cm in diameter.
- Shield and store these containers in the fume hood until pick up.
- WM technicians will place the waste containers into a metal can at the time of collection.

2.3.6 Transuranic Waste (TRU)

Definition:
This waste consists of radioactive elements with an atomic number greater than 89.
This category of waste includes materials such as:

- uranium / thorium ore
- uranium / thorium / radium chemical compounds
- uranium tailings

- For collection and packaging consult the Radiation Safety Manager.

2.3.7 Shipping Vials and Holders

Definition:
A shipping vial is the primary container that the radioisotope is shipped in. The shipping vial holder is the secondary container which holds the primary container. Some shipping vials holders maybe lead lined.

- Empty shipping vials shall be triple rinsed, radiation warning symbols defaced and then disposed of as dry waste.

- Plastic shipping vial holders must also be defaced of the radiation warning symbol and disposed of to the dry waste container.
- Shipping vial holders with lead lining shall be disposed of through the WMF. These holders should be wipe tested to ensure they are free of contamination prior to pick up.
- If any shipping vial holders remain in the laboratory, ensure that the radiation warning symbol is removed if it is not used to hold nuclear substances.

2.3.8 Unusual Waste (UNW)

For any unusual waste not described in this manual, please consult the Radiation Safety Manager

2.4 Penetrable Waste (sharps, broken glass, etc.)

Definition:
This waste consists of any object that can penetrate the skin. This includes: needles, syringes, scalpel blades, lancets, capillary tubes, broken pipettes, broken glassware (contaminated), broken blood tubes, and broken culture dishes, slides, cover slips, tubing with needles attached, wooden applicator sticks or any other objects that can puncture skin or a plastic bag.

- Items that have come in contact with infectious substances should be autoclaved or inactivated prior to disposal. If this waste can not be autoclaved, the container must have a Biohazard label as well as a sharps label affixed to it. **Do not** attempt to autoclave chemically contaminated sharps.
- All contaminated sharps whether chemical, radiological, or biological can be collected in the same sharps container.
- Collect all sharps waste in specially designed puncture proof plastic containers that are labelled appropriately. (Affix sharps labels and biohazard labels if applicable. See Appendix H)
- The sharps can be picked up by WMF personnel on their weekly biological waste pick up or the sharps containers can be placed inside the Biowaste bin that are picked up by an external waste contractor. If they are being sent to an external waste facility, they must remain in the sharps container separate from the inner sealed bag.
- **Never discard sharps waste loosely into another waste vessel. Sharps must always remain in a sharps container.**
- Collect broken glass in a lined heavy-duty cardboard box and seal all seams with tape. Label the box as "*Waste: Broken Glass"* and leave for the custodial staff to dispose of.

- If broken glass is classified as „infectious" it should be autoclaved and disposed of as above. If it is not autoclaved, this waste should be disposed of in a sharps container and labelled with the sharps and biohazardous labels.
- **Never** discard sharp waste into the regular garbage bin or mix it with other categories of waste.

2.5 Mixed Waste

There are three principal classes of hazardous waste: biological, chemical, and radiological. Each principal class of hazardous waste should be collected separately. In some instances it may not be possible to separate the waste due to the nature of the experiment. Any hazardous waste which contains more than one principal class of hazardous waste is called mixed waste. The table below gives guidelines for mixed waste. Consult a Safety Manager prior to undertaking an experiment which will generate mixed waste.

Infectious and radioactive waste	Identify the waste as biohazardous, affix a Biohazard label, and dispose of the waste according to the procedures for radioactive waste.
Prions and chemical waste	Contact the Biosafety Manager for the appropriate disposal procedures.
Biological and chemical waste	Separate the two classes as much as possible. If the waste is chemical in nature, where infectious agents could survive, consult with the Biosafety Manager.
Chemical and radioactive waste	Treat as radioactive waste and identify the chemicals present.
Biological, chemical and radioactive	If the waste is infectious consult with the Biosafety Manager. If the waste is not infectious follow the procedures given for the disposal of radioactive waste.

3. Processing Instructions

3.1 Biohazardous Waste

3.1.1 Collecting the waste

Waste that is collected and packaged for disposal must be stored in a cold area (fridge, freezer) until the day of pick up. The waste is then transferred to a designated and locked storage location (facility) by the waste generator. Waste that is designated for the external facility is transported off campus and therefore must be packaged in accordance with the Transportation of

Dangerous Goods regulations and the person offering the container for transport must be TDG certified.

For waste that is designated for WMF, waste generators must ensure that the packages are ready for transport once the hazardous waste disposal form is sent to the WMF.

Adhere to the following guidelines for either category of waste:

- Containers must not weigh more than 20 kg.
- Use the appropriate size and container for collecting the waste.
- Ensure that all containers are structurally capable of withstanding the aggregate weight of all containers within.
- Do not overfill containers. Three quarters full is usually the acceptable quantity for sharps and external biohazard bins.
- Ensure that all inner containers (e.g. plastic bags) are sealed or tied shut.
- Ensure that the lids on containers are secured tightly and boxes are taped shut. For external bins, ensure that the outer lids are tie wrapped on.
- Ensure that all the containers that are offered for pick up are included on the hazardous waste disposal form.

3.1.2 Labelling the waste

All waste containers must be properly labelled according to the following requirements:

For shipments off campus:

- The waste generator must determine the type of waste that their bin will fall under (see Appendix C).
- Affix the label corresponding to that type of waste and the external waste contractor‟s Bar Code label to the bin. These labels incorporate the transportation of dangerous goods UN numbers.
- In order to comply with regulations the generator should record the name, department, building, room number and telephone number of the person that generated the waste. This will be the contact person if more information is required regarding the contents of the container.

For shipments to WMF:

- Labels can be purchased from WMF.
- Each container must be labelled with the appropriate hazardous waste label (see appendix D for Hazardous waste label).
- All fields on the label must be completed in full as follows:
    - Waste Class(es): Circle all the appropriate hazard class(es) for the contents of the container.
    - Chemical or infectious agent or mixture name: Record all chemical or infectious agents that are shipped in the container (use proper shipping names).

        - Waste shipment number: Corresponds to the number on the Hazardous Waste Disposal form (see Appendix F).
        - Package number: Number of the container within the shipment (e.g. 1 of 20).
        - Generator: Record the name, department, building, room number and telephone number of the person that generated the waste. This will be the contact person if WMF personnel require more information about the contents of the container.
        - Shipper: Record the name, department, and phone number of the person shipping the waste if the shipper is different from the waste generator, otherwise indicate it is the same individual. This is the person who packaged the waste and arranged for disposal.
        - Ensure that the biological waste label is securely attached to the container so that it will not come off during transport.
    - All other labels must be removed from the container or otherwise made illegible (painted, scratched out).
    - Waste that must be transported from locations off campus must be transported according to federal Transportation of Dangerous Goods (TDG) regulations. There are special requirements for packaging and labelling. Please consult the Biosafety Manager for packaging and labelling and training requirements on a case by case basis.

3.1.3 Storing waste containers

- Store biologicals in a location that provides the maximum amount of safety for personnel in the lab. Remember that custodial and maintenance staff may come into contact with packages of biological waste so ensure that all precautions are taken to avoid unsafe working conditions for all personnel.
- Store biological waste in a cool or cold location (e.g. fridge or freezer if possible) until the day of pick up.
- If there is a designated, non-refrigerated, locked storage facility in your area, transport the biological waste to it on the day of pick up. If there is a designated refrigerated locked facility available, the waste may be transported to it at any time.
- If there isn't a designated storage area assigned to your department or there isn't an internal procedure in place, ensure that WMF and the external waste personnel are aware of the waste storage location so that the waste containers get picked up.

3.1.4 Waste disposal form

- Hazardous waste disposal forms can be purchased from WMF and must be used for all biological waste shipments. (See Appendix F for an example of the form). Each form is uniquely numbered for tracking purposes, so use only one form per shipment. Photocopy the original sheet if there is not sufficient room on one sheet to enter all containers for a shipment.

This will ensure that all containers within a given shipment are labelled with the same waste shipment number.

- Complete all fields on the top of the form as follows:
  - Date: Record the date the form is sent to WMF
  - Record the name, department, building, room number, and telephone number of the person generating the waste (not the shipper if shipper and generator are different).
  - Pick up location: Record the room that the waste is stored in. This is the room that WMF personnel will go to on pick up day.
  - Record the number of containers in the shipment.
- Record an accurate description of the biologicals in each container. This must be the proper biological name of all constituents in the container
- Record the number of containers that correspond to the waste description within each package.
- Total quantity refers to the total quantity of biologicals of a given waste description in the container.
- Record the number of the containers according to the waste label attached to the package.

3.1.5 Requesting waste removal

WMF personnel will pick up biological waste at least one day each week (typically Thursday). In order to transport the biological waste safely and legally, WMF personnel must produce a shipping document for each shipment of biological waste using the information provided on the hazardous waste disposal form. Hazardous waste disposal forms must be received by WMF personnel by 1300 hours on Tuesday to arrange for waste pick up for that week. Forms that are not received by this deadline will not be picked up until the following week. Forms can be either mailed directly to the WMF through interdepartmental mail (Waste Management Facility, 113 North Road), or faxed to 966-6146.

3.2 Chemical Waste

Waste generators must ensure that the packages are ready for transport to WMF once the hazardous waste disposal form is sent to the WMF.

3.2.1 Collecting the waste

Definition:
A container is the primary containment for liquid or solid waste. In the case of 4 litre or 10 litre **plastic** containers, 20 litre pails, and 210 litre drums, the container is also the package and shall have the chemical waste label affixed to it. If multiple containers are included in the same box, this box is considered a package.

- Do not pack incompatible chemical waste in the same package or box (consult MSDS for each chemical).
- Packages must not weigh more than 20 kg (except in the case of drum shipments).
- Use the appropriate size and the correct container for collecting the waste.
  - Maximum 5L for flammable waste.
- If reusing an empty -container for waste collection ensure that the original label is defaced.
- Ensure that all packages are structurally capable of withstanding the aggregate weight of all containers within.
- Ensure that all containers are properly packaged. All containers other than 4 or 10 litre plastic containers, 20 litre pails, or 210 litre drums must be enclosed in a package with sufficient packing material to ensure that the container(s) will not be damaged during transport.
- Ensure that lids on containers are secured tightly and boxes are taped shut.
- Avoid contaminating the outside of the container during filling. Containers and packages with visible signs of external contamination will not be accepted.
- Ensure that all the containers and packages that are offered for pick up are included on the hazardous waste disposal form.
- 20 packages is the maximum that will be accepted per shipment.

3.2.2 Labelling the waste

Labels can be purchased from WMF. All waste containers and packages must be properly labelled according to the following requirements:

- Each package must be labelled with the appropriate hazardous waste label (see Appendix D for Hazardous Waste label).
- Each container must always be labelled with the container number and contents prior to being packed. Numbers and content labels must correspond to the information on the Hazardous Waste Disposal form which corresponds to the package in which the containers are held. This label may be hand written as long as it is legible.
- When more than one container is in a package, each container within must be labelled according to this section.
- Use proper chemical names on all labels. Acronyms, trade names, or chemical formulas are not acceptable.
- All fields on the label must be completed in full as follows:
  - Waste Class(es): Circle all the appropriate hazard class(es) for the contents of the container.
  - Chemical or infectious agent or mixture name: Record all chemical or infectious agents that are shipped in the container (use proper shipping names).
  - Waste shipment number: Corresponds to the number on the Hazardous Waste Disposal form (see Appendix F).
  - Package number: Number of the container within the shipment (e.g. 1 of 20).

        - Generator: Record the name, department, building, room number and telephone number of the person that generated the waste. This will be the contact person if WMF personnel require more information about the contents of the container.
        - Shipper: Record the name, department, and phone number of the person shipping the waste if the shipper is different from the waste generator, otherwise indicate it is the same individual. This is the person who packaged the waste and arranged for disposal.
        - Ensure that the chemical waste label is securely attached to the container so that it will not come off during transport.
    - All other labels must be removed from the container or otherwise made illegible (painted, scratched out).
    - Waste that must be transported from locations off campus must be transported according to federal Transportation of Dangerous Goods (TDG) regulations. There are special requirements for packaging and labelling. Please consult with the WMF person for packaging and labelling and training requirements on a case by case basis.

3.2.3 Storing waste containers

- Store waste chemicals in a location that provides the maximum amount of safety for personnel in the lab. Remember that custodial and maintenance staff may come into contact with packages of chemical waste, so ensure that all precautions are taken to avoid unsafe working conditions for all personnel.
- Store chemical waste according to compatibility with other chemical waste in the storage area. Never store incompatible chemical waste in a manner that will allow reactions to occur in the event of a spill or release (refer to MSDS).
- Store waste chemicals for the shortest possible length of time. Do not store waste chemicals for extended periods.
- Ensure that WMF personnel are aware of the waste storage location so that the waste containers get picked up. Choose your location carefully.
- Consider spill containment trays for your waste storage area.

3.2.4 Waste disposal form

- Hazardous waste disposal forms can be purchased from WMF and must be used for all chemical waste shipments. (See Appendix F for example of form). Each form is uniquely numbered for tracking purposes, so use only one form per shipment. Photocopy the original sheet if there is not sufficient room on one sheet to enter all packages for a shipment. This will ensure that all packages within a given shipment are labelled with the same waste shipment number.
- Complete all fields on the top of the form as follows:
    - Date: Record the date the form is sent to WMF

- Record the name, department, building, room number, and telephone number of the person generating the waste (not the shipper if shipper and generator are different).
- Pick up location: Record the room that the waste is stored in. This is the room that WMF personnel will go to on pick up day.
- Record the number of packages in the shipment.

- Record an accurate description of the chemicals in each container. This must be the proper chemical name of all constituents in the container. If the chemical is a mixture, record all chemicals that are included in the mixture. Acronyms, trade names, or chemical formulas are not suitable information and must not be used on the hazardous waste disposal form or on the labels on containers or packages.
- Record the proportion of all chemicals in a mixture in the appropriate column. This information must be a percentage (%), do not use concentrations. This information must be accurate to ensure safe disposal of the waste.
- Record the number of containers that correspond to the waste description within each package.
- Total quantity refers to the total quantity of chemicals of a given waste description in the same package.
- Record the number of the package according to the waste label attached to the package.

3.2.5 Requesting waste removal

WMF personnel will pick up chemical waste at least one day each week. In order to transport the chemical waste safely and legally, WMF personnel must produce a shipping document for each shipment of chemical waste using the information provided on the hazardous waste disposal form. Hazardous waste disposal forms must be received by WMF personnel by **1300 hours Friday** to arrange for waste pick up the following week. Forms that are not received by this deadline will not be picked up until the second following week. Forms can be either mailed directly to the WMF through interdepartmental mail (Waste Management Facility, 113 North Road), or faxed to 966-6146.

3.3 Radioactive Waste

Radioactive waste must **never** be placed in regular garbage bins. It is the responsibility of the Permit Holder and generator to ensure that waste is properly segregated, identified and labelled for disposal.

3.3.1 Collecting the waste

- Do not mix beta emitter with gamma emitter waste.
- Do not mix long lived ($T_{1/2}$ > 1 year) radioisotope waste with short lived ($T_{1/2}$ < 1 year) radioisotope waste.

- Collect all radioactive waste separately according to the categories identified in section 2.3.
- Use the appropriate size and the correct container for collecting waste.
- Ensure that the container is structurally capable of withstanding the aggregate weight of its contents.
- Ensure that lids on containers are secured tightly and boxes are taped shut.
- Containers shall not weigh more than 20 kg.

3.3.2 Labelling the waste

Labels can be purchased from DHSE. All waste containers must be properly labelled according to the following requirements:

- Affix a Radioactive Waste Label (see Appendix E) to the container prior to its use. Complete the "type of waste" and "isotope" section. This will reduce the chance of mixing different radioisotopes and categories of waste. Also laboratory workers and custodial staff can readily identify the containers.
- When the waste container is full, complete the rest of the Radioactive Waste label.
- All other labels must be removed from the container or otherwise made illegible (defaced).

3.3.3 Storing waste containers

- Store radioactive waste in a location that provides the maximum amount of safety for personnel in the lab. Remember that custodial and maintenance staff may come into contact with packages of hazardous waste, so ensure that all precautions are taken to avoid unsafe working conditions for all personnel.
- Each laboratory shall establish a location for the consolidation of radioactive waste. This location should be in the same laboratory where the waste is generated.
- All liquid waste shall be placed in a tray or on top of enough absorbent material to absorb the liquid in the event of a spill.
- Radioactive waste must be shielded and stored in such a manner that the dose to personnel is as low as reasonably possible. Under no circumstances shall the dose exceed 2.5 μSv/hr in a radioactive work area.
- Any form of shielding material used around radioactive waste must be designed, constructed, and handled in such a way that it can be easily moved by WM technicians at the time of waste pick up.
- Avoid storing radioactive waste in the laboratory for decay purposes.
- If research has stopped for a time period greater than 1 month, dispose of all radioactive waste immediately, regardless if the container is full or not.

3.3.4 Waste disposal form

- Radioactive Waste Disposal forms can be purchased from DHSE. (see Appendix G for an example of the form).
- When completing the form provide specific information for the physical and chemical nature descriptions.
- The total activity for each container shall be determined by the procedures outlined in section 3.3.4.1.
- If the number of containers to be picked up is greater than the space provided on one form, continue onto a new form.
- If the waste is also infectious or contains chemicals, indicate this on the form.
- To request radioactive waste removal from the laboratory, complete a Radioactive Waste Disposal form.
- Mail the first two copies of the form to DHSE. The third copy should be retained for your records. No pick up is authorized unless the Radiation Safety Office receives this form.

3.3.4.1 Calculating the activity in waste

The following is a list of methods one may use to determine the amount of activity in each waste container at the time of disposal.

3.3.4.1.1 Dry

Dry waste usually consists of material that may have come in contact with a nuclear substance. Therefore, the activity will be estimated and the estimate should be very low. However, if you dispose of gels or cleaned a spill then the activity can be calculated and recorded accordingly.

3.3.4.1.2 Liquid

The activity of liquid waste can be determined by taking a sample (1 ml aliquot) of the waste and counting the sample in a liquid scintillation counter or gamma counter. The total activity can be calculated as follows:

$$\text{total activity in liquid waste} = \frac{\text{Net CPM} \times V}{E \times v \times 2.2} \times 10^{-6} uCi \quad (1)$$

where Net CPM = sample CPM - background CPM
v = volume of the sample (ml)
V = total volume of the waste (ml)
E = counting efficiency of equipment

3.3.4.1.3 Liquid scintillation vials

There are two methods for determining the amount of activity for liquid scintillation vial waste.

Either keep a running total of the activity disposed to the waste container or determine the average activity and multiply by the number of vials disposed to the waste container. Regardless of which method is used, one must correct for decay.

3.3.4.1.4 Protein iodination

Since all protein iodination waste goes into one waste container, the original amount of activity minus the activity used in the experiment will be the activity disposed.

3.3.4.1.5 Unused nuclear substance

The amount of activity remaining in the shipping vial can be determined from the inventory sheet. Correct for decay.

$$A = A_o - U$$

Where A_o = purchased activity
U = total activity used in experiment
A = activity remaining in the shipping vial

3.3.4.1.6 Transuranic waste

Consult the Radiation Safety Manager.

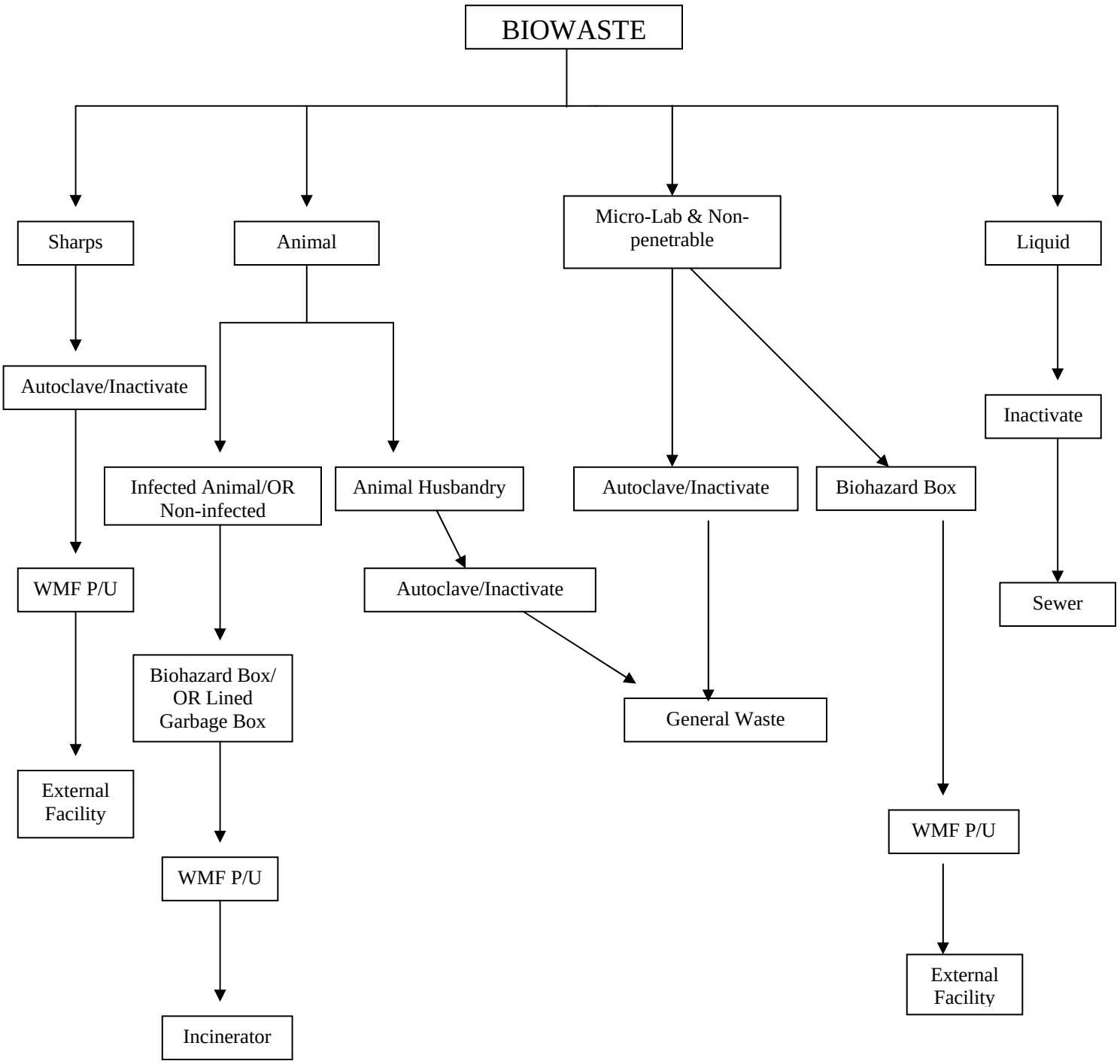
3.3.5 Requesting waste removal

- Removal of radioactive waste from laboratories takes place every Monday. If Monday is a holiday, pick up is the following Wednesday.
- To request removal of radioactive waste from the laboratory forward the Radioactive Waste Disposal form to the Radiation Safety Office, DHSE.
- The Radioactive Waste Disposal form must be received by the Radiation Safety Office by 9:00 a.m. Monday in order to have the waste removed that day.
- WM technicians have the right to refuse pick up of any improperly packaged or labelled waste to ensure their safety.

Appendices

Appendix A	Biological Waste Flowchart
Appendix B	Radioactive Waste Summary Chart
Appendix C	Biological Waste Segregation Labels
Appendix D	Hazardous Waste Label
Appendix E	Radioactive Waste Label
Appendix F	Hazardous Waste Disposal Form
Appendix G	Radioactive Waste Disposal Form
Appendix H	Sharps and Biohazard Labels

Appendix A: Biological Waste Flowchart



Appendix B: Radioactive Waste Summary Table

Category of Waste	Examples	Container Type	Max. Weight	Comments
Dry waste (DRY)	Glass, gloves, bench cover, plastic or metal articles, etc.	Plastic lined cardboard box	20 kg	Do not add liquid waste to this type of waste. Only residual liquid is acceptable.
Animal carcasses (COM)	Carcasses part or whole	Individually packaged in plastic and stored in a fridge/freezer	Consult RSM	Do not package scalpels, gloves, towels, etc. with the animal
Aqueous (AQU)	Soluble liquid which is not poisonous or toxic	Plastic container with a secure lid	10 L	Do not add any test tubes, gels or other solids to this waste.
Non Aqueous (NAQ)	Liquid which is poisonous and/or toxic	Plastic container compatible with waste. Secure lid.	10 L	Do not add any test tubes, gels or other solids to this waste.
Protein Iodination (PRO)	All the waste generated from the procedure.	Plastic container(s) small enough to fit inside a one-gallon can.	n/a	Collect all waste together. Store waste in the fume hood and shield.
Liquid scintillation vials (LSV)	10 ml or 20 ml glass or plastic vials with cocktail solution.	Plastic container with a secure lid or a plastic lined cardboard box.	10 L or 20 kg	Do not mix plastic and glass vials in same waste container.
Unused radioactive material (URM)	Complete or partial shipment.	Original shipping vial and holder.	n/a	Refer to section 2.3.3.3 for instructions.
Transuranic waste (TRU)	Uranium, thorium chemical compounds, ore, waste rock	Metal drums or 20 L plastic pails.	n/a	Contact the RSM
Shipping vial holders	Plastic or lead lined	n/a	n/a	Dispose of plastic holders to the dry waste. Collect the lead holders and send to WMF for recycling.
Sharps	Scalpels, needles, syringes	Sharps container.	4 L	Ensure syringes are totally empty prior to disposal. Not classified as radioactive waste.

Appendix C: Biological Waste Segregation Labels

INFECTIOUS SUBSTANCE, AFFECTING HUMANS

UN 2814

RG 2

HYDROCLAVE

INFECTIOUS SUBSTANCE, AFFECTING HUMANS

UN 2814

RG 3 or TSE Waste

INCINERATE

Human Anatomical Waste

INCINERATE

Cytotoxic or Pharmaceutical Waste

INCINERATE

Appendix D: Hazardous Waste Label

CAUTION - HAZARDOUS WASTE

DHSE
DEPARTMENT OF HEALTH SAFETY & ENVIRONMENT

Circle Waste Class(es)	Flammable	Pesticide	Poison	Animal Carcasses
	Oxidizer	Corrosive	Infectious	

Chemical or Infectious Agent or Mixture name: _____

Waste Shipment Form Number _____ **Package #** _____ **of** _____

Generator

Name _____ Dept _____

Ph # _____-_____Room _____Bldg_____

Shipper

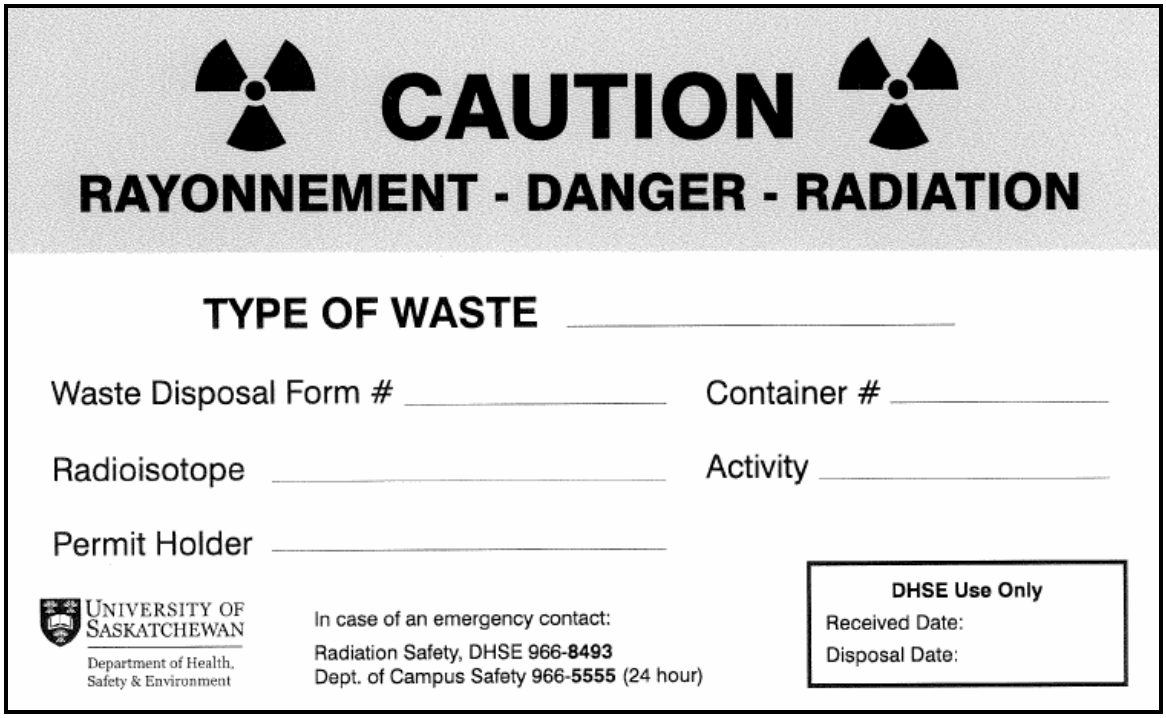
Name _____

Dept _____ Ph # _____-_____

Don't handle if leaking. Wear gloves & avoid contact with package contents. Report all incidents to

Waste Management Facility @ 966-8497 or after hours @ 966-5555

Appendix E: Radioactive Waste Label



Appendix F: Hazardous Waste Disposal Form

WASTE MANAGEMENT SECTION

HAZARDOUS WASTE DISPOSAL FORM

PLEASE PRINT

Date: _____

Department: _____

Building & Room: _____

Pick up Location _____
(if other than above)

WASTE
SHIPMENT NO.: 13375

Number of packages
in this shipment:

Contact
Name: _____

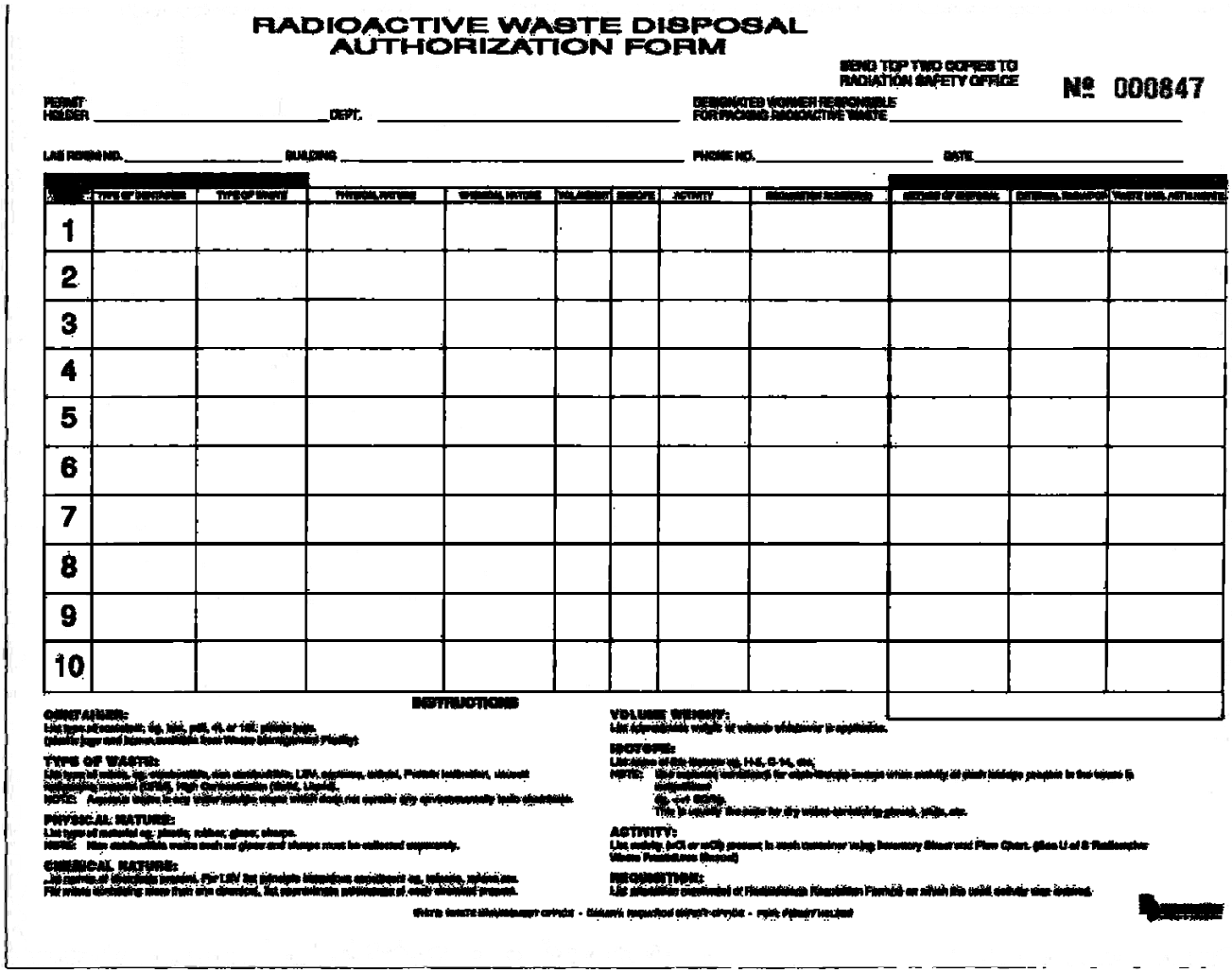
Telephone: _____

Waste Description & Container Type*	Percentage	No. of Containers	Total Quantity L/Kg	Pkg No.

* State type of container such as glass, metal, plastic, etc.
MIXTURES (more than 2 components): Print ***"MIXTURE"*** and state ***total*** quantity in container.
Then list all hazardous components and their concentrations within this mixture.

WARNING: **DO NOT** package imcompatables in the same container! Separate: FLAMMABLES OXIDIZERS CORROSIVES
PESTICIDES POISONS

Appendix G: Radioactive Waste Disposal Form



RADIOACTIVE WASTE DISPOSAL AUTHORIZATION FORM

SEND TOP TWO COPIES TO RADIATION SAFETY OFFICE

№ 000847

PERMIT HOLDER _____ DEPT. _____ DESIGNATED WORKER RESPONSIBLE FOR PICKING RADIOACTIVE WASTE _____

LAB ROOM NO. _____ BUILDING _____ PHONE NO. _____ DATE _____

1											
2											
3											
4											
5											
6											
7											
8											
9											
10											

INSTRUCTIONS

CONTAINER:

TYPE OF WASTE:

PHYSICAL NATURE:

CHEMICAL NATURE:

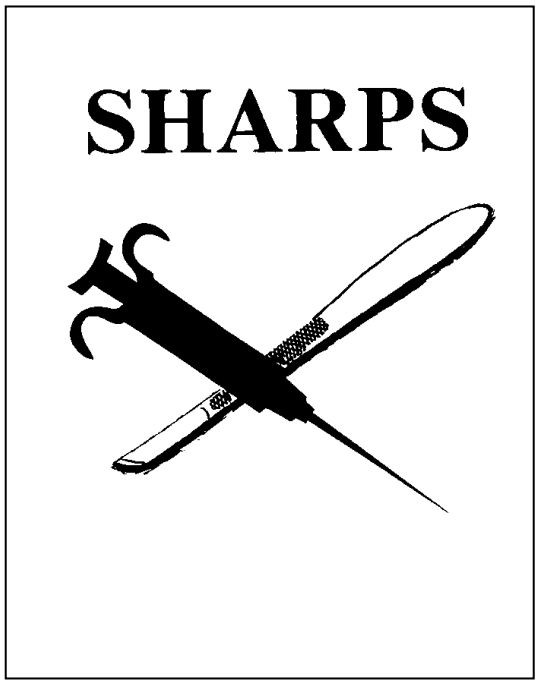
VOLUME/WEIGHT:

ISOTOPE:

ACTIVITY:

RECORDATION:

Appendix H: Sharps and Biohazard Labels



APPENDIX E

CULTURAL RESOURCES COORDINATION PLAN

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Map 3-1. Proposed On-site Sediment Sampling Locations and Alternative Sampling Locations

LIST OF TABLES

Table 3-1. Proposed Surface Sediment Sampling Locations

ACRONYMS AND ABBREVIATIONS

ACHP	Advisory Council on Historic Preservation
APE	area of potential effects
ARPA	Archeological Resources Protection Act of 1979
CCT	Confederated Tribes of the Colville Reservation
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CRCP	cultural resources coordination plan
EPA	U.S. Environmental Protection Agency
FOIA	Freedom of Information Act
Lake Roosevelt	Franklin D. Roosevelt Lake
MOA	Memorandum of Agreement
NAGPRA	Native American Graves Protection and Repatriation Act
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NPS	National Park Service
QAPP	quality assurance project plan
RCW	Revised Code of Washington
RI/FS	remedial investigation and feasibility study
RM	river mile
SHPO	State Historic Preservation Officer
Site	Upper Columbia River site
STI	Spokane Tribe of Indians
Teck	Teck American Incorporated
THPO	Tribal Historic Preservation Officer
UCR	Upper Columbia River
USBR	U.S. Bureau of Reclamation
WAC	Washington Administrative Code

1 INTRODUCTION

This document presents the cultural resources coordination plan (CRCP) for the Upper Columbia River (UCR) site (Site) remedial investigation and feasibility study (RI/FS) with emphasis placed for sampling activities associated with the methods development for white sturgeon/sediments program.

1.1 BACKGROUND

As specified in the Statement of Work associated with the June 2, 2006 Settlement Agreement (USEPA 2006), "For all RI/FS activities at the Site involving sediment collection or ground penetration/disturbance, the Company shall work with the 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." The purpose of this CRCP is to describe known or likely physical impacts of proposed sediment sampling, provide relevant background information, 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 Site.

The Site is located wholly within Washington State and includes approximately 150 river miles of the Columbia River extending from the U.S.-Canadian border to the Grand Coulee Dam. The Colville Indian Reservation borders the UCR from approximately river mile (RM) 690 to the Grand Coulee Dam. The Spokane Indian Reservation borders the UCR to the east from approximately RM 650 to RM 640. Franklin D. Roosevelt Lake (Lake Roosevelt) and associated lands are administered by the U.S. Bureau of Reclamation (USBR) and the National Park Service (NPS) of the U.S. Department of the Interior.

The U.S. Environmental Protection Agency (EPA) has responsibilities under the National Historic Preservation Act (NHPA) to consider how its undertakings would affect historic properties. As defined in the NHPA, "historic properties" include archaeological resources, historic-period buildings and structures, and traditional cultural places listed in or determined eligible for listing in the National Register of Historic Places. To meet the NHPA requirements, EPA must ensure that sampling and other activities would avoid, minimize, or mitigate any adverse effects to any historic properties.

The CRCP is organized into six sections, as follows: 1) this introductory section, which includes summary information on the archaeology, prehistory, Native peoples, and Euroamerican historical development of the project area; 2) an overview of the relevant

federal, state, and tribal laws and regulations, and other appropriate procedures and requirements; 3) a description of the proposed sampling program and its potential physical effects; and 4) a plan for coordination and consultation with all affected parties to address known and likely impacts to cultural resources in implementing the proposed work.

1.2 CULTURAL SETTING

The broader context of the cultural development of the upper Columbia region[1] provides the critical framework for understanding the importance of the cultural resources in the area. Archaeological and historical resources reflect broad patterns of cultural use and development, just as ongoing traditional use of areas and natural resources represents cultural continuity that can be important to individual and social identities. This section of the CRCP serves as a brief introduction to the cultural history of the upper Columbia region.

Archaeological research contributes significantly to our understanding of the prehistoric past. In the upper Columbia region, systematic archaeological research began in the late 1930s and has continued to the present. Almost 500 archaeological resources have been recorded in and along Lake Roosevelt, representing prehistoric, protohistoric, ethnohistoric, and historic-period human use and occupation. Research at some of these resources has provided the outlines of prehistoric cultural development in the upper Columbia region. Human presence in the region extends back at least 11,000 years. These first humans lived in small groups and were mobile foragers, hunting and gathering plants. The presence of the Columbia River led to an early focus on the abundance of riverine resources. Beginning about 8,000 years ago, populations appear to have increased and led to a gradual trend to less mobility and more permanent settlements. The growing population also led to use of a greater diversity of resources and increasing reliance on fish.

Permanent settlements increased in size and became concentrated in the river valleys beginning about 6,000 years ago, probably in response to continued population growth. Use of resources in upland areas expanded to meet the needs of the burgeoning

[1] The phrase "upper Columbia region" herein refers to the drainage of the upper Columbia River from around Grand Coulee to the Arrow Lakes area in British Columbia. The upper Columbia region includes, but is not limited to the Site as defined in the Settlement Agreement. This distinction is important because general patterns of cultural development in the upper Columbia region as a whole provide the framework for addressing the significance of the cultural resources within the Site boundaries.

populations and settlements. These trends continued until about 1,000 years ago, when there is evidence for a decline in population size. There were fewer settlements, villages were smaller, and there was less use of upland areas.

Cultural patterns of the late prehistoric period were reflected in the lives of the Native peoples at the time of Euroamerican contact. At the time of contact, the UCR was the homeland of the Lakes, Colville, Spokane, and Sanpoil peoples. The Lakes people occupied the Columbia River valley from the vicinity of modern Northport, Washington, north into the Arrow Lakes area of modern British Columbia. The Colville lived along the river downstream of the Lakes as far as around the mouth of the Spokane River. Downriver of the Colville were the Spokane, in the Spokane River drainage, and the Sanpoil, who lived along the Columbia River from around the mouth of the Spokane River to the near the modern location of the Grand Coulee Dam.

All of these groups spoke Interior Salish languages and shared many cultural features. Their cultural differences largely reflected differences in the local environments in which they lived. The social, political, and economic foundation of these groups was historically the winter village. The villages were concentrated in the river valleys, and each village was politically independent. Residents of the villages relied on provisions gathered, dried, and stored during the summer to survive through the winter. With the coming of spring, families began moving out of the winter village and shifting among the warm-season camps near resource locations. Gathering of plants and hunting game in upland areas were important subsistence activities during this season, but salmon constituted the most important food staple. Kettle Falls was a major aboriginal fishery, attracting people from throughout the region.

Native life began to change with the introduction of elements of Euroamerican culture. Horses reached the region in the 1700s and significantly changed Native travel and transportation. European diseases such as smallpox appeared in the late 1700s and had disastrous consequences for Native groups. Populations may have declined as much as 80 percent between the 1780s and 1840s. Direct contact with Euroamericans came in the early 1800s, when fur-trade posts were established on the Spokane River and at Kettle Falls.

When American settlement began in the 1840s, it bypassed the upper Columbia region. The discovery of gold in the region in the 1850s led to a major influx of Americans and growing conflict between the new settlers and Indian groups. A series of treaties with Indian groups was signed in 1855 but did not include the peoples of the upper Columbia region. As American settlement continued, the federal government responded by creating the Colville Reservation in 1872 for the Colville and Spokane people. The separate Spokane Reservation was established in 1881. Both reservations have subsequently lost

lands to the allotment process in the late 1800s and early 1900s and inundation from the waters of Lake Roosevelt. The Colville Reservation is now the home of the Confederated Tribes of the Colville Reservation; the Spokane Reservation is the home of the Spokane Tribe of Indians.

As already noted, the direct Euroamerican presence in the upper Columbia region began with the establishment of fur-trade posts on the Spokane River and at Kettle Falls. These posts were constructed between 1810 and 1825. The fur traders were followed by Christian missionaries in the 1830s and 1840s. A more substantial Euroamerican presence in the region developed in the 1850s, with the discovery of gold near Fort Colvile. Conflicts between miners and Indians led to a military campaign in the Spokane River valley in 1858 and the establishment of an army post (Fort Colville) near Kettle Falls in 1859.

American settlement in the upper Columbia River drainage accelerated in the 1860s, initially spurred by mining. Farmers eventually followed the miners, but agricultural activity was limited until the construction of the Spokane Falls and Northern Railway through the region in 1890. With improved access to markets, farming—especially orchard crops—developed as one of the economic mainstays of the area, although mining has continued to play an important role.

The growing demands for agriculture led to plans to construct a dam at Grand Coulee. The dam would provide water for irrigation and inexpensive hydroelectric power. Construction of the dam began in 1934 and was completed in 1942. More than 82,000 acres above the dam was flooded, resulting in the relocation of 11 towns and about 3,000 residents. Since its creation, Lake Roosevelt has provided a growing number of recreational and tourist activities, which have become increasingly important to local economies.

2 OVERVIEW OF LAWS AND REGULATIONS

Implementation of the RI/FS would occur primarily on federal and Tribal lands. Federal and Tribal laws and regulations addressing cultural resources will therefore provide the primary legal framework for this coordination plan. It is possible, however, that implementation of the RI/FS may require activities on private or non-federal, non-Tribal public lands. This overview therefore includes a brief description of relevant state laws and executive orders. Ferry, Lincoln, and Stevens counties, which border the UCR, do not appear to have any ordinances addressing cultural resources that would be relevant to the Site RI/FS.

Relevant federal, Tribal, and state laws and regulations directly addressing cultural resources are briefly outlined below, as well as pertinent executive orders issued by the President of the United States and the Governor of Washington.

2.1 FEDERAL LEGISLATION AND REGULATIONS

An overview of federal legislation and regulations is provided below. There are three key laws relevant to Site RI/FS activities. The NHPA guides all federal agency actions that could affect cultural resources. Implementation of the RI/FS constitutes an "undertaking" as defined in the NHPA and therefore complying with the NHPA requirements is the responsibility of EPA. The Archeological Resources Protection Act of 1979 (ARPA) and the Native American Graves Protection and Repatriation Act (NAGPRA) apply to activities that could affect archaeological resources and Indian burials on federal and Tribal lands. These laws and their implementing regulations would therefore apply to RI/FS activities conducted on federal and Tribal lands..

2.1.1 National Historic Preservation Act of 1966, as Amended through 1992 (16 USC 470-470w)

The NHPA is the centerpiece of federal legislation protecting cultural resources. In the Act, Congress states that the federal government will "provide leadership in the preservation of the prehistoric and historic resources of the United States," including resources that are federally owned, administered, or controlled. For federal agencies, Sections 106 and 110 of the Act provide the foundation for how federal agencies are to manage cultural resources, but other sections provide further guidance. The

implementing regulations for the NHPA are in 36 CFR Part 800. These regulations are summarized below.

2.1.1.1 Section 106

Similar to the National Environmental Policy Act of 1969 (NEPA), Section 106 of the NHPA requires federal agencies to take into account the effects of their actions or programs specifically on historic and archeological properties, prior to implementation. This is accomplished through consultation with the State Historic Preservation Officer (SHPO) and/or the Advisory Council on Historic Preservation (ACHP). On lands held by a Tribe with a Tribal Historic Preservation Officer (THPO), the THPO has the same duties and responsibilities as the SHPO. If an undertaking on federal lands may affect properties having historic value to a federally recognized Indian Tribe, such Tribe shall be afforded the opportunity to participate as interested persons during the consultation process defined in 36 CFR 800. Compliance can also be accomplished using agreed-upon streamlined methods and agreement documents such as Programmatic Agreements.

The Section 106 process is designed to identify possible conflicts between historic preservation objectives and the proposed activity, and to resolve those conflicts in the public's interest through consultation. Neither the NHPA nor the Advisory Council's regulations require that all historic properties be preserved. Rather, they only require the agency proposing the undertaking to consider the effects of the proposed undertaking prior to implementation.

Failure to take into account the effects of an undertaking on historic or cultural properties can result in formal notification from the ACHP to the head of the federal agency of foreclosure of the ACHP's opportunity to comment on the undertaking pursuant to NHPA. A notice of foreclosure can be used by litigants against the federal agency in a manner that can halt or delay critical activities or programs.

The process for compliance with Section 106 consists of the following steps.

1. **Identification of Historic Properties**—Identification of historic properties located within the area of potential effects (APE) is accomplished through review of existing documentation and/or field surveys.
2. **Property Evaluation**—Evaluation of the identified historic properties using National Register criteria (36 CFR Part 63) in consultation with the SHPO and, if necessary, the ACHP. Properties that meet the criteria will be considered "Eligible" for listing in the National Register, and will be subject to further review under Section 106. Properties that do not meet the criteria will be

considered "Not Eligible" for listing in the National Register, and will not be subject to further Section 106 review.

3. **Determination of Effect**—An assessment is made of the effects of the proposed project on properties that were determined to meet the National Register criteria, in consultation with the SHPO and if necessary, the ACHP. One of the following effect findings will be made:

   - No Historic Properties Affected—If no historic properties are found or no effects on historic properties are found, the agency official provides appropriate documentation to the SHPO/THPO and notifies consulting parties. However, the federal agency must proceed to the assessment of adverse effects when it finds that historic properties may be affected or the SHPO/THPO or Council objects to a "No Historic Properties Affected" finding. The agency must notify all consulting parties and invite their views.
   - No Historic Properties Adversely Affected—When the Criteria of Adverse Effect are applied (36 CFR 800.5(a)), and it is found that historic properties will not be adversely affected by the undertaking, the agency may make a finding of "No Historic Properties Adversely Affected." This finding is submitted to the SHPO for concurrence. Typically, the Council will not review "No Adverse Effect" determinations. However, the Council will intervene and review "No Historic Properties Adversely Affected" determinations if it deems it appropriate, or if the SHPO/THPO or another consulting party and the federal agency disagree on the finding and the agency cannot resolve the disagreement. If Indian Tribes disagree with the finding, they can request the Council's review directly, but this must be done within the 30-day review period. Agencies must retain records of their findings of "No Historic Properties Adversely Affected" and make them available to the public. The public should be given access to the information when they so request, subject to Freedom of Information Act (FOIA) and other statutory limits on disclosure, including the confidentiality provisions in Section 304 of the NHPA. Failure of the agency to carry out the undertaking in accordance with the finding requires the agency official to reopen the Section 106 process and determine whether the altered course of action constitutes an adverse effect.
   - Historic Properties Adversely Affected—Adverse effects occur when an undertaking may directly or indirectly alter characteristics of a historic property that qualify it for inclusion in the Register. Reasonably foreseeable effects caused by the undertaking that may occur later in time,

be farther removed in distance, or be cumulative also need to be considered. The finding of "Historic Properties Adversely Affected" is submitted to the SHPO for concurrence. The SHPO/THPO may suggest changes in a project or impose conditions so that adverse effects can be avoided and thus result in a "No Historic Properties Adversely Affected" determination

4. **Resolution of Adverse Effects/Mitigation**—When adverse effects are found, the consultation must continue among the federal agency, SHPO/THPO, and consulting parties to attempt to resolve them. The agency official must notify the Council when adverse effects are found and should invite the Council to participate in the consultation when circumstances as outlined within 36 CFR 800.6(a)(1)(i)(A)-(C) exist. A consulting party may also request the Council to join the consultation.

   When resolving adverse effects without the Council, the agency official consults with the SHPO/THPO and other consulting parties to develop a Memorandum of Agreement (MOA). The MOA will outline the steps or actions to be taken prior to implementation of the project, in order to mitigate the adverse effects on the historic property. Stipulations included in an MOA may include (but are not limited to) documentation, modification of the project to lessen the adverse effects on the property, efforts to sell or relocate the resource, or step-by-step consultation with interested parties throughout the process to ensure it is carried out according to plan.

   The MOA is executed between the agency official and the SHPO/THPO and filed with required documentation with the Council. This filing is the formal conclusion of the Section 106 process and must occur before the undertaking is approved.

In some cases, streamlining of the Section 106 process can be accomplished through the use of Programmatic Agreements. The Advisory Council and the agency official may negotiate a Programmatic Agreement to govern the implementation of a particular program or the resolution of effects from complex projects or multiple undertakings. Programmatic Agreements are particularly useful when programs or projects affecting historic properties are similar and repetitive, and have known effects, such as routine maintenance or a series of similar rehabilitation projects.

2.1.1.2 Section 101(d)(2)

This section of the NHPA provides for the assumption by federally recognized Indian Tribes of all or any part of the functions of a SHPO with respect to Tribal lands (e.g., all lands within the exterior boundaries of any Indian reservation and all dependent Indian communities). Section 101(d)(2) requires federal agencies, in carrying out their Section 106 responsibilities, to consult with federally recognized Indian Tribes that attach religious or cultural significance to a historic property. The agency will consult with federally recognized Indian Tribes in the Section 106 process to identify, evaluate, and treat historic properties that have religious or cultural importance to those groups.

2.1.1.3 Section 110

Section 110 of the NHPA is intended to ensure that historic preservation is integrated into the ongoing programs of Federal agencies. This section of the Act requires agencies to identify, evaluate, and nominate for listing in the National Register, historic properties owned or controlled by the agency; use historic properties to the maximum extent feasible; ensure documentation of historic properties that are to be altered or damaged; carry out programs and projects that further the purpose of the Act; and undertake such planning and actions as may be necessary to minimize harm to any formally designated National Historic Landmark properties.

2.1.1.4 Section 111

Section 111 of the NHPA requires agency officials, to the extent practicable, to establish and implement alternatives for historic properties, including adaptive use, that are not needed for current or projected agency uses or requirements. Further, Section 111 allows the proceeds from any lease to be retained by the agency to defray the cost of administration, maintenance, repair, and related expenses of historic properties.

2.1.1.5 Section 112

Section 112 of the NHPA requires that agency officials who are responsible for protection of historic properties pursuant to the NHPA ensure that all actions taken by employees or contractors meet professional historic preservation standards established by the Secretary of the Interior (Professional Qualifications Standards of the *Secretary of the Interior's Standards and Guidelines in Archaeology and Historic Preservation*).

2.1.1.6 Section 304

Section 304 of the NHPA requires that information about the location, character, or ownership of a historic property be withheld from public disclosure when the federal agency head or other public official determines that disclosure may cause a significant invasion of privacy, risk and/or harm to the historic property, or impede the use of a traditional religious site by practitioners.

2.1.1.7 CERCLA and the NHPA

EPA's *CERCLA Compliance with Other Laws Manual: Part II. Clean Air Act and Other Environmental Statutes and State Requirements* (USEPA 1989) outlines how "substantive compliance" with the NHPA is to be achieved in Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) actions.[2] The initial step is determining if cultural resources are known or are likely to be present "in or near the area under study in the RI." This step may require conducting a survey of both the location of the proposed remedial action and any associated actions that would occur off-site. The CERCLA manual referenced above defines three stages of a survey: Stage IA, literature search and sensitivity study; Stage IB, field investigation; and Stage II, site definition and evaluation. All studies should include Stage IA but implementation of Stage IB is contingent on the results of Stage IA, and the need for Stage II is contingent on the results of Stage IB. If results of the survey identify significant cultural resources (i.e., resources listed or considered eligible for listing on the National Register), effects of the proposed remedial action and associated actions to the significant resources must be evaluated. Adverse effects to significant resources must be either avoided or mitigated. Any proposed mitigation measures must be incorporated into the remedial design process.

2.1.2 Archeological Resources Protection Act of 1979 (16 USC 470aa-470ll)

ARPA is essentially an update to the 1906 Antiquities Act. It expands and strengthens the activities prohibited under the Antiquities Act, increases the criminal penalties for violation, establishes civil penalties, and provides further guidelines for the issuance of permits. This Act continues to apply only to federal and Indian lands (the definition of "Indian lands" in ARPA differs very slightly from the definition of "Tribal lands" in the

[2] As stated in the Agreement, "The Parties intend that this RI/FS, while not being carried out under an administrative order or judicial order issued pursuant to the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), will be consistent with the National Contingency Plan ('NCP'), 40 CFR Part 300."

NHPA). Most archaeological excavations and collection of artifacts on these lands are allowed only with an ARPA permit. Trafficking in illegally obtained archeological resources from federal and Indian lands is also prohibited. Individuals convicted of violating the Act are liable for the value of the archaeological resource itself, and the cost of restoration or repair of the damage caused by illegal excavation or collection.

The implementing regulations are 43 CFR Part 7 (Department of the Interior), which applies to Federal lands that are not within military reservations or national forests. The regulations include detailed definitions of "archaeological resource" and "Indian lands" (lands held in trust by the United States on behalf of a federally recognized Tribe or individual members of a federally recognized Tribe).

2.1.3 Native American Graves Protection and Repatriation Act (25 USC 3001-3013)

NAGPRA establishes that Native American human remains and associated funerary objects found on federal or Tribal lands belong to the lineal descendants of the Native American. When the lineal descendants cannot be determined, the remains belong to the Tribe on whose land the remains were found (when found on Tribal lands), or to the Indian Tribe with the "closest cultural affiliation."[3] This latter rule also applies to unassociated funerary objects, sacred objects, and objects of cultural patrimony (all defined in the Act) NAGPRA applies to both human remains intentionally excavated (which would require an ARPA permit) and those accidentally discovered.

NAGPRA also requires all federal agencies and museums to inventory their holdings of Native American human remains and funerary objects. Once the inventories are completed, the agencies and museums are to notify the appropriate Tribes of the remains and other objects in their collections. The remains and associated funerary objects are to be returned (repatriated) at the request of the lineal descendant(s) or Tribe. The same requirement applies to unassociated funerary objects, sacred objects, and objects of cultural patrimony for which a cultural affiliation can be demonstrated. Exceptions to the repatriation requirement are objects that are "indispensable for completion of a specific scientific study, the outcome of which would be of major benefit to the United States."

The implementing regulations are 43 CFR Part 10, which largely expand on the elements of the statute. The regulations detail 1) the process of consultation with Indian Tribes to

[3] Cultural affiliation is defined in the implementing regulations [43 CFR 10.2(e)] and refers to a relationship of shared group identity, which can be reasonably traced historically or prehistorically between a present day Indian tribe or Native Hawaiian organization and an identifiable earlier group.

address either intentional excavation of human remains or inadvertent discovery of human remains; 2) how agencies and museums are to inventory their collections; and 3) the repatriation process. When human remains, funerary objects, sacred objects, and objects of cultural patrimony are inadvertently discovered on federal lands the following steps are to be followed: 1) ongoing activity in the area of the find must cease and a reasonable effort made to protect the find; and 2) the federal land agency (i.e., the federal agency on whose lands the remains or objects have been found) must be immediately notified by telephone, with written confirmation. The federal land agency must then notify the appropriate Tribe(s) and further secure and protect the discovery. The activity may be halted for up to 30 days while an appropriate response to the find is negotiated by the federal agency and the appropriate Tribe(s).

2.1.4 American Indian Religious Freedom Act (42 USC 1996)

This Act states that it is the policy of the United States to protect and preserve the rights of American Indians to practice traditional religions. That policy includes rights of access to sacred sites and to the use and possession of sacred objects. There are no implementing regulations.

2.2 PRESIDENTIAL EXECUTIVE ORDERS

Presidential Executive Orders define policies and procedures for federal agencies to facilitate their execution of laws passed by the U.S. Congress or clarify how specific laws are to be implemented. Presidential executive orders can be considered instructions or directives from the President to federal agencies on how to carry out specific laws. The executive orders listed below are either directly related to cultural resources or define relationships between federal agencies and tribes.

2.2.1 Executive Order 11593. Protection and Enhancement of the Cultural Environment

Issued in 1971, this executive order stated that the federal government would provide leadership in "preserving, restoring, and maintaining the historic and cultural environment of the Nation." Federal agencies were directed to inventory cultural resources under their jurisdiction and nominate National Register-eligible properties to the National Register. Properties that have been determined eligible are not to be transferred, sold, demolished, or altered without providing the Advisory Council on

Historic Preservation with an opportunity to comment. Properties to be demolished or substantially altered were to be documented prior to demolition or alteration. National Register properties or National Register-eligible properties under federal control were to be maintained following standards set by the Secretary of the Interior. Executive Order 11593 also assigns specific responsibilities to the Secretary of the Interior, including managing the National Register of Historic Places and assisting and advising other federal agencies in the management of cultural resources.

2.2.2 Executive Order 13007. Indian Sacred Sites

Issued in 1996, Executive Order 13007 directs federal agencies to provide access and ceremonial use of Indian sacred sites, where practicable, legal, and not inconsistent with essential agency functions. Agencies are also directed to avoid adversely impacting sacred sites and maintain the confidentiality of such sites. A "sacred site" as defined by this executive order is a specific location that is sacred because of its religious significance to or ceremonial use in an Indian religion.

2.2.3 Executive Order 13175. Consultation and Coordination with Indian Tribal Governments

Issued in 2000, this Executive Order directs federal agencies to consult with Tribal officials in the development of policies and regulations that have "tribal implications" or that preempt Tribal law. Executive Order 13175 also emphasizes the importance of government-to-government relationships between the U.S. government and Tribes. Agencies must designate an official responsible for implementing the Executive Order and must document Tribal consultation in the development of the relevant policies and regulations.

2.3 TRIBAL LEGISLATION AND REGULATIONS

Tribal laws and regulations addressing cultural resources would apply to lands on the reservations and off-reservation trust lands. The Confederated Tribes of the Colville Reservation (CCT) and the Spokane Tribe of Indians (STI) are the two Tribes whose laws and regulations would be potentially applicable to the Site. The legal code of the CCT addresses cultural resources, as summarized below. This code applies to both on-reservation actions and off-reservation actions by federal agencies that could affect cultural resources. STI does not currently have laws that specifically address cultural

resources. Both Tribes have THPOs, who have the same authority and responsibilities as the SHPO on their respective reservations and on off-reservation trust lands.

2.3.1 Confederated Tribes of the Colville Reservation. Colville Tribal Law and Order Code Chapter 4-4, Cultural Resources Protection

This Colville Tribal Code establishes the Colville Cultural Resources Board, which has the responsibility of developing policies and procedures to protect cultural resources of interest and concern to the Colville Tribes, both on and off the Colville Reservation. The Board reviews proposed federal agency actions off the reservation and is responsible for reviewing all proposed on-reservation actions that could affect significant cultural resources. The code also establishes a Colville Register of Historic and Archaeological Properties for listing of historic properties on the Colville Reservation.

This code defines the roles and responsibilities of the Colville History and Archaeology Department, which include identifying significant cultural resources on the reservation, nominating properties to the National Register and the Colville Register, and promoting efforts to protect cultural resources on the reservation.

Chapter 4-4 of Colville Tribal Code prohibits the excavation, disturbance, or other adverse effects to archaeological resources and historic properties on the reservation without a permit issued by the History and Archaeology Department. The code defines the procedure for the issuance of permits and the duties of permittees.

2.4 STATE LEGISLATION AND REGULATIONS

Washington State laws and regulations regarding archaeological and historical resources, as well as the law protecting Indian graves, are not applicable on federal lands or on Tribal trust lands. These laws would apply, however, to any RI/FS-related activities that would affect private lands or non-federal or non-Tribal public lands.

2.4.1 Revised Code of Washington (RCW) Chapter 27.44, Indian Graves and Records

This legislation prohibits the removal or other disturbance of Indian burials, cairns, and "glyptic or painted records." "Burials" and "graves" are not defined in the statute. Excavation or removal of burials is permitted only under provisions of a permit issued by

the Washington Department of Archaeology and Historic Preservation. Procedures for obtaining permits are defined in WAC Chapter 25-48.

2.4.2 RCW Chapter 27.53, Archaeological Sites and Resources

This legislation prohibits the excavation or disturbance of archaeological sites on public and private lands in Washington except under provisions of a permit issued by the Washington Department of Archaeology and Historic Preservation. Procedures for obtaining permits are defined in WAC Chapter 25-48.

2.4.3 RCW Chapter 68.60, Abandoned and Historic Cemeteries and Historic Graves

This legislation prohibits the destruction, alteration, or other disturbance of historical and abandoned cemeteries and historic graves (Indian graves and burials are protected in RCW Chapter 27.44). A historic cemetery is defined in the statute as one established before November 1889. A historic grave is a grave or graves outside of a cemetery placed prior to June 1990.

2.4.4 RCW Chapter 43.21C, State Environmental Policy Act

This legislation directs state and local agencies in Washington to address environmental impacts of proposed projects. The implementing rules (WAC Chapter 197-11) require that impacts to historic and cultural resources are to be addressed in the State Environmental Policy Act process.

3 PROPOSED SAMPLING PROGRAM

A summary of the proposed sampling locations (coordinates) are provided within Table 3-1; with a detailed description of sampling techniques provided within the Quality Assurance Project Plan (QAPP). As indicated within the QAPP, sediment sampling activities will be completed to depths no greater than 6 inches below ground surface using using a decontaminated steel (modified) van Veen grab or Eckman box core sampler.

During this work, three locations between the trans-boundary reach and Kettle Falls would be sampled. Specifically, these as include Deadman's Eddy, China Bend, and Marcus Flats (an upper and lower portion) (Map 3-1), with sampling station coordinates provided within Table 3-1. In the event that samples cannot be retrieved from the aforementioned areas alternative sampling areas have also been identified. These include Northport and the Little Dalles (Map 3-1), with corresponding sampling station coordinates also presented within Table 3-1.

Surface sediment samples will be collected using a decontaminated steel (modified) van Veen grab, Eckman, or Ponar (or similar) box core sampler. These samplers are capable of collecting up to 20 liters (5.3 gallons) of sample per grab, with up to 50 gallons of sediment collected at each sampling station. A backup sampler will also be available in the event that the primary grab is damaged, malfunctions, or is lost. Sampling stations will be approached at slow boat speeds with minimal wake to minimize disturbance of bottom sediments prior to sampling, particularly in shallow sampling locations.

The sampler will be deployed using a hydraulic winch and an overhead davit or boom at a controlled rate of speed approximately equal to 30 centimeters per second (cm/sec) (1 foot per second [ft/sec]). The position of the sampler relative to the riverbed will be shown on the vessel's depth sounder or by rigging the hydrowire to a meter wheel or using pre-marked meter lengths on the cable itself. After the sample is collected, the sampling device will be lifted slowly off the bottom, then steadily raised to the surface at a speed of about 30 cm/sec (1 ft/sec).

The material in the sampler will be photographed and the photograph labeled with station location, date, and time of sample. The overlying water will then be siphoned off near one corner of the sampler. Next, a decontaminated stainless steel trowel or spoon may be used to collect only the upper 10 to 15 cm (4 to 6 inches) of sediment from inside the sampler.

4 COORDINATION PLAN

The objective of the CRCP is to ensure that implementation of the RI/FS and associated sampling activities does not adversely affect any cultural resources. The plan therefore defines a general process and more specific procedures to meet this objective.

The two chief challenges in meeting this objective are 1) the iterative process of remedial investigations; and 2) the high density of cultural resources in the study area. The iterative process is a challenge because there are likely to be several rounds of sampling (and associated actions) that extend over several years. Coordination and consultation must therefore also be an iterative process as methods and locations are defined for each round of sampling.

The high density of cultural resources is a challenge because it is highly likely that every round of intrusive sampling will occur at the identified location of one or more cultural resource(s). At the same time, the high density is potentially misleading by suggesting that all cultural resources in the UCR have been identified. Most—if not all—of the Lake Roosevelt lands have been surveyed for cultural resources in the past. Few of the surveys conducted prior to about 1975 are likely to have met current regulatory and professional standards. In addition, many of the previous surveys focused on archaeological resources to the exclusion of other types of cultural resources (and older archaeological surveys documented only evidence of prehistoric use or occupation). Finally, it is likely that there are some locations previously surveyed at which burials or buried archaeological resources are present but not evident and therefore not recorded at the time of the survey (many surveys both in the past and in the present rely entirely or primarily on surface evidence of archaeological resources or burials).

This plan therefore defines procedures that address sampling at both known locations of cultural resources and locations where no cultural resources are presently recorded.

4.1 GENERAL CONSULTATION FRAMEWORK

Successful implementation of the RI/FS and of this CRCP, given the issues defined above, will require ongoing consultation and coordination with the NPS, the USBR, the CCT, the STI, and the Washington SHPO (i.e., the consulting parties). Other consulting parties (as defined in 36 CFR 800.2(c)) may be recognized in the future whose participation would be important for general consultation or coordination in the RI/FS process or for specific sampling locations. For the purposes of cultural resources coordination activities, the

"consulting parties" referred to in this plan are distinguished from other "participating parties" to the RI/FS process.

4.2 CULTURAL RESOURCE PROCEDURES IN THE SAMPLING PROCESS

This section defines general procedures to be followed in the sampling process to minimize the potential for inadvertent disturbance of cultural resources. More specific protocols to respond to discoveries are defined in the following sections.

A Tribal cultural resources specialist or a professional archaeologist will be present on-site to monitor sediment sampling conducted at a known cultural resource or within 100 m (330 ft) of a known resource. The protocol for this monitoring is defined below.

4.2.1 Archaeological Monitoring in the Sampling Program

To assure compliance with the NHPA and the applicable requirements, procedures, and standards of the NPS, USBR, CCT, and STI, the following procedures have been developed to address potential discoveries, including inadvertent discoveries, of cultural materials and deposits (including sacred objects, funerary objects, and objects of cultural patrimony as defined in NAGPRA) and Indian burials and human remains (as defined in NAGPRA) during sediment and soil sampling and associated activity that could result in ground disturbance.

4.2.1.1 Notification of Planned Sediment and Soil Sampling

Teck American Incorporated (Teck) shall notify EPA at least 15 days in advance of any sample collection activity, unless shorter notice is agreed to by EPA. Notification to EPA may be provided by e-mail or by letter. As for all RI/FS activities at the Site involving sediment collection or ground penetration/disturbance, Teck shall 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. Further, sediment sampling cannot be performed at the Site without 1) clearance of proposed sediment sample locations by tribal and federal/state cultural resources coordinators, and; 2) approval by EPA.

The names and contact information for potentially affected parties (i.e., representatives of the federal land-managing agencies and Tribes) are provided in Attachment 1 of this plan. Teck will work with EPA to establish a procedure for timely notification of these parties.

4.2.1.2 Professional Archaeologist and Tribal Representative On-Site

An archeological monitor and/or Tribal representative will be present on-site when sampling or sampling-related activity occurs. The archaeological monitor and/or Tribal representative will visually examine all samples to determine if evident or likely artifacts are present or if other deposits are present that are likely to be cultural in origin. The archaeological monitor and/or Tribal representative will not make physical contact with the sample unless artifacts or other cultural deposits are present. If artifacts or likely archaeological deposits are present, the archaeologist or Tribal representative will record the location of the materials and photograph the materials in place in such a manner to provide information on provenience. The artifacts and other archaeological materials will then be re-deposited at their original location.

The archaeological monitor and/or Tribal representative will document their observations on a daily basis, including field notes and photographs that record the location, character of the sampling or other ground-disturbing activity, any archaeological discoveries made, and any decisions made within the provisions of this plan by the archaeological monitor and Tribal representative in response to any archaeological discoveries. A standardized archaeological monitoring form may be substituted for the field notes referenced above.

All archaeological monitors and Tribal representatives will be required to have read the applicable health and safety plan and to have complete understanding of the archaeological monitoring provisions of this plan. The archaeological monitors will also be required to meet requirements for personal protective equipment. In addition, all on-site personnel are subject to the directions of the task field supervisor at all times.

4.2.1.3 Discoveries: Archaeological Monitors 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 archaeologist 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 at the sampling location. Such relocation will be coordinated with the on-site sampling manager or 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 Teck Technical Team will remain on-site 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 archaeological discoveries must be provided to EPA for further coordination with consulting parties within 24 hours of the discovery. All telephone notification of discoveries must be promptly followed by notification in writing (via e-mail or conventional mail).

4.2.1.4 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. To comply with 43 CFR 10.4(b), any discoveries of human remains must be reported to the NPS and USBR immediately by telephone, followed by written notification. Any discoveries within the boundaries of the Colville or the Spokane reservations must also be reported immediately to the respective Tribe.

Teck will notify EPA for further coordination with consulting parties (consisting minimally of the NPS, USBR, CCT, STI, and the Washington State Historic Preservation Officer). The Teck Technical Team will assist the archaeological monitor and Tribal representative in securing the location of the discovery.

If no archaeological monitor or Tribal representative is present, the Teck Technical Team will secure the location of the discovery in such a manner that both maintains the physical integrity of the remains and any associated objects and precludes further disturbance, or a member of the Teck Technical Team will remain on-site until an archaeologist or Tribal representatives can arrive to assess the find.

Other conditions for responses to discoveries of archaeological materials may be defined in the permit(s) issued for the sampling program. Responses to any discoveries of burials must comply with provisions of NAGPRA and its implementing regulations (in addition to those referenced above), as well as the existing protocols of the NPS, USBR, CCT, and STI (copies of these protocols are provided in Attachment 1).

4.2.1.5 Discoveries: Archaeological Monitors Not Present

Should suspected or evident artifacts or other archaeological deposits be encountered during sampling or associated ground-disturbing activity that is not being monitored by a professional archaeologist or Tribal representative, further sampling and other ground-disturbing activity will be halted in the immediate vicinity of the discovery and the location secured from further disturbance. 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 this security). In consultation with the land-managing agency or appropriate Tribe, as well as other interested parties, Teck will arrange for the location of the discovery to be examined by a professional archaeologist and/or 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, a minimum of one Teck field-staff member per sampling boat or shoreline sampling group will be provided with training in recognizing these materials by a professional archaeologist prior to the initiation of any sediment and soil sampling.

4.2.2 Curation

Artifacts and other cultural materials that may be recovered during the sampling program (with the exception of human remains and associated items subject to NAGPRA) will be curated at a facility that meets the standards of 36 CFR 79. The appropriate facility or facilities will be designated by the NPS and USBR in consultation with the Tribes for items recovered from federal lands. The appropriate Tribe will designate the curation facility for cultural materials recovered from Tribal lands.

4.2.3 Reporting

Within 150 days of completion of each sampling activity that is covered under this plan,[4] a professional archaeologist will prepare a confidential[5] written report and presents the results of the archaeological monitoring and responses to any discoveries of archaeological resources or burials. The report will include 1) copies of field notes, descriptions and maps of all locations at which sampling-related archaeological monitoring was conducted; 2) descriptions of any discoveries made during such monitoring and the outcome of the discoveries (including the rationale for the decisions for the disposition of any finds); 3) descriptions and maps of all non-monitored locations at which inadvertent discoveries were made and the outcome of those discoveries; and 4) recommendations for any changes in the monitoring protocol or coordination plan that may be appropriate to address results of the monitoring or how well existing coordination procedures worked.

The draft report will be provided to EPA for review and dissemination to the consulting parties for review and comment.

4.3 CONFIDENTIALITY

Teck shall make its best efforts, in accordance with state and federal law, to ensure that its employees and contractors keep the discovery of any found or suspected human remains, other cultural items, and potential historic properties confidential. Pertinent Teck employees and contractors will be required to read and sign a confidentiality statement that specifies procedures to be followed in response to media and public contacts regarding archaeological and other cultural resources. To the extent permitted by law,

[4] Sampling or other RI/FS activities that do not require coordination under this plan will not result in generation of this reporting requirement.
[5] Refer to Section 5.3, "Confidentiality."

prior to any release of information, EPA, Teck, and the 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.

5 REFERENCES

USEPA (United States Environmental Protection Agency). 1989. CERCLA compliance with other laws manual: Part II. Clean act act and other environmental statutes and state requirements. U.S. Environmental Protection Agency, Region 10, Seattle, WA.

USEPA. 2006. Settlement agreement for implementation of remedial investigation and feasibility study at the Upper Columbia River Site. June 2, 2006. U.S. Environmental Protection Agency, Region 10, Seattle, WA.

6 GLOSSARY OF TERMS

Burial—A burial is defined in NAGPRA as "[a]ny natural or prepared physical location, whether originally below, on, or above the surface of the earth, into which as part of the death rite or ceremony of a culture, individual human remains are deposited."

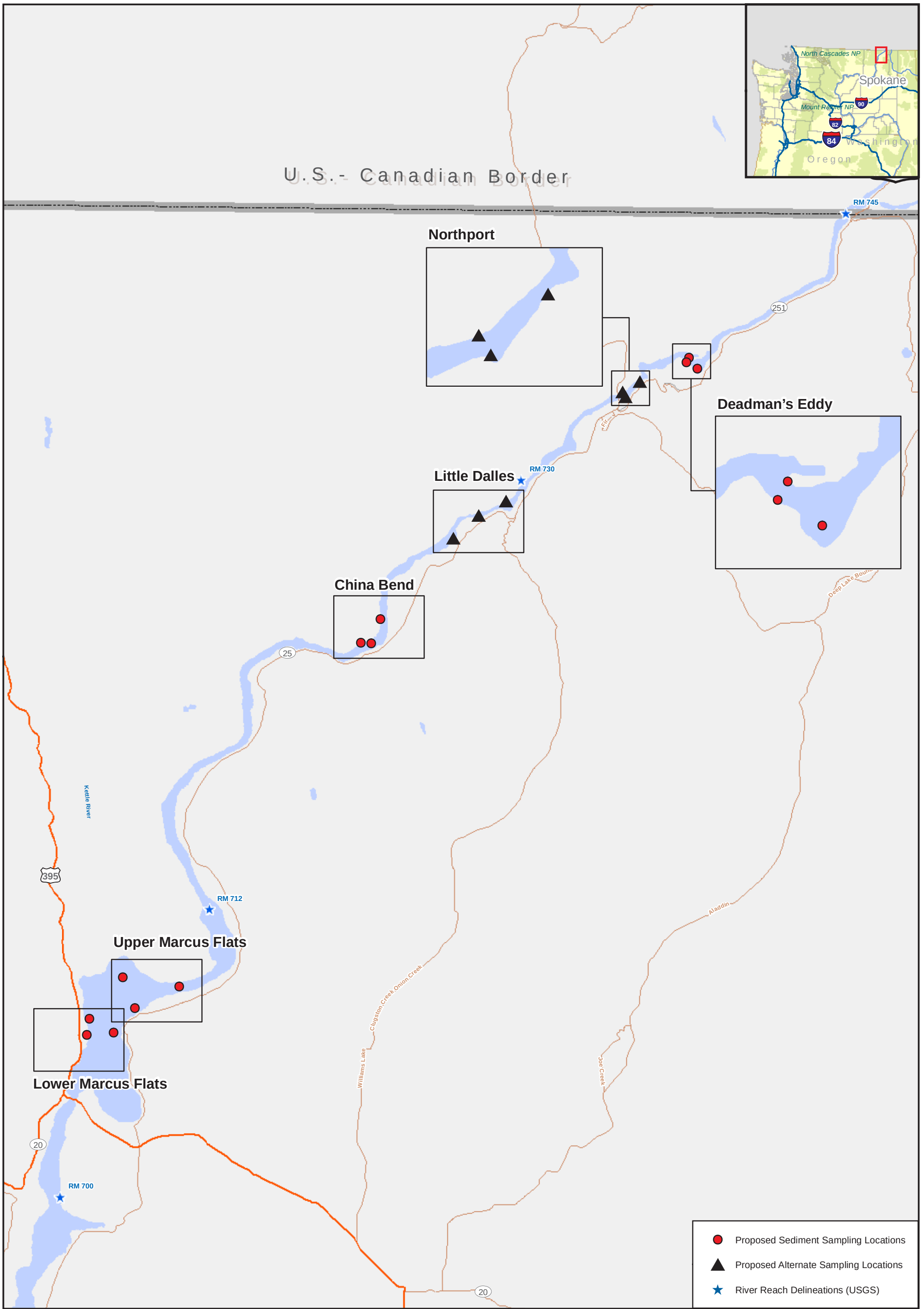
Curation—Long-term storage and preservation of archaeological collections. Archaeological collections from federal lands must be curated at facilities that meet the standards of 36 CFR 79.

Ethnohistoric—Information on Native peoples gathered from historical accounts.

Historic, historic-period, historical—The NHPA uses the term "historic" to refer to properties that are listed or have been determined eligible for listing on the National Register of Historic Places. To avoid confusion with this definition of "historic," "historic-period" or "historical" are used to reference resources, places, events, and people associated with the period since the appearance of Euroamericans and the beginning of written accounts (ca. 1780–1810 in the Pacific Northwest).

Protohistoric—The period of time transitional from prehistory to history. In the Pacific Northwest, the protohistoric can be generally defined as from the late 1600s until late 1700s.

Map



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Map 3-1 **Proposed On-site Sediment Sampling Locations and Alternate Sampling Locations**
Upper Columbia River, WA

TABLE

Table 3-1. Proposed Surface Sediment Sampling Locations

Sampling Area Description	UTM Coordinates	
	Easting	Northing
On-Site Samples		
Deadman's Eddy	446405.316	5420949.545
	446795.613	5420448.714
	446288.597	5420740.789
China Bend	432020.704	5408773.751
	431604.246	5407646.304
	431112.592	5407674.889
Marcus Flats - Upper Portion	422651.955	5391668.047
	420593.484	5390655.659
	420027.511	5392090.602
Marcus Flats - Lower Portion	419596.598	5389522.361
	418470.318	5390165.566
	418354.187	5389414.844
Northport (Alternate)	443442.45	5419135.82
	444108.47	5419838.75
	443302.5	5419361.44
Little Dalles (Alternate)	435417.18	5412544.52
	437874.45	5414280.9
	436606.68	5413599.7

ATTACHMENT 1

PROTOCOLS AND PROCEDURES FOR INADVERTENT DISCOVERIES AND/OR INTENTIONAL EXCAVATIONS

Attachment – Inadvertent Discoveries on Interior lands

Draft Lake Roosevelt Protocols for Native American Graves Protection and Repatriation Act (NAGPRA) Inadvertent Discoveries or Intentional Excavations: National Park Service and the Bureau of Reclamation

This protocol is intended to cover NAGPRA items exposed by inadvertent discoveries or intentional excavations within the boundaries of lands managed by the National Park Service/Lake Roosevelt National Recreation Area and the Bureau of Reclamation/Grand Coulee Dam Project. The term "NAGPRA items" in this document refers to human remains associated funerary objects, and objects of cultural patrimony as they are defined in 25 USC 3001 and its implementing regulations (43 CFR Part 10). Funding of actions is not covered under this protocol.

1. If potentially human remains are encountered, any activity in the vicinity of the discovery shall cease and all appropriate effort shall be made to determine if the remains are human. Secure the area and take protective measures to assure that the remains are not in danger of further depredation or disturbance.

2. A National Park Service law enforcement officer will be immediately notified. Law Enforcement, in consultation with the Park Archaeologist (if needed), will determine if the find is human, whether it is of recent origin, and if it is part of a crime scene.

   If Law Enforcement has determined that the find is human and not of Law Enforcement concern, they will notify the Park Archaeologist and the Chief of Cultural Resources, who will contact the appropriate Tribal representatives and the Bureau of Reclamation archaeologist about the Inadvertent Discovery. Live phone contact is required; backup staff are identified if the primary contacts are unavailable. Phone contact will be followed up by written confirmation. Contact Phone Numbers are provided at the end of the Protocols.

3. As soon as the items have been determined to be human, then all effort shall be made in the field to determine whether the remains are Native American.

4. If the items are determined not to be Native American, then Washington State burial laws apply and shall be followed (Title 68, Chapter 68.50 RCW HUMAN NAGPRA ITEMS.

5. If the ethnicity of the human remains cannot be determined in the field, further analysis of the bones and/or associated funerary objects or other archeological materials may be required. The, NPS and Reclamation shall consult with the Tribal representatives regarding the types of analysis to be conducted.

6. If it is determined that the human remains are Native American, a Written Plan of Action will be prepared that will outline the procedures that will be taken to address the NAGPRA regulations on Inadvertent Discoveries.

7. The manner of treatment will be decided in consultation between the NPS, BOR and the Tribal representatives.

8. If it is possible to rebury or cap the NAGPRA items in place, then that decision shall be documented in the Written Plan of Action (see below).

9. Should excavation or removal be the preferred option, NPS will review the excavation proposal and issue an ARPA permit following the NPS guidelines on ARPA permit requirements. The Reclamation contract language for burials recovered in the shoreline of the NRA will also apply and should agree with the Written Plan of Action and these protocols.

10. Provenience information will be collected as specified by the Written Plan of Action. The Reclamation contract language for burials recovered from the shoreline of the National Recreation Area will also apply and should agree with the Written Plan of Action and these protocols.

11. Recording of provenience may include any or all of the following: documenting the location of the burial or scattered NAGPRA items and general site conditions on a site form or on an addendum to an existing form; describing the surface visible NAGPRA items to the degree that can be accomplished without causing additional disturbance to the grave; and documenting the location of the burial on a USGS 7.5' topographic sheet and with a GPS unit.

12. NAGPRA items will be removed using standard professional archaeological practices. Such practices may include collection of horizontal provenience data referenced to a site datum point. If excavation is required, vertical provenience data shall be tracked through the use of stratigraphic or controlled 10-cm levels within a standard grid unit, screening of all excavated fill through 1/8-inch screen mesh, and photographic and to-scale plan map documentation of excavated features. All recovered items shall be listed in the field during collection to minimize handling after recovery.

13. Inadvertent discoveries that result from activities requiring easements or other non- ARPA permits (such as access, construction, etc.) shall be dealt with by the permitting agencies, which may be Reclamation or the NPS. This protocol document will be included with documents issued to permittees.

14. The Written Plan of Action for individual discoveries will detail exact procedures for further implementation of NAGPRA. A sample Written Plan of Action is included below.

15. Contact Names and Numbers.

- Camille Pleasants, CCT THPO (509) 634-2654, FAX 634-2694,
  John Pouley, Project Director Archaeologist, 509-634-2699. After work hours Mr. Pouley can be reached at 633-0498. In the event that neither Ms. Pleasants or Mr. Pouley can be contacted, then Guy Moura, TCP Coordinator, will be contacted at (509) 634-2695 (office), 633-8361 (home), 631-1705 (cell), who shall participate in the NAGPRA consultation process on Ms. Pleasants' behalf until her return.

  Ray DePuydt, Park Archeologist or Frank Andrews Jr. are the primary contacts for the Lake Roosevelt National Recreation Area. Mr. DePuydt's phone number is (509) 738-6266, ext 101, and internet address is ray_depuydt@nps.gov. Frank Andrews Jr. phone number is (509) 633-9441 ext. 132 and his internet address is frank_andrews@nps.gov.

- Sean Hess, Power Office Archaeologist, is Reclamation's primary contact for NAGPRA on Lake Roosevelt. His phone number is (509) 633-9233, cell 631-0213, FAX (509) 633-9138, and internet address is "shess@pn.usbr.gov," he may also be reached in cases of emergency at 633-7158. If Mr. Hess is not available, then Lynne MacDonald, Regional Archaeologist, is Reclamation's alternate contact. Her phone number is (208) 378-5316, FAX 378-5305, and internet address is "lmacdonald@pn.usbr.gov." In the event neither Mr. Hess nor Ms. MacDonald is available, Reclamation's Contracting Officer will be contacted directly at (208) 378-5364.

- Randy Abrahamson, THPO, and John Matt, Cultural Program Director, are the primary contacts for the Spokane Tribe of Indians. Mr. Abrahamson's number is (509) 258-4315 randya@spokanetribe.com and John Matt's is (509) 258-4060 johnm@spokanetribe.com.

Template NAGPRA Plan of Action for Lake Roosevelt

This plan of action shall comply with the requirements of the Native American Graves Protection and Repatriation Act (NAGPRA) (25 USC 3001 et seq.), its implementing regulations (43 CFR Part 10) and the Archaeological Resources Protection Act (ARPA) (16 USC 470 et seq.) with its implementing regulations (43 CFR Part 7).

1. The kinds of objects to be considered as cultural items as defined in Sec. 10.2 (b):
   - ✓ Human remains
   - ✓ Associated funerary objects
   - ✓ Unassociated funerary objects
   - ✓ Objects of cultural patrimony
   - ✓ Sacred objects

These objects are cultural objects as defined under NAGPRA 43CFR Part 10.2 (d).

2. The specific information used to determine custody pursuant to Sec. 10.6:
   - ✓ Traditional association (this is where tribe's area of interest is cited with reference to Lake Roosevelt)
   - ✓ Cultural affiliation
   - ✓ Evidence: Geographical, archaeological, linguistic, folklore, oral tradition, historical

3. The planned treatment, care, and handling of human remains and other objects as defined in NAGPRA

4. The planned archaeological recording of the human remains and other objects as defined in NAGPRA

5. The kinds of analysis planned for each kind of object

6. Any steps to be followed to contact Indian tribe officials at the time of intentional excavation or inadvertent discovery of specific human remains and other objects as defined in NAGPRA

7. The kind of traditional treatment, if any, to be afforded the human remains and other objects as defined in NAGPRA by members of the Indian tribe

8. The nature of reports to be prepared

9. The planned disposition of human remains, and other objects as defined in NAGPRA.

Spokane Tribe of Indians
P.O. Box 100-Wellpinit, WA 99040
Tel 509-458-6500, Fax 509-458-6575

Century of Survival
1881-1981:
Procedure for the Inadvertent Disturbance or Discovery of Spokane Human Remains and Cultural Resources

Introduction

Because many ground-disturbing processes, both natural and cultural, have the effect of prompting the destruction of evidence of Spokane Tribal heritage, it is the policy of the Spokane Tribe of Indians (hereafter "Spokane Tribe") to leave Spokane human remains and cultural resources in place and undisturbed. Purposeful disturbance of these resources without proper permit and consultation and/or approval of the Spokane Tribe is a violation of federal, Tribal, State, and/or local law. The National Historic Preservation Act (NHPA) and the Native American Graves Protection and Repatriation Act (NAGPRA) require that federal agencies take responsibility for damage to or loss of human burials caused by the project actions or that occur on off-reservation lands under the management jurisdiction. The Spokane Tribe has been delegated the federal authority as a Tribal Historic Preservation Office for Reservation lands pursuant to Section 101 (d)(2) of the National Historic Preservation Act.

Geographic Area of Applicability

This procedure for the inadvertent disturbance or discovery of Spokane human remains and cultural resources applies to all lands within the boundaries of the Spokane Indian Reservation and is advisory for all lands within the Spokane Tribe's aboriginal territory, as determined in proceedings before the Indian Claims Commission. For the purposes of cultural resource management, the ceded territory is bounded by and includes the Columbia River on the west, the Canadian border to the north, the Idaho border to the east, Rosalia to the southeast, Rosalia to the southeast, and Ritzville to the southwest.

Procedure

In cases of inadvertent disturbance or discovery of Spokane human burials or cultural resources, the following procedure is to be followed:

1. Upon inadvertent disturbance or discovery of human burials or cultural resources, any action(s) affecting the burials or resources shall immediately be halted.
2. The person(s) making the discovery shall immediately notify the appropriate office of the coroner or police. Upon a determination of the appropriate death investigation authority that the location of the remains is not the result of a crime, the following procedures shall apply:
    a) The entity making such disturbance or discovery shall notify the landowner, occupant, or manager. If the land occupant or manager is notified in lieu of the landowner, the occupant or manager will immediately notify the landowner. The entity making the disturbance or discovery will immediately notify the Spokane Tribal Historic Preservation Office, Wellpinit, Washington, in person or by telephone (at 509-258-4315), or by fax (at 509-248-6965), of the disturbance or discovery. The entity is advised to keep written documentation of such contact.
    b) The entity making the disturbance, or discovery will exert its best effort to protect such remains and/or objects until the landowner and/or land occupant or manager arrives to protect these remains and/or objects. Within 24 hours of notification, the

landowner shall supply protection for such remains and/or objects, until disposition or control of such remains and objects has been implemented.

3. The Spokane Tribal Historic Preservation Officer or designated representative(s) shall inspect in person the affected sited, human remains, or cultural resources, and shall determine, if possible evidence at the site, oral history, and/or existing records, the cultural affiliation of such site, human remains, and/or objects, until disposition or control of such remains and objects has been implemented.

   a. If the exposed human remains or cultural resources are clearly Native American and have known lineal descendants or owners, the Spokane Tribal Historic Preservation Officer shall then have the opportunity to make disposition or to take control of such human remains and/or associated funerary objects.

   b. If the exposed human remains and /or associated funerary objects are clearly prehistoric or non-modern Native American in origin and have no known lineal descendants, or if the lineal descendants decline the disposition or control, the Spokane Tribe, as the Indian Tribe which has the closest cultural affiliation and aboriginally occupying the are, claims ownership of such human remains and associated funerary objects, as they choose.[1] The Tribe's ownership and right to disposition and control of the human remains and/or associated funerary objects refers to the entire burial, to the extent it can be recovered, and does not allow in any case for separation of part of an individual's remains from other parts or from their associated funerary objects.

   c. If the exposed human remains and/or associated funerary objects are historic and non-Native American in origin, the Spokane Tribal Historic Preservation Officer will notify the Washington State Historic Preservation Officer (SHPO), Disposition and control over such burials will be determined the SHPO.

   d. If the exposed human remains and/or associated funerary objects are of uncertain or unidentifiable cultural identity, but clearly non-modern in origin, the Spokane Tribal Historic Preservation Officer will use reasonable means, such as professional consultation, to obtain a determination of the responsibility of the entity disturbing such remains. After cultural identity has been satisfactorily determined, the disposition or control of such remains and /or objects shall follow as otherwise provided in this procedure.

   e. If the exposed human remains and/or associated funerary objects are modern or possibly modern in origin, regardless of cultural affiliation, the Spokane Tribal Historic Preservation Officer will notify the local law enforcement authorities. Disposition and control over such burials will be determined by the law enforcement authorities.

[1] For the purposes of this procedure, modern is here defined as less than 50 years old; non-modern is defined as 50 years of age or older. For human remains, the age of such remains is defined as beginning at the death of the individual, to the present.

4. Within 48 hours of notification, the entity with right of disposition and control shall notify the landowner concerning plans for disposition and control over such objects. Actual disposition and control shall be implemented as soon as possible, although may be delayed is so agreed by the landowner and the entity with right of disposition and control, or is the extent of the damage or other circumstances require delay in disposition and control.

The entity performing any action which inadvertently disturbs or damages Spokane human remains or cultural resources shall be responsible for costs of inspection of the damage or disruption by Tribal staff; removal, reburial, and/or restoration of the site; identification of resources. Costs may include but are not limited to staff, equipment, supplies, laboratory costs, and travel. If the entity performing the action which inadvertently disturbs or damages such resource is not also the land owner, such entity is responsible for reimbursing the land owner for costs incurred by the land owner as a direct result of this procedure. In no case shall the required associated with the action or resources involved.

The Spokane Tribal Historic Preservation Office shall make best effort to minimize the costs associated with Inadvertent Disturbance or Discovery, especially when the entity involved fully cooperates with preservation and protection efforts; however, appropriate project undertaking funding shall ensure that sufficient measures are taken to complete the activities described in these procedures.

An entity solely reporting human remains or cultural resources to the Spokane Tribe, provided they have not damaged or disturbed such resources, or caused or been responsible for damage or disturbance of such resources, shall not be responsible for any additional costs under this section.

Relationship to Other Applicable Laws

Full compliance with all aspects of this procedure shall be considered by the Spokane Tribe as full and complete consultation and cooperation with the Spokane Tribe, as required by law, for the purposes of Inadvertent Disturbance and Discovery of human remains and cultural resources.

Limitations

Compliance with this procedure for a particular disturbance or discovery does not constitute consultation and cooperation with the Spokane Tribe on other disturbances or discoveries.

Notification of the Spokane Tribe under this procedure does not release the entity from responsibility for violations of federal, Tribal, state or local law.

Violations

Any entity discovering or disturbing any Spokane human remains or cultural resources who does not follow the procedure described here, shall be considered in violation of this procedure. Such action shall be considered deliberate and causing unauthorized damage to the affected resource; this action is subject to prosecution under applicable federal, Tribal, state and/or local laws.

Recovery of Eroding Human Remains

When approval from the appropriate authorities is given for the collection of scattered human remains or recovery of exposed and immediately endangered remains, standard professional practices will be used to ensure that all associated remains and grave goods are recovered, and that the location is documented to assist future monitoring or management practices. However, those making the recovery shall not open up areas around the burial or discovery with the intention of discovering additional burials and materials or to learn more about the site context. Excavations of this sort are strictly for the salvage of eroding or disturbed burials.

The methods for documentation are to be consistent with practices employed by the Spokane Tribe, including collection of locational data, controlled excavation of the burial pit, and screening of the pit fill.

A professional archaeologist shall be in the field with the burial recovery crew at all times, and shall participate in the documentation of burials in all aspects where their involvement does not violate traditional custom or practices. If permitted by the Spokane, to scale map documentation of excavated features (i.e., distribution of remains and grave goods in the burial pit) is recommended.

The project entity is responsible for the preparation of a site plan map that shows the locations of surface-visible cultural features, significant topographic features, and other information needed to relocate the site in subsequent years for management purposes.

Photographs shall be taken that show the location of excavated burials in relation to identifiable landmarks. Human remains will not be visible in the photograph if not approved by the Spokane Tribe; this authorization will be decided on a case by case basis. The location of un-recovered remains or each excavated grave will be documented on a 7.5′ USGS quadrangle topographic map. GPS measurement of location is required.

Associated artifacts and grave goods may be subjected to examination and documentation if that is approved by the Spokane Tribe. Permission from the Spokane Tribal Business Council for examination and documentation of Native American burials and grave good, beyond that required to determine if the remains are Native American in origin, shall be gained in writing and a copy of the written approval shall be provided to the contracting professional investigation of the burial(s).

If the remains are Euro-American in ancestry, standard non-destructive analysis shall be completed of remains and any associated grave goods or mortuary materials.

All grave goods shall be stored with the appropriate skeletal remains.

Any recovered remains will be boxed according to Tribal standards (appropriate size and material to be decided by Tribal Elder in consultation); the contracted investigator will retain and protect the burials in their custody until repatriation occurs or, if such would prove necessary after completion of NAGPRA consultations, the Tribe notifies them to deliver the burial(s) to another location. We anticipate that, after completion of notification processes defined in NAGPRA, Native American remains would be repatriated to Spokane Tribe in Wellpinit, Washington.

Coordination

The Tribal Historic Preservation Officer, is the primary contact for the Spokane Tribe for notification purposes as well as consultation on matters of cultural patrimony. The phone number is (509) 258-4315, or FAX (509) 258-6965. The THPO shall be immediately notified whenever a human burial or scattered human remains are found on any Reservation or ceded land location.

Definitions

Cultural Resources

Cultural resources include (but not by way of limitation): archeological, historic, traditional, and ethnographic resources older than 50 years or originating more than 50 years ago. These include artifacts, features, and sites; pictographs and petroglyphs; traditional cultural properties; sacred sites and continuing practices; traditional gathering areas and resources; the Spokane and Columbia rivers; oral histories, myths, and stories; traditional ceremonies (separate from those practiced at historic sites), gatherings, and activities; and recordings of these in various formats. Those cultural resources specifically excluded from this definition are burial sites, human remains, and associated funerary objects, which possess certain qualities for the Spokane People that are not to be disclosed or discussed in this context.

To further expand this operational definition of cultural resources, three categories of property types should be noted; ancestral lifeways, property is usually an archaeological resource that contains material remains or physical evidence of past human life or activities, including the record of the effects of human activities on the environment. They are capable of revealing scientific and/or humanistic information through archaeological research. For the purposes of the Spokane Tribe, these sites are those that can be dated as originating prior to contact, that is, A.D. 1730.

An historic property may also be archeological in nature, but is better delimited by the time period of contact between the Spokane(e) Peoples and Euro-Americans, that is, between 1730 and 1950. This transitional period and the material culture generated may provide useful insights on assimilation and cultural resistance. In the long run, these contrasts will offer broader cultural and chronological reconstructions, documenting significant events, occupations or activities, and/or structures or landscapes whether extant or vanished, apart from the value of any existing structure or landscape.

Additional cultural properties are those associated with cultural practices or beliefs of a living community that are rooted in that community's history or are important in maintaining its cultural identity. These may also include traditional resource areas, those which traditionally support subsistence or other consumptive or ceremonial use of natural resources. Use can be on-site and visible, inferred from effects, or off-site and referenced in traditional narratives. Traditional ceremonial use may also involve sites, structures, each with their own special local names; as such they are eligible for listing in the National Register Historic Places.

Damage to Cultural Resources

Any intentional or unintentional disturbance to any cultural resource which has not been authorized by the Spokane Tribal Council as appropriate for that resource is considered damage. Damage to cultural resources includes (but not by way of limitation) looting, vandalism, disturbance , or displacement of any artifact, human remains or associated cultural objects, cultural features or sites, sacred sites, or burial sites; collection of non-modern artifacts (older than 50 years) from the surface of the ground; painting, drawing, carving, or other defacement of pictographs or petroglyphs; digging or disturbance in cultural sites; disturbance, clearing, or spraying pesticides in traditional gathering areas; handling of Spokane burial remains or associated objects by non-Tribal members; and desecration of burial grounds.

Entity or Person

For the purposes of the procedure "entity or person" shall mean an individual, corporation, partnership, trust, institution, association, or any other private entity or any officer, employee, agent, department, or instrumentality of the United States, of any Native American Tribe, and/or of any State or political subdivision thereof.

Objects of Cultural Patrimony

For the Spokane Tribe these objects include (not by way of limitation) Spokane Elders' oral histories, myths, stories; burial remains and associated objects of individuals without known descendants; objects associated with cemeteries and sacred sites; and the recordings in any and all media of these classes of objects.

APPENDIX F

QUALITY ASSURANCE MANUAL FOR COLUMBIA ANALYTICAL SERVICES

QUALITY ASSURANCE MANUAL

Columbia Analytical Services, Inc.

1317 South 13th Avenue
Kelso, Washington 98626
(360) 577-7222

Effective Date: March 1, 2009

Approved by:

Laboratory Director/Technical Director: _____
Jeff Christian

Quality Assurance Manager: _____
Julie Gish

Technical Director - Metals: _____
Jeff Coronado

Technical Director - Inorganics: _____
Harvey Jacky

Technical Director - Organics: _____
Jeff Grindstaff

Technical Director - Microbiology: _____
Lynda Huckestein

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Initials: _____ Date: _____

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3.0 INTRODUCTION AND COMPANY QUALITY ASSURANCE POLICY

Columbia Analytical Services, Inc. (CAS) is an employee-owned professional analytical services laboratory which performs chemical and microbiological analyses on a wide variety of sample matrices, including drinking water, groundwater, surface water, wastewater, soil, sludge, sediment, tissue, industrial and hazardous waste, and other material.

It is a policy at CAS that there will be sufficient Quality Assurance (QA) activities conducted in the laboratory to ensure that all analytical data generated and processed will be scientifically sound, legally defensible, of known and documented quality, and will accurately reflect the material being tested. This goal is achieved by ensuring that adequate Quality Control (QC) procedures are used throughout the monitoring process, and by establishing a means to assess performance of these Quality Control and other QA activities. Policies and procedures are established in order to meet the quality objectives of clients, accrediting authorities, and certifying organizations. The Quality System is established to meet the requirements of The NELAC Institute (TNI) National Environmental Laboratory Accreditation Program (NELAP).

CAS maintains control of analytical results by adhering to written standard operating procedures (SOPs) and by observing sample custody requirements. All analytical results are calculated and reported in units consistent with project specifications to allow comparability of data.

We recognize that quality assurance requires a commitment to quality by everyone in the organization - individually, within each operating unit, and throughout the entire laboratory.

CAS is a network of laboratories. In addition to the Kelso, WA facility, to which this manual is applicable, CAS also operates laboratories in California, Florida, New York, Arizona, and Texas.

The information in this document has been organized according to the format described in *EPA Requirements for Quality Management Plans, EPA QA/R-2,* USEPA, 2001; and *EPA Requirements for Quality Assurance Project Plans, EPA QA/R-5,* USEPA, 2001.

4.0 PROGRAM DESCRIPTION

The purpose of the QA program at CAS is to ensure that our clients are provided with analytical data that is scientifically sound, legally defensible, and of known and documented quality. The concept of Quality Assurance can be extended, and is expressed in the mission statement of CAS:

> "The mission of Columbia Analytical Services, Inc., is to provide high quality, cost-effective, and timely professional testing services to our customers. We recognize that our success as a company is based on our ability to maintain customer satisfaction. To do this requires constant attention to customer needs, maintenance of state-of-the-art testing capabilities and successful management of our most important asset - our people - in a way that encourages professional growth, personal development and company commitment."

In support of this mission, our QA program addresses all aspects of laboratory operations, including laboratory organization and personnel, standard operating procedures, sample management, sample and quality control data, calibration practices, standards traceability data, equipment maintenance records, method proficiency data (such as method detection limit studies and control charts), document control/storage and staff training records.

4.1 Facilities and Equipment

CAS features over 45,000 square feet of laboratory and administrative workspace. The laboratory has been designed and constructed to provide safeguards against cross-contamination of samples and is arranged according to work function, which enhances the efficiency of analytical operations. The ventilation system has been specially designed to meet the needs of the analyses performed in each work space. Also, CAS minimizes laboratory contamination sources by employing janitorial and maintenance staff to ensure that good housekeeping and facilities maintenance are performed. In addition, the segregated laboratory areas are designed for safe and efficient handling of a variety of sample types. These specialized areas (and access restrictions) include:

- Shipping and Receiving/Purchasing
- Sample Management Office, including controlled-access sample storage areas
- Inorganic/Metals Sample Preparation Laboratories (2)
- Inorganic/Metals "clean room" sample preparation laboratory
- ICP-AES Laboratory
- ICP-MS Laboratory
- AA Laboratory
- Water Chemistry & General Chemistry Laboratories (3)
- Semi-volatile Organics Sample Preparation Laboratory
- Gas Chromatography/High Performance Liquid Chromatography Laboratories (2)

- Gas Chromatography/Mass Spectrometry Laboratory
- Petroleum Hydrocarbon Laboratory
- Semi-volatile Organics Drinking Water Laboratories (2)
- Volatile Organics Laboratory
  - Separate sample preparation laboratory
  - Access by semi-volatile sample preparation staff only after removing lab coat and solvent-contaminated gloves, etc.
- Microbiology Laboratory
- Laboratory Deionized Water Systems (2)
- Laboratory Management, Client Service, Report Generation and Administration
- Data Archival, Data Review and support functions areas
- Information Technology (IT) and LIMS

In addition, the designated areas for sample receiving, refrigerated sample storage, dedicated sample container preparation and shipping provide for the efficient and safe handling of a variety of sample types. Figure 4-1 shows the facility floor plan. The laboratory is equipped with state-of-the-art analytical and administrative support equipment. The equipment and instrumentation are appropriate for the procedures in use. Appendix C lists the major equipment, illustrating the laboratory's overall capabilities and depth.

4.2 Technical Elements of the Quality Assurance Program

The Quality Assurance Program provides a platform on which technical operations are based. The program provides laboratory organization, procedures, and policies by which the laboratory operates. The necessary certifications and approvals administered by external agencies are maintained. This includes method approvals and audit administration. In addition, internal audits are performed to assess compliance with policies and procedures. Standard Operating Procedures (SOPs) are maintained for technical and administrative functions. A document control system is used for SOPs, as well as laboratory notebooks, and this QA Manual. A list of QA Program documents is provided in Appendix A.

Acceptable calibration procedures are defined in the SOP for each test procedure. Calibration procedures for other laboratory equipment (balances, thermometers, etc.) are also defined. Quality Control (QC) procedures are used to monitor the testing performed. Each analytical procedure has associated QC requirements to be achieved in order to demonstrate data quality. The use of method detection limit studies, control charting, technical training and preventative maintenance procedures further ensure the quality of data produced. Proficiency Testing (PT) samples are used as an external means of monitoring the quality and proficiency of the laboratory. PT samples are obtained from qualified vendors and are performed on a regular basis. In addition to method proficiency, documentation of analyst training is performed to ensure proficiency and competency of laboratory analysts and technicians. Sample handling and custody procedures are defined in SOPs. Procedures are also in place to monitor the sample storage areas. The technical elements of the QA program are discussed in further detail in later sections of this QA manual.

4.3 Operational Assessments

There are a number of methods used to assess the laboratory and its daily operations. In addition to the routine quality control (QC) measurements to measure quality, the senior laboratory management examines a number of other indicators to assess the overall ability of the laboratory to successfully perform analyses for its clients. On-time performance, report quality, training, and Quality Assurance are a few of the items that are used to assess performance from an external perspective. A frequent, routine assessment must also be made of the laboratory's facilities and resources in anticipation of accepting an additional or increased workload.

CAS utilizes a number of different methods to ensure that adequate resources are available in anticipation of the demand for service. Regularly scheduled senior staff meetings, tracking of outstanding proposals and an accurate, current synopsis of incoming work all assist the senior staff in properly allocating resources to achieve the required results. All Requests for Proposal (RFP) documents are reviewed by the Project Chemist and appropriate managerial staff to identify any project specific requirements that differ from the standard practices of the laboratory. Any requirements that cannot be met are noted and communicated to the client, as well as requesting the client to provide any project specific Quality Assurance Plans (QAPPs) if available. A weekly status meeting is also conducted with the laboratory staff by the Client Services Manager to inform the staff of the status of incoming work, future projects, or project requirements.

4.4 Document Control

Procedures for control and maintenance of documents are described in the *SOP for Document Control (ADM-DOC_CTRL).* The procedures described in the SOP include distribution, tracking, filing, and copyrighting of CAS controlled documents. The requirements of the SOP apply to all standards preparation logbooks, instrument maintenance logbooks, run logbooks, certificates of analysis, standard operating procedures (SOPs), quality assurance manuals (QAMs), quality assurance project plans (QAPPs), Environmental Health & Safety (EHS) manuals, and other controlled CAS documents.

Each controlled copy of a controlled document will be released only after a document control number is assigned and the recipient is recorded on a document distribution list. Filing and distribution is performed by the Quality Assurance Manager, or designee, and ensure that only the most current version of the document is distributed and in use. A document control number is assigned to logbooks. Completed logbooks that are no longer in use are archived in a master logbook file.

CAS maintains a records system that ensures all laboratory records (including raw data, reports, and supporting records) are retained and available. The archiving system is described in the *SOP for Data Archiving (ADM-ARCH).*

4.5 Subcontracting

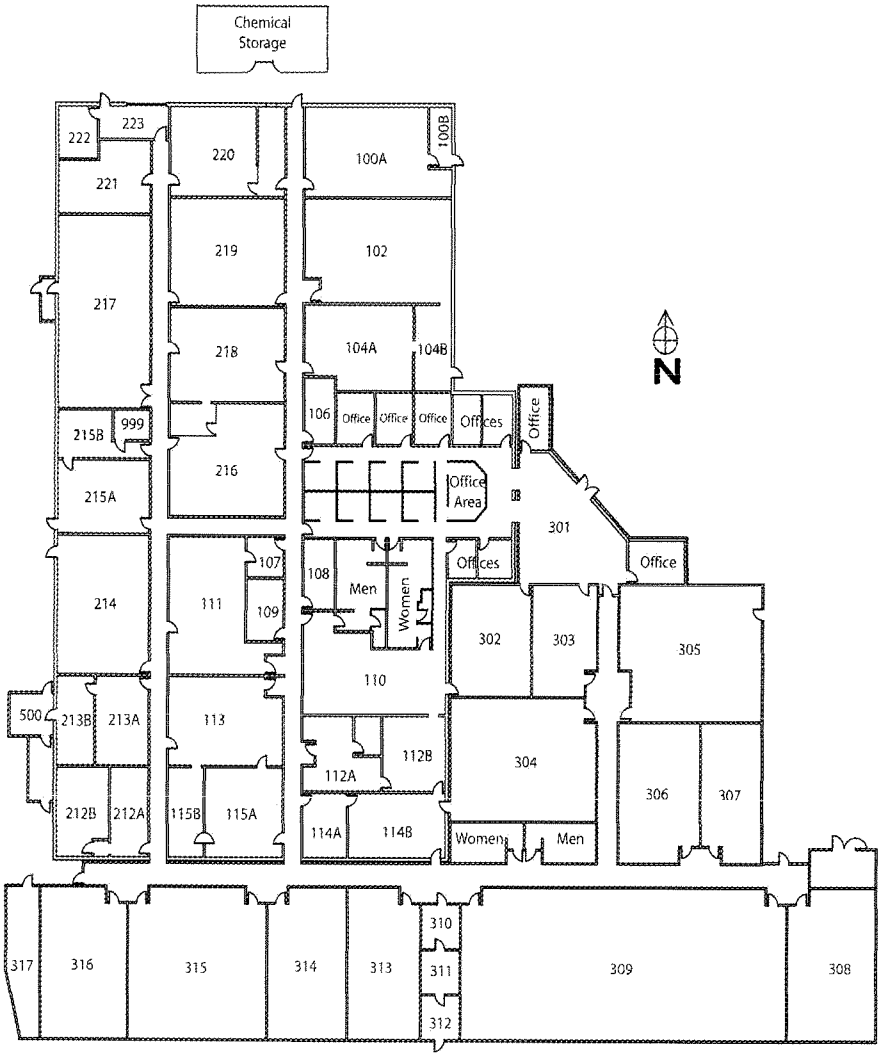
Analytical services are subcontracted when CAS/Kelso needs to balance workload or when the requested analyses are not performed by CAS/Kelso. Subcontracting is only done with the knowledge and approval of the client. Subcontracting to another CAS laboratory is preferred over external laboratory subcontracting. Further, sub-contracting is done using capable and qualified laboratories. Established procedures are used to qualify external subcontract laboratories. These procedures are described in the *SOP for Qualification of Subcontract Laboratories Outside of CAS Network (ADM-SUBLAB).* The Corporate Quality Assurance staff is responsible for qualifying and oversight of subcontract laboratories.

4.6 Procurement

The quality level of reagents and materials (grade, traceability, etc.) required is specified in analytical SOPs. Department supervisors ensure that the proper materials are purchased. Inspection and verification of material ordered is performed at the time of receipt by receiving personnel. The receiving staff labels the material with the date received. Expiration dates are assigned (by the laboratory user) as appropriate for the material. Storage conditions and expiration dates are specified in the analytical SOP. The procedures for purchasing and procurement are described in the *SOP for Purchasing through CAS Purchasing Department in Kelso (SOP ADM-PUR).* Also, refer to section 10.4 for a discussion of reference materials.

Figure 4-1
CAS/Kelso Laboratory Floor Plan

Room #	
100A	Semivolatile GC Lab
100B	Electrical Room
102	Semivolatile GC Lab
104A	Petroleum Hydrocarbon Lab
104B	Petroleum Hydrocarbon Lab
106	Deionized Water System Room
107	Storage
108	Zero Headspace Extraction
109	Storage
110	Lunch Room
111	General Chemistry Lab
112A	Microbiology Lab
112B	Copy Center
113	Metals Lab
114A	Sample Preparation
114B	Sample Preparation
115A	Metals Lab
115B	Metals Lab
212A	Metals Lab
212B	Low Level Mercury Lab
213A	Sample Preparation
213B	Sample Preparation
500	Janitorial Room
214	General Chemistry Lab
215A	Drinking Water Lab
215B	Data Storage
999	Computer Room
216	Data Review Area
217	Sample Storage
218	Volatiles Lab
219	Semivolatile GC/MS Lab
220	Semivolatile GC/MS Lab
221	Drinking Water Lab
222	Purchasing
223	General Receiving
301	Lobby
302	Lunch Room
303	Conference Room
304	Sample Storage
305	Sample Receiving
306	Pharmaceutical A
307	Pharmaceutical B
308	Pharmaceutical C
309	Organics Extractions Lab
310	Communication Room
311	Electrical Room
312	Fire Room/Water System
313	Glass Room
314	Clean Room
315	Metals Digestion Room
316	Tissue Preparation
317	Mechanical



5.0 PROFESSIONAL CONDUCT AND ETHICAL PRACTICES

One of the most important aspects of the success of CAS is the emphasis placed on the integrity of the data provided and services performed. To promote product quality, employees are required to comply with certain standards of conduct and ethical practices. The following examples of CAS policy are representative of these standards, and are not intended to be limiting or all-inclusive:

- Under no circumstances is the willful act of fraudulent manipulation of analytical data condoned. Such acts are to be reported immediately to senior management for appropriate corrective action. Unless specifically required in writing by a client, alteration, deviation or omission of written contractual requirements is not permitted. Such changes must be in writing and approved by senior management.

- Falsification of data in any form will not be tolerated. While much analytical data is subject to professional judgment and interpretation, outright falsification, whenever observed or discovered, will be documented, and appropriate remedies and punitive measures will be taken toward those individuals responsible. Employee discipline is progressive in its severity and each situation is handled individually in that the discipline is designed to fit the circumstances. Potential disciplinary actions may include a verbal warning, written warning, a second written notice (more severe and more strongly worded than a warning), suspension without pay, demotion, or termination.

- It is the responsibility of all CAS employees to safeguard sensitive company and client information. The nature of our business and the well being of our company and of our clients is dependent upon protecting and maintaining proprietary company/client information. All information, data, and reports (except that in the public domain) collected or assembled on behalf of a client is treated as confidential. Information may not be given to third parties without the consent of the client. Unauthorized release of confidential information about the company or its clients is taken seriously and is subject to formal disciplinary action.

All employees are required to sign and adhere to the requirements set forth in the CAS *Confidentiality and Conflicts of Interest Employee Agreement* and the CAS *Commitment to Excellence in Data Quality Policy.* All employees receive in-house ethics training and are periodically reminded of their data quality and ethical conduct responsibilities.

CAS makes every attempt to ensure that employees are free from any commercial, financial, or other undue pressures that might affect their quality of work. Related policies are described in the CAS Employee Handbook. This includes the CAS Ombudsman Program, the CAS Open Door Policy, and the use of flexible work hours. Operational assessments are regularly made to ensure that project planning is performed and that adequate resources are available during anticipated periods of increased workloads (Section 4.3). Procedures for subcontracting work are established, and within the CAS laboratory network additional capacity is typically available for subcontracting, if necessary.

6.0 ORGANIZATION AND RESPONSIBILITIES

The CAS/Kelso staff, consisting of approximately 130 employees, includes chemists, technicians and support personnel. They represent diverse educational backgrounds and experience, and provide the comprehensive skills that the laboratory requires. During seasonal workload increases, additional temporary employees may be hired to perform specific tasks.

CAS is committed to providing an environment that encourages excellence. Everyone within CAS shares responsibility for maintaining and improving the quality of our analytical services. The responsibilities of key personnel within the laboratory are described below. Table 6-1 lists the CAS/Kelso personnel assigned to these key positions. Managerial staff members are provided the authority and resources needed to perform their duties. An organizational chart of the laboratory, as well as the resumes of these key personnel, can be found in Appendix B.

- The role of the **Laboratory Director** is to provide technical, operational, and administrative leadership through planning, allocation and management of personnel and equipment resources. The Laboratory Director provides leadership and support for the QA program and is responsible for overall laboratory efficiency and the financial performance of the Kelso facility. The Laboratory Director has the authority to stop work in response to quality problems. The Laboratory Director also provides resources for implementation of the QA program, reviews and approves this QA Manual, reviews and approves standard operating procedures (SOPs), and provides support for business development by identifying and developing new markets through continuing support of the management of existing client activities.
- The responsibility of the **Quality Assurance Manager** (QAM) is to oversee implementation of the quality program and to coordinate QA activities within the laboratory. The QAM works with laboratory production units to establish effective quality control and assessment plans. The QAM has the authority to stop work in response to quality problems. The QAM is responsible for maintaining the QA Manual and performing an annual review of it; reviewing and approving SOPs and coordinating the annual review of each SOP; maintaining QA records such as metrological records, archived logbooks, PT sample results, etc.; document control; conducting PT sample studies; approving nonconformity and corrective action reports; maintaining the laboratory's certifications and approvals; performing internal QA audits; preparing QA activity reports; etc. The QAM reports directly to the Laboratory Director. The QAM also interacts with the CAS Quality Assurance Director. It is important to note that when evaluating data, the QAM does so in an objective manner and free of outside, or managerial, influence.

  The Chief Quality Officer (CQO) is responsible for the overall QA program at all the CAS laboratories. The CQO is responsible for ensuring that annual internal audits are performed at each CAS laboratory; maintaining a data base of information about state certifications and accreditation programs; writing laboratory-wide SOPs; maintaining a data base of CAS-approved subcontract laboratories; providing assistance to the laboratory QA staff and laboratory managers; preparing a quarterly QA activity report; etc.

- In the case of absence of the Laboratory Director or QA Manager, deputies are assigned to act in that role. Default deputies for these positions are the Client Services Manager or Organics Department Manager (for the Laboratory Director) and the CQO or Laboratory Director (for the QA Manager).

- The **Environmental Health and Safety Officer** (EH&S) is responsible for the administration of the laboratory health and safety policies. This includes the formulation and implementation of safety policies, the supervision of new-employee safety training, the review of accidents, incidents and prevention plans, the monitoring of hazardous waste disposal and the conducting of departmental safety inspections. The EH&S officer is also designated as the Chemical Hygiene Officer. The EH&S Officer has a dotted-line reporting responsibility to CAS' EH&S Director.

- The **Client Services and Sample Management Office Manager** is responsible for the Client Services Department (customer services/project chemists, and Electronic Data Deliverables group) and the sample management office/bottle preparation sections. The Client Services Department provides a complete interface with clients from initial project specification to final deliverables. The sample management office handles all the activities associated with receiving, storage, and disposal of samples. The Client Services Manager has the authority to stop subcontractor work in response to quality problems.

- The **Project Chemist** is a senior-level scientist assigned to each client to act as a technical liaison between the client and the laboratory. The project chemist is responsible for ensuring that the analyses performed by the laboratory meet all project, contract, and regulatory-specific requirements. This entails coordinating with the CAS laboratory and administrative staff to ensure that client-specific needs are understood, and that the services CAS provides are properly executed and satisfy the requirements of the client.

- The Analytical Laboratory is divided into operational units based upon specific disciplines. Each department is responsible for establishing, maintaining and documenting a quality control program based upon the unique requirements within the department. Each **Department Manager and Supervisor** has the responsibility to ensure that quality control functions are carried out as planned, and to guarantee the production of high quality data. Department managers and bench-level supervisors have the responsibility to monitor the day-to-day operations to ensure that productivity and data quality objectives are met. Each department manager has the authority to stop work in response to quality problems in their area. Analysts have the responsibility to carry out testing according to prescribed methods, SOPs, and quality control guidelines particular to the laboratory in which he/she is working.

- The **Sample Management Office** plays a key role in the laboratory QA program by maintaining documentation for all samples received by the laboratory, and by assisting in the archival of all laboratory results. The sample management office staff is also responsible for the proper disposal of samples after analysis.

- **Information Technology** (IT) staff are responsible for the administration of the Laboratory Information Management System (LIMS) and other necessary support services. Other functions of the IT staff include laboratory network maintenance, IT systems development and implementation, education of analytical staff in the use of scientific software, Electronic Data Deliverable (EDD) generation, and data back-up, archival and integrity operations.

Table 6-1
Summary of Technical Experience and Qualifications

Personnel	Years of Experience	Project Role
Jeff Christian, B.S.	30	Laboratory Director
Julie Gish, M.S.	18	Quality Assurance Manager
Lynda Huckestein, B.S.	20	Client Services Manager Sample Management Office Manager
Jeff Coronado, B.S.	19	Metals Department Manager
Harvey Jacky, B.S.	20	General Chemistry Department Manager
Gregory Salate, Ph.D.	9	Extractions Department Manager
Jeff Grindstaff, B.S.	20	Organics Chromatography & Mass Spectrometry Department Manager
Loren Portwood, B.S.	18	Organics Drinking Water Department Manager
Eileen Arnold, B.A.	27	Environmental Health and Safety Officer
Mike Sullivan, B.S.	8	CAS Information Technology Director
Lee Wolf, B.S.	23	CAS Chief Quality Officer
Steve Vincent, B.S.	33	CAS President

7.0 INFORMATION MANAGEMENT

The generation, compilation, reporting, and archiving of electronic data is a critical component of laboratory operations. In order to generate data of known and acceptable quality, the quality assurance systems and quality control practices for electronic data systems must be complete and comprehensive and in keeping with the overall quality assurance objectives of the organization. CAS management provides the tools and resources to implement electronic data systems and establishes information technology standards and policies. Appendix C lists major automated data processing equipment.

7.1 Software Quality Assurance Plan

CAS has defined practices for assuring the quality of the computer software used throughout all laboratory operations to generate, compile, report, and store electronic data. These practices are described in the CAS Software Quality Assurance Plan (SQAP). The purpose of the SQAP is to describe the policies and practices for the procurement, configuration management, development, validation and verification, data security, maintenance, and use of computer software. The policies and practices described in the plan apply to purchased computer software as well as to internally developed computer software. Key components of configuration management plan are policies for controlling the software version that is in use in the laboratory.

7.2 IT Support

The local CAS Information Technology (IT) department is established to provide technical support for all computing systems. The IT department staff continually monitors the performance and output of operating systems. The IT department oversees routine system maintenance and data backups to ensure the integrity of all electronic data. A software inventory is maintained. Additional IT responsibilities are described in the SQAP.

In addition to the local IT department, CAS corporate IT provides support for network-wide systems. CAS also has personnel assigned to information management duties such as development and implementation of reporting systems; data acquisition, and Electronic Data Deliverable (EDD) generation.

7.3 Information Management Systems

CAS has various systems in place to address specific data management needs. The CAS Laboratory Information Management System (LIMS) is used to manage sample information and invoicing. Access is controlled by password. This system is used to establish and define sample identification, analysis specifications, and provide a means of sample tracking. This system is used during sample login to generate the internal Service Request. The Service

Request provides a summary of client information, sample information, required analyses, work instructions, deliverable requirements and other necessary information provided on the chain of custody. The LIMS also is the basis for valuable sample tracking mechanisms used throughout the laboratory. Laboratory analysts generate responsibility reports from the LIMS and perform internal chain of custody via the LIMS.

Where possible, instrument data acquired locally is immediately moved to a server (Microsoft Windows2003® domain). This provides a reliable, easily maintained, high-volume acquisition and storage system for electronic data files. With password entry, users may access the system from many available computer stations, improving efficiency and flexibility. The server is also used for data reporting, EDD generation, and administrative functions. Access to these systems is controlled by password. A standardized EDI (electronic data interchange) format is used as a reporting platform, providing functionality and flexibility for end users. With a common standardized communication platform, the EDI provides data reporting in a variety of hardcopy and electronic deliverable formats, including Staged Electronic Data Deliverable (SEDD) format.

7.4 Backup and Security

CAS laboratory data is either acquired directly to the centralized acquisition server or acquired locally and then transferred to the server. All data is eventually moved to the centralized data acquisition server for reporting and archiving. Differential backups are performed on all file server information once per day, Sunday through Thursday. Full backups are performed each Friday night. Tapes are physically stored in a locked media cabinet within a locked, temperature controlled computer room, with every other full backup also securely stored offsite.

Access to sample information and data is on a need-to-know basis. Access is restricted to the person's areas of responsibility. Passwords are required on all systems. No direct external, non-CAS access is allowed to any of our network systems.

The external e-mail system and Internet access is established via a single gateway to discourage unauthorized entry. CAS uses a closed system for company e-mail. Files, such as electronic deliverables, are sent through the external e-mail system only via a trusted agent. The external messaging system operates through a single secure gateway. Email attachments sent in and out of the gateway are subject to a virus scan. Because the Internet is not regulated, we use a limited access approach to provide a firewall for added security. Virus screening is performed continuously on all network systems.

8.0 SAMPLE MANAGEMENT

8.1 Sampling and Sample Preservation

The quality of analytical results is highly dependent upon the quality of the procedures used to collect, preserve and store samples. CAS recommends that clients follow sampling guidelines described in 40 CFR 136, 40 CFR 141, USEPA SW-846, and state-specific sampling guidelines, if applicable. Sampling factors that must be taken into account to insure accurate, defensible analytical results include:

- Amount of sample taken
- Type of container used
- Type of sample preservation
- Sample storage time
- Proper custodial documentation

CAS uses the sample preservation, container, and holding-time recommendations published in a number of documents. The primary documents of reference are: USEPA SW-846, Third Edition and Updates I, II, IIA, IIB, III, IV for hazardous waste samples; USEPA 600/4-79-020, 600/4-91-010, 600/4-82-057, 600/R-93/100, 600/4-88-039, 600/R-94-111, and Supplements; EPA 40CFR parts 136 and 141; and *Standard Methods for the Examination of Water and Wastewater* for water and wastewater samples (see Section 18 for complete citations). The container, preservation and holding time information for these references is summarized in Table 8-1 for soil, water, and drinking water. The current EPA CLP Statement of Work should be referred to for CLP procedures. Where allowed by project sampling and analysis protocols (such as Puget Sound Protocols) the holding time for sediment, soil, and tissue samples may be extended for a defined period when stored frozen at -20°C.

CAS routinely provides sample containers with appropriate preservatives for our clients. Containers are purchased as precleaned to a level 1 status, and conform to the requirements for samples established by the USEPA. Certificates of analysis for the sample containers are available to clients if requested. Reagent water used for sampling blanks (trip blanks, etc.) and chemical preservation reagents are tested by the laboratory to ensure that they are free of interferences and documented. Our sample kits typically consist of foam-lined, precleaned shipping coolers, (cleaned inside and out with appropriate cleaner, rinsed thoroughly and air-dried), specially prepared and labeled sample containers individually wrapped in protective material, (VOC vials are placed in a specially made, foam holder), chain-of-custody (COC) forms, and custody seals. Container labels and custody seals are provided for each container.

Figure 8-1 shows the chain-of-custody form routinely used at CAS and included with sample kits. For large sample container shipments, the containers may be shipped in their original boxes. Such shipments will consist of several boxes of labeled sample containers and sufficient materials (bubble wrap, COC forms, custody seals, shipping coolers, etc.) to allow the sampling personnel to process the sample containers and return them to CAS. The proper preservative is added to the sample containers prior to shipment, unless otherwise instructed by the client.

If any returning shipping cooler exhibits an odor or other abnormality after receipt and subsequent decontamination by laboratory personnel, a second, more vigorous decontamination process is employed. Containers exhibiting an odor or abnormality after the second decontamination process are promptly and properly discarded. CAS keeps client-specific shipping requirements on file and utilizes major transportation carriers to guarantee that sample shipping requirements (same-day, overnight, etc.) are met. CAS also provides courier service that makes regularly scheduled trips to the Greater Portland, Oregon Metropolitan area.

When CAS ships environmental samples to other laboratories for analysis each sample bottle is wrapped in protective material and placed in a plastic bag (preferably Ziploc®) to avoid any possible cross-contamination of samples during shipping. The sample management office (SMO) follows formalized procedures for maintaining the chain of custody of the sample(s) (*SOP for Chain of Custody for Sample Transfer between Laboratories* [SOP ADM-COC]), proper packaging and shipment, specification of proper methodology, etc. Blue or gel ice is the only temperature preservative used by CAS, unless otherwise specified by the client or receiving laboratory.

8.2 Sample Receipt and Handling

Standard Operating Procedures are established for the receiving of samples into the laboratory. These procedures ensure that samples are received and properly logged into the laboratory, and that all associated documentation, including chain of custody forms, is complete and consistent with the samples received. Complete documentation of all sample storage is maintained in order to preserve the integrity of the samples.

Once samples are delivered to the CAS sample management office (SMO), a Cooler Receipt and Preservation Check Form (CRF - See Figure 8-2 for an example) is used to assess the shipping cooler and its contents as received by the laboratory personnel. Verification of sample integrity includes the following activities:

- Assessment of custody seal presence/absence, location and signature;
- Temperature of sample containers upon receipt;
- Chain of custody documents properly used (entries in ink, signature present, etc.);
- Sample containers checked for integrity (broken, leaking, etc.);

- Sample is clearly marked and dated (bottle labels complete with required information);
- Appropriate containers (size, type) are received for the requested analyses;
- The minimum amount of sample material is provided for the analysis.
- Sample container labels and/or tags agree with chain of custody entries (identification, required analyses, etc.);
- Assessment of proper sample preservation (if inadequate, corrective action is employed); and
- VOC containers are inspected for the presence/absence of bubbles. (Assessment of proper preservation of VOC containers is performed by lab personnel).

Samples are logged into a Laboratory Information Management System (LIMS). Any anomalies or discrepancies observed during the initial assessment are recorded on the CRF and COC documents. Potential problems with a sample shipment are addressed by contacting the client and discussing the pertinent issues. When the Project Chemist and client have reached a satisfactory resolution, the login process may continue and analysis may begin. During the login process, each sample is given a unique laboratory code and a service request form is generated. The LIMS generates a Service Request that contains client information, sample descriptions, sample matrix information, required analyses, sample collection dates, analysis due dates and other pertinent information. The service request is reviewed by the appropriate Project Chemist for accuracy, completeness, and consistency of requested analyses and for client project objectives.

Samples are stored as per method requirements until they undergo analysis, unless otherwise specified, using various refrigerators or freezers, or designated secure areas. CAS has five walk-in cold storage units which house the majority of sample containers received at the laboratory. In addition, there are four additional refrigerators, including dedicated refrigerated storage of VOC samples. The dedicated storage areas for VOC samples are monitored using storage blanks, as described in the *SOP for VOA Storage Blanks (VOC-BLAN)*. CAS also has seven sub-zero freezers capable of storing samples at -20° C primarily used for tissue and sediment samples requiring specialized storage conditions. The temperature of each sample storage unit is monitored daily and the data recorded in a bound logbook. Continuous-graph temperature recorders have also been placed in the walk-in refrigerators to provide a permanent record of the storage conditions to which samples are exposed.

CAS adheres to the method-prescribed or project-specified holding times for all analyses. The sampling date and time are entered into the LIMS system at the time of sample receipt and login. Analysts then monitor holding times by obtaining analysis-specific reports from the LIMS. These reports provide holding time information on all samples for the analysis, calculated from the sampling date and the holding time requirement. To document holding time compliance, the date and time analyzed is printed or written on the analytical raw data. For analyses with a holding time prescribed in hours it is essential that the sample collection time is provided, so holding time compliance can be demonstrated. If not, the sample collection time is assumed as the earliest in the day (i.e. the most conservative).

Unless other arrangements have been made in advance, upon completion of all analyses and submittal of the final report, aqueous samples and sample extracts are retained at ambient temperature for 30 days, soil samples are retained at ambient temperature for 60 days, and tissue samples are retained frozen for 3 months. Upon expiration of these time limits, the samples are either returned to the client or disposed of according to approved disposal practices. All samples are characterized according to hazardous/non-hazardous waste criteria and are segregated accordingly. All hazardous waste samples are disposed of according to formal procedures outlined in the *CAS Environmental Health and Safety Manual.* All waste produced at the laboratory, including the laboratory's own various hazardous waste streams, is treated in accordance with applicable local and Federal laws. Documentation is maintained for each sample from initial receipt through final disposal to ensure that an accurate history of the sample from "cradle to grave" is available.

8.3 Sample Custody

Sample custody transfer at the time of sample receipt is documented using chain-of-custody (COC) forms accompanying the samples. During sample receipt, it is also noted if custody seals were present. This is described in the *SOP for Sample Receiving (SMO-GEN).* Figure 8-1 is a copy of the chain-of-custody form routinely used at CAS.

Facility security and access is important in maintaining the integrity of samples received at CAS/Kelso. Access to the laboratory facility is limited by use of locked exterior doors with a coded entry, except for the reception area and sample receiving doors, which are manned during business hours and locked at all other times. In addition, the sample storage area within the laboratory is a controlled access area with locked doors with a coded entry. The CAS facility is equipped with an alarm system and CAS employs a private security firm to provide nighttime and weekend security.

A barcoding system is used to document internal sample custody. Each person removing or returning samples from/to sample storage while performing analysis is required to document this custody transfer. The system uniquely identifies the sample container and provides an electronic record of the custody of each sample. For sample extracts and digestates the analyst documents custody of the sample extract or digestate by signing on the benchsheet, or custody record, that they have accepted custody. The procedures are described in the *SOP for Sample Tracking and Internal Chain of Custody (SMO-SCOC).*

8.4 Project Setup

The analytical method(s) to be used for sample analysis are chosen based on the client's requirements. Unless specified otherwise, the most recent versions of reference methods are used. For SW-846 methods, some projects may require the most recent *promulgated* version, and some projects may require the most recent *published* version. The Project Chemist will ensure that the correct method version is used. LIMS codes are chosen to identify the analysis method used for analysis. The Project Chemist ensures that the correct methods are selected for analysis, deliverable requirements are identified, and due dates are specified on the LIMS generated Service Request. To communicate and specify project-specific requirements, a Tier V form (Figure 8-3) is used and accompanies the service request form.

Table 8-1
Sample Preservation and Holding Times

DETERMINATION[a]	MATRIX[b]	CONTAINER[c]	PRESERVATION	MAXIMUM HOLDING TIME
Bacterial Tests				
Coliform, Colilert (Standard Methods)	W, DW	P, Bottle or Bag	Cool, 4°C, 0.008% $Na_2S_2O_3$[d]	6-24 hours[e]
Coliform, Fecal and Total (Standard Methods)	W, DW	P,G	Cool, 4°C, 0.008% $Na_2S_2O_3$[d]	6-24 hours[e]
Fecal Streptococci (SM 9230B)	W	P,G	Cool, 4°C, 0.008% $Na_2S_2O_3$[d]	6-24 hours[e]
Inorganic Tests				
Acidity (SM 2310B)	W	P,G	Cool, 4°C	14 days[EPA]
Alkalinity (SM 2320B)	W, DW	P,G	Cool, 4°C	14 days[EPA]
Ammonia (SM 4500NH3)	W, DW	P,G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Biochemical Oxygen Demand (SM 5210B)	W	P,G	Cool, 4°C	48 hours
Bromate (EPA 300.1)	W, DW	P,G	50mg/L EDA, cool to 4°C	28 days
Bromide (EPA 300.1)	W, DW	P,G	None Required	28 days
Chemical Oxygen Demand (SM 5220C)	W	P,G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Chloride (EPA 300.0)	W, DW	P,G	None Required	28 days
Chloride (EPA 9056)	W	P,G	Cool, 4°C	Analyze immediately
Chlorine, Total Residual (SM 4500Cl F)	W, DW	P,G	None Required	24 hours
Chlorite (EPA 300.1)	W, DW	P,G	50mg/L EDA, cool to 4°C	14 days
Chlorophyll-A (SM 11200H)	W	G Amber	Cool, 4°C	Analyze immediately
Chromium VI (EPA 7196A)	W	P,G	Cool, 4°C	24 hours
Color (SM 2120B)	W, DW	P,G	Cool, 4°C	48 hours
Cyanide, Total and Amenable to Chlorination (EPA 335.4, 9010, 9012) (SM 4500CN E,G)	W, DW	P,G	Cool, 4°C, NaOH to pH>12, plus 0.6 g Ascorbic Acid	14 days
Cyanide, Weak Acid Dissociable (SM 4500CN I)	W	P,G	Cool, 4°C, NaOH to pH >12	14 days
Ferrous Iron (CAS SOP)	W, DW	G Amber	Cool, 4°C	24 hours
Fluoride (EPA 300.0)	W, DW	P,G	None Required	28 days
Fluoride (EPA 9056)	W	P,G	Cool, 4°C	Analyze immediately
Hardness (SM 2340C)	W, DW	P,G	HNO_3 to pH<2	6 months
Hydrogen Ion (pH) (SM 4500H B)	W, DW	P,G	None Required	Analyze immediately
Kjeldahl and Organic Nitrogen (ASTM D3590-89)	W	P,G	Cool, 4°C, H_2SO_4 to pH<2	28 days

Table 8-1 (continued)
Sample Preservation and Holding Times[a]

DETERMINATION[a]	MATRIX[b]	CONTAINER[c]	PRESERVATION	MAXIMUM HOLDING TIME
Nitrate (EPA 300.0)	W, DW	P,G	Cool, 4°C	48 hours
Nitrate (EPA 353.2)	W, DW	P,G	Cool, 4°C, H_2SO_4 to pH<2	48 hours
Nitrate (EPA 9056)	W	P,G	Cool, 4°C	Analyze immediately
Nitrate-Nitrite (EPA 353.2)	W, DW	P,G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Nitrite (EPA 300.0)	W, DW	P,G	Cool, 4°C	48 hours
Nitrite (EPA 353.2)	W, DW	P,G	Cool, 4°C, H_2SO_4 to pH<2	48 hours
Nitrite (EPA 9056)	W	P,G	Cool, 4°C	Analyze immediately
Orthophosphate (EPA 365.3)	W, DW	P,G	Cool, 4°C	Analyze immediately
Oxygen, Dissolved (Probe) (SM 4500O G)	W, DW	G, Bottle and Top	None Required	Analyze immediately
Oxygen, Dissolved (Winkler)	W, DW	G, Bottle and Top	Fix on Site and Store in Dark	8 hours
Perchlorate (EPA 314.0)	W, DW	P,G	Protect from temp. extremes	28 days
Phenolics, Total (EPA 420.1)	W	G Only	Cool, 4°C, H_2SO_4 to pH<2	28 days
Phosphorus, Total (EPA 365.3)	W	P,G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Residue, Total (EPA 160.3 & SM 2540B)	W	P,G	Cool, 4°C	7 days
Residue, Filterable (TDS) (SM 2540C)	W	P,G	Cool, 4°C	7 days
Residue, Nonfilterable (TSS) (SM 2540D)	W	P,G	Cool, 4°C	7 days
Residue, Settleable (SM 2540F)	W	P,G	Cool, 4°C	48 hours
Residue, Volatile (EPA 160.4)	W	P,G	Cool, 4°C	7 days
Silica (SM 4500SiO2 C)	W	P Only	Cool, 4°C	28 days
Specific Conductance (EPA 120.1 & SM 2510B)	W, DW	P,G	Cool, 4°C	28 days
Sulfate (EPA 300.0)	W, DW	P,G	Cool, 4°C	28 days
Sulfate (EPA 9056)	W	P,G	Cool, 4°C	Analyze immediately
Sulfide (SM 4500S2 F)	W	P,G	Cool, 4°C, Add Zinc Acetate plus Sodium Hydroxide to pH>9	7 days
Sulfite (SM 4500SO3 B)	W	P,G	None Required	24 hours
Surfactants (MBAS) (SM 5540C)	W	P,G	Cool, 4°C	48 hours
Tannin and Lignin (SM 5550B)	W	P,G	Cool, 4°C	28 days
Turbidity (EPA 180.1)	W, DW	P,G	Cool, 4°C	48 hours

Table 8-1 (continued)
Sample Preservation and Holding Times[a]

DETERMINATION[a]	MATRIX[b]	CONTAINER[c]	PRESERVATION	MAXIMUM HOLDING TIME
Metals				
Metals, except CrVI and Mercury (EPA 200.7, 200.8, 200.9, 6010, 6020)	W, DW	P,G	HNO_3 to pH<2	6 months
	S	G, Teflon-Lined Cap	Cool, 4°C	6 months
Chromium VI (EPA 7195/7191)	W	P,G	Cool, 4°C	24 hours
Mercury (EPA 245.1, 7470, 7471, 1631E)	W	P,G	HNO_3 to pH<2	28 days
	S	P,G	Cool, 4°C	28 days
Organic Tests				
Oil and Grease, Hexane Extractable Material (EPA 1664)	W	G, Teflon-Lined Cap	Cool, 4°C, H_2SO_4 to pH<2	28 days
Organic Carbon, Total (EPA 415.1, 9060 & SM 5310C)	W	P,G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Organic Halogens, Total (EPA 9020)	W	G, Teflon-Lined Cap	Cool, 4°C, H_2SO_4 to pH<2, No headspace	28 days
Organic Halogens, Adsorbable (EPA 1650B)	W	G, Teflon-Lined Cap	Cool, 4°C, HNO_3 to pH<2	6 months
Petroleum Hydrocarbons, Total (EPA 8015)	W	G, Teflon-Lined Cap	Cool, 4°C, HCl or H_2SO_4 to pH<2	7 days until extraction; 40 days after extraction
	S	G, Teflon-Lined Cap	Cool, 4°C	14 days until extraction; 40 days after extraction

Table 8-1 (continued)
Sample Preservation and Holding Times[a]

DETERMINATION[a]	MATRIX[b]	CONTAINER[c]	PRESERVATION	MAXIMUM HOLDING TIME
Volatile Organics				
Petroleum Hydrocarbons, Volatile (Gasoline-Range Organics) (EPA 8015)	W	G, Teflon-Lined Septum Cap	Cool, 4°C, HCl to pH<2 No Headspace	14 days
	S	G, Teflon-Lined Cap	Cool, 4°C Minimize Headspace	14 days
Purgeable Halocarbons (EPA 624, 8021, 8260)	W	G, Teflon-Lined Septum Cap, No Headspace	**No Residual Chlorine Present**: HCl to pH<2, Cool, 4°C, No Headspace **Residual Chlorine Present**: 10% $Na_2S_2O_3$, HCl to pH<2, Cool, 4°C	14 days
	S	G, Teflon-Lined Cap	Cool, 4°C, Minimize Headspace	14 days
	S	Method 5035	Encore, Freeze at -20°C Methanol, Cool, 4°C Sodium Bisulfate Cool, 4°C	7 days 48 hrs to prepare from Encore, 14 days after preparation. 48 hrs to prepare from Encore, 14 days after preparation.
Purgeable Aromatic Hydrocarbons (including BTEX and MTBE) (EPA 624, 8021, 8260)	W	G, Teflon-Lined Septum Cap, No Headspace	**No Residual Chlorine Present**: HCl to pH<2, Cool, 4°C, No Headspace **Residual Chlorine Present**: 10% $Na_2S_2O_3$, HCl to pH<2, Cool 4°C	14 days
	S	G, Teflon-Lined Cap	Cool, 4°C, Minimize Headspace	14 days
	S	Method 5035	Encore, Freeze at -20°C Methanol, Cool, 4°C Sodium Bisulfate Cool, 4°C	7 days 48 hrs to prepare from Encore, 14 days after preparation. 48 hrs to prepare from Encore, 14 days after preparation.
Acrolein, Acrylonitrile, Acetonitrile (EPA 624, 8260)	W	G, Teflon-Lined Septum Cap	Adjust pH to 4-5, Cool, 4°C, No Headspace	14 days
EDB and DBCP (EPA 8260)	W,S	G, Teflon-Lined Cap	Cool, 4°C, 3 mg $Na_2S_2O_3$, No Headspace	28 days

Table 8-1 (continued)
Sample Preservation and Holding Times[a]

DETERMINATION[a]	MATRIX[b]	CONTAINER[c]	PRESERVATION	MAXIMUM HOLDING TIME
Semivolatile Organics				
Petroleum Hydrocarbons, Extractable (Diesel-Range Organics) (EPA 8015)	W,S	G, Teflon-Lined Cap	Cool, 4°C	7 days until extraction;[f] 40 days after extraction
Alcohols and Glycols (EPA 8015)	W,S	G, Teflon-Lined Cap	Cool, 4°C[g]	7 days until extraction;[f] 40 days after extraction
Acid Extractable Semivolatile Organics (EPA 625, 8270)	W,S	G, Teflon-Lined Cap	Cool, 4°C[g]	7 days until extraction;[f] 40 days after extraction
Base/Neutral Extractable Semivolatile Organics (EPA 625, 8270)	W,S	G, Teflon-Lined Cap	Cool, 4°C[g]	7 days until extraction;[f] 40 days after extraction
Polynuclear Aromatic Hydrocarbons (EPA 625, 8270, 8310)	W,S	G, Teflon-Lined Cap	Cool, 4°C, Store in Dark[g]	7 days until extraction;[f] 40 days after extraction
Organochlorine Pesticides and PCBs (EPA 608, 8081)	W,S	G, Teflon-Lined Cap	Cool, 4°C	7 days until extraction;[f] 40 days after extraction
Organophosphorus Pesticides (EPA 8141)	W,S	G, Teflon-Lined Cap	Cool, 4°C[g]	7 days until extraction;[f] 40 days after extraction
Nitrogen- and Phosphorus-Containing Pesticides (EPA 8141)	W,S	G, Teflon-Lined Cap	Cool, 4°C[g]	7 days until extraction;[f] 40 days after extraction
Chlorinated Herbicides (EPA 8151)	W,S	G, Teflon-Lined Cap	Cool, 4°C[g]	7 days until extraction;[f] 40 days after extraction
Organotins (CAS SOP)	W,S	G, Teflon-Lined Cap	Cool, 4°C	7 days until extraction;[f] 40 days after extraction
Chlorinated Phenolics (EPA 1653A)	W	G, Teflon-Lined Cap	H_2SO_4 to pH<2, Cool, 4°C[g]	30 days until extraction; 30 days after extraction
Resin and Fatty Acids (NCASI 85.02)	W	G, Teflon-Lined Cap	NaOH to pH $\geq$10, Cool, 4°C[g]	30 days until extraction; 30 days after extraction

Table 8-1 (continued)
Sample Preservation and Holding Times[a]

DETERMINATION[a]	MATRIX[b]	CONTAINER[c]	PRESERVATION	MAXIMUM HOLDING TIME
Drinking Water Organics				
Purgeable Organics (EPA 524.2)	DW	G, Teflon-Lined Septum Cap	Ascorbic Acid, HCl to pH≤2, Cool, 4°C, No Headspace	14 days
EDB, DBCP, and TCP (EPA 504.1)	DW	G, Teflon-Lined Septum Cap	Cool, 4°C, 3 mg $Na_2S_2O_3$, No Headspace	14 days
Carbamates, Carbamoyloximes (EPA 531.1)	DW	G, Amber, Teflon-Lined Cap	1.8 mL monochloroacetic acid to pH<3; 80 mg/L $Na_2S_2O_3$ if Res.Cl.; Cool, 4°C	28 days
Chlorinated Herbicides (EPA 515.4)	DW	G, Amber, Teflon-Lined Cap	If Res.Cl, 2mg/4omL NaS; Cool, <6°C	14 days until extraction; 21 days after extraction
Chlorinated Pesticides (EPA 508.1, 525.2)	DW	G, Amber, Teflon-Lined Cap	50 mg/L NaS, HCl to pH≤ 2; Cool, 4°C	14 days until extraction; 30 days after extraction
Diquat and Paraquat (EPA 549.2)	DW	G, Amber, Teflon-Lined Cap	100 mg/L $Na_2S_2O_3$ if Res.Cl., Cool, 4°C,	7days until extraction; 21 days after extraction
Endothall (EPA 548.1)	DW	G, Amber, Teflon-Lined Cap	Cool, 4°C	7 days until extraction; 14 days after extraction
Glyphosate (EPA 547)	DW	G, Amber, Teflon-Lined Cap	100 mg/L $Na_2S_2O_3$, Cool, 4°C	14 days
Haloacetic Acids (EPA 552.2)	DW	G, Amber, Teflon-Lined Cap	100 mg/L NH_4Cl, Cool, 4°C	14 days until extraction; 7 days after extraction
Semivolatile Organics (EPA 525.2)	DW	G, Amber, Teflon-Lined Cap	50 mg/L NaS, HCl to pH≤ 2; Cool, 4°C	14 days until extraction; 30 days after extraction
Toxicity Characteristic Leaching Procedure (TCLP)				
Mercury (EPA 1311/7470)	HW	P,G	Sample: Cool, 4°C TCLP extract: HNO_3 to pH<2	28 days until extraction; 28 days after extraction
Metals, except Mercury (EPA 1311/6010)	HW	P,G	Sample: Cool, 4°C TCLP extract: HNO_3 to pH<2	180 days until extraction; 180 days after extraction
Volatile Organics (EPA 1311/8260)	HW	G, Teflon-Lined Cap	Sample: Cool, 4°C Minimize Headspace TCLP extract: Cool, 4°C, HCl to pH<2, No Headspace	14 days until extraction; 14 days after extraction

Table 8-1 (continued)
Sample Preservation and Holding Times[a]

DETERMINATION[a]	MATRIX[b]	CONTAINER[c]	PRESERVATION	MAXIMUM HOLDING TIME
Toxicity Characteristic Leaching Procedure (TCLP)				
Semivolatile Organics (EPA 1311/8270)	HW	G, Teflon-Lined Cap	Sample: Cool, 4°C, Store in Dark[g] TCLP extract: Cool, 4°C, Store in Dark[g]	14 days until TCLP ext'n; 7 days until extraction; 40 days after extraction
Organochlorine Pesticides (EPA 1311/8081)	HW	G, Teflon-Lined Cap	Sample: Cool, 4°C TCLP extract: Cool, 4°C	14 days until TCLP ext'n; 7 days until extraction; 40 days after extraction
Chlorinated Herbicides (EPA 1311/8151)	HW	G, Teflon-Lined Cap	Sample: Cool, 4°C TCLP extract: Cool, 4°C	14 days until TCLP ext'n; 7 days until extraction; 40 days after extraction

a For EPA SW-846 methods the method number is listed generically, without specific revision suffixes.
b DW = Drinking Water, W = Water; S = Soil or Sediment; HW = Hazardous Waste
c P = Polyethylene; G = Glass
d For chlorinated water samples
e The maximum holding time is dependent upon the geographical proximity of sample source to the laboratory.
f Fourteen days until extraction for soil, sediment, and sludge samples.
g If the water sample contains residual chlorine, 10% sodium thiosulfate is used to dechlorinate.

Figure 8-1
Chain of Custody Form

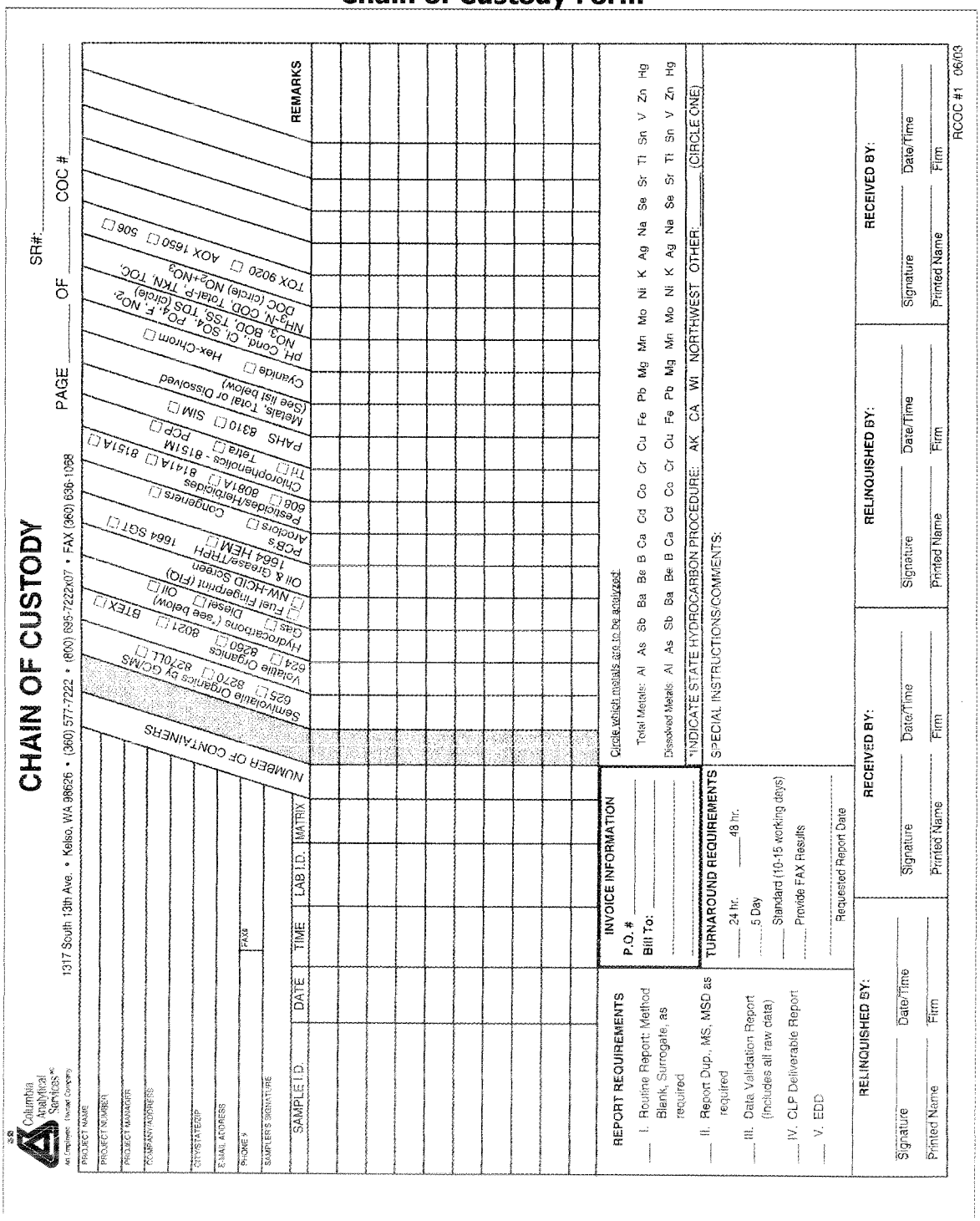


Figure 8-2

Columbia Analytical Services, Inc. PC_____
Cooler Receipt and Preservation Form

Client / Project:_____ Service Request *K09*_____

Received:_____ Opened:_____ By:_____

1. Samples were received via? *US Mail* *Fed Ex* *UPS* *DHL* *GH* *GS* *PDX* *Courier* *Hand Delivered*
2. Samples were received in: (circle) *Cooler* *Box* *Envelope* *Other*_____ *NA*
3. Were custody seals on coolers? NA Y N If yes, how many and where?_____
   If present, were custody seals intact? Y N If present, were they signed and dated? Y N
4. Is shipper's air-bill filed? If not, record air-bill number:_____ NA Y N

5. **Temperature of cooler(s) upon receipt (°C):** _____ _____ _____ _____
   Temperature Blank (°C): _____ _____ _____ _____
   Thermometer ID: _____ _____ _____ _____
6. If applicable, list Chain of Custody Numbers: _____ _____ _____ _____
7. Packing material used. *Inserts* *Baggies* *Bubble Wrap* *Gel Packs* *Wet Ice* *Sleeves* *Other*_____
8. Were custody papers properly filled out (ink, signed, etc.)? NA Y N
9. **Did all bottles arrive in good condition (unbroken)?** *Indicate in the table below.* NA Y N
10. Were all sample labels complete (i.e analysis, preservation, etc.)? NA Y N
11. Did all sample labels and tags agree with custody papers? *Indicate in the table below* NA Y N
12. **Were appropriate bottles/containers and volumes received for the tests indicated?** NA Y N
13. Were the pH-preserved bottles tested* received at the appropriate pH? *Indicate in the table below* NA Y N
14. Were VOA vials and 1631 Mercury bottles received without headspace? *Indicate in the table below.* NA Y N
15. **Are CWA Microbiology samples received with >1/2 the 24hr. hold time remaining from collection?** NA Y N
16. Was C12/Res negative? NA Y N

Sample ID on Bottle	Sample ID on COC	Sample ID on Bottle	Sample ID on COC

Sample ID	Bottle Count	Bottle Type	Out of Temp	Head-space	Broken	pH	Reagent	Volume added	Reagent Lot Number	Initials

*Does not include all pH preserved sample aliquots received. See sample receiving SOP (SMO-GEN).

*Additional Notes, Discrepancies, & Resolutions:*_____

Page 1 of: *1* *2*

Figure 8-3
Tier V Form

Client :

Project Chemist :

Project Name :

Service Request :

Project Number :

SMO LimsTemplate ID :

Project Description :

QAPP/SOW Information :

Reporting

Tier Level :

PDF:

Report to :

In result field use :

EDD :

Flagging Requirements :

Other Requirements :

Sample Considerations

Sample Limitations :

Sample Prep/Analysis :

Non-Standard Holdtimes :

Historical Data :

Comments :

9.0 ANALYTICAL PROCEDURES

CAS employs methods and analytical procedures from a variety of sources. The primary method references are: USEPA SW-846, Third Edition and Updates I, II, IIA, IIB, III, IVA, IVB, and online updates for hazardous waste samples, and USEPA 600/4-79-020, 600/4-91-010, 600/4-82-057, 600/R-93/100, 600/4-88-039, 600/R-94-111, and Supplements; and *Standard Methods for the Examination of Water and Wastewater* for water and wastewater samples. Complete citations for these references can be found in Section 18.0. Other published procedures, such as state-specific methods, program-specific methods (such as Puget Sound Protocols), or in-house methods may be used. Several factors are involved with the selection of analytical methods to be used in the laboratory. These include the method detection limit, the concentration of the analyte being measured, method selectivity, accuracy and precision of the method, the type of sample being analyzed, and the regulatory compliance objectives. The implementation of methods by CAS is described in SOPs specific to each method. A list of NELAP-accredited methods are given in Appendix E. Further details are described below.

9.1 Standard Operating Procedures (SOPs) and Laboratory Notebooks.

CAS maintains SOPs for use in both technical and administrative functions. SOPs are written following standardized format and content requirements. Each SOP is reviewed and approved by a minimum of two managers (the Laboratory Director and/or Department Manager and the Quality Assurance Manager). All SOPs undergo a documented annual review to make sure current practices are described. The QA Manager maintains a comprehensive list of current SOPs. The document control process ensures that only the most currently prepared version of an SOP is being used. The QA Manual, QAPPs, SOPs, standards preparation logbooks, maintenance logbooks, et al., are controlled documents. The procedures for document control are described in the *SOP for Document Control* (ADM-DOC_CTRL). In addition to SOPs, each laboratory department maintains a current file, accessible to all laboratory staff, of the current methodology used to perform analyses. Laboratory notebook entries are standardized following the guidelines in the *SOP for Making Entries into Logbooks and onto Benchsheets* (ADM-DATANTRY). Entries made into laboratory notebooks are reviewed and approved by the appropriate supervisor at a regular interval.

9.2 Deviation from Standard Operating Procedures

When a customer requests a modification to an SOP (such as a change in reporting limit, addition or deletion of target analyte(s), etc.), the project chemist handling that project must discuss the proposed deviation with the department manager in charge of the analysis and obtain their approval to accept the project. The project chemist is responsible for documenting the approved or allowed deviation from the SOP by placing a detailed description of the deviation attached to the quotation or in the project file and also providing an appropriate comment on the service request when the samples are received.

For circumstances when a deviation or departure from company policies or procedures involving any non-technical function is found necessary, approval must be obtained from the appropriate supervisor, manager, the laboratory director, or other level of authority. Frequent departure from policy is not encouraged. However, if frequent departure from any policy is noted, the laboratory director will address the possible need for a change in policy.

9.3 Modified Procedures

CAS strives to perform published methods as described in the referenced documents. If there is a material deviation from the published method, the method is cited as a "Modified" method in the analytical report. Modifications to the published methods are listed in the standard operating procedure. Standard operating procedures are available to analysts and are also available to our clients for review, especially those for "Modified" methods. Client approval is obtained for the use of "Modified" methods prior to the performance of the analysis.

9.4 Analytical Batch

The basic unit for analytical quality control is the analytical batch. The definition that CAS has adopted for the analytical batch is listed below. The overriding principle for describing an analytical batch is that all the samples in a batch, both field samples and quality control samples, are to be handled exactly the same way, and all of the data from each analysis is to be manipulated in exactly the same manner. The minimum requirements of an analytical batch are:

1) The number of (field) samples in a batch is not to exceed 20.

2) All (field) samples in a batch are of the same matrix.

3) The QC samples to be processed with the (field) samples include:

   a) Method Blank (a.k.a. Laboratory Reagent Blank)

      Function: Determination of laboratory contamination.

   b) Laboratory Control Sample (a.k.a. Laboratory Fortified Blank)

      Function: Assessment of method performance

   c) Matrix Spiked (field) Sample (a.k.a. Laboratory Fortified Sample Matrix)*

      Function: Assessment of matrix bias

   d) Duplicate Matrix Spiked (field) Sample or Duplicate (field) Sample (a.k.a. Laboratory Duplicate)*

      Function: Assessment of batch precision

   * A sample identified as a field blank, an equipment blank, or a trip blank is not to be matrix spiked or duplicated.

4) A single lot of reagents is used to process the batch of samples.

5) Each operation within the analysis is performed by a single analyst, technician, chemist, or by a team of analysts/technicians/chemists.

6) Samples are analyzed in a continuous manner over a timeframe not to exceed 24-hours.

7) (Field) samples are assigned to batches commencing at the time that sample processing begins. For example: for analysis of metals, sample processing begins when the samples are digested. For analysis of organic constituents, it begins when the samples are extracted.

8) The QC samples are to be analyzed in conjunction with the associated field samples prepared with them. However, for tests which have a separate sample preparation step that defines a batch (digestion, extraction, etc.), the QC samples in the batch do not require analysis each time a field sample within the preparation batch is analyzed (multiple instrument sequences to analyze all field samples in the batch need not include re-analyses of the QC samples).

9) The batch is to be assigned a unique identification number that can be used to correlate the QC samples with the field samples.

10) Batch QC refers to the QC samples that are analyzed in a batch of (field) samples.

11) Project-specific requirements may be exceptions. If project, program, or method requirements are more stringent than these laboratory minimum requirements, then the project, program, or method requirements will take precedence. However, if the project, program, or method requirements are less stringent than these laboratory minimum requirements, these laboratory minimum requirements will take precedence.

9.5 Specialized Procedures

CAS not only strives to provide results that are scientifically sound, legally defensible, and of known and documented quality; but also strives to provide the best solution to analytical challenges. Procedures using specialized instrumentation and methodology have been developed to improve sensitivity (provide lower detection limits), selectivity (minimize interferences while maintaining sensitivity), and overall data quality for low concentration applications. Examples are trace-level Mercury and methylmercury analyses, reductive precipitation metals analysis, specialized GC/MS analyses, LC/MS analyses, and ultra-low level organics analyses (including PAHs, pesticides and PCBs).

9.6 Sample Cleanup

CAS commonly employs several cleanup procedures to minimize known common interferences prior to analysis. EPA methods(3620, 3630, 3640, 3660, 3665) for cleanup of sample extracts for organics analysis are routinely used to minimize or eliminate interferences that may adversely affect sample results and data usability.

10.0 CALIBRATION PROCEDURES AND FREQUENCY

All equipment and instruments used at CAS are operated, maintained and calibrated according to the manufacturer's guidelines and recommendations, as well as to criteria set forth in the applicable analytical methodology. Operation and calibration are performed by personnel who have been properly trained in these procedures. Documentation of calibration information is maintained in appropriate reference files. Brief descriptions of the calibration procedures for our major laboratory equipment and instruments are described below. Calibration verification is performed according to the applicable analytical methodology. Calibration verification procedures and criteria are listed in laboratory Standard Operating Procedures. Documentation of calibration verification is maintained in appropriate reference files.
Records are maintained to provide traceability of reference materials.

Equipment which has been subjected to overloading or mishandling, or has been shown by verification or otherwise to be defective; is taken out of service until it has been repaired. The equipment is placed back in service only after verifying by calibration that the equipment performs satisfactorily. An evaluation of the effect of this defect on previous calibrations or tests is made and documented appropriately.

10.1 Temperature Control Devices

Temperatures are monitored and recorded for all of the temperature-regulating support equipment such as sample refrigerators, freezers, and standards refrigerators. Bound record books are kept which contain daily-recorded temperatures, identification and location of equipment, acceptance criteria and the initials of the technician who performed the checks. The procedure for performing these measurements is provided in the *SOP for Support Equipment Monitoring and Calibration (SOP ADM-SEMC).* The SOP also includes the use of acceptance criteria and correction factors.

Where the operating temperature is specified as a test condition (such as ovens, incubators, evaporators) the temperature is recorded on the raw data. All thermometers are identified according to serial number, and the calibration of these thermometers is checked annually against a National Institute of Standards and Technology (NIST) certified thermometer. The NIST thermometer is recertified by a professional metrology organization on an annual basis.

10.2 Analytical Balances

The calibration of each analytical balance is checked by the user each day of use with three Class S or S-1 weights, which assess the accuracy of the balance at low, mid-level and high levels bracketing the working range. Records are kept which contain the recorded measurements, identification of the balance, acceptance criteria, and the initials of user who performed the check. The procedure for performing these measurements and use of acceptance criteria is described in the SOP ADM-SEMC. The weights are recertified using NIST traceable standards by a professional metrology organization on an annual basis.

As needed, the balances are recalibrated using the manufacturers recommended operating procedures. Analytical balances are serviced on a semi-annual basis by a professional metrology organization. New certificates of calibration for each balance are issued to the laboratory on a semi-annual basis.

10.3 Water Purification Systems

CAS uses two independent water purification systems is designed to produce deionized water meeting method specifications. One system consists of a series of pumps, filters, and resin beds designed to yield deionized water meeting the specifications of ASTM Type II water, and *Standard Methods for the Examination of Water and Wastewater* (SM1080, 20th Ed.) *High Quality* water. Activated carbon filters are also in series with the demineralizers to produce "organic-free" water. A second system consists of pumps, filters, and treatment components designed to yield deionized water meeting the specifications of ASTM Type I water, and *Standard Methods for the Examination of Water and Wastewater* (SM1080, 20th Ed.) *High Quality* water. Following a written SOP, the status of each system is monitored continuously for conductivity and resistivity with an on-line meter and indicator light, and readings recorded daily in a bound record book. The meter accuracy is verified annually. Deionizers are rotated and replaced on a regular schedule. Microbiology water is checked at a point downstream of the purification system at a tap in the laboratory, and monitoring documented.

10.4 Source and Preparation of Standard Reference Materials

All analytical measurements generated at CAS are performed using materials and/or processes that are traceable to a reference material. Metrology equipment (analytical balances, thermometers, etc.) is calibrated using reference materials traceable to the National Institute of Standards and Technology (NIST). These primary reference materials are themselves recertified on an annual basis. All sampling containers provided to the client by the laboratory are purchased as precleaned (Level 1) containers, with certificates of analysis available for each bottle type. This information is provided to the client when requested.

Consumable reference materials routinely purchased by the laboratories (e.g., analytical standards) are purchased from nationally recognized, reputable vendors. All vendors have fulfilled the requirements for ISO 9001 certification and/or are accredited by A_2LA. CAS relies on a primary vendor for the majority of its analytical supplies. Consumable primary stock standards are obtained from certified commercial sources or from sources referenced in a specific method. Supelco, Ultra Scientific, AccuStandard, Chem Services, Inc., Aldrich Chemical Co., Baker, Spex, etc. are examples of the vendors used. Reference material information is recorded in the appropriate logbook(s) and materials are stored under conditions that provide maximum protection against deterioration and contamination. The logbook entry includes such information as an assigned logbook identification code, the source of the material (i.e. vendor identification), solvent (if applicable) and concentration of analyte(s), reference to the certificate of analysis and an assigned expiration date. The date that the standard is received in the laboratory is marked on the container. When the reference material is used for the first time, the date of usage and the initials of the analyst are also recorded on the container.

Stock solutions and calibration standard solutions are prepared fresh as often as necessary according to their stability. All standard solutions are properly labeled as to analyte concentration, solvent, date, preparer, and expiration date; these entries are also recorded in the appropriate notebook(s) following the *SOP for Making Entries into Logbooks and onto Benchsheets* (SOP No. ADM-DATANTRY). Prior to sample analysis, all calibration reference materials are verified with a second, independent source of the material (see section 11.3.5).

10.5 Inductively Coupled Plasma-Atomic Emission Spectrograph (ICP-AES)

Each emission line on the ICP is calibrated daily against a blank and against standards. Analyses of calibration standards, initial and continuing calibration verification standards, and inter-element interference check samples are carried out as specified in the applicable method SOP and analytical method (i.e. EPA 200.7, 6010B, 6010C, CLP SOW, etc.).

10.6 Inductively Coupled Plasma-Mass Spectrometer (ICP-MS)

Each element of interest is calibrated for using a blank and a single standard. Prior to calibration, a short-term stability check is performed on the system. Following calibration, an independent check standard is analyzed, and a continuing calibration verification standard (CCV) is analyzed with every ten samples.

10.7 Atomic Absorption Spectrophotometers (AAS)

These instruments are calibrated daily using a minimum of four standards and a blank. Calibration is validated using reference standards, and is verified at a minimum frequency of once every ten samples. Initial calibration points cannot be "dropped" from the resulting calibration curve.

10.8 GC/MS Systems

All GC/MS instruments are calibrated at a minimum of five different concentration levels for the analytes of interest (unless specified otherwise) using procedures outlined in Standard Operating Procedures and/or appropriate USEPA method citations. All reference materials used for this function are vendor-certified standards. Calibration verification is performed at method-specified intervals following the procedures in the SOP and reference method. Compounds selected as system performance check compounds (SPCCs) must show a method-specified response factor in order for the calibration to be considered valid. Calibration check compounds (CCCs) must also meet method specifications for percent difference from the multipoint calibration. For isotope dilution procedures, the internal standard response(s) and labeled compound recovery must meet method criteria. Method-specific instrument tuning is regularly checked using bromofluorobenzene (BFB) for volatile organic chemical (VOC) analysis, or decafluorotriphenylphosphine (DFTPP) for semi-volatile analysis. Mass spectral peaks for the tuning compounds must conform both in mass numbers and in relative intensity criteria before analyses can proceed. Calibration policies for organics chromatographic analyses are described in the *SOP for Calibration of Instruments for Organics Chromatographic Analyses (SOP SOC-CAL).*

10.9 Gas Chromatographs and High Performance Liquid Chromatographs

Calibration and standardization follow SOP guidelines and/or appropriate USEPA method citations. All GC and HPLC instruments are calibrated at a minimum of five different concentration levels for the analytes of interest (unless specified otherwise). The lowest standard is equivalent to the method reporting limit; additional standards define the working range of the GC or LC detector. Results are used to establish response factors (or calibration curves) and retention-time windows for each analyte. Calibration is verified at a minimum frequency of once every ten samples, unless otherwise specified by the reference method. *SOP for Calibration of Instruments for Organics Chromatographic Analyses (SOP SOC-CAL).*

10.10 LC/MS Systems

Calibration and tuning procedures are included in analytical SOPs written specifically for these tests. In general, multiple concentration levels for the analytes of interest are used to generate calibration curves. All reference materials used for this function are vendor-certified standards. Calibration and tuning verification is performed at SOP-defined intervals. Any other system performance checks are described in the applicable SOP. Calibration policies for organics chromatographic analyses are described in the *SOP for Calibration of Instruments for Organics Chromatographic Analyses (SOP SOC-CAL).*

10.11 UV-Visible Spectrophotometer (manual colorimetric analyses)

Routine calibrations for colorimetric and turbidimetric analyses involve generating a 5-point calibration curve including a blank. Initial calibration points cannot be "dropped" from the resulting calibration curve. Correlation coefficients must meet method or SOP specifications before analysis can proceed. Independent calibration verification standards (ICVs) are analyzed with each batch of samples. Continuing calibration is verified at a minimum frequency of once every ten samples. Typical UV-Visible spectrophotometric methods at CAS include total phenolics, phosphates, surfactants and tannin-lignin.

10.12 Flow Injection Analyzer (automated colorimetric analysis)

A minimum of six standards and a blank are used to calibrate the instrument for cyanide analysis. A blank and (minimum of) five standards are used to calibrate the instrument for all other automated chemistries. Initial calibration points cannot be "dropped" from the resulting calibration curve. Standard CAS acceptance limits are used to evaluate the calibration curve prior to sample analysis.

10.13 Ion Chromatographs

Calibration of the ion chromatograph (IC) involves generating a calibration curve with the method-specified number of points (or more). Initial calibration points cannot be "dropped" from the resulting calibration curve. A correlation coefficient of $\geq$ 0.995 for the curve is required before analysis can proceed. Quality Control (QC) samples that are routinely analyzed include blanks and laboratory control samples. The target analytes typically determined by the IC include nitrate, nitrite, chloride, fluoride, sulfate and drinking water inorganic disinfection byproducts. Calibration verification is performed at method-specified intervals following the procedures in the SOP and reference method.

10.14 Turbidimeter

Calibration of the turbidimeter requires analysis of three Nephelometric Turbidity Unit (NTU) formazin standards. Quality Control samples that are routinely analyzed include blanks, Analytical Products Group® QC samples (or equivalent) and duplicates.

10.15 Ion-selective electrode

The method-prescribed numbers of standards are used to calibrate the electrodes before analysis. The slope of the curve must be within acceptance limits before analysis can proceed. Quality Control samples that are routinely analyzed include blanks, LCSs and duplicates.

10.16 Pipets

The calibration of pipets and autopipettors used to make critical-volume measurements is verified following the *SOP for Checking Pipet Calibration*. Both accuracy and precision verifications are performed, at intervals applicable to the pipet and use. The results of all calibration verifications are recorded in bound logbooks.

10.17 Other Instruments

Calibration for the total organic carbon (TOC), total organic halogen (TOX), and other instruments is performed following manufacturer's recommendations and applicable SOPs.

11.0 QUALITY CONTROL

A primary focus of Columbia Analytical Services Quality Assurance (QA) Program is to ensure the accuracy, precision and comparability of all analytical results. Prior to using a procedure for the analysis of field samples, acceptable method performance is established by performing demonstration of capability analyses and performance characteristics are established by performing method detection limit studies and assessing accuracy and precision according to the reference method. CAS has established Quality Control (QC) objectives for precision and accuracy that are used to determine the acceptability of the data that is generated. These QC limits are either specified in the methodology or are statistically derived based on the laboratory's actual historical data obtained from the various QC measurements for each analytical method. The Quality Control objectives are defined below.

11.1 Quality Control Objectives

11.1.2 Demonstration of Capability - Where required by mandatory test method, regulation, or accreditation protocols, a demonstration of capability (DOC) is made prior to using any test method. This demonstration is made following regulatory, accreditation, or method specified procedures. In general, this demonstration does not test the performance of the method in real world samples, but in the applicable clean matrix free of target analytes and interferences.

A quality control reference material or quality control sample is obtained. The analyte(s) is (are) diluted in a volume of clean matrix (for analytes which do not lend themselves to spiking, e.g., TSS, the demonstration of capability may be performed using quality control samples). Where specified, the method-required concentration levels are used. Four aliquots are prepared and analyzed according to the test procedure. The mean recovery and standard deviations are calculated and compared to the corresponding acceptance criteria for precision and accuracy in the test method or laboratory-generated acceptance criteria (if there are not established mandatory criteria). All parameters must meet the acceptance criteria. Where spike levels are not specified, actual Laboratory Control Sample results or MDL study results may be used to meet this requirement, provided acceptance criteria is met.

11.1.3 Accuracy - Accuracy is a measure of the closeness of an individual measurement (or an average of multiple measurements) to the true or expected value. Accuracy is determined by calculating the mean value of results from ongoing analyses of laboratory-fortified blanks, standard reference materials, and standard solutions. In addition, laboratory-fortified (i.e. matrix-spiked) samples are also measured; this indicates the accuracy or bias in the actual sample matrix. Accuracy is expressed as percent recovery (% REC.) of the measured value, relative to the true or expected value. If a measurement process produces results whose mean is not the true or expected value, the process is said to be biased. Bias is the systematic error either inherent in a method of analysis (e.g., extraction efficiencies) or

caused by an artifact of the measurement system (e.g., contamination). CAS utilizes several quality control measures to eliminate analytical bias, including systematic analysis of method blanks, laboratory control samples and independent calibration verification standards. Because bias can be positive or negative, and because several types of bias can occur simultaneously, only the net, or total, bias can be evaluated in a measurement

11.1.4 Precision - Precision is the ability of an analytical method or instrument to reproduce its own measurement. It is a measure of the variability, or random error, in sampling, sample handling and in laboratory analysis. The American Society of Testing and Materials (ASTM) recognizes two levels of precision: repeatability - the random error associated with measurements made by a single test operator on identical aliquots of test material in a given laboratory, with the same apparatus, under constant operating conditions, and reproducibility - the random error associated with measurements made by different test operators, in different laboratories, using the same method but different equipment to analyze identical samples of test material.

"Within-batch" precision is measured using replicate sample or QC analyses and is expressed as the relative percent difference (RPD) between the measurements. The "batch-to-batch" precision is determined from the variance observed in the analysis of standard solutions or laboratory control samples from multiple analytical batches.

11.1.5 Control Limits - The control limits for accuracy and precision originate from two different sources: For analyses having enough QC data, control limits are calculated at the 99% confidence limits. For analyses not having enough QC data, or where the method is prescriptive, control limits are taken from the method on which the procedure is based. If the method does not have stated control limits, then control limits are assigned method-default or reasonable values. Control limits are updated periodically when new statistical limits are generated for the appropriate surrogate, laboratory control sample, and matrix spike compounds (typically once a year) or when method prescribed limits change. The updated limits are reviewed by the Quality Assurance Manager. The new control limits replace the previous limits and data is assessed using the new values. The current acceptance limits for accuracy and precision are available from the laboratory and on the accompanying CD-ROM. For inorganics, the precision limit values listed are for laboratory duplicates. For organics, the precision limit values listed are for duplicate laboratory control samples or duplicate matrix spike analyses.

11.1.6 Representativeness - Representativeness is the degree to which the field sample, being properly preserved, free of contamination, and analyzed within holding time, represents the overall sample site or material. This can be extended to the sample itself, in that representativeness is the degree to which the subsample that is analyzed represents the entire field sample submitted for analysis. CAS has sample handling procedures to ensure that the sample used for analysis is representative of the entire sample. These include the *SOP for Subsampling and Compositing of Samples* and the *SOP for Tissue Sample Preparation*. Further, analytical SOPs specify appropriate sample handling and sample sizes to further ensure the sample aliquot that is analyzed is representative in entire sample.

11.1.7 Comparability – Comparability expresses the confidence with which one data set can be compared to another and is directly affected by data quality (accuracy and precision) and sample handling (sampling, preservation, etc). Only data of known quality can be compared. The objective is to generate data of known quality with the highest level of comparability, completeness, and usability. This is achieved by employing the quality controls listed below and standard operating procedures for the handling and analysis of all samples. Data is reported in units specified by the client and using CAS or project-specified data qualifiers.

11.2 Method Detection Limits and Method Reporting Limits

Method Detection Limits (MDL) for methods performed at CAS/Kelso are determined annually, and may change slightly from year to year. If and MDL study is not performed annually, an MDL verification chedk is performed quarterly on every instrument used in the analysis. The MDLs are determined by following the *SOP for the Determination of Method Detection Limits and Limits of Detection,* which is based on the procedure in 40 CFR Part 136, Appendix B. As required by NELAP and DoD protocols, the validity of MDLs is verified using MDL verification samples. The Method Reporting Limit (MRL) is the lowest amount of an analyte in a sample that can be quantitatively determined with stated, acceptable precision and accuracy under stated analytical conditions (i.e. the lower limit of quantitation). Therefore, analyses are calibrated to the MRL, or lower. To take into account day-to-day fluctuations in instrument sensitivity, analyst performance, and other factors, the MRL is established at three times the MDL (or greater). The current MDLs and MRLs are available from the laboratory.

11.3 Quality Control Procedures

The specific types, frequencies, and processes for quality control sample analysis are described in detail in method-specific standard operating procedures and listed below. These sample types and frequencies have been adopted for each method and a definition of each type of QC sample is provided below. In addition, a number of other quality control processes that may impact analytical results are also described below.

11.3.1 Method Blank (a.k.a. Laboratory Reagent Blank)

The method blank is an analyte-free matrix (water, soil, etc.) subjected to the entire analytical process. When analyte-free soil is not available, anhydrous sodium sulfate, organic-free sand, or an acceptable substitute is used. The method blank is analyzed to demonstrate that the analytical system itself does not introduce contamination. The method blank results should be below the Method Reporting Limit (MRL) or, if required for DoD projects, < ½ MRL for the analyte(s) being tested. Otherwise, corrective action must be taken. A method blank is included with the analysis of every sample preparation batch, every 20 samples, or as stated in the method, whichever is more frequent.

11.3.2 Calibration Blanks

For some methods, calibration blanks are prepared along with calibration standards in order to create a calibration curve. Calibration blanks are free of the analyte of interest and, where applicable, provide the zero point of the calibration curve. Additional project-specific requirements may also apply to calibration blanks.

11.3.3 Continuing Calibration Blanks

Continuing calibration blanks (CCBs) are solutions of either analyte-free water, reagent, or solvent that are analyzed in order to verify the system is contamination-free when CCV standards are analyzed. The frequency of CCB analysis is either once every ten samples or as indicated in the method, whichever is greater. Additional project-specific requirements may also apply to continuing calibration blanks.

11.3.4 Calibration Standards

Calibration standards are solutions of known concentration prepared from primary standard or stock standard materials. Calibration standards are used to calibrate the instrument response with respect to analyte concentration. Standards are analyzed in accordance with the requirements stated in the particular method being used.

11.3.5 Initial (or Independent) Calibration Verification Standards

Initial (or independent) calibration verification standards (ICVs) are standards that are analyzed *after* calibration with newly prepared standard(s) but *prior to* sample analysis, in order to verify the validity and accuracy of the standards used in the calibration. Once it is determined that there is no reference material defect or systematic error in preparation of the calibration standard(s), standards are considered valid and may be used for subsequent calibrations and quantitative determinations (as expiration dates and methods allow). The ICV standards are prepared from materials obtained from a source independent of that used for preparing the calibration standards ("second-source"). ICVs are also analyzed in accordance with method-specific requirements.

11.3.6 Continuing Calibration Verification Standards

Continuing calibration verification standards (CCVs) are midrange standards that are analyzed in order to verify that the calibration of the analytical system is still acceptable. The frequency of CCV analysis is either once every ten samples, or as indicated in the method.

11.3.7 Internal Standards

Internal standards are known amounts of specific compounds that are added to each sample prior to instrument analysis. Internal standards are generally used for GC/MS and ICP-MS procedures to correct sample results that have been affected by changes in instrument conditions or changes caused by matrix effects. The requirements for evaluation of internal standards are specified in each method and SOP.

11.3.8 Surrogates

Surrogates are organic compounds which are similar in chemical composition and chromatographic behavior to the analytes of interest, but which are not normally found in environmental samples. Depending on the analytical method, one or more of these compounds is added to method blanks, calibration and check standards, and samples (including duplicates, matrix spike samples, duplicate matrix spike samples and laboratory control samples) prior to extraction and analysis in order to monitor the method performance on each sample. The percent recovery is calculated for each surrogate, and the recovery is a measurement of the overall method performance.

$$Recovery\ (\%) = (M/T) \times 100$$

Where: M = The measured concentration of analyte,
T = The theoretical concentration of analyte added.

11.3.9 Laboratory Control Samples (a.k.a. Laboratory Fortified Blanks)

The laboratory control sample (LCS) is an aliquot of analyte-free water or analyte-free solid (or anhydrous sodium sulfate or equivalent) to which known amounts of the method analyte(s) is (are) added. A reference material of known matrix type, containing certified amounts of target analytes, may also be used as an LCS. An LCS is prepared and analyzed at a minimum frequency of one LCS per 20 samples, with every analytical batch or as stated in the method, whichever is more frequent. The LCS sample is prepared and analyzed in exactly the same manner as the field samples.

The percent recovery of the target analytes in the LCS is compared to established control limits and assists in determining whether the methodology is in control and whether the laboratory is capable of making accurate and precise measurements at the required reporting limit. Comparison of batch-to-batch LCS analyses enables the laboratory to evaluate batch-to-batch precision and accuracy.

$$Recovery\ (\%) = (M/T) \times 100$$

Where: M = The measured concentration of analyte,
T = The theoretical concentration of analyte added.

11.3.10 Matrix Spikes (a.k.a. Laboratory Fortified Sample Matrix)

Matrix spiked samples are aliquots of samples to which a known amount of the target analyte (or analytes) is(are) added. The samples are then prepared and analyzed in the same analytical batch, and in exactly the same manner as are routine samples. For the appropriate methods, matrix spiked samples are prepared and analyzed and at a minimum frequency of one spiked sample (and one duplicate spiked sample, if appropriate) per twenty samples. The spike recovery measures the effects of interferences caused by the sample matrix and reflects the accuracy of the method for the particular matrix in question. Spike recoveries are calculated as follows:

$$Recovery\ (\%) = (S - A) \times 100 \div T$$

Where: S = The observed concentration of analyte in the spiked sample,
A = The analyte concentration in the original sample, and
T = The theoretical concentration of analyte added to the spiked sample.

11.3.11 Laboratory Duplicates and Duplicate Matrix Spikes

Duplicates are additional replicates of samples that are subjected to the same preparation and analytical scheme as the original sample. Depending on the method of analysis, either a duplicate analysis (and/or a matrix spiked sample) or a matrix spiked sample and duplicate matrix spiked sample (MS/DMS) are analyzed. The relative percent difference between duplicate analyses or between an MS and DMS is a measure of the precision for a given method and analytical batch. The relative percent difference (RPD) for these analyses is calculated as follows:

$$Relative\ Percent\ Difference\ (RPD) = (S1 - S2) \times 100 \div S_{ave}$$

Where S1 and S2 = The observed concentrations of analyte in the sample and its duplicate, or in the matrix spike and its duplicate matrix spike, and

S_{ave} = The average of observed analyte concentrations in the sample and its duplicate, or in the matrix spike and its duplicate matrix spike.

Depending on the method of analysis, either duplicates (and/or matrix spikes) or MS/DMS analyses are performed at a minimum frequency of one set per 20 samples. If an insufficient quantity of sample is available to perform a laboratory duplicate or duplicate matrix spikes, duplicate LCSs will be prepared and analyzed.

11.3.12 Interference Check Samples

An interference check sample (ICS) is a solution containing both interfering and analyte elements of known concentration that can be analyzed to verify background and interelement correction factors in metals analyses. The ICS is prepared to contain known concentrations (method or program specific) of elements that will provide an adequate test of the correction factors. The ICS is analyzed at the beginning and end of an analytical run or at a method-specified frequency. Results must meet method criteria and any project-specific criteria.

11.3.13 Post Digestion Spikes

Post digestion spikes are samples prepared for metals analyses that have an analyte spike added to determine if matrix effects may be a factor in the results. The spike addition should produce a method-specified minimum concentration above the method reporting limit. A post digestion spike is analyzed with each batch of samples and recovery criteria are specified for each method.

11.3.14 Control Charting

The generation of control charts is routinely performed at CAS. Surrogate, Matrix Spike and LCS recoveries are all monitored and charted. In addition, the laboratory also monitors the Relative Percent Difference (RPD) measurement of precision. Control charts are available to each individual laboratory unit to monitor the data generated in its facility using control charts that have been programmed to identify various trends in the analytical results. If trends in the data are perceived, various means of corrective action may then be employed in order to prevent future problems with the analytical system(s). Finally, data quality reports using control charts are generated for specific clients and projects pursuant to contract requirements. The control charting procedure is described in the SOP for *Control Charting Quality Control Data* (ADM-CHRT).

11.3.15 Glassware Washing

Glassware washing and maintenance play a crucial role in the daily operation of a laboratory. The glassware used at CAS undergoes a rigorous cleansing procedure prior to every usage. A number of SOPs have been generated that outline the various procedures used at CAS; each is specific to the end-use of the equipment as well as to the overall analytical requirements of the project. In addition, other equipment that may be routinely used at the laboratory is also cleaned following instructions in the appropriate SOP.

12.0 DATA REDUCTION, VALIDATION, AND REPORTING

CAS reports the analytical data produced in its laboratories to the client via the certified analytical report (CAR). This report includes a transmittal letter, a case narrative, client project information, specific test results, quality control data, chain of custody information, and any other project-specific support documentation. The following procedures describe our data reduction, validation and reporting procedures.

12.1 Data Reduction and Review

Results are generated by the analyst who performs the analysis and works up the data. All data is initially reviewed and processed by analysts using appropriate methods (e.g., chromatographic software, instrument printouts, hand calculation, etc.). Equations used for calculation of results are found in the applicable analytical SOPs. The resulting data set is either manually entered (e.g., titrimetric or microbiological data) into an electronic report form or is electronically transferred into the report from the software used to process the original data set (e.g., chromatographic software). Once the complete data set has been transferred into the proper electronic report form(s), it is then printed. The resulting hardcopy version of the electronic report is then reviewed by the analyst for accuracy. Once the primary analyst has checked the data for accuracy and acceptability, the hardcopy is forwarded to the supervisor or second qualified analyst, who reviews the data for errors. Where calculations are not performed using a validated software system, the reviewer rechecks a minimum of 10% of the calculations. When the entire data set has been found to be acceptable, a final copy of the report is printed and signed by the laboratory supervisor, departmental manager or designated laboratory staff. The entire data package is then placed into the appropriate service request file, and an electronic copy of the final data package is forwarded to the appropriate personnel for archival. Data review procedures are described in the *SOP for Laboratory Data Review Process.*

Policies and procedures for manual editing of data are established. The analyst making the change must initial and date the edited data entry, without obliteration of the original entry. The policies and procedures are described in the *SOP for Making Entries into Logbooks and onto Benchsheets* (SOP ADM-DATANTRY).

Policies and procedures for electronic manual integration of chromatographic data are established. The analyst performing the integration must document the integration change by printing both the "before" and "after" integrations and including them in the raw data records. The policies and procedures are described in the *SOP for Manual Integration of Chromatographic Peaks* (SOP ADM-INT).

12.2 Confirmation Analysis

12.2.1 Gas Chromatographic and Liquid Chromatographic Analyses

For gas chromatographic (GC) and liquid chromatographic (LC) analyses, all positive results are confirmed by a second column, a second detector, a second wavelength (HPLC/UV), or by GC/MS analysis, unless exempted by one of the following situations:

- The analyte of interest produces a chromatogram containing multiple peaks exhibiting a characteristic pattern, which matches appropriate standards. This is limited to petroleum hydrocarbon analyses (e.g., gasoline and diesel) and does not include polychlorinated biphenyls.

- The sample meets all of the following requirements:

    1. All samples (liquid or solid) come from the same source (e.g., groundwater samples from the same well) for continuous monitoring. Samples of the same matrix from the same site, but from different sources (e.g., different sampling locations) are not exempt.

    2. All analytes have been previously analyzed in sample(s) from the same source (within the last year), identified and confirmed by a second column or by GC/MS. The chromatogram is largely unchanged from the one for which confirmation was carried out. The documents indicating previous confirmation must be available for review.

12.2.2 Confirmation Data

Confirmation data will be provided as specified in the method. Identification criteria for GC, LC or GC/MS methods are summarized below:

- GC and LC Methods

    1. The analyte must fall within plus or minus three times the standard deviation (established for the analyte/column) of the retention time of the daily midpoint standard in order to be qualitatively identified. The retention-time windows will be established and documented, as specified in the appropriate Standard Operating Procedure (SOP).

    2. When sample results are confirmed by two dissimilar columns or detectors, the agreement between quantitative results must be evaluated. The relative percent difference between the two results is calculated and evaluated against SOP and/or method criteria.

- GC/MS Methods - Two criteria are used to verify identification:

    1. Elution of the analyte in the sample will occur at the same relative retention time (RRT) as that of the analyte in the standard.

    2. The mass spectrum of the analyte in the sample must, in the opinion of a qualified analyst or the department manager, correspond to the spectrum of the analyte in the standard or the current GC/MS reference library.

12.3 Data Review and Validation

The integrity of the data generated is assessed through the evaluation of the sample results, calibrations, and QC samples (method blanks, laboratory control samples, sample duplicates, matrix spikes, trip blanks, etc.). A brief description of the evaluation of these analyses is described below, with details listed in applicable SOPs. The criteria for evaluation of QC samples are listed within each method-specific SOP. Other data evaluation measures may include (as necessary) a check of the accuracy check of the QC standards and a check of the system sensitivity. Data transcriptions and calculations are also reviewed.

Note: Within the scope of this document, all possible data assessment requirements for various project protocols cannot be included in the listing below. This listing gives a general description of data evaluation practices used in the laboratory in compliance with NELAP Quality Systems requirements. Additional requirements exist for certain programs, such as projects under the DoD QSM protocols, AFCEE QAPP protocols, and project-specific QAPPs.

- Method Calibration – Following the analysis of calibration blanks and standards according to the applicable SOP the calibration correlation coefficient, average response factor, etc. is calculated and compared to specified criteria. If the calibration meets criteria analysis may continue. If the calibration fails, any problems are isolated and corrected and the calibration standards reanalyzed. Following calibration and analysis of the independent calibration verification standard(s) the percent difference for the ICV is calculated. If the percent difference is within the specified limits the calibration is complete. If not, the problem associated with the calibration and/or ICV are isolated and corrected and verification and/or calibration is repeated.

- Continuing Calibration Verification (CCV) – Following the analysis of the CCV standard the percent difference is calculated and compared to specified criteria. If the CCV meets the criteria analysis may continue. If the CCV fails, routine corrective action is performed and documented and a 2nd CCV is analyzed. If this CCV meets criteria, analysis may continue, including any reanalysis of samples that were associated with a failing CCV. If the routine corrective action failed to produce an immediate CCV within criteria, then either acceptable performance is demonstrated (after additional corrective action) with two consecutive calibration verifications, or a new initial calibration is performed. For DoD projects, the concentration of these two consecutive must be varied as required by the DoD QSM, Version 3.

- Method Blank – Results for the method blank are calculated as performed for samples. If results are less than the MRL (<½ MRL for DoD projects), the blank may be reported. If not, associated sample results are evaluated to determine the impact of the blank result. If possible, the source of the contamination is determined. If the contamination has affected sample results the blank and samples are reanalyzed. If positive blank results are reported, the blank (and sample) results are flagged with an appropriate flag, qualifier, or footnote.

- Sample Results (Inorganic) – Following sample analysis and calculations (including any dilutions made due to the sample matrix) the result is verified to fall within the calibration range. If not, the sample is diluted and analyzed to bring the result into calibration range. When sample and sample duplicates are analyzed for precision, the calculated RPD is compared to the specified limits. The sample and duplicate are reanalyzed if the criteria are exceeded. The samples may require re-preparation and reanalysis. For metals, additional measures as described in the applicable SOP, may be taken to further evaluate results (dilution tests and/or post-digestion spikes). Results are reported when within the calibration range, or as estimates when outside the calibration range. When dilutions are performed the MRL is elevated accordingly and qualified. Efforts are made to meet the project MRL's including alternative analysis.

- Sample Results (Organic) – For GC/MS analyses, it is verified that the analysis was within the prescribed tune window. If not, the sample is reanalyzed. Following sample analysis and calculations (including any dilutions made due to the sample matrix) peak integrations, retention times, and spectra are evaluated to confirm qualitative identification. Internal standard responses and surrogate recoveries are evaluated against specified criteria. If internal standard response does not meet criteria, the sample is diluted and reanalyzed. Results outside of the calibaration range are diluted to within the calibration range. For GC and HPLC tests, results from confirmation analysis are evaluated to confirm positive results and to determine the reported value. The procedure to determine which result to report is described in the SOP *Confirmation Procedure for GC and HPLC Analysis(SOC-CONF).* If obvious matrix interferences are present, additional cleanup of the sample using appropriate procedures may be necessary and the sample is reanalyzed. When dilutions are performed the MRL is elevated accordingly and qualified. Efforts are made to meet the project MRL's including additional cleanup.

- Surrogate Results (Organic) – Following sample analysis and data reduction, the percent recovery of each surrogate is compared to specified control limits. If recoveries are acceptable, the results are reported. If recoveries do not fall within control limits, the sample matrix is evaluated. When matrix interferences are present or documented, the results are reported with a qualifier that matrix interferences are present. If no matrix interferences are present and there is no cause for the outlier, the sample is reprepared and reanalyzed. However, if the recovery is above the upper control limit with non-detected target analytes, the sample may be reported. All surrogate recovery outliers are appropriately qualified on the report.

- Duplicate Sample and/or Duplicate Matrix Spike Results – The RPD is calculated and compared to the specified control limits. If the RPD is within the control limits the result is reported. If not, an evaluation of the sample is made to verify that a homogenous sample was used. Despite the use of homogenizing procedures prior to sample preparation or analysis, the sample may not be homogenous or duplicate sample containers may not have been sample consistently. If non-homogenous, the result is reported with a qualifier about the homogeneity of the sample. Also, the results are compared to the MRL. If the results are less than five times the MRL, the results are reported with a qualifier that the high RPD is due to the results being near the MRL. If the sample is homogenous and results above five times the MRL, the samples and duplicates are reanalyzed. If re-analysis also produces out-of-control results, the results are reported with an appropriate qualifier.

- Laboratory Control Sample Results – Following analysis of the LCS the percent recovery is calculated and compared to specified control limits. If the recovery is within control limits, the analysis is in control and results may be reported. If not, this indicates that the analysis is not in control. Samples associated with the 'out of control' LCS, shall be considered suspect and the samples re-extracted or re-analyzed or the data reported with the appropriate qualifiers. For analysis where a large number of analytes are in the LCS, it becomes more likely that some analytes (marginal exceedences) will be outside the control limits. The procedure described in the 2003 NELAC standards,l Appendix D.1.1.2.1 are used to determine if the LCS is effective in validating the analytical system and the associated samples.

- Matrix Spike Results – Following analysis of the MS the percent recovery is calculated and compared to specified control limits. If the recovery is within control limits the results may be reported. If not, and the LCS is within control limits, this indicates that the matrix potentially biases analyte recovery. It is verified that the spike level is at least five times the background level. If not, the results are reported with a qualifier that the background level is too high for accurate recovery determination. If matrix interferences are present or results indicate a potential problem with sample preparation, steps may be taken to improve results; such as performing any additional cleanups, dilution and reanalysis, or re-preparation and reanalysis. Results that do not meet acceptance limits are reported with an appropriate qualifier.

12.4 Data Reporting

When an analyst determines that a data package has met the data quality objectives (and/or any client-specific data quality objectives) of the method and has qualified any anomalies in a clear, acceptable fashion, the data package is reviewed by a trained chemist. Prior to release of the report to the client, the project chemist reviews and approves the entire report for completeness and to ensure that any and all client-specified objectives were successfully achieved. The original raw data, along with a copy of the final report, is filed in project files by service request number for archiving. CAS maintains control of analytical results by adhering to standard operating procedures and by observing sample custody requirements. All data are calculated and reported in units consistent with project specifications, to enable easy comparison of data from report to report.

To the extent possible, samples shall be reported only if all QC measures are acceptable. If a QC measure is found to be out of control, and the data is to be reported, all samples associated with the failed quality control measure shall be reported with the appropriate data qualifier(s). The *SOP for Data Reporting and Report Generation* addresses the flagging and qualification of data. The CAS-defined data qualifiers, state-specific data qualifiers, or project-defined data qualifiers are used depending on project requirements. A case narrative may be written by the project chemist to explain problems with a specific analysis or sample, etc.

For subcontracted analyses, the Project Chemist verifies that the report received from the subcontractor is complete. This includes checking that the correct analyses were performed, the analyses were performed for each sample as requested, a report is provided for each analysis, and the report is signed. The Project Chemist accepts the report if all verification items are complete. Acceptance is demonstrated by forwarding the report to the CAS client.

12.5 Documentation

CAS maintains a records system which ensures that all laboratory records of analysis data retained and available. Analysis data is retained for 5 years from the report date unless contractual terms or regulations specify a longer retention time. The archiving system is described in the *SOP for Data Archiving*.

12.5.1 Documentation and Archiving of Sample Analysis Data

The archiving system includes the following items for each set of analyses performed:

- Benchsheets describing sample preparation (if appropriate) and analysis;
- Instrument parameters (or reference to the data acquisition method);
- Sample analysis sequence;
- Instrument printouts, including chromatograms and peak integration reports for all samples, standards, blanks, spikes and reruns;
- Logbook ID number for the appropriate standards;
- Copies of report sheets submitted to the work request file; and
- Copies of Nonconformity and Corrective Action Reports, if necessary.

Individual sets of analyses are identified by analysis date and service request number. Since many analyses are performed with computer-based data systems, the final sample concentrations can be automatically calculated. If additional calculations are needed, they are written on the integration report or securely stapled to the chromatogram, if done on a separate sheet.

For organics analysis, data applicable to all analyses within the batch, such as GCMS tunes, CCVs, batch QC, and analysis sequences; are kept using a separate documentation system. This system is used to archive data on a batch-specific basis and is segregated according to the date of analysis. This system also includes results for the most recent calibration curves, as well as method validation results.

12.6 Deliverables

In order to meet individual project needs, CAS provides several levels of analytical reports. Standard specifications for each level of deliverable are described in Table 12-1. Variations may be provided based on client or project specifications. This includes (but is not limited to) to following specialized deliverables:

- ADEC – Alaska Department of Conservation specified data package
- ACOE/HTRW – Army Corps of Engineers specified data package and reporting requirements (HTRW, CERP, FUDS, etc.)
- AFCEE – Air Force Center for Environmental Excellence project-specific reporting

When requested, CAS provides Electronic Data Deliverables (EDDs) in the format specified by client need or project specification. CAS is capable of generating EDDs with many different formats and specifications. The EDD is prepared by report production staff using the electronic version of the laboratory report to minimize transcription errors. User guides and EDD specification outlines are used in preparing the EDD. The EDD is reviewed and compared to the hard-copy report for accuracy.

Table 12-1
Descriptions of CAS Standard Data Deliverables

Tier I. Routine Certified Analytical Report (CAR) includes the following:

1. Transmittal letter
2. Sample analytical results
3. Method blank results
4. Surrogate recovery results and acceptance criteria for applicable organic methods
5. Chain of custody documents
6. Dates of sample preparation and analysis for all tests

Tier II and IIA. In addition to the Tier I Deliverables, this CAR includes the following:

1. Matrix spike result(s) with calculated recovery and including associated acceptance criteria
2. Duplicate or duplicate matrix spike result(s) (as appropriate to method), with calculated relative percent difference
3. Tier IIA also includes Laboratory Control Sample (LCS) result(s) with calculated recovery and including associated acceptance criteria

Tier III. Data Validation Package. In addition to the Tier II Deliverables, this CAR includes the following:

1. Case narrative
2. Calibration records and results of initial and continuing calibration verification standards, with calculated recoveries
3. Results of laboratory control sample (LCS) or Quality Control check sample, with calculated recovery and/or associated acceptance limit criteria
4. Results of calibration blanks or solvent blanks (as appropriate to method)
5. Summary forms for associated QC and calibration parameters
6. Copies of all raw data, including extraction/preparation bench sheets, chromatograms, and instrument printouts. For GC/MS, this includes tuning criteria and mass spectra of all positive hits. Results and spectra of TIC compounds will be included upon request.

Tier IV. CLP-Level Data Validation Package.

A complete Data Validation Package containing all sample results, quality control and calibration results, and raw data necessary to fulfill all deliverable requirements of an EPA Contract Laboratory Program (CLP) data package.

13.0 PERFORMANCE AND SYSTEM AUDITS

Quality audits are an essential part of CAS/Kelso's quality assurance program. There are two types of audits used at the facility: System Audits are conducted to qualitatively evaluate the operational details of the QA program, while Performance Audits are conducted by analyzing proficiency testing samples in order to quantitatively evaluate the outputs of the various measurement systems.

13.1 System Audits

The system audit examines the presence and appropriateness of laboratory systems. External system audits of CAS/Kelso are conducted regularly by various regulatory agencies and clients. Table 13-1 summarizes some of the major programs in which CAS/Kelso participates. Programs and certifications are added as required. Additionally, internal system audits of CAS/Kelso are conducted regularly under the direction of the Quality Assurance Manager. The internal audit procedures are described in the *SOP for Internal Audits*. The internal audits are performed as follows:

- Comprehensive lab-wide system audit – performed annually. This audit is conducted such that systems, technical operations, hardcopy data, and electronic data are assessed.
- Hardcopy report audits – minimum of 3 per quarter.
- Electronic audit trail reviews – each applicable instrument per quarter.

All audit findings, and corrective actions are documented. The results of each audit are reported to the Laboratory Director and Department Managers for review. Any deficiencies identified are summarized in the audit report. Managers must respond with corrective actions correcting the deficiency within a defined timeframe. Should problems impacting data quality be found during an internal audit, any client whose data is adversely impacted will be given written notification within the corrective action period (if not already provided).

Electronic data audits may be performed in conjunction with hardcopy data audits. The electronic audits focus on organic chromatographic data and include an examination of audit trails, peak integrations, calibration practices and files, GCMS tuning data, peak response data, use of appropriate files, and other components of the analysis. The audit also verifies that the electronic data supports the hardcopy reported data.

Additional internal audits or data evaluations may be performed as needed to address any potential data integrity issues that may arise.

13.2 Performance Audits

CAS/Kelso also participates in the analysis of interlaboratory proficiency testing (PT) samples. Participation in PT studies is performed on a regular basis and is designed to evaluate all analytical areas of the laboratory. CAS routinely participates in the following studies:

- Water Pollution (WP) and additional water parameters, 2 per year.
- Water Supply (WS) PT studies, 2 per year.
- Hazardous Waste/Soil PT studies, 2 per year.
- Underground Storage Tank PT studies, 2 per year.
- Microbiology (WS and WP) PT studies, 2 per year.
- Other studies as required for specific certifications, accreditations, or validations.

PT samples are processed by entering them into the LIMS system as samples (assigned Service Request, due date, testing requirements, etc.) and are processed the same as field samples. The laboratory sections handle samples the same as field samples, performing the analyses following method requirements and performing data review. The laboratory sections submit results to the QA Manager for subsequent reporting to the appropriate agencies or study provider. Results of the performance evaluation samples and audits are reviewed by the Quality Assurance Manager, Laboratory Director, the laboratory staff, and the CAS Quality Assurance Director. For any results outside acceptance criteria, the analysis data is reviewed to identify a possible cause for the deficiency, and corrective action is taken and documented.

Table 13-1
Current CAS Performance and System Audit Programs

Federal and National Programs

- The TNI (The NELAC Institute) National Environmental Laboratory Accreditation Program (NELAP) Accredited Drinking Water, Non-Potable Water, Solid & Hazardous Waste, and Biological Tissue Laboratory
- Naval Facilities Engineering Service Center
  Validated Laboratory for NFESC Parameters
- U.S. Air Force, Air Force Center for Environmental Excellence (AFCEE)
  Approved Laboratory for AFCEE Projects
- U.S. Army Corps of Engineers
  Approved Laboratory for USACE Projects
- U.S. EPA Region 8
  Approved Drinking Water Laboratory

State and Local Programs

- State of Alaska, Department of Environmental Conservation
  UST Laboratory, Lab I.D. UST040
- State of Arizona, Department of Health Services
  License No. AZ0339
- State of Arkansas, Department of Environmental Quality
  Certified Environmental Laboratory, Lab I.D. 88-0637
- State of California, Department of Health Services, Environmental Laboratory Accreditation Program
  Certification No. 2286
- State of Colorado, Department of Public Health and Environment
  Certified Drinking Water Laboratory
- State of Florida, Department of Health
  Primary NELAP Accreditation No. E87412
- State of Georgia, Department of Natural Resources
  Certified Drinking Water Laboratory
- State of Hawaii, Department of Health
  Certified Drinking Water Laboratory
- State of Idaho, Department of Health and Welfare
  Certified Drinking Water Laboratory
- State of Indiana, Department of Health
  Certified Drinking Water Laboratory, Lab I.D. C-WA-01
- State of Louisiana, Department of Environmental Quality
  Accredited Environmental Laboratory, Lab I.D. 3016
- State of Louisiana, Department of Health and Hospitals
  Accredited Drinking Water Laboratory, Lab I.D. LA080001
- State of Maine, Department of Human Services
  Certified Environmental Laboratory, Lab I.D. WA0035
- State of Michigan, Department of Environmental Quality
  Certified Drinking Water Laboratory, Lab I.D. 9949

Table 13-1 (continued)

State and Local Programs (continued)

- State of Minnesota, Department of Health
  Certified Environmental Laboratory, Lab I.D. 053-999-368
- State of Montana, Department of Health and Environmental Sciences
  Certified Drinking Water Laboratory, Lab I.D. 0047
- State of Nevada, Division of Environmental Protection
  Certified Drinking Water Laboratory, Lab I.D. WA35
- State of New Jersey, Department of Environmental Protection
  Accredited Environmental Laboratory, Lab I.D. WA005
- State of New Mexico, Environment Department
  Certified Drinking Water Laboratory
- State of North Carolina, Department of Environment and Natural Resources
  Certified Environmental Laboratory, Lab I.D. 605
- State of Oklahoma, Department of Environmental Quality
  General Water Quality/Sludge Testing, Lab I.D. 9801
- State of Oregon, ORELAP Laboratory Accreditation Program
  Accredited Environmental Laboratory, Lab I.D. WA200001
- State of South Carolina, Department of Health and Environmental Control
  Certified Environmental Laboratory, Lab I.D. 61002
- State of Utah, Department of Health, Division of Laboratory Services
  Accredited Environmental Laboratory
- State of Washington, Department of Ecology, Environmental Laboratory Accreditation Program
  Accreditation No. C1203
- State of Wisconsin, Department of Natural Resources
  Accredited Environmental Laboratory, Lab I.D. 998386840

14.0 PREVENTIVE MAINTENANCE

Preventive maintenance is a crucial element of the Quality Assurance program. Instruments at CAS (e.g., ICP/MS and ICP systems, GC/MS systems, atomic absorption spectrometers, analytical balances, gas and liquid chromatographs, etc.) are maintained under commercial service contracts or by qualified, in-house personnel. All instruments are operated and maintained according to the instrument operating manuals. All routine and special maintenance activities pertaining to the instruments are recorded in instrument maintenance logbooks. The maintenance logbooks used at CAS contain extensive information about the instruments used at the laboratory.

An initial demonstration of analytical control is required on every instrument used at CAS before it maybe used for sample analysis. If an instrument is modified or repaired, a return to analytical control is required before subsequent sample analyses can occur. When an instrument is acquired at the laboratory, the following information is noted in a bound maintenance notebook specifically associated with the new equipment:

- The equipment's serial number;
- Date the equipment was received;
- Date the equipment was placed into service;
- Condition of equipment when received (new, used, reconditioned, etc.); and
- Prior history of damage, malfunction, modification or repair (if known).

Equipment records also include a copy of the manufacturer's manual(s) and dates and results of calibrations.

Preventive maintenance procedures, frequencies, etc. are available for each instrument used at CAS. They may be found in the various SOPs for routine methods performed on an instrument and may also be found in the operating or maintenance manuals provided with the equipment at the time of purchase.

Responsibility for ensuring that routine maintenance is performed lies with the section supervisor. The supervisor may perform the maintenance or assign the maintenance task to a qualified bench level analyst who routinely operates the equipment. In the case of non-routine repair of capital equipment, the section supervisor is responsible for providing the repair, either by performing the repair themselves with manufacturer guidance or by acquiring on-site manufacturer repair. Each laboratory section maintains a critical parts inventory. The parts inventories include the items needed to perform the preventive maintenance procedures listed in Appendix D.

This inventory or "parts list" also includes the items needed to perform any other routine maintenance and certain in-house non-routine repairs such as gas chromatography/mass spectrometry jet separators and electron multipliers and ICP/MS nebulizer. When performing maintenance on an instrument (whether preventive or corrective), additional information about the problem, attempted repairs, etc. is also recorded in the notebook. Typical logbook entries include the following information:

- Details and symptoms of the problem;
- Repairs and/or maintenance performed;
- Description and/or part number of replaced parts;
- Source(s) of the replaced parts;
- Analyst's signature and date; and
- Demonstration of return to analytical control.

See the table in Appendix D for a list of preventive maintenance activities and frequency for each instrument.

15.0 CORRECTIVE ACTION

To the extent possible, samples shall be reported only if all quality control measures are acceptable. If a quality control measure is found to be out of control, and the data is to be reported, all samples associated with the failed quality control measure shall be reported with the appropriate data qualifier(s). Failure to meet established analytical controls, such as the quality control objectives outlined in Section 11, prompts corrective action. In general, corrective action may take several forms and may involve a review of the calculations, a check of the instrument maintenance and operation, a review of analytical technique and methodology, and reanalysis of quality control and field samples. If a potential problem develops that cannot be solved directly by the responsible analyst, the supervisor, team leader, the department manager, and/or the Quality Assurance Manager may examine and pursue alternative solutions. In addition, the appropriate project chemist may be notified in order to ascertain if contact with the client is necessary.

In the event that analyses produce nonconformances with data or results, the problem and the corresponding corrective actions taken are documented on Nonconformity and Corrective Action Reports (See Figure 15-1) following the requirements in the SOP for Corrective Action (SOP No. ADM-CA). This form is utilized to document corrective actions in response to out-of-control situations. The Quality Assurance Manager reviews each problem, ensuring that appropriate corrective action has been taken by the appropriate personnel. The Nonconformity and Corrective Action Report (NCAR) is filed in the associated service request file and a copy is kept by the Quality Assurance Manager. The Quality Assurance Manager periodically reviews all NCARs looking for chronic, systematic problems that need more in-depth investigation and alternative corrective action consideration. In addition, the appropriate project chemist is promptly notified of any problems in order to inform the client and proceed with any action the client may want to initiate.

In addition to internal communication of data issues, the laboratory also maintains a system for dealing with customer complaints. The person who initially receives the feedback (typically the project chemist) is responsible for documenting the complaint. If the project chemist is unable to satisfy the customer, the complaint is brought to the attention of the Client Services Manager, Laboratory Director, or QA Manager for final resolution. The complaint and resolution are documented. The procedure is described in the *SOP for Handling Customer Feedback* (ADM-FDBK).

Corrective action due to a performance audit or a proficiency(PT) sample finding is initiated by the Quality Assurance Manager; the affected laboratory supervisors and managers are promptly informed of performance audit results requiring corrective action.

Figure 15-1

Columbia Analytical Services, Inc.

Nonconformity and Corrective Action Report

NONCONFORMITY

NCAR No. _____

PROCEDURE (SOP or METHOD): EVENT DATE: _____

EVENT: ☐ Missed Holding Time ☐ QC Failure ☐ Lab Error (spilled sample, spiking error, etc.)
☐ Method Blank Contamination ☐ Login Error ☐ Project Management Error
☐ Equipment Failure ☐ Unacceptable PT Sample Result
☐ SOP Deviation ☐ Other (describe):

SAMPLES / PROJECTS / CUSTOMERS / SYSTEMS AFFECTED

DETAILED DESCRIPTION

ORIGINATOR: _____ DATE: _____

PROJECT MANAGER(S): _____ NOTIFIED BY: _____ DATE: _____

CORRECTIVE ACTION AND OUTCOME

Re-establishment of conformity must be demonstrated and documented. Describe the steps that were taken, or are planned to be taken, to correct the particular Nonconformity and prevent its reoccurrence. Include Project Manager instructions here.

Is the data to be flagged in the Analytical Report with an appropriate qualifier? ☐ **No** ☐ **Yes**

APPROVAL AND NOTIFICATION

Supervisor Verification and Approval of Corrective Action _____ Date: _____
Comments:

QA PM Verification and Approval of Corrective Action _____ Date: _____
Comments:

Customer Notified by ☐ Telephone ☐ Fax ☐ E-mail ☐ Narrative ☐ Not notified

Project Manager Verification and Approval of Corrective Action _____ Date: _____
Comments:

(Attach record or cite reference where record is located.)

16.0 QUALITY ASSURANCE REPORTS

Quality assurance requires an active, ongoing commitment by CAS personnel at all levels of the organization. Communication and feedback mechanisms are designed so that analysts, supervisors and managers are aware of QA issues in the laboratory. Analysts performing routine testing are responsible for generating a data quality narrative or data review document with every analytical batch processed. This report also allows the analyst to provide appropriate notes and/or a case narrative if problems were encountered with the analyses. A Non-Conformity and Corrective Action Report (NCAR) (see Section 15.0) may also be attached to the data prior to review. Supervisors or qualified analysts review all of the completed analytical batches to ensure that all QC criteria have been examined and any deficiencies noted and corrected if possible.

It is the responsibility of each laboratory unit to provide the project chemist with a final report of the data, accompanied by signature approval. Footnotes and/or narrative notes must accompany any data package if problems were encountered that require further explanation to the client. Each data package is submitted to the appropriate project chemist, who in turn reviews the entire collection of analytical data for completeness. The project chemist must also review the entire body of data to ensure that any and all client-specified objectives were successfully achieved. A case narrative may be written by the project chemist to explain any unusual problems with a specific analysis or sample, etc.

The Quality Assurance Manager (QAM) provides overview support to the project chemists as required (e.g., contractually specified, etc.). The QAM is also responsible for the oversight of all internal and external audits, for all proficiency testing sample and analysis programs, and for all laboratory certification/accreditation responsibilities. The QAM provides the Laboratory Director with quarterly reports that summarize the various QA/QC activities that occurred during the previous quarter. The report addresses such topics as the following:

- Status, schedule, and results of internal and external audits;
- Status, schedule, and results of internal and external proficiency testing studies;
- Status of certifications, accreditations, and approvals;
- Status of QA Manual and SOP review and revision;
- Status of MDLs studies;
- Discussion of QC problems in the laboratory;
- Discussion of corrective action program issues;
- Status of staff training and qualification; and
- Other topics as appropriate.

Any operational or quality assurance problems noted by the Laboratory Director are then addressed during the senior staff operations meetings with all appropriate department managers. The Laboratory Director also performs al documented management review annually of the quality and management systems to identify any necessary changes or improvements to the quality system or quality assurance policies.

17.0 PERSONNEL TRAINING

Technical position descriptions are available for all employees, regardless of position or level of seniority. These documents are maintained by the Human Resources personnel and are available for review. In order to assess the technical capabilities and qualifications of a potential employee, all candidates for employment at CAS are evaluated, in part, against the appropriate technical description.

Training begins the first day of employment at CAS when the company policies are presented and discussed. Safety and QA/QC requirements are integral parts of all technical SOPs and, consequently, are integral parts of all training processes at CAS. Safety training begins with the reading of the *Environmental Health and Safety Manual.* Employees are also required to attend periodic safety meetings where additional safety training may be performed by the Environmental, Health and Safety Officer. Employees are responsible for complying with the requirements of the QA Manual and QA/QC requirements associated with their function(s).

Each employee participates in Ethics training, which is part of the CAS Improper Practices Prevention Program. CAS also encourages its personnel to continue to learn and develop new skills that will enhance their performance and value to the Company. Ongoing training occurs for all employees through a variety of mechanisms. The "CAS University" education system, external and internal technical seminars and training courses, and laboratory-specific training exercises are all used to provide employees with professional growth opportunities.

A training plan is developed whenever an employee starts a new procedure to new position. The training plan includes a description of the step-by-step process for training an employee and for initial demonstration of proficiency. Where the analyst performs the entire procedure, a generic training plan may be used. In cases where work cells are used, a training plan specific to the work cell is established.

17.1 Initial Demonstration of Capability (IDOC)

Training in analytical procedures typically begins with the reading of the Standard Operating Procedure (SOP) for the method. Hands-on training begins with the observation of an experienced analyst performing the method, followed by the trainee performing the method under close supervision, and culminating with independent performance of the method on quality control samples. Successful completion of the applicable Demonstration of Capability analysis qualifies the analyst to perform the method independently. Demonstration of Capability is performed by one of the following:

- Successful completion of an Initial Precision and Recovery (IPR) study (required where mandated by the method).

- Analysis of 4 consecutive Laboratory Control Samples, with acceptable accuracy and precision.

- Where spiking is not possible but QC standards are used ("non-spiked" Laboratory Control Samples), analysis of 4 consecutive Laboratory Control Samples with acceptable accuracy and precision.

- Where one of the three above is not possible, special requirements are as follows:

    - Total Settleable Solids: Successful single-blind PT sample analysis and duplicate results with RPD<10%.
    - Color: Four consecutive prepared LCSs with acceptable accuracy and precision of <10% RSD.
    - Physical Tests (Grain size, Corrosivity to Steel, etc.): Supervisor acknowledgement of training and approval.

A flowchart identifying the Demonstration of Proficiency requirements is given in Figure 17-1. The flowchart identifies allowed approaches to assessing Demonstration of Capability when a 4-replicate study is not mandated by the method, when spiking is not an option, or when QC samples are not readily available.

17.2 Continuing Demonstration of Proficiency

A periodic demonstration of proficiency is required to maintain continuing qualification. Continuing Demonstration of Proficiency is required each year, and may be performed one of the following ways:

- Successful performance on external (independent) single-blind PT sample analyses using the test method, or a similar test method using the same technology.

- Performing Initial Demonstration of Capability as described above, with acceptable levels of precision and accuracy.

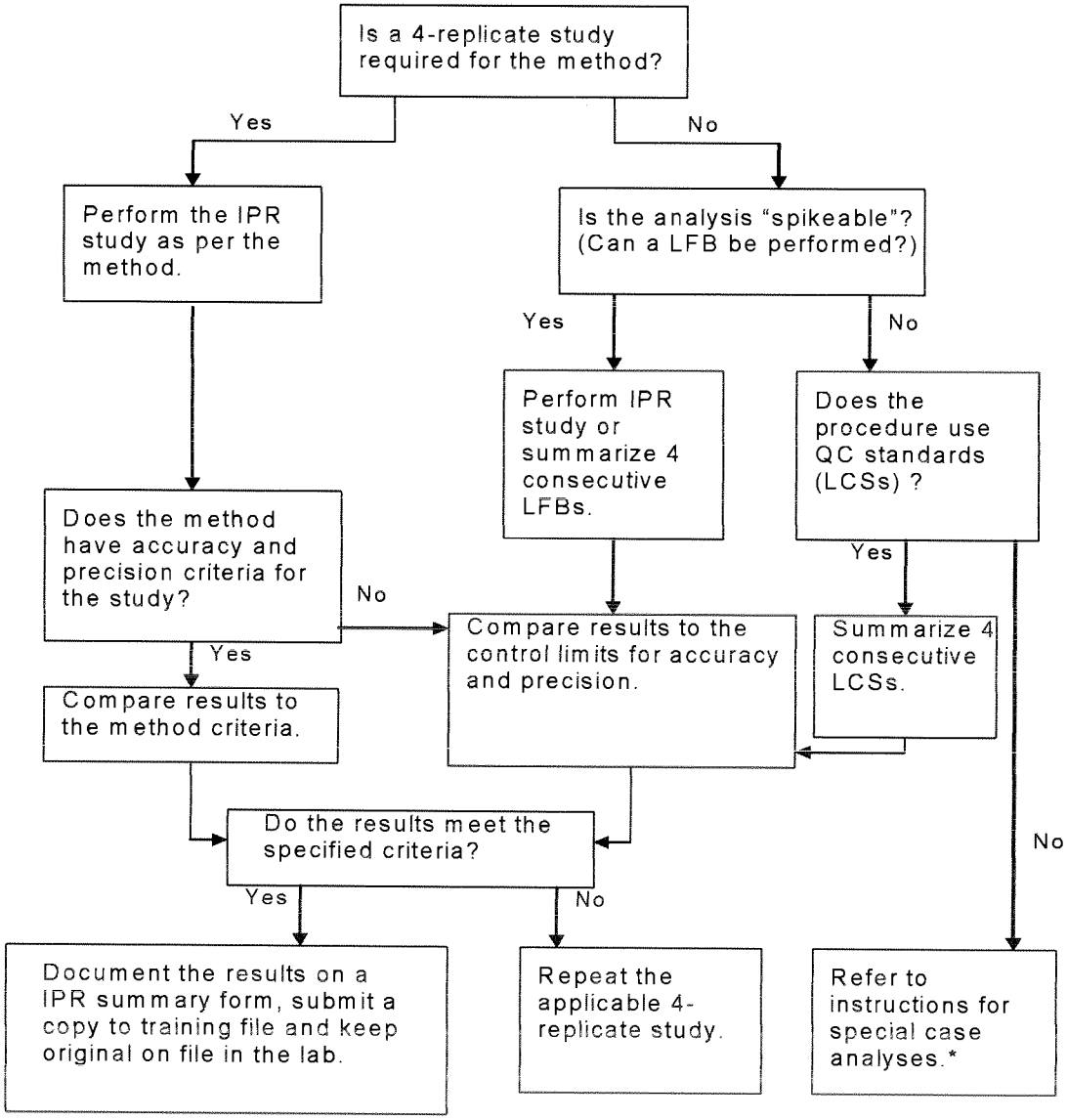
- Analysis of at least 4 consecutive LCSs with acceptable levels of accuracy and precision from in-control analytical batches.

- For methods for which PT samples are not available and a spiked analysis (LFB, MDL, etc.) is not possible, analysis of field samples that have been analyzed by another analyst with statistically indistinguishable results.

17.3 Documentation of Training

Records are maintained to indicate the employee has the necessary training, education, and experience to perform their functions. Information of previously acquired skills and abilities for a new employee is maintained in Human Resources personnel files and CAS resumes. A database is used to record the various technical skills and training acquired while employed by CAS. Information includes the employee's name, a description of the skill including the appropriate method and SOP reference, the mechanism used to document proficiency, and the date the training was completed. General procedures for documenting technical training are described in the *SOP for Documentation of Training (SOP No. ADM-TRANDOC).*

Figure 17-1
Initial Demonstration of Capability Requirements[a]



[a] For IDOC IPR or LFB studies, "second-source" reference materials are used, as per NELAP requirements
*Total Settleable Solids: Successful PT sample analysis and duplicate results with RPD<10%.
*Color: Four consecutive prepared LCSs with acceptable accuracy and precision of <10% RSD.
* Physical Tests (Grain size, Corrosivity to Steel, etc.): Supervisor acknowledgement of training and approval.

18.0 REFERENCES FOR ANALYTICAL PROCEDURES

The analytical methods used at CAS generally depend upon the end-use of the data. Since most of our work involves the analysis of environmental samples for regulatory purposes, specified federal and/or state testing methodologies are used and followed closely. Typical methods used at CAS are taken from the following references:

- *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, SW-846, Third Edition, (September 1986) and Updates I (July 1992), II (September 1994), IIA (August 1993), IIB (January 1995), III (December 1996), Final Update IV (February 2007), and updates posted online at http://www.epa.gov/epaoswer/hazwaste/test/sw846.htm. See Chapters 1, 2, 3, and 4.
- *Methods for Chemical Analysis of Water and Wastes*, EPA-600/4-79-020, (Revised March 1983).
- *Methods for the Determination of Inorganic Substances in Environmental Samples*, EPA/600/R-93/100 (August 1993).
- *Methods for the Determination of Metals in Environmental Samples*, EPA/600/4-91/010 (June 1991) and Supplements.
- *Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater*, EPA 600/4-82-057 (July 1982) and 40 CFR Part 136, Appendix A.
- *Methods for the Determination of Organic Compounds in Drinking Water*, EPA/600/4-88/039 (December 1988) and Supplements.
- *Standard Methods for the Examination of Water and Wastewater*, 18th Edition (1992); 19th Edition (1995), 20th Edition (1998). See Introduction in Part 1000.
- 40 CFR Part 136, Guidelines for Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act.
- 40 CFR Part 141, National Primary Drinking Water Regulations.
- *Analytical Methods for Petroleum Hydrocarbons*, ECY 97-602, Washington State Department of Ecology, June 1997.
- State-specific total petroleum hydrocarbon methods for the analysis of samples for gasoline, diesel, and other petroleum hydrocarbon products (Alaska, Arizona, California, Oregon, Washington, Wisconsin, etc.).

- Annual Book of ASTM Standards, Part 31, Water.
- EPA Contract Laboratory Program, Statement of Work for Organic Analysis, SOW Nos. OLM03.1, OLM03.2, OLM04.2, and OLM04.3.
- EPA Contract Laboratory Program, Statement of Work for Inorganic Analysis, SOW No. ILM04.0, ILM04.1, and ILM05.2.
- *U. S. EPA Contract Laboratory Program National Functional Guidelines for Organic Data Review*, EPA-540/R-94/012 (February 1993).
- *U. S. EPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review*, EPA-540/R-94/013 (February 1994).
- National Institute for Occupational Safety and Health (NIOSH) *Manual of Analytical Methods*, Third Edition (August 1987); Fourth Edition (August 1994).
- *Recommended Protocols for Measuring Selected Environmental Variables in Puget Sound*, for USEPA and USACE (March 1986), with revisions through April 1997.
- WDOE 83-13, *Chemical Testing Methods for Complying with the State of Washington Dangerous Waste Regulations* (March 1982) and as Revised (July 1983 and April 1991).
- *Identification and Listing of Hazardous Waste,* California Code of Regulations, Title 22, Division 4.5, Chapter 11.
- *Analytical Methods for the Determination of Pollutants in Pulp and Paper Industry Wastewater*, EPA 821-R-93-017 (October 1993).
- *Analytical Methods for the Determination of Pollutants in Pharmaceutical Manufacturing Industry Wastewaters*, EPA 821-B-98-016 (July 1998).
- National Council of the Pulp and Paper Industry for Air and Stream Improvement (NCASI).
- *Good Automated Laboratory Practices, Principles and Guidance to Regulations For Ensuring Data Integrity In Automated Laboratory Operations*, EPA 2185 (August 1995).
- *Manual for the Certification of Laboratories Analyzing Drinking Water*, 4th Edition, EPA 815-B-97-001 (March 1997).
- National Environmental Laboratory Accreditation Program (NELAP), 2003 Quality Standards.
- *Department of Defense Quality Systems Manual for Environmental Laboratories*, Final Version 3 (January 2006).

APPENDIX A

LIST of QA PROGRAM DOCUMENTS

and

STANDARD OPERATING PROCEDURES

Quality Assurance Manual	2/6/2009
Software Quality Assurance Plan	7/11/05
CAS-Kelso Certifications/Accreditations	Cert_kel.xls
Columbia Analytical Services MDL Tracking Spreadsheet	Mdl_list.xls
Technical Training Summary Database	TrainDat.mdb
Approved Signatories List	AppSignatories.pdf
Personnel resumes/qualifications	HR Department
Personnel Job Descriptions	HR Department
Quality Control Acceptance Criteria	Qclimits.xls
Master Logbook of Laboratory Logbooks	Masterlog-001
Standard Operating Procedure Database	TrainDat.mdb

ADMINISTRATIVE STANDARD OPERATING PROCEDURES

ADMINISTRATIVE - CORPORATE	FILE NAME
CHECKING NEW LOTS OF CHEMICALS FOR CONTAMINATION	ADM-CTMN
CONTROL LIMITS	ADM-CTRL_LIM
CORRECTIVE ACTION	ADM-CA
DATA RECALL	ADM-DATARECALL
HANDLING CUSTOMER FEEDBACK	ADM-FDBK
DETERMINATION OF METHOD DETECTION LIMITS AND LODS	ADM-MDL
DOCUMENT CONTROL	ADM-DOCCTRL
DOCUMENTATION OF TRAINING	ADM-TRANDOC
ELECTRONIC DATA AUDITING	ADM-E_DATAAUDIT
ESTIMATION OF UNCERTAINTY OF MEASUREMENTS	ADM-UNCERT
MAKING ENTRIES INTO LOGBOOKS AND ONTO BENCHSHEETS	ADM-DATANTRY
MANAGERIAL REVIEW OF THE LABORATORY'S QUALITY SYSTEM	ADM-MGMTRVW
MANUAL INTEGRATION OF CHROMATOGRAPHIC PEAKS	ADM-INT
PREPARATION OF ELECTRONIC DATA FOR ORGANIC ANALYSES ELECTRONIC DATA AUDITS	ADM-EDATA
PREPARATION OF STANDARD OPERATING PROCEDURES	ADM-SOP
PROFICIENCY TESTING SAMPLE ANALYSIS	ADM-PTS
PURCHASING THROUGH CAS PURCHASING DEPARTMENT IN KELSO	ADM-PUR
QUALIFICATION OF SUBCONTRACT LABORATORIES OUTSIDE OF CAS NETWORK	ADM-SUBLAB

SIGNIFICANT FIGURES	ADM-SIGFIG
CONFIRMATION of ORGANIC ANALYTE IDENTIFICATION and QUANTITATION	ADM-CONFIRM
PREVENTATIVE ACTION	ADM-PA

ADMINISTRATIVE – LOCAL LABORATORY	FILE NAME
CHECKING PIPETTE CALIBRATION	ADM-CPIP
CONTINGENCY PLAN FOR LABORATORY EQUIPMENT FAILURE	ADM-ECP
CONTROL CHARTING QUALITY CONTROL DATA	ADM-CHRT
DATA ARCHIVING	ADM-ARCH
DATA REPORTING AND REPORT GENERATION	ADM-RG
DEPARTMENT OF DEFENSE PROJECTS LABORATORY PRACTICES AND PROJECT MANAGEMENT	ADM-DOD
ELECTRONIC DATA BACKUP AND ARCHIVING	ADM-EBACKUP
INTERNAL QUALITY ASSURANCE AUDITS	ADM-IAUD
LABORATORY BALANCE MONITORING AND CALIBRATION	ADM-BAL
LABORATORY DATA REVIEW PROCESS	ADM-DREV
METHOD DETECTION LIMIT DOCUMENTATION AND CONTROL	ADM-MDLC
PROJECT MANAGEMENT	ADM-PCM
REAGENT LOGIN AND TRACKING	ADM-RLT
SUPPORT EQUIPMENT MONITORING AND CALIBRATION	ADM-SEMC
SAMPLE BATCHES	ADM-BATCH
SAMPLE MANAGEMENT SOPS	**FILE NAME**
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FOREIGN SOILS HANDLING TREATMENT	SMO-FSHT
SAMPLE DISPOSAL	SMO-SDIS
SAMPLE RECEIVING	SMO-GEN
SAMPLE TRACKING AND LABORATORY CHAIN OF CUSTODY	SMO-SCOC
TECHNICAL STANDARD OPERATING PROCEDURES	
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STANDARD OPERATING PROCEDURES TABLE OF CONTENTS

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COLIFORM, TOTAL	BIO-9221TC
COLIFORM, FECAL (MEMBRANE FILTER PROCEDURE)	BIO-9222D
COLILERT® and COLITAG	BIO-9223
FECAL STREPTOCOCCUS/ENTEROCOCCUS	BIO-9230B
COLILERT® COMPLETED TEST VERIFICATION OF E. COLI IN MUG CULTURES	BIO-CCT
ENTEROLERT	BIO-ENT
HEPTEROTROPHIC PLATE COUNT	BIO-HPC
MICROBIOLOGY QUALITY ASSURANCE AND QUALITY CONTROL	BIO-QAQC
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EPA CLP ORGANICS ANALYSES	CLP_ORGA
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CONTINUOUS LIQUID - LIQUID EXTRACTION	EXT-3520
SOLID PHASE EXTRACTION	EXT-3535
SOLID PHASE EXTRACTION - Method 3535A	EXT-3535A
SOXHLET EXTRACTION	EXT-3540
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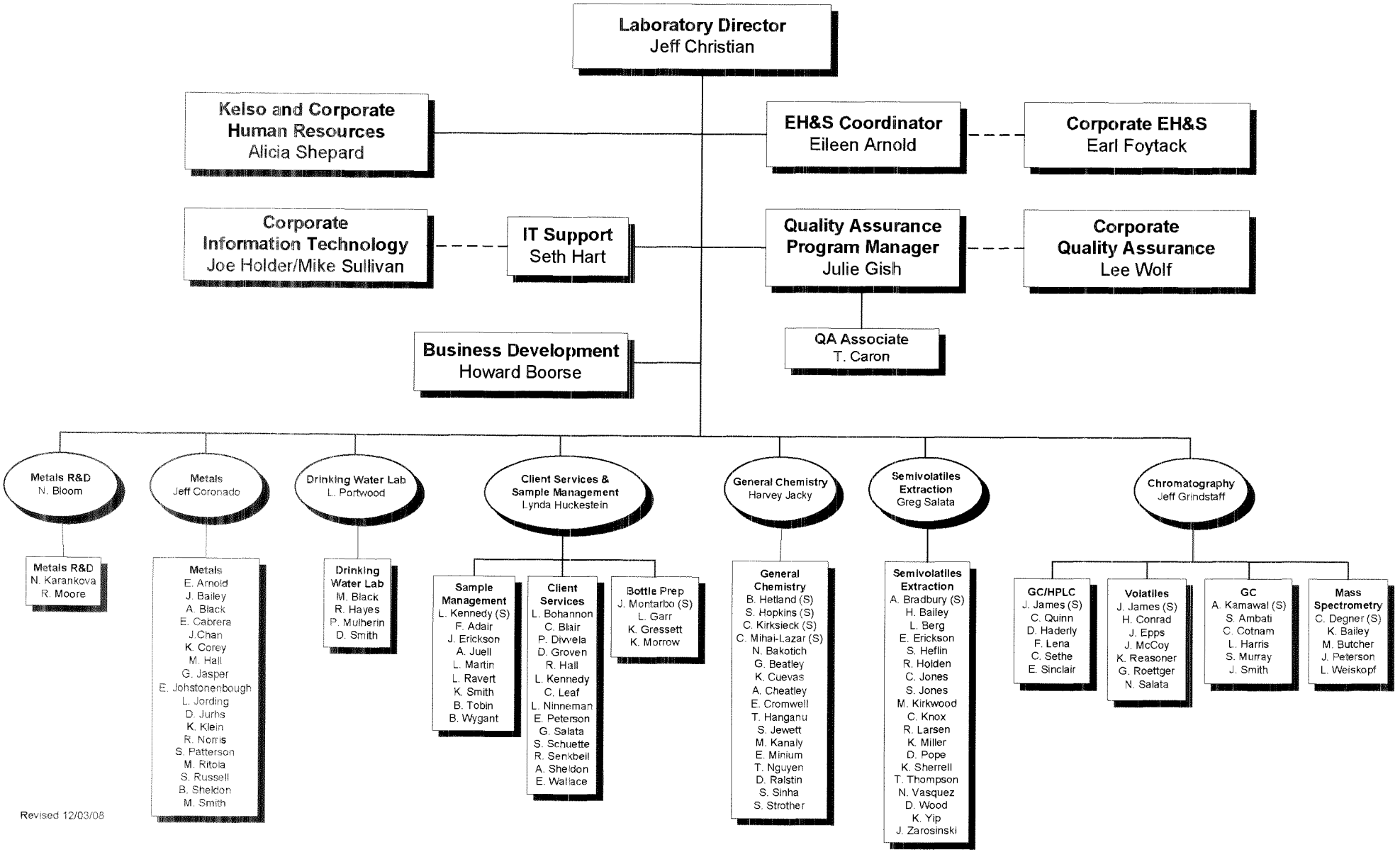
N-NITROSAMINES BY GC/MS/MS	SVD-521
SEMIVOLATILE ORGANIC COMPOUNDS BY GC/MS (METHOD 525.2)	SVD-525
SELECTED PESTICIDES AND FLAME RETARDANTS IN DRINKING WATER BY GC/MS (EPA METHOD 527)	SVD-527
DETERMINATION OF EXPLOSIVES AND RELATED COMPOUNDS IN DRINKING WATER BY GC/MS	SVD-529
CARBAMATES AND CARBAMOYLOXIMES IN WATER BY POST-COLUMN DERIVITIZATION HPLC	SVD-531 -1
GLYPHOSATE IN DRINKING WATER BY HPLC	SVD-547
ENDOTHALL IN DRINKING WATER BY GC/MS	SVD-548
DIQUAT AND PARAQUAT BY HPLC	SVD-549
HALOACETIC ACIDS IN DRINKING WATER	SVD-552
PURGE AND TRAP FOR AQUEOUS SAMPLES	VOC-5030
PURGE AND TRAP/EXTRACTION FOR VOC IN SOIL AND WASTE SAMPLES , CLOSED SYSTEM	VOC-5035
VOLATILE ORGANIC COMPOUNDS BY GC/MS	VOC-524.2
AROMATIC VOLATILE ORGANICS (BTEX) BY GC - METHOD 602	VOC-602BTEX
VOLATILE ORGANIC COMPOUNDS BY GC/MS	VOC-624
AROMATIC VOLATILE ORGANICS (BTEX) BY GC - METHOD 8021	VOC-8021BTEX
VOLATILE ORGANIC COMPOUNDS BY GC/MS	VOC-8260
VOLATILE ORGANIC COMPOUNDS BY GC/MS SELECTIVE ION MONITORING	VOC-8260S
VOA STORAGE BLANKS	VOC-BLAN
SAMPLE SCREENING FOR VOLATILE ORGANIC COMPOUNDS IN SOIL, WATER AND MISC. MATRICES	VOC-BVOC
WA-DOH DRINKING WATER PROTOCOL	VOC-WA.DOH
ZERO HEADSPACE EXTRACTION (EPA METHOD 1311)	VOC-ZHE

APPENDIX B

ORGANIZATIONAL CHARTS and RESUMES OF KEY PERSONNEL

Columbia Analytical Services

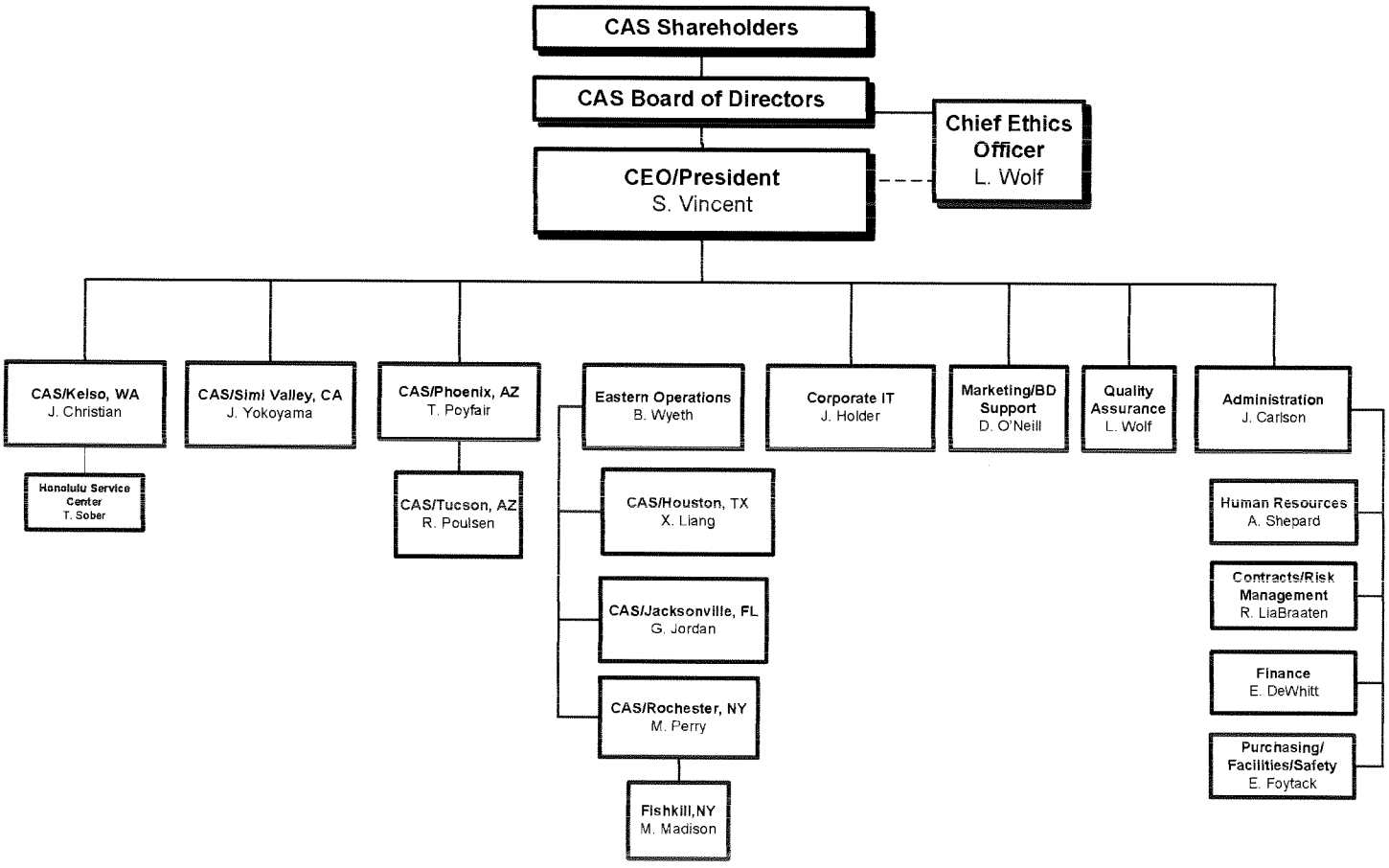
Environmental and General Testing Division
Kelso, Washington
Laboratory Organization



Revised 12/03/08

Columbia Analytical Services

Laboratory Division Organization



Revised 12/03/08

JEFFREY D. CHRISTIAN

1989 TO PRESENT

Columbia Analytical Services, Inc., 1317 S. 13th Avenue, Kelso, WA 98626 (360) 577-7222

Current Position

VICE PRESIDENT/NW REGIONAL DIRECTOR – 1996 to Present

Responsibilities

Responsible for all phases of laboratory operations at the Kelso (WA) and Redding (CA) facilities, including project planning, budgeting, and quality assurance. Primary duties include the direct management of the Kelso laboratory (i.e. serves as the Kelso Laboratory Director, 1993-present). Also responsible for additional duties acquired as a member of the Columbia Analytical Services Holdings, Inc., Board of Directors.

Experience

Laboratory Director, Kelso Laboratory, *Columbia Analytical Services, Inc., Kelso, Washington,* 1993-1995. Responsible for all phases of laboratory operations, including project planning, budgeting, and quality assurance.

Operations Manager, Kelso Laboratory, *Columbia Analytical Services, Inc., Kelso, Washington,* 1992-1993. Responsibilities included directing the daily operation of the Kelso laboratory. Other responsibilities and duties included functioning as a technical consultant to clients, providing assistance in developing and planning analytical schemes to match client objectives, and writing and developing analytical procedures/methods. Also, served as Project Manager for State of Alaska Department of Environmental Conservation contract and Coordinator for EPA Special Analytical Services (SAS) contracts.

Project Chemist and Manager, Metals Analysis Laboratory, *Columbia Analytical Services, Kelso, Washington,* 1989-1992. Responsible for directing the daily operation of the Metals Laboratory, including the sample preparation, AAS, ICP-OES, and ICP-MS Laboratories.

Scientist, *Weyerhaeuser Technology Center, Federal Way, Washington,* 1986-1989. Responsibilities included supervising atomic spectroscopy laboratory which included flame and furnace AAS, ICP-OES, and sample preparation capabilities to handle a wide variety of sample types. Interfaced with internal and external clients to provide technical support. Wrote and developed analytical procedures/methods.

Lead Technician, Metals Lab, *Weyerhaeuser Technology Center, Federal Way, Washington,* 1981-1986. Responsibilities included primary ICP and AAS analyst for EPA-CLP contract work. Extensive experience in wide variety of environmental and product-related testing.

Research Assistant, *ITT Rayonier, Olympic Research Division, Shelton, Washington,* 1978-1981. Responsibilities included performing water quality tests, product-related analytical tests, corrosion tests (i.e., potentiometric polarization techniques), and operated pilot equipment specific to the pulp and paper industry.

Education

B.S., Chemistry, *Evergreen State College, Olympia, Washington,* 1993.
ICP/MS Training Course, *VG-Elemental,* 1992.
Coursework, *Pacific Lutheran University, Tacoma, Washington.* 1988-1989.
Coursework, *Tacoma Community College, Tacoma, Washington.* 1970-1971, 1988-1989.
Perkin-Elmer Advanced Furnace, *Norwalk, Connecticut,* 1986.
CERTIFICATION, Chemistry, *L.H. Bates Technical, Tacoma, Washington,* 1978.
Coursework, *Central Washington University, Ellensburg, Washington.* 1969-1970.

Publications/ Presentations

On request.

JULIE GISH

1996 TO PRESENT

Columbia Analytical Services

Columbia Analytical Services, Inc., 1317 South 13th Ave., Kelso, WA 98626 360.577.7222

Current Position

TECHNICAL MANAGER I, KELSO LAB QUALITY ASSURANCE MANAGER – 2008 to Present

Responsibilities

Responsible for the overall implementation of the laboratory QA program. Responsible for the Quality Assurance Manual, certifications, documenting SOPs, and maintaining proficiency testing (PT) records. Oversee balance calibration and sample storage temperature control. Maintain certifications/accreditations for regulatory agencies and client certifications or approval programs. Act as primary point of contact during laboratory audits and provides audit responses and initiates any corrective actions. Coordinate the analysis and reporting of PT samples. Conduct internal audits and make recommendations for corrective action.

Experience

Scientist IV, Semi-Volatile Mass Spectrometry Laboratory, *Columbia Analytical Services, Inc., Kelso, Washington,* 2002-2008. Primary responsibilities were analysis, interpretation and report generation for semivolatile organics by GC/MS. Analyses included EPA 625, 8270, SIM, and other miscellaneous methodology.

Technical Manager I, Semi-Volatile GC Organics Laboratory, *Columbia Analytical Services, Inc., Kelso, Washington,* 1999-2002. Primary responsibilities include supervision and oversight of semi-volatile GC department. This includes initiating new methods, staff training, workload management, and instrument maintenance/troubleshooting. Duties include departmental compliance with CAS QA and Safety policies. Responsible for analysis, interpretation and report generation for pesticides and PCB's by EPA Methods 608, 8080, 8081, 8082, EPA 8141A, Organotins, and CLP Pesticides.

Scientist III, Semi-Volatile Organics Laboratory, *Columbia Analytical Services, Inc., Kelso, Washington,* 1996-1999. Primary responsibilities were analysis, interpretation and report generation for pesticides and PCB's by EPA Methods 608, 8080, 8081, 8082, and CLP-Pesticides. Secondary responsibilities include organics semi-volatile sample preparation.

Scientist, Volatile Organics Sample Preparation, *Employer's Overload, Longview, Washington – assigned to the Columbia Analytical Services, Inc., Kelso, Washington facility,* 1996. Primary duties included the preparation of water, soil, sediment and tissue samples using EPA Methods 3510, 3520, 3540, 3550, and 3545. Other duties were the further clean up of extracts using EPA Methods 3620 (Florsil), 3610 (Alumina), 3630 (Silica gel), 3650 (Acid/Base Partitioning), and 3660 (Sulfur).

Organics Chemist and GC/MS Chemist, *Coffey Laboratories, Portland, Oregon,* 1990-1996. Primary responsibilities included sample preparation and analysis for EPA FID, ECD, and HPLC using various EPA SW-846 and 500-series methods, as well as other methodology. Later, moved to GC/MS position which included sample preparation, analysis, and associated instrument maintenance for EPA Methods 625, 8027, and 525 BNA's. Also responsible for data review and approval of data packages.

QC Manager/QC Supervisor and Product Manager, Corn Products, *Frito-Lay, Inc., Vancouver, Washington,* 1982-1990. Manager of the QC department overseeing three supervisors and approximately 30 technicians. Responsible for department cost, accuracy, timeliness of data and safety performance. Later, responsible for production oversight of brand name snacks. Responsible for cost, quality and safety performance over three shifts. Managed four supervisors directly and approximately 60 employees indirectly.

Food Technologist, QA Department, *Kraft, Inc., Buena Park, California*, 1978-1981. Responsible for audits, formulations, finished product evaluation, batch reviews and technical support.

Education

MS, Food Science, Minor in Industrial Engineering, *Oregon State Univ. Corvallis, Oregon,* 1978.
BS, Food Science, Minor in Business Administration, *Utah State University, Logan, Utah,* 1975

Publications/ Presentations

Quality Improvement Team Leader, Coffey Laboratories, Portland, Oregon. 1991

Methods Improvement Program, Coffey Laboratories, Portland, Oregon. Seminars on Development and Implementation 1990.

Statistical Process Control and Total Quality Management, Frito-Lay, Vancouver, Washington. Routine Training Classes 1986-1988

LYNDA A. HUCKESTEIN

1989 TO PRESENT

Columbia Analytical Services, Inc., 1317 S. 13th Avenue, Kelso, WA 98626 (360) 577-7222

Current Position

CLIENT SERVICES MANAGER IV – 1998 to Present

Responsibilities

Management of the Client Services Departments: Project Management, Electronic Data Deliverables and Report Generation, and Sample Management. Personally responsible for approximately 1.5 million dollars of client work annually performing technical project management and client service. Provides technical and regulatory interpretation assistance as-well-as project organization to work received by the laboratory.

Documentation of Demonstration of Capabilities is available for review.

Experience

Project Chemist, *Columbia Analytical Service, Inc., Kelso, Washington,* 1992-1998. Primary responsibilities included technical project management and client service in areas of pulp & paper, marine services, mining, and DOD. Also responsible for providing technical and regulatory interpretation assistance as-well-as project organization to work received by the laboratory

Project Chemist and Department Manager, General Chemistry Laboratory, *Columbia Analytical Services, Inc.,* 1989-1992. Responsible for management of the General Chemistry laboratory for routine wastewater, bioassay, and microbiological analyses. Also responsible for supervision of staff, data review, and reporting.

Analyst III, *Columbia Analytical Services, Inc., Kelso, Washington,* 1989. Primary responsibilities included coliform testing, total recoverable petroleum hydrocarbon extractions and analysis, BODs, ammonias, and TKN, in addition to miscellaneous wet chemistry analyses.

Microbiologist/Chemist, *Coffey Laboratories, Portland, Oregon,* 1983. Coliform analysis; water chemistry.

Laboratory Assistant, *Oregon State University, Corvallis, Oregon,* 1983. Wheat spike dissection and tissue culture.

Education

BS, Microbiology, *Oregon State University, Corvallis, Oregon,* 1983.

JEFFREY A. CORONADO

1989 TO PRESENT

Columbia Analytical Services, Inc., 1317 S. 13th Avenue, Kelso, WA 98626 (360) 577-7222

Current Position

Responsibilities

TECHNICAL MANAGER IV, METALS DEPARTMENT MANAGER – 2001 to Present

Primary responsibilities include management of the Metals laboratory department. Responsible for training oversight, data review, report accuracy and timeliness QA/QC implementation, tracking department workload, and scheduling and performance of the Metals department. Also responsible for departmental budgets, method development efforts, and resource allocation.

Documentation of Demonstration of Capabilities is available for review.

Experience

Metals Department Manager, *Columbia Analytical Services, Inc., Kelso, Washington,* 1992-2001. Responsibilities included management of all aspects of the metal laboratory operation, including personnel training and evaluation, review of all metals data, and report generation. Also responsible for client service on a number of ongoing CAS accounts. Technical duties include primary analytical responsibility for trace level metals analysis by ICP/MS. Analyses range from routine water and soil analysis, to marine tissues, as well as industrial applications such as ultra-trace QA/QC work for various semiconductor clients. Also responsible for a number of specialized sample preparation techniques including trace metals in seawater by reductive precipitation, and arsenic and selenium speciation by ion-exchange chromatography. Developed methodology for performing mercury analysis at low part per trillion levels by cold vapor atomic fluorescence..

Supervisor, GFAA Laboratory, *Columbia Analytical Services, Inc., Kelso, Washington,* 1989-1992. Responsibilities included supervision of metals analysis by graphite furnace atomic absorption following SW-846 and EPA CLP methodologies. Duties include workload scheduling, data review, instrument maintenance, personnel training and evaluation.

Education

Field Immunoassay Training Course, *EnSys Inc.*, 1995.
Winter Conference on Plasma Spectrochemistry, *San Diego, California,* 1994.
ICP-MS Training Course, *VG-Elemental*, 1992.
BS, Chemistry, *Western Washington University, Bellingham, Washington,* 1988.
BA, Business Administration, *Western Washington University, Bellingham, Washington,* 1985.

JEFFREY A. GRINDSTAFF

1991 TO PRESENT

Columbia Analytical Services, Inc., 1317 S. 13th Avenue, Kelso, WA 98626 (360) 577-7222

Current Position

TECHNICAL MANAGER III, CHROMATOGRAPHY AND MASS SPECTROMETRY LABORATORIES – 1997 to Present

Responsibilities

Primary responsibilities include management of the GC/MS SemiVoa and VOA laboratory departments. Responsible for training oversight, data review, report accuracy and timeliness QA/QC implementation, tracking department workload, and scheduling and performance of the GC/MS departments. Also responsible for departmental budgets, method development efforts, and resource allocation. Also performs GC/MS maintenance and troubleshooting.

Documentation of Demonstration of Capabilities is available for review.

Experience

Manager, GC/MS VOA Laboratory, *Columbia Analytical Services, Inc., Kelso, Washington,* 1994-1997. Responsible for supervision of GC/MS VOA staff, method development, training, data review, tracking department workload, scheduling analyses, and general maintenance and troubleshooting of GC/MS systems.

Scientist III, GC/MS VOA Laboratory, *Columbia Analytical Services, Inc., Kelso, Washington,* 1991-1994. Responsibilities included scheduling workload, data review, instrument maintenance and troubleshooting, and personnel training and evaluation. Also responsible for supervision of extraction personnel and instrument analysts. Additional supervisory duties included report generation and data review for GC analyses. Responsibilities also included project management and customer service.

Chemist, *Enseco-CRL, Ventura, California,* 1990-1991. Established GC/MS department including inventory maintenance, preparation of state certification data packages, method development, SOPs, and extended data programs. Performed daily maintenance and troubleshooting of GC and GC/MS instrumentation. Scheduled and performed routine and non-routine VOA analyses.

GC/MS Chemist, VOA Laboratory *Coast-to-Coast Analytical Service, San Luis Obispo, California,* 1990-1991. Responsible for standard preparation for VOA analyses and instrument calibration, tuning, and maintenance. Also implemented and further developed EPA methods for quantitative analysis of pesticides and priority pollutants..

Education

Mass Selective Detector Maintenance, *Hewlett-Packard Education Center,* 1993.
Interpretation of Mass Spectra I, *Hewlett-Packard Analytical Education Center,* 1992.
B.S., Chemistry, *California Polytechnic State University, San Luis Obispo, California,* 1989.
A.A., Liberal Arts, *Allan Hancock College, Santa Maria, California.* 1986

Publications/ Presentations

Alternate Method to Lower Detection Limits to Satisfy Regulatory Action Levels for Volatiles in Groundwater, with David Edelman, Kairas Parvez, and Paul Laymon. TAPPI National Meeting, Orlando, Florida. 1996

Affiliations

American Chemical Society. 1989

HARVEY L. JACKY

1999TO PRESENT

Columbia Analytical Services™

Columbia Analytical Services, Inc., 1317 South 13th Ave., Kelso, WA 98626 360.577.7222

Current Position

TECHNICAL MANAGER II – 2008 to Present

Responsibilities

Oversee the operation of the General Chemistry and Microbiology groups. Responsible for the quality and timeliness of the inorganic laboratories analytical reports, departmental budgets, workload coordination, method development efforts, cost-effectiveness, and resource allocation.

Documentation of Demonstration of Capabilities is available for review.

Experience

Project Manager III, *Columbia Analytical Services, Inc., Kelso, WA*, 1999-2008. Responsible for technical project management, ensuring overall data quality and compliance with customer requirements, and providing technical support to clients regarding laboratory application to projects. Additionally, acts as a consultant to clients regarding industrial/environmental compliance issues; serving as liaison between clients and regulatory agencies.

Director of Project Management, *Coffey Laboratories, Portland, Oregon*, 1997-1999. Responsible for technical project management. Communicated with clients to determine needs and expectations. Monitored laboratory production and ensured the timely completion of analytical projects. Technical consultant for clients regarding environmental compliance. Supervised and managed other members of the project management team. Served as a member of the senior management team for oversight of general operations, strategic planning, finances, and policy.

Project Manager/Chemist, *Coffey Laboratories, Portland, Oregon*, 1997-1999. Served as primary liaison between Coffey Laboratories and major clients. Ensured that work was completed in a timely manner and done to client specifications. Served as technical consultant regarding environmental chemistry, soil remediation, and waste water industrial compliance. Clients included the Oregon Department of Transportation, Hazmat Unit, Portland, Oregon; Raythion Demilitarization Co., Umatilla, Oregon; Hydroblast - Wastewater Evaporator Systems, Vancouver, Washington; and Union Pacific Railroad, Northwest Region, Klamath Falls, Oregon.

Technical Sales Representative, *Coffey Laboratories, Portland, Oregon*, 1995-1997. Responsible for marketing and sales, including actively prospecting for new potential clients. Additional responsibilities included procurement and preparation of all major project bids; ensuring that client expectations were met; and maintaining customer satisfaction. Served as consultant regarding industrial compliance issues, environmental remediation projects, and hazardous waste management.

Senior Chemist/Laboratory Chemical Hygiene Officer, *Coffey Laboratories, Portland, Oregon*, 1988-1995. Performed analytical tests including Anions by Ion Chromatography (EPA 300.0), PAHs by HPLC (EPA 8310), Cyanides (EPA 335), and other inorganic, wet chemistry, and organic analytical tests on a wide variety of sample matrices. Responsible for the initial quality assurance review of work performed, supervised and managed personnel. Developed and implemented Laboratory Chemical Hygiene Plan. Directed personnel in regards to safety issues and hazardous waste management. Served as consultant and teacher regarding analytical methodology, environmental compliance, and industrial hygiene.

Education

40-Hour Hazmat Certification, *PBS Environmental*, 1996.
Industrial Emergency Response, *SFSP Seminar*, 1991
BS, Zoology, *Oregon State University, Corvallis, Oregon*, 1988.
BS, General Science, *Oregon State University, Corvallis, Oregon*, 1988.
COURSEWORK, General Studies, *Linfield College, McMinnville, Oregon*, 1981-1982.

Publications/ Presentations

Biochemical and Physical Factors Involved in the Application and Measurement of a Soil Bioremediation System. Biogeochemistry, Portland State University, 1996

LOREN E. PORTWOOD

1992 TO PRESENT

Columbia Analytical Services, Inc., 1317 S. 13th Avenue, Kelso, WA 98626 (360) 577-7222

Current Position

SCIENTIST IV, DRINKING WATER LABORATORY MANAGER– 2008 to Present

Responsibilities

Responsible for the overall operation and supervision of the Organic Drinking Water department, including oversight of UCMR2 analyses. Perform analyses and conduct data review. Perform method development. Work with project management of drinking water accounts. Development of Standard Operating Procedures for drinking water methods. Operation of Varian GC/MS, Agilent GC/ECD and Agilent HPLC.

Documentation of Demonstration of Capabilities is available for review.

Experience

Scientist IV, Drinking Water Laboratory, *Columbia Analytical Services, Inc., Kelso, Washington,* 2002-2008. Plan, conduct, and, as lead analyst, supervise analyses using advanced instrumentation such as HPLC with post column derivatization, GC/MS, and GC/ECD. Responsible for data interpretation, QC, and data reporting. Also responsible for preparation of SOPs; handling routine and advanced maintenance and troubleshooting of instrumentation; and assisting in the training of staff department analysts. Assists the department manager and/or other senior scientists in setting up more complex procedures.

Technical Manager I, Petroleum Hydrocarbon Laboratory Supervisor, Primary responsibilities included oversight of the PHC laboratory, including initiating new processes and staff development and training. Responsible for CAS QA compliance, routine system checks. Technical mentor to PHC staff. Also duties listed below under Scientist II and Scientist III.

Scientist III, Petroleum Hydrocarbon Laboratory, Columbia Analytical Services, Inc., Kelso, Washington, 1997-1998. Duties primarily as listed below.

Scientist II, Petroleum Hydrocarbon Laboratory, Columbia Analytical Services, Inc., Kelso, Washington, 1996-1997. Duties primarily as listed below, and including HPLC methods 8310, 8315, and 8330.

Scientist I, Petroleum Hydrocarbon Laboratory, Columbia Analytical Services, Inc., Kelso, Washington, 1993-1996. Primary responsibilities included the analysis, reporting, and archiving of water, soil, and product samples for semi-volatile petroleum hydrocarbons. Methods of analysis include EPA method 8015 and various state modifications thereof (OR, WA, CA, AK). Additional responsibilities include sample preparation, instrument maintenance, and assistance with other departmental analyses.

Bench Chemist I, Organic Extractions Laboratory, Columbia Analytical Services, Inc., Kelso, Washington, 1992-1993. Primary responsibilities included performing a wide range of organics extractions and cleanups for water, soil, and oil to be analyzed in the GC, GC/MS, and PHC laboratories.

Chemist, Treclen Laboratories, Spokane, Washington, 1990-1992. Primary responsibilities included inorganic water and soil testing by EPA methods. Developed testing which was accredited by the EPA, including metal digestions, phosphates, and TSS/ TDS.

Education

BS, Chemistry, Emphasis in Biochemistry, *Whitworth College, Spokane, Washington,* 1990.
Several vendor chromatography, GC, HPLC, and Quality training courses, 1993-2002.

EILEEN M. ARNOLD

1987 TO PRESENT

Columbia Analytical Services, Inc., 1317 S. 13th Avenue, Kelso, WA 98626 (360) 577-7222

Current Position

SCIENTIST IV, METALS LABORATORY, KELSO HEALTH AND SAFTEY OFFICER – 1994 to Present

Responsibilities

Duties include the operation and maintenance of the Inductively Coupled Argon Plasma (ICAP) Emission Spectrometer. This involves digestion, instrumental analysis, and report generation for environmental samples using approved EPA techniques. Health and Safety Officer responsibilities included development and implementation of the Kelso Health and Safety program, including accident investigation and incident review, maintenance of all safety related equipment and documents, and performance of monthly safety audits.

Documentation of Demonstration of Capabilities is available for review.

Experience

Project Chemist, Client Services Group, Kelso Health and Safety Officer, *Columbia Analytical Services, Inc., Kelso, Washington,* 1992-1994. Duties included technical project management and customer service. Responsible for meeting the clients' needs of timely and appropriate analyses, and to act as liaison for all client-related activities within Columbia Analytical Services, Inc. Health and Safety Officer responsibilities included development and implementation of the Kelso Health and Safety program, including accident investigation and incident review, maintenance of all safety related equipment and documents, and performance of monthly safety audits.

Scientist IV, Metals Laboratory, Health and Safety Officer, *Columbia Analytical Services, Inc., Kelso, Washington, 1987-1992.* Duties include the operation and maintenance of the Inductively Coupled Argon Plasma (ICAP) Emission Spectrometer. This involves digestion, instrumental analysis, and report generation for environmental samples using approved EPA techniques. Health and Safety Officer responsibilities included development and implementation of the Kelso Health and Safety program, including accident investigation and incident review, maintenance of all safety related equipment and documents, and performance of monthly safety audits.

Chemist, *Dow Corning Corporation, Springfield, Oregon,* 1986-1987. Responsibilities included ICP and atomic absorption work in silicon manufacturing. Methods development for ICP analysis of minor impurities found in silicon.

Chemist, *Ametek, Inc., Harleysville, Pennsylvania,* 1982-1985. Responsibilities included product research and development chemist involved in production of thin-film semiconductors for use as solar cells. Work involved AA and SEM techniques.

Chemist, *Janbridge, Inc., Philadelphia, Pennsylvania,* 1978-1982. Responsibilities included maintaining electroplating process lines through wet chemical analysis techniques, and performed Quality Assurance testing on printed circuit boards.

Education

BA, Chemistry, *Immaculata College, Immaculata, Pennsylvania,* 1977.

Affiliations

American Chemical Society, Member since 1987.

GREGORY G. SALATA

2003 TO PRESENT

Columbia Analytical Services™

Columbia Analytical Services, Inc., 1317 South 13th Ave., Kelso, WA 98626 360.577.7222

Current Position	**PROJECT/EXTRACTIONS MANAGER V** – 2003 to Present
Responsibilities	Responsibilities include Project Management, including quotation preparation and data reporting, as well as providing technical support to the laboratory as needed. Responsibilities also include oversight of the organic extractions lab, managing resources and providing technical support for all organic preparation work flows. 2003-Present.
Experience	**Project Manager,** *B&B Laboratories, College Station, Texas,* 1999-2003. Supervisor/responsible for analysis of TPH (waters, tissues, sediments), organotins (waters, tissues, sediments), Atterberg Limits (sediments), and total organic/inorganic carbon (sediments, waters). Also responsible for report generation on specific projects. Instrumentation operated included GCs with FID and FPD detectors, Combustion TOC, Water TOC, and Dionex Accelerated Solvent Extractor. **Graduate Student,** *Texas A&M University, College Station, Texas,* 1991-1999. While working toward MS in Oceanography, performed organic extractions for pesticides, PCBs, PAHs, and butyltins. While working toward Ph.D. in Oceanography determined stable carbon isotope ratios in sediments, waters, and bacterial phospholipid fatty acids. Other responsibilities included field sample collection, and operation/maintenance of FinniganMAT 252 isotope ratio MS. **Analytical Chemist,** *Science Applications International (SAIC), San Diego, California,* 1989-1990. Performed organic extraction and GC/FID analysis on sediment/rock samples for the Exxon Valdez oil spill. **GC Chemist,** *Analytical Technologies, San Diego, California,* 1987-1989. Responsible for analysis of volatile organics using purge and trap and GC/PID/ELCD.
Education	**Ph.D., Oceanography,** *Texas A&M University, College Station, Texas.* 1999 **MS, Oceanography,** *Texas A&M University, College Station, Texas.* 1993 **BA, Chemistry,** *University of California San Diego, Revelle College, La Jolla, California.* 1987
Publications/ Presentations	*Dr. Salata has a number of publications and published abstracts. For a list of these publications and published abstracts, please contact CAS.*
Affliations	American Chemical Society

LEE E. WOLF

1988 TO PRESENT

Columbia Analytical Services, Inc., 1317 South 13th Ave., Kelso, WA 98626 360.577.7222

Current Position

QUALITY ASSURANCE DIRECTOR AND CHIEF QUALITY OFFICER – 2008 to Present

Responsibilities

Directing the overall corporate-wide quality systems and ethics programs for all CAS facilities. Responsible for ensuring that CAS quality systems and data integrity standards are implemented at all facilities. Act as liaison with government entities involving quality, technical and operational issues. Provide QA input and policy as needed for operations, development initiatives, special projects, planning, and information technology implementation. Provide assistance to QA Program Managers.

Experience

Technical Manager IV, Quality Assurance Program Manager, *Columbia Analytical Services, Inc., Kelso, Washington* – 2002 to 2008. As part of the management team, responsibilities included the overall management and implementation of the laboratory QA program. This included maintaining accreditations and certifications, and maintaining all necessary documents (QA Manual, SOPs, and QA records). Acted as primary point of contact during laboratory audits and provided audit responses and corrective actions. Coordinated performance audits (PE/PT testing) and conducted internal audits.

Scientist IV, Quality Assurance Program Manager, *Columbia Analytical Services, Inc., Kelso, Washington,* 1996-2002. Duties primarily as listed above.

Project Chemist/Principal Organic Scientist, *Columbia Analytical Services, Inc., Kelso, Washington,* 1994-1996. Responsibilities included GC and GC/MS method development and special projects coordination. Acts as technical advisor to the GC and GC/MS laboratories and GC/MS interpretation specialist and CLP organics specialist. Also responsible for Project Chemist functions, including management of projects for clients, identifying client needs, and preparation of data reports.

Semivolatile Organics Department Manager, *Columbia Analytical Services*, 1988-1994. Responsibilities included overall management of the department. Supervised GC/MS analyses, data review, reporting and related QA/QC functions. Responsible for supervision of staff, training, and scheduling. Beginning in 1992, responsibilities included being a Project Chemist for organics EPA-SAS and other clients. This involved scheduling projects for clients, identifying client requirements, and preparing data reports.

GC/MS Chemist, *U.S. Testing Co., Richland, Washington*, 1985-1988. Responsibilities included GC and GC/MS analysis of water and soil samples for volatiles and semivolatiles by EPA protocol, including Methods 8240, 8270 and CLP. Coordinated extraction and GC-GC/MS areas to manage sample/data flow through the lab. Also performed HPLC analysis and pesticide analysis by GC using EPA Methods.

Laboratory Assistant, *Eastern Washington University, Cheney, Washington,* 1985. Responsibilities included supervision and instruction of organic chemistry labs. Experience with GC and IR operation. Responsible for lab safety.

Education

Pharmaceutical Laboratory Control Systems, *Univ. of Wisconsin Short Course, Las Vegas,* 2004
Test Method Validation in Pharmaceutical Development and Production, *Univ. of Wisconsin Short Course, Las Vegas,* 2004
Documenting Your Quality System, *A2LA Short Course, Las Vegas, Nevada*, 1998.
Internal Laboratory Audits, *A2LA Short Course, Las Vegas, Nevada,* 1998.
Mass Spectra Interpretation, *ACS Short Course, Denver, Colorado*, 1992.
BS, Chemistry, *Eastern Washington University, Cheney, Washington,* 1985.

Publications/ Presentations

Selected Ion Monitoring: Issues for Method Development, Panel Discussion, Association of Official Analytical Chemists, (AOAC) Pacific Northwest Regional Meeting, 1995.

Method Enhancement Techniques for Achieving Low level Detection of Butyl Tin in Marine Sediments and Tissues, Association of Official Analytical Chemists (AOAC) Pacific Northwest Regional Meeting, 1994.

The Determination of Low-Level Concentrations of Polynuclear Aromatic Hydrocarbons (PAHs) in Soil and Water Using Gas Chromatography/Mass Spectroscopy Selected Ion Monitoring (GC/MS SIM), HazMat West, Long Beach, California, 1992.

STEPHEN W. VINCENT

1986 TO PRESENT

Columbia Analytical Services, Inc., 1317 S. 13th Avenue, Kelso, WA 98626 (360) 577-7222

Current Position Responsibilities

PRESIDENT, CAS HOLDINGS INC. – 1986 to Present

Responsible for the overall growth and profitability of the CAS laboratory network. This includes establishing and implementing long-range objectives, plans, and policies, and representing the company with its major customers, technical community, and the public.

Experience

Laboratory Manager, *Weyerhaeuser Company, Federal Way, Washington,* 1979-1986. Responsibilities involved all phases of technical and administrative management. This included management of organic, inorganic, and microbiological analyses and management of capital; an annual operating budget of approximately $2 million; management of thirty staff members; contract procurement, and project management. Projects included an EPA Inorganic CLP contract; an EPA acid rain deposition contract; a contract with the Fish and Wildlife Service to measure trace organic contaminants in animal tissues; and others.

Analytical Chemist, *Weyerhaeuser Company, Longview, Washington,* 1975-1979. Responsibilities: Method development, routine analysis and supervision for the Weyerhaeuser Multi-Region Support Lab. Responsible for setting up a company-wide laboratory audit, round robin, and quality assurance program.

Education

Market Strategy for Technology Based Companies, *Executives Program, Stanford University.* 1994.

Advanced Technical Management Program, *University of California at Los Angeles, Department of Business, Engineering and Management,* 1991.

Completion of Coursework for MS, Pulp and Paper Technology, *University of Washington, Seattle, Washington,* 1984.

Post Graduate Coursework, Engineering and Management, *University of California at Los Angeles, Graduate School of Engineering and Applied Science, Los Angeles, California,* 1981.

BS, Oceanography, *University of Washington, Seattle, Washington,* 1974.

Publications/ Presentations

Mr. Vincent has a number of publications and presentations. For a list of these publications and presentations, please contact CAS.

Affiliations

American Chemical Society.
Technical Association of the Pulp and Paper Industry.

APPENDIX C

MAJOR ANALYTICAL EQUIPMENT

GENERAL CHEMISTRY/WATER CHEMISTRY LABORATORY			
Equipment Description	**Year Acquired**	**Manufacturer or Laboratory Maintained (MM/LM)**	**# of Trained Operators**
Analytical Balances (10):			
Precisa and Mettler models	1988-2008	MM	15
Autoclave - Market Forge Sterilmatic	1988	LM	5
Autotitrator – Thermo Orion 500	2007	LM	3
Calorimeters (2):			
Parr 1241 EA Adiabatic	1987	LM	4
Parr 6300 Isoparabolic	2005	LM	4
Centrifuge - Damon/IEC Model K	1992	LM	15
Colony Counter - Quebec Darkfield	1988	LM	4
Conductivity Meters (2):			
YSI Model 3200	2004	LM	4
VWR	2001	LM	4
Digestion Systems (5):			
COD (4)	1987, 1989	LM	5
Kjeldahl, Lachat 46-place (1)	1999	LM	3
Dissolved Oxygen Meter - YSI Model 58 (3)	1987, 1988, 1991	LM	5
Distillation apparatus (Midi) - Easy Still (2)	1996, 2000	LM	7
Drying Ovens (11):			
Shel-Lab and VWR models	1988 - 2003	LM	15
Flash Point Testers (2):			
ERDCO Setaflash Tester	1991	LM	4
Petroleum Systems Services	2005	LM	4
Flow-Injection Analyzers (2):			
Bran-Leubbe	2002	LM	4
Lachat 8500	2007	LM	4
Ion Chromatographs (4)			
Dionex 2000i with Peaknet Data Systems	1988	LM	3
Dionex DX-120 with Peaknet Data System	1998	LM	3
Dionex ICS-2500 with Chromchem Data System	2002	LM	3
Dionex ICS-2000 with Chromchem Data System	2006	LM	3
Ion Selective Electrode Meters (5)			
Fisher Scientific Accument Model 50	1997	LM	6
Fisher Scientific Accument Model 25	1993	LM	6
Fisher Scientific Accument Model 20	2000	LM	6
Orion Model 920A	1990	LM	6
Corning pH/ion Meter Model 135	1992	LM	6
Microscope - Olympus	1988	LM	1
Muffle Furnace- Sybron Thermolyne Model F-A1730	1991	LM	15
pH Meters (2):			
Fisher Scientific Accument Model 20	1993	LM	6
Fisher Scientific Accument Model AR25	2005	LM	6

GENERAL CHEMISTRY/WATER CHEMISTRY LABORATORY (continued)			
Equipment Description	**Year Acquired**	**Manufacturer or Laboratory Maintained (MM/LM)**	**# of Trained Operators**
Shatter Box - GP 1000	1989	LM	5
Sieve Shakers (2):			
CE Tyler - Portable RX 24	1990	LM	5
WS Tyler - RX 86	1991	LM	5
Thomas-Wiley Laboratory Mill, Model 4	1989	LM	7
Total Organic Carbon (TOC) Analyzers (2)			
Coulemetrics Model 5012	1997	LM	3
O-I Corporation Model 1010	2002	LM	3
Total Organic Halogen (TOX) Analyzers (3):			
Mitsubishi TOX-Sigma	1995	LM	4
Mitsubishi TOX-100 (2)	2001	LM	4
Turbidimeter - Hach Model 2100N	1996	LM	8
UV-Visible Spectrophotometers (3):			
Hitachi 100-40 Single Beam	1986	LM	5
Beckman-Coulter DU520	2005	LM	5
Perkin Elmer Lambda 25	2008	LM	5
Vacuum Pumps (2):			
Welch Duo-Seal Model 1376	1990	LM	13
Busch R-5 Series Single Stage	1991	LM	13
Water Baths/Incubators (6):			
Hach Model 15320 Incubator	1986	LM	15
Precision Model L-6 (2)	1989, 1990	LM	15
VWR 1540	1991	LM	15
Fisher 11-680-626M Incubator	1992	LM	15
Fisher Isotemp Incubator	2001	LM	15

METALS LABORATORY			
Equipment Description	**Year Acquired**	**Manufacturer or Laboratory Maintained (MM/LM)**	**# of Trained Operators**
Analytical Balance (6)			
Mettler AE 200 analytical balance	1990	MM	12
Various Mettler, Sartorius, and Ohaus models (5)	1988	MM	12
Atomic Absorption Spectrophotometers (5):			
Varian SpectrAA Zeeman/220 AA w/Data Systems (2)	2000	LM	3
CETAC Mercury Analyzer	2000	LM	2
Perkin Elmer AAnalyst 200 Flame AA	2005	MM	2
Atomic Fluorescence Spectrophotometer			
Brooks-Rand Model III (2)	1996, 2005	LM	3
Leeman Mercury Analyzer (1)	2006	LM	2
Centrifuge - IEC Model Clinical Centrifuge	1990	LM	12
Drying Oven - VWR Model 1370F	1990	LM	12
Freeze Dryers (2) - Labconco	1992, 2006	LM	5
Inductively Coupled Plasma Atomic Emission Spectrometer (ICP-AES) (3)			
Thermo Jarrell Ash Model 61E	1988	LM	4
Thermo Jarrell Ash, Model IRIS	2000	MM	4
Thermo Scientific Model iCAP 6500	2007	MM	3
Inductively Coupled Plasma Mass Spectrometers (ICP-MS):			
VG Excell	2001	MM	3
Thermo X-Series	2006	MM	2
Muffle Furnace - Thermolyne Furnatrol Model 53600 (2)	1991, 2005	LM	5
Shaker - Burrell Wrist Action Model 75	1990	LM	12
TCLP Extractors (3)	1989, 2002	LM	5

SEMIVOLATILE ORGANICS SAMPLE PREPARATION LABORATORY			
Equipment Description	**Year Acquired**	**Manufacturer or Laboratory Maintained (MM/LM)**	**# of Trained Operators**
Analytical Balance (4)			
Mettler PM480, AE166, BB300	1999 - 2005	MM	18
OHaus EP613	2006	MM	18
Centrifuge - Sorvall Model GLC-1	1988	LM	18
Drying Ovens (2)			
Fisher Model 655G	1991	LM	18
VWR Model 1305U	1999	LM	18
Evaporators (14):			
Organomation N-Evap (7)	1989-98, 2001, 2006	LM	18
Organomation S-Evap (7)	1989-1991, 2006	LM	18
Extractor Heaters: Lab-Line Multi-Unit Models for Continuous Liquid-Liquid and Soxhlet Extractions (102)	1987-1992, 2007	LM	12
Extractors (52):			
Branson Model 450 Sonifier (2)	1991	LM	6
Tekmar Sonicator	1994	LM	6
Fisher Scientific Sonicator	1994	LM	6
Soxhtherm (48)	2000, 2008	LM	8
Extractors, TCLP (10):			
Millipore TCLP Zero Headspace Extractors (10)	1987-1992	LM	2
TCLP Extractor - Tumbler (12 position)	1989	LM	2
Gel Permeation Chromatography (GPC) (5)			
ABC single column (3)	1998, 1999, 2007	LM	4
ABC Autoprep 1000	1995	LM	4
J2 Scientific	2005	LM	4
Muffle Furnace - 4	1994-2006	LM	4
Solid Phase Extractors (8) – Horizon SPE-Dex 4790	2003, 2006	LM	4
Ultrasonic Water Bath – VWR 550D	2007	LM	18
Vacuum Pump – Edwards	1992	LM	8

GC SEMIVOLATILE ORGANICS INSTRUMENT LABORATORY			
Equipment Description	**Year Acquired**	**Manufacturer or Laboratory Maintained (MM/LM)**	**# of Trained Operators**
Analytical Balance - Mettler AT 250	1989	MM	7
Chromatography Data Systems (12)			7
HP Enviroquant (8)	1994-2002	LM	
Thruput Target (4)	1998-2000	LM	
Gas Chromatographs (11):			
Hewlett-Packard 5890 GC with HP 7673 Autosampler and Dual ECD Detectors (4)	1990 – 1995	LM	7
Hewlett-Packard 5890 GC with HP 7673 Autosampler and Dual FPD Detectors	1991	LM	7
Agilent 6890 GC with Agilent 7683 Autosampler and Dual ECD Detectors (5)	2001, 2005, 2007	LM	7
Agilent 6890 GC with Agilent 7683 Autosampler and Dual FPD Detectors	2003	LM	7
Agilent 7890A Dual ECD Detectors Agilent 7683B autosampler	2008	LM	7

GC/MS SEMIVOLATILE ORGANICS INSTRUMENT LABORATORY			
Equipment Description	**Year Acquired**	**Manufacturer or Laboratory Maintained (MM/LM)**	**# of Trained Operators**
Accelerated Solvent Extractor - Dionex ASE 200	1996	LM	5
HP Enviroquant Chromatography Data Systems (9)	1994-2002	LM	5
Gas Chromatograph: Hewlett-Packard 5890 with HP 7673 autosampler and FID Detector	1994	LM	5
Semivolatile GC/MS Systems (9):			
Agilent 6890/5973 with ATAS Optic2 LVI and HP 7673 Autosampler (2)	1997, 2001	LM	5
Agilent 5890/5970 and HP 7673 Autosampler	1990	LM	5
Agilent 5890/5970 with ATAS Optic2 LVI and HP 7673 Autosampler	1994	LM	5
Agilent 5890/5972 with ATAS Optic2 LVI and HP 7673 Autosampler (3)	1993, 1994, 1998	LM	5
Agilent 6890/5973 with ATAS Optic3 LVI and 7683 Autosampler	2004	LM	
Agilent 6890/5973 with Agilent PTV Injector and 7683 Autosampler	2007	LM	4
Semivolatile GC/MS/MS – Waters Quattro Micro GC Micromass with Agilent 6890, Agilent PTV Injector, 7683B Autosampler	2008	MM	1

PETROLEUM HYDROCARBONS GC/HPLC LABORATORY			
Equipment Description	**Year Acquired**	**Manufacturer or Laboratory Maintained (MM/LM)**	**# of Trained Operators**
Analytical Balance - Mettler BB240	1994	MM	6
Aspirator pump – GAST	2004	LM	6
Drying Oven - Fisher Model 630F	1991	LM	6
Evaporator - Organomation N-Evap	1990	LM	6
HP Enviroquant Chromatography Data Systems (8)	1994-2002	LM	6
Gas Chromatographs (6):			
Hewlett-Packard 5890 Series II with PID/PID/FID(2)	1991	LM	4
EST-ENCON Purge and Trap Concentrator	1991	LM	4
Dynatech Archon 5100 Autosampler	1992	LM	4
Hewlett-Packard 5890 GC with HP 7673 Autosampler and FID Detector	1995	LM	4
Agilent 6890 with Dual FID Detectors and Agilent 7873 Autosampler (3)	2001, 2005	LM	4
High-Performance Liquid Chromatographs (2):			
HP 1090M Series II with Diode Array UV Detector	1999	LM	4
HP 1050/1100 Series with Fluorescence & Diode Array UV Detectors	2004	LM	4
High-Performance Liquid Chromatograph/Mass(2) Spectrometer - Thermo Electron TSQ Quantum LC/MS/MS and Autosampler	2005	MM	2
API 5000 LC/MS/MS and SIL-20AC Autosampler	2008	MM	2

VOLATILE ORGANICS LABORATORY			
Equipment Description	**Year Acquired**	**Manufacturer or Laboratory Maintained (MM/LM)**	**# of Trained Operators**
Analytical Balance - Mettler PE 160	1989	MM	5
Fisher Vortex Mixer	1989	LM	5
HP Enviroquant Chromatography Data Systems (10)	1994-2002	LM	5
Drying Ovens (2):			
Narco 420	1989	LM	5
VWR 1305 U	1991	LM	5
Sonic Water Bath - Branson Model 2200	1989	LM	5
Volatile GC/MS Systems (7):			
Agilent 5890/5970	1989	LM	5
Tekmar 3000 Purge and Trap Concentrator	1995	LM	5
Dynatech ARCHON 5100 Autosampler	1996	LM	5
Agilent 5890/5971	1991	LM	5
Tekmar 3000 Purge and Trap Concentrator	2001	LM	5
Dynatech ARCHON 5100 Autosampler	1995	LM	5
Agilent 5890/5972A	1993	LM	5
Tekmar 3000 Purge and Trap Concentrator	1995	LM	5
Dynatech ARCHON 5100 Autosampler	1996	LM	5
Agilent 6890/5973	2001	LM	5
Tekmar 3100 Purge and Trap Concentrator	2001	LM	5
Varian Archon Autosampler	2001	LM	5
Agilent 6890/5973	2005	LM	5
Tekmar Velocity Purge and Trap Concentrator	2005	LM	5
Tekmar Aquatech Autosampler	2005	LM	5
Agilent 6890/5973 (2)	2007	LM	5
Tekmar 3000 Purge and Trap Concentrator	2007	LM	5
Varian Archon 5100 Autosampler	2007	LM	5

DRINKING WATER ORGANICS LABORATORY			
Equipment Description	**Year Acquired**	**Manufacturer or Laboratory Maintained (MM/LM)**	**# of Trained Operators**
Analytical Balance - Mettler BB300	1991	MM	2
Extractors (10) – Horizon SPE-DEX Solid Phase Extractor	2003/2008	LM	2
Aglinet Enviroquant Chromatography Data Systems (2)	2003	LM	2
Varian Saturn Chromatography Data System	2003	LM	2
Evaporator - Organomation N-Evap	2003	LM	2
Agilent 1100 HPLC w/post-column derivitization:	2003	LM	2
UV/Fluoescence detectors	2003	LM	2
Pickering PCX-5200 Post-column derivitization unit	2003	LM	2
Agilent 6890N GC/Dual ECD system w/ autosamplers	2003	LM	2
Agilent 7890 GC/Dual ECD w/autosamplers	2008	LM	2
Varian Ion trap GC/MS:	2003	LM	2
Varian 3800 GC w/CP8400 autosampler	2006	LM	2
Varian Saturn 2100T mass spectrometer	2003	LM	2
Thremo Ion Trap GC/MS w/TriPlus autosampler	2008	LM	2

Metals Method Development Laboratory			
Equipment Description	**Year Acquired**	**Manufacturer or Laboratory Maintained (MM/LM)**	**# of Trained Operators**
Perkin-Elmer ICP/MS Elan 9000 w/ Perkin-Elmer AS-93+ Autosampler	2008	LM	2
Perkin-Elmer Series 200 IC	2008	LM	2
Brooks Rand III Atomic Fluoresence Spectrophotometer - 2	2008	LM	2
Oriel Atomic Fluoresence Spectrophotometer – Lab Designed	2008	LM	2
Balances - 4	2008	LM	2
Ovens - 2	2008	LM	2
Buck AA Spectrophotometer Model 205	2008	LM	2
Forma Scientific Bio Freezer	2008	LM	2
Digital Shaker SK-71	2008	LM	2

AUTOMATED DATA PROCESSING EQUIPMENT			
Equipment Description	**Year Acquired**	**Manufacturer or Laboratory Maintained (MM/LM)**	**# of Trained Operators**
1-WAN: LIMS Sample Manager using Oracle 10g DBMS running on Redhat Advanced Server 3.0 (Linux) platform connected/linked on a frame relay WAN environment	1994-2004	LM	NA
1 - Network Server Pentium 4 class, 1 for Reporting and Data Acquisition running Windows 2003 Advanced Server, 1 for Applications running Windows 2003 Advanced Server. Data acquisition capacity at 65GB with redundant tape and disk arrays.	2004	LM	NA
Approximately 50+ HP and Dell Laserjet printers (various types including models III, 4, 5, 8150, 4000, 4050, 4250, 8150, 1720dn, W5300)	1991 - 2007	LM	NA
Approximately 180 Gateway/Dell PC/Workstations running Windows 2000/XP on LAN connected via 10BT/100BT and TCP/IP for LIMs Terminal Emulation	1993 - 2004	LM	NA
Microsoft Office 2003 Professional as the base application for all PC/Workstations. Some systems using Office 2000/97.	1996 - 2004	LM	NA
E-Mail with link to SMTP for internal/external messaging. Web mail via Outlook Web Access interface. Microsoft Outlook 2003.	1994 - 2006	LM	NA
Standard Excel (R) reporting platform application linked to LAN/WAN for data connectivity and EDD generation.	1996 - 2004	LM	NA
Standard Excel (R) reporting platform application linked to LAN/WAN for data connectivity and EDD generation.	1996 - 2004	LM	NA
Facsimile Machines - Brother 4750e (2); Brother SuperG3 (1); Canon CFX-L4000 (1)	1991 - 2007	LM	NA
Copiers/Scanners: Konica BizHub 420 (1), BizHub 600 (1), BizHub 920 (2), BizHub Pro 1050 (3). The 920s and 1050s are accessible via LAN for network scanning.	2000 - 2007	LM	NA
Dot Matrix Epson FX-880, LQ-1050, LX-300	1991 - 2004	LM	NA
Thruput, MARRS, Stealth, Harold, Blackbird, EDDGE, StarLIMS reporting software systems.	1998 - 2004	LM	NA

NA: Not applicable. This equipment administered by IT staff but may be used by all staff.

APPENDIX D

PREVENTIVE MAINTENANCE PROCEDURES

Instrument	Activity	Frequency
Refrigerators and Coolers	Record temperatures	Daily
	Clean coils	Annually
	Check coolant	Annually or if temperature outside limits
Vacuum Pumps	Clean and change pump oil	Every month or as needed
Fume Hoods	Face velocity measured	Quarterly
	Sash operation	As needed
	Change filters	Annually
	Inspect fan belts	Annually
Ovens	Clean	As needed or if temperature outside lim.
	Record temperatures	Daily, when in use
Incubators	Record temperatures	Daily, morning and evening
Water Baths	Record temperatures	Daily, morning and evening
	Wash with disinfectant solution	When water is murky, dirty, or growth appears
Autoclave	Check sterility	Every month
	Check temperature	Every month
	Clean	When mold or growth appears
Analytical Balances	Check alignment	Before every use
	Check calibration	Daily
	Clean pans and compartment	After every use
Dissolved Oxygen Meter	Change membrane	When fluctuations occur
pH probes	Condition probe	When fluctuations occur
Fluoride ISE	Store in storage solution	Between uses
Ammonia ISE	Store in storage solution	Between uses
UV-visible Spectrophotometer	Wavelength check	Annually
Total Organic Carbon Analyzers	Check IR zero	Weekly
	Check digestion/condensation vessels	Each use
	Clean digestion chamber	Every 2000 hours, or as needed
	Clean permeation tube	Every 2000 hours, or as needed
	Clean six-port valves	Every 200 - 2000 hours, or as needed
	Clean sample pump	Every 200 - 2000 hours, or as needed
	Clean carbon scrubber	Every 200 - 2000 hours, or as needed
	Clean IR cell	Every 2000 - 4000 hours, or as needed

Instrument	Activity	Frequency
Total Organic Halogen Analyzers	Change cell electrolyte	Daily
	Change electrode fluids	Daily
	Change pyrolysis tube	As needed
	Change inlet and outlet tubes	As needed
	Change electrodes	As needed
Flow Injection Analyzer	Check valve flares	Each use
	Check valve ports	Each use
	Check pump tubing	Each use
	Check light counts	Each use
	Check flow cell flares	Quarterly
	Change bulb	As needed
	Check manifold tubing	Each use
	Check T's and connectors	Each use
Ion Chromatographs	Change column	Every six months or as needed
	Change valve port face & hex nut	Every six months or as needed
	Clean valve slider	Every six months or as needed
	Change tubing	Annually or as needed
	Eluent pump	Annually
Atomic Absorption Spectro-photometers - FAA and CVAA	Check gases	Daily
	Clean burner head	Daily
	Check aspiration tubing	Daily
	Clean optics	Every three months
	Empty waste container	Weekly
Atomic Absorption Spectro-photometers - GFAA	Check gases	Daily
	Check argon dewar	Daily
	Change graphite tube	Daily, as needed
	Clean furnace windows	Monthly
ICP - AES	Check argon dewar	Daily
	Replace peristaltic pump tubing	Daily
	Empty waste container	Weekly
	Clean nebulizer, spray chamber, and torch	Every two weeks
	Replace water filter	Quarterly
	Replace vacuum air filters	Monthly

Instrument	Activity	Frequency
ICP - MS	Check argon dewar	Daily
	Check water level in chiller	Daily
	Complete instrument log	Daily
	Replace peristaltic pump tubing	Daily
	Clean sample and skimmer cones	As needed
	Clean RF contact strip	As needed
	Inspect nebulizer, spray chamber, and torch	Clean as needed
	Clean lens stack/extraction lens	As needed
	Check rotary pump oil	Monthly
	Change rotary pump oil	Every six months
Gel-Permeation Chromatographs	Clean and repack column	As needed
	Backflush valves	As needed
High Pressure Liquid Chromatographs	Backflush guard column	As needed
	Backflush column	As needed
	Change guard column	As needed when back pressure too high
	Change column	Annually or as needed
	Change in-line filters	As needed
	Leak check	After column maintenance
	Change pump seals	As needed
	Change pump diaphragm	Annually
	Clean flow cell	As needed
	Fluorescence detector check	Daily
	Diode array absorbance check	Daily
Gas Chromatographs, Semivolatiles	Check gas supplies	Daily, replace if pressure reaches 50psi
	Change in-line filters	Quarterly or after 30 tanks of gas
	Change septum	Daily
	Change injection port liner	Weekly or as needed
	Clip first 6-12" of capillary column	As needed
	Change guard column	As needed
	Replace analytical column	As needed when peak resolution fails
	Check system for gas leaks	After changing columns and after any power failure
	Clean FID	Weekly or as needed
	Clean ECD	Quarterly or as needed
	Leak test ECD	Annually

Instrument	Activity	Frequency
Gas Chromatograph/Mass Spectrometers, Semivolatiles	Check gas supplies	Daily, replace if pressure reaches 50psi
	Change in-line filters	Annually or as needed
	Change septum	Daily, when in use
	Change injection port liner	Weekly or as needed
	Clip first 6-12" of capillary column	As needed
	Change guard column	As needed
	Replace analytical column	As needed when peak resolution fails
	Clean source	As needed when tuning problems
	Change pump oil	As specified by service specifications
Purge and Trap Concentrators	Change trap	Every four months or as needed
	Change transfer lines	Every six months or as needed
	Clean purge vessel	Daily
Gas Chromatographs, Volatiles	Check gas supplies	Daily, replace when pressure reaches 50 psi
	Change in-line filters	Quarterly or after 30 tanks of gas
	Change septum	Daily
	Clip first 6-12" of capillary column	As needed
	Change guard column	As needed
	Replace analytical column	As needed when peak resolution fails
	Check system for gas leaks	After changing columns and after any power failure
	Clean PID lamp	As needed
	Clean FID	As needed
	Change ion exchange resin	Every 60 days
	Replace nickel tubing	Quarterly or as needed
Gas Chromatograph/Mass Spectrometers, Volatiles	Check gas supplies	Daily, replace when pressure reaches 50 psi
	Change in-line filters	Annually or as needed
	Change septum	Daily
	Clip first foot of capillary column	As needed
	Change guard column	As needed
	Replace analytical column	As needed when peak resolution fails
	Clean jet separator	As needed
	Clean source	As needed when tuning problems
	Change pump oil	As specified by service specifications

APPENDIX E

LIST OF NELAC ACCREDITED METHODS

APPENDIX F

ADDITIONAL AGENCY-SPECIFIC DOCUMENTS

APPENDIX A-2

QUALITY ASSURANCE PROJECT PLAN FOR THE ASSESSMENT OF SEDIMENT TOXICITY TO WHITE STURGEON (*ACIPENSER TRANSMONTANUS)* AMENDMENT NO. 1 (TAI, JUNE 2010)

UPPER COLUMBIA RIVER

REMEDIAL INVESTIGATION AND FEASIBILITY STUDY

Quality Assurance Project Plan for the

Assessment of Sediment Toxicity to White Sturgeon (*Acipenser transmontanus*)

Amendment No. 1

Prepared for

Teck American Incorporated

P.O. Box 3087

Spokane, Washington 99220, USA

Prepared by

Saskatoon, SK S7N 3B5, Canada

and

Environmental Toxicology Laboratory
Toxicology Centre
University of Saskatchewan
44 Campus Drive
Saskatoon, SK S7N 3B5, Canada

in consultation with

Exponent **Parametrix** **HydroQual**

June 2010

SECTION A: PROJECT MANAGEMENT

A1 TITLE AND APPROVAL SHEET

QUALITY ASSURANCE PROJECT PLAN FOR THE "ASSESSMENT OF SEDIMENT TOXICITY TO WHITE STURGEON (*Acipenser transmontanus*) AMENDMENT NO. 1"

Quality Assurance Project Plan Approvals

EPA Project Coordinator:	Helen Bottcher	Helen H. Bottcher	Date: 6/14/2010
EPA Quality Assurance (QA) Manager:	for Gina Grepo-Grove		Date: 6/14/10
Teck Project Coordinator:	Marko Adzic		Date: 06-12-10
Teck Technical Team Coordinator & Task Manager:	Markus Hecker		Date: 6/17/10

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Map 1 Assessment of Sediment Toxicity to White Sturgeon Sediment Sampling Locations

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Table A-1 Universal Transverse Mercator Coordinates of Sediment Sampling Stations for White Sturgeon Toxicity Testing

A3 DISTRIBUTION LIST

EPA Project Coordinator:	Helen Bottcher
EPA QA Manager:	Gina Grepo-Grove
Teck Project Coordinator:	Marko Adzic
Teck Technical Team Coordinator & Task Manager:	Markus Hecker
Study Team Leader:	David Vardy

A4 INTRODUCTION

A4.1 Introduction

This amendment outlines proposed minor modifications to four of the sediment sampling stations outlined within the May 2010 *Assessment of Sediment Toxicity to White Sturgeon (Acipenser transmontanus)* Quality Assurance Project Plan (QAPP). The modifications outlined herein are limited to minor updates in physical positioning (i.e., coordinates) of sediment sampling stations.

All other aspects associated with field sampling and handling procedures, laboratory analysis, Quality Assurance/Quality Control (QA/QC) measures, and data validation activities remain unchanged from the approved QAPP (May 2010).

A4.2 Modifications

Based on technical input and at the request of the U.S. Environmental Protection Agency, minor modifications to target sediment sampling stations have been made to four sediment sampling stations. As illustrated within Map 1, one target station within the Lower Portion of Marcus Flats and two target stations within China Bend have been slightly modified to more closely align with the thalweg. In addition, one alternate station at Little Dalles was also refined. A summary of sediment sampling station coordinates using the Universal Transverse Mercator system is listed within Table A-1 and are illustrated within Map 1.

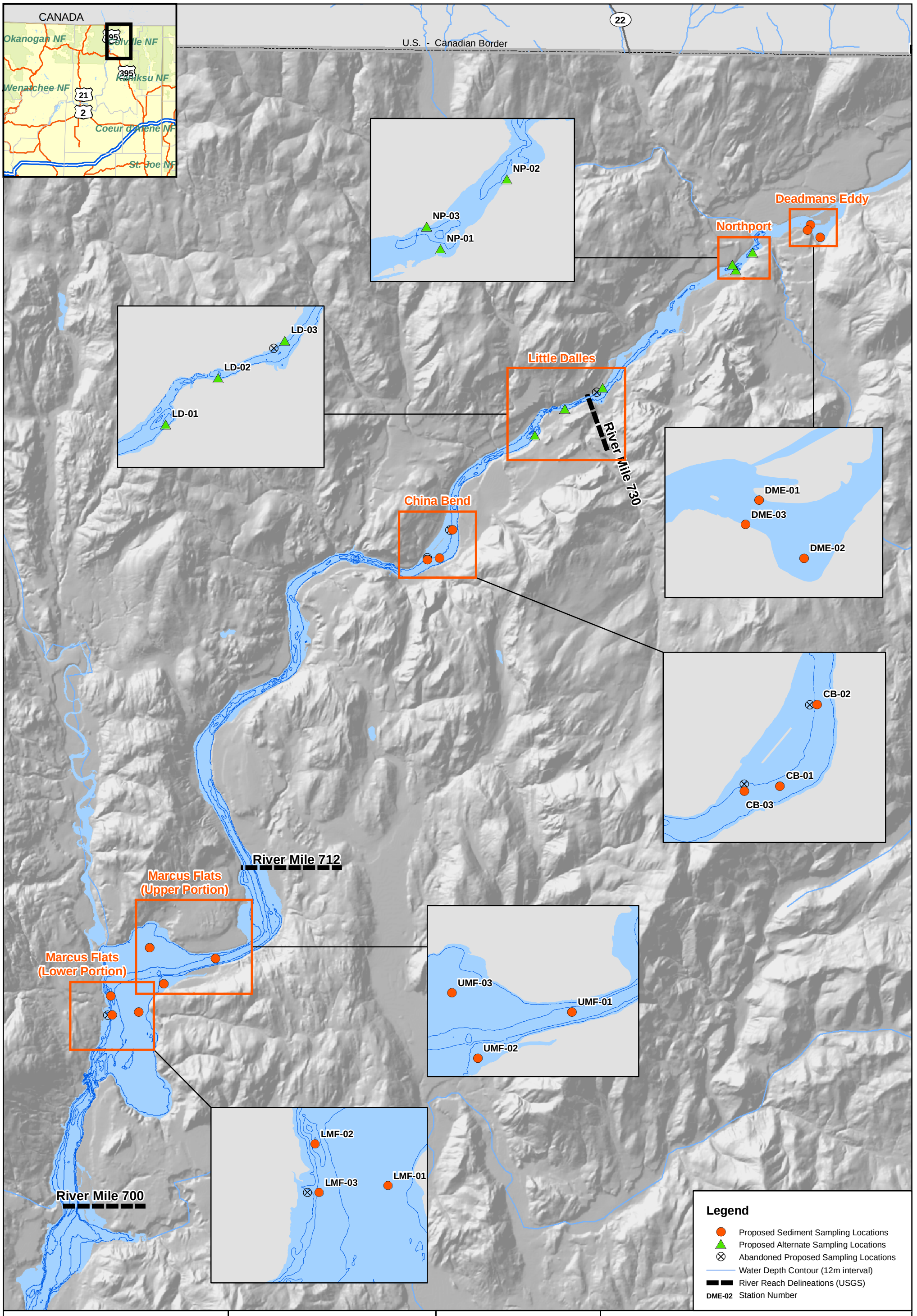
Table A-1. Universal Transverse Mercator Coordinates of Sediment Sampling Stations for White Sturgeon Toxicity Testing.

Sampling Area Description		Universal Transverse Mercator Coordinates	
		Easting	Northing
Deadman's Eddy (DME)			
	DME-01	446405.316	5420949.545
	DME-02	446795.613	5420448.714
	DME-03	446288.597	5420740.789
China Bend (CB)			
	CB-01	431604.246	5407646.304
	CB-02	432120.704	5408773.751
	CB-03	431112.592	5407574.889
Marcus Flats - Upper Portion (UMF)			
	UMF-01	422651.955	5391668.047
	UMF-02	420593.484	5390655.659
	UMF-03	420027.511	5392090.602
Marcus Flats - Lower Portion (LMF)			
	LMF-01	419596.598	5389522.361
	LMF-02	418470.318	5390165.566
	LMF-03	418534.187	5389414.844
Northport (NP) - Alternative Location			
	NP-01	443442.450	5419135.820
	NP-02	444108.470	5419838.750
	NP-03	443302.500	5419361.440
Little Dalles (LD) - Alternative Location			
	LD-01	435417.180	5412544.520
	LD-02	436606.680	5413599.700
	LD-03	438123.570	5414445.120

SECTION B: REFERENCES

Teck. 2010. Quality Assurance Project Plan for the Assessment of Sediment Toxicity to White Sturgeon (*Acipenser transmontanus*), Upper Columbia River RI/FS. Submitted and approved by EPA, May 2010. Prepared for Teck American Incorporated, Prepared by Entrix, Exponent, Parametrix, Inc., HydroQual, and Cardwell Consulting, LLC.

Maps



Map 1 **Assessment of Sediment Toxicity to White Sturgeon Sediment Sample Locations**

Upper Columbia River, WA

APPENDIX A-3

QUALITY ASSURANCE PROJECT PLAN FOR THE ASSESSMENT OF SEDIMENT TOXICITY TO WHITE STURGEON (*ACIPENSER TRANSMONTANUS)* AMENDMENT NO. 2 (TAI, JULY 2010)

UPPER COLUMBIA RIVER

REMEDIAL INVESTIGATION AND FEASIBILITY STUDY

Quality Assurance Project Plan for the

Assessment of Sediment Toxicity to White Sturgeon (*Acipenser transmontanus*)

Amendment No. 2

Prepared for

Teck American Incorporated

P.O. Box 3087

Spokane, Washington 99220, USA

Prepared by

Saskatoon, SK S7N 3B5, Canada

and

Environmental Toxicology Laboratory
Toxicology Centre
University of Saskatchewan
44 Campus Drive
Saskatoon, SK S7N 3B5, Canada

in consultation with

Exponent **Parametrix** **HydroQual**

July 2010

SECTION A: PROJECT MANAGEMENT

A1 TITLE AND APPROVAL SHEET

QUALITY ASSURANCE PROJECT PLAN FOR THE "ASSESSMENT OF SEDIMENT TOXICITY TO WHITE STURGEON (*Acipenser transmontanus*) AMENDMENT NO. 2"

Quality Assurance Project Plan Approvals

EPA Project Coordinator:	Helen Bottcher	Helen H Bottcher	Date: 7/16/2010
EPA Quality Assurance (QA) Manager:	for Gina Grepo-Grove		Date: 7/19/10
Teck Project Coordinator:	Marko Adzic		Date: 07-16-10
Principal Investigator:	Dr. Markus Hecker		Date: 07-16-10

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SECTION B: REFERENCES B-1

Appendix A White Sturgeon Methods Development Work Technical Memorandum No. 1 – Mixing and Homogenization of Sediments (July 9, 2010); includes Approval Letter

Appendix B White Sturgeon Methods Development Work Technical Memorandum No. 2 – Method Results and Recommendations (July 9, 2010); includes Approval Letter

Appendix C White Sturgeon Methods Development Work Technical Memorandum No. 3 – Study Design (July 13, 2010); includes Approval Letter

Appendix D White Sturgeon Methods Development Work Technical Memorandum No. 4 – Time to Steady State (July 14, 2010)

Appendix E White Sturgeon Methods Development Work Evaluation and Comparison of Porewater, Sediment-Interface Water Sampling Devices - Preliminary Data for Days 0, 2, 4, and 8

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Table A-2 Exposure System Treatments Based on Results from Methods Development Work and Available Substrates

Table A-3 Parameters Measured and Frequency in Sturgeon Exposure Chambers

Table A-4 Required Sample Containers, Preservation, and Holding Times for Overlying Water, Sediment-Water Interface Water, and Porewater Samples

A3 DISTRIBUTION LIST

EPA Project Coordinator:	Helen Bottcher
EPA QA Manager:	Gina Grepo-Grove
Teck Project Coordinator:	Marko Adzic
Principal Investigator:	Dr. Markus Hecker
Study Team Leader:	David Vardy

A4 INTRODUCTION

A4.1 Introduction

As detailed within the May 2010 Quality Assurance Project Plan (QAPP) for the *Assessment of Sediment Toxicity to White Sturgeon (Acipenser transmontanus)* (Teck 2010c), information regarding final study design and optimization of flow-through fluvial exposure chambers were being evaluated per the *Methods Development for the White Sturgeon Sediment Toxicity Study* QAPP and its Amendments (Teck 2010a, b, d). Results from methods development work and associated final study design are presented herein.

All other aspects associated with field sampling and handling procedures, laboratory analysis, Quality Assurance/Quality Control (QA/QC) measures, and data validation activities remain unchanged from the approved QAPP (May 2010) and its amendment (June 2010).

A4.2 Modifications

A summary of observations and associated recommendations optimizing the design and performance of flow-through fluvial exposure chambers and test conditions for sediment toxicity tests using white sturgeon are presented within Table A-1. Details associated with this summary are presented within technical memoranda; see Appendices A through E. Similarly, and based on field sampling efforts detailed within Amendment No. 1 to the May 2010 *Assessment of Sediment Toxicity to White Sturgeon (Acipenser transmontanus)* QAPP, the number of treatments and exposures; laboratory analyses, and associated sample containers have been optimized, see Table A-2, A-3, and A-4 respectively.

SECTION B: REFERENCES

Teck. 2010a. Quality Assurance Project Plan for Methods Development for the White Sturgeon Sediment Study, Upper Columbia River RI/FS. Submitted and approved by EPA, April 2010. Prepared for Teck American Incorporated, Prepared by ENTRIX, Inc., in Consultation with Exponent, Inc., Parametrix, Inc., HydroQual Inc., and Cardwell Consulting, LLC

2010b. Quality Assurance Project Plan for Methods Development for the White Sturgeon Sediment Study - Amendment No. 1, Upper Columbia River RI/FS. Submitted and approved by EPA, April 2010. Prepared for Teck American Incorporated, Prepared by ENTRIX, Inc., in Consultation with Exponent, Inc., Parametrix, Inc., HydroQual Inc., and Cardwell Consulting, LLC

2010c. Quality Assurance Project Plan for the Assessment of Sediment Toxicity to White Sturgeon (*Acipenser transmontanus*), Upper Columbia River RI/FS. Submitted and approved by EPA, May 2010. Prepared for Teck American Incorporated, Prepared by ENTRIX, Inc., in Consultation with Exponent, Parametrix, and HydroQual

2010d. Quality Assurance Project Plan for Methods Development for the White Sturgeon Sediment Study - Amendment No. 2, Upper Columbia River RI/FS. Submitted and approved by EPA, June 2010. Prepared for Teck American Incorporated, Prepared by ENTRIX, Inc., in Consultation with Exponent, Inc., Parametrix, Inc., HydroQual Inc., and Cardwell Consulting, LLC

2010e. Quality Assurance Project Plan for the Assessment of Sediment Toxicity to White Sturgeon (*Acipenser transmontanus*) - Amendment No. 1, Upper Columbia River RI/FS. Submitted and approved by EPA, June 2010. Prepared for Teck American Incorporated, Prepared by ENTRIX, Inc., in Consultation with Exponent, Parametrix, and HydroQual

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TABLES

Table A-1. Parameters, Methods, Measurements and Recommendations to Optimize the Design of the Exposure Systems and Test Conditions for the Assessment of Sediment Toxicity to White Sturgeon (*Acipenser transmontanus)*.

Order	Parameter	Goal	Test Conditions	Measurement	Recommendation
1	Flow condition	Establish parameters and operational conditions that enable the maintenance of homogenous flow conditions in the test system.	Initial flow rate of 19 L/min, with incremental changes of +/- 2 L/min to achieve desired end state	Video record of fluorescein dye movement	Initial flow rate of 20 L/min to accommodate low flow requirement for yolksac larvae, and then increase flow rates to 25 L/min around the time when larvae initiate exogenous feeding
2	Gravel volume and distributions	Establish optimum density of gravel to create pseudo-hyporheic zone	Gravel: 0, 3, 7, 10 and 13 stones per 100 cm^2	Conductivity measurements	4 stones per 100 cm^2
3	Porewater sampling	Establish porewater sampling method	Airstone suction device in different depths of sediment using variable strength and duration of suction (via manual use of syringe). Initial volume to be collected 30 mL, with incremental changes of +/- 5 mL to obtain sufficient sample volume.	Only porewater is collected with no overlying water in the sample • Dye concentration measurements.	12 ports, with a volume of 8-10 mL each; no ports within the first and last 4 inches of the fluvial chamber.
4	Sediment depth	Establish optimum depth of sediment for ELS sturgeon and to maximize porewater collection	Initial depth at 2 inches, with trials of 3 and 4 inches	Porewater sampling at 0.5 and 1 inch and overlying water sampling within the 1 cm of water overlying the sediment • Dye concentration measurements.	Two (2) inches of sediment, with airstones positioned on top of 0.5 inches and below 1.5 inches of sediment

Table continues

Table A-1 continued - Parameters, Methods, Measurements and Recommendations to Optimize the Design of the Exposure Systems and Test Conditions for the Assessment of Sediment Toxicity to White Sturgeon (*Acipenser transmontanus)*.

Order	Parameter	Goal	Test Conditions	Measurement	Recommendation
5	Gradients between pore- and overlying water	Establish operational conditions that minimize gradients in water quality parameters between pore- and overlying water.	Each flow/sediment depth combination that is tested.	Time-resolved measurements of: • Dye concentration • Conductivity • DOC • pH	Flow-rates between 17 and 25L are appropriate as they do not affect gradients. Porewater sampling depth between 1 and 1.5 inches recommended due to observed gradients. Short time-dependency of gradients between overlying water and porewater indicates that a reduced equilibration time of 4 to 7 days prior to introduction of fish is sufficient.
6	Time to steady-state	Establish operational conditions that minimize time to steady-state.	Characterize time to steady-state between pore- and overlying water after establishing optimal flow and gravel conditions.	Time-resolved measurements of: • Alkalinity • Ammonia • Conductivity • DO • DOC • Hardness • pH	48 hours is sufficient for all parameters, with the exception of DOC which may not reach steady state
7	Cleaning methods	Establish most efficient method for cleaning	Introduce food 3X daily and scrape tanks at days 2, 3, 4 and 5.	Measure turbidity of samples using light scattering methods	Modified pipette, with spatula used to remove biofilm, if necessary
8	Laboratory control sediment	Define clean sediment with characteristics similar to UCR sediments	Research lab controls used in other bioassays Create sediment from clean silica sand and/or granite with grain size 0.5 to 2 mm and preference to dark color	Measure grain size and color	Control sediment: Hagen Geosystem Black Fine Gravel (ART #12648), all analytes below screening ecological values (SEVs). Acceptable for use. Reference sediments from Genelle and Lower Arrow Lake, gravelly sand, all analytes below SEVs. Acceptable for use.

Table A-2. Exposure System Treatments Based on Results from Methods Development Work and Available Substrates.

Treatment Group	No. of Biology Replicates	No. of Chemistry Only Replicates
LMF - 02	3	1
UMF - 01	4	2
NP - 03	2	0
LD - 01	4	2
DME [a]	2	1
GE	3	1
LALL	4	2
Laboratory Control Substrate [b]	4	2
Water Only (No Sediment)	4	0

Notes:
LMF – Lower Marcus Flats
UMF – Upper Marcus Flats
NP – Northport
LD – Little Dalles
DME – Deadman's Eddy
GE – Genelle (reference sediment)
LALL – Lower Arrow Lake (reference sediment)
[a] Test chambers for materials collected as part of methods development work from the gravel bar at DME will be established but may not be employed as required by the U.S. Environmental Protection Agency
[b] As determined during methods development work laboratory control sediments will consist of Hagen Geosystems Substrate.

Table A-3. Parameters Measured and Frequency in Sturgeon Exposure Chambers.

	Sediment [a]		Pore/SWI/Overlying Water	
Analyte/Parameter	CAS	U of S	CAS	U of S
Conventional Parameters				
Alkalinity			W	start[b], W
Hardness			W	start[b], W
TDS			W	
TOC / DOC	start, end		W	
pH	start, end			start[b] D
DO				D
Temperature				D
Conductivity				D
Cations/Anions				
Calcium			W	
Chloride			W	
Fluoride			W	
Magnesium			W	
Potassium			W	
Sodium			W	
Sulfate			W	
Nutrients				
Ammonia				W
Nitrate+Nitrite				W
Common Metals and Metalloids				
Aluminum	start, end		W	
Antimony	start, end		W	
Arsenic	start, end		W	
Barium	start, end		W	
Beryllium	start, end		W	
Cadmium	start, end		W	
Chromium	start, end		W	
Cobalt	start, end		W	
Copper	start, end		W	
Iron	start, end		W	
Lead	start, end		W	
Manganese	start, end		W	
Mercury	start, end		W	
Molybdenum	start, end		W	
Nickel	start, end		W	
Selenium	start, end		W	
Silver	start, end		W	
Thallium	start, end		W	
Vanadium	start, end		W	
Zinc	start, end		W	

	Sediment [a]		Pore/SWI/Overlying Water	
Analyte/Parameter	CAS	U of S	CAS	U of S
Other				
AVS	start, end			
SEM	start, end			
Grain Size	start			
Total PCBs[c, d]	start			
Total DDT[c, d]	start			
Biological Measurements				
Length				Measure Day 0, end of test, and all dead fish; photo document periodically
Weight				Measure Day 0 and end of test; all dead fish
Survival				D

Notes:

D Daily measurements conducted by the U of S to control for appropriate water quality required for successful sturgeon culture

W Weekly measurements will be conducted by the U of S to assess changes in exposure conditions that require immediate corrective action. During the beginning of the exposure these parameters will be measured more frequently (e.g. every 2 to 5 days).

AVS = acid volatile sulfides (only measured in sediments)

DO = dissolved oxygen (only measured in water samples)

SEM = simultaneously extracted metals (only measured in sediments)

TDS = total dissolved solids (only measured in water samples)

TOC = total organic carbon (only measured in sediments)

DOC = dissolved organic carbon (only measured in water samples)

[a] samples will also be archived per Table B-4 of the May 2010 Quality Assurance Project Plan for the Assessment of Sediment Toxicity to White Sturgeon (*Acipenser transmontanus*)

[b] parameters to be analyzed / adjusted in artificial river water

[c] Total PCBs and DDT will be analyzed using EPA Methods 8082 and 8081A, respectively. Detection limits and accuracy for total PCB analyses will be ~(0.05 – 0.2) µg/kg and (53-143) % recovery, respectively. Detection limits and accuracy for total DDT analyses will be ~(0.07 – 0.3) µg/kg and (53-143) % recovery, respectively.

[d] Samples will be collected in 8 oz. wide mouth glass jars with no headspace and maintained at 4±2°C prior to analysis by the laboratory. Extraction will be performed within 14 days of sample collection.

Table A-4. Required Sample Containers, Preservation, and Holding Times for Overlying Water, Sediment-Water Interface Water, and Porewater Samples.

	Container [a]		Preservation	Holding Time	Proposed Minimum Laboratory Sample Size [b]
	Type	Size			
Conventional Parameters					
Alkalinity as $CaCO_3$	HDPE	1000 mL	4±2ºC	14 days	25 mL
Dissolved organic carbon	HDPE	250 mL	H_2SO_4 to pH <2; 4±2ºC	28 days	25 mL
Hardness as $CaCO_3$	HDPE	with metals	1 mL of 1:1 HNO_3; 4±2ºC	6 months	with metals[e]
Total dissolved solids	HDPE	with alkalinity	4±2ºC	7 days	200 mL
Total suspended solids	HDPE	with alkalinity	4±2ºC	7 days	200 mL
Major Ions					
Calcium, magnesium, potassium, sodium	HDPE	with metals	1 mL of 1:1 HNO_3; 4±2ºC	6 months	with metals[e]
Chloride, fluoride, sulfate	HDPE	250 mL	4±2ºC	28 days	5 mL
Nutrients					
Ammonia	HPDE	250 mL	H_2SO_4 to pH <2; 4±2ºC	28 days	5 mL
Nitrate + nitrite	HDPE	250 mL	H_2SO_4 to pH <2; 4±2ºC	28 days	5 mL
Common metals and metalloids [c]	HDPE	250 mL	1 mL of 1:1 HNO_3; 4±2ºC	6 months	15 to 20 mL
Mercury [d]	FP or G with FP-lined lids	500 mL	BrCl in lab within 28 days of collection; 4±2ºC	90 days	100 mL

Notes:
BrCl = bromine chloride
FP = fluoropolymer
G = glass
HDPE = high density polyethylene bottle
H_2SO_4 = sulfuric acid
HNO_3 = nitric acid
[a] Sample container sizes may be modified to meet laboratory requirements
[b] Extra sample volume will be collected at a frequency of 5 percent of samples to accommodate requirements for laboratory quality control samples.
[c] Surface water samples will be collected and analyzed for dissolved metals and metalloids. A total of 1 L of water will be collected for the common metals/metalloids analyses (dissolved), and 500 mL will be collected for analysis of mercury.
[d] Due to volume limitations mercury analyses will not be performed on porewater samples.
[e] These analyses will be conducted from the same sample collected for metals analysis; therefore, no additional volume is required.

APPENDIX A

WHITE STURGEON METHODS DEVELOPMENT WORK TECHNICAL MEMORANDUM NO. 1 – MIXING AND HOMOGENIZATION OF SEDIMENTS (JULY 9, 2010); INCLUDES APPROVAL LETTER

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 900
Seattle, Washington 98101-3140

July 12, 2010

CERTIFIED MAIL – RETURN RECEIPT REQUESTED

Reply To: ECL-111

Marko Adzic
Teck American Incorporated
501 North Riverpoint Boulevard, Suite 300
Spokane, Washington 99202

RE: UCR Sturgeon Sediment Toxicity Testing – Mixing and Homogenization of Sediments

Dear Mr. Adzic,

This letter is in response to a Technical Memorandum, *Sturgeon sediment toxicity testing – mixing and homogenization of sediments*. The Technical Memorandum was submitted to the United States Environmental Agency via email on July 9, 2010. It summarizes the results of testing performed to confirm the effectiveness of sediment homogenization procedures. The procedures that were tested are described in detail in Standard Operating Procedure Number 8 of the approved May 2010 *Quality Assurance Project Plan for the Assessment of Sediment Toxicity to White Sturgeon (Acipenser transmontanus)*. Test results showed that three hours of tumbling in a modified cement mixer is sufficient to ensure the sediments are well mixed.

With this letter, EPA is approving the Technical Memorandum and the recommendation of a three hour mixing time. Teck American Incorporated is authorized to begin mixing sediments per the approved Technical Memorandum upon receipt of this letter.

Sincerely,

Helen A. Bottcher

Helen Bottcher
Project Manager

cc: Dan Audet, U.S. Department of the Interior
Patti Bailey, Confederated Tribes of the Colville Reservation
Randy Connolly, Spokane Tribe of Indians
John Roland, Washington State Department of Ecology

ENTRIX
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EXTERNAL MEMORANDUM

TO: Helen Bottcher, US EPA Region 10
FROM: Markus Hecker, Ph.D., ENTRIX, Inc.
DATE: July 9, 2010
PROJECT: UCR Sturgeon Sediment Toxicity Testing
SUBJECT: Sturgeon sediment toxicity testing - mixing and homogenization of sediments

This summary memo provides recommendations regarding mixing and homogenizing sediments to be used in the study described in the May 2010 *Assessment of Sediment Toxicity to White Sturgeon (Acipenser transmontanus)* QAPP. All sediments (including reference sediments, sediments from the Site, and control sediments) need to be mixed sufficiently to ensure homogeneity of the material, prior to layering it into the fluvial exposure chambers. The following sections summarize the work done during methods development to arrive at the proposed mixing method and duration; details and all data are provided in Appendix A of this memo.

Sediment Mixing

Objective: Confirm the effectiveness and reliability of sediment homogenization procedures outlined within Standard Operating Procedure Number 8 (SOP-8) of the May 2010 QAPP *Assessment of Sediment Toxicity to White Sturgeon (Acipenser transmontanus)* (see Appendix B of this memo). Sediments collected from the sandbar at Deadman's Eddy (see Appendix C of this memo) were used in this mixing study.

Results and Recommendations: Sediments for the definitive sturgeon study should be mixed for three hours, as results for Cu, Cd and Zn indicate that sediment achieves homogeneity after this amount of mixing time. The cement mixer will be used in the test as it has been shown to be an effective method of mixing sediment. Methods will follow those in SOP #8, with samples being tumbled for 3 hours, stopping every half an hour to rotate the drum and scrap any sediment from the side before repeating the process.

Pb results are more variable (still >20% variation after three hours of mixing), like due to the fact that Pb is present in part as larger solid particles as opposed to associated with fines as surface oxides and bound to organic ligands, and to the size of the sub-subsample collected for

quantification. If a larger sub-subsample had been collected and digested, and the digestate diluted prior to analysis, it is likely that the variation among sub samples would be less. The volume of bulk sediment added to the experimental systems will be such that the variation observed in very small sub-subsamples will not be observed among exposure systems (see Appendix A, data summary report for further discussion of this issue). It can be concluded, based on the results for Cu, Cd and Zn, that the sediments are sufficiently homogenized to be used in further experimentation. As a corrective action, larger sub-sub samples can be collected and submitted for reanalysis to verify that the above-explanation is the cause of the observed variation in concentrations of Pb.

Following mixing, sediments will be placed into 5 gallon HDPE buckets, overlaid with water, and stored at 4°C under a nitrogen atmosphere until placement into the fluvial system chambers.

Appendices

Sediment Mixing Test

Appendix A Data Summary Report

Appendix B SOP #8: Sample Management: Receiving, Preservation, Storage, Documentation, Decontamination, and disposal.

Appendix C Field report for sediment collection at Deadman's Eddy

Appendix A: Summary Data Report

Experiment #: 9 **Date:** 5/20/-7/04/10 **Expt. Leader:** DV/JD/MH

Title: Sediment Mixing

Goal:

Confirm the effectiveness and reliability of sediment homogenization procedures outlined within Standard Operating Procedure Number 8 (SOP-8) of the May 2010 QAPP *Assessment of Sediment Toxicity to White Sturgeon (Acipenser transmontanus)*.

Experimental Design:

Samples collected from the gravel bar at Deadman's Eddy (see Appendix C) were mixed and homogenized in a specially designed 'concrete mixer.' The large rotating drum of the mixer contains a plastic liner that has been tested to confirm lack of leaching of metals into a water rinsate. Composited sediment was tumbled for a period long enough (e.g., hours) to create a visual appearance of complete mixing. Two sediment samples each were taken from the top, middle, and bottom layers of the drum and analyzed for Cu, Cd, Pd and Zn to verify the visual determination of a homogenized sediment. If analyses had greater than ±20 percent maximum calculated difference in concentration, then the sample was tumbled for another period and the analysis repeated. Methods for sample collection and storage were as stated in the April 2010 QAPP; analysis of metal concentrations was conducted by Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) at the U of S.

Decision Criteria:

Sediments were determined to be completely homogenized when all six samples collected were within ±20 percent the maximum calculated difference. Photographs of homogenized sediment were taken to document the visual appearance of samples at homogeneity.

Results:

Rinsate:

The cement mixer was scrubbed with 5% HCl, followed by Liqui-Nox, and thoroughly rinsed with reverse osmosis (RO) water. 50 L of nanopure water was then tumbled in the mixer for a period of 3 hours. The average of two rinsate samples (ppb), ± standard deviation, for Cu, Zn, Cd and Pb were 0.68 ± 0.33, 0.92 ± 0.2, 0.1 ± 0.02 and 0.03 ± 0.01, respectively (Table 1).

Homogenization:

Two sets of six samples were analyzed for homogeneity, for a total of 12 data points for each metal of concern. The decision criteria for sediment homogenization states that the 6 samples (2 from the top, middle and bottom of the mixer) will be analyzed for Cu, Zn, Cd, and Pb and that concentrations ≤ 20% of the mean of the six samples will be considered acceptable. Cu, Zn and Cd results all were well below the 20% criterion, whereas not all Pb results were below the criterion. When comparing all 12 samples, Pb exceeds 20% 6 times (50%, 48%, 26%, 33%, 33% and 21%); (Recovery analysis, Table 2).

Conclusions:

Results for Cu, Cd and Zn indicate that the sediment achieved homogeneity after three hours mixing time. The cement mixer appears to be an effective method of mixing sediment and we propose to use the cement mixer method for mixing sediments for the definitive study. Methods will follow those in SOP #8, with samples being tumbled for 3 hours, stopping every half an hour to rotate the drum and scrap any sediment from the side before repeating the process.

The probable cause for the greater variation in concentrations of Pb among subsamples than was observed for Cu, Zn or Cd is that Pb likely is present in part as larger solid particles as opposed to associated with fines as surface oxides and bound to organic ligands. Since concentrations of Cu, Zn and Cd all indicated that the bulk sediment was homogenized, the greater variation in concentrations of Pb is likely due to the size of the sub-subsample collected for quantification. A sub-subsample of 0.1 g dw was taken for digestion. If a larger sub-subsample had been collected and digested, and the digestate diluted prior to analysis, it is likely that the variation among sub samples would be less. Since the Pb generally is occluded in the solid matrix of particles it is less likely to contribute directly to toxicity in porewater. This conclusion is supported by the results reported by Besser et al. (2008)[1] for location L7, which is in the vicinity of Deadman's Eddy. In that study of the toxic potential of metals in sediments from the UCR, the concentration of Pb in bulk sediment from L7 was 590 μg Pb/g, dw while the concentration in the porewater was 7.1 μg Pb/l. At other locations such as L6, which is downstream from L7, the concentration in the bulk sediment was 200 μg Pb/g, dw but the concentration in the pore water was 250 μg Pb/l. A fractionation of the sediment at L7 showed that more than 50% of the Pb was in the residual unextractable fraction and an additional 40% was present as a sulfide (or organic) but most likely an insoluble sulfide material. These results taken together indicate that Pb in the vicinity of Deadman's Eddy is more likely to be bound in the matrix of the sediments and less likely to contribute to lead concentrations in pore water. The volume of bulk sediment added to the experimental systems will be such that the variation observed in very small sub-subsamples will not be observed among exposure systems.

It can be concluded based on the results for Cu, Cd and Zn that the sediments are sufficiently homogenized to be used in further experimentation. As a corrective action, larger sub-sub samples can be collected and submitted for reanalysis to verify that the above-explanation is the cause of the observed variation in concentrations of Pb.

[1] Besser, J.M., Brumbaugh, W.G., Ivey, C.D., Ingersoll, C.G., Moran, P.W. 2008. Biological and Chemical Characterization of Metal Bioavailability in Sediments from Lake Roosevelt, Washington, USA. *Arch. Environ. Contam. Toxicol.* .54: 557-570.

Table 1. *Cu, Cd, Zn and Pb analysis for rinsate of cement mixer. Nanopure results indicate concentration levels of metals of concern in nanopure water before being introduced into the cement mixer. The average for two cement mixer samples are presented along with standard deviation (SD).*

	Cu (ppb)	**Zn (ppb)**	**Cd (ppb)**	**Pb (ppb)**
Detection Limit (DL)	0.07	0.19	0.02	0.003
Blank	< DL	< DL	0.064	< DL
Nanopure 1	< DL	0.01	0.099	< DL
Nanopure 2	< DL	0.027	0.092	0.001
Cement mix 1	0.45	1.062	0.109	0.033
Cement mix 2	0.91	0.783	0.083	0.018
Avg. Cement	0.68	0.92	0.1	0.03
SD Cement	0.33	0.2	0.02	0.01

Sediment Homogenization -- Test Data

		Instrument analysis (these are numbers as they come out of the ICP)				Acceptable instrument limits: ± 10% recove (This is the lab QA/QC data)			
		Cu ppb	Zn ppb	Cd ppb	Pb ppb	Cu ppb	Zn ppb	Cd ppb	Pb ppb
Level of Detection (LOD)		0.051	0.146	0.003	0.005				
	BLANK 13	-0.865	-3.769	-0.026	0.003	-2.561	-10.535	-0.013	0.011
	BLANK 14	-0.868	-3.818	-0.004	0.002				
	BLANK 15	-0.874	-3.81	-0.014	0				
	BLANK 16	-0.869	-3.796	-0.008	0				
	BLANK 18	-0.871	-3.8	0.019	0.001				
	BLANK 19	-0.828	-2.948	0.017	0.006				
average		-0.8625	-3.65683	-0.00267	0.002				
	1643 e	22.09	77.4	6.587	11.56	0.570143	-1.91362	-0.01518	-0.34722
	1643 e	21.62	74.98	6.591	11.45	2.685671	1.272823	-0.07592	0.607639
	1643 e	22.94	75.46	6.58	11.55	-3.25581	0.640801	0.091102	-0.26042
	Control A (MB)	-0.36	-0.585	0.196	0.079				
	Control B (MB)	-0.387	1.901	0.064	0.062				
	Control C (MB)	-0.448	0.489	0.063	0.087				
	Top 1A	329.6	2873	2.431	115	-2.2174	-0.36681	-2.98666	5.193735
	Top 1B	315.3	2852	2.29	127.6				
	Middle 1A	336.4	2887	2.508	121.7	5.941563	0.017316	0.555115	25.8379
	Middle 1B	378.9	2888	2.536	206.5				
	Bottom 1A	339.5	2862	2.523	117.4	-1.69238	-0.01747	-2.20782	27.12601
	Bottom 1B	328.2	2861	2.414	204.8				

	Instrument analysis (these are numbers as they come out of the ICP)				Acceptable instrument limits: ± 10% recove This is the lab QA/QC data)			
	Cu ppb	Zn ppb	Cd ppb	Pb ppb	Cu ppb	Zn ppb	Cd ppb	Pb ppb
Top 2A	413.3	2768	2.334	145.1	-9.16535	3.905572	1.185436	9.369144
Top 2B	343.9	2993	2.39	175.1				
Middle 2A	363.1	2783	2.502	93	-2.5996	0.784314	-1.45985	21.25318
Middle 2B	344.7	2827	2.43	143.2				
Bottom 2A	342.6	2608	2.493	92.25	-3.69249	0.286752	-4.79193	9.757887
Bottom 2B	318.2	2623	2.265	112.2				
PACS A	98.55	135.6	4.544	96.11	1.050905	3.188958	4.930609	1.761499
PACS B	98.74	140.4	4.969	98.18	0.860136	-0.23798	-3.96122	-0.35434
PACS C	101.5	144.2	4.826	99.21	-1.91104	-2.95098	-0.96938	-1.40716

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	ery	Method analysis (this is the data after correction for blanks, tare weight, etc.) USE THESE DATA				Acceptable methods limits: ± 30% recovery			
		Cu ppb	Zn ppb	Cd ppb	Pb ppb	Cu ppb	Zn ppb	Cd ppb	Pb ppb
f Detection (LOD)									
BLANK 13									
BLANK 14									
BLANK 15									
BLANK 16									
BLANK 18									
BLANK 19									
1643 e									
1643 e									
1643 e									
Control A (MB)	Control A	-0.06	-0.09	0.03	0.01				
Control B (MB)	Control B	-0.06	0.28	0.01	0.01				
Control C (MB)	Control C	-0.06	0.07	0.01	0.01				
Top 1A	Top 1A	51.17	446.01	0.38	17.85	-2.28	-0.43	-3.05	5.13
Top 1B	Top 1B	48.89	442.21	0.36	19.78				
Middle 1A	Middle 1A	52.44	450.03	0.39	18.97	5.19	-0.74	-0.20	25.13
Middle 1B	Middle 1B	58.18	443.45	0.39	31.71				
Bottom 1A	Bottom 1A	52.40	441.75	0.39	18.12	-2.44	-0.76	-2.95	26.43
Bottom 1B	Bottom 1B	49.91	435.04	0.37	31.14				

		Method analysis (this is the data after correction for blanks, tare weight, etc.) USE THESE DATA				Acceptable methods limits: ± 30% recovery			
		Cu ppb	Zn ppb	Cd ppb	Pb ppb	Cu ppb	Zn ppb	Cd ppb	Pb ppb
Top 2A	Top 2A	61.88	414.40	0.35	21.72	-8.36	4.72	2.00	10.17
Top 2B	Top 2B	52.33	455.43	0.36	26.64				
Middle 2A	Middle 2A	55.36	424.32	0.38	14.18	-1.83	1.55	-0.69	21.99
Middle 2B	Middle 2B	53.37	437.71	0.38	22.17				
Bottom 2A	Bottom 2A	52.35	398.54	0.38	14.10	-4.90	-0.92	-6.00	8.56
Bottom 2B	Bottom 2B	47.46	391.25	0.34	16.74				
PACS A	PACS A	15.46	21.27	0.71	15.07	-2.12	0.06	1.69	-1.43
PACS B	PACS B	13.70	19.48	0.69	13.62	9.47	8.43	4.87	8.31
PACS C	PACS C	16.25	23.08	0.77	15.88	-7.35	-8.48	-6.57	-6.87

ent Homoger

QAPP acceptable limits for homogenization: ± 20% of mean

	USE THESE DATA				USE THESE DATA			
	All data points				6 samples			
	Cu	Zn	Cd	Pb	Cu	Zn	Cd	Pb
	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
f Detection (LOD)								
BLANK 13								
BLANK 14								
BLANK 15								
BLANK 16								
BLANK 18								
BLANK 19								
1643 e								
1643 e								
1643 e								
Control A (MB)								
Control B (MB)								
Control C (MB)								
Top 1A	3.42	-3.32	-1.57	15.37	1.91	-0.66	0.22	22.14
Top 1B	7.72	-2.44	4.44	6.21	6.28	0.20	6.12	13.72
Middle 1A	1.02	-4.25	-5.21	10.07	-0.53	-1.57	-3.37	17.27
Middle 1B	-9.82	-2.73	-4.80	-50.32	-11.53	-0.08	-2.96	-38.28
Bottom 1A	1.09	-2.33	-4.80	14.10	-0.46	0.30	-2.96	20.97
Bottom 1B	5.80	-0.78	1.21	-47.63	4.33	1.81	2.95	-35.81

QAPP acceptable limits for homogenization: ± 20% of mean

	USE THESE DATA				USE THESE DATA			
	All data points				6 samples			
	Cu ppb	Zn ppb	Cd ppb	Pb ppb	Cu ppb	Zn ppb	Cd ppb	Pb ppb
Top 2A	-16.80	4.00	5.96	-2.98	-15.03	1.40	4.25	-12.80
Top 2B	1.22	-5.50	2.13	-26.31	2.72	-8.36	0.35	-38.35
Middle 2A	-4.50	1.71	-2.66	32.78	-2.92	-0.96	-4.53	26.37
Middle 2B	-0.74	-1.40	-1.25	-5.11	0.78	-4.15	-3.10	-15.13
Bottom 2A	1.18	7.68	-2.53	33.17	2.67	5.17	-4.39	26.80
Bottom 2B	10.41	9.37	9.08	20.66	11.77	6.91	7.42	13.10
PACS A								
PACS B								
PACS C								

Appendix B SOP #8 Sample Management: Receiving, Preservation, Storage, Documentation, Decontamination, and disposal.

STANDARD OPERATING PROCEDURE SOP-8

SAMPLE MANAGEMENT: RECEIVING, PRESERVATION, STORAGE, DOCUMENTATION, DECONTAMINATION, AND DISPOSAL

Purpose

This standard operating procedure (SOP) specifies the requirements for sample receipt, control, record keeping, decontamination, and disposal at the Environmental Toxicology Laboratory (ETL) at the University of Saskatchewan (U of S).

Scope and Applicability

This SOP applies to the ETL for samples supplied from the Upper Columbia River white sturgeon studies.

Safety Considerations

Safety training and medical monitoring requirements are described in the Health and Safety Plan for the Upper Columbia River Remedial Investigation and Feasibility Study (TCAI 2007).

In addition, there are various safety concerns regarding the receipt, storage, and disposal of sample containers at the ETL. Upon receipt, the sample containers will be monitored for breakage. If sample containers are broken, the appropriate personnel will be immediately notified and the Department of Health, Safety and Environment (DHSE) will be called in order to assess the hazard. DHSE will also be contacted in the case of chemical spills and will be responsible for the disposal of hazardous wastes.

Personal Protective Equipment

Personnel protective equipment (PPE), consisting of lab coats, safety glasses, and latex gloves will be worn at all times when handling samples.

Waste Management

All waste will be managed and disposed of in accordance with U of S DHSE regulations. Waste management practices will include the control of all standards and solutions. This means that if required expired or used standards, associated solvents and other chemicals used for

preservation and biological or element analysis will be disposed of in labeled waste containers and DHSE will be notified for waste pick up.

Spill Decontamination

If a spill occurs in the laboratory, DHSE will be notified immediately. The area where the spill occurred will be evacuated and marked.

Equipment, Materials, and Reagents

The sample storage area is equipped with a locked freezer, refrigerator and a liquid nitrogen Dewar flask in which samples are stored as appropriate. Access to these storage areas is limited to laboratory personnel with appropriate authorization that work at the Toxicology Centre (lockable walk-in cold room and freezer, and liquid nitrogen storage room), or only to the white sturgeon UofS study team (separate lockable fridge and freezer units). A list of personnel with access to refrigerators, freezers and dewars and other storage areas will be established once the hiring and training portion of the studies is completed. Sediments and archived samples will be sealed with a breakable seal that is dated and initialed. The freezer and Dewar flask are connected to phone and audible alarm systems that monitor temperature and notify laboratory personnel in cases of temperature and/or power related issues. A calibrated balance is also kept in the sample storage area and is used to weigh sub-samples. Sample storage at 4°C will occur in a lockable walk-in refrigerator that is connected to a phone alarm system. Temperature in the walk-in refrigerator is monitored continuously by an automated temperature logging system, and checked manually every morning during weekdays. In case of a building power outage, an auxiliary generator automatically provides power to freezers and the walk-in refrigerator and an alarm is sent to U of S Public Safety office.

No materials or reagents are used in sample receipt.

METHOD, PROCEDURES, AND REQUIREMENTS

Sample Receipt

The physical condition of coolers or other containers used for transportation, and each individual sample container will be inspected upon arrival at the ETL. The following objectives have been established for sample receiving:

A. Inspect sample coolers and samples for signs of damage upon receipt at the laboratory.

B. Attach air bill or shipping receipt to the chain-of-custody (COC) form.

C. Examine individual samples and record their status (frozen/ not frozen; immersed in preservation liquid, etc.) on a sample receipt form.

D. Verify that a COC form is submitted with samples, and that the COC contains all information required for analysis and reporting. Maintain custody of samples by ensuring that all dates, times, and signatures are provided on the COC forms.

E. Identify and reconcile any discrepancies between the COC and sample labels.

F. Verify that sample containers, labeling, or other requirements are correct. Assign a unique lab identification number to each sample and log samples into the sample tracking sheet (STS) (see attached STS.) Identify any hazards or special precautions associated with the incoming samples.

G. Notify appropriate laboratory and field study personnel when samples have arrived. These individuals are to be identified in either a Work Plan or Sampling and Analysis Plan (SAP).

H. Track and document the handling of samples from receipt through data reporting to final disposal. This will be accomplished by keeping all of the log forms in a binder kept in the laboratory.

Sample Documentation

Upon arrival, the shipping receipts will be collected from the cooler and be stapled to the COC form. Samples submitted to the ETL will be accounted for by documenting their arrival and condition on COC and sample tracking sheets. Within the ETL, the STS will be used to monitor the samples whereabouts at all times. Aliquots removed will be recorded on the STS. While handling samples, any anomalies or problems will be noted in bound laboratory notebooks.

Sample Storage and Preservation

Samples will be stored in liquid nitrogen, freezer, refrigerator or locked storage room at room temperature (formalin preserved sturgeon samples) in the laboratory. This room is accessible only to lab personnel. The freezer and (walk-in) refrigerators will be set at -20°C and +4°C, respectively, and the temperature will be monitored daily. If for any reason there is a power outage or an increase in temperature, the facility manager on call and/or other lab personnel will be immediately notified by the automated phone alarm system that will automatically call the cell phone of the person on duty. Also, the walk-in refrigerator for the storage of sediments is connected to a backup generator that insures continuous operation in case of a power outage. The necessary action will then be taken to ensure that sample integrity is not compromised. If samples are removed from any of the storage compartments/units for any reason, this activity will be documented on the STS form. Copies of the forms will be placed in the records archive. When samples are removed for preparation and analysis, a sample extraction form will be completed.

Storage Container and Compositing Equipment Decontamination

All equipment used for storage (e.g. HPDE buckets, instruments to move samples) as well as all other equipment that could come into contact with chemically affected materials will be thoroughly cleaned, before and after each use, by washing with Liquinox® (a laboratory-grade detergent) and rinsing with deionized water followed by dilute nitric acid and another wash of deionized water. Decontamination procedures may be modified and/or revised based upon the data obtained or the equipment used (e.g. no acid will be used if the equipment or parts of the equipment consist of non-coated metal). Sub-samples of final deionized water rinses after acid washing will be collected for metal analysis to insure successful decontamination of equipment.

Decontamination waste is expected to consist of dilute nitric acid. Decontamination solutions will be properly disposed through the Department of Health, Safety and Environment (DHSE) of the U of S.

Sediment Sample Transport and Storage [1]

Freshly collected sediment will be placed in 5 gallon HDPE buckets from Columbia Analytical Services (CAS). Buckets will be cleaned and shipped to the field site in a protective covering to ensure they are contamination free. Buckets will be completely filled with sediment except for a small layer of river water above the sediment. The container will be filled to the brim to reduce oxygen exposure. The container will be purged with an inert gas (for example, nitrogen) before filling and then again before capping tightly. Sediment samples will never be frozen. All sediment containers will be properly labeled with a waterproof marker before sampling. Each label will include: the study title, station location or sample identification, date and time of collection, sample type, and name of collector. Labeled containers will be stabilized in an upright position in the transport/storage container. Following collection from each location the sediment samples will be immediately transferred to a refrigerated truck and stored upright at 4°C until placed in refrigerated room (walk-in refrigerator) at the ETL.

Sediment Sample Compositing[2]

Compositing will be accomplished in the laboratory in the following manner:

1. Overlying water will be siphoned off, not decanted, prior to compositing.

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[1] These procedures follow ASTM guidelines 1391-03 (2008) Standard Guide for Collection, Storage, Characterization, and Manipulation of Sediments for Toxicological Testing and for Selection of Samplers Used to Collect Benthic Invertebrates.

[2] These procedures follow ASTM guidelines 1391-03 (2008) Standard Guide for Collection, Storage, Characterization, and Manipulation of Sediments for Toxicological Testing and for Selection of Samplers Used to Collect Benthic Invertebrates.

2. All utensils that are used to process samples will be made of inert materials such as high quality stainless steel, or high density polyethylene (HDPE).
3. Unrepresentative materials (for example, twigs, shells, leaves, large stones, wood chips etc.) will be removed and documented before homogenization.
4. A high-grade stainless steel concrete mixer (or similar industrial mixing device made out of stainless steel or HDPE) will be used to thoroughly homogenize samples (homogenization will occur at medium to low mixing speed for a minimum of 30 minutes).
5. Reference sediments will be mixed first.
6. The sediment mixer will be cleaned thoroughly between uses (low percent nitric acid bath followed by thorough rinsing with ultraclean water, as appropriate).

Partitioning sediments for biological testing will be accomplished by removing small portions from random locations in the sediment mixer and distributing them randomly in all corresponding exposure chambers until the appropriate volume of sediment is contained in each. During distribution, the sediment will be periodically mixed to minimize stratification effects due to differential settling. Remaining sediments will be placed into 5 gallon HDPE buckets, overlaid with water, and stored at 4°C under a nitrogen atmosphere.

Scheduled Monitoring

All Dewar flasks, refrigerators, and freezers used in the ETL will be examined frequently due to constant use and will be monitored at a minimum daily. Freezer temperatures are maintained at a nominal -20°C. If the freezer temperature rises to equal or greater than -15°C, if the liquid nitrogen levels decrease such that it triggers the alarm, or if the refrigerator temperature rises over +7°C, corrective action must be taken. Actions include adjusting the thermostats, refilling liquid nitrogen, having the unit serviced, or moving the samples to another unit.

Sample Accountability

To ensure that all samples will be accounted for, the following guidelines will be followed:

A. The person obtaining the sample or submitting the sample to the laboratory for analysis must establish sample identity.
B. Integrity of sample must be maintained from collection to delivery.
C. Composition of sample must remain the same during handling and storage before analysis.
D. Evidence must exist of sample's receipt and COC record filled out, and appropriate personnel notified of the sample arrival.

E. Person preparing sample must not allow composition of sample to change or integrity to be questioned.

F. Analyst must ensure correct sample is analyzed.

G. Analyst must record all data contributing to the analysis.

H. Records must be kept to trace sample from retrieval through data reporting.

I. Special storage conditions must be documented.

Label and COC Discrepancies

Discrepancies between the sample labels and COC will be noted on the COC or Sample Receipt Form. The sample manager will resolve any documentation discrepancies by contacting the personnel that submitted the samples. For discrepancies impacting sample viability (i.e., improper sample temperature) where a Corrective Action Report (CAR) is required to be completed, the sample manager will coordinate with the sample submitter, quality assurance (QA), and Project Study Group representatives to determine the appropriate corrective action.

RECORDS, DOCUMENTATION, AND QUALITY CONTROL (QC) REQUIREMENTS

The primary analyst shall document any anomalies and/or deviation from the specified method in a bound, serially numbered, laboratory notebook with tear-out carbon copies. All electronic files and hardcopies will be kept at the participating laboratory.

The carbon copies from data notebooks will be removed and archived in a separate building. Copies of the COC forms, the STS, and laboratory notes will be kept in three-ring binders in separate places at all times in case of fire or other disaster.

RESPONSIBILITIES

Project Manager. Dr. Markus Hecker will oversee and approve all project activities, authorize necessary actions and adjustments, and act as liaison between the principle investigator and other U of S personnel, Teck American personnel, and the sponsor Project Manager.

Principle Investigator. Prof. John P. Giesy will advise the Project Manager in overseeing and approving all project activities, authorize necessary actions and adjustments related to U of S activities to accomplish program QA objectives; and act as liaison between agencies, staff, and the sponsor Project Manager.

Study Team Leaders (STLs). David Vardy and Jonathon Doering, under the supervision of Markus Hecker, will oversee all research activities and supervise all personnel involved with the assemblage of the experimental exposure systems. The STLs will ensure that proper sample

collection, preservation, storage, transport, and COC QC procedures are followed and will inform the Project QA Manager when problems occur, and will communicate and document corrective actions taken. The STLs will discuss study activities with the Project Manager.

Quality Assurance (QA) Manager. Dr. Shaun Roark will initiate audits on work completed by project personnel. The manager will review program QA activities, quality problems, and quality-related requests. In response to experimental findings, the QA manager will approve corrective actions. The QA manager will report quality non-conformances to the Project Manager.

QUESTIONS OR COMMENTS

Please feel free to contact the following persons with any questions, comments, etc., you may regarding the procedures outlined in this SOP.

Markus Hecker
mhecker@entrix.com
(306) 966-5233

Paul D. Jones, Ph.D.
paul.jones@usask.ca
(306) 966-5062

John P. Giesy, Ph.D.
john.giesy@usask.ca
(306) 966-2096

REFERENCES

Comprehensive Analytical Laboratory Services Quality Assurance Management Plan, April 1997.

Environmental Analytical Laboratory, Laboratory Quality Control Plan, April 1997.

TCAI (Teck Cominco American, Inc.). 2007. Upper Columbia River: Draft general health and safety plan for the remedial investigation and feasibility study. Prepared for Teck Cominco American Incorporated. December 27, 2007. Integral Consulting Inc., Mercer Island, Washington, and Parametrix, Bellevue, Washington.

Appendix C Field report for sediment collection at Deadman's Eddy

The four UTM corner coordinates were located using a consumer-grade, hand-held Global Positioning System (GPS) unit (Magellan Triton) and marked using wooden stakes. See Figures 1 through 4. The following methods were used to locate and provide documentation for each on-shore surface grab sample.

- Based on field observations of the sediment composition a transect line was laid between the northeast and northwest corners using a string marker.

- The distance between the two corners was measured by tape as 458 feet (139.5 meters). Based on this measured distance, the transect was divided into 50 foot (15.2 meter) increments or ten references points, with a total transect distance of 450 feet (137.2 meters). The 10 reference points were labeled A (northeast corner) to J (northwest corner).

- The 10 grab sample points were located at various distances in the sand sediments south of the 50 foot transect reference points and marked with flags. Two grab samples were collected south of transect reference point E, as the reference point A (northeast corner) sediment material was comprised of cobbles and boulders. UTM coordinates and elevations were recorded using the hand-held GPS unit for each flagged grab sample point. Attachment A provides the individual grab sample location data.

- Each of the 10 grab samples were collected using a decontaminated shovel and placed into decontaminated polyethylene (PE) 5-gallon bucket. The upper 4 inches (10 centimeters) of sediment was removed to access the underlying sample area. Grab samples were generally collected between 4 and 12 inches (30 centimeters) below the ground surface; 12 inches being the maximum depth prescribed by the QAPP. Unique sample numbers and container numbers were assigned based on QAPP SOP-4. See Figures 5 and 6

- Sample data and observations were recorded on field sample logs (Attachment B). The field sample logs include information on the sample time, UTM coordinates, sample texture and colors, general characteristics, photographic record, and other relevant notes. A bound environmental field book (Attachment C) was used to record general information regarding project personnel, activities, and operations.

- Photographic documentation was collected (Attachment D). Photographs of the locations, samples, and procedures are sequentially identified using a white board marker to record pertinent information (e.g., time, date, and location). The photograph directory is labeled TAI-DME 5_27_2010. The photographs are labeled IMG_0001 to IMG_0091. The individual grab sample photographs (numbers) are recorded on the field sample logs for reference.

- Archaeological monitoring of ground-disturbing activities was conducted by a qualified archaeologist who meets the U.S. Secretary of Interior's Professional Qualification Standards (as outlined in 36 CFR Part 61). The DME sediment sampling program was monitored by a URS Registered Professional Archeologist (RPA) Sarah McDaniel, RPA in

accordance with protocols outlined in Appendix C of the QAPP (April 2010). Ms. McDaniel's archaeological monitoring results are provided in Attachment E.

Field Observations

The field sampling event was attended by the following persons:

Sampling and Support
- Eric Weatherman, Captain, Columbia Navigation, Inc.
- Alan Burkhart, Columbia Navigations, Inc.
- Sarah McDaniel, RPA, URS Corporation
- Jeffrey E. Leppo LG, URS Corporation

Observers
- Joseph Wichmann, PhD, Technical Advisor, representing Citizens for a Clean Columbia
- Steve Demus, CH2M Hill, providing EPA technical oversight

Figure 5 shows sampling, support, and observer personnel present on May 27, 2010 (Jeffery Leppo is not present in the photograph). The DME location is situated on the west side of the Columbia River and is a depositional sediment bar comprised primarily of sands, gravels, cobbles and boulders. Figures 6 and 7 present surface conditions at DME. Ten sediment grab samples (five gallons each) were obtained from within the DME sampling area delineated by the four corner markers. The primary sample matrix consisted of dark gray and yellowish brown well-graded sands. The presence of buried cobbles and boulders was encountered at several locations at depths ranging from 5 to 8 inches (13 to 20 cm) below ground surface; in these instances the sand sediments were collected above these materials. Figures 8 and 9 present typical grab sample collection activities.

The ten sediment grab samples were labeled TAI-US-DME-HS-1 through TAI-US-DME-HS-10 and are illustrated within Map 1. The corresponding container tag numbers were DME-1 through DME-10. Grab samples were transported by vehicle to Spokane, Washington under chain-of-custody protocol and delivered to representatives of Teck on May 28, 2010. The grab samples were then transported by Teck to the Teck Metals, Ltd facility in Trail, British Columbia, Canada, with subsequent shipping to the University of Saskatchewan, Aquatic Exposure Laboratory. Please refer to Appendix F for the chain-of-custody and shipping documents.

The archaeological monitoring reported no cultural resources were identified or disturbed as a result of this on-shore sediment sampling program.

A benchmark at the Northport (WA) boat launch was established as a reference point for both UTM coordinates and elevation data. The data is entered into the Environmental Field Book, page 1. Photographs IMG_001 and IMG_002 provide a view of the location.

Deviations and Corrective Actions

No reportable deviations, contingencies, or corrective actions were required for this project phase as defined by the QAPP or SOPs.

Attachments:

Figures 1-9: May 27, 2010 Site Photographs
Map 1: Sediment Sample Locations
Attachment A: Sample Locations and Coordinates Table
Attachment B: Field Data/Sampling Diaries
Attachment C: Environmental Field Book
Attachment D: Photographic Record
Attachment E: Archaeological Monitoring Results
Attachment F: Chain-of-Custody

Figure 1
Photograph of the northeast corner coordinate, view to west

Figure 2
Southeast corner coordinate, view to southeast.

Figure 3
Southwest corner coordinate, view to northeast.

Figure 4
Northwest corner coordinate, view to northwest.

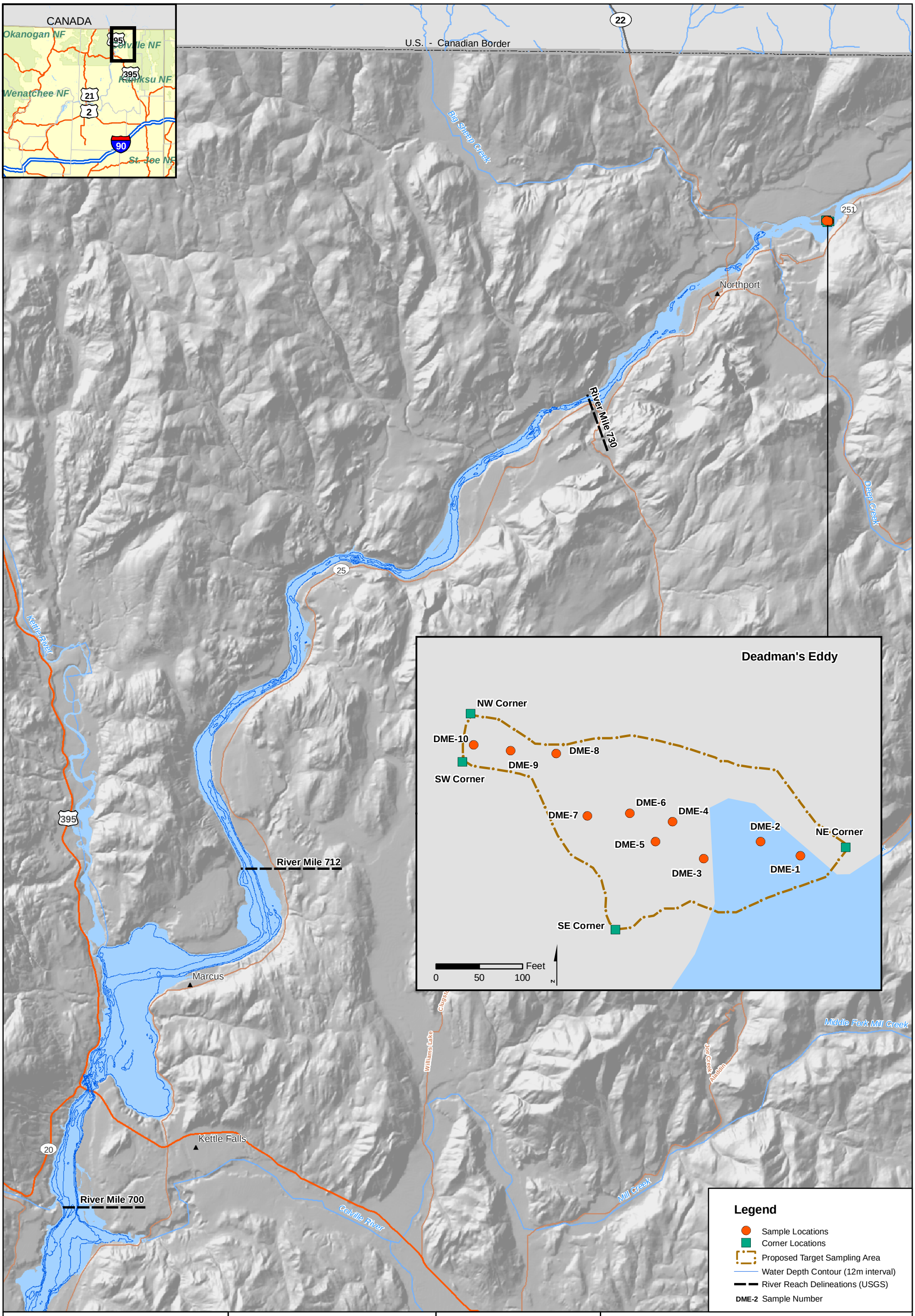
Figure 5
Sampling and support, and observer personnel, view to east.

Figure 6
Deadman's Eddy surface conditions, view to northwest.

Figure 7
Deadman's Eddy surface conditions, view to south

Figure 8
Grab sample collection, sample number TAI-US-DME-HS-1, view to northeast.

Figure 9
Grab sample test pit, sample number TAI-US-DME-HS-1.



Sediment Sample Locations

Km
0 2.5 5

Miles
0 1.5 3

N

URS Corporation

Source:
GIS base layer Information provided by Parametrix Inc.

Map 1 **Methods Development for the White Sturgeon Sediment Toxicity Study (Deadman's Eddy)**

Upper Columbia River, WA

ATTACHMENT A
Sample Locations and Coordinates Table

Sample Locations and Coordinates
Methods Development - White Sturgeon Sediment Toxicity Study
Upper Columbia River - Deadman's Eddy (U.S.)

Attachment A

Sample Container Tag No.	Reference Point	Reference Point Distance from NE to NW Corner (m) (1) (2)	Northing (UTM) (3)	Easting (UTM)	Elevation (m)	Distance from Transect Line (m)
DME-1	B	15.2	5421094	447142	392	1.5
DME-2	C	30.5	5421099	447128	392	4.6
DME-3	D	45.7	5421093	447108	397	16.8
DME-4	E	61.0	5421106	447097	399	7.6
DME-5	E	61.0	5921099	447091	398	21.3
DME-6	F	76.2	5421109	447082	399	10.7
DME-7	G	91.4	5421108	447067	398	18.3
DME-8	H	106.7	5421130	447056	397	3.0
DME-9	I	121.9	5421131	447040	399	7.0
DME-10	J	137.2	5421133	447027	398	9.1

Notes:

(1) Total transect line distance from northeast corner to northwest corner was hand measured at approximately 139.5 meters

(2) Northeast Corner - N5421068, E447077, Elevation 401,Northwest Corner - N5421144, E447026, Elevation 398

(3) Coordinates based on Universal Transverse Mercator (UTM) using North American Datum of 1983 (NAD83), Zone 11

Grab sample points (container tag no.) located approximately perpendicular to and south of transect line

ATTACHMENT B
Field Data/Sampling Diaries

URS

FIELD SAMPLE LOG - SEDIMENTS

Upper Columbia River - Methods Development White Sturgeon Sediment Toxicity Study

U.S. Location - Deadman's Eddy

Date: 5 / 27 /2010

Time: 12:17

Sample No. : TAI-US-DME-HS- 1 **Container Tag : DME** 1

ELEVATION (M)	UTM Northing (NAD83)	UTM Easting (NAD83)
392	5421094	447142

PHYSICAL CHARACTERISTICS

☑ SW	Well graded sand, gravelly sand, little to no fines.	☐ SM	Silty sands, sand-silt mixtures	☐ GW	Well graded gravels, gravel-sand mixtures, little to no fines
☐ SP	Poorly graded sand, gravelly sand, little to no fines.	☐ SC	Clayey sands, sand-clay mixtures	☐ GP	Poorly graded gravels, gravel-sand mixtures, little to no fines
☐ ML	Inorganic silts, very fine sands, rock flour, silt or clay silts with low plasticity	☐ CL	Clayey sands, sand-clay mixtures	☐ GM	Silty gravels, gravel-sand-silt mixtures
Color (Munsell) Moist	very dark gray 10 YR 3 / 1			☐ GC	Clayey gravels, gravel-sand-clay mixtures

Visible Organic Matter: Yes ☐ No ☑ Description:

Other Matrix Descriptions:

Odors: Yes ☐ No ☑ Description:

Sample Depth: 4 to 8 inches
Sample Depth: 10 to 20 cm

Obvious Abnormalities (wood, shells, organisms, etc): Yes ☐ No ☑

Cultural Resources: Archaeologist Sarah McDaniel Resources Found or Identified? Yes ☐ No ☑ (Please refer to archaeologist's observation record)

Other Notes:

Cobbles and boulders @ 6 to 8 inches below surface

Boat Contractor: Columbia Navigation, Inc, Capt. Eric Weatherman

Photo Directory: TAI-DME 5_27_2010

Sampler Type: HS (hand sample)

Photo File No(s): IMG_033 to 038

Sampler Name: Jeff Leppo

Sample Signature:

Date: 5 / 27 /2010

Time: 12:30

URS

FIELD SAMPLE LOG - SEDIMENTS

Upper Columbia River - Methods Development White Sturgeon Sediment Toxicity Study

U.S. Location - Deadman's Eddy

Date: 5 / 27 /2010

Time: 12:35

Sample No. : TAI-US-DME-HS- 2 **Container Tag : DME** 2

ELEVATION (M)	UTM Northing (NAD83)	UTM Easting (NAD83)
392	5421099	447128

PHYSICAL CHARACTERISTICS

☐ SW	Well graded sand, gravelly sand, little to no fines	☐ SM	Silty sands, sand-silt mixtures	☐ GW	Well graded gravels, gravel-sand mixtures, little to no fines
☑ SP	Poorly graded sand, gravelly sand, little to no fines	☐ SC	Clayey sands, sand-clay mixtures	☐ GP	Poorly graded gravels, gravel-sand mixtures, little to no fines
☐ ML	Inorganic silts, very fine sands, rock flour, silt or clay silts with low plasticity	☐ CL	Clayey sands, sand-clay mixtures	☐ GM	Silty gravels, gravel-sand-silt mixtures
Color (Munsell) Moist: Brown 10 YR 4 / 3; Brownish yellow 10 YR 6 / 6				☐ GC	Clayey gravels, gravel-sand-clay mixtures

Visible Organic Matter: Yes ☐ No ☑ Description:

Other Matrix Descriptions: Mixed matrix colors

Odors: Yes ☐ No ☑ Description:

Sample Depth: 4 to 6 inches
Sample Depth: 10 to 15 cm

Obvious Abnormalities (wood, shells, organisms, etc): Yes ☐ No ☑

Cultural Resources: Archaeologist Sarah McDaniel **Resources Found or Identified? Yes** ☐ **No** ☑ (Please refer to archaeologist's observation record)

Other Notes:

Primarily fine sands, increasing uniformity w/ depth. Cobbles and boulders @ 5 to 6 inches below surface. Mixed color matrix for sands

Boat Contractor: Columbia Navigation, Inc, Capt. Eric Weatherman

Photo Directory: TAI-DME 5.27.10

Sampler Type: HS (hand sample)

Photo File No(s): IMG_0039 to 0042

Sampler Name: Jeff Lappo

Sample Signature:

Date: 5 / 27 /2010

Time: 12:50

URS

FIELD SAMPLE LOG - SEDIMENTS

Upper Columbia River - Methods Development White Sturgeon Sediment Toxicity Study

U.S. Location - Deadman's Eddy

Date: 5 / 27 /2010

Time: 13 :05

Sample No. : TAI-US-DME-HS- 3 Container Tag : DME 3

ELEVATION (M)	UTM Northing (NAD83)	UTM Easting (NAD83)
397	5421093	447108

PHYSICAL CHARACTERISTICS

☑ SW	Well graded sand, gravelly sand, little to no fines.	☐ SM	Silty sands, sand-silt mixtures	☐ GW	Well graded gravels, gravel-sand mixtures, little to no fines
☐ SP	Poorly graded sand, gravelly sand, little to no fines.	☐ SC	Clayey sands, sand-clay mixtures	☐ GP	Poorly graded gravels, gravel-sand mixtures, little to no fines
☐ ML	Inorganic silts, very fine sands, rock flour, silt or clay silts with low plasticity	☐ CL	Clayey sands, sand-clay mixtures	☐ GM	Silty gravels, gravel-sand-silt mixtures

Color (Munsell) Moist / Dry: Dark gray 10 YR 4 / 1; Yellowish brown 10 YR 5 / 6

☐ GC Clayey gravels, gravel-sand-clay mixtures

Visible Organic Matter: Yes ☐ No ☑ Description:

Other Matrix Descriptions: mixed matrix colors

Odors: Yes ☐ No ☑ Description:

Sample Depth: 4 to 12 inches
Sample Depth: 10 to 30 cm

Obvious Abnormalities (wood, shells, organisms, etc): Yes ☐ No ☑

Cultural Resources: Archaeologist Sarah McDaniel Resources Found or Identified? Yes ☐ No ☑ (Please refer to archaeologist's observation record)

Other Notes:

Layered sand horizons - dark gray & yellow brown

Boat Contractor: Columbia Navigation, Inc, Capt. Eric Weatherman

Photo Directory: TAI-DME 5_27_10

Sampler Type: HS (hand sample)

Photo File No(s): IMG_0043 to 0048

Sampler Name: Jeff Leppo

Sample Signature:

Date: 5 / 27 /2010

Time: 13:08

URS

FIELD SAMPLE LOG - SEDIMENTS

Upper Columbia River - Methods Development White Sturgeon Sediment Toxicity Study

U.S. Location - Deadman's Eddy

Date: 5 / 27 /2010

Time: 13 : 15

Sample No. : TAI-US-DME-HS- 4 **Container Tag : DME** 4

ELEVATION (M)	UTM Northing (NAD83)	UTM Easting (NAD83)
399	5421106	447097

PHYSICAL CHARACTERISTICS

☑ SW	Well graded sand, gravelly sand, little to no fines.	☐ SM	Silty sands, sand-silt mixtures	☐ GW	Well graded gravels, gravel-sand mixtures, little to no fines
☐ SP	Poorly graded sand, gravelly sand, little to no fines.	☐ SC	Clayey sands, sand-clay mixtures	☐ GP	Poorly graded gravels, gravel-sand mixtures, little to no fines
☐ ML	Inorganic silts, very fine sands, rock flour, silt or clay silts with low plasticity	☐ CL	Clayey sands, sand-clay mixtures	☐ GM	Silty gravels, gravel-sand-silt mixtures

Color (Munsell) Moist/Dry

Dark Gray 10 YR 3 / 1

Dark yellowish brown 10 YR 4 / 6

☐ GC — Clayey gravels, gravel-sand-clay mixtures

Visible Organic Matter Yes ☐ No ☑ **Description:**

Other Matrix Descriptions: Mixed color matrix

Odors Yes ☐ No ☑ **Description:**

Sample Depth: 4 to 12 inches

Sample Depth: ~~10~~ to 30 cm

Obvious Abnormalities (wood, shells, organisms, etc): Yes ☐ No ☑

Cultural Resources: Archaeologist Sarah McDaniel **Resources Found or Identified?** Yes ☐ No ☑ (Please refer to archaeologist's observation record)

Other Notes:

Layered sand horizons / striations of dark gray and dark yellowish brown sands

Vertical deposition

Boat Contractor: Columbia Navigation, Inc, Capt. Eric Weatherman

Photo Directory: TAI-DME 5-27-2010

Sampler Type: HS (hand sample)

Photo File No(s): IMG_0049 to 0053

Sampler Name: Jeff Leppo

Sample Signature:

Date: 5 / 27 /2010

Time: 13:18

URS

FIELD SAMPLE LOG - SEDIMENTS

Upper Columbia River - Methods Development White Sturgeon Sediment Toxicity Study

U.S. Location - Deadman's Eddy

Date: 5 / 27 /2010

Time: 13 : 25

Sample No. : TAI-US-DME-HS- 5 **Container Tag : DME** 5

ELEVATION (M)	UTM Northing (NAD83)	UTM Easting (NAD83)
398	5421099	447091

PHYSICAL CHARACTERISTICS

☑ SW	Well graded sand, gravelly sand, little to no fines	☐ SM	Silty sands, sand-silt mixtures	☐ GW	Well graded gravels, gravel-sand mixtures, little to no fines
☐ SP	Poorly graded sand, gravelly sand, little to no fines	☐ SC	Clayey sands, sand-clay mixtures	☐ GP	Poorly graded gravels, gravel-sand mixtures, little to no fines
☐ ML	Inorganic silts, very fine sands, rock flour, silt or clay silts with low plasticity	☐ CL	Clayey sands, sand-clay mixtures	☐ GM	Silty gravels, gravel-sand-silt mixtures
Color (Munsell) Moist	Dark gray 10 YR 3 / 1 ~~Dark yellowish brown 10 YR 4 / 6~~			☐ GC	Clayey gravels, gravel-sand-clay mixtures
Visible Organic Matter	Yes ☐ No ☑ Description:			Other Matrix Descriptions: Mixed color matrix	
Odors	Yes ☐ No ☑ Description:			Sample Depth: 4 to 12 inches Sample Depth: 10 to 30 cm	

Obvious Abnormalities (wood, shells, organisms, etc): Yes ☐ No ☑

Cultural Resources: Archaeologist Sarah McDaniel **Resources Found or Identified? Yes** ☐ **No** ☑ (Please refer to archaeologist's observation record)

Other Notes:

Layered sand horizons, dark gray and dark yellowish brown.

Boat Contractor: Columbia Navigation, Inc, Capt. Eric Weatherman	**Photo Directory:** TAI-DME 5-27-10
Sampler Type: HS (hand sample)	**Photo File No(s):** IMG_0054 to 0059

Sampler Name: Jeff Leppo

Sample Signature: Jeff Leppo

Date: 5 / 27 /2010

Time: 13:30

URS

FIELD SAMPLE LOG - SEDIMENTS

Upper Columbia River - Methods Development White Sturgeon Sediment Toxicity Study

U.S. Location - Deadman's Eddy

Date: 5 / 27 /2010

Time: 13 : 35

Sample No. : TAI-US-DME-HS- 6 **Container Tag : DME** 6

ELEVATION (M)	UTM Northing (NAD83)	UTM Easting (NAD83)
399	5421109	447082

PHYSICAL CHARACTERISTICS

☑ SW	Well graded sand, gravelly sand, little to no fines.	☐ SM	Silty sands, sand-silt mixtures	☐ GW	Well graded gravels, gravel-sand mixtures, little to no fines
☐ SP	Poorly graded sand, gravelly sand, little to no fines.	☐ SC	Clayey sands, sand-clay mixtures	☐ GP	Poorly graded gravels, gravel-sand mixtures, little to no fines
☐ ML	Inorganic silts, very fine sands, rock flour, silt or clay silts with low plasticity	☐ CL	Clayey sands, sand-clay mixtures	☐ GM	Silty gravels, gravel-sand-silt mixtures
Color (Munsell)	Dark gray 10 YR 3 / 1 ~~Dark yellowish brown 10 YR 4 / 6~~			☐ GC	Clayey gravels, gravel-sand-clay mixtures
Visible Organic Matter	Yes ☐ No ☑ Description:			Other Matrix Descriptions: Mixed color matrix	
Odors	Yes ☐ No ☑ Description:			Sample Depth: _____ to _____ inches Sample Depth: _____ to _____ cm	

Obvious Abnormalities (wood, shells, organisms, etc): Yes ☐ No ☑

Cultural Resources: Archaeologist Sarah McDaniel **Resources Found or Identified? Yes** ☐ **No** ☑ (Please refer to archaeologist's observation record)

Other Notes:

Mixed sand layers / horizons of dark gray and dark yellowish brown, vertical deposition
Evidence of beach washing

Boat Contractor: Columbia Navigation, Inc, Capt. Eric Weatherman

Photo Directory: TAI-DME 5-27-2010

Sampler Type: HS (hand sample)

Photo File No(s): IMG_0060 to 0065

Sampler Name: Jeff Leppo

Sample Signature:

Date: 5 / 27 /2010

Time: 13:40

URS

FIELD SAMPLE LOG - SEDIMENTS

Upper Columbia River - Methods Development White Sturgeon Sediment Toxicity Study

U.S. Location - Deadman's Eddy

Date: 5 / 27 /2010

Time: 13:50

Sample No. : TAI-US-DME-HS- 7 **Container Tag : DME** 7

ELEVATION (M)	UTM Northing (NAD83)	UTM Easting (NAD83)
398	5421108	447067

PHYSICAL CHARACTERISTICS

☑ SW	Well graded sand, gravelly sand, little to no fines	☐ SM	Silty sands, sand-silt mixtures	☐ GW	Well graded gravels, gravel-sand mixtures, little to no fines
☐ SP	Poorly graded sand, gravelly sand, little to no fines	☐ SC	Clayey sands, sand-clay mixtures	☐ GP	Poorly graded gravels, gravel-sand mixtures, little to no fines
☐ ML	Inorganic silts, very fine sands, rock flour, silt or clay silts with low plasticity	☐ CL	Clayey sands, sand-clay mixtures	☐ GM	Silty gravels, gravel-sand-silt mixtures

Color (Munsell) Dark gray 10 YR 3 / 1

~~Brownish Yellow 10 YR 6 / 6~~

☐ GC Clayey gravels, gravel-sand-clay mixtures

Visible Organic Matter Yes ☐ No ☑ **Description:**

Other Matrix Descriptions: mixed color matrix

Odors Yes ☐ No ☑ **Description:**

Sample Depth: 4 to 12 inches

Sample Depth: ~~10~~ to 30 cm

Obvious Abnormalities (wood, shells, organisms, etc): Yes ☐ No ☑

Cultural Resources: Archaeologist Sarah McDaniel **Resources Found or Identified? Yes** ☐ **No** ☑ (Please refer to archaeologist's observation record)

Other Notes:

mixed color matrix, relatively even distribution, no layering/striations

Boat Contractor: Columbia Navigation, Inc, Capt. Eric Weatherman

Photo Directory: TAI-DME 5_27_2010

Sampler Type: HS (hand sample)

Photo File No(s): IMG0066 to 0071

Sampler Name: Jeff Leppo

Sample Signature: Jeff Lepp

Date: 5 / 27 /2010

Time: 13:52

URS

FIELD SAMPLE LOG - SEDIMENTS

Upper Columbia River - Methods Development White Sturgeon Sediment Toxicity Study

U.S. Location - Deadman's Eddy

Date: 5 / 27 /2010

Time: 14:00

Sample No. : TAI-US-DME-HS- 8 **Container Tag : DME** 8

ELEVATION (M)	UTM Northing (NAD83)	UTM Easting (NAD83)
397	5421130	447056

PHYSICAL CHARACTERISTICS

☑ SW	Well graded sand, gravelly sand, little to no fines.	☐ SM	Silty sands, sand-silt mixtures	☐ GW	Well graded gravels, gravel-sand mixtures, little to no fines
☐ SP	Poorly graded sand, gravelly sand, little to no fines.	☐ SC	Clayey sands, sand-clay mixtures	☐ GP	Poorly graded gravels, gravel-sand mixtures, little to no fines
☐ ML	Inorganic silts, very fine sands, rock flour, silt or clay silts with low plasticity	☐ CL	Clayey sands, sand-clay mixtures	☐ GM	Silty gravels, gravel-sand-silt mixtures
Color (Munsell)	Dark gray 10 YR 3 / 1 Dark yellowish brown 10 YR 4 / 6			☐ GC	Clayey gravels, gravel-sand-clay mixtures

Visible Organic Matter Yes ☐ No ☑ Description:	Other Matrix Descriptions: Mixed color matrix
Odors Yes ☐ No ☑ Description:	Sample Depth: 4 to 6 inches Sample Depth: 10 to 15 cm

Obvious Abnormalities (wood, shells, organisms, etc): Yes ☐ No ☑

See notes below

Cultural Resources: Archaeologist Sarah McDaniel **Resources Found or Identified? Yes** ☐ **No** ☑ **(Please refer to archaeologist's observation record)**

Other Notes:

Mixed layered sand horizons of dark gray and dark yellowish brown over gravels and cobbles - coarse materials w/ yellowish brown (10YR5/8) fine sand (SP). Roots present (near shrubs), some limited organic litter (wood particles)

Boat Contractor: Columbia Navigation, Inc, Capt. Eric Weatherman	**Photo Directory:** TAI-DME 5-27-2010
Sampler Type: HS (hand sample)	**Photo File No(s):** IMG_0072 to 0079

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 27 /2010

Time: 14:05

URS

FIELD SAMPLE LOG - SEDIMENTS

Upper Columbia River - Methods Development White Sturgeon Sediment Toxicity Study

U.S. Location - Deadman's Eddy

Date: 5 / 27 /2010

Time: 14:15

Sample No. : TAI-US-DME-HS- 9 **Container Tag : DME** 9

ELEVATION (M)	UTM Northing (NAD83)	UTM Easting (NAD83)
399	5421131	447040

PHYSICAL CHARACTERISTICS

☑ SW	Well graded sand, gravelly sand, little to no fines.	☐ SM	Silty sands, sand-silt mixtures	☐ GW	Well graded gravels, gravel-sand mixtures, little to no fines
☐ SP	Poorly graded sand, gravelly sand, little to no fines.	☐ SC	Clayey sands, sand-clay mixtures	☐ GP	Poorly graded gravels, gravel-sand mixtures, little to no fines
☐ ML	Inorganic silts, very fine sands, rock flour, silt or clay silts with low plasticity	☐ CL	Clayey sands, sand-clay mixtures	☐ GM	Silty gravels, gravel-sand-silt mixtures

Color (Munsell): Dark gray 10 YR 3 / 1; Brownish yellow 10 YR 6 / 6

☐ GC Clayey gravels, gravel-sand-clay mixtures

Visible Organic Matter Yes ☐ No ☑ **Description:**

Other Matrix Descriptions: mixed color matrix

Odors Yes ☐ No ☑ **Description:**

Sample Depth: 4 to 12 inches
Sample Depth: 10 to 30 cm

Obvious Abnormalities (wood, shells, organisms, etc): Yes ☐ No ☑

Cultural Resources: Archaeologist Sarah McDaniel **Resources Found or Identified? Yes** ☐ **No** ☑ (Please refer to archaeologist's observation record)

Other Notes:

Evenly mixed sands, no visible layers/striations. Few gravels w/ depth. Coarser sands appear to be brownish yellow

Boat Contractor: Columbia Navigation, Inc, Capt. Eric Weatherman

Photo Directory: TAI-DME 5_27_2010

Sampler Type: HS (hand sample)

Photo File No(s): IMG_0080 to 0084

Sampler Name: Jeff Leppo

Sample Signature:

Date: 5 / 27 /2010

Time: 14:17

URS

FIELD SAMPLE LOG - SEDIMENTS

Upper Columbia River - Methods Development White Sturgeon Sediment Toxicity Study

U.S. Location - Deadman's Eddy

Date: 5 / 27 /2010

Time: 14 : 21

Sample No. : TAI-US-DME-HS- 10 **Container Tag : DME** 10

ELEVATION (M)	UTM Northing (NAD83)	UTM Easting (NAD83)
398	5421133	447027

PHYSICAL CHARACTERISTICS

☑ SW	Well graded sand, gravelly sand, little to no fines.	☐ SM	Silty sands, sand-silt mixtures	☐ GW	Well graded gravels, gravel-sand mixtures, little to no fines
☐ SP	Poorly graded sand, gravelly sand, little to no fines.	☐ SC	Clayey sands, sand-clay mixtures	☐ GP	Poorly graded gravels, gravel-sand mixtures, little to no fines
☐ ML	Inorganic silts, very fine sands, rock flour, silt or clay silts with low plasticity	☐ CL	Clayey sands, sand-clay mixtures	☐ GM	Silty gravels, gravel-sand-silt mixtures
Color (Munsell)	Dark gray 10 YR 3 / 1 Yellowish brown 10 YR 5 / 6			☐ GC	Clayey gravels, gravel-sand-clay mixtures
Visible Organic Matter	Yes ☐ No ☑ Description:			Other Matrix Descriptions:	
Odors	Yes ☐ No ☑ Description:			Sample Depth: 4 to 12 inches Sample Depth: 10 to 30 cm	

Obvious Abnormalities (wood, shells, organisms, etc): Yes ☐ No ☑

Cultural Resources: Archaeologist Sarah McDaniel **Resources Found or Identified? Yes** ☐ **No** ☑ **(Please refer to archaeologist's observation record)**

Other Notes:

Mixed matrix, evenly distributed colors & grain size

Boat Contractor: Columbia Navigation, Inc, Capt. Eric Weatherman

Photo Directory: TAI-DME 5-27-2010

Sampler Type: HS (hand sample)

Photo File No(s): IMG_0085 to 0089

Sampler Name: Jeff Leppo

Sample Signature:

Date: 5 / 27 /2010

Time: 14:25

ATTACHMENT C
Environmental Field Book

URS

Location URS Office Spokane Date 5/26/10

Project / Client UCR Methods Sediment Study

Deadman's Eddy (1 of 1)

Field Prep & Mobilization - Surface Sediments

General QAPP References

* Sample Coordinates:

Deadman's Eddy Gravel Bar

	Northing	Easting
NE Corner	5421097	447158
NW Corner	5421144	447026
SW Corner	5421127	447023
SE Corner	5421068	447077

Polygon - 20 meters (66 ft) Radius

- establish grid from 4 Corners

* Collect Benchmark UTM + Elev @ Northport Boat Launch

* Grain Size Sands (0.5 to 2mm)

* Steel Shovel, see QAPP Decon

* Remove Top 4 in (10.16 cm)

Collect 4 to 12 in (10-31 cm)

No samples below (12 in) or (31 cm)

14

TAI

Location Teck American Inc Date 5/27/10 (1)

Project / Client UCR Deadman's Eddy

White Sturgeon - Methods - Sediments

0840 Arrive @ site
D

Attendees
Sarah McDaniel, URS
Steve Demus, CH2MHill
Joe Wickman
Alan Burkhart, Columbia Nav.
Eric Neeltermon, Columbia Nav.

Establish BM for UTM / Elev.
Zone 11, NAD83
Elev. ~~402~~ meters 411 M
5419055 N, 443452 E

Photos Take 1st 2 Photos.
TAI-DME 5_27_2010 IMG_0001 to 0002

Safety Meeting
Boat Setup
Slips Trip & Falls
PF Devices

GPS Unit - Magellan Triton (Hand-held)

15

Location UCR Deadman's Date 5/27/10 (2)

Project / Client Eddy TAI

White Sturgeon Methods - Sediment

0910 - Leave dock for DME
0940 - Arrive @ DME Sandbar. Landed on cut / current northeast sampling area. Beached craft on sand @ water's edge. 397
Appr. Water Elev. GPS ~~401~~ m
0955 Stake out NE Corner
@ N 5421097, 447058E

1010 Stake out SE Corner
@ 5421068, 447077 E
395 m elev.

1020 Stake @ SW Corner
N5421127, 447023, 395m

1030 Stake @ NW Corner m
5421144, 447026, 398 Elev

Photos DME 5_27_2010 IMG_0003 - IMG_0020

Location UCR Date 5/27/10

Project / Client Deadmon's Eddy TAI

White Sturgeon Methods - Sediment (3)

General Photos - Views From Approx midale crew

— Sarah McD @ center of sampling area (where photos shot from)

1 — Picture to NE Δ from center

2 — Photo to SE Δ from center

3 Photo to SW & NW

Photos

TAI - DnE 5_27_2010 IMG_0003 to IMG_0020

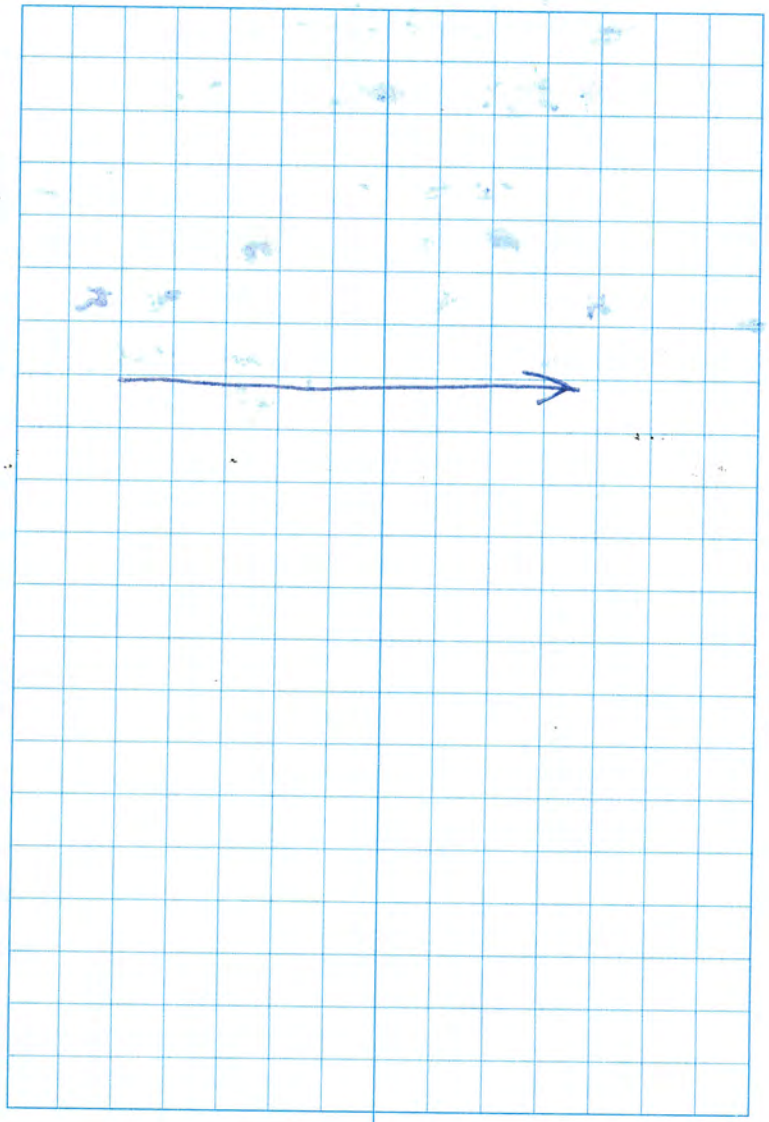
GPS Unit - Magellan, hand held.

— Variable elevation readings observed, not consistent with topography

Location UCR Date 5/27/10

Project / Client Deadmon's Eddy TAI

White Sturgeon methods - sediments 4

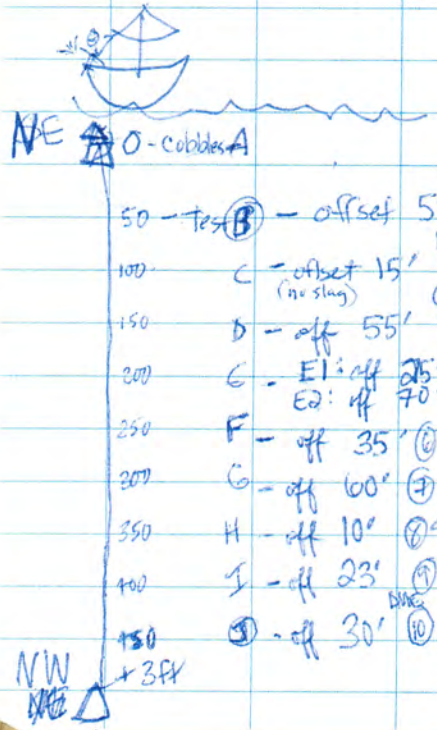


Location UCR Deadman's Eddy Date 5/27/10

Project / Client TAI

White Sturgeon Methods - Sediment (5)

String line set up between NE Δ and NW Δ as reference line - logical place between sand bar & rock bar to set line, then systematic interval of 50 ft intervals measured out Total length of line: 453 ft.



Location UCR Deadman's Eddy Date 5/27/10

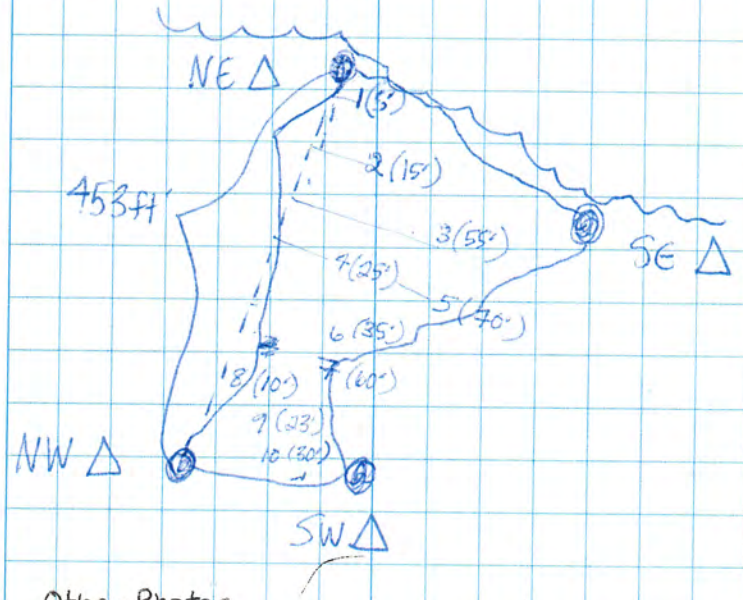
Project / Client TAI

White Sturgeon Methods - Sediment (6)

Complete Transect layout & station markings. Photos TAI-DME 5_27_2010 IMG_0021-0024

1115 Decon buckets w/ alconox, DI, Alcohol Photos TAI-DME5_27_2010 IMG_0025 to 0027

1120 Search to start layout of LO grab sample points based on station points



Other Photos

Site TAI-DME5_27_2010 IMG_0028-0032

Samples TAI-DME5-27_2010 IMG_0033-0091

-See fieldlogs for specific photos

Location UCR Deadmen's Eddy Date 5/27/10

Project / Client TAI

White Sturgeon Methods - Sediments (7)

Weather conditions - change throughout session from 55°F and cloudy to increasing rain. Steady rain continues thru to end of sampling

1435 - leave site, head for Northport Boat Launch. Unload buckets & gear into truck.

1515 - Leave for Spokane

Note: Fieldsheets/logs prepared for each 10 grabs sampled, included descriptions, sample numbers, UTM coordinates etc.

Location UCR Deadmen's Eddy Date 5/27/10

Project / Client TAI (8)

White Sturgeon Methods - Sediments

1815 - Return to Spokane, complete sample QA/QC and C of C for delivery to TAI

Container No.	Sample Time
DME-1	1217
DME-2	1235
DME-3	1305
DME-4	1315
DME-5	1325
DME-6	1335
DME-7	1350
DME-8	1400
DME-9	1415
DME-10	1421

* C of C No. DME-COC-001

1850 Finish demob for day

Jeffrey E. Leppo

ATTACHMENT D
Photographic Record
Provided on Compact Disc (CD)

ATTACHMENT E
Archaeological Monitoring Results

URS

MEMORANDUM

TO:	Marko Adzic, Teck American Incorporated
FROM:	Sarah McDaniel, RPA
DATE:	June 23, 2010
FILE:	36310054.00002
SUBJECT:	Archaeological Monitoring Results, On-Shore Sediment Sampling - Deadman's Eddy, Upper Columbia River, Stevens County, Washington Methods Development for the White Sturgeon Sediment Toxicity Study

Introduction

URS Corporation (URS) conducted field services for Teck American Incorporated (Teck) along the Upper Columbia River (UCR) at Deadman's Eddy (DME). Specifically, on-shore sediment samples were collected from the gravel bar at Deadman's Eddy located in Stevens County, Washington, on May 27, 2010. The field services scope of work was based on the requirements and standard operating procedures (SOPs) outlined within the *Quality Assurance Project Plan – Methods Development for the White Sturgeon Sediment Toxicity Study* (QAPP) prepared for Teck in April 2010 and as approved by the U.S. Environmental Protection Agency (EPA). This cultural resource monitoring report has been prepared in support of the above-mentioned work and is consistent with the protocols outlined in Appendix C Cultural Resources Coordination Plan of the aforementioned approved QAPP.

As per the QAPP, archaeological monitoring of ground-disturbing activities was conducted by a qualified archaeologist meeting the Secretary of Interior's Professional Qualification Standards (as outlined in 36 CFR Part 61). This memorandum documents results of the monitoring that occurred on May 27, 2010, by URS archaeologist Sarah McDaniel, Registered Professional Archeologist (RPA) in conjunction with the on-shore sediment sampling. No cultural resources were identified or disturbed as a result of this investigation.

Location

The DME project site is located along the Columbia River (River Mile 738.5), about two miles northeast of the town of Northport, Washington, in Stevens County. The sampling area is found in Section 26, Township 39 ½ North, Range 40 East, on the USGS 7.5' Series Boundary, Washington quadrangle (Figure 1). The DME location is identified within the QAPP (April 2010) and delineated within four coordinates under the Universal Transverse Mercator (UTM) system using North American Datum for 1983 (NAD83, Zone 11). The four UTM corner coordinates are identified as:

- Northeast Corner –Easting (447158), Northing (5421097)
- Southeast Corner –Easting (447077), Northing (5421068)
- Southwest Corner –Easting (447023), Northing (5421127)
- Northwest Corner –Easting (447026), Northing (5421144)

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Spokane, WA 99212-2722
Tel: 509.928.4413
Fax: 509.928.4415

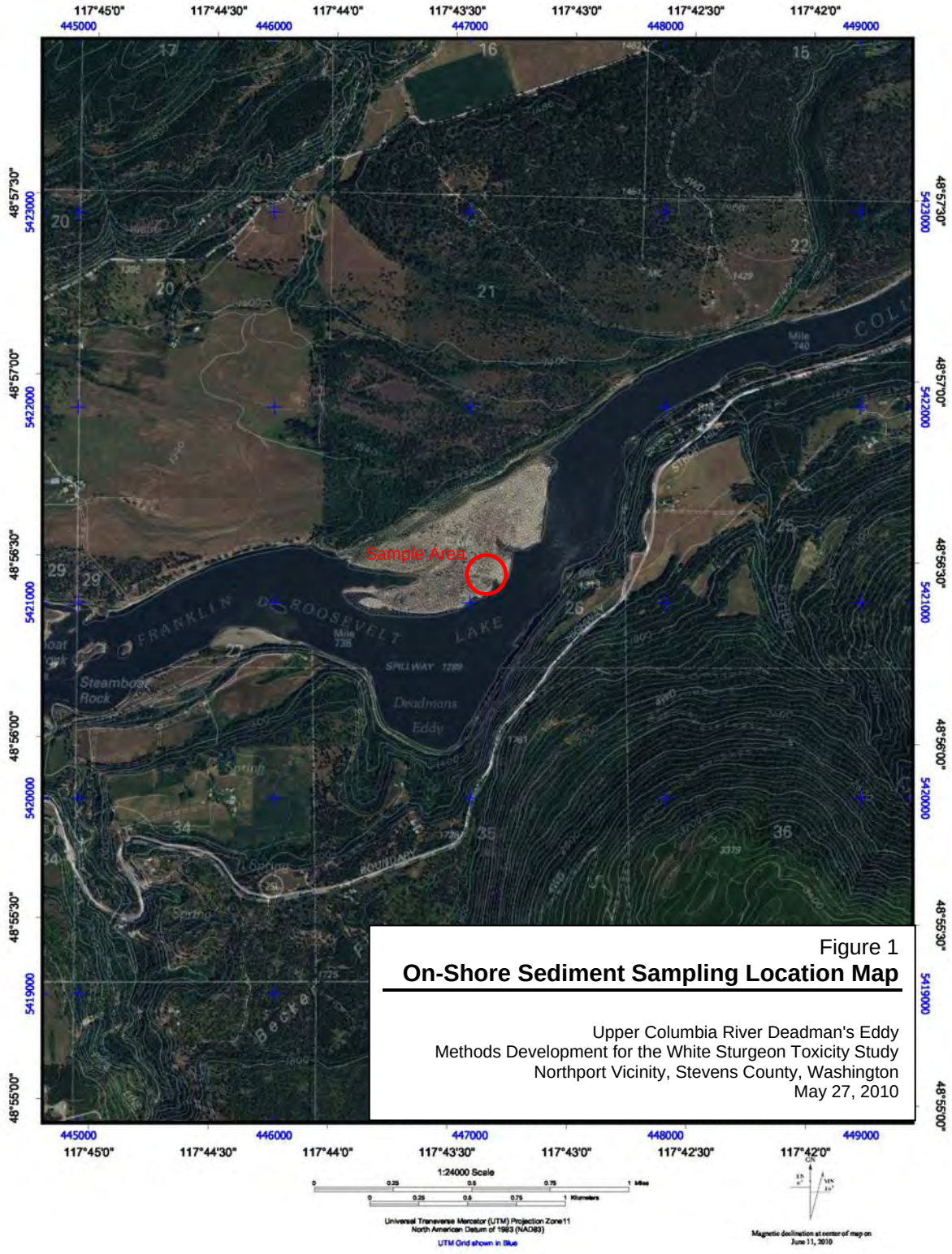

Figure 1
On-Shore Sediment Sampling Location Map

Upper Columbia River Deadman's Eddy
Methods Development for the White Sturgeon Toxicity Study
Northport Vicinity, Stevens County, Washington
May 27, 2010

Background Research

Prior to the fieldwork, a records search was conducted by URS to identify any previously recorded archaeological sites, historic resources, or cultural surveys within one mile radius of the project Area. The May 2010 search was conducted via the online Washington State Department of Archaeology and Historic Preservation (DAHP) Washington Information System for Architectural and Archaeological Records Data (WISAARD) database. This restricted-access, searchable GIS database depicts locations of the following: 1) previously-recorded archaeological sites, 2) cultural resource surveys conducted after 1995, 3) historic register properties, and 4) cemeteries. Regional ethnographic, historic, and archaeological references were also consulted as part of this pre-field review.

General sensitivity of the sampling area is high based on the quantity of archaeological sites that can be found along this stretch of the UCR. Results of the records search indicate that there are two archaeological sites (45ST89 and 45ST90) located over 0.25 mile to the east and to the west, respectively, of the DME sampling area; but none are known to be present within the sampling area. Previously-recorded site types include pre-contact period resources, such as shell, bone, caches, sweatlodges, hearths, and stone tool materials, as well as historic period resources related to mining and homesteading. These sites appear to be found at slightly higher elevations than the project site, which is seasonally inundated by the Columbia River, but are often found eroding into the Columbia River.

Ethnographic literature (e.g., Bouchard and Kennedy 1979, 1984; Kennedy and Bouchard 1998; Pearkes 2002) does not indicate specific place-names for the project site, but describes a number of ethnogeographic locales in this general area. For example, a small Lakes village was reportedly located about three miles upriver from Northport, which would put it in the vicinity of the project site. The project site may also be at or near the locale of an "aboriginal campsite," described as being located "northeast from the gravel bar immediately upriver from Nigger Creek and across the river from Deadmans Eddy", which was occupied until around 1910 (Bouchard and Kennedy 1979:320; Chance 1967:77). Clair Hunt's Homesteaders Map of the North Half of the Colville Indian Reservation (http://content.wsulibs.wsu.edu/u?/maps,720), dated 1900, depicts the locations of several Indian allotments along the west side of the Columbia River in the area of Nigger Creek and the project site. In sum, ethnographic and historic references indicate the project site, which falls within ceded North Half of the Colville Indian Reservation, has been used by ancestral to contemporary Lakes and Colville peoples and could contain evidence of this prior use, especially as related to fishing or habitation activities. Historic use of the area could also be found as related to mining and homesteading activities.

Field Methods

One the day of the site visit, project observers, including boat operators and environmental representatives, were advised of the potential for archaeological resources and to avoid contact with any such resources should they be encountered. As some of the individuals are local residents and familiar with the history of this area, URS asked if any were aware of the presence of potential cultural resources or the origin of the name "Deadman's Eddy." Eric Weatherman, of Columbia Navigation Inc., believed the name has something to do with an historic train derailment, but was uncertain as to the accuracy of this information (personal communication, May 27, 2010). Technical Advisor for Citizens for a Clean Columbia Joe Wichmann, Ph.D., stated that the gravel bar on which the project sampling occurred had

been altered by historic mining activities (personal communication, May 27, 2010). None of the individuals questioned knew of any specific cultural resource concerns within the project site.

The DME location is on the west side of the Columbia River and is a depositional sediment bar composed primarily of sands, gravels, cobbles and boulders. Within this area, 10 grab sample points were collected at 50-foot intervals. At each sample point, a 5-gallon bucket was filled by a URS geologist using a shovel, within an area previously-approved for sampling in the QAPP. Coordinates of the samples were plotted under the UTM system using North American Datum for 1983 (NAD83) (Table 1), as shown in Map 1, Sediment Sample Locations.

Individual grab sample points were visually inspected for any evidence of cultural resources prior to any sampling. Sediment removed for sampling was also visually inspected by the archaeologist during ground disturbance. As outlined within the approved QAPP, the hand excavation removed the upper 4 inches (10 centimeters) of sediment to access the underlying sample area, and grab samples were generally collected between 4 and 12 inches (30 centimeters) below the ground surface. The presence of buried cobbles and boulders was observed at several locations, with the sand sediments collected above these materials. Depth of the shovel sampling did not exceed 12 inches.

Table 1. Grab Sample Locations Coordinates.

Northing (UTM-NAD83)	Easting (UTM-NAD83)	Elevation (m)
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5421099	447128	392
5421093	447108	397
5421106	447097	399
5921099	447091	398
5421109	447082	399
5421108	447067	398
5421130	447056	397
5421131	447040	399
5421133	447027	398

Field Observations

The project site is used as a local “party spot” by adolescents, with campfire rings, rubber tires and other modern debris observed across the gravel bar. Two metal artifacts, including a tin cup and unidentifiable metal fragment, were observed near the project site but were not impacted by the sediment removal. The gravel bar that comprises the project site is largely characterized by rounded river cobbles that appear to have been re-deposited as a result of natural riverine forces, and possibly the reported historic mining activities.

The project site is subject to frequent inundation, as evidenced by the overall absence of vegetation and soil development (Photo 1). Sediment consists of black and tan sand deposits (Photo 2) along with river cobbles. No significant cultural resources were observed during the pre-investigation surface examination, and none were encountered during the limited subsurface sediment sampling activities. Additional sediment sampling at this same QAPP locale, using the same techniques of shovel excavation and extending to the same limited depths of about 12 inches, is unlikely to affect any significant, buried resources given the frequent inundation of this landform and the absence of surficial artifacts.

Photo 1. Overview of the Deadman's Eddy sample area, facing south. Lathe at bottom left of photo demarks the northeast corner of the DME sediment sampling area.

Photo 2. Deadman's Eddy sediment sampling methods, facing east.

References

Bouchard, Randy and Dorothy I.D. Kennedy
1979 Ethnogeography of the Franklin D. Roosevelt Lake Area. British Columbia Indian Language Project. Prepared for the Bureau of Reclamation, U.S. Department of the Interior.

1984 Indian Land Use and Occupancy in the Franklin D. Roosevelt Lake Area of Washington State. British Columbia Language Project. Prepared for the Colville Confederated Tribes and the United States Bureau of Reclamation.

Chance, David H.
1967 *Archaeological Survey of Coulee Dam National Recreation Area, Part 2: Spring Draw Down of 1967*. Report of Investigations No. 42. Laboratory of Anthropology, Washington State University, Pullman.

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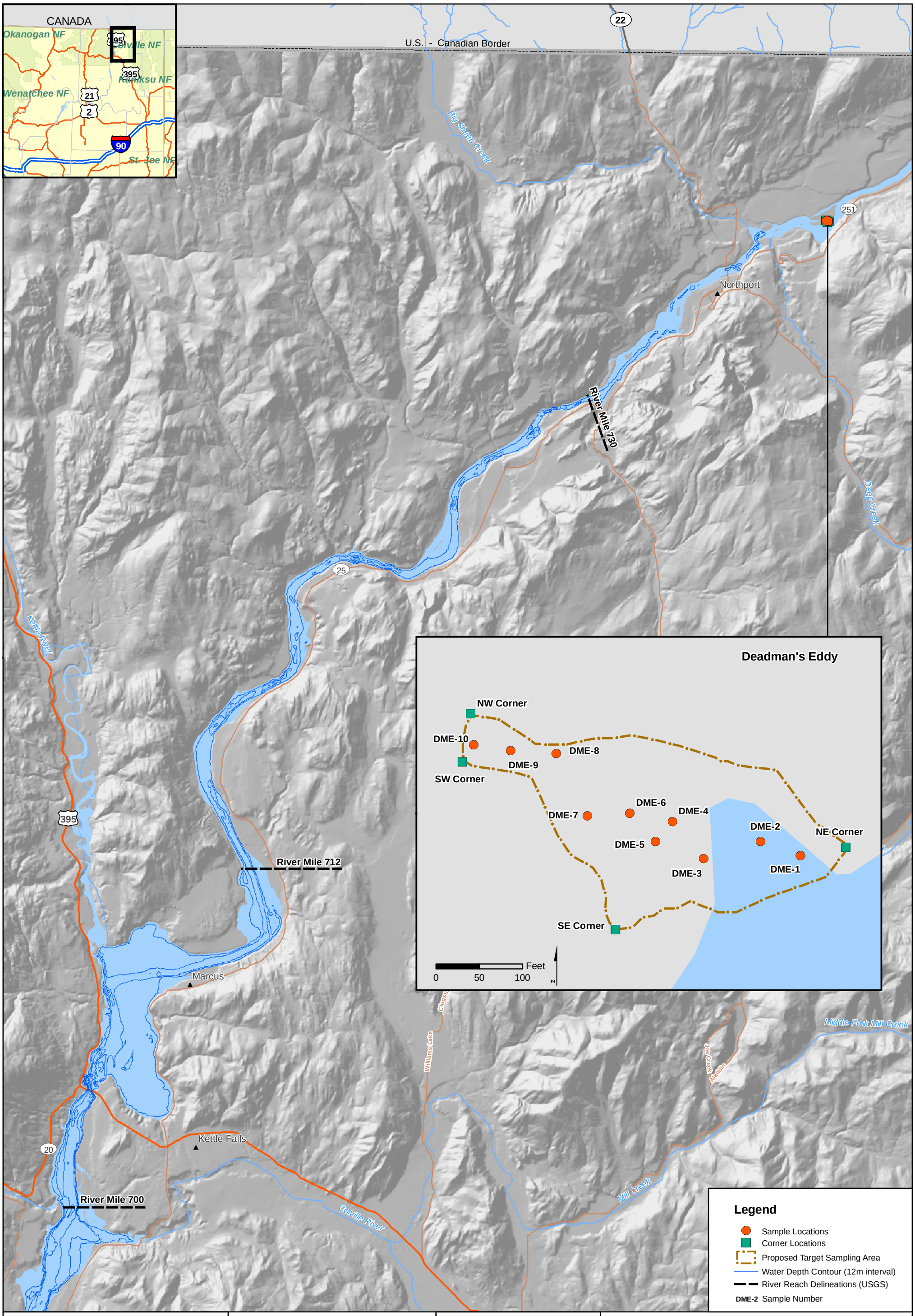
1998 Northern Okanagan, Lakes, and Colville. In *Handbook of North American Indians*, Vol. 12, Plateau, pp. 238-252. William C. Sturtevant, series editor. Smithsonian Institution, Washington, D.C.

Pearkes, Eileen Delehanty
2002 *The Geography of Memory: Recovering Stories of a Landscape's First People*. Kutenai House Press, Wilaw, British Columbia, Canada.



Sediment Sample Locations

Km
0 2.5 5

Miles
0 1.5 3

N

URS Corporation

Source:
GIS base layer Information provided by Parametrix Inc.

Map 1 **Methods Development for the White Sturgeon Sediment Toxicity Study (Deadman's Eddy)**

Upper Columbia River, WA

ATTACHMENT F
Chain-of-Custody

Revenue Canada
Customs and Excise

CANADA CUSTOMS INVOICE

Page 1 of 1

1. Vendor (Name and Address) TECK AMERICAN INC. 501 N RIVERPOINT BLVD SUITE 300 SPOKANE, WA 99202	2. Date of Direct Shipment to Canada MAY 27 , 2010 3. Other References (Include Purchaser's Order No.) SAMPLES FOR TESTING PURPOSES
4. Consignee (Name and Address) TECK METALS LTD. 25 ALDRIDGE AVE. TRAIL, B.C. V1R 4L8	5. Purchaser's Name and Address (if other than Consignee) 6. Country of Transhipment 7. Country of Origin of Goods USA IF SHIPMENT INCLUDES GOODS OF DIFFERENT ORIGINS ENTER ORIGINS AGAINST ITEMS IN 12
8. Transportation: Give Mode and Place of Direct Shipment Canada PRIVATE VEHICLE EX SPOKANE, WA TECK REPRESENTATIVE: MARKO ADZIC	9. Conditions of Sale and Terms of Payment (i.e. Sale, Consignment Shipment, Leased Goods, etc.) NOT SOLD. SAMPLES FOR TESTING PURPOSES 10. Currency of Settlement US DOLLARS

11. No. of Pkgs	12. Specification of Commodities (Kind of Packages, Marks and Numbers, General Description and Characters (i.e. Grade, Quality)	13. Quantity (State Unit)	Selling Price 14. Unit Price	Selling Price 15. Total
10	5 GALLON BUCKETS CONTAINING GRANULATED SLAG/SILICA SEDIMENT SAMPLES 79YT PARS 007471 / TECKCOMINCO METALS **H.S. 2621.90.00.00**	120 KGS.		$10.00 NO COMMERCIAL VALUE. NOT SOLD. VALUE FOR CUSTOMS PURPOSES ONLY.

RELEASED / Dé douane
JUN 01 2010

18. If any of fields 1 to 17 are included on the attached commercial invoice, check this box [ ] Commercial Invoice No. _____	16. Total Weight Net	Gross 120 KGS.	17. Invoice Total $10.00

19. Exporter's Name and Address (if other than Vendor)	20. Originator (Name and Address) TECK METALS LTD. TRAIL, B.C. V1R 4L8
21. Departmental Ruling (if applicable)	22. If fields 23 to 25 are not applicable, check this box [x]

23. If included in field 17 indicate amount:	24. If not included in field 17 indicate amount:	25. Check (if applicable):
(i)Transportation charges, expenses and insurance from the place of direct shipment to Canada	(i)Transportation charges, expenses and insurance to the place of direct shipment to Canada	(i) Royalty payments or subsequent proceeds are paid or payable by the purchaser [ ]
(ii)Costs for construction, erection and assembly incurred after importation into Canada	(ii)Amounts for commissions other than buying commissions	(ii)The purchaser has supplied goods or services for use in the production of these goods [ ]
(iii)Export packing	(iii)Export packing	

TECK COMINCO METALS LTD. TRAIL, B.C. CANADA V1R 4L8

WAREHOUSE SHIPPING INSTRUCTIONS FOR OUTBOUND SHIPMENTS

(THIS FORM MUST ACCOMPANY ALL OUTGOING SHIPMENTS WHEN THE SHIPMENT IS SENT TO THE WAREHOUSE)

teckcominco

SHIP TO:

Company Name: Uof Saskatchewan Toxicology centre Date: June 1, 2010

Street : 44 CAMPUS DRIVE

City : SASKatoon Province: SASK. Attn Markus Hecker

Postal Code: S7N 5B3 Phone No. (306) 966-5733

CONTACT TRAFFIC DEPT. FOR DOCUMENTATION FOR EXPORT SHIPMENTS.

Description of Goods Being Shipped: (Show total weight or volume or dangerous goods in each package)

10 Barrels of sediments on Pallet

1, CHAIN of CUSTODY Required !!

Reason Material Being Shipped:

(Note: Purchasing must be advised of any goods being sent to a supplier. Contact Purchasing if you have any questions.)

Credit Return ☐ Exchange ☐ Repair & Return ☐ Sample ☐ Testing ☒ Warranty ☐

Reason: River Sediment Bio Testing

P.O. Number _____ Supplier Return Authorization No. (or Invoice No.) _____

Buyer Contacted _____ Supplier Contact (Who Authorized Return): _____

Shipping Instructions:

Air ☐ Courier ☐ Mail ☐ Truck ☐ Prepaid ☒ Collect ☐

Approximate Value of Shipment No Commercial Value Charge Code for Prepaid Shipments 1154

IMPORTANT: DANGEROUS GOOD DECLARATION						
Is this material classified under the T.D.G.R. YES ☐ NO ☒	Proper Shipping Name:					
Certain materials are classified as Dangerous goods under the Transportation of Dangerous goods Regulations (T.D.G.R.) and require special packaging, labeling and documentation. Complete the information requested here if the regulations apply to this material.	Major Component - If * N. O. S. **					
	Identification No. (UN, NA of PIN)					
If in doubt, contact Warehouse Shipper, Phone 4975	Primary Class		Sub. Class		Packing Group	

Environment Protection Bill Duncan

PLANT ORIGINATOR (PRINT) ACTIVITY (PRINT)

SIGNATURE OF PLANT ORIGINATOR PHONE NO. 4336

ALL OF ABOVE PORTION OF FORM MUST BE COMPLETED BY ORIGINATOR

Warehouse Remarks (To be completed by Warehouse Personnel)		
Date Shipped:	**Carrier:**	**Way Bill No.**
No. of Cartons:	**Total Weight:** 750 lbs	**Warehouse Shipper:**

WHITE - TRAFFIC COPY **GREEN** - SUPPLIER COPY (INCLUDE WITH OUTBOUND SHIPMENT) **CANARY** - WAREHOUSE COPY

PINK - THIS COPY TO BE RETURNED TO INITIATOR BY WAREHOUSE ONCE SHIPMENT SENT **GOLD** - ACCOUNTS PAYABLE (IF REQUIRED)

URS

CHAIN of CUSTODY

Page 1 of 1

Client: Teck American Incorporated
501 North Riverpoint Blvd, Ste 300
Spokane, WA 99202

Project Manager: Kris McCaig, kris.mccaig@teck.com

Project: Upper Columbia River White Sturgeon Sediment Toxicity Study

Telephone No: 509-459-4451

Fax No: 509-459-4400

P.O #

Lab Turn-around Time: Please refer to project QAPP (April 2010)

DEADMAN'S EDDY - U.S.

Sample I.D.	Container Tag No	No. of Containers	Matrix	Sampling Date	Sampling Time	Analytical / Physical Parameters: Upper Columbia River - Quality Assurance Project Plan Methods Development for the White Sturgeon Sediment Toxicity Study, April 2010		Sample Notes and Comments	Lab ID No.
TAI-US-DME-1-HS -1	DME1	1	Sed	5/27/10	1217	✓			
TAI-US-DME-1-HS -2	DME2	1	Sed	5/27/10	1235	✓			
TAI-US-DME-1-HS -3	DME3	1	Sed	5/27/10	1305	✓			
TAI-US-DME-1-HS -4	DME4	1	Sed	5/27/10	1315	✓			
TAI-US-DME-1-HS -5	DME5	1	Sed	5/27/10	1325	✓			
TAI-US-DME-1-HS -6	DME6	1	Sed	5/27/10	1335	✓			
TAI-US-DME-1-HS -7	DME7	1	Sed	5/27/10	1350	✓			
TAI-US-DME-1-HS -8	DME8	1	Sed	5/27/10	1400	✓			
TAI-US-DME-1-HS -9	DME9	1	Sed	5/27/10	1415	✓			
TAI-US-DME-1-HS -10	DME10	1	Sed	5/27/10	1421	✓			

Custodial Record

	Date	Time
Relinq. by Sampler (Sign & Print Name): Jeffrey E. Lappo	5/28/10	0900
Received by: Alexandra Vermeulen	5/28/10	0900
Relinquished by: Alexandra Vermeulen	6/01/10	10.45 am
Received by: K.S. Page	06/01/10	10:45
Relinquished by:	Date	Time
Received by Laboratory:	Date	Time

Sample Receiving Notes

Unique Chain of Custody No.: DME-COC-001

Laboratory Work Order No.:

URS

MEMORANDUM

TO:	Marko Adzic, Teck American Incorporated
FROM:	Sarah McDaniel, RPA
DATE:	June 23, 2010
FILE:	36310054.00002
SUBJECT:	Archaeological Monitoring Results, On-Shore Sediment Sampling - Deadman's Eddy, Upper Columbia River, Stevens County, Washington Methods Development for the White Sturgeon Sediment Toxicity Study

Introduction

URS Corporation (URS) conducted field services for Teck American Incorporated (Teck) along the Upper Columbia River (UCR) at Deadman's Eddy (DME). Specifically, on-shore sediment samples were collected from the gravel bar at Deadman's Eddy located in Stevens County, Washington, on May 27, 2010. The field services scope of work was based on the requirements and standard operating procedures (SOPs) outlined within the *Quality Assurance Project Plan – Methods Development for the White Sturgeon Sediment Toxicity Study* (QAPP) prepared for Teck in April 2010 and as approved by the U.S. Environmental Protection Agency (EPA). This cultural resource monitoring report has been prepared in support of the above-mentioned work and is consistent with the protocols outlined in Appendix C Cultural Resources Coordination Plan of the aforementioned approved QAPP.

As per the QAPP, archaeological monitoring of ground-disturbing activities was conducted by a qualified archaeologist meeting the Secretary of Interior's Professional Qualification Standards (as outlined in 36 CFR Part 61). This memorandum documents results of the monitoring that occurred on May 27, 2010, by URS archaeologist Sarah McDaniel, Registered Professional Archeologist (RPA) in conjunction with the on-shore sediment sampling. No cultural resources were identified or disturbed as a result of this investigation.

Location

The DME project site is located along the Columbia River (River Mile 738.5), about two miles northeast of the town of Northport, Washington, in Stevens County. The sampling area is found in Section 26, Township 39 ½ North, Range 40 East, on the USGS 7.5' Series Boundary, Washington quadrangle (Figure 1). The DME location is identified within the QAPP (April 2010) and delineated within four coordinates under the Universal Transverse Mercator (UTM) system using North American Datum for 1983 (NAD83, Zone 11). The four UTM corner coordinates are identified as:

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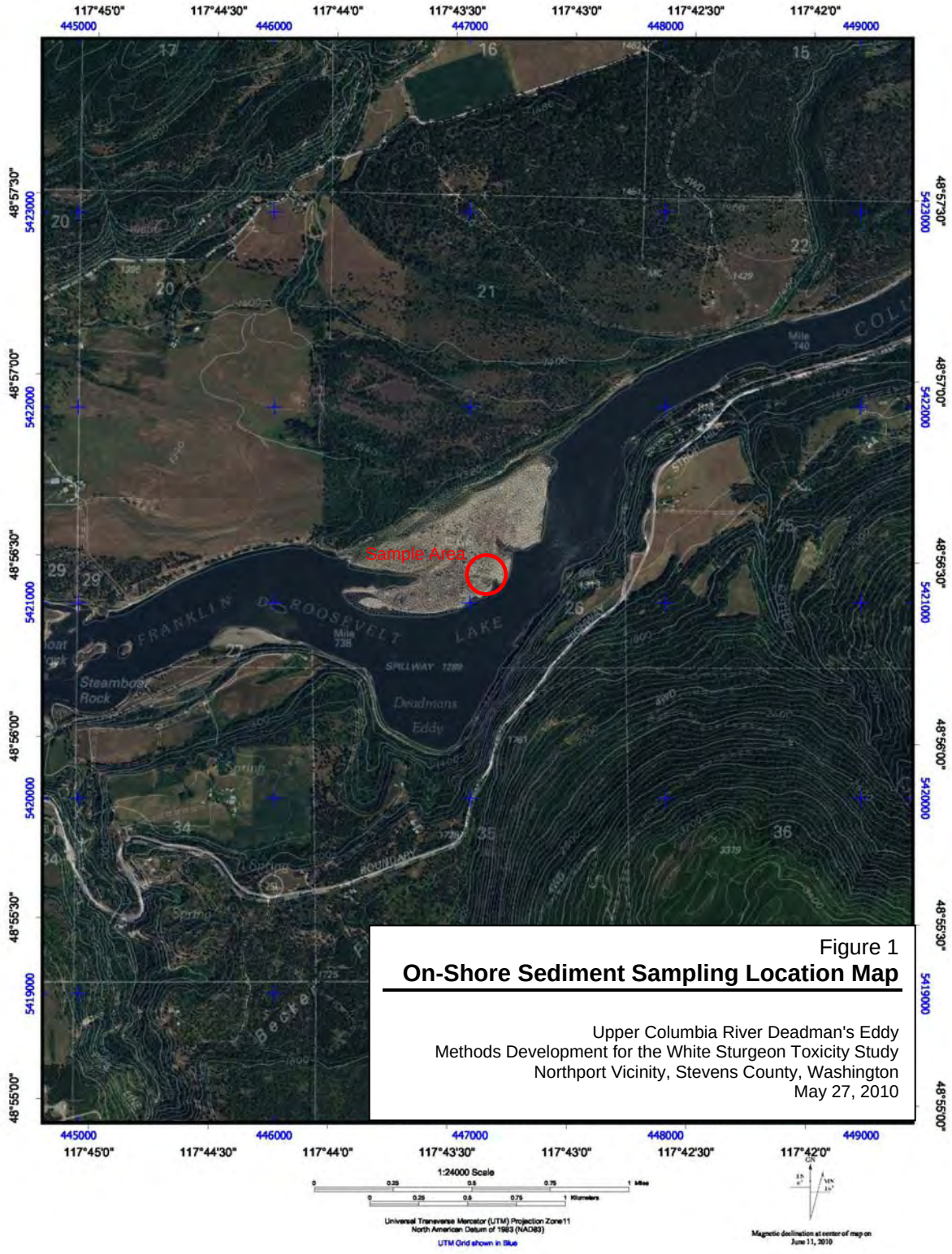

Figure 1
On-Shore Sediment Sampling Location Map

Upper Columbia River Deadman's Eddy
Methods Development for the White Sturgeon Toxicity Study
Northport Vicinity, Stevens County, Washington
May 27, 2010

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Photo 1. Overview of the Deadman's Eddy sample area, facing south. Lathe at bottom left of photo demarks the northeast corner of the DME sediment sampling area.

Photo 2. Deadman's Eddy sediment sampling methods, facing east.

References

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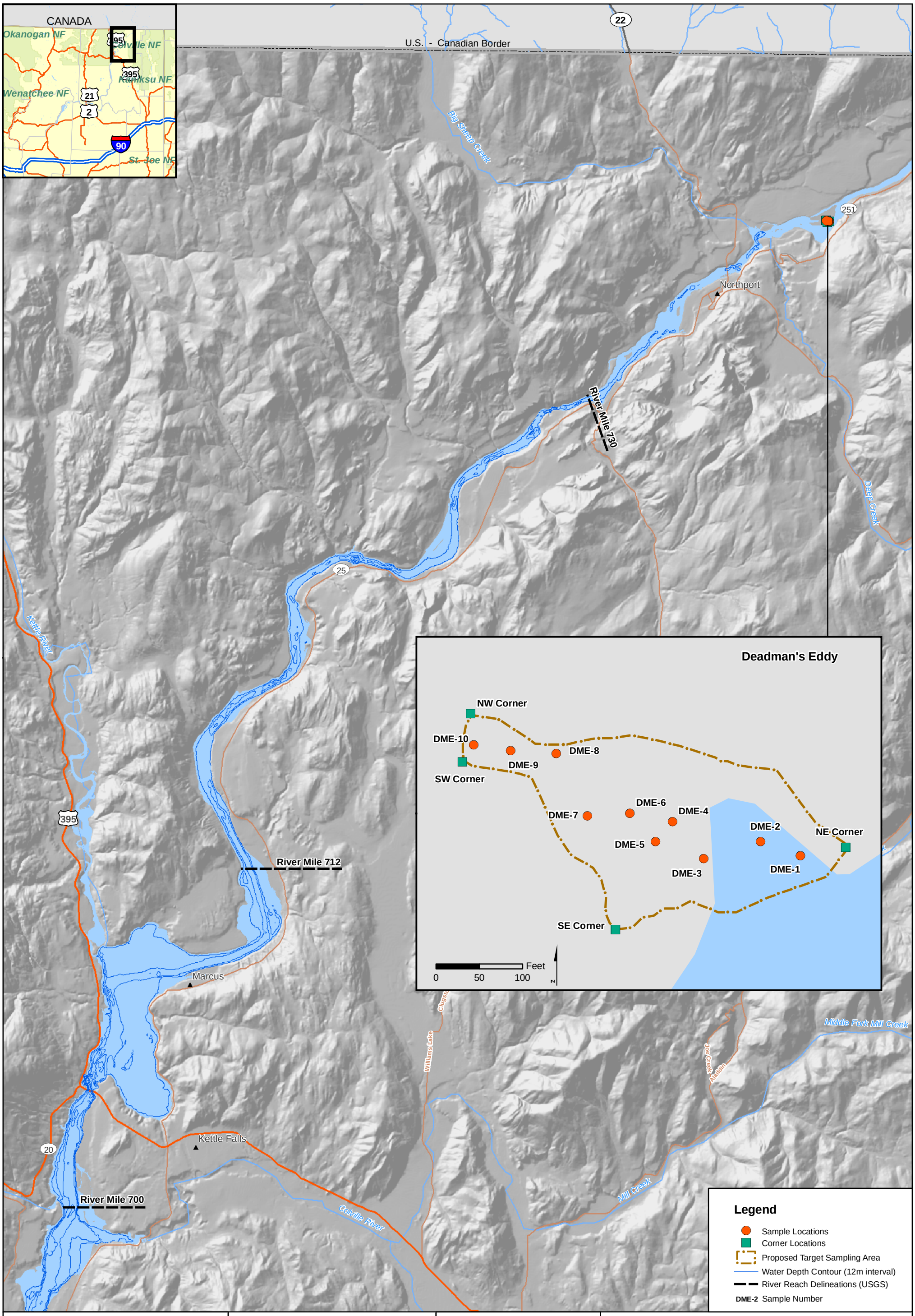

Sediment Sample Locations

Km
0 2.5 5

Miles
0 1.5 3

N

URS Corporation

Source:
GIS base layer Information provided by Parametrix Inc.

Map 1 **Methods Development for the White Sturgeon Sediment Toxicity Study (Deadman's Eddy)**

Upper Columbia River, WA

APPENDIX B

WHITE STURGEON METHODS DEVELOPMENT WORK TECHNICAL MEMORANDUM NO. 2 – METHOD RESULTS AND RECOMMENDATIONS (JULY 9, 2010); INCLUDES APPROVAL LETTER

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 900
Seattle, Washington 98101-3140

July 13, 2010

CERTIFIED MAIL – RETURN RECEIPT REQUESTED

Reply To: ECL-111

Marko Adzic
Teck American Incorporated
501 North Riverpoint Boulevard, Suite 300
Spokane, Washington 99202

RE: UCR Sturgeon Sediment Toxicity Testing – Methods Results and Recommendations

Dear Mr. Adzic,

This letter is in response to a Technical Memorandum, *Sturgeon sediment toxicity testing –methods results and recommendations*, submitted to the United States Environmental Agency (EPA) via email on July 9, 2010. The Technical Memorandum summarizes the results of testing performed to evaluate and establish methodologies for the white sturgeon sediment toxicity program. It also provides information supporting the use of reference sediments collected upstream of the site. The parameters tested and reported upon in the Technical Memorandum are described in detail in the approved April 2010 *Quality Assurance Project Plan, Methods Development for the White Sturgeon Sediment Toxicity Study.*

With this letter, EPA is approving the Technical Memorandum and all of the recommendations for the design of the fluvial chambers that are described within the memorandum. Specifically, EPA approves the recommendations for the following paramaters:

1. Flow condition
2. Gravel volume and distributions
3. Porewater sampling
4. Sediment depth
6. Time to steady-state
7. Cleaning methods
8. Laboratory control sediment

Results for parameter number 5, Gradients between Pore water and Overlying Water, were not presented in the Technical Memorandum. These results should be provided to EPA, as soon as they are available, in a separate submittal.

EPA is also approving the use of reference sediments collected upstream of the site at the Genelle and Lower Arrow Lake sediment sampling stations.

A few outstanding items must be approved by EPA before the toxicity tests can begin. Results for Parameter 5 (see above) must be submitted, along with any resulting recommendations for adjustments in flow. A technical memorandum needs to be submitted for approval that describes the final study design and any adjustments resulting from the collection of fewer samples than planned. Finally, day 8 results from ongoing studies using DGT probes, peepers, and modified pipettes must be used to support a final decision on which devices will be used to collect samples during the full study.

EPA looks forward to resolving these outstanding issues quickly so that the laboratory is ready to begin the tests when the fish start to hatch.

Sincerely,

Helen H Bottcher

Helen Bottcher
Project Manager

cc: Dan Audet, U.S. Department of the Interior
Patti Bailey, Confederated Tribes of the Colville Reservation
Randy Connolly, Spokane Tribe of Indians
John Roland, Washington State Department of Ecology

ENTRIX
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EXTERNAL MEMORANDUM

TO: Helen Bottcher, US EPA Region 10
FROM: Markus Hecker, Ph.D., ENTRIX, Inc.
DATE: July 9, 2010
PROJECT: UCR Sturgeon Sediment Toxicity Testing
SUBJECT: Sturgeon sediment toxicity testing - methods results and recommendations

The overall goal of the herein described and discussed studies was to inform and establish appropriate and relevant methodologies for the sturgeon sediment toxicity test described within the May 2010 *Assessment of Sediment Toxicity to White Sturgeon (Acipenser transmontanus)* QAPP. Specifically, the objectives of this work were to optimize the performance of flow-through fluvial simulation systems and associated exposure chambers, and confirm reference area sediments (including laboratory control sediments). It has to be noted that the information and observations recorded during this work are not be used to inform risk-based management decisions, and they solely are aimed to inform and refine technical elements of future sediment toxicity tests using white sturgeon early life-stages. Tasks associated with this work were divided into two general categories: 1) Fluvial exposure system evaluation, and 2) Reference sediment confirmation.

This summary memo provides recommendations for the design of the fluvial chambers for the definitive sturgeon sediment toxicity study. The following sections summarize the work done during methods development to arrive at this optimized chamber design and verify that reference and control sediments are acceptable for use in the study; details and all data are provided in Appendix A.

Optimized design for exposure chambers

While test systems comparable to those to be utilized as part of this study have been previously employed at the U of S Aquatic Exposure Laboratory to evaluate surface water chronic exposures to fish including white sturgeon, they have not been used or specifically tested for the purpose of conducting flow-through sediment toxicity tests. To ensure that future sediment

toxicity tests using the test species (white sturgeon) are completed successfully, it is important that anticipated system design elements for the fluvial flow through system be tested and evaluated prior to the start of future sediment toxicity testing. Specifically, parameters associated with the design (e.g., depth of sediment, fluvial chamber dimensions and layout, location of sampling devices, artificial control substrate) and operational conditions (e.g., flow rates, porewater sampling depth and volumes, gravel distribution, time to steady-state, cleaning techniques) were to be tested and established to inform the definite study design of the summer 2010 white sturgeon sediment toxicity studies (Table 1). Detailed method descriptions are provided in each of the individual reports provided in Appendix A. A brief summary of the experiments conducted and their objectives is provided here.

Order 1: Flow conditions

Objective: Evaluate and establish homogenous water flow conditions to ensure uniform distribution of influx and within the posterior chamber, and to minimize "dead spaces" at inflow and outflow.

Results and Recommendations: Stable and homogenous flows were achieved at flow rates greater than 17 L/min. It is therefore recommended to initiate work to be performed under the May 2010 *Quality Assurance Project Plan for the Assessment of Sediment Toxicity to White Sturgeon* (*Acipenser transmontanus*) with a flow rate of 20 L/min to accommodate low flow requirement for yolksac larvae, and then increase flow rates to 25 L/min around the time when larvae initiate exogenous feeding, and are large enough to easily withstand these flows. The here proposed flow-rates will result in ground velocities that are less than those occurring in the UCR, and do not impact sediments layered into the chambers (e.g. causing re-suspension).

Order 2: Gravel (stones) volume and distributions

Objective: Indentify the effect of different volumes and distribution of gravel on hydrological conditions in fluvial chambers.

Results and Recommendations: Addition of stones to the fluvial exposure chambers had no impact on flow conditions and little to no impact on water quality. In our experience early life-stages of white sturgeon appear less stressed when provided a refuge under experimental conditions. A density of 4 stones per 100 cm^2 is recommended as the optimal loading density.

Order 3: Porewater sampling (suction device)

Objective: Establish methods for porewater sampling by means of suction (airstones).

Results & Recommendations: To insure that during a sampling event there will be equal drawing of porewater throughout the sediment layer, a minimum of 12 ports should be sampled. A volume of 8-10 mL will be drawn from each port, resulting in a total sample volume of approximately 100 mL, which will be sufficient for the water quality and COPC analyses proposed in the white sturgeon sediment toxicity studies QAPP. Also, given the variation observed at the ports located closest to the in- and outflow of the test chambers, it is proposed to not sample at ports within the first and last 4 inches of the fluvial test systems. This study did not permit the assessment of the influence of the removed sediment volumes on re-equilibration of porewater; however, it is assumed that the proposed withdrawal volume of 100 mL per chamber will not significantly deplete the porewater. This volume is significantly less than the maximum amount that could be removed without detection of dye from overlying water, namely 110 and 80 mL per port using a design of 8 or 16 ports, respectively and two inches of sediment.

Order 4: Sediment Depth

Objective: Establish optimum depth of sediment for ELS sturgeon and to maximize porewater collection.

Results and Recommendations: It is recommended to utilize a sampling depth of 1.5 inches with a total sediment depth of 2 inches, due to the enhanced sampling properties as defined by the large retrievable volumes without ingestion of overlying water when sampling porewater from this depth. Because total depth of sediments did not significantly affect porewater sampling, and considering volume restrictions for certain sediments, it is proposed to use a depth of 2 inches in the definite exposure studies. It also is important to note that volumes of porewater that could be sampled without incorporation of overlying water increased significantly with sediment depths greater than 1 inch, but this was dependent on the depth of airstone installment rather than overall sediment depth

Order 5: Gradients between pore- and overlying water

Objective: Evaluate potential gradients between porewater and overlying water under different hydrological conditions (e.g., flow velocity) using dyed sediments – monitor basic water quality parameters at different sediment depths, and at the sediment-water interface.

Results and Recommendations: To be completed and submitted in a separate memo.

Order 6: Time to steady-state

Objective: The objective is to identify the minimum period of time necessary for the exposure chamber to attain a steady-state based on basic water quality parameters. The objective of this work is not to attain steady-state conditions for chemicals of potential concern (COPCs); but rather, to ensure that non-COPCs do not adversely affect test results (i.e., introduce uncertainty) when organisms are introduced.

Results and Recommendations: A minimum of 48 hours is proposed for allowing sediments to reach steady-state within the fluvial chambers. Temperature, conductivity, dissolved oxygen, pH, colour, and total dissolved solids all reached steady state (<10 percent variation between measurements) within 48 hours. Ammonia and nitrate did not reach steady-state, but this is likely due to the natural variability of these measurements and therefore does not influence the recommended period for equilibration. DOC did not reach steady-state during the 96 hr test period, but the experiment is ongoing to determine if DOC measurements with variability below ±10 percent between measurement events can be achieved.

Order 7: Optimum cleaning techniques

Objective: Identify optimum cleaning techniques avoiding utilization of suction devices, and installment of large particle filters – with and without addition of diet (bloodworms, oligochaetes; semi-moist diet, other).

Results and Recommendations: A modified pipette is proposed as the primary cleaning method for sediment within the exposure chamber. Cleaning by the use of a modified pipette allowed the technician to select and remove unwanted debris from the exposure chamber with minimal disturbance to the sediment. In addition, the risk of injury to fish will be minimized. Siphoning may prove effective when cleaning reservoirs or screens, but only when direct contact with fish and sediment is not involved. The aid of the spatula may prove useful in instances were biofilm is strongly adhere to surfaces, but it is proposed that the spatula be used only as a backup after cleaning with the modified pipette.

Order 8: Artificial laboratory control sediment

Objective: Selection of a laboratory control sediment that has physical characteristics appropriate for ELS of sturgeon and is comparable to sediments used historically in fish early

life stage tests. The purpose of such a sediment is to benchmark this study with other fish early life stage studies reported in the literature to ensure comparability of results.

Results and Recommendations: The Hagen Geosystem Black Fine Gravel (ART #12648) is a suitable laboratory reference control sediment. This sediment is within the required 0.5 to 2 mm grain size with an average grain size of 1.11 mm and a lowest and highest grain size of 0.85 mm and 1.68 mm, respectively. This sediment is predominantly dark in coloration and very similar in appearance to some of the riverine sediments that have been collected. This sediment did not change water quality parameters more than 10% compared to the average water quality parameters measured in test chambers with reference sediments. Analysis by CAS shows this sediment to be free of contamination by all chemicals/metals analyzed.

Deviations to Methods QAPP

During the course of the methods development work, the following deviations from the approach specified in the QAPP or in the subsequent Change Orders occurred (Table 2). None of these deviations, however, were such that they affected addressing the study objectives as set forth in Section A3.1 of the Sturgeon Method Development QAPP. A more detailed description of the different deviations that occurred for some of the experiments are described in the individual reports attached to this memo (Appendix A).

Reference sediment confirmation

Off site sampling locations were selected at putative reference sites (Map 1 and Appendix B). These included re-sampling areas previously used as reference locations. The objective of this task was to evaluate and confirm off site reference area sediments upstream of the Trail facility with sediment characteristics (grain size) similar to that of areas where white sturgeon spawn.

Ten competent grab samples (five gallons each) were obtained from both the Genelle and Lower Arrow Lake locations; for a total of 20 grab samples. The river bottom composition of the Birchbank Eddy was primarily composed of cobble and boulder-sized material. Three attempts were made to collect sediments at this location, but the presence of a course substrate precluded the recovery of a suitable fine to coarse sand matrix so no sample was collected.

Both reference sediments that were retrieved resembled a gravelly sand substrate, which is in accordance with both substrate requirements for successful sturgeon culture and expected sediment composition in the upper reach of the UCR to be tested in the definite sediment toxicity studies with white sturgeon early life-stages. Analysis of the two off-site reference sediments showed all measured metals and organic chemicals are significantly below the

screening ecological values (SEVs; from the Screening Level Ecological Risk Assessment) (see Appendix A, Summary Data Report #8 for data). Therefore, based on both the physical (grain size) and chemical analyses, these sediments are considered valid for use as reference sediments in the definitive sturgeon test.

Table 1. Parameters, Methods, Measurements and Recommendations for the Design of the Exposure Systems and Test Conditions for the 2010 Studies with White Sturgeon ELS to Investigate Sediment Related Toxicity.

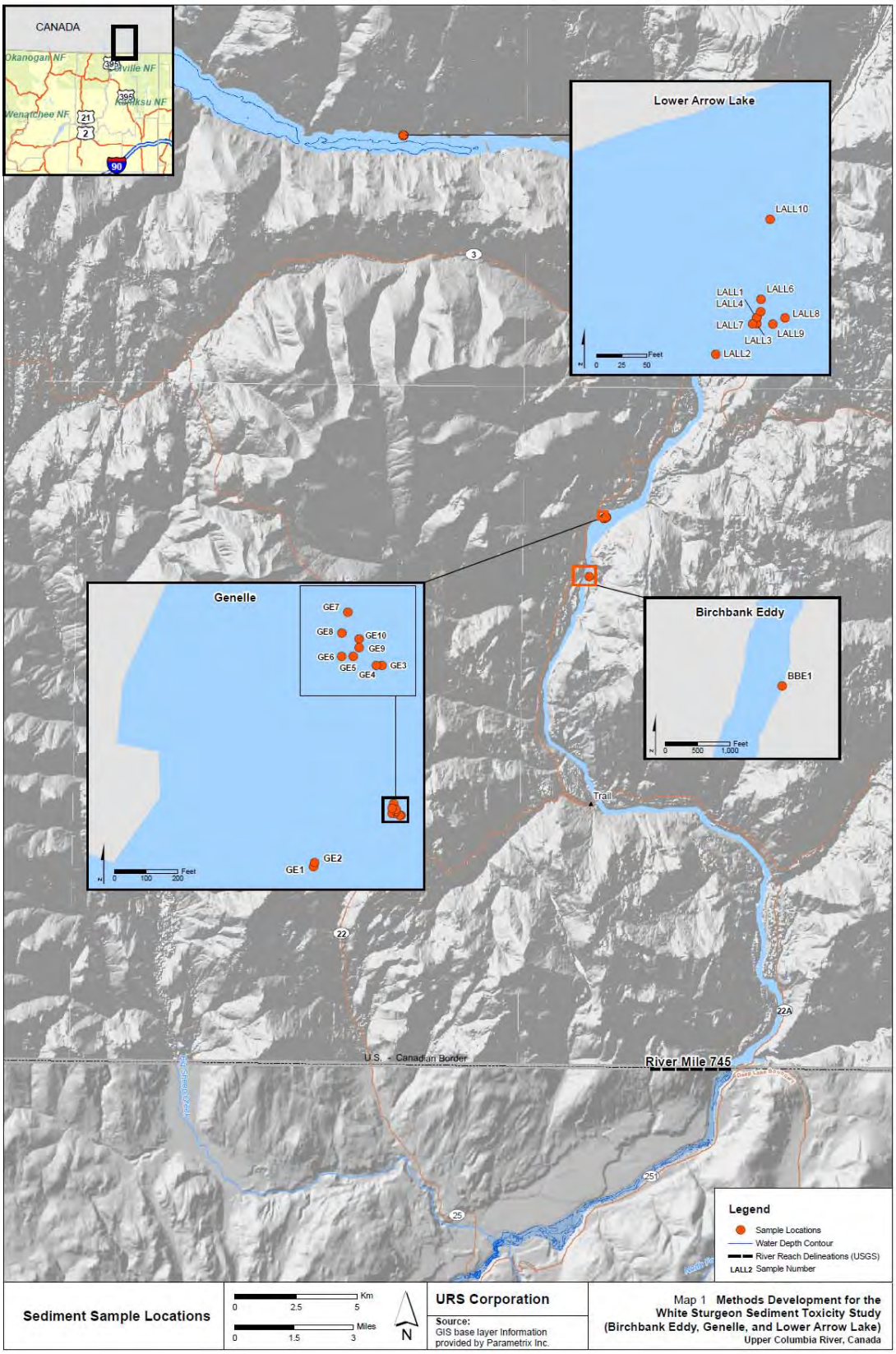
Order	Parameter	Goal	Test Conditions	Measurement	Recommendation
1	Flow condition	Establish parameters and operational conditions that enable the maintenance of homogenous flow conditions in the test system.	Initial flow rate of 19 L/min, with incremental changes of +/- 2 L/min to achieve desired end state	Video record of fluorescein dye movement	Initial flow rate of 20 L/min to accommodate low flow requirement for yolksac larvae, and then increase flow rates to 25 L/min around the time when larvae initiate exogenous feeding
2	Gravel volume and distributions	Establish optimum density of gravel to create pseudo-hyporheic zone	Gravel: 0, 3, 7, 10 and 13 stones per 100 cm_2	Conductivity measurements	4 stones per 100 cm^2
3	Porewater sampling	Establish porewater sampling method	Airstone suction device in different depths of sediment using variable strength and duration of suction (via manual use of syringe). Initial volume to be collected 30 mL, with incremental changes of +/- 5 mL to obtain sufficient sample volume.	Only porewater is collected with no overlying water in the sample • Dye concentration measurements.	12 ports, with a volume of 8-10 mL each; no ports within the first and last 4 inches of the fluvial chamber.
4	Sediment depth	Establish optimum depth of sediment for ELS sturgeon and to maximize porewater collection	Initial depth at 2 inches, with trials of 3 and 4 inches	Porewater sampling at 0.5 and 1 inch and overlying water sampling within the 1 cm of water overlying the sediment • Dye concentration measurements.	Two (2) inches of sediment, with airstones positioned on top of 0.5 inches and below 1.5 inches of sediment

Table 1. (cont.)

Order	Parameter	Goal	Test Conditions	Measurement	Recommendation
5	Gradients between pore- and overlying water	Establish operational conditions that minimize gradients in water quality parameters between pore- and overlying water.	Each flow/sediment depth combination that is tested.	Time-resolved measurements of: • Dye concentration • Conductivity • DOC • pH	To be done.
6	Time to steady-state	Establish operational conditions that minimize time to steady-state.	Characterize time to steady-state between pore- and overlying water after establishing optimal flow and gravel conditions.	Time-resolved measurements of: • Alkalinity • Ammonia • Conductivity • DO • DOC • Hardness • pH	48 hours is sufficient for all parameters, with the exception of DOC which may not reach steady state
7	Cleaning methods	Establish most efficient method for cleaning	Introduce food 3X daily and scrape tanks at days 2, 3, 4 and 5.	Measure turbidity of samples using light scattering methods	Modified pipette, with spatula used to remove biofilm, if necessary
8	Laboratory control sediment	Define clean sediment with characteristics similar to UCR sediments	Research lab controls used in other bioassays Create sediment from clean silica sand and/or granite with grain size 0.5 to 2 mm and preference to dark color	Measure grain size and color	Control sediment: Hagen Geosystem Black Fine Gravel (ART #12648) is sandy, with all analytes below screening ecological values (SEVs). Acceptable for use. Reference sediments from Genelle Eddy and Lower Arrow Lake are gravelly sand, with all analytes below screening ecological values (SEVs). Acceptable for use.

Table 2. Deviations from the procedures described in the 2010 Methods Development for White Sturgeon Sediment Toxicity Study QAPP.

Order	Parameter	Test conditions	Deviation
1	Flow condition	- Water samples taken every 4 inches throughout the chamber for dye quantification; 9 x 9 = 81 samples	- 9 positions throughout water column and three locations (inflow, middle, outflow) were analyzed; 9x3 = 27 samples.
2	Gravel volume and distribution	- Sediments layered 2, 3 and 4" - Stone densities of 0, 3, 7, 10 and 17 per 100cm2 tested	- 4" deemed unnecessary to meet the study objectives ; only 2 and 3" tested; - >7 stones per 100cm^2 not tested; too crowded.
3	Porewater sampling	- Porewater sampling ports will be placed at depths of 0.5 and 1" below the sediment surface for sampling	- 0.5" not tested; too little sediment on top, airstone would be exposed; tested 1, 2, 3, 4 " in static tests, and 1, 1.5" in flow through
4	Sediment depth	- Sediment depth at 2" with trials of 3 and 4" - Porewater sampling at 0.5 and 1"	-4" deemed unnecessary to meet the study objectives ,only 2 and 3" tested; - 0.5" not tested; too little sediment on top, airstone would be exposed; tested 1, 1.5 and 2".
5	Gradients	- Use of dyed sediment - Performed with and without gravel on top - Parameters to be evaluated included dye concentrations, Dissolve Oxygen Concentration, conductivity and pH - High and low velocities to be tested according to flows found in the UCR at DE and MF, respectively.	- Dye not used because dye would not readily seep into sediment; - Only performed with gravel as it was determined that ~4 stones per 100cm^2 will be definite study design; - Dye not used for reasons mentioned above; Dissolve Organic Carbon measure instead of oxygen; - UCR velocities in river too great for WS larvae, tested 17L/min and 25L/min.
6	Time to steady-state	- Table 1 in Amendment #2 indicates that peeper samples will be analyzed for DOC and pH	- Impossible to measure pH and DOC in small volumes recovered from peepers. Included 20 additional min peepers into both water only exposures to obtain sufficient volumes for DOC analyses at two time points (4 and 8 days post initiation of experiment).
7	Cleaning methods	- Avoid use of suction devices and use only spatula to scrap surfaces.	- Spatula did not work; - Siphon method sucked up too much sediment; -Turkey baster worked best; Therefore, proceeded with 5 day measurements - 1 day measurements were done with spatula and siphon methods; video recorded to show problems.
8	Laboratory control sediment	- Vendors will provide certificate of analysis for contaminants.	- Change order form issued to send to CAS for analysis.


CANADA
Okanogan NF
Colville NF
Wenatchee NF
Kaniksu NF
Lower Arrow Lake
LALL10
LALL1
LALL4
LALL6
LALL8
LALL7
LALL3
LALL9
LALL2
Genelle
GE7
GE8
GE10
GE9
GE6
GE5
GE4
GE3
GE1
GE2
Birchbank Eddy
BBE1
Trail
U.S. - Canadian Border
River Mile 745
Legend
Sample Locations
Water Depth Contour
River Reach Delineations (USGS)
LALL2 Sample Number
Sediment Sample Locations
Km
Miles
N
URS Corporation
Source:
GIS base layer information provided by Parametrix Inc.
Map 1 Methods Development for the White Sturgeon Sediment Toxicity Study (Birchbank Eddy, Genelle, and Lower Arrow Lake)
Upper Columbia River, Canada

APPENDIX

Sturgeon Test Methods

Appendix A Data summary reports for:

- Flow condition
- Gravel volume and distribution
- Sediment depth and porewater sampling (airstones)
- Time to steady-state
- Cleaning methods
- Control and reference sediments

Appendix B Field reports for collection of reference sediments

Appendix A Data summary reports for:

- Flow condition
- Gravel volume and distribution
- Sediment depth and porewater sampling (airstones)
- Gradients between porewater and overlying water
- Time to steady-state
- Cleaning methods
- Control and reference sediments

Summary Data Report

Experiment #: 1 **Date:** 5/20/ - 6/27/10 **Expt. Leader:** DV/JD/MH

Title: Determination of Optimum Flow Rate in Fluvial Test Chamber.

Goal:
Evaluate and establish homogenous water flow conditions to ensure uniform distribution of inflow and flow within the posterior chamber, and to minimize "dead spaces" at inflow and outflow of test chamber.

Experimental Design:
A fluorescent dye (Fluorescein) was used to measure water flow; such dyes are cost-effective and easily and accurately measured with a fluorometer and observed with an ultraviolet (UV) lamp. Flow-rates ranging from 5 to 25 L/min were tested in duplicate. After the dye was introduced into the test chamber (t = 0), it was made visible by UV lighting, and dispersal of dye and associated water flows were recorded by means of a digital video camera across the entire chamber. Additionally, at flow rates that appeared acceptable as gauged against the goal of this experiment (i.e., ≥17 L/min), water samples were taken at t = 10 sec (intake), t = 20 sec (middle) and t = 30 sec (outflow) at 3 locations equally distributed over the cross-section of the chamber. This was repeated for cross-sections close to the inflow, centre and outflow of the test chamber, resulting in a total of 3 x 9 = 27 water samples. The first and last sampled cross-sections were located at the inflow and outflow screens of the sediment exposure chamber, respectively, to identify potential dead spaces (see Figure 1). Samples obtained during the second experiment (flow-rates ≥17 L/min) were analyzed for dye concentrations using a microtiter plate fluorescent reader (Polastar Optima, BMG Labtech, Offenburg, Germany), as described in UCR-SOP#13, and dye concentrations were mapped throughout the chamber. Sampling was conducted using 10 mL pipettes modified such that samples could be taken at different depths throughout the chambers. Dye concentration experiments during which water samples for fluorometer quantification were collected were run either in two (17 and 25 L/min) ot three (20 L/min) replicates.

Data Presentation:
Descriptive statistics (mean ± SD) of relative dye intensities. Fluorescence measurements are expressed relative to the maximum fluorescence intensity (FLU) measured during each experiment (FLU/maximum FLU). Assessment and evaluation of water flow conditions within the exposure chamber was also based on visual observations and records (e.g., video).

Results:
The dye experiment revealed a significant impact of flow rate on the uniformity of flow throughout the test chamber (Table 1). Flow rates less than 17 L/min caused uneven flows that were biased towards one side of the test chamber (Figure 2 A&B). Flow rates equal to or greater than 17 L/min resulted in even flows across the chamber both horizontally and vertically (Figure 2 C&D). When measuring dye concentrations using the fluorometer,

there was still some remaining variation at a flow rate of 17 L/min (Figure 3A). At flow rates greater 17 L/min there were only minor differences in fluorescent dye concentrations across sampled cross-sections regardless of the position in the chamber (Figure 3 B&C).

Table 1: *Assessment of flow properties based on video-dye experiment.*

Flow Rate	**Comment**
5 L/min	Uneven flow, too much variability
8 L/min	Uneven flow, too much variability
13 L/min	Difficulties in obtaining acceptable flow conditions
17 L/min	Acceptable flow conditions
20 L/min	Acceptable flow conditions
25 L/min	Acceptable flow conditions

Conclusions:

Stable and homogenous flows were achieved at flow rates greater than 17 L/min. It is therefore recommended to initiate work to be performed under the May 2010 Quality Assurance Project Plan for the Assessment of Sediment Toxicity to White Sturgeon (*Acipenser transmontanus*) with a flow rate of 20 L/min to accommodate low flow requirement for yolksac larvae, and then increase flow rates to 25 L/min around the time when larvae initiate exogenous feeding, and are large enough to easily withstand these flows. The here proposed flow-rates will result in ground velocities that are less than those occurring in the UCR, and do not impact sediments layered into the chambers (e.g. causing re-suspension).

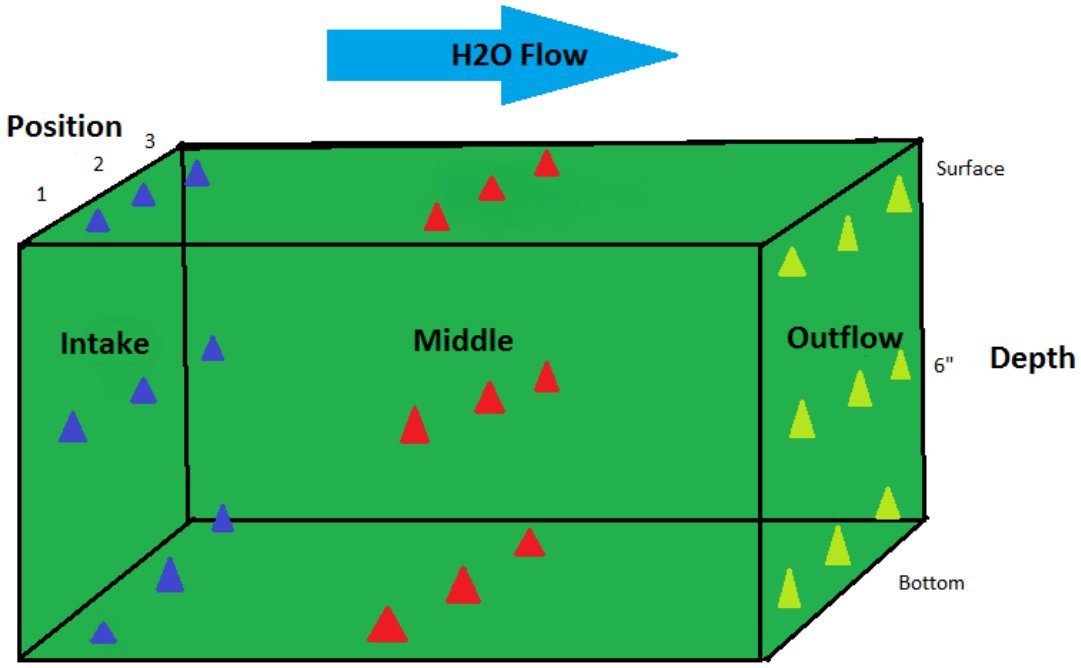


Figure 1: *Illustration of Sampling Point Distribution for Collecting Water Samples Throughout an Exposure Chamber During the Flow Condition Experiment.*

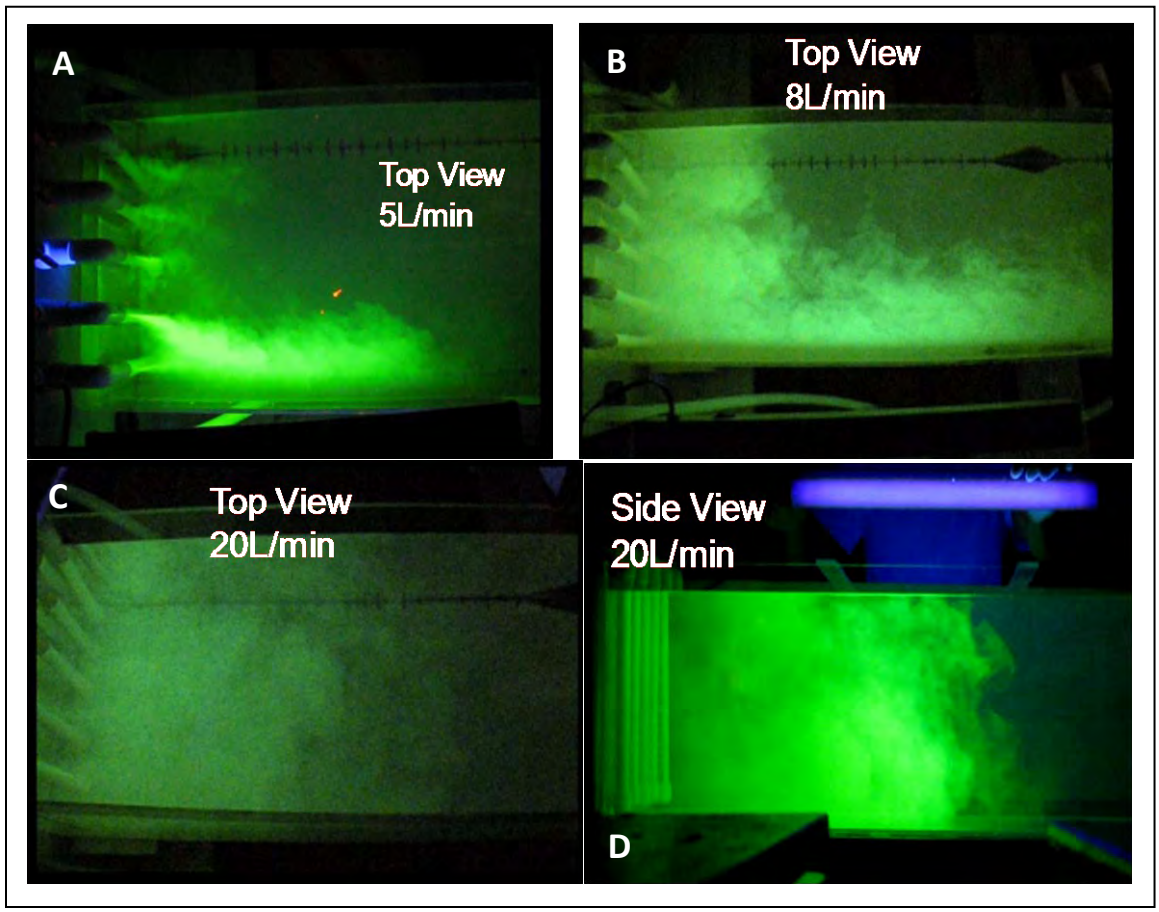


Figure 2: *Photographs of dye distribution in test chamber at low (<17 L/min;* ***A&B****) and high (≥ 17 L/min;* ***C&D****) flow rates.*

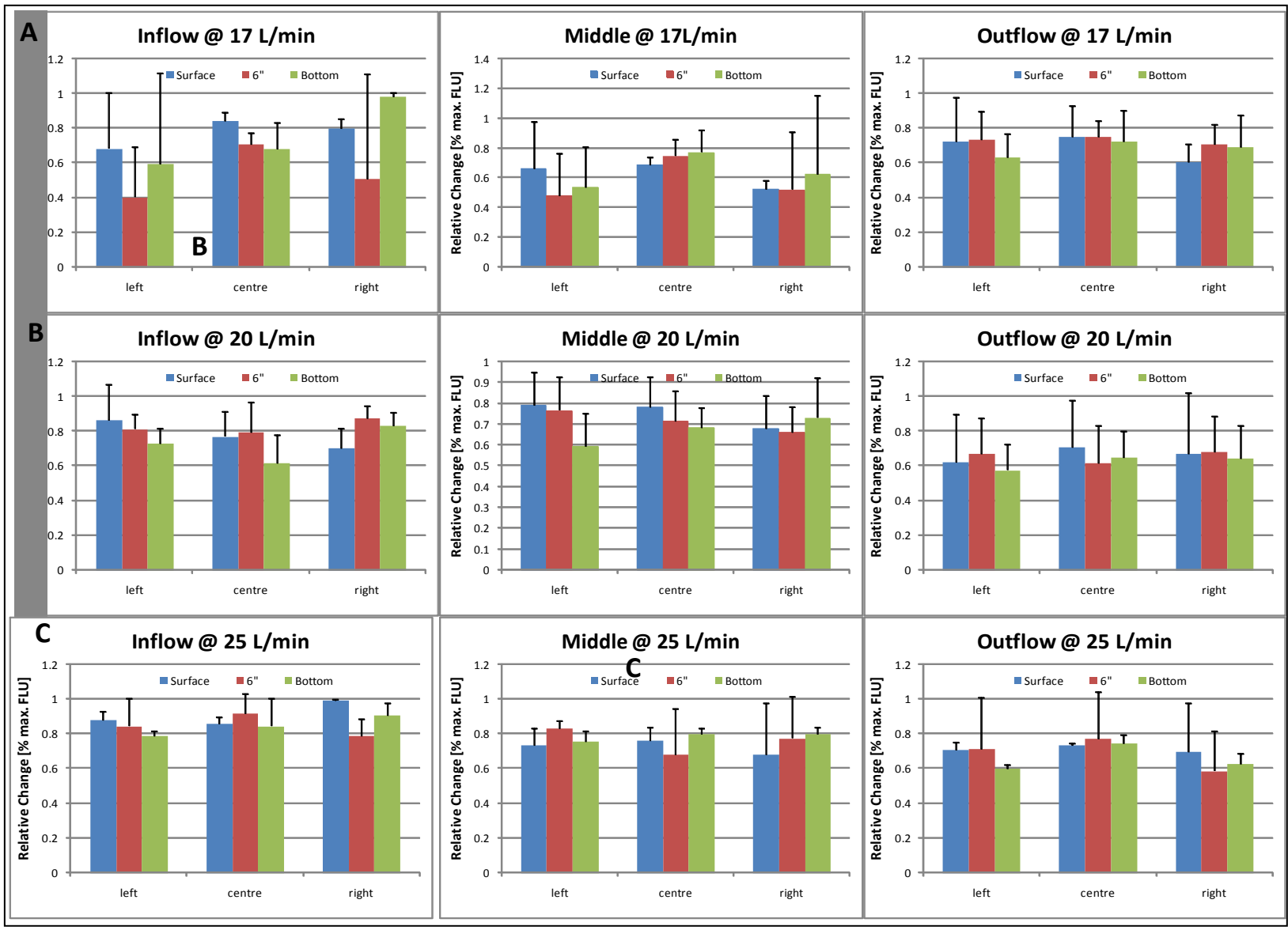


Figure 3: *Mean ± 1SD relative dye concentrations at sampling points in cross sections sampled at the inflow, middle, and outflow of the test chamber at flow rates of 17 (A), 20 (B) and 25 (C) L/min. Cross sectional position in exposure system (viewed from inflow end of test chamber): 1=left; 2=centre; 3=right. Values are expressed relative to the maximum dye concentration measured in the same experiment (maximum dye concentration = 1).*

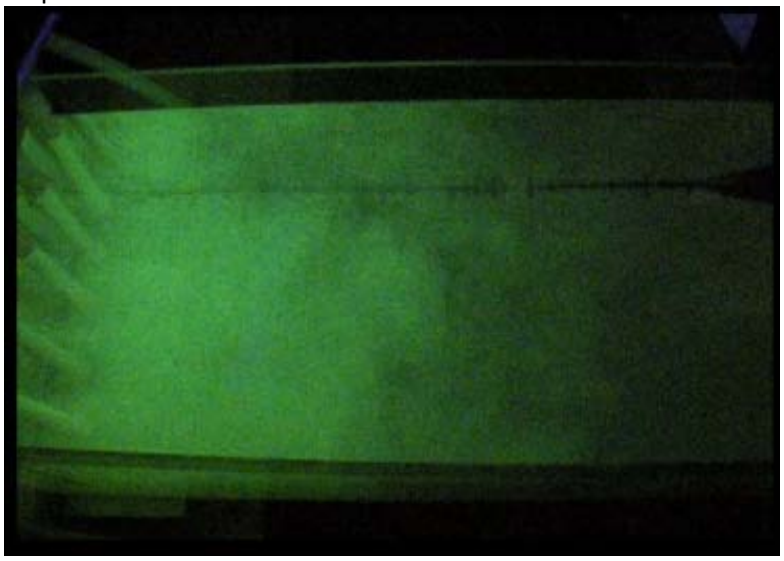
Video Log

Flow Rate	Comments	Side View Video	Top View Video
5L/min	Severe rightward tendency. Vertically even.	Uploaded	Uploaded
5L/min	Equipment malfunction	Lost (hardware failure)	Lost (hardware failure)
8L/min	Strong topward tendency due to backdraft.	Uploaded	Lost (hardware failure)
8L/min	Extreme left and topward tendency.	Uploaded	Uploaded
8L/min	Faster flow tendency for top and left.	Uploaded	Uploaded
8L/min	Severe rightward tendency. Vertically even.	Uploaded	Uploaded
8L/min	Extreme left and topward tendency.	Uploaded	Uploaded
8L/min	Equipment malfunction	Lost (hardware failure)	Lost (hardware failure)
13L/min	Slight left and topward tendency.	Uploaded	Uploaded
13L/min	Equipment malfunction	Lost (hardware failure)	Lost (hardware failure)
17L/min	Slight rightward tendency. Vertically even.	Uploaded	Uploaded
17L/min	Fairly even overall.	Uploaded	Uploaded
17L/min	Slight topward tendency due to backdraft.	Uploaded	Uploaded
17L/min	Vertically even with slight backdraft.	Uploaded	Uploaded
17L/min	Equipment malfunction	Lost (hardware failure)	Lost (hardware failure)
17:/min		Uploaded	Uploaded
19L/min	Fairly even.	Uploaded	Lost (hardware failure)
19L/min	Fairly even.	Uploaded	Uploaded
19L/min	Equipment malfunction	Lost (hardware failure)	Lost (hardware failure)
20L/min	Equipment malfunction	Lost (hardware failure)	Lost (hardware failure)
20L/min	Fairly even.	Uploaded	Lost (hardware failure)
20L/min	Fairly even. Slight topward tendency.	Uploaded	Lost (hardware failure)
20L/min	Vertically even.	Uploaded	Lost (hardware failure)
20L/min	Vertically even.	Uploaded	Lost (hardware failure)
20L/min	Fairly even.	Uploaded	Lost (hardware failure)
20L/min	Vertically even.	none taken	Uploaded
20L/min		Uploaded	Uploaded
20L/min		Uploaded	Uploaded
23L/min	Fairly even.	Uploaded	Uploaded
25L/min		Uploaded	Uploaded
25L/min		Uploaded	Uploaded

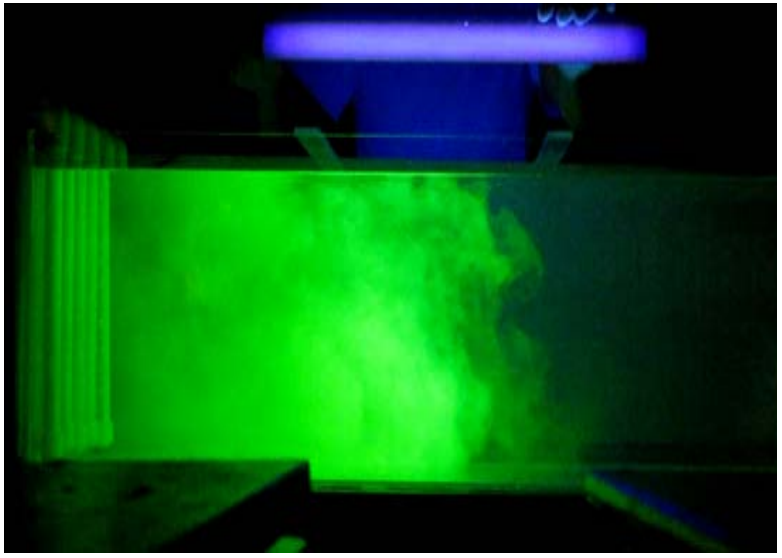
Still Images

20L/min

Top View

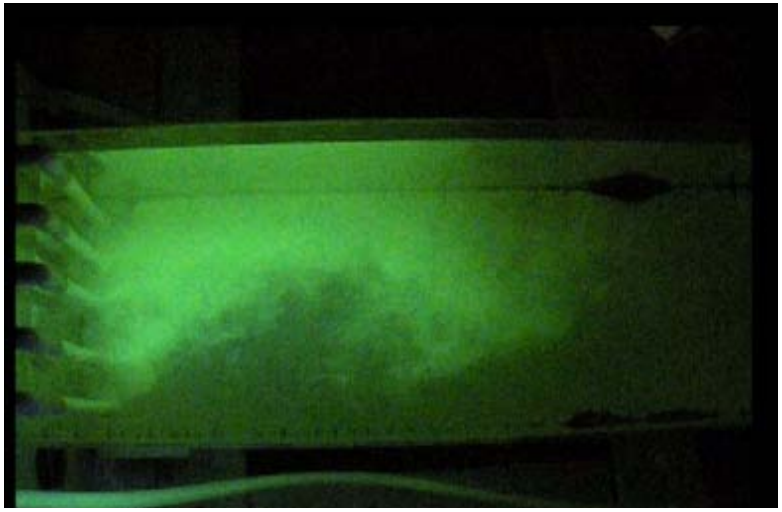


Side View

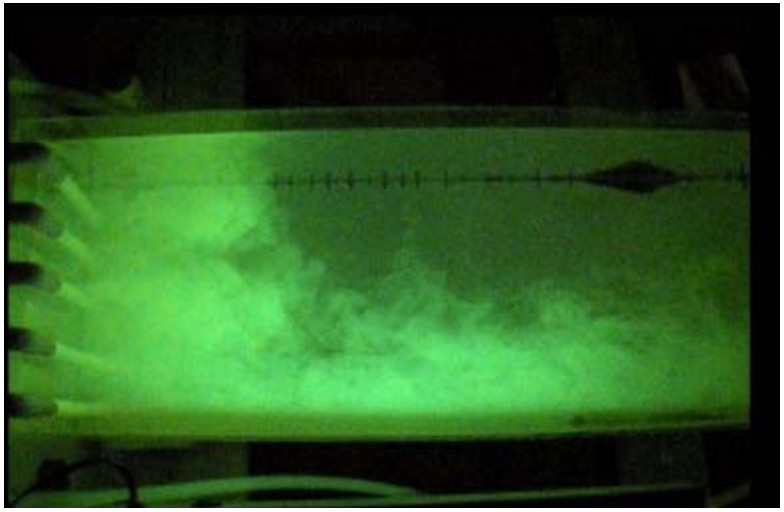


8L/min

Top View

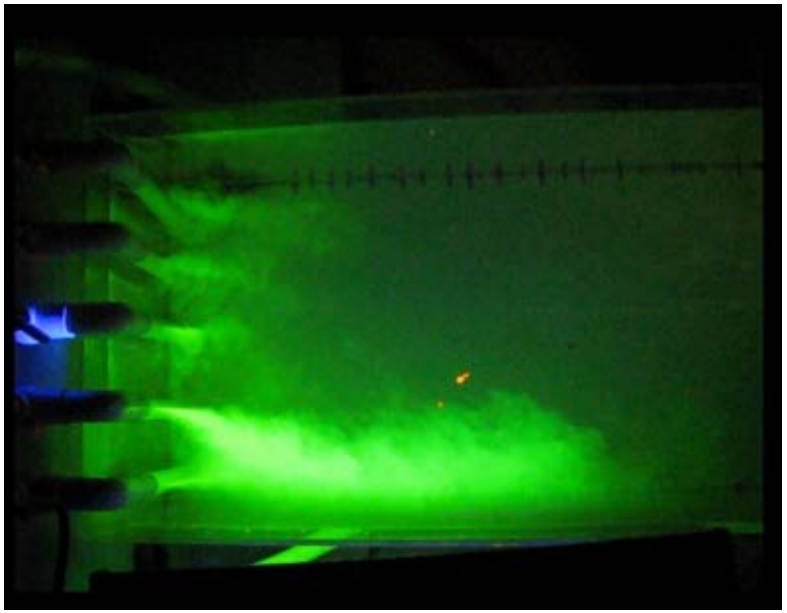


Side View



5L/min

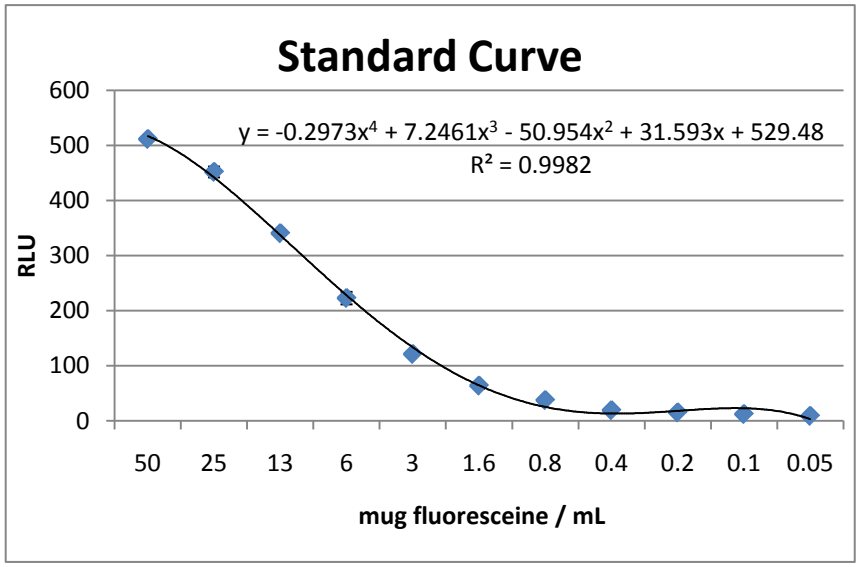
Top View

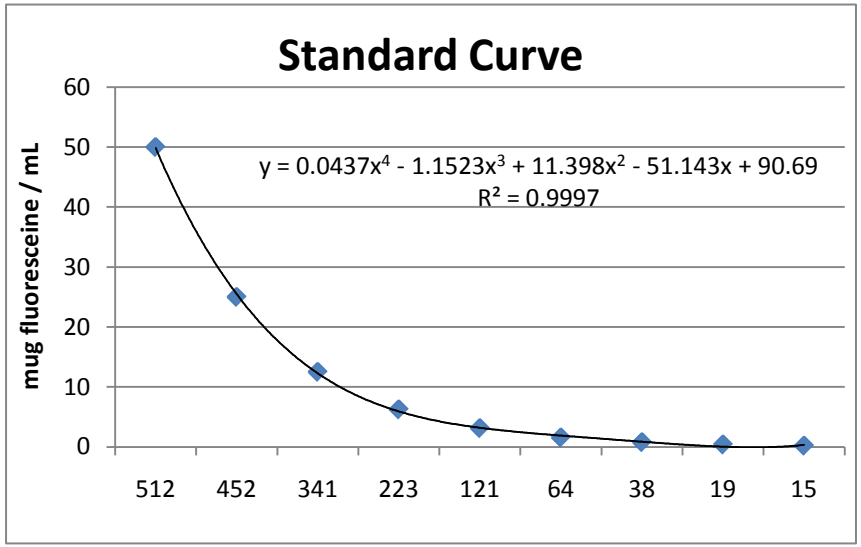


Fluoresceine Standard Curve

Standard curve

	50	25	13	6	3	1.6	0.8	0.4	0.2	0.1	0.05	Blank
A	513	441	340	218	121	63	35	20	15	9	10	9
B	510	455	338	215	121	59	36	17	16	14	9	10
C	512	460	344	236	122	70	42	21	15	14	8	6
AV	512	452	341	223	121	64	38	19	15	12	9	8
SD	2	10	3	11	1	6	4	2	1	3	1	2



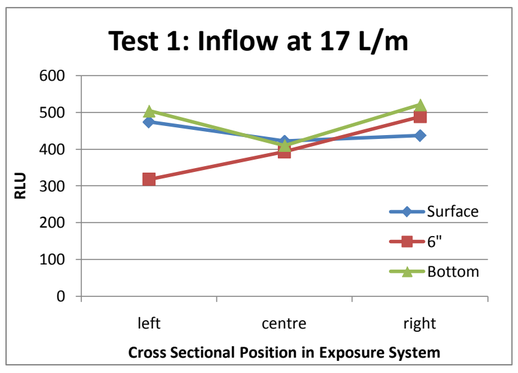


INFLOW

Test one; 17 L/m

Vertical Position	RLUs:	left	centre	right
	Surface	474	422	437
	6"	318	393	488
	Bottom	504	410	521

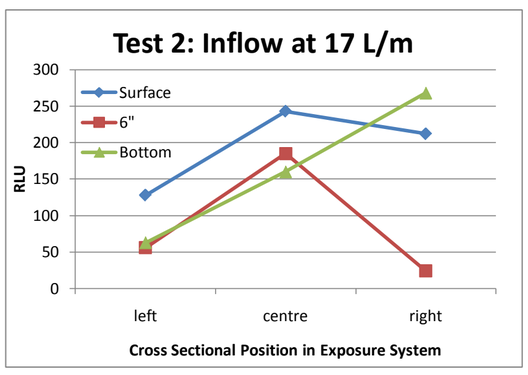
Vertical Position	Rel Change:	left	centre	right
	Surface	0.90978887	0.80998081	0.838772
	6"	0.61036468	0.75431862	0.93666
	Bottom	0.96737044	0.78694818	1



Test two; 17 L/m

Vertical Position	RLUs:	left	centre	right
	Surface	128	243	212
	6"	56	185	24
	Bottom	63	160	268

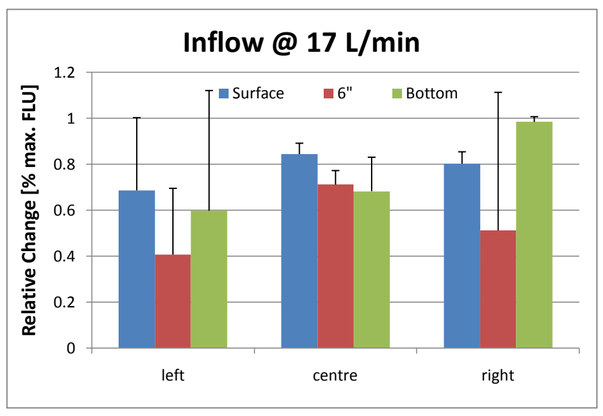
Vertical Position	Rel Change:	left	centre	right
	Surface	0.46209386	0.87725632	0.765343
	6"	0.20216606	0.66787004	0.086643
	Bottom	0.22743682	0.57761733	0.967509



Summary (Relative Change: % max. FLUs); 17 L/m

Vertical Position	Average	left	centre	right
	Surface	0.685941365	0.843618562	0.8020573
	6"	0.406265374	0.711094327	0.5116514
	Bottom	0.597403632	0.682282753	0.9837545

Vertical Position	SD	left	centre	right
	Surface	0.316568174	0.04757097	0.0519219
	6"	0.288640011	0.061128379	0.6010533
	Bottom	0.523212079	0.148019262	0.0229746

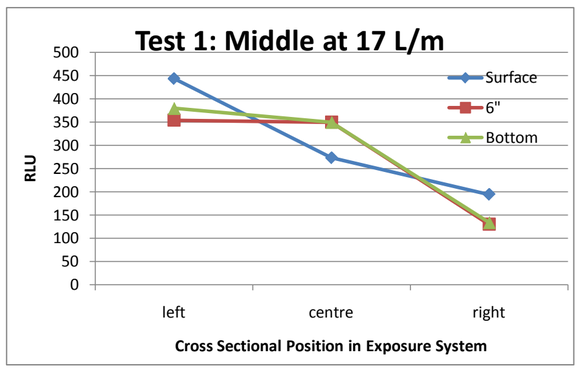


MIDDLE

Test one; 17 L/m

Vertical Position	RLUs:	left	centre	right
	Surface	444	273	194
	6"	354	350	130
	Bottom	380	350	134

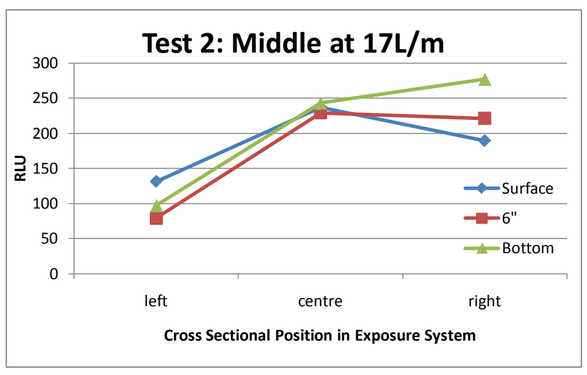
Vertical Position	Rel Change:	left	centre	right
	Surface	0.852207	0.523992	0.372361
	6"	0.679463	0.671785	0.24952
	Bottom	0.729367	0.671785	0.257198



Test two; 17 L/m

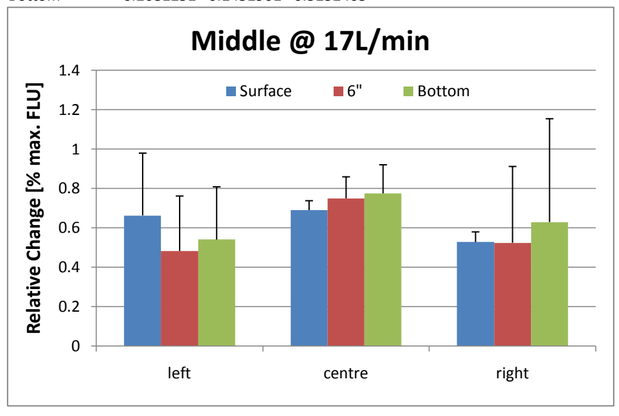
Vertical Position	RLUs:	left	centre	right
	Surface	131	237	189
	6"	79	229	221
	Bottom	97	243	277

Vertical Position	Rel Change:	left	centre	right
	Surface	0.472924	0.855596	0.68231
	6"	0.285199	0.826715	0.797834
	Bottom	0.350181	0.877256	1



Vertical Position	Average	left	centre	right
	Surface	0.6625657	0.689794	0.5273357
	6"	0.4823306	0.7492499	0.523677
	Bottom	0.5397736	0.7745207	0.6285988

Vertical Position	SD	left	centre	right
	Surface	0.2681937	0.234479	0.2191675
	6"	0.2787868	0.1095519	0.3877164
	Bottom	0.2681251	0.1452901	0.5252405

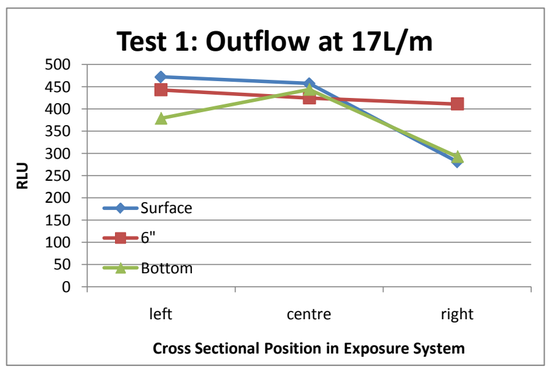


OUTFLOW

Test one; 17 L/m

Vertical Position	RLUs:	left	centre	right
	Surface	472	457	281
	6"	443	425	411
	Bottom	379	444	293

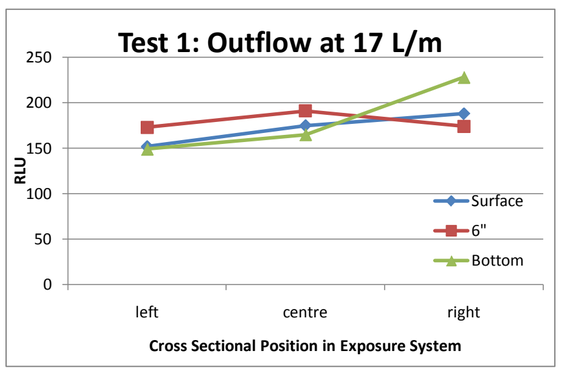
Vertical Position	Rel Change:	left	centre	right
	Surface	0.90595	0.877159	0.539347
	6"	0.850288	0.815739	0.788868
	Bottom	0.727447	0.852207	0.56238



Test two; 17 L/m

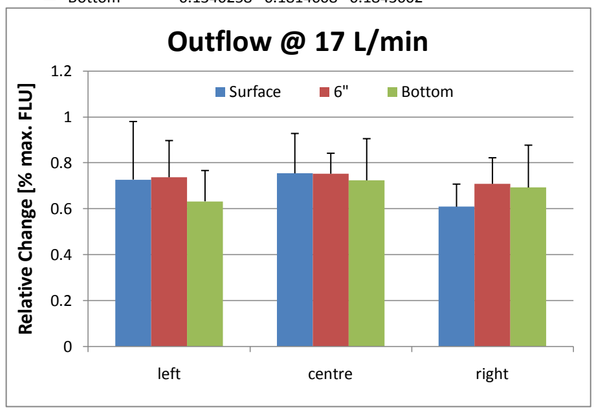
Vertical Position	RLUs:	left	centre	right
	Surface	152	175	188
	6"	173	191	174
	Bottom	149	165	228

Vertical Position	Rel Change:	left	centre	right
	Surface	0.548736	0.631769	0.6787
	6"	0.624549	0.689531	0.628159
	Bottom	0.537906	0.595668	0.823105



Vertical Position	Average	left	centre	right
	Surface	0.7273433	0.7544641	0.6090239
	6"	0.7374183	0.7526348	0.7085132
	Bottom	0.6326767	0.7239376	0.6927424

Vertical Position	SD	left	centre	right
	Surface	0.2525882	0.1735172	0.0985374
	6"	0.1596217	0.0892427	0.1136382
	Bottom	0.1340258	0.1814008	0.1843602

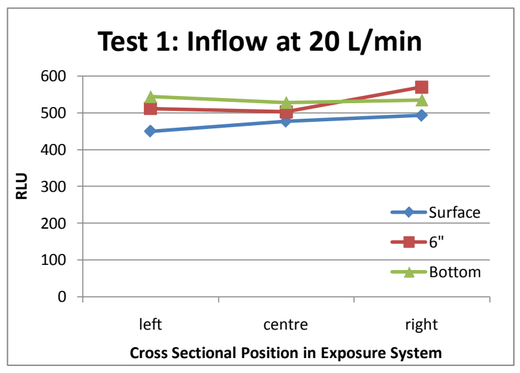


INFLOW

Test one; 17 L/m

Vertical Position	RLUs:	left	centre	right
	Surface	450	477	493
	6"	512	503	570
	Bottom	544	528	535

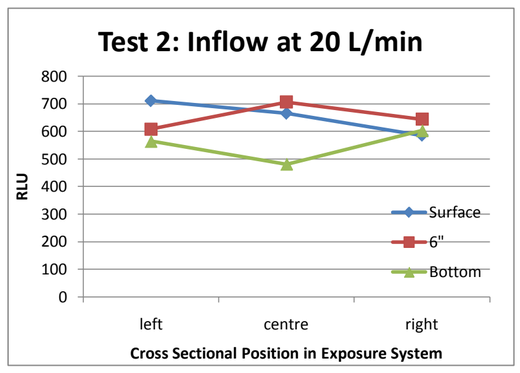
Vertical Position	Rel Change:	left	centre	right
	Surface	0.63291139	0.67088608	0.69339
	6"	0.72011252	0.70745429	0.801688
	Bottom	0.76511955	0.74261603	0.752461



Test two; 17 L/m

Vertical Position	RLUs:	left	centre	right
	Surface	711	665	585
	6"	608	706	644
	Bottom	564	481	603

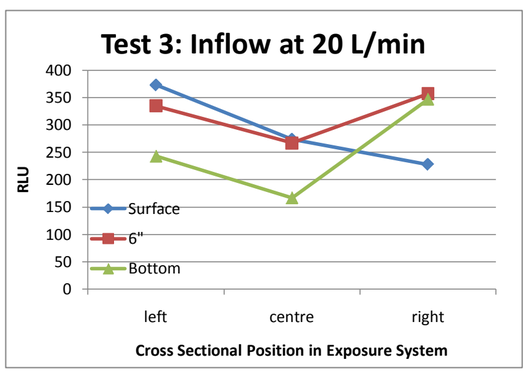
Vertical Position	Rel Change:	left	centre	right
	Surface	1	0.93530239	0.822785
	6"	0.85513361	0.99296765	0.905767
	Bottom	0.79324895	0.67651195	0.848101



Test three; 17 L/m

Vertical Position	RLUs:	left	centre	right
	Surface	373	274	228
	6"	335	267	357
	Bottom	243	167	347

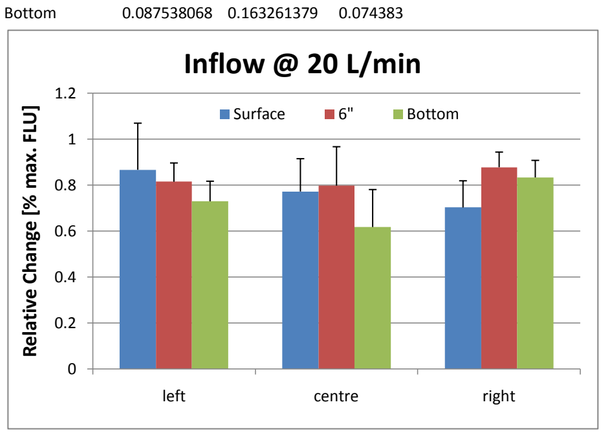
Vertical Position	Rel Change:	left	centre	right
	Surface	0.96632124	0.70984456	0.590674
	6"	0.86787565	0.69170984	0.92487
	Bottom	0.62953368	0.43264249	0.898964



Summary (Relative Change: % max. FLUs); 17 L/m

Vertical Position	Average	left	centre	right
	Surface	0.866410879	0.772011009	0.7022827
	6"	0.814373927	0.797377262	0.8774416
	Bottom	0.729300725	0.617256825	0.8331754

Vertical Position	SD	left	centre	right
	Surface	0.202916417	0.142749772	0.1163109
	6"	0.08188101	0.169569078	0.0662965
	Bottom	0.087538068	0.163261379	0.074383

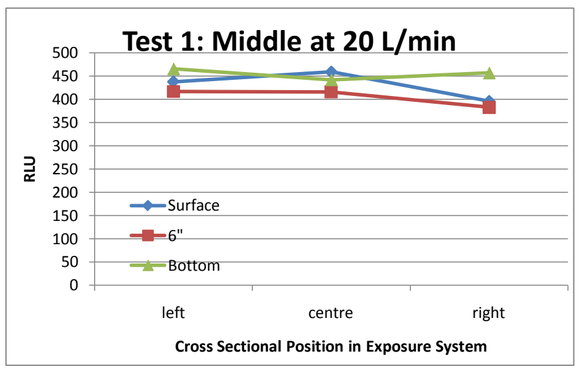


MIDDLE

Test one; 17 L/m

Vertical Position	RLUs:	left	centre	right
	Surface	438	459	396
	6"	417	416	383
	Bottom	466	442	457

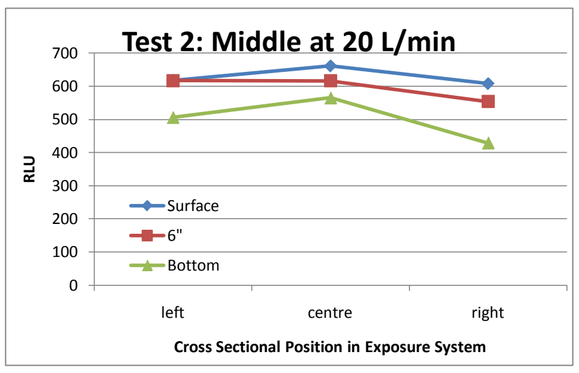
Vertical Position	Rel Change:	left	centre	right
	Surface	0.616034	0.64557	0.556962
	6"	0.586498	0.585091	0.538678
	Bottom	0.655415	0.62166	0.642757



Test two; 17 L/m

Vertical Position	RLUs:	left	centre	right
	Surface	618	661	608
	6"	617	616	554
	Bottom	506	565	429

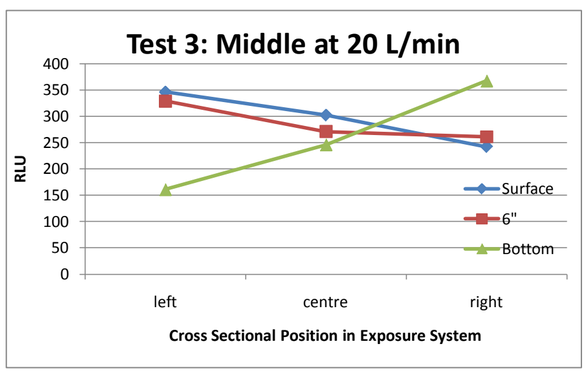
Vertical Position	Rel Change:	left	centre	right
	Surface	0.869198	0.929677	0.855134
	6"	0.867792	0.866385	0.779184
	Bottom	0.711674	0.794655	0.603376



Test three; 17 L/m

Vertical Position	RLUs:	left	centre	right
	Surface	346	302	242
	6"	329	271	261
	Bottom	161	246	367

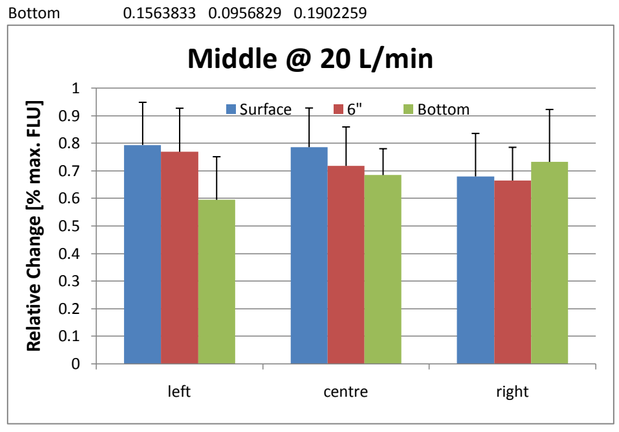
Vertical Position	Rel Change:	left	centre	right
	Surface	0.896373	0.782383	0.626943
	6"	0.852332	0.702073	0.676166
	Bottom	0.417098	0.637306	0.950777



Summary (Relative Change: % max. FLUs); 17 L/m

Vertical Position	Average	left	centre	right
	Surface	0.7938684	0.7858765	0.6796795
	6"	0.7688738	0.7178498	0.664676
	Bottom	0.594729	0.6845402	0.7323031

Vertical Position	SD	left	centre	right
	Surface	0.1546075	0.1420857	0.1559244
	6"	0.1581312	0.1413091	0.1206641
	Bottom	0.1563833	0.0956829	0.1902259

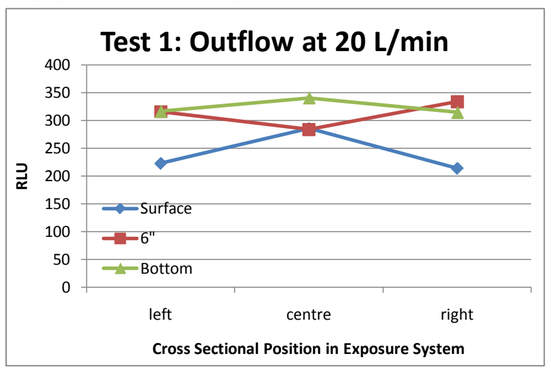


OUTFLOW

Test one; 17 L/m

Vertical Position	RLUs:	left	centre	right
	Surface	223	286	214
	6"	316	284	334
	Bottom	317	341	315

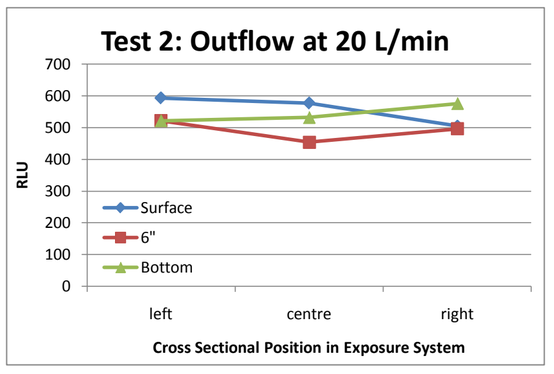
Vertical Position	Rel Change:	left	centre	right
	Surface	0.313643	0.40225	0.300985
	6"	0.444444	0.399437	0.469761
	Bottom	0.445851	0.479606	0.443038



Test two; 17 L/m

Vertical Position	RLUs:	left	centre	right
	Surface	593	577	505
	6"	522	454	496
	Bottom	522	532	576

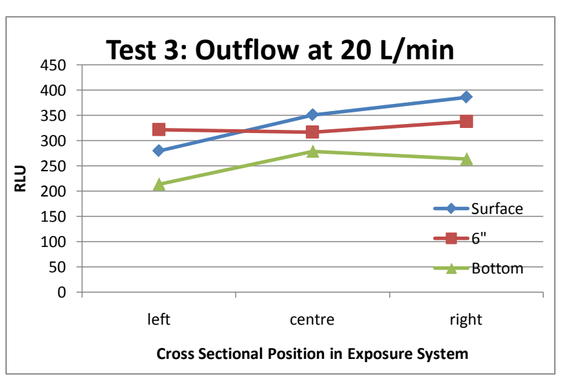
Vertical Position	Rel Change:	left	centre	right
	Surface	0.834037	0.811533	0.710267
	6"	0.734177	0.638537	0.697609
	Bottom	0.734177	0.748242	0.810127



Test three; 17 L/m

Vertical Position	RLUs:	left	centre	right
	Surface	280	351	386
	6"	322	317	338
	Bottom	214	279	264

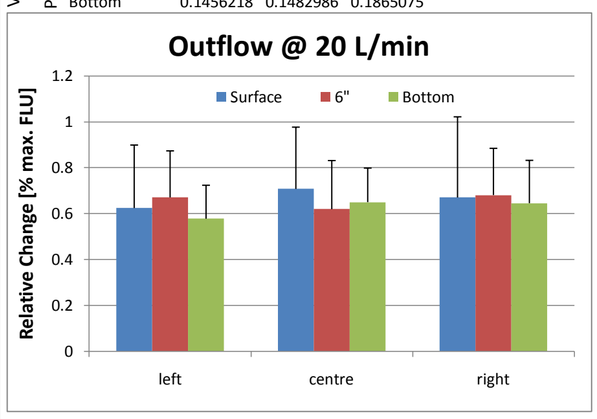
Vertical Position	Rel Change:	left	centre	right
	Surface	0.725389	0.909326	1
	6"	0.834197	0.821244	0.875648
	Bottom	0.554404	0.722798	0.683938



Summary (Relative Change: % max. FLUs); 17 L/m

Vertical Position	Average	left	centre	right
	Surface	0.624356	0.7077033	0.6704173
	6"	0.6709395	0.6197394	0.6810059
	Bottom	0.5781441	0.6502153	0.6457008

Vertical Position	SD	left	centre	right
	Surface	0.2745143	0.2690112	0.3512074
	6"	0.2024253	0.2115304	0.2034521
	Bottom	0.1456218	0.1482986	0.1865075

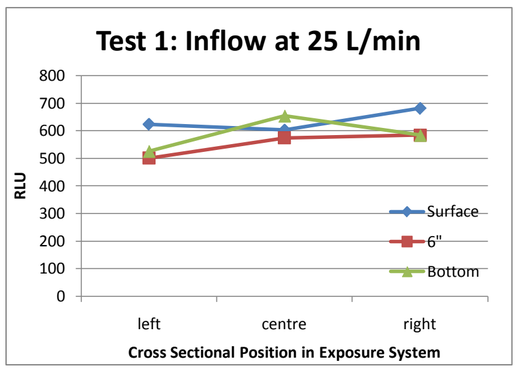


INFLOW

Test one; 17 L/m

Vertical Position	RLUs:	left	centre	right
	Surface	624	603	681
	6"	501	574	584
	Bottom	526	654	584

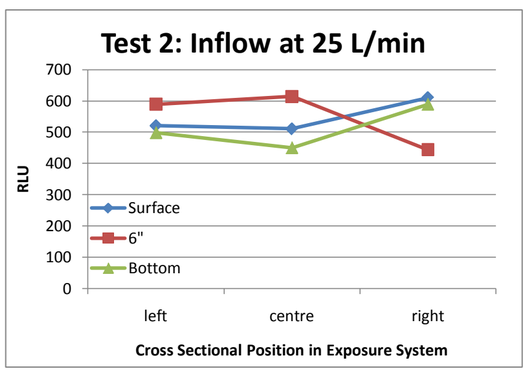
Vertical Position	Rel Change:	left	centre	right
	Surface	0.91629956	0.88546256	1
	6"	0.73568282	0.84287812	0.857562
	Bottom	0.77239354	0.96035242	0.857562



Test two; 17 L/m

Vertical Position	RLUs:	left	centre	right
	Surface	521	511	610
	6"	589	614	444
	Bottom	498	450	589

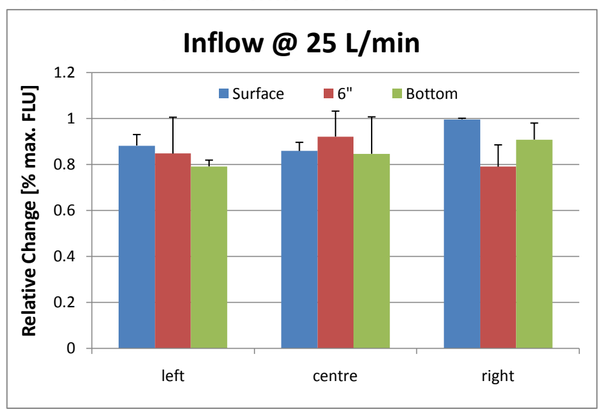
Vertical Position	Rel Change:	left	centre	right
	Surface	0.8485342	0.83224756	0.993485
	6"	0.95928339	1	0.723127
	Bottom	0.81107492	0.73289902	0.959283



Summary (Relative Change: % max. FLUs); 17 L/m

Vertical Position	Average	left	centre	right
	Surface	0.882416881	0.858855056	0.9967427
	6"	0.847483104	0.92143906	0.7903447
	Bottom	0.791734229	0.846625723	0.9084229

Vertical Position	SD	left	centre	right
	Surface	0.047917344	0.037628686	0.0046066
	6"	0.158109478	0.111101947	0.0950602
	Bottom	0.027351866	0.160833842	0.0719276

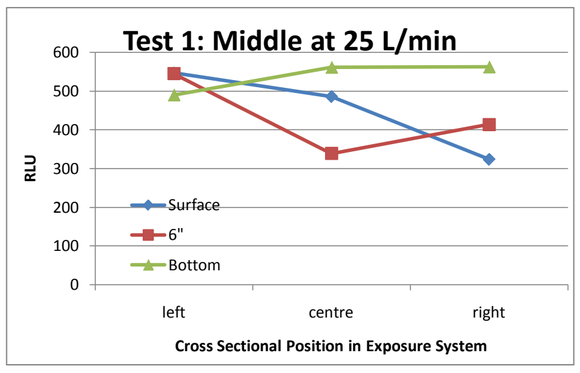


MIDDLE

Test one; 17 L/m

Vertical Position	RLUs:	left	centre	right
	Surface	547	486	324
	6"	545	339	414
	Bottom	490	562	563

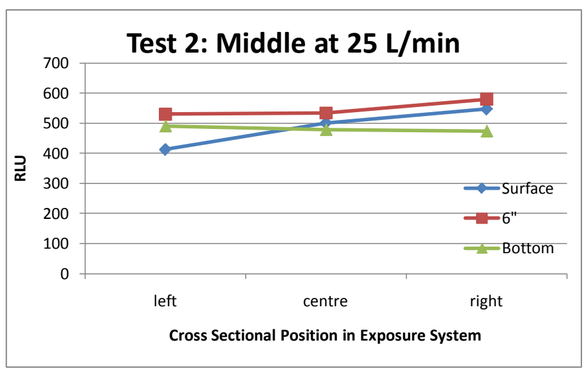
Vertical Position	Rel Change:	left	centre	right
	Surface	0.803231	0.713656	0.475771
	6"	0.800294	0.497797	0.60793
	Bottom	0.71953	0.825257	0.826725



Test two; 17 L/m

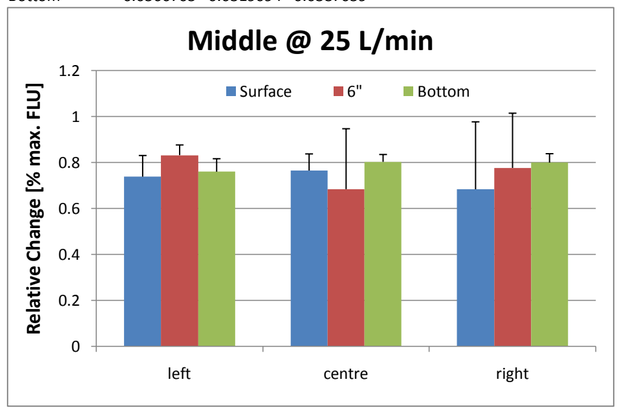
Vertical Position	RLUs:	left	centre	right
	Surface	413	501	547
	6"	530	534	580
	Bottom	491	479	474

Vertical Position	Rel Change:	left	centre	right
	Surface	0.672638	0.815961	0.890879
	6"	0.863192	0.869707	0.944625
	Bottom	0.799674	0.78013	0.771987



Vertical Position	Average	left	centre	right
	Surface	0.7379345	0.7648086	0.6833252
	6"	0.8317429	0.6837521	0.7762775
	Bottom	0.7596022	0.8026936	0.7993562

Vertical Position	SD	left	centre	right
	Surface	0.0923426	0.0723402	0.2935261
	6"	0.044476	0.2629797	0.2380799
	Bottom	0.0566705	0.0319094	0.0387059

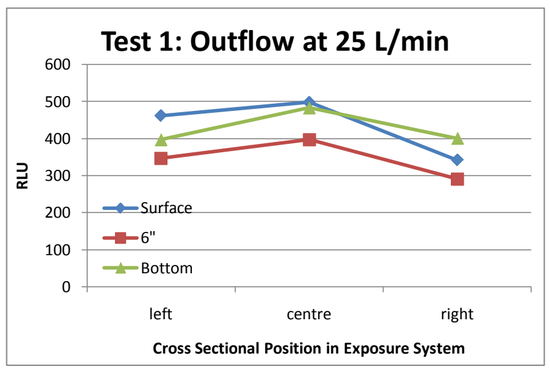


OUTFLOW

Test one; 17 L/m

Vertical Position	RLUs:	left	centre	right
	Surface	462	498	342
	6"	347	397	291
	Bottom	397	483	401

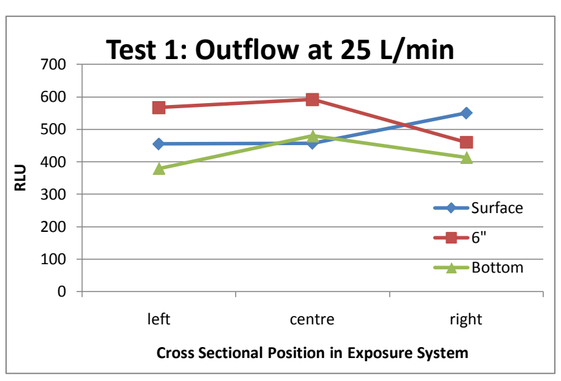
Vertical Position	Rel Change:	left	centre	right
	Surface	0.678414	0.731278	0.502203
	6"	0.509545	0.582966	0.427313
	Bottom	0.582966	0.709251	0.58884



Test two; 17 L/m

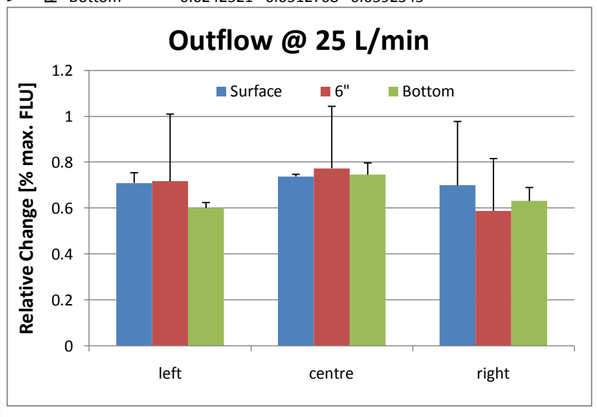
Vertical Position	RLUs:	left	centre	right
	Surface	455	457	550
	6"	567	592	460
	Bottom	379	480	413

Vertical Position	Rel Change:	left	centre	right
	Surface	0.741042	0.7443	0.895765
	6"	0.923453	0.964169	0.749186
	Bottom	0.617264	0.781759	0.672638



Vertical Position	Average	left	centre	right
	Surface	0.7097282	0.7377886	0.6989841
	6"	0.7164988	0.7735678	0.5882492
	Bottom	0.600115	0.745505	0.6307392

Vertical Position	SD	left	centre	right
	Surface	0.0442849	0.009208	0.2782909
	6"	0.2926771	0.2695513	0.2275985
	Bottom	0.0242521	0.0512708	0.0592545



Summary Data Report

Experiment #: 2 **Date:** 5/20/-6/27/10 **Expt. Leader:** DV/JD/MH

Title: Determination of Optimum Stone Volume and Distribution in Fluvial Test Chambers.

Goal:

Indentify the effect of different volumes and distribution of stones on hydrological conditions in fluvial chambers.

Experimental Design:

1. Stone volume selection

Stones (Geosubstrate # 12422, Hagen) (10 to 20 mm diameter) were placed in exposure chambers without sediment to visually assess optimal spatial densities. Spatial densities of stones tested included: 0, 3, 5 and 7 stones per 100 cm^2. Tests with densities greater than 7 stones per 100 cm^2 were not included because of crowding issues.

2. Water quality evaluation

Conductivity measurements (Symphony Probe, VWR; UCR-SOP #16) were taken at 0, 24 and 48 hrs in the 1 cm water layer overlying the stones to assess variation in water quality. Stone densities of 0, 3, 5 and 7 stones per 100 cm^2 were tested in exposure chambers without sediment while stone densities of 0, 4 and 7 stones per 100 cm^2 were tested in exposure chambers with sediment. Sediments were layered at a thickness of 2 and 3 inches into the exposure portion of the test chambers and stones were placed on top. Sediment depths greater than 3 inches were not included based on the evaluation of optimum sediment depths; refer to summary data report for Experiment Nos. 3 and 4.

3. Flow condition evaluation

Flow condition was evaluated visually by use of fluorescent dye to determine if the stones altered the flow of water.

Decision Criteria:

Conductivity measurements to evaluate variation in water quality: target value of <30% variation among samples taken. Visual assessment of flow conditions using fluorescent dye.

Results:

1. Stone volume selection

Visual assessment of stone densities of 3 and 7 stones per 100 cm^2 appeared too sparse and too crowded, respectively, whereas stone densities of 4 and 5 per 100 cm^2 appeared appropriate leaving sufficient room to enable observations of sediments while providing appropriate shelter for white sturgeon early life-stages (Figure 1).

2. Water quality evaluation

Conductivity analysis revealed less than 15% variation among samples taken from all stone densities at 0, 24 and 48 hrs in exposure systems with and without sediment (Figure 2). Variation in conductivity was less than 10% in exposure systems with sediment and stone densities of 4 and 7 stones per 100 cm^2 (Figure 3).

3. Flow condition evaluation

Visual assessments of flow condition revealed no impact on water flow with the incorporation of stones into the exposure chamber or with increased stone densities in chambers with or without sediment (see enclosed video records).

Conclusions:

Addition of stones to the fluvial exposure chambers had no impact on flow conditions and little to no impact on water quality. In our experience early life-stages of white sturgeon appear less stressed when provided a refuge under experimental conditions. A density of 4 stones per 100 cm^2 is recommended as the optimal loading density.

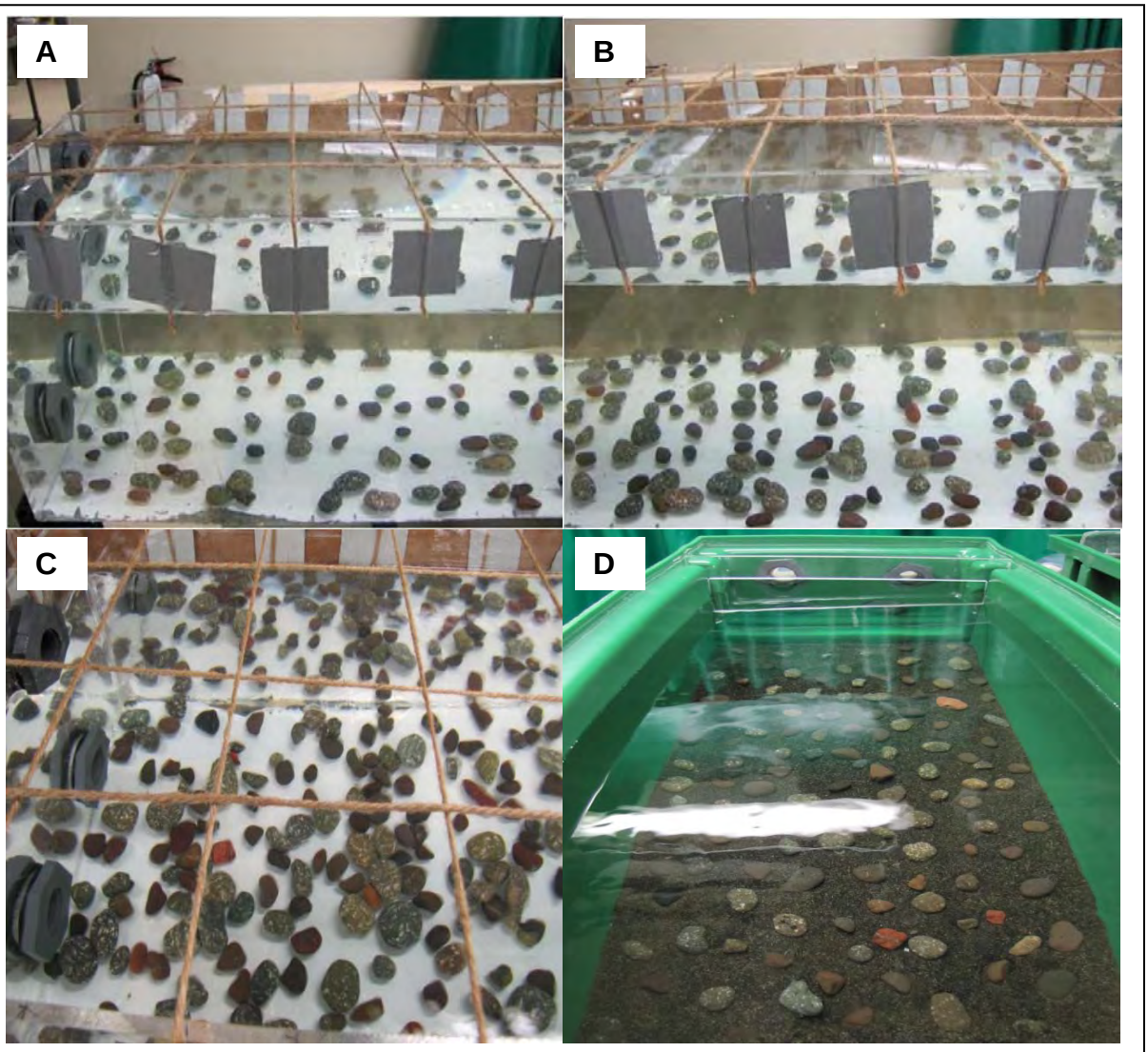


Figure 1: *Photographs of exposure systems with stone densities of 3 per 100 cm^2 without sediment (A), 5 per 100 cm^2 without sediment (B), 7 per 100 cm^2 without sediment (C), and 4 per 100cm^2 with sediment.*

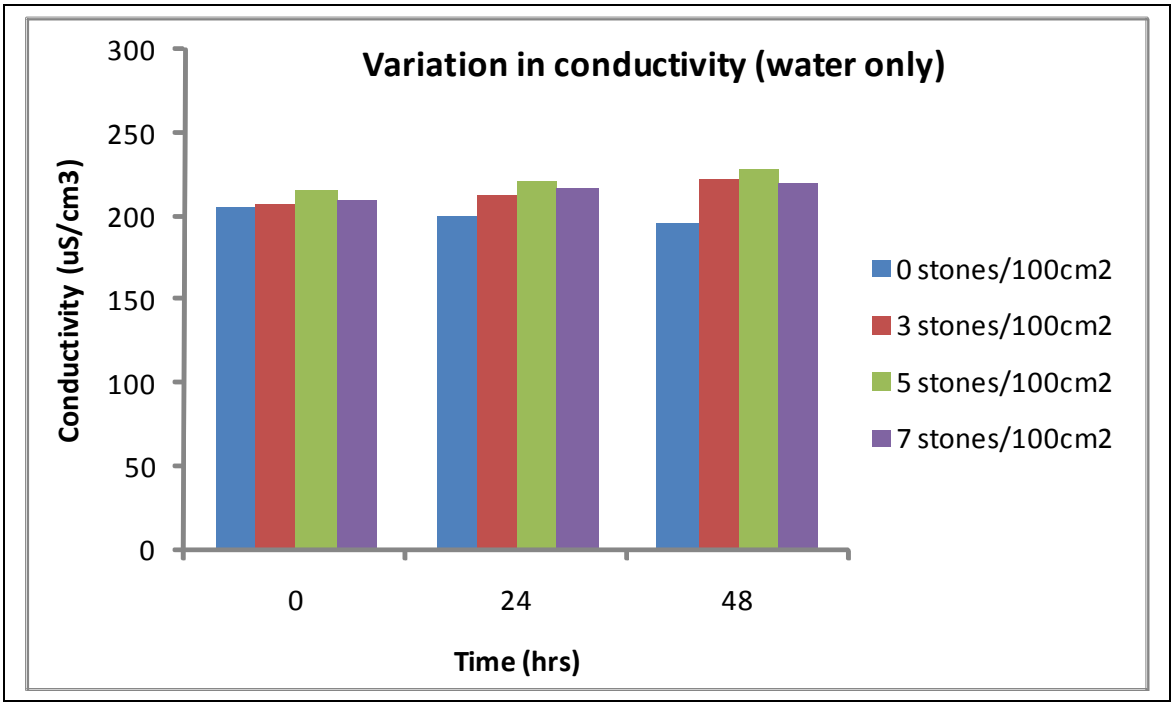


Figure 2: *Variation in conductivity in water-only exposure systems over 48 hrs at stone densities of 0, 3, 5 and 7 stones per 100 cm^2.*

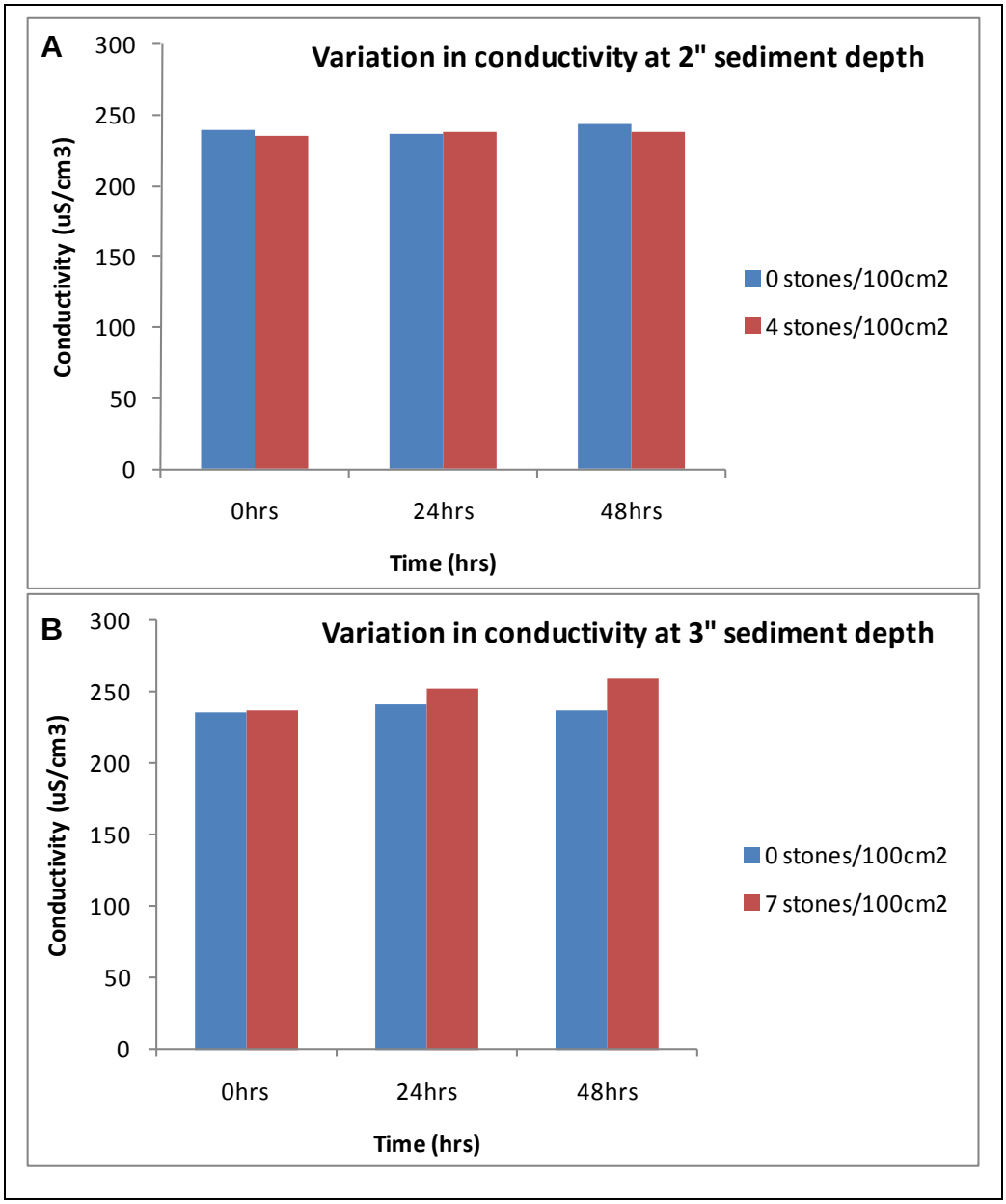


Figure 3: *Variation in conductivity at 2" sediment depth over 48 hrs with 0 and 4 stones per 100 cm^2 (A) and variation in conductivity at 3" sediment depth over 48 hrs with 0 and 7 stones per 100 cm^2 (B).*

Gravel Volume and Distribution

Number of Stones pe	Matrix	Time (hours post stone addition)	Conductivity (uS/cm3)	Average conductivity (uS/cm3) of 0 stone density	% variation from 0 stone density	% variation from time 0
0	2" sediment	0hrs	240	240.0	0	0
0	2" sediment	24hrs	236.6		1.4	1.4
0	2" sediment	48hrs	243.5		1.4	1.5
4	2" sediment	0hrs	235.7		1.8	0
4	2" sediment	24hrs	239		0.4	1.4
4	2" sediment	48hrs	238.8		0.5	1.3
0	3" sediment	0hrs	236.5	238.2	0.7	0
0	3" sediment	24hrs	241.2		1.3	2.0
0	3" sediment	48hrs	236.9		0.5	0.2
7	3" sediment	0hrs	237.5		0.3	0
7	3" sediment	24hrs	252.7		6.1	6.4
7	3" sediment	48hrs	259.3		8.9	9
		Standard deviation	7.273629205			
0	water only	0	206.4	201.4		0
0	water only	24	201.3			2.5
0	water only	48	196.4			4.8
3	water only	0	207.7		3.1	0
3	water only	24	213.3		5.9	##########
3	water only	48	222.9		10.7	##########
5	water only	0	216.5		7.5	0
5	water only	24	221.7		10.1	2.4
5	water only	48	228.9		13.7	5.7
7	water only	0	210		4.3	0
7	water only	24	217.4		7.9	3.5
7	water only	48	220		9.2	4.8
		Standard deviation	9.519306538			

0 stones/100cm^2

3 stones/100cm^2

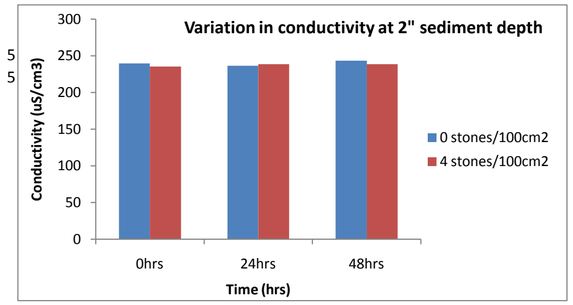
5 stones/100cm^2

7 stones/100cm^2

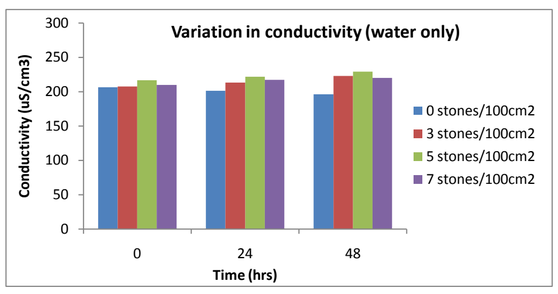
Gravel Volume and Distribution

5

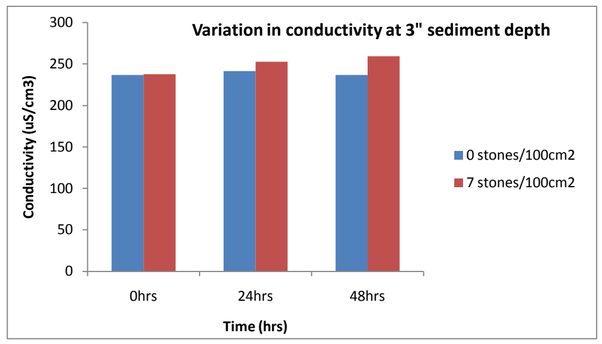
5



Variation in conductivity at 2" sediment depth over 48hrs with 0 and 4 stones per 100cm2

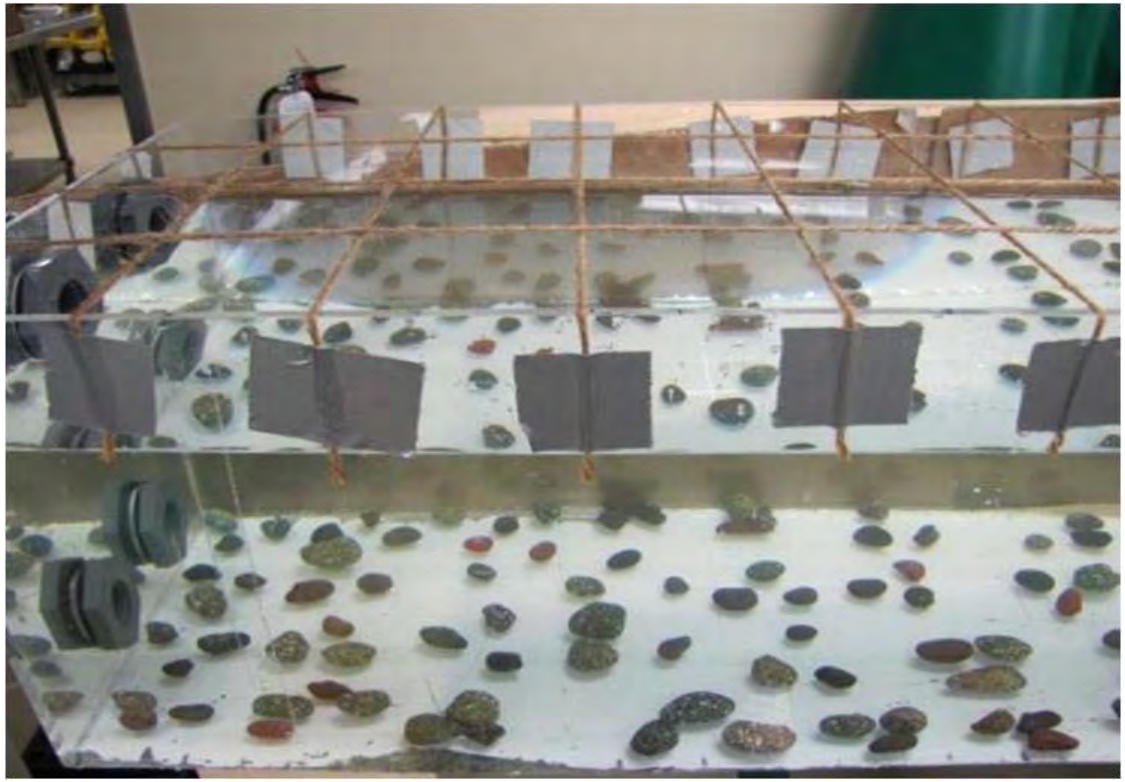


Variation in conductivity at 0, 3, 5 and 7 stones per 100cm2.

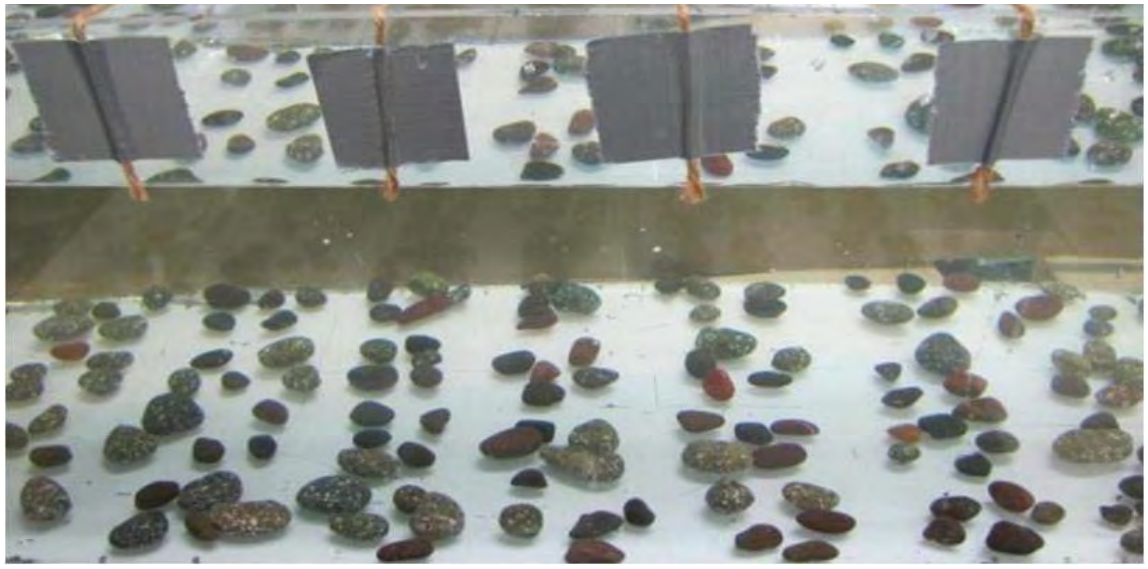


Variation in conductivity at 3" sediment depth over 48hrs with 0 and 7 stones per 100cm2

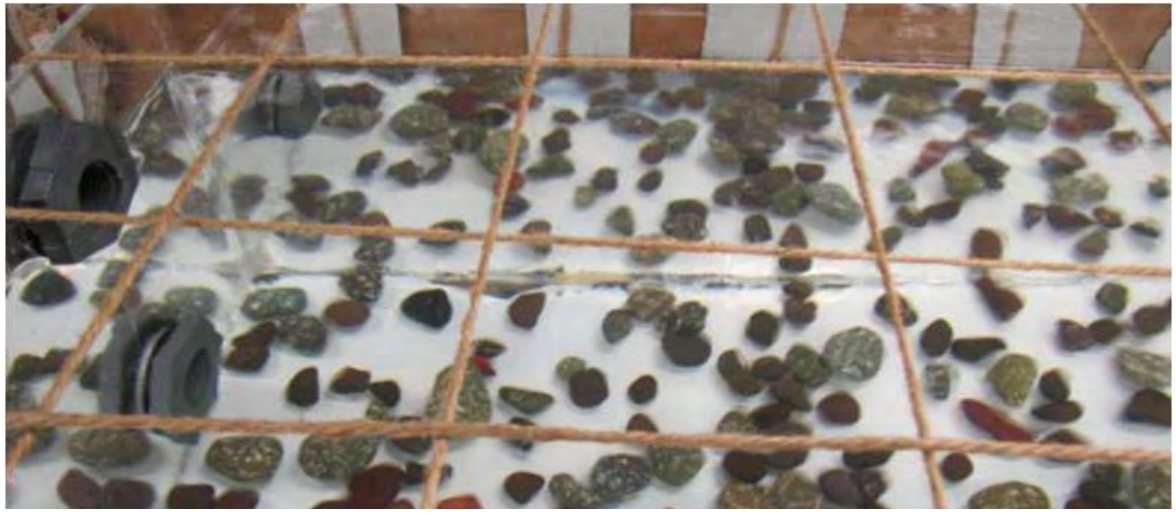
3 Rocks per 100cm2



5 Rocks per 100cm 2



7 Rocks per 100cm2



4 Rocks per 100cm2

Summary Data Report

Experiment #: 6 **Date:** 5/20/-7/04/10 **Expt. Leader:** DV/JD/MH

Title: Time to 'Steady-state' After Introduction of Test Sediments into the Test Chambers

Goal:

The objective is to identify the minimum period of time necessary for the exposure chamber to attain a steady-state based on basic water quality parameters. The objective of this work is not to attain steady-state conditions for chemicals of potential concern (COPCs); but rather, to ensure that non-COPCs do not adversely affect test results (i.e., introduce uncertainty) when organisms are introduced.

Experimental Design:

Basic water quality parameters were monitored in test chambers containing river sediment at 0, 12, 24, and 48 h, and every 48 h thereafter until steady state. Measurements included conductivity, dissolved oxygen (DO), ammonia, nitrate, colour, total dissolved solids (TDS), and pH at the inflow and outflow of the exposure chamber.

Decision Criteria:

'Steady-state' is attained when measured water quality parameters do not vary more than 10 percent from one measurement event to the next.

Results:

Over the course of the experiment values for temperature, dissolved oxygen, pH, and colour had no significant variability (greater than ±10 percent between measurement events) at either the inflow or outflow of the test chamber. Values for ammonia and nitrate had significant variability at both the inflow and outflow of the test chamber between measurement events. The measurements for conductivity, total dissolved solids (TDS), and dissolved organic carbon (DOC) are considered the most likely parameters to determine steady-state. Conductivity and TDS had no significant variability during the experiment. DOC did have variability during the experiment with measurements as high as 41.67% between the readings at 48 and 96 hours at the inflow and 21.43% at the outflow.

Conclusions:

Steady-state is achieved for temperature, conductivity, dissolved oxygen, pH, colour, and total dissolved solids within 48 hours. Ammonia and nitrate did not reach steady-state, but this is likely due to the natural variability of these measurements. DOC did not reach steady-state but the experiment is ongoing to determine if DOC measurements with variability below ±10 percent between measurement events can be achieved.

A Measured parameters at inflow over 96 hours

Inflow						
Hour	**Conductivity**		**TDS**		**DOC**	
		% Difference		% Difference		% Difference
0	176.6		118		1.9	
12	177.3	0.40				
24	178.8	0.85	119	0.85	1.3	46.15
48	177.6	0.68	121	1.68	1.2	8.33
96	181.5	2.20	129	6.61	1.7	41.67

B Measured parameters at outflow over 96 hours

Outflow						
Hour	**Conductivity**		**TDS**		**DOC**	
		% Difference		% Difference		% Difference
0	179.3		119		1.8	
12	176.9	1.36				
24	175.5	0.80	120	0.84	1.5	20.00
48	177.5	1.14	122	1.67	1.4	7.14
96	178.2	0.39	117	4.27	1.7	21.43

	Inflow				
Time (hrs)	Temp (°C)	% Difference	DO (mg/L)	DO (%)	% Difference
0	15.4		8.42	86.7	
12	15.9	3.246753247		90.5	4.382929642
24	16	0.628930818	8.39	85.5	5.847953216
48	15.7	1.910828025	8.8	88.5	3.50877193
96	16.1	2.547770701	8.9	90.6	2.372881356

Time (hrs)	Conductivity	% Difference	pH	% Differe	Colour
0	176.6		7.82		clear
12	177.3	0.396375991	7.98	2.04604	clear
24	178.8	0.846023689	7.82	2.04604	clear
48	177.6	0.675675676	7.98	2.04604	clear
96	181.5	2.195945946	7.98	0	clear

Time (hrs)	Ammonia (p	% Difference	Ammonia (p	% Differe	Nitrate (ppm NC	% Difference
0	0.04		0.048		0.25	
12	0.04	0	0.048	0	0.02	1150
24	0.04	0	0.048	0	0.5	2400
48	< 0.02	300	< 0.024	3900	0.25	100
96	0.02	100	0.04	1900	0.02	1150

Time (hrs)	Nitrate (ppm	% Difference	TDS (mg/L) DL =5	% Differe	DOC (mg/L) DL =0.2	% Difference
0	1.1		118		1.9	
12	1.1	0				
24	2.2	100	119	0.84746	1.3	46.15384615
48	1.1	100	121	1.68067	1.2	8.333333333
96	1.1	0	129	6.61157	1.7	41.66666667

Outflow

Time (hrs)	Temp (°C)	% Difference	DO (mg/L)	DO (%)	% Difference
0	15.5		8.55	87	
12	15.7	1.290322581		90.7	4.252873563
24	15.3	2.614379085	8.56	87.1	4.133180253
48	15.7	2.614379085	8.89	88.9	2.066590126
96	15.9	1.27388535	8.79	90.8	2.137232846

Time (hrs)	Conductivity	% Difference	pH	% Differe	Colour
0	179.3		7.82		clear
12	176.9	1.3566987	7.95	1.6624	clear
24	175.5	0.797720798	7.8	1.92308	clear
48	177.5	1.13960114	7.94	1.79487	clear
96	178.2	0.394366197	7.99	0.62972	clear

Time (hrs)	Ammonia (p	% Difference	Ammonia (p	% Difference
0	0.04		0.048	
12	0.04	0	0.048	0
24	0.04	0	0.048	0
48	< 0.02	300	< 0.024	300
96	0.02	100	0.24	1900

Time (hrs)	Nitrate (ppm	% Difference	Nitrate (ppm	% Difference
0	0.25		1.1	
12	0.25	0	1.1	0
24	0.25	0	1.1	0
48	0.25	0	1.1	0
96	0.02	1150	1.1	0

Time (hrs)	TDS (mg/L)	% Difference	DOC (mg/L)	% Difference
	5		0.2	
0	119		1.8	
12				
24	120	0.840336134	1.5	20
48	122	1.666666667	1.4	7.14286
96	117	4.273504274	1.7	21.4286

	Temp (°C)	DO (%)	DO (mg/L)	Conductivity (uS/cm)	pH
Day 2: 02/07/2010					
CONTROL					
Rep 1	15	87.1	8.69	176.4	7.71
Rep 2	15	87.9	8.87	175.1	7.91
Rep 3	14.9	87.4	8.85	175	7.96
DE	15.4	89	8.86	171.7	7.81
Rep 1	15.2	88.6	8.88	170.4	7.88
Rep 2	15	88	8.85	169.7	7.8
Rep 3					
H2O @ 5					
Rep 1	15	87.6	8.82	322	7.71
Rep 2	14.9	87.6	8.83	319	8.08
Rep 3	14.9	87.6	8.78	320	8.14
H2O @ 2					
Rep 1	15.5	87.4	8.7	174.8	7.86
Rep 2	15.5	87.7	8.74	173.9	7.87
Rep 3	15.6	87.2	8.68	173.9	7.84
Day 4: 04/07/2010					
CONTROL					
Rep 1	15.1	90.9	9.05	173.1	8.06
Rep 2	15.2	91.7	9.19	175.5	7.49
Rep 3	15.2	91.5	9.12	175.2	7.06
DE					
Rep 1	15.2	91.2	9.16	171	7.04
Rep 2	15.1	91.6	9.2	170	7.18
Rep 3	15.2	90.5	9.15	169.8	7.3
H2O @ 5					
Rep 1	15.1	90.5	9.05	322.6	7.59
Rep 2	15.2	89.9	9.02	321.9	8
Rep 3	15.2	89.2	8.02	320.8	8.1
H2O @ 2					
Rep 1	15.7	91	9.02	175.9	7.66
Rep 2	15.7	91.2	9.05	174.4	7.78
Rep 3	15.6	91.3	9.08	173.7	7.75
Day 8: 08/07/2010					
CONTROL					
Rep 1	15.3	92.4	9.28	174.2	7.43

Rep 2	15.2	92	9.24	176.3	7.88
Rep 3	15.4	93.1	9.31	176.4	7.76
DE					
Rep 1	15.2	92.4	9.28	174.2	7.43
Rep 2	15.2	92.2	9.26	172.3	7.67
Rep 3	15.2	92.1	9.25	172	7.8
H2O @ 5					
Rep 1	15	90	8.99	321.1	7.91
Rep 2	15.1	90.9	9.13	320.1	8.05
Rep 3	15.1	91.2	9.1	319.7	8.05
H2O @ 2					
Rep 1	15.5	92.8	9.18	173.6	7.72
Rep 2	15.6	92.4	9.19	173.1	7.48
Rep 3	15.5	92.2	9.2	172.8	7.48

	Temp (°C)	DO (%)	DO (mg/L)	Conductivity (uS/cm)	pH
Day 2: 02/07/2010					
CONTROL					
Rep 1	15	87.1	8.69	176.4	7.71
Rep 2	15	87.9	8.87	175.1	7.91
Rep 3	14.9	87.4	8.85	175	7.96
DE	15.4	89	8.86	171.7	7.81
Rep 1	15.2	88.6	8.88	170.4	7.88
Rep 2	15	88	8.85	169.7	7.8
Rep 3					
H2O @ 5					
Rep 1	15	87.6	8.82	322	7.71
Rep 2	14.9	87.6	8.83	319	8.08
Rep 3	14.9	87.6	8.78	320	8.14
H2O @ 2					
Rep 1	15.5	87.4	8.7	174.8	7.86
Rep 2	15.5	87.7	8.74	173.9	7.87
Rep 3	15.6	87.2	8.68	173.9	7.84
Day 4: 04/07/2010					
CONTROL					
Rep 1	15.1	90.9	9.05	173.1	8.06
Rep 2	15.2	91.7	9.19	175.5	7.49
Rep 3	15.2	91.5	9.12	175.2	7.06
DE					
Rep 1	15.2	91.2	9.16	171	7.04
Rep 2	15.1	91.6	9.2	170	7.18
Rep 3	15.2	90.5	9.15	169.8	7.3
H2O @ 5					
Rep 1	15.1	90.5	9.05	322.6	7.59
Rep 2	15.2	89.9	9.02	321.9	8
Rep 3	15.2	89.2	8.02	320.8	8.1
H2O @ 2					
Rep 1	15.7	91	9.02	175.9	7.66
Rep 2	15.7	91.2	9.05	174.4	7.78
Rep 3	15.6	91.3	9.08	173.7	7.75
Day 8: 08/07/2010					
CONTROL					
Rep 1	15.3	92.4	9.28	174.2	7.43

Rep 2	15.2	92	9.24	176.3	7.88
Rep 3	15.4	93.1	9.31	176.4	7.76
DE					
Rep 1	15.2	92.4	9.28	174.2	7.43
Rep 2	15.2	92.2	9.26	172.3	7.67
Rep 3	15.2	92.1	9.25	172	7.8
H2O @ 5					
Rep 1	15	90	8.99	321.1	7.91
Rep 2	15.1	90.9	9.13	320.1	8.05
Rep 3	15.1	91.2	9.1	319.7	8.05
H2O @ 2					
Rep 1	15.5	92.8	9.18	173.6	7.72
Rep 2	15.6	92.4	9.19	173.1	7.48
Rep 3	15.5	92.2	9.2	172.8	7.48

Summary Data Report

Experiment #: 7 **Date:** 5/20/-7/04/10 **Expt. Leader:** DV/JD/MH

Title: Determination of Most Efficient Cleaning Method Minimizing Re-Suspension of Sediments.

Goal:

Identify optimum cleaning techniques without utilization of invasive suction devices while employing large particle filters-with and without addition of diet (bloodworms, oligochaetes, semi-moist diet, and *Artemia*).

Experimental Design:

Food was introduced simulating three feeding event per day using *Artemia*, worms and semi-moist diet. At days 2, 3, 4, and 5 chambers were manually cleaned (daily) to remove as much biofilm as possible without significant re-suspension of sediments. At 5, 10, 20, and 30 minutes after each cleaning event, bottom near water samples (approximately 1 cm above the sediment surface) were taken as described in section 7.7.2.1 of the methods development QAPP (April 2010). Turbidity of samples as a measure of re-suspended matter was determined using light scattering methods as described in EPA Method 180.1 or Standard Method 2130B (Standard Method 1995).

Three different cleaning techniques were initially investigated at the beginning of the experiment:

1.) Siphoning the sediment surface with the use of a 3/8" ID hose.
2.) Scraping the sediment surface with the use of a plastic spatula.
3.) Pipetting debris with the use of a modified pipette.

After initial attempts it was decided that siphoning and scraping with a spatula were not appropriate methods of cleaning sediment surfaces as they were too invasive and ineffective, respectively.

Decision Criteria:

Optimum cleaning techniques were determined as a function of minimizing re-suspension of sediment and efficiency of cleaning as determined by measurements of turbidity. It is acknowledged that any type of physical removal of bio-growth will cause re-suspension to a certain degree, and the final method to be established will be a compromise between efficiency of cleaning and amount of sediment resuspended during the cleaning event.

Results:

1. Siphoning

Siphoning debris from the sediment surface was effective but was deemed too invasive as it removed and disturbed sediment in the process (siphoning video, cleaning techniques). Grains of sediment were removed from the chamber in the cleaning process. Past experience demonstrated an increased risk of fish injury as some organisms would be sucked into the cleaning tube. Turbidity analyses did not reveal any significant differences between pre-cleaning conditions or at any time period of up to 30 minutes post cleaning (Figure 1A). Investigation of siphoning as a cleaning method was discontinued after day 2.

2. Scrapping with a spatula

Scrapping with a spatula was ineffective. It was time consuming and once the debris was dislodged from the sediment surface it was difficult to remove from exposure chamber (spatula video, cleaning techniques). Turbidity analyses revealed an increase in turbidity 5 and 10 minutes post cleaning and decreasing there after (Figure 1B). Investigation of scrapping with a spatula as a cleaning method was discontinued after day 2.

3. Modified pipette

Pipetting the sediment surface to remove debris proved to be the most efficient and less invasive method. Biofilm and food could be easily dislodged from the sediment surface with minimal disturbance to sediment and effectively removed from the exposure chamber (modified pipette video, cleaning techniques). Turbidity analysis revealed no significant differences between pre-cleaning conditions or at any time period of up to 30 minutes post cleaning for the entirety of the experiment (day 2 -5), with the one exception at day 3, 10 minutes post cleaning (Figure 1C). Turbidity analyses at this time point revealed 0.6 NTU. This is considered to be a condition of other factors than cleaning techniques as all other turbidity results were within normal ranges throughout the 30 minute test. The possible introduction of foreign material during sampling could explain elevated turbidity levels at this time point.

Conclusions:

Cleaning by the use of a modified pipette allowed the technician to select unwanted debris and remove it from the exposure chamber with minimal disturbance to the sediment. In addition, the risk of injury to fish is minimized. Siphoning may prove effective when cleaning reservoirs or screens, but only when direct contact with fish and sediment is not involved. The aid of the spatula may prove useful in instances were biofilm is strongly adhere to surfaces, but it is our recommendation that the modified pipette be used as the primary cleaning method for sediment within the exposure chamber.

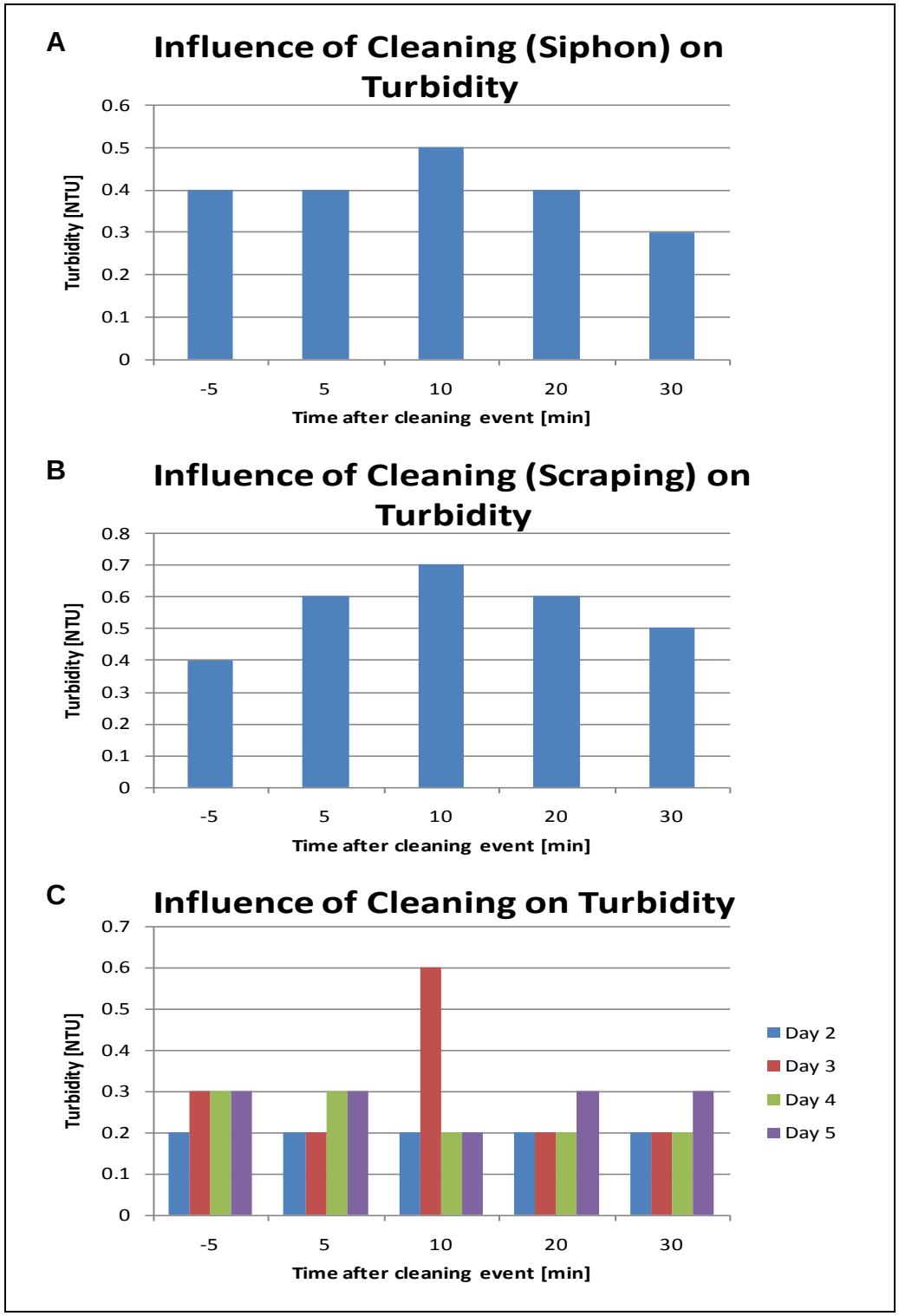


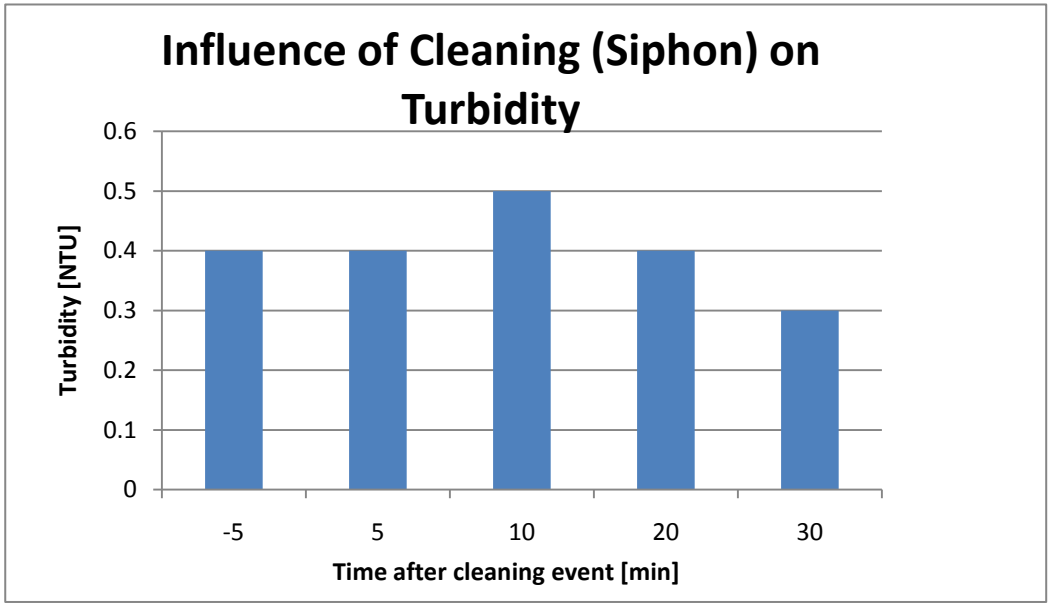
Figure 1: *Turbidity in surface water prior (-5 [minutes]) and after (5, 10, 20 and 30 [minutes]) addition of food to fluvial test chamber at days 2 (A, B, C), 3 (C), 4(C) and 5(C) after initiation of feeding routine as determined by nephelometry using different cleaning techniques (A: Siphoning; B: Scraping; C: Modified Pipette). NTU = Nephelometric Turbidity Units (NTU).*

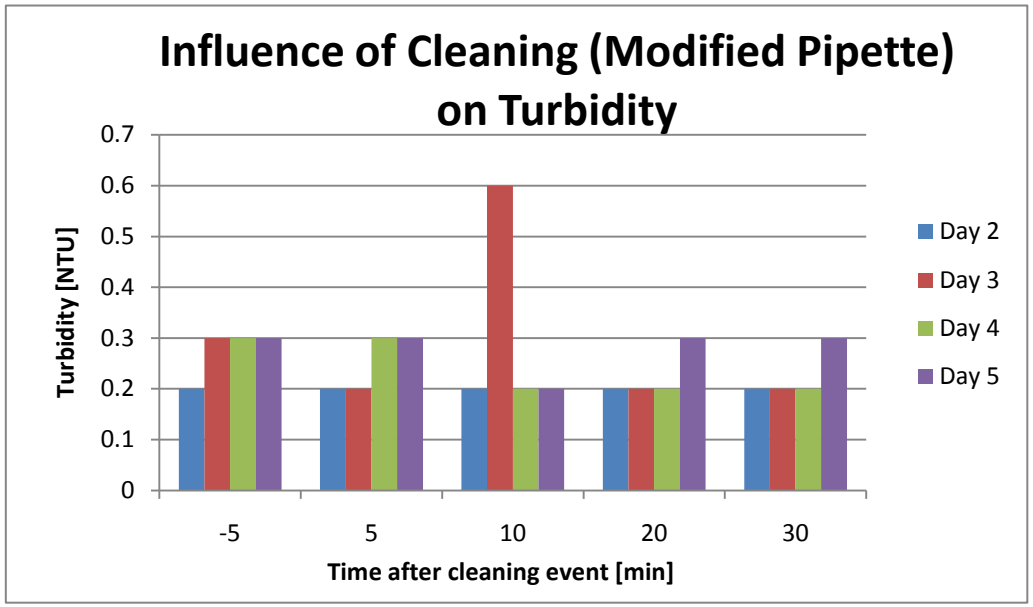
Cleaning Experiment DL: 0.1 NTU

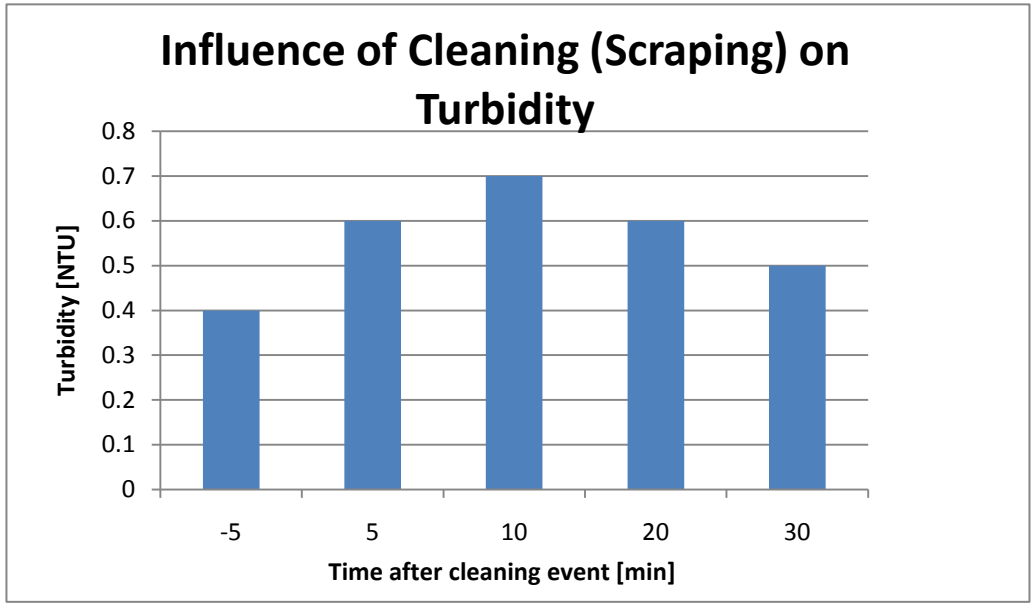
Day	Time after cleaning (min)	Control (turbidity; NTU)	Feeding exposure: pipette method (turbidity; NTU)
2	-5		0.2
	5	0.3	0.2
	10		0.2
	20		0.2
	30	0.3	0.2
3	-5		0.3
	5	0.1	0.2
	10		0.6
	20		0.2
	30	0.1	0.2
4	-5		0.3
	5	0.2	0.3
	10		0.2
	20		0.2
	30	0.2	0.2
5	-5	0.1	0.3
	5	0.3	0.3
	10		0.2
	20		0.3
	30	0.2	0.3

Day 2
Day 3
Day 4
Day 5

Feeding exposure: siphon method (turbidity; NTU)	Feeding exposure: spatula method (turbidity; NTU)
0.4	0.4
0.4	0.6
0.5	0.7
0.4	0.6
0.3	0.5




Influence of Cleaning (Modified Pipette) on Turbidity
Turbidity [NTU]
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-5
5
10
20
30
Time after cleaning event [min]
Day 2
Day 3
Day 4
Day 5


Influence of Cleaning (Scraping) on Turbidity
Turbidity [NTU]
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-5
5
10
20
30
Time after cleaning event [min]

Summary Data Report

Experiment #: 8 **Date:** 5/20/-7/04/10 **Expt. Leader:** DV/JD/MH

Title: Artificial Laboratory Control Sediment

Goal:

The objective is to select a laboratory control sediment that has physical characteristics suitable for ELS of sturgeon and is comparable to sediments used historically in fish early life stage tests.

Experimental Design:

Several different silica sand and crushed/ground granites available from commercial vendors were considered. Sediments were layered into the test chamber and water quality parameters were assessed in comparison to average reference riverine sediment water quality parameters.

Decision Criteria:

Criteria used to select a suitable laboratory reference sediment were:

- Grain sizes between 0.5 and 2 mm in diameter
- Color similar to UCR sediments (preference for dark coloration)
- pH, dissolved oxygen, hardness, and alkalinity do not differ by more than 50 percent from average values determined for riverine sediments
- Certificate of analysis for contamination

Results:

Several different candidate sediments were selected including: Hagen Geosystem Black Fine Gravel (ART# 12648), Hagen Geosystem Extra Fine White River Gravel (ART# 12647), Hagen Geosystem Pacific Gravel (ART# 12404), Hagen Geosystem Black Beach Gravel (ART# 12418), Aquaterra Black Sand (#80035), Aquaterra Natural Tan Sand (#80075), and Pure Water Pebbles Cumberland River Gems (#30095). The Hagen Geosystem Black Fine Gravel (ART# 12648) was the only sediment that met both the grain size and color criteria and so was selected for further trials.

No certificate of analysis for contamination was available from the manufacturer so samples of the Black Fine Gravel were analyzed at Columbia Analytical Services (CAS). The Hagen Geosystem Black Fine Gravel did not exceed any of the screening ecological values (SEV; from the SLERA) for chemicals/metals analyzed. The Black Fine Gravel did not change water quality parameters in any significant (±50%) way compared to average water quality parameters found in test chambers with reference riverine sediments.

Upon analysis for percent gravel and percent sand, it was found that the two reference sediments (Ginelle and Lower Arrow Lake) were a gravelly sand with approximately 25% gravel content. Analysis by CAS shows that none of the chemicals/metals analyzed exceeded SEVs in any of the three reference sediments.

Conclusions:

The Hagen Geosystem Black Fine Gravel (ART #12648) is a suitable laboratory reference control sediment. This sediment is within the 0.5 to 2 mm grain size with an average grain size of 1.11 mm and a lowest and highest grain size of 0.85 mm and 1.68 mm, respectively. This sediment is predominantly dark in coloration and very similar in appearance to some riverine sediments of interest. This sediment did not change water quality parameters more than 10% compared to the average water quality parameters measured in test chambers with riverine sediments. Analysis by CAS shows this sediment to be free of contamination by all chemicals/metals analyzed.

All three of the reference sediments are suitable, as they are within the desired grain size, have an appropriate color, and are free of contamination.

Figure 1.0 Candidate Sediments: 1) Aquaterra Black Sand (#80035), 2) Pure Water Pebbles Cumberland River Gems (#30095), 3) Hagen Geosystem Pacific Gravel (ART# 12404), 4) Hagen Geosystem Black Fine Gravel (ART# 12648), 5) Aquaterra Natural Tan Sand (#80075), 6) Hagen Geosystem Extra Fine White River Gravel (ART# 12647)

Figure 2.0 Hagen Geosystem Black Fine Gravel (ART# 12648) selected for further trials. Grain size of 0.85 to 1.68 mm with an average grain size of 1.11 mm. Dark coloration similar to UCR sediments.

Table 1.0 Grain Size of Hagen Geosystem Black Fine Gravel (ART# 12648)

	Grain Size (mm)
	1.54
	0.89
	0.81
	1.58
	0.91
	0.98
	1.68
	0.85
	0.89
	0.97
Average =	1.11

Figure 3.0 Candidate reference sediment and river reference sediments. 1) Hagen Geosystem Black Fine Gravel (ART# 12648), 2) Deadman's Eddy, 3) Lower Arrow Lake, 4) Ginelle Eddy.

Figure 4.0 Hagen Geosystem Black Fine Gravel (ART# 12648) packaging (front).

Figure 4.1 Hagen Geosystem Black Fine Gravel (ART# 12648) packaging (back)

Table 2.0 Hagen Geosystem Black Fine Gravel (ART # 12648) Water Quality Parameters Compared to Reference Riverine Sediments

	Hour	**pH**		**DO**		**Hardness**		**Alkalinity**	
			% Dif.		% Dif.		% Dif.		% Dif.
	0	7.7	2.60	89	1.14	84	7.69	54	5.88
	24	7.5	5.33	85	3.53	74	5.41	48	6.25
Riverine Sediment (Average) WQ		7.9		88		78		51	

Preliminary laboratory results from CAS, as received on July 7, 2010

			GE Composite 05/12/10 K1005430-001								LALL Composite 05/13/10 K1005430-002		Lab Reference Sediment Received at CAS 06/22/10 K1006419-001					
Parameter	Units	Basis	Primary		Duplicate		Triplicate				Primary		Primary		Duplicate		Triplicate	
Total Carbon	percent	Unfilt	0.106								0.089		3.95					
pH	SU	WW	6.29		6.41						6.27		9.28		9.35			
Sulfide	µmol/g	DW	0.06						ave		0.004	*U*	0.03					
Total Solids	percent	WW	85.7		88.6						86.2		100		100			
Cobbles	percent	DW	0		0		0				0		0		0		0	
Very Coarse Gravel	percent	DW	0	*12*	0	*37*	0	*25*	25		0	*29*	0	*0*	0	*0.1*	0	*0*
Coarse Gravel	percent	DW	0		0		0				0		0		0		0	
Medium Gravel	percent	DW	0		19.6		6.4				13.7		0		0		0	
Fine Gravel	percent	DW	7.4		11.6		10.3				6.57		0		0		0	
Very Fine Gravel	percent	DW	4.48		6.14		8.17				9.11		0		0.12		0	
Very Coarse Sand	percent	DW	11.5	*81*	8.88	*61*	13	*72*	71		12.7	*67*	6.98	*99*	10.7	*101*	9.21	*99*
Coarse sand	percent	DW	38.1		27.7		34.4				18.5		78.6		80.4		80	
Med. Sand	percent	DW	24.3		19.2		20.1				22.4		13.4		8.03		10	
Fine Sand	percent	DW	5.35		4.29		3.8				12		0.39		1.28		0.08	
Very fine sand	percent	DW	1.54		1.08		0.84				1.53		0.11		0.11		0.08	
Silt	percent	DW	0.55	0.6	0.24		0.21	0.2			0.67	0.7	0.32	0.3	0.17	0.2	0.24	0.2
Clay	percent	DW	0.45	0.5	0.35		0.26	0.3			0.39	0.4	0.31	0.3	0.27	0.3	0.18	0.2
Aluminum	mg/kg	Unfilt	2100		2860						2070		198		244			
Antimony	mg/kg	Unfilt	0.043		0.013						0.069		0.009	*U*	0.012			
Arsenic	mg/kg	Unfilt	2.47		1						0.52		1.01		1.17			
Barium	mg/kg	Unfilt	19.3		27						29.2		13.7		15.4			
Beryllium	mg/kg	Unfilt	0.11		0.12						0.1		0.07		0.07			
Cadmium	mg/kg	Unfilt	0.123		0.131						0.097		0.068		0.071			
Calcium	mg/kg	Unfilt	1170		1420						910		354000		355000			
Chromium	mg/kg	Unfilt	4.86		3.9						3.52		0.98		1.03			
Cobalt	mg/kg	Unfilt	1.6		2.3						1.3		0.4		0.5			
Copper	mg/kg	Unfilt	4.6		8.1						2.4		1.2		1.3			
Iron	mg/kg	Unfilt	5790		7140						5120		1160		2440			
Lead	mg/kg	Unfilt	5.62		5.95						6.1		7.27		7.5			
Magnesium	mg/kg	Unfilt	1560		2140						1160		10400		11900			
Manganese	mg/kg	Unfilt	77.4		90.7						56.3		96.3		98.8			
Mercury	mg/kg	Unfilt	0.002	*U*	0.002	*U*					0.002	*U*	0.005					
Molybdenum	mg/kg	DW											0.73		0.88			
Nickel	mg/kg	Unfilt	6.09		7.89						4.11		1.03		1.42			
Potassium	mg/kg	Unfilt	496		584						364		164		191			
Selenium	mg/kg	Unfilt	0.2	*U*	0.2	*U*					0.2	*U*	0.2	*U*	0.2	*U*		
Silver	mg/kg	Unfilt	0.03		0.036						0.021		0.025		0.025			
Sodium	mg/kg	Unfilt	47		54						32		29		30			
Thallium	mg/kg	Unfilt	0.037		0.027						0.044		0.063		0.07			
Vanadium	mg/kg	Unfilt	8.5		12.4						8.4		2.6		3.1			
Zinc	mg/kg	Unfilt	33.9		34						22.6		15.5		20.5			

Preliminary laboratory results from CAS, as received on July 7, 2010

			GE Composite 05/12/10 K1005430-001			LALL Composite 05/13/10 K1005430-002	Lab Reference Sediment Received at CAS 06/22/10 K1006419-001		
Parameter	Units	Basis	Primary	Duplicate	Triplicate	Primary	Primary	Duplicate	Triplicate
Antimony	µmol/g	Unfilt	0.0048 *U*			0.0047 *U*	0.0041 *U*		
Arsenic	µmol/g	Unfilt	0.02 *U*			0.02 *U*	0.0036		
Cadmium	µmol/g	Unfilt	0.0005 *U*			0.0007	0.0003		
Chromium	µmol/g	Unfilt	0.0037			0.0055	0.003		
Copper	µmol/g	Unfilt	0.01			0.007	0.0045		
Lead	µmol/g	Unfilt	0.012			0.022	0.009		
Mercury	µmol/g	Unfilt	0.00005 *U*			0.00005 *U*	0.00004 *U*		
Nickel	µmol/g	Unfilt	0.007			0.004 *U*	0.002		
Zinc	µmol/g	Unfilt	0.089			0.051	0.0308		
2,4'-DDD	µg/kg	DW	0.13 *U*			0.13 *U*			
4,4'-DDD	µg/kg	DW	0.11 *U*			0.11 *U*			
2,4'-DDE	µg/kg	DW	0.16 *U*			0.16 *U*			
4,4'-DDE	µg/kg	DW	0.11 *U*			0.11 *U*			
2,4'-DDT	µg/kg	DW	0.058 *U*			0.058 *U*			
4,4'-DDT	µg/kg	DW	0.17 *U*			0.17 *U*			
2-Chlorobiphenyl	µg/kg	DW	1.2 *U*			1.2 *U*			
2,3-Dichlorobiphenyl	µg/kg	DW	0.13 *U*			0.13 *U*			
2,4'-Dichlorobiphenyl	µg/kg	DW	0.21 *U*			0.21 *U*			
2,2',5-Trichlorobiphenyl	µg/kg	DW	0.096 *U*			0.096 *U*			
2,3',4'-Trichlorobiphenyl	µg/kg	DW	0.11 *U*			0.11 *U*			
2,4,4'-Trichlorobiphenyl	µg/kg	DW	0.064 *U*			0.064 *U*			
2,4',5-Trichlorobiphenyl	µg/kg	DW	0.056 *U*			0.056 *U*			
3,4,4'-Trichlorobiphenyl	µg/kg	DW	0.052 *U*			0.052 *U*			
2,2',3,5'-Tetrachlorobiphenyl	µg/kg	DW	0.065 *U*			0.065 *U*			
2,2',4,5'-Tetrachlorobiphenyl	µg/kg	DW	0.058 *U*			0.058 *U*			
2,2',5,5'-Tetrachlorobiphenyl	µg/kg	DW	0.059 *U*			0.059 *U*			
2,3,3',4'-Tetrachlorobiphenyl	µg/kg	DW	0.046 *U*			0.046 *U*			
2,3,4,4'-Tetrachlorobiphenyl	µg/kg	DW	0.039 *U*			0.039 *U*			
2,3',4,4'-Tetrachlorobiphenyl	µg/kg	DW	0.035 *U*			0.035 *U*			
2,3',4',5-Tetrachlorobiphenyl	µg/kg	DW	0.051 *U*			0.051 *U*			
2,4,4',5-Tetrachlorobiphenyl	µg/kg	DW	0.044 *U*			0.044 *U*			
3,3',4,4'-Tetrachlorobiphenyl	µg/kg	DW	0.047 *U*			0.047 *U*			
3,4,4',5-Tetrachlorobiphenyl	µg/kg	DW	0.05 *U*			0.05 *U*			
2,2',3,4,5'-Pentachlorobiphenyl	µg/kg	DW	0.038 *U*			0.038 *U*			
2,2',3,4',5'-Pentachlorobiphenyl	µg/kg	DW	0.053 *U*			0.053 *U*			
2,2',3,4',5-Pentachlorobiphenyl	µg/kg	DW	0.035 *U*			0.035 *U*			
2,2',3,5',6-Pentachlorobiphenyl	µg/kg	DW	0.049 *U*			0.049 *U*			
2,2',4,4',5-Pentachlorobiphenyl	µg/kg	DW	0.045 *U*			0.045 *U*			
2,2',4,5,5'-Pentachlorobiphenyl	µg/kg	DW	0.049 *U*			0.049 *U*			
2,3,3',4,4'-Pentachlorobiphenyl	µg/kg	DW	0.033 *U*			0.033 *U*			
2,3,3',4',6-Pentachlorobiphenyl	µg/kg	DW	0.035 *U*			0.035 *U*			
2,3,4,4',5-Pentachlorobiphenyl	µg/kg	DW	0.023 *U*			0.023 *U*			
2,3',4,4',5'-Pentachlorobiphenyl	µg/kg	DW	0.067 *U*			0.067 *U*			
2,3',4,4',5-Pentachlorobiphenyl	µg/kg	DW	0.031 *U*			0.031 *U*			
2,3',4,4',6-Pentachlorobiphenyl	µg/kg	DW	0.046 *U*			0.046 *U*			
3,3',4,4',5-Pentachlorobiphenyl	µg/kg	DW	0.043 *U*			0.043 *U*			
2,2',3,3',4,4'-Hexachlorobiphenyl	µg/kg	DW	0.031 *U*			0.031 *U*			
2,2',3,3',4,6'-Hexachlorobiphenyl	µg/kg	DW	0.075 *U*			0.075 *U*			
2,2',3,4,4',5'-Hexachlorobiphenyl	µg/kg	DW	0.064 *U*			0.064 *U*			
2,2',3,4,5,5'-Hexachlorobiphenyl	µg/kg	DW	0.035 *U*			0.035 *U*			
2,2',3,4',5',6-Hexachlorobiphenyl	µg/kg	DW	0.067 *U*			0.067 *U*			
2,2',3,5,5',6-Hexachlorobiphenyl	µg/kg	DW	0.043 *U*			0.043 *U*			
2,2',4,4',5,5'-Hexachlorobiphenyl	µg/kg	DW	0.038 *U*			0.038 *U*			
2,3,3',4,4',5'-Hexachlorobiphenyl	µg/kg	DW	0.031 *U*			0.031 *U*			
2,3,3',4,4',5-Hexachlorobiphenyl	µg/kg	DW	0.042 *U*			0.042 *U*			
2,3,3',4,4',6-Hexachlorobiphenyl	µg/kg	DW	0.028 *U*			0.028 *U*			
2,3',4,4',5,5'-Hexachlorobiphenyl	µg/kg	DW	0.046 *U*			0.046 *U*			
2,3,4,4',5,6-Hexachlorobiphenyl	µg/kg	DW	0.03 *U*			0.03 *U*			
2,3',4,4',5',6-Hexachlorobiphenyl	µg/kg	DW	0.027 *U*			0.027 *U*			
3,3',4,4',5,5'-Hexachlorobiphenyl	µg/kg	DW	0.041 *U*			0.041 *U*			
2,2',3,3',4,4',5-Heptachlorobiphenyl	µg/kg	DW	0.026 *U*			0.026 *U*			
2,2',3,3',4,5,6'-Heptachlorobiphenyl	µg/kg	DW	0.03 *U*			0.03 *U*			

Preliminary laboratory results from CAS, as received on July 7, 2010

			GE Composite 05/12/10 K1005430-001			LALL Composite 05/13/10 K1005430-002	Lab Reference Sediment Received at CAS 06/22/10 K1006419-001		
Parameter	Units	Basis	Primary	Duplicate	Triplicate	Primary	Primary	Duplicate	Triplicate
2,2',3,3',4,5',6'-Heptachlorobiphenyl	µg/kg	DW	0.052 *U*			0.052 *U*			
2,2',3,4,4',5,5'-Heptachlorobiphenyl	µg/kg	DW	0.095 *U*			0.095 *U*			
2,2',3,4,4',5',6-Heptachlorobiphenyl	µg/kg	DW	0.081 *U*			0.081 *U*			
2,2',3,4,4',6,6'-Heptachlorobiphenyl	µg/kg	DW	0.052 *U*			0.052 *U*			
2,2',3,4',5,5',6-Heptachlorobiphenyl	µg/kg	DW	0.047 *U*			0.047 *U*			
2,3,3',4,4',5,5'-Heptachlorobiphenyl	µg/kg	DW	0.029 *U*			0.029 *U*			
2,2',3,3',4,4',5,5'-Octachlorobiphenyl	µg/kg	DW	0.043 *U*			0.043 *U*			
2,2',3,3',4,4',5,6-Octachlorobiphenyl	µg/kg	DW	0.031 *U*			0.031 *U*			
2,2',3,3',4,5',6,6'-Octachlorobiphenyl	µg/kg	DW	0.041 *U*			0.041 *U*			
2,2',3,4,4',5,5',6-Octachlorobiphenyl	µg/kg	DW	0.039 *U*			0.039 *U*			
2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	µg/kg	DW	0.031 *U*			0.031 *U*			
Decachlorobiphenyl (PCB 209)	µg/kg	DW	0.041 *U*			0.041 *U*			

Preliminary laboratory results from CAS compared to sediment screening criteria[a]

					GE Composite 05/12/10 K1005430-001			LALL Composite 05/13/10 K1005430-002	Lab Reference Sediment Received at CAS 06/22/10 K1006419-001		
Parameter	Units	Basis	Sediment Screening SEV	Exceedance	Primary	Duplicate	Triplicate	Primary	Primary	Duplicate	Triplicate
Antimony	mg/kg	Unfilt	0.40	No	0.043	0.013		0.069	0.009 *U*	0.012	
Arsenic	mg/kg	Unfilt	9.79	No	2.47	1		0.52	1.01	1.17	
Beryllium	mg/kg	Unfilt	0.46	No	0.11	0.12		0.1	0.07	0.07	
Cadmium	mg/kg	Unfilt	0.99	No	0.123	0.131		0.097	0.068	0.071	
Chromium	mg/kg	Unfilt	43.4	No	4.86	3.9		3.52	0.98	1.03	
Copper	mg/kg	Unfilt	31.6	No	4.6	8.1		2.4	1.2	1.3	
Lead	mg/kg	Unfilt	35.8	No	5.62	5.95		6.1	7.27	7.5	
Mercury	mg/kg	Unfilt	0.18	No	0.002 *U*	0.002 *U*		0.002 *U*	0.005		
Nickel	mg/kg	Unfilt	22.7	No	6.09	7.89		4.11	1.03	1.42	
Silver	mg/kg	Unfilt	0.545	No	0.03	0.036		0.021	0.025	0.025	
Zinc	mg/kg	Unfilt	121	No	33.9	34		22.6	15.5	20.5	
4,4'-DDD	µg/kg	DW	96	No	0.11 *U*			0.11 *U*			
Total DDD (all ND, max DL shown)	µg/kg	DW	4.88	No	0.13 *U*			0.13 *U*			
4,4'-DDE	µg/kg	DW	21	No	0.11 *U*			0.11 *U*			
Total DDE (all ND, max DL shown)	µg/kg	DW	3.16	No	0.16 *U*			0.16 *U*			
4,4'-DDT	µg/kg	DW	19	No	0.17 *U*			0.17 *U*			
Total DDT (all ND, max DL shown)	µg/kg	DW	4.16	No	0.17 *U*			0.17 *U*			
Total DDx (all ND, max DL shown)	µg/kg	DW	5.28	No	0.17 *U*			0.17 *U*			
Total PCBs (all ND, max DL shown)	µg/kg	DW	59.8	No	1.2 *U*			1.2 *U*			

[a] - Results received from CAS as of July 7, 2010.

Appendix B Field reports for collection of reference sediments

MEMORANDUM

TO:	Marko Adzic, Teck American Incorporated
FROM:	Jeffrey E. Leppo, LG
DATE:	June 30, 2010
FILE:	36310054.00001
SUBJECT:	Field Report and Records – Methods Development for the White Sturgeon Sediment Toxicity Study Sediment Sampling, British Columbia, Canada

Introduction

URS Incorporated (URS) conducted field services for Teck American Incorporated (Teck) on the Columbia River (CR) at Birchbank Eddy (BBE), Genelle (GE), and Lower Arrow Lake (LALL) sediment sampling locations in British Columbia, Canada on May 12 and 13, 2010. The field services scope of work was based on the requirements and standard operating procedures (SOP) outlined within the *Quality Assurance Project Plan – Methods Development for the White Sturgeon Sediment Toxicity Study* (QAPP) prepared for Teck in April 2010.

Field records attached to this memorandum include:

- Photographs of the locations, general sampling procedures, and grab samples
- Field Data/Sampling Diary sheets for each sample location and station
- Photocopy of the hard-bound Environmental Field Book daily record
- Chain-of-custody for May 12 and 13, 2010 grab samples

Scope of Work

Three below-water sediment sampling locations and coordinates are identified in the QAPP, including BBE, GE, and LALL located above Trail, British Columbia. Each of the three general sample locations was accessed by boat and positioned for sediment grab sampling by Gravity Environmental, Inc. (Gravity) based on the QAPP coordinates. The longitude and latitude coordinates for each grab sample station were marked using the sample boat's global positioning system (GPS) and recorded on the individual field data/sampling diaries. Table 1 presents coordinates of each grab sample location. Sediment sample locations are shown in Map 1.

All sediment samples were collected using a decontaminated compressed air operated Power Grab sampler. Sediment was collected as ten grab samples at each general location and transferred to five-gallon decontaminated polyethylene buckets; dependent on the river bottom composition and sample recovery. Unique sample numbers and tags were assigned based on QAPP SOP-4 instructions.

Photographs of each location, sample procedures, and grab samples were taken and are sequentially identified using a white board to record pertinent information (e.g., time, date, and location) within Attachment A. Typical sampling activities and sediments collected during this event are presented in Figures 1 through 15.

Individual photo files are labeled with the name of the station and a sequential number within the photographic directory for each of the three locations, as follows:

Birchbank Eddy – BBE_001 to BBE_021
Genelle – GE_001 to GE_045
Lower Arrow Lake – LALL_001 to LALL_035

Field data and sampling diary sheets were prepared for each grab sample (Attachment B). Field sampling diaries include observations on the weather, time, latitude and longitude, water depth, sediment texture and characteristics, photograph record, abnormalities, and other relevant notes. A bound environmental field book (Attachment C) was used to record general information regarding project personnel, activities, and operations.

Field Observations

Ten competent grab samples (five gallons each) were obtained from both the Genelle and Lower Arrow Lake locations; for a total of 20 grab samples. The river bottom composition of the Birchbank Eddy was primarily composed of cobble and boulder-sized material. Three attempts were made to collect sediments at this location; unfortunately, the presence of a course substrate precluded the recovery of a suitable fine to coarse sand matrix. Please refer to the Birchbank Eddy photos and field diary for reference.

Grab samples were transported to shore and relinquished under chain-of-custody protocol to Dr. Markus Hecker (Principal Investigator) and representatives of the University of Saskatchewan, Aquatic Exposure Laboratory. Samples were placed in a refrigerated truck maintained to approximately 4° C and transported to the University of Saskatchewan. Please refer to Attachment D for the chain-of custodies.

Deviations and Corrective Actions

The presence of a cobble and boulder river bottom cover precluded the ability to collect a competent sample from the Birchbank Eddy location.

No other reportable deviations, contingencies, or corrective actions required for this project phase as defined by the QAPP or SOPs.

Attachments:

Table 1: Sample Coordinates
Map 1: Sediment Sample Locations
Figures 1-15: Site Photographs
Attachment A: Photographic Record
Attachment B: Field Data/Sampling Diaries
Attachment C: Environmental Field Book
Attachment D: Chain-of-Custodies

Table 1
Sample Numbers and Coordinates
Methods Development - White Sturgeon Sediment Toxicity Study
Upper Columbia River - Birchbank Eddy, Genelle, and Lower Arrow Lake (Canada)

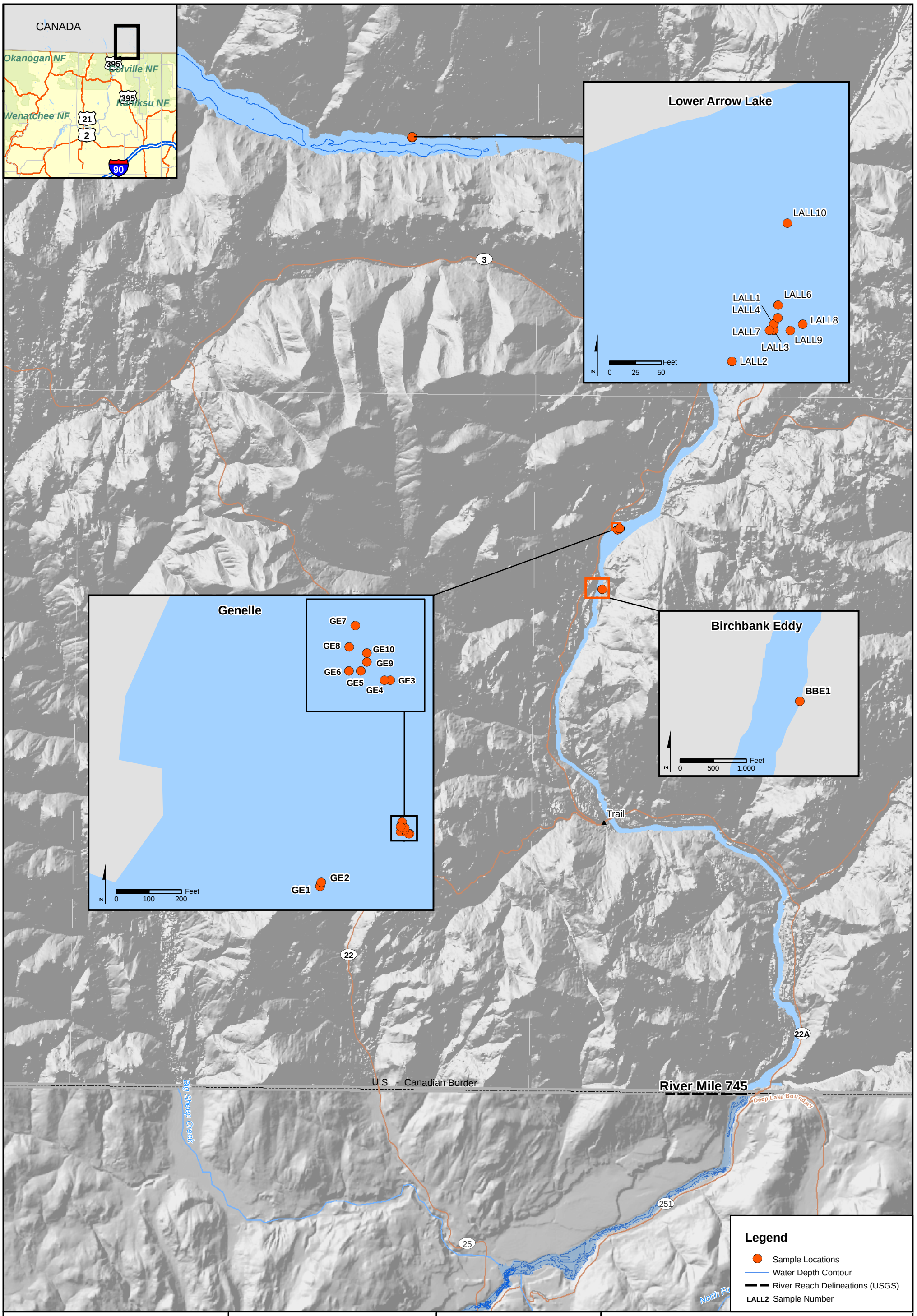
Site Name	Sample No.	Container Tag No.	Northing (UTM) [2]	Easting (UTM)
Birchbank Eddy	TAI-CAN-BBE-1-PG-1	N/A[1]	5447789.379	448050.484
Genelle	TAI-CAN-GE-1-PG-1	GE1	5450155.375	448668.936
Genelle	TAI-CAN-GE-1-PG-2[3]	GE2	5450159.069	448670.185
Genelle	TAI-CAN-GE-1-PG-3	GE3	5450204.621	448753.173
Genelle	TAI-CAN-GE-1-PG-4	GE4	5450204.632	448751.959
Genelle	TAI-CAN-GE-1-PG-5	GE5	5450206.530	448747.120
Genelle	TAI-CAN-GE-1-PG-6	GE6	5450206.553	448744.692
Genelle	TAI-CAN-GE-1-PG-7	GE7	5450215.805	448745.992
Genelle	TAI-CAN-GE-1-PG-8[3]	GE8	5450211.445	448744.760
Genelle	TAI-CAN-GE-1-PG-9	GE9	5450208.371	448748.352
Genelle	TAI-CAN-GE-1-PG-10	GE10	5450210.224	448748.369
Lower Arrow Lake	TAI-CAN-LALL-1-PG-1	LALL1	5465801.313	440479.821
Lower Arrow Lake	TAI-CAN-LALL-1-PG-2	LALL2	5465790.327	440467.594
Lower Arrow Lake	TAI-CAN-LALL-1-PG-3	LALL3	5465799.460	440479.801
Lower Arrow Lake	TAI-CAN-LALL-1-PG-4	LALL4	5465801.313	440479.821
Lower Arrow Lake	TAI-CAN-LALL-1-PG-5	LALL5	5465803.152	440481.052
Lower Arrow Lake	TAI-CAN-LALL-1-PG-6	LALL6	5465806.858	440481.092
Lower Arrow Lake	TAI-CAN-LALL-1-PG-7	LALL7	5465799.473	440478.590
Lower Arrow Lake	TAI-CAN-LALL-1-PG-8	LALL8	5465801.221	440488.296
Lower Arrow Lake	TAI-CAN-LALL-1-PG-9	LALL9	5465799.407	440484.644
Lower Arrow Lake	TAI-CAN-LALL-1-PG-10	LALL10	5465830.918	440483.775

Notes:

(1) Sample could not be collected because river bottom comprised of cobbles and boulders

(2) Coordinates based on Universal Transverse Mercator (UTM) using North American Datum of 1983 (NAD83), Zone 11

(3) Sample coordinates miss-recorded in field. Presented UTM coordinates have been corrected.



Sediment Sample Locations

Km
0 2.5 5

Miles
0 1.5 3

N

URS Corporation

Source:
GIS base layer Information provided by Parametrix Inc.

Map 1 **Methods Development for the White Sturgeon Sediment Toxicity Study (Birchbank Eddy, Genelle, and Lower Arrow Lake)**
Upper Columbia River, Canada

FIGURES 1 through 15
Site Photographs

Figure 1
Photograph of Birchbank Eddy Station, view to north. Note cobbley river bottom.

Figure 2
Deployment of the Power Grab sediment sampling device, Birchbank Eddy Station, view to the north.

Figure 3
Retrieval of Power Grab sediment sample at Birchbank Eddy Station, view to the north.

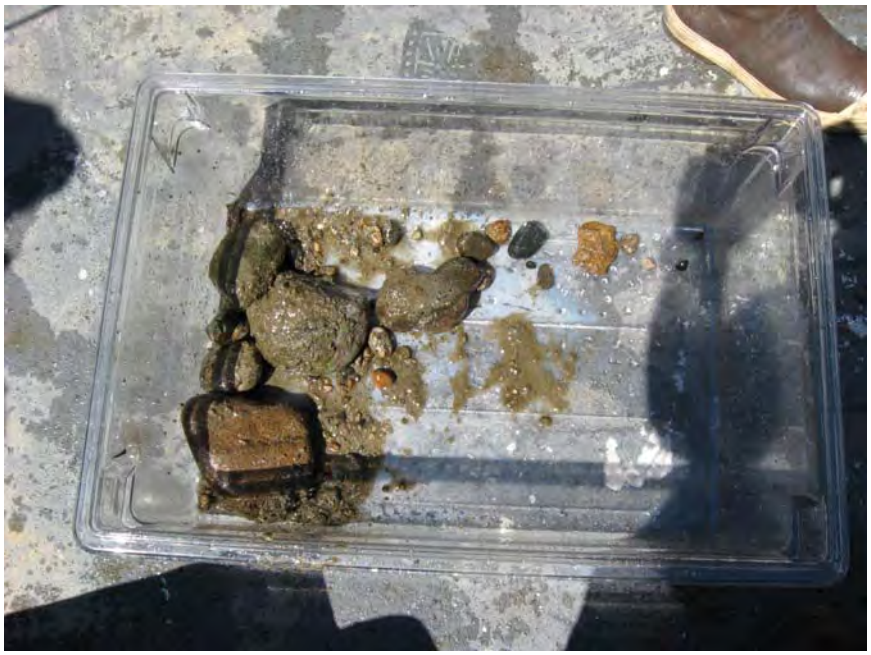


Figure 4
Poor recovery at Birchbank Eddy Station. Note cobbles and absence of finer sediment material.

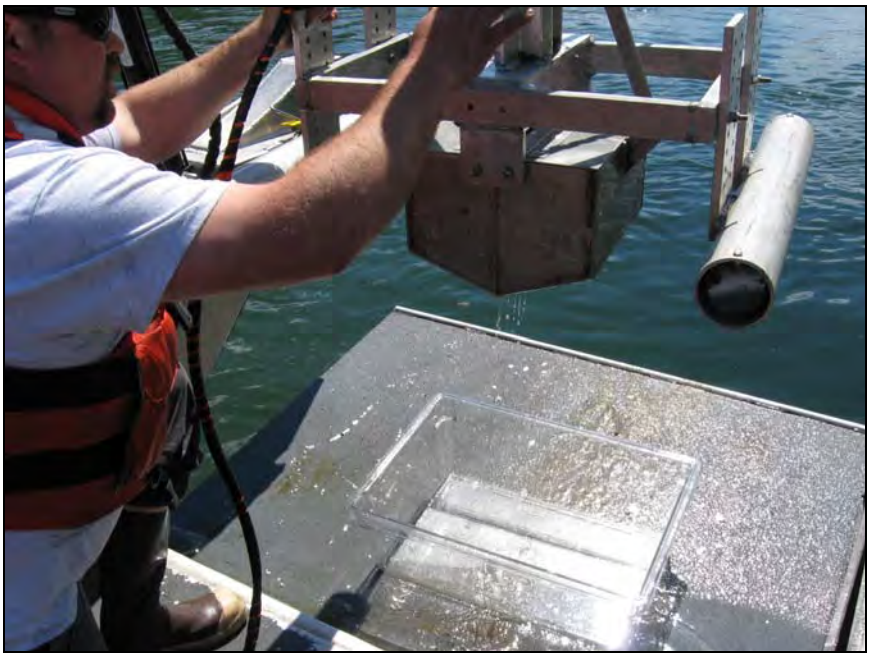


Figure 5
Preparing to deposit Power Grab sediment grab sample into sample tray at the Genelle Station.

Figure 6
Sediment grab sample following placement in sample tray at the Genelle Station.

Figure 7
Close-up view of Genelle Station sediment grab sample.

Figure 8
Transfering Genelle Station sediment grab sample from sample tray.

Figure 9
Sediment grab sample number GE4 following placement in sample container, Genelle Station.

Figure 10
Shoreline at Genelle Station, view toward east.

Figure 11
Shoreline at Genelle Station, view to southeast.

Figure 12
Sediment grab sample number LALL2 in sample tray, Lower Arrow Lake Station

Figure 13
Sediment grab sample number LALL4 in sample tray, Lower Arrow Lake Station

Figure 14
Close-up of grab sample number LALL4 in sample tray, Lower Arrow Lake Station

Figure 15
Shoreline at Lower Arrow Lake Station, view to northeast

ATTACHMENT A
Photographic Record
Provided on Compact Disc (CD)

ATTACHMENT B
Field Data/Sampling Diaries

Birchbank Eddy

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 1	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE ✓	GE	LALL
DATE: 5/12/2010			
WEATHER CONDITIONS: Sunny, clear, 65 to 70°F			
SEDIMENT SAMPLER TYPE: Power Grab			
URS FIELD PERSONNEL: Gary Panther, Jeff Leppo			
Other Notes: No sample. No fine to coarse grain sands.			

Station Reference UTM Coordinates

Lat	~~Easting:~~	46 10.843
Long	~~Northing:~~	117 42.771

Sample No.	TAI-CAN-BBE-1-PG-1
Container Tag No.	NA
Time	12:39
UTM Easting	See Above
UTM Northing	"
Field Photo No.	UCR Birchbank Eddy
Camera Image No.	BBE_001 to BBE_021, Photo sequence < Sample Area
Water Depth (cm)	229 (7.5ft)
Sampler Depth Penetration (cm)	2 to 5 cm
Sediment Texture (ASTM/Unified)	GW, well graded gravels w/ cobbles & boulders, little to no fines or sand
Sediment Color (Munsell)	Variable matrix parent material & colors
Odors	No odors
Leakage Disturbance	Very poor recovery - unable to close sampler
Abnormalities	(1) Freshwater clam
Other Notes	Cobble to boulder sized material as river bottom. Sand limited to matrix interstices.

Sampler Name: Jeff Leppo

Sample Signature: JL Jeff

Date: 5/19/2010

Time: 16:00

Genelle

Page 1 of 1

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 1	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE ✓	LALL
DATE: 5 / 12 /2010			
WEATHER CONDITIONS: Clear, sunny, 65 to 70°F			
SEDIMENT SAMPLER TYPE: Power Grab			
URS FIELD PERSONNEL: Gary Panther, Jeff Leppo			
Other Notes:			

Station Reference UTM Coordinates

~~Easting~~ Lat:	49 12.123
~~Northing~~ Long:	117 42.280

Sample No.	TAI-CAN-GE-1-PG-1
Container Tag No.	GE1
Time	1330
UTM Easting	See above
UTM Northing	" "
Field Photo No.	UCR Genelle
Camera Image No.	GE001 to GE_006, Photosequence - sampling, sample
Water Depth (cm)	179 (5.8 ft)
Sampler Depth Penetration (cm)	15 (5 to 6 in.)
Sediment Texture (ASTM/Unified)	SW - well graded sands, little to no fines, few small gravels
Sediment Color (~~Munsell~~)	Grayish brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	Minimal visible organic material - small wood particles on surface - removed as feasible

Sampler Name: Jeff Leppo

Sample Signature:

Date: 5 / 19 /2010

Time: 19:02

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 2	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE ✓	LALL
DATE:	5/12/2010		
WEATHER CONDITIONS:	Clear, sunny, 65 to 70°F		
SEDIMENT SAMPLER TYPE:	Power Grab		
URS FIELD PERSONNEL:	Gary Panther, Jeff Leppo		
Other Notes:			

Station Reference UTM Coordinates

~~Easting:~~ Lat	49 10.125
~~Northing:~~ Long	117 42.279

Sample No.	TAI-CAN-GE-1-PG-2
Container Tag No.	GE2
Time	1400
UTM Easting	See above
UTM Northing	" "
Field Photo No.	UCR Genelle
Camera Image No.	GE_007 to GE_011
Water Depth (cm)	162 (5.3 ft)
Sampler Depth Penetration (cm)	15 (5 to 6 in.)
Sediment Texture (ASTM/Unified)	SW - well graded sands, little to no fines, few small gravels to large
Sediment Color (~~Munsell~~)	Grayish brown
Odors	None observed
Leakage Disturbance	Good recovery - cobbles present
Abnormalities	Small roots
Other Notes	Increase invisible organic matter - roots removed, as feasible. Move to center of eddy for next sample based on field observations Few cobbles.

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5/19/2010

Time: 19:06

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 3	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE ✓	LALL
DATE: 5 / 12 /2010			
WEATHER CONDITIONS: Clear, sunny, 65 to 70 °F			
SEDIMENT SAMPLER TYPE: Power Grab			
URS FIELD PERSONNEL: Gary Panther, Jeff Leppo			
Other Notes:			

Station Reference UTM Coordinates

Lat	~~Easting:~~	49 12.150
Long	~~Northing:~~	117 42.211

Sample No.	TAI-CAN-GE-1-PG-3
Container Tag No.	GE3
Time	1450
UTM Easting	See above
UTM Northing	" "
Field Photo No.	UCR Genelle
Camera Image No.	GE_012 to GE_016
Water Depth (cm)	180 (5.9ft)
Sampler Depth Penetration (cm)	23 (8 to 10 in)
Sediment Texture (ASTM/Unified)	SW - well graded Sands, little to no fines, few small gravels
Sediment Color (~~Munsell~~)	Grayish brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	Good sample located close to middle of eddy. Little to no visible organic matter. Good place for remaing grab samples

Sampler Name: Jeff Leppo

Sample Signature: Jeff Leppo

Date: 5 / 19 /2010

Time: 19:07

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 4	BIRCHBANK EDDY	GENELLE ✓	LOWER ARROW LAKE
STATION CODE:	BBE	GE	LALL

Station Reference UTM Coordinates

~~Easting:~~ Lat	49 12.150
~~Northing:~~ Long	117 42.212

DATE:	5 / 12 /2010
WEATHER CONDITIONS:	Clear, sunny, 65 to 70°F
SEDIMENT SAMPLER TYPE:	Power Grab
URS FIELD PERSONNEL:	Gary Panther, Jeff Leppo
Other Notes:	

Sample No.	TAI-CAN-GE-1-PG-4
Container Tag No.	GE4
Time	1508
UTM Easting	See above
UTM Northing	" "
Field Photo No.	UCR Genelle
Camera Image No.	GE_017 to GE_021
Water Depth (cm)	192 (6.3 ft)
Sampler Depth Penetration (cm)	27 (10 to 11 in)
Sediment Texture (ASTM/Unified)	SW - well graded sands, little to no fines, few small gravels
Sediment Color (Munsell)	Grayish brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	No visible organic matter

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 19 /2010

Time: 1908

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 5	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE ✓	LALL
DATE: 5/12/2010			
WEATHER CONDITIONS: Clear, sunny, 65 to 70°F			
SEDIMENT SAMPLER TYPE: Power Grab			
URS FIELD PERSONNEL: Gary Panther, Jeff Leppo			
Other Notes:			

Station Reference UTM Coordinates

~~Easting~~ Lat:	49 12.151
~~Northing~~ Long:	117 42.216

Sample No.	TAI-CAN-GE-1-PG-5
Container Tag No.	GE5
Time	1514
UTM Easting	See above
UTM Northing	" "
Field Photo No.	UR-GENELLE
Camera Image No.	GE_022 to GE_024
Water Depth (cm)	228 (7.5 ft)
Sampler Depth Penetration (cm)	25 (10 in.)
Sediment Texture (ASTM/Unified)	SW-well graded sands, little to no fines, few small gravels
Sediment Color (~~Munsell~~)	Grayish brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	No visible organic matter

Sampler Name: Jeff Leppo

Sample Signature:

Date: 5/19/2010

Time: 19:10

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 6	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE ✓	LALL

DATE: 5 / 12 /2010

WEATHER CONDITIONS: Clear, Sunny, 65 to 70°F

SEDIMENT SAMPLER TYPE: Power Grab

URS FIELD PERSONNEL: Gary Panther, Jeff Leppo

Other Notes:

Station Reference UTM Coordinates

Lat ~~Easting~~:	49 12.151
Long ~~Northing~~:	117 42.218

Sample No.	TAI-CAN-GE-1-PG-6
Container Tag No.	GE6
Time	1522
UTM Easting	See above
UTM Northing	" "
Field Photo No.	UCR Genelle
Camera Image No.	GE_025 to GE_027
Water Depth (cm)	177 (5.8ft)
Sampler Depth Penetration (cm)	28 (11 in.)
Sediment Texture (ASTM/Unified)	SW-well graded sands, little to no fines, few small gravels
Sediment Color (~~Munsell~~)	Grayish brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	No visible organic matter.

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 19 /2010

Time: 19:12

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 7	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE ✓	LALL
DATE:	5 / 12 /2010		
WEATHER CONDITIONS:	Clear, sunny, 65 to 70°F		
SEDIMENT SAMPLER TYPE:	Power Grab		
URS FIELD PERSONNEL:	Gary Panther, Jeff Leppo		
Other Notes:			

Station Reference UTM Coordinates

Lat	~~Easting:~~	49 12.156
Long	~~Northing:~~	117 42.217

Sample No.	TAI-CAN-GE-1-PG-7
Container Tag No.	GE7
Time	1535
UTM Easting	See above.
UTM Northing	" "
Field Photo No.	UCR Genelle
Camera Image No.	GE_031
Water Depth (cm)	182 (6.0 ft.)
Sampler Depth Penetration (cm)	25 (10 in.)
Sediment Texture (ASTM/Unified)	SW-well graded sands, little to no fines, few small gravels
Sediment Color (~~Munsell~~)	Grayish brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	Dark gray stringers w/in grayish brown color matrix. Possible evidence of different depositions or disturbance (natural)

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 19 /2010

Time: 19:4

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 8	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE✓	LALL

DATE: 5 / 12 /2010

WEATHER CONDITIONS: Clear, sunny, 70°F ∞

SEDIMENT SAMPLER TYPE: Power Grab

URS FIELD PERSONNEL: Gary Panther, Jeff Leppo

Other Notes:

Station Reference UTM Coordinates

~~Easting~~ Lat:	49 12.066
~~Northing~~ Long:	117 42.128

Sample No.	TAI-CAN- GE -1-PG - 8
Container Tag No.	GE 8
Time	1541
UTM Easting	See above
UTM Northing	" "
Field Photo No.	UCR Genelle
Camera Image No.	GE_032
Water Depth (cm)	204 (6.7 ft.)
Sampler Depth Penetration (cm)	25 (10 in)
Sediment Texture (ASTM/Unified)	SW-well graded sands, little to no fines, few small gravels
Sediment Color (~~Munsell~~)	Grayish brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	No visible organic matter.

Sampler Name: Jeff Leppo

Sample Signature:

Date: 5 / 19 /2010

Time: 19:17

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 9	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE ✓	LALL

Station Reference UTM Coordinates

~~Easting~~ Lat:	49 12.152
~~Northing~~ Long:	117 42.215

DATE: 5 / 12 /2010

WEATHER CONDITIONS: Clear, sunny, 70 to 70°F

SEDIMENT SAMPLER TYPE: Power Grab

URS FIELD PERSONNEL: Gary Panther, Jeff Leppo

Other Notes:

Sample No.	TAI-CAN-GE-1-PG-9
Container Tag No.	GE9
Time	1548
UTM Easting	See above
UTM Northing	" "
Field Photo No.	UCR-Genelle
Camera Image No.	GE_033
Water Depth (cm)	179 (5.9 ft)
Sampler Depth Penetration (cm)	20 (8 in.)
Sediment Texture (ASTM/Unified)	SW-well graded sands, little to no fines, few small gravels
Sediment Color (~~Munsell~~)	Grayish brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	No visible organic matter

Sampler Name: Jeff Leppo

Sample Signature:

Date: 5 / 19 /2010

Time: 19:19

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 10	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE	LALL
DATE:	5 / 12 /2010		
WEATHER CONDITIONS:	Clear, sunny, 70-75°F		
SEDIMENT SAMPLER TYPE:	Power Grab		
URS FIELD PERSONNEL:	Gary Panther, Jeff Leppo		
Other Notes:			

Station Reference UTM Coordinates

Lat	~~Easting:~~	49 12.153
Long	~~Northing:~~	117 42.215

Sample No.	TAI-CAN-GE-1-PG-10
Container Tag No.	GE10
Time	1555
UTM Easting	See above.
UTM Northing	" "
Field Photo No.	UCR Genelle
Camera Image No.	GE_028 to GE_030, also GE_034 to GE_045 (Area + Core
Water Depth (cm)	192 (6.3 ft)
Sampler Depth Penetration (cm)	25 (10 in.)
Sediment Texture (ASTM/Unified)	SW-well graded sands, little to no fines, few small gravels
Sediment Color (~~Munsell~~)	Grayish brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	No visible organic matter

Sampler Name: Jeff Leppo

Sample Signature: Jeff Leppo

Date: 5 / 19 /2010

Time: 19:13

Lower Arrow Lake

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 1	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE	LALL
DATE:	5 / 13 /2010		
WEATHER CONDITIONS:	Clear, sunny, 60 to 65 °F		
SEDIMENT SAMPLER TYPE:	Power Grab		
URS FIELD PERSONNEL:	Gary Panther, Jeff Leppo		
Other Notes:			

Station Reference UTM Coordinates

~~Easting:~~ Lat	49 20.522
~~Northing:~~ Long	117 49.164

Sample No.	TAI-CAN-LALL-1-PG-1
Container Tag No.	LALL1
Time	0940
UTM Easting	See above
UTM Northing	" "
Field Photo No.	UCR - Lower Arrow Lake
Camera Image No.	LALL_01 to LALL_012. Photo Sequence of sampling & Sample
Water Depth (cm)	207 (6.8 ft)
Sampler Depth Penetration (cm)	23 (8 to 10 in)
Sediment Texture (ASTM/Unified)	SW - well graded sands, little to no fines, few small gravels
Sediment Color (~~Munsell~~)	Light brown
Odors	No odors
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	Some organic matter / litter on surface, overlying sand sediment

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 19 /2010

Time: 17:20

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 2	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE	LALL ✓
DATE: 5 / 13 /2010			

Station Reference UTM Coordinates

~~Easting~~ Lat	49 20.516
~~Northing~~ Long	117 49.174

WEATHER CONDITIONS:	Clear, sunny, 60 to 65°F
SEDIMENT SAMPLER TYPE:	Power Grab
URS FIELD PERSONNEL:	Gary Panther, Jeff Leppo
Other Notes:	

Sample No.	TAI-CAN-LALL-1-PG-2
Container Tag No.	LALL2
Time	0950
UTM Easting	See above.
UTM Northing	" "
Field Photo No.	UCR - Lower Arrow Lake
Camera Image No.	LALL_013 & LALL_014
Water Depth (cm)	210 (6.9 ft)
Sampler Depth Penetration (cm)	23 (8 to 10 in)
Sediment Texture (ASTM/Unified)	SW - well graded sands, little to no fines, few small gravels
Sediment Color (Munsell)	Light brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	Limited organic matter / litter on sediment surface. Good sand samples.

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 19 /2010

Time: 19:21

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 3	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE	LALL ✓
DATE:	5/13/2010		
WEATHER CONDITIONS:	Clear, Sunny, 60 to 65°F		
SEDIMENT SAMPLER TYPE:	Power Grab		
URS FIELD PERSONNEL:	Gary Panther, Jeff Leppo		
Other Notes:			

Station Reference UTM Coordinates

Lat	~~Easting:~~	49 20.521
Long	~~Northing:~~	117 49.164

Sample No.	TAI-CAN-LALL-1-PG-3
Container Tag No.	LALL3
Time	1005
UTM Easting	See above
UTM Northing	" "
Field Photo No.	UCR - Lower Arrow Lake
Camera Image No.	LALL_015
Water Depth (cm)	213 (7.0 ft.)
Sampler Depth Penetration (cm)	28 (11 in)
Sediment Texture (ASTM/Unified)	SW - well graded sands, little to no fines, few small gravels
Sediment Color (Munsell)	Light brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	Little to no visible organic matter

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 19 /2010

Time: 19:22

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 4	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE ✓
STATION CODE:	BBE	GE	LALL
DATE:	5 / 13 /2010		
WEATHER CONDITIONS:	Clear, sunny, 60 to 65°F		
SEDIMENT SAMPLER TYPE:	Power Grab		
URS FIELD PERSONNEL:	Gary Panther, Jeff Leppo		
Other Notes:			

Station Reference UTM Coordinates

~~Easting~~ Lat:	49 20.522
~~Northing~~ Long:	117 49.164

Sample No.	TAI-CAN-LALL-1-PG - 4
Container Tag No.	LALL4
Time	1013
UTM Easting	See above
UTM Northing	See above
Field Photo No.	UCR Lower Arrow Lake
Camera Image No.	LALL-016 to LALL-018
Water Depth (cm)	201 (6.6 ft)
Sampler Depth Penetration (cm)	23 (8 to 10 in.)
Sediment Texture (ASTM/Unified)	SW-well graded sands, little to no fines, few small gravels
Sediment Color ~~(Munsell)~~	Light brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	Little to no visible organic matter

Sampler Name: Jeff Leppo

Sample Signature: Jeff Leppo

Date: 5 / 19 /2010

Time: 19:23

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 5	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE	LALL ✓
DATE:	5 / 13 /2010		
WEATHER CONDITIONS:	Clear, sunny, 60 to 65°F		
SEDIMENT SAMPLER TYPE:	Power Grab		
URS FIELD PERSONNEL:	Gary Panther, Jeff Leppo		
Other Notes:			

Station Reference UTM Coordinates

Lat	~~Easting~~:	49 20.523
Long	~~Northing~~ ✓:	117 49.163

Sample No.	TAI-CAN-LALL-1-PG-5
Container Tag No.	LALL 5
Time	1020
UTM Easting	See above.
UTM Northing	" "
Field Photo No.	UCR – Lower Arrow Lake
Camera Image No.	LALL_019
Water Depth (cm)	219 (7.2ft)
Sampler Depth Penetration (cm)	25 (10 in)
Sediment Texture (ASTM/Unified)	SW-well graded sands, little to no fines, few small gravels
Sediment Color (~~Munsell~~)	Light brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	Little to no visible organic matter.

Sampler Name: Jeff Leppo

Sample Signature: Jeff Leppo

Date: 5 / 19 /2010

Time: 19:23

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 6	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE	LALL ✓
DATE:	5 / 13 /2010		
WEATHER CONDITIONS:	Clear, sunny, 65° to 70°F		
SEDIMENT SAMPLER TYPE:	Power Grab		
URS FIELD PERSONNEL:	Gary Panther, Jeff Leppo		
Other Notes:			

Station Reference UTM Coordinates

Lat	~~Easting:~~	49 20.525
Long	~~Northing:~~	117 49.163

Sample No.	TAI-CAN-LALL-1-PG-6
Container Tag No.	LALL6
Time	1030
UTM Easting	See above
UTM Northing	" "
Field Photo No.	UCR Lower Arrow Lake
Camera Image No.	~~222 (7.3ft) 224~~ LALL_020 & LALL_021
Water Depth (cm)	~~23 (8 to 10in)~~ 222 (7.3 ft)
Sampler Depth Penetration (cm)	23 (8 to 10in)
Sediment Texture (ASTM/Unified)	SW-well graded sands, little to no fines, few small gravels
Sediment Color (~~Munsell~~)	Light brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	Little to no visible organic matter.

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 19 /2010

Time: 19:24

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 7	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE	LALL ✓
DATE:	5/13/2010		
WEATHER CONDITIONS:	Partly cloudy, 65°F		
SEDIMENT SAMPLER TYPE:	Power Grab		
URS FIELD PERSONNEL:	Gary Panther, Jeff Leppo		
Other Notes:			

Station Reference UTM Coordinates

Lat	~~Easting:~~	49 20.521
Long	~~Northing:~~	117 49.165

Sample No.	TAI-CAN-LALL-1-PG-7
Container Tag No.	LALL7
Time	1043
UTM Easting	See above.
UTM Northing	" "
Field Photo No.	UCR Lower Arrow Lake
Camera Image No.	LALL-022
Water Depth (cm)	229 (7.5 ft.)
Sampler Depth Penetration (cm)	23 (8 to 10 in)
Sediment Texture (ASTM/Unified)	SW-well graded sands, little to no fines, few small gravels
Sediment Color (~~Munsell~~)	Light brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	Little to no visible organic matter.

Sampler Name: _____

Sample Signature: _____

Date: _____/_____/2010

Time:

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 8	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE	LALL ✓
DATE:	5 / 13 /2010		
WEATHER CONDITIONS:	Partly cloudy, 60-65°F		
SEDIMENT SAMPLER TYPE:	Power Grab		
URS FIELD PERSONNEL:	Gary Panther, Jeff Leppo		
Other Notes:			

Station Reference UTM Coordinates

Lat	~~Easting?~~	49 20.522
Long	~~Northing:~~	117 49.157

Sample No.	TAI-CAN-LALL1-PG-8
Container Tag No.	LALL8
Time	1055
UTM Easting	See above.
UTM Northing	" "
Field Photo No.	UCR Lower Arrow Lake
Camera Image No.	LALL-023 to LALL-029 Photosequence of sample and area
Water Depth (cm)	232 (7.6 ft)
Sampler Depth Penetration (cm)	23 (9 in)
Sediment Texture (ASTM/Unified)	SW - well graded sands, little to no fines, few small to med. gravels
Sediment Color (Munsell)	Light brown
Odors	None observed
Leakage Disturbance	Two grab efforts, poor recovery on first grab
Abnormalities	None observed
Other Notes	Little to no visible organic matter. Matrix more variable with increase in gravel size. Need to move to concentrate on more uniform sand matrix.

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 19 /2010

Time: 19:27

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 9	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE	LALL ✓
DATE:	5 / 13 /2010		
WEATHER CONDITIONS:	Partly cloudy, cool, 55 to 60°F		
SEDIMENT SAMPLER TYPE:	Power Grab		
URS FIELD PERSONNEL:	Gary Panther, Jeff Leppo		
Other Notes:			

Station Reference UTM Coordinates

Lat	~~Easting:~~	49 20.521
Long	~~Northing:~~	117 49.160

Sample No.	TAI-CAN-LALL-1-PG-9
Container Tag No.	LALL 9
Time	1105
UTM Easting	See above
UTM Northing	" "
Field Photo No.	UCR Lower Arrow Lake
Camera Image No.	LALL-030
Water Depth (cm)	222 (7.3 ft)
Sampler Depth Penetration (cm)	23 (9 in.)
Sediment Texture (ASTM/Unified)	SW - well graded sands, little to no fines, few small gravels
Sediment Color (Munsell)	Light brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	Little to no visible organic matter

Sampler Name: _____

Sample Signature: _____

Date: _____ / _____ /2010

Time:

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 10	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE	LALL ✓
DATE:	5 / 13 /2010		
WEATHER CONDITIONS:	Partly cloudy, 55 to 60°F		
SEDIMENT SAMPLER TYPE:	Power Grab		
URS FIELD PERSONNEL:	Gary Panther, Jeff Leppo		
Other Notes:			

Station Reference UTM Coordinates

Lat	~~Easting:~~	49 20.530
Long	~~Northing:~~	117 49.161

Sample No.	TAI-CAN-LALL-1-PG-10
Container Tag No.	LALL10
Time	1110
UTM Easting	See above
UTM Northing	" "
Field Photo No.	UCR Lower Arrow Lake
Camera Image No.	LALL-031 to LALL-035. Photosequence of sample and CofC
Water Depth (cm)	216 (7.1 ft.)
Sampler Depth Penetration (cm)	25 (10 in)
Sediment Texture (ASTM/Unified)	SW- well graded sands, little to no fines, few small gravels
Sediment Color (~~Munsell~~)	Light brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	Little to no visible organic matter

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 19 /2010

Time: 19:28

ATTACHMENT C
Environmental Field Book

URS

"Rite in the Rain"®
ALL-WEATHER WRITING PAPER

ALL-WEATHER
ENVIRONMENTAL FIELD BOOK

Name Jeff Leppo, Gary Panther — URS Corp. Spokane, WA
Address 920 N. Argonne Rd Suite 300 Spokane 99212
Phone (509) 928 4413

Project UCR White Sturgeon Sediment Toxicity Study

36310054.00001

This book is printed on "Rite in the Rain" All-Weather Writing Paper - A unique paper created to shed water and enhance the written image. It is widely used throughout the world for recording critical field data in all kinds of weather. For best results, use a pencil or an all-weather pen.

Specifications for this book:

Page Pattern		Cover Options	
Left Page	Right Page	Polydura Cover	Fabrikoid Cover
Columnar	1/4" Grid	N/A	Item No. 550-4F

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PAGE	REFERENCE	DATE
4 to 10	Birch bank Eddy and Genelle sediment Sampling record	5/12/10
11 to 12	Lower Arrow Lake Sediment sampling record	5/13/10

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67 Error codes, Hazardous classifications, Container types
68 Sampling guidelines (Liquids)
69 Sampling guidelines (Solids)
70 Approximate Volume of Water in Casing or Hole, Ground Water Monitoring Well
71 PVC Pipe casing tables
72 Soil Classification
73 Soil Classification
74 Conversions (Length, Weight, Volume, Temp, etc...)
75 Conversions (Concentrations, Volume/Flow or Time, Velocity, Acceleration)
76 Maximum Concentration of Contaminants for the Toxicity Characteristic

CONTENTS

PAGE	REFERENCE	DATE

Location _____ Date _____

Project / Client _____

Teck Contact: David Espenhain
250. 231.0104

Start
Page 4 →

4

Location TRAIL Boat Launch. Date 5.12.10

Project / Client UCR - Sediment

Jeff Leppo, Gary Panther

0800 Boat Launch in TRAIL - MEET w/ marcus + crew. Discuss field protocol. marcus is worried that we do not have HDPE Bags for Buckets - calls make - will Decon Buckets.

Discuss CoCs - will use CoCs w/ Carbon for 1ST Location

Launch BOTH Boats - Load Gear -

0855

(P) Photo No. 1 - Boat @ Launch Clearwater (Gravity Environmental)

Boats: Monarch, Eric Weatherman & Columbia Navigation Captains

Clearwater, Shawn Hinz Gravity Environmental

5

Location Trail Boat Launch Date 5/12/10

Project / Client UCR - Sediment

Other Persons @ Dock

* Markus Hecker - ENTRIX and Univ. of Sesketchewan
* Jonathon Doering - Uof S
* Jeff ~~Drohsam~~ - Uof Sask Thomson
* Renee Trudeau - Gravity Environmental
* Allen Burkhart - Columbia

0915 Weather: Clear skies, 55°F Dry conditions.

Gravity

10:10 Work Continues w/ hydraulics for power grab. sampler.

* Prep Decon Setup for buckets. Markus/MarkoAdzic Bucket decon procedure agreed on under QAPP SOP

6

Location Trail Boat Launch Date 5/12/10

Project / Client UCR Sediment Sampling

10:30 Shawn & Eric go to pick up parts for pulley / pump on powergrab.

11:24 H&S Tailgate Mtg
Fire Ext, Trips & Falls, Hyd Systems, Helmets crowns
A-Frame, man-overboard

11:35 Leave Gyro Park Boat Launch, head up river

11:50 Arrive @ Birchbank Eddy
1st Locale
Rocky bottom - cobble and boulder sized materials on riverbottom.
Extends over area into deeper water, and up the bank

Lat N 49 10.619 1st Site
Long W 117 42.915 Exam

7

Location Birch Bank Eddy Date 5/12/10

Project / Client UCR Sediment

12:00 Discuss cobble / boulder. Sand filled interstices between rocks
Difficult to gather significant sand sample
2nd Location @ Birchbank - review
N 49 10.637
W 117 42.877
- same bottom, cobbles & boulders w/ limited sand interstices
Not able to sample w/ powergrab
(Collect / Take Photos)
River Sounding - out to 14 ft depth appears cobble & boulders,
12:10 or lim. to visibility
3rd Location 7.5 ft Depth

N 46 10.843
W 117 42.771

Set up to collect sample

8

Location Birchbank Eddy Date 5/12/10

Project / Client to Genelle
UCR Sediment

Birchbank Eddy - 3rd Location
Setup for power-grab sampler
See grab sample no. TAI-CAN-BBE-1-PG-1
- cobbles, gravels with sand

12:50 Markus & crews agree to move and forego BBE samply due to bottom metrix

12:55 Move to Genelle

13:15 Arrive @ Genelle. Identify sand bottom sediments, mixed with other areas of gravel/sand mixtures. Within eddy between river courses.

Start Sampling - See Field Diary

9

Location Genelle Date 5/12/10

Project / Client to Trail Boat Launch
UCR Sediment

16:05 Complete sediment sampling @ Genelle. Good recoveries w/ well graded sands. Collect all 10 grab samples from TAI-CAN-GE-1-PG-1 ~~QL~~
TAI-CAN-GE-1-PG-10
Containers GE1 to GE10

Agreed Upon - Marko & Markus * Liquinox, Then river water rinse was field approved follow discussion of the use of liners / no liners

1655 Finish w/ sample & decon. Prep for move back down to Trail Boat Launch

10

Location Trail Boat Launch Date 5/12/10

Project / Client UCR Sediment

1720 - Arrive back @ Trail Boat Launch

Work w/ Markus on QA/QC of sample labels, date/time numbers etc.
Prep. COCs

1740 - Sign + relinquish Chain of Custody with Jonathon Doering, Univ. of Saskatchewan.
- take photo for copy.
Gravity Env. Crew doing boat cleanup + maintenance

1800 Leave site, head to motel
1815 - Arrive @ hotel

11

Location Lower Arrow Lake Date 5/13/10

Project / Client UCR Sediment

0845 - Arrive @ Arrow Lake
Personnel - see notes from 5/12/10
Boats - see notes from 5/12/10
] same
mobilization + Safety Meeting
0910 - Start up boats, prep for departure
Head out to sediment sample point
0930 Decon power grab, lexan tray + all bucket inserts w/ water rinse, liquinox scrub + water rinse.
1110 - collect last grab sample LALL10
1120 - Finish up w/ sample platform work - cleanup/decon
Head to dock
1135 Return to dock

1150 - Complete CofC relinquish to Jon Doering

12

Location Lower Arrow Lake Date 5/13/10

Project / Client UCR Sediment

Camera / photo copies to:

Jonathon Doering
jad929@mail.usask.ca
306-270-3372 (cell)
306-966-~~4223~~ (office)
4557

1220 - Call Merko w/ update/status
1230 - Crews finish up demob, head home.

~~*~~ See field diaries for reference sediment sample site observations, sample info / descriptions, and locations

13

Location Date

Project / Client

ATTACHMENT D
Chain-of-Custody

URS

Client: Teck American Incorporated
501 North Riverpoint Blvd, Ste 300
Spokane, WA 99202

Project Manager: Kris McCaig, kris.mccaig@teck.com

CHAIN of CUSTODY

Page 1 of 1

Project: Upper Columbia River - White Sturgeon Sediment Toxicity Study

Telephone No. 509-459-4451

Fax No. 509-459-4400

P.O. #

Method of Shipment

TAT: Standard
Per QAPP, April 2010

Sample I.D.	Container Tag No.	No. of Containers	Matrix	Sampling Date	Sampling Time	Analytical/Physical Parameters: Upper Columbia River - Quality Assurance Project Plan Methods Development for the White Sturgeon Sediment Toxicity Study, April 2010		Notes and Comments
TAI-CAN-GE-1-PG -1	GE1	1	Sed	5/12/10	1330	✓		Samplers: Jeff Leppo / Gary Panther – URS Corp (Spokane)
TAI-CAN-GE-1-PG -2	GE2	1	Sed	5/12/10	1400	✓		
TAI-CAN-GE-1-PG -3	GE3	1	Sed	5/12/10	1450	✓		
TAI-CAN-GE-1-PG-4	GE4	1	Sed	5/12/10	1508	✓		
TAI-CAN-GE-1-PG-5	GE5	1	Sed	5/12/10	1514	✓		
TAI-CAN-GE-1-PG-6	GE6	1	Sed	5/12/10	1522	✓		
TAI-CAN-GE-1-PG -7	GE7	1	Sed	5/12/10	1535	✓		
TAI-CAN-GE-1-PG -8	GE8	1	Sed	5/12/10	1541	✓		
TAI-CAN-GE-1-PG -9	GE9	1	Sed	5/12/10	1548	✓		
TAI-CAN-GE-1-PG -10	GE10	1	Sed	5/12/10	1555	✓		

Reference Location: GENELLE

REFERENCE UTM COORDINATES

EASTING: 448723.51

NORTHING: 5450261.18

Coordinates for QAPP Reference only. Please refer to Field Diaries for Lat/Long data for each grab sample.

Sample Received Intact: Yes No

Sample Receiving Notes: (Jonathon Doering)

Reling. by sampler (Sign & Print Name) Jeffrey E. Leppo	Date 5/12/10	Time 1735	5/12/10	1735 recieved by JD
Relinquished by	Date	Time		
Relinquished by	Date	Time		
Relinquished by	Date	Time	Date	Time

URS

Client: **Teck American Incorporated**
501 North Riverpoint Blvd, Ste 300
Spokane, WA 99202

Project Manager: **Kris McCaig, kris.mccaig@teck.com**

CHAIN of CUSTODY

Page 1 of 1

Project: **Upper Columbia River - White Sturgeon Sediment Toxicity Study**

Telephone No. 509-459-4451 | Fax No. 509-459-4400

P.O. #

Method of Shipment

TAT: Standard
Per QAPP, April 2010

Sample I.D	Container Tag No.	No. of Containers	Matrix	Sampling Date	Sampling Time	Analytical/Physical Parameters: Upper Columbia River - Quality Assurance Project Plan Methods Development for the White Sturgeon Sediment Toxicity Study, April 2010		Notes and Comments
TAI-CAN-LALL-1-PG -1	LALL1	1	Sed	5/13/10	0940	✓		Field samplers – Jeff Leppo and Gary Panther
TAI-CAN-LALL-1-PG -2	LALL2	1	Sed	5/13/10	0950	✓		
TAI-CAN-LALL-1-PG -3	LALL3	1	Sed	5/13/10	1005	✓		
TAI-CAN-LALL-1-PG-4	LALL4	1	Sed	5/13/10	1013	✓		
TAI-CAN-LALL-1-PG-5	LALL5	1	Sed	5/13/10	1020	✓		
TAI-CAN-LALL-1-PG-6	LALL6	1	Sed	5/13/10	1030	✓		
TAI-CAN-LALL-1-PG -7	LALL7	1	Sed	5/13/10	1043	✓		
TAI-CAN-LALL-1-PG -8	LALL8	1	Sed	5/13/10	1055	✓		
TAI-CAN-LALL-1-PG -9	LALL9	1	Sed	5/13/10	1105	✓		
TAI-CAN-LALL-1-PG -10	LALL10	1	Sed	5/13/10	1110	✓		

Reference Location: **LOWER ARROW LAKE**

REFERENCE UTM COORDINATES

EASTING: 435940

NORTHING: 5466319

UTM coordinates for reference only. From UCR QAPP White Sturgeon Sediment Toxicity Tests

Sample Received Intact: Yes No

Sample Receiving Notes:

Relinq. by Sampler (Sign & Print Name)	Jeffrey E. Leppo	Date 5/13/10	Time 1205
Received By	Jonathon Doering	5/13/10	1205
Relinquished by		Date	Time
Relinquished by		Date	Time
Relinquished by		Date	Time
		Date	Time

APPENDIX C

WHITE STURGEON METHODS DEVELOPMENT WORK TECHNICAL MEMORANDUM NO. 3 – STUDY DESIGN (JULY 13, 2010); INCLUDES APPROVAL LETTER

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 900
Seattle, Washington 98101-3140

July 14, 2010

CERTIFIED MAIL – RETURN RECEIPT REQUESTED

Reply To: ECL-111

Marko Adzic
Teck American Incorporated
501 North Riverpoint Boulevard, Suite 300
Spokane, Washington 99202

RE: UCR Sturgeon Sediment Toxicity Testing – Study Design

Dear Mr. Adzic:

With this letter, the United States Environmental Protection Agency (EPA) is providing partial approval of the technical memorandum *Sturgeon Sediment Toxicity Testing – Study Design* (study design memo). The study design memo is dated July 13, 2010 and it was submitted by Dr. Markus Hecker of ENTRIX on behalf of Teck American Incorporated (Teck). The study design memo meets the final requirement for approval by EPA stated in Section B3.3 of the Methods Development QAPP that "Teck will consult with EPA on final design parameters for the sturgeon exposure system prior to setting up the chambers for the sediment toxicity study. Following the consultation, Teck will provide EPA with a written addendum to the Draft Quality Assurance Project Plan for the Assessment of Sediment Toxicity to White Sturgeon that describes the parameterization of the chambers along with the acceptable performance criteria (e.g., allowable excursions from preferred measures)."

EPA is approving the portions of the study design memo that relate to the set-up of the exposure chambers, summarized in Table 2. EPA is also requiring the changes described below.

MANIPULATION OF SAMPLES – EPA does not agree that fines should be separated from sandy portions of the samples prior to homogenization, as recommended in the study design memo for sample LMF-02. This sample must be handled and prepared using the same procedures as those for all of the other samples. EPA agrees that large woody debris and large gravel (>5mm) that are readily removable by hand should be removed. However Teck must not alter the samples in any other way prior to homogenization.

STUDY DESIGN – EPA is requiring modifications to the test matrix proposed in the text and summarized in Table 2. Please see the attached Table, which is a revision of Table 2. The modifications required are:

1. Teck will include a "chemistry" replicate for samples LMF-02, UMF-01, LD-01, GE, and LALL. In the chemistry replicates, airstones, DGT probes and peepers are to be used to collect samples at the sediment / porewater interface, as proposed by Teck and depicted in Figure 4 of the study design memo. EPA believes that one chemistry replicate per sample is sufficient and is not requiring two chemistry replicates for samples LMF-02, UMF-01, LD-01 and LALL, as proposed by Teck. If sufficient lab space is available after Teck addresses EPA's second required design modification, Teck may choose to run two chemistry replicates. However, only one is required.

2. Replicate chamber(s) must be set up using the remaining material collected from Deadman's Eddy for the methods development work. EPA recognizes that there are uncertainties with this material, but we believe that the benefit of gaining additional information outweighs the risks. EPA will make a final determination as to whether the Deadman's Eddy chambers must be included in the study after reviewing the technical memoranda submitted by Teck earlier today. To ensure that the Deadman's Eddy material can be included in the study, if that is EPA's final decision, Teck must set up the Deadman's Eddy chambers at the same time as the rest of the chambers.

With this partial approval, Teck is authorized to place sediment in the test chambers per the revised Table 2 (attached). EPA has carefully reviewed the study design memo. Our team needs some additional time to discuss aspects of the memo not addressed in this letter. We also plan to review the Technical Memorandum on Parameter 5 of the Methods Development Work and the day-8 data from the ongoing methods development work, both of which were received late this afternoon, before rendering a decision on other aspects of the study design memo. Please be assured that we are well aware of the time constraints under which you are operating, and will get a final approval letter with any additional required changes to you this Friday.

If you have any questions about this approval, please don't hesitate to contact me.

Sincerely,

Helen H. Bottcher

Helen Bottcher
Project Manager

cc: Dan Audet, U.S. Department of the Interior
Patti Bailey, Confederated Tribes of the Colville Reservation
Randy Connolly, Spokane Tribe of Indians
John Roland, Washington State Department of Ecology

Attachment

Revised Table 2 – study design memo

Treatment Group	# of Possible Replicates	# of Replicates[1]	Comments	Differential Exposure Experiment
UCR				
LMF-02	4-5	3 biology, 1 chemistry	Remove wood debris, include surface layer of fines in sample	Insufficient Volume
LMF-03	1	1	Remove large stones; assume sufficient sample volume	Insufficient Volume
UMF-01	9-10	4 biology, 1 chemistry	Use as is	Yes
NP-03	2-3	2-3	Use as is	Insufficient Volume
LD-01	9-10	4 biology, 1 chemistry	Use as is	Yes
Deadman's Eddy	2 (?)	as many as possible with available volume, ideally 3 biology, 1 chemistry	Use as is	Insufficient Volume (?)
References				
GE	4	3 biology, 1 chemistry	Use as is	Insufficient Volume
LALL	9-10	4 biology, 1 chemistry	Use as is	Yes
Controls				
Control Substrate	>10	4 biology, 1 chemistry	Use as is	Yes
Water Only	>10	4 biology, 0 chemistry[2]	Use as is	Yes

Notes:

1. Teck may run additional chemistry replicates where there is sufficient sediment and lab space
2. EPA does not believe that a chemistry replicate is needed for the water only exposure, but Teck may run chemistry replicate(s) if there is sufficient lab space

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EXTERNAL MEMORANDUM

TO: Helen Bottcher, US EPA Region 10
FROM: Markus Hecker, Ph.D., ENTRIX, Inc.
DATE: July 13, 2010
PROJECT: UCR Sturgeon Sediment Toxicity Testing
SUBJECT: Sturgeon sediment toxicity testing - Study design

This memo describes the study design for the sturgeon sediment toxicity test described within the May 2010 *Assessment of Sediment Toxicity to White Sturgeon (Acipenser transmontanus)* Quality Assurance Project Plan (QAPP). It lays out the approach and rationale for the within-Site, reference, and control sediments that will be used, the number of replicates per sediment, and how additional chemistry measurements (if required) can be accommodated.

AVAILABLE MATRICES

Based on the successfully sampled sites and retrievable volumes of sediments collected (Table 1) as part of the here described sampling efforts a total of eight and two samples from the UCR and upstream reference areas, respectively, are available for use in the sediment toxicity studies with white sturgeon (Figures 1 & 2). Of the eight UCR sediments, three have a fine silty nature (Figure 2: LMF-01, UMF-02&03), which is sub-optimal for the conduct of exposure studies with the test species for reasons of potential health impacts (e.g. clogging of gills). This results in a total of five UCR and two reference sediments available for inclusion into the exposure studies.

Overall, the successfully sampled sites are representative of the originally proposed regional sampling pattern with one sampling site having been sampled in each of the original or alternative locations as listed in the May 2010 sediment toxicity QAPP. Furthermore, sites are assumed to represent a range of metal concentrations as reported by previous studies conducted by the USGS and US EPA (Bortleson et al. 2001; Cox et al. 2005; Era and Serdar 2001; Johnson et al. 1988; Majewski et al. 2003; Paulson et al. 2006; USEPA 2003, 2006) at approximately the same locations (Figure 3). In fact, locations represent areas in which some of the greatest exposure concentrations were reported in whole sediments (Figure 3).

MANIPULATION OF SAMPLES

Due to the nature of sediments collected at sites LMF-02 and LMF-03, samples need to be manipulated prior to use in the exposure studies with white sturgeon. Specifically, this requires removal of debris (wood, larger gravel [>0.5mm], and other organic materials if feasible) by hand. Furthermore, sample LMF-02 is characterized by a significant proportion of fine silty material (Figure 2: LMF-02). While it is not recommended to "sieve" samples prior to using them in the toxicity tests, it is recommended to remove the fine silty portion of the sample prior to mixing to the extent possible to prevent potential risks associated with these fines as described above. The preferable method to separate fines from sandy portions is by hand using a plastic spatula, shovel or similar device where possible (samples appear layered, and thus, physical removal seems possible). Alternatively, the sample can be sieved to exclude fine particles. However, this is not recommended as the first choice as this would result in the loss of the majority of the organic fraction.

SEDIMENT ANALYSIS

Samples LMF-02 and LMF-03 were characterized by significant amount of wood debris, which, for site LMF-02, may be the result of a historic wood mill that was present at this location. Because such activities and/or the general presences of wood materials represent a potential source for organic chemicals it is therefore recommended to extend the currently proposed analytical set of COPCs to include organics as described for the analysis of reference sediments in the April 2010 methods development QAPP. This analysis would be conducted on the samples collected from the exposure chambers at the time of test initiation. Furthermore, sample LMF-02 appears to be characterized by a significant proportion of fines which can be representative of the presence of elevated concentrations of organic matter that can serve as a potential sink for organic chemicals.

STUDY DESIGN

Only limited sediment volumes were obtained from three UCR sampling sites (Table 1). This limits the number of replicates that can be tested for these substrates. This is especially true for sediments LMF-03 and LMF-02, which contain debris and larger rocks that need to be removed prior to sediment mixing, further reducing the total available volumes (Figure 2: LMF-02&03). Sufficient sample volumes and qualities were obtained from all other successfully sampled locations. As a consequence of the reduced number of samples available for toxicity testing, additional laboratory capacities have been made available. To increase statistical power of the experiments and to reduce uncertainty, therefore, it is proposed to increase replicate numbers from three to four parallel test chambers per sample where permitted by sample volume. In

addition, the test protocol requires one control substrate and a clean water only control group to be tested in parallel (four replicates each) to the above described sediments. The study design also includes two reference sediments (LLAL and GE) in four replicates each. Due to reduced sample volume, NP-03 and LMF-03 will be tested in two and one replicate chambers, respectively. However, final decisions on exact replicate numbers per sample will depend on available volumes after sediment mixing has been completed.

In addition to the above-described study design for testing of white sturgeon early life-stages, a sub-set (two replicate chambers each) of parallel experiments will be conducted with those sediments for which sufficient (50 gal) volumes were retrieved (UMF-01, LD-01, LLAL), and the controls. These experiments aim at the differential assessment of exposure with COPCs through porewater and the sediment-water interface water (SWI). These systems will be operated under the same conditions as the test systems receiving white sturgeon, with the difference that additional passive sampling devices will be installed for differential assessment of porewater and SWI and no biological measurements will be made. Specifically, these experiments will utilize suction and diffusive sampling techniques in measuring aquatic exposure point concentrations of metals (i.e., porewater and SWI). Specific sampling techniques/devices to be assessed include:

A. Suction – ceramic airstone; and

B. Diffusive Samplers:
   - Peeper[1]
   - DGT (Diffusive Gradients in Thin-film)

All sampling devices will be installed as described in the report to Order #6 of the 2010 "*Methods Development for the White Sturgeon Sediment Toxicity Study*" (Figure 4). Peepers and DGTs will be installed at days 0, 20 and 50 after initiation of the experiments, and retrieval of devices will occur after 7 days (i.e. 7, 27 and 57 days). Three peepers and one DGT will be removed per sampling event, and analyzed as describe in the report to Order #6 of the methods development work. In addition, at each of the sampling times (days 7, 27 and 57) triplicate porewater and SWI samples will be obtained by means of suction and modified pipette, respectively. A summary of the proposed sampling schedule and analyses to be conducted is provided in Table 1.

[1] Details associated with the use of peepers are outlined and presented within the QAPP for Methods Development for the White Sturgeon Sediment Toxicity Study - Amendment No 1 (April 2010).

The reason for exclusion of the passive sampling devices from the experiments where data will be collected on test organisms is the relatively large impact of DGT probe and peeper extraction on sediment integrity and associated re-suspension processes that can confound biological observations and have an impact on the test species. However, the same number of fish will be added to these test systems to insure comparable test conditions in the DGT/peeper analytical exposure characterization experiment.

In addition to the above described study design, EPA suggested including dilutions of natural sediment to supplement the 2010 sediment toxicity studies with white sturgeon to be conducted by the UofS. However, there are a number of logistical issues and study design concerns associated with this proposed approach:

1. It is anticipated that installment of passive samplers would also be required for dilutions. The proposed design would reduce the replicates for the passive sampling portion of the studies to one for all samples to be tested. We are concerned that this sacrifice of statistical power by reducing the passive sampling design to one replicate per treatment group is jeopardizing the interpretability of the data as it will not be possible to distinguish between random and true effects. While one of the sediment samples during the fish portion of the sediments will also be tested in only one replicate (LMF-03), all remaining treatment groups will be tested at 2 to 4 replicates, and thus, it will possible to relate this individual measurement to the overall response pattern observed during the *in vivo* portion of the study.

2. If dilution of sediments is to be conducted, appropriate controls will have to be included (at a minimum one reference sediment and the artificial control substrate each in triplicate + passive sampling portion of study). Without these it will be impossible to distinguish effects due to dilution (change in matrix) from potential COPCs induced toxicities.

3. It is assumed that the LLAL sediment will be used for dilution of the sediments. Even when using a total of only four replicates (3 for *in vivo* portion and one for the DGT portion of the studies) **there will be insufficient volume to conduct experiments** (Table 3B; red cell). Furthermore, as discussed under bullet 1 above, it is not recommended to only include one replicate for the DGT portion of the studies.

4. There is significant concern about using different dilutions for different sediments as proposed by EPA. In controlled toxicity testing it is desirable (and common practice) to keep variables as constant as possible. We would discourage using different dilutions due to potential matrix effects as this makes comparisons among treatments more difficult and

requires inclusion of additional controls. If a 10% and 50% dilution is to be tested this would require doubling controls as well (one for 10% and one for 50% dilution).

Overall, it is ENTRIX' opinion that there is a significant risk in sacrificing the solid (in terms of replicates) study design to accommodate as many parameters as possible. The sampled sediments are assumed to provide a range of exposures to COPCs that is representative of that assumed in the original QAPP based on the larger amount of sampling sites (Figure 3). It is ENTRIX' opinion that we should continue with the plan to increase replications (where possible) and to include passive sampling device experiments (at least 2 replicates per treatment group) as this increases the power of the study. ENTRIX acknowledges the risk of the occurrence of an "unbound" LOAEC as the result of the overall study. If such a scenario should occur, it is recommended to follow up with a second series of studies enabling the characterization of exact thresholds (e.g. by means of dilution series to be tested in 2011). The data obtained during the 2010 studies would then form the basis for these studies by enabling selection of relevant samples, and the optimization of the further approach.

Finally, it was recommended by EPA to include the substrate collected from the gravel/sand bar at Deadman's Eddy for use in the 2010 methods development studies. However, we recommend not including this matrix as an additional treatment group for the following reasons:

1. This substrate was not collected using the same methodologies than those in the river.

2. While some portions of the sandbar are submerged during periods of the year, a portion of the samples was collected from higher grounds that have not been under water for multiple years. As a consequence, the composition of this substrate as well at its physical and chemical properties are likely to be very different than the remaining samples that were taken under water, and thus, not directly comparable to each other.

3. There is only a limited volume (20 gal) remaining of this substrate, limiting the number of possible replicates.

4. To accommodate this additional sample we would have to reduce replications for the other samples, reducing the overall power associated with each experiment.

SUMMARY RECOMMENDATION

The proposed design (four replicates per *in vivo* test; two replicates per DGT chemical analysis test; no dilution) will result in a total of 41 test chambers to be tested during the sediment

toxicity studies. A summary of the sediment samples available for testing, and proposed replications is provided in Table 2.

REFERENCES

Bortleson, G.C., S.E. Cox, M.D. Munn, R.J. Schumaker, and E.K. Block. 2001. Sediment-quality assessment of Franklin D. Roosevelt Lake and the upstream reach of the Columbia River, Washington, 1992. Water Supply Paper 2496, USGS, Denver, CO, USA.

Cox, S.E., P.R. Bell, J.S. Lowther, and P.C. Van Metre. 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. U.S. Geological Survey, Reston, VA. 70 pp.

Era, B. and D. Serdar. 2001. Reassessment of toxicity of Lake Roosevelt sediments. Publication No. 01-03-043. Environmental Assessment Program, Washington State Department of Ecology, Olympia, WA. 54 pp.

Johnson, A., B. Yake, and D. Norton. 1988. An assessment of metals contamination in Lake Roosevelt. Publication No. 89-e26. Washington State Department of Ecology, Olympia, Washington.

Majewski, M.S., S.C. Kahle, J.C. Ebbert, and E.G. Josberger. 2003. Concentrations and distribution of slag-related trace elements and mercury in fine-grained beach and bed sediments of Lake Roosevelt, Washington, April–May, 2001: U.S. Geological Survey Water-Resources Investigations Report 03-4170, 29 pp.

Paulson, A.J., R.J. Wagner, R.F. Sanzolone, and S.E. Cox. 2006. 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. U.S. Department of the Interior, U.S. Geological Survey, Reston, VA.

USEPA. 2003. Upper Columbia River expanded site inspection report; Northeast Washington. TDD:01-02-0028. Contract: 68-S0-01-01. U.S. Environmental Protection Agency, Region 10, Seattle, WA.

USEPA. 2006. Settlement agreement for implementation of remedial investigation and feasibility study at the Upper Columbia River Site. June 2, 2006. U.S. Environmental Protection Agency, Region 10, Seattle, WA.

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Table 1. Proposed sampling schedule, analyses and sample numbers for the differential exposure experiment using passive and active water sampling devices.

Sampling Day [a]	COPCs (Cd, Cu, Pb and Zn)	pH	DOC	Conductivity	Alkalinity	Anions/ Cations
Suction						
Day 7	3	3	3	3	3	3
Day 27	3	3	3	3	3	3
Day 57	3	3	3	3	3	3
Modified Pipette						
Day 7	3	3	3	3	3	3
Day 27	3	3	3	3	3	3
Day 57	3	3	3	3	3	3
Peeper						
Day 7	3					
Day 27	3					
Day 57	3					
DGT						
Day 7	3					
Day 27	3					
Day 57	3					
∑	***36***	***12***	***12***	***12***	***12***	***12***

[a] Sampling Day refers to the sampling for parameter after initiation of experiment.

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Table 2. Proposed sediment samples as per the June 2010 sediment sampling effort in the UCR, and replication for definite sediment toxicity studies with white sturgeon, at the University of Saskatchewan.

Treatment Group	# of Possible Replicates	# of Replicates [a]	Comments	Differential Exposure Experiment
UCR				
LMF-02	4-5	4	Remove wood debris; consider organic contaminants	Insufficient Volume
LMF-03	1	1	Remove large stones; assume sufficient volume	Insufficient Volume
UMF-01	9-10	4 + 2	Use as is	Yes
NP-03	2-3	2-3	Use as is	Insufficient Volume
LD-01	9-10	4 + 2	Use as is	Yes
References				
GE	4	4	Use as is	Insufficient Volume[b]
LALL	9-10	4 + 2	Use as is	Yes
Controls				
Control Substrate	>10	4 + 2	Use as is	Yes
Water Only	>10	4 + 2	Use as is	Yes

[a] The numbers refer to the number of replicates to be tested with fish plus two separate treatment system for the differential exposure experiment (without test organisms.

[b] 20 gallons of GE sediment were used in methods development studies.

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Table 3A. Example matrix for white sturgeon sediment toxicity study design assuming three and two replicates for in vivo fish exposure and DGT exposure chambers, respectively.

Proposed Exposure Chambers	**Study Design Corrections (2 DGT replicates)**			
Sample/Treatment Group	# Fish Replicates	# DGT Replicates	Volume of Dilution Sediment (gal)	Volume Available (gal)
NP-03	2	0	0	15
LD-01	3	2	0	25
LD-01 diluted 50% ?	3	2	12.5	25
UMF-01	3	2	0	25
UMF-01 diluted 50%	3	2	12.5	25
LMF-02	3	2	0	18
LMF-02 diluted 50%	2	0	5	7
LMF-03	1	0	0	1
LALL (reference)	3	2	25	50
GE (reference)	2	1		30[a]
GE diluted 50%	1	1	7.5	
Control	3	2		n/a
Control diluted 50%	3	2	12.5	
total number of replicates	33	18	75	

Total # of replicates: 50
Reference Sediment Volume: -25

Assuming LLAL sediment will be used for dilution (same rules would apply if GE sediment would be used)

[a] 20 gallons of GE sediment were used in methods development studies.

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Table 3B. Example matrix for white sturgeon sediment toxicity study design assuming three and one replicates for in vivo fish exposure and DGT exposure chambers, respectively.

Proposed Exposure Chambers	**Study Design Corrections (1 DGT replicate)**			
Sample/Treatment Group	Fish Replicates	DGT Replicates	Volume of Dilution Sediment (gal)	Volume Available
NP-03	2	0	0	15
LD-01	3	1	0	25
LD-01 diluted 50% ?	3	1	7.5	25
UMF-01	3	1	0	25
UMF-01 diluted 50%	3	1	7.5	25
LMF-02	3	1	0	18
LMF-02 diluted 50%	2	0	5	7
LMF-03	1	0	0	1
DME (Dead Man's Eddy)	0	0	0	0
LALL (reference)	3	1	25	50
GE (reference)	2	1		30[a]
GE diluted 50%	1	1	7.5	
Control	3	1		n/a
Control diluted 50%	3	1	7.5	
total number of replicates	34	10	60	

Total # of replicates: 44
Reference Sediment Volume: **-10**

Assuming LLAL sediment will be used for dilution (same rules would apply if GE sediment would be used)

[a] 20 gallons of GE sediment were used in methods development studies.

Figure 1: Photographs of sediments collected at the two reference locations upstream of the U.S.-Canada border at Genelle (GE) and Lower Arrow Lakes (LLAL).

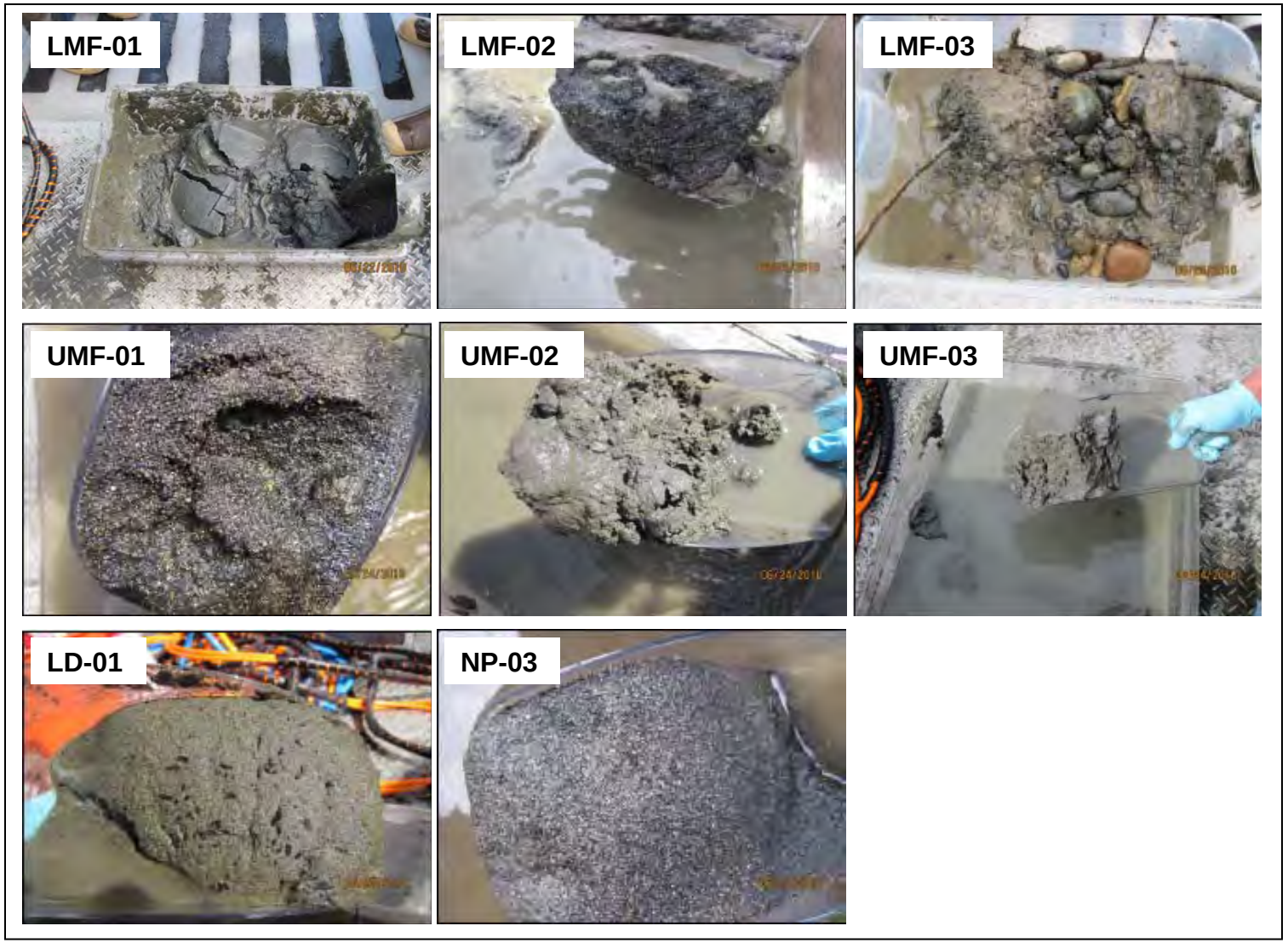

Figure 2: Photographs of sediments successfully collected at the originally proposed UCR sampling sites in the area of Lower (LMF-01-03) and Upper (UMF-01-03) Marcus Flats, Little Dalles (LD-01) and Northport (NP-03).

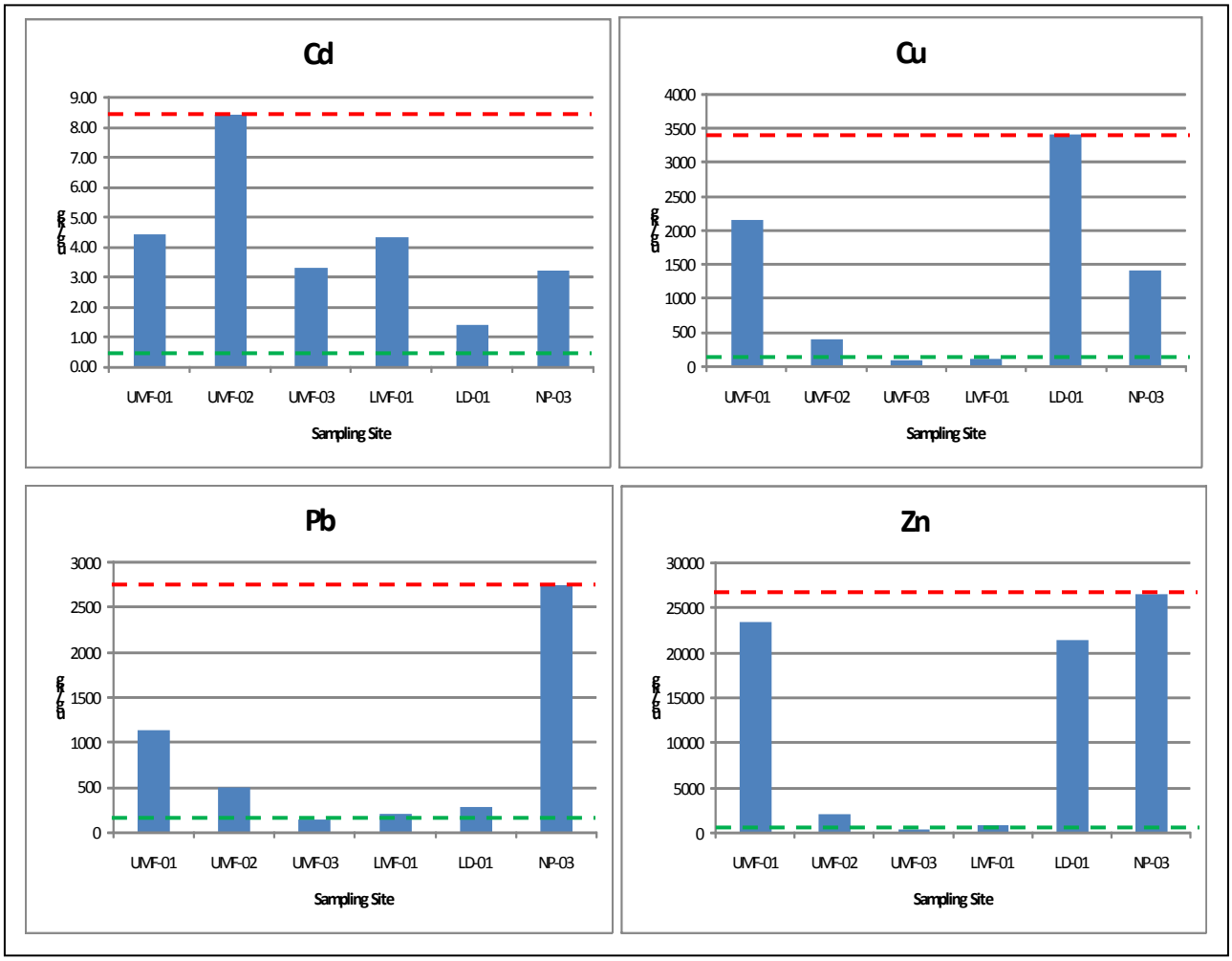

Figure 3: Concentrations (μg/kg) of Cd, Cu, Pb and Zn previously reported by the USGS or US-EPA at the same sampling locations that were successfully sampled as part of the June 2010 sediment sampling effort by Teck. Dotted red line: Maximum concentration of metal reported for all proposed sampling sites in the 2010 sediment toxicity QAPP; Dotted green line: Minimum concentration of metal reported for all proposed sampling sites in the 2010 sediment toxicity QAPP.

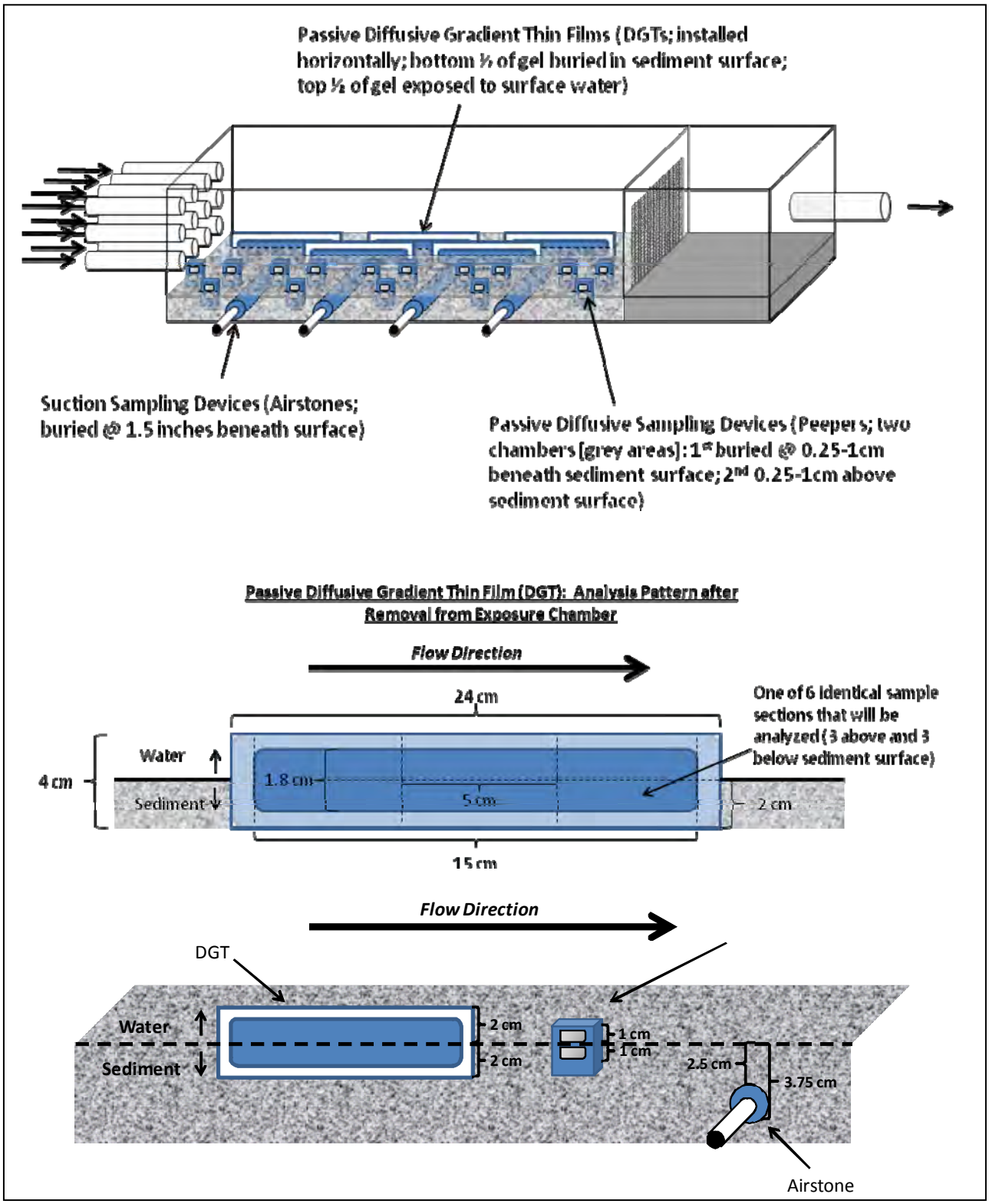

Figure 4: Schematic of sampling device installation in the test systems used for the differential exposure experiment. Note: The here presented dimensions are not to scale, and definite designs may deviate. Also, no sampling devices will be installed within 4 inches from the inflow and outflow of the test chambers.

APPENDIX D

WHITE STURGEON METHODS DEVELOPMENT WORK TECHNICAL MEMORANDUM NO. 4 – TIME TO STEADY STATE (JULY 14, 2010) –UPDATED; INCLUDES APPROVAL LETTER

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 900
Seattle, WA 98101-3140

OFFICE OF
ENVIRONMENTAL CLEANUP

July 16, 2010

CERTIFIED MAIL – RETURN RECEIPT REQUESTED

Reply To: ECL-111

Marko Adzic
Teck American Incorporated
501 North Riverpoint Boulevard, Suite 300
Spokane, Washington 99202

RE: UCR Sturgeon Sediment Toxicity Program – EPA Direction on Final Study Design

Dear Mr. Adzic:

The purpose of this letter is three-fold:

1) To provide approval, conditioned upon incorporation of EPA's comments in the section below entitled "Technical Memo on Order #5, of the technical memorandum *Sturgeon sediment toxicity testing – results and recommendations: Order #5* dated July 13, 2010
2) To provide approval, conditioned upon incorporation of EPA's comments in the section below entitled "Study Design Memo" of the technical memorandum *Sturgeon sediment toxicity testing – Study Design* dated July 13, 2010
3) To communicate to Teck all final changes and clarifications the study design that are required

Technical Memo on Order #5. EPA received a technical memorandum on July 13, 2010, entitled *Sturgeon sediment toxicity testing – results and recommendations: Order #5*. This technical memo describes the results of the last outstanding item of the methods development studies. EPA agrees with the results and recommendations provided in this technical memorandum, and approves a sampling depth of 3.4 centimeters for the full study.

EPA disagrees with language in Appendix A of the technical memorandum. The text states that there was a "clear" decrease in DOC concentrations in the DME sediments after 96h, "indicating that steady-state for this sediment and parameter was not reached after this time." While there was apparent decrease (see Figure 3 of Appendix A), the decrease was not statistically significant and may be within the range of analytical variability. EPA does not agree that the data provided in this technical memorandum supports a determination that the DME sample had not reached steady state after 96 hours. Therefore, Teck must resubmit the Technical Memo deleting the text quoted above from the last paragraph of the main body text

and from the second paragraph on page 2 of Appendix A. Consistent with the authorization set forth in the second to last paragraph of this letter, Teck may proceed with toxicity tests. The revised Technical Memo must be submitted to EPA no later than July 23, 2010.

Study Design Memo. EPA provided comments on and partial approval of the technical memorandum *Sturgeon sediment toxicity testing – Study Design* on July 14, 2010. Our additional comments and required changes to the recommendations in the study design technical memo are below. Teck must prepare and submit, for EPA approval, a final QAPP amendment that incorporates the following comments. Teck must also incorporate in the final QAPP amendment the changes required in EPA's July 14, 2010 letter. The final QAPP amendment must be submitted to EPA prior to introducing fish into the exposure chambers.

SEDIMENT ANALYSIS – EPA agrees with the recommendation by Teck American Incorporated (Teck) in the study design memo to analyze sediment samples for organic COPCs after placing sediments into test chambers. In addition, Teck must archive samples at the end of exposures (appropriately collected and preserved) for analyses. If toxicity is observed that cannot be explained by the contaminants being measured or other factors, Teck will be required to analyze the preserved samples for organics that are detected in samples at test initiation. These analyses will include all organics that were not eliminated in the Screening Level Ecological Risk Assessment.

CHEMISTRY REPLICATES -- EPA is not convinced that the presence of DGT and peeper samplers in chemistry replicates will adversely affect the fish. It is EPA's opinion that the approved tank cleaning technique is likely to be as disruptive, if not more so, than occasionally removing DGT or peeper sampling devices from the test chambers. Teck must collect the same biological information (i.e., fish survival growth and behavior) in the chemistry replicates that is collected in the biology replicates. If the biological results in the chemistry chambers are within the range of responses observed in the biology chambers, then data from the chemistry replicate chamber may be used as another replicate in the statistical analysis of the data. If the biological responses observed in the chemistry replicate chambers are outside the range observed in the biology chambers, then the biological data will not be used, and only the chemistry data from the chemistry replicates will be used in the data analysis.

DEADMAN'S EDDY SAMPLES – Teck must include in the study the Deadman's Eddy sediments that were collected for methods development. EPA recognizes that there are uncertainties associated with this material, including the fact that the sediments were collected in the dry and were composited from subsamples collected over a broad area. However, we believe that these sediments still have value because they may have different chemistry and grain size characteristics than the other samples, and would provide an additional data point along the gradient of conditions observed in UCR sediments. EPA will view the resulting data cautiously, and will agree to exclude the resulting data from the study analysis if the sample produces results that are inconsistent with the other site sediment samples. To determine whether data from the Deadman's Eddy samples could be used, EPA would consider a number of factors, including but not limited to:

- How quickly the sediments reach equilibrium, relative to other site samples

- Whether grain size, DOC, pH or other basic parameters differ significantly from the other site samples
- Whether any observed toxicity seems to be related to the chemistry – i.e., how well the sample fits the dose response curve established with the other samples.

There may not be enough material left from this sample to make up four test chambers (i.e., the ideal of three biology chambers and one chemistry chamber). Therefore, the existing chamber set up for the methods development tests should be used as a biology chamber. The remaining material not used for methods development work should be used to set up the chemistry chamber and as many biology chambers as possible. Any other needed changes (e.g., the addition of gravel / stones) to the existing chamber should be made at the same time the new chambers are being prepared. EPA recognizes that using the existing chamber may introduce additional uncertainty because these chambers have had longer to equilibrate than the other chambers.

DECONTAMINATION OF PEEPERS – Due to high variability in the peeper results during methods development testing, additional steps should be taken to ensure and demonstrate that peepers are effectively decontaminated prior to deployment. Teck must submit, by July 23, 2010, an SOP describing in detail the peeper decontamination procedures used for the full study. In addition, Teck must include blank peeper samples (i.e. beakers with metal-free water and peepers only) in the study, at the start, at the completion of the change to exogenous feeding, and near the end of the test (approximately days 0, 27, and 50).

EPA's understanding is that water samples from the biology replicate chambers will be collected using airstones and pipettes, while water sample collection from the chemistry replicate chambers will also include the use of peepers and DGTs (per the amended methods development QAPP). Further, it is our understanding that toxicity testing deployments of these sampling devices will be as described in Figure 4 of the study design memo dated July 13, 2010. If EPA is incorrect in its understanding of these issues, please contact me prior to introducing fish into the exposure chambers.

Finally, EPA will evaluate the adequacy of this test in meeting the data quality objective based on the data that are produced. However, the number of samples collected for this study falls short of the objective of the RI/FS to investigate the nature and extent of contamination and risk to sturgeon at the Site and more work will be required to meet the DQOs. More work may include repeating this study in the future with more samples, collecting other types of samples such as additional surface sediment chemistry and porewater chemistry samples, using other data generated for this or other investigations, or using information from the literature to inform the risk assessment for sturgeon.

Teck is authorized to begin toxicity tests per the approved study design memo, including the changes described in this letter, and according to the amended QAPP, *Quality Assurance Project Plan for the Assessment of Sediment Toxicity to White Sturgeon (Acipenser transmontanus)*, May 2010. Please prepare and submit a final QAPP amendment documenting these changes for EPA approval.

EPA is pleased to see the studies get underway, and we look forward to receiving regular updates as the study progresses.

Sincerely,

Helen H. Bottcher

Helen Bottcher
Project Manager

cc: Dan Audet, U.S. Department of the Interior
Patti Bailey, Confederated Tribes of the Colville Reservation
Randy Connolly, Spokane Tribe of Indians
John Roland, Washington State Department of Ecology

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EXTERNAL MEMORANDUM

TO: Helen Bottcher, US EPA Region 10
FROM: Markus Hecker, Ph.D., ENTRIX, Inc.
DATE: July 14, 2010
PROJECT: UCR Sturgeon Sediment Toxicity Testing
SUBJECT: Sturgeon sediment toxicity testing - results and recommendations: Order #5

The overall goal of the herein described and discussed studies was to inform and establish appropriate and relevant methodologies for the sturgeon sediment toxicity test described within the May 2010 *Assessment of Sediment Toxicity to White Sturgeon (Acipenser transmontanus)* QAPP. Specifically, the objectives of this work were to optimize the performance of flow-through fluvial simulation systems and associated exposure chambers, and confirm reference area sediments (including laboratory control sediments). It has to be noted that the information and observations recorded during this work are not be used to inform risk-based management decisions, and they solely are aimed to inform and refine technical elements of future sediment toxicity tests using white sturgeon early life-stages.

This memo reports results and recommendations for the final task: evaluation of gradients in the fluvial exposure chambers. The following sections summarize the work done under this task, and provides recommendations for test chamber functions.

Optimized design for exposure chambers

Detailed method descriptions are provided in the individual report included in Appendix A. A brief summary of the objectives and experiments conducted and is provided here. Table 1 now includes recommendations for Order #5 and therefore is complete.

Order 5: Gradients between pore- and overlying water

Objective: Evaluate potential gradients between porewater and overlying water under different hydrological conditions (e.g., flow velocity)– monitor basic water quality parameters at different sediment depths, and at the sediment-water interface.

Results and Recommendations: Based on the results from this study and the findings from Orders #3 and #4, sampling ports at shallower sampling depths of 3.4 cm is recommended. Also, the short time-dependency of gradients between overlying water and porewater indicates that a reduced equilibration time prior to introduction of test organisms will not be problematic for the definite exposure studies.

Gradients in conductivity, pH and dissolved organic carbon (DOC) between porewater and overlying water were measured by means of suction devices that were installed at 10.2 cm intervals along the entire length of the centre of the sediment exposure chamber. Flows rates ranged from greater (25 L/min) to lesser flow rates (17 L/min); these flow-rates were deemed appropriate for maintaining conditions appropriate for white sturgeon ELS culture. There were gradients among measurement parameters between overlying water and porewater. These appeared, however, to not be influenced by flow-rate or duration with the exception of a small difference in the reference sediment at the greatest porewater sampling depth and dissolved organic carbon at early time periods. This indicates that gradients are relatively stable and do not change over time under constant flow-conditions. Time-dependent increases in conductivity observed at greater sampling depth could be indicative of shallower sediment horizons reaching steady-state more quickly, particularly for sediments with greater amounts of fines. Furthermore, sediment-sampling depth had no effect on pH or DOC.

In general, DOC concentrations were highly variable in porewater when measured 24h after initiation of the experiment. It is assumed that these differences between the early (24h) and later measurements are due to the fact that the DME substrate tested was of a dry nature prior to submersion in the test systems, and therefore, at 24h there were still significant dissolution processes ongoing. Similarly, the reference sediment used was mixed and introduced into the test system, likely resulting in a very different initial porewater composition after storage for an extended time. It is assumed that after 48h this dissolution or exchange between overlying and porewater was mostly completed or had stabilized. While the artificial substrate group showed no further change in porewater DOC concentrations after 48h, there was still an apparent decrease in DOC concentrations in the DME sediments after 96h. It is difficult, however, to extrapolate from this observation to riverine sediments because the DME substrate was dry, and thus, it can be assumed that water saturated sediments will behave very differently due to the lack of initial dissolution processes. This also may explain the differences observed between the DME and reference substrate. Depth of porewater sampling did not have a marked effect on DOC patterns.

Table 1. Parameters, Methods, Measurements and Recommendations for the Design of the Exposure Systems and Test Conditions for the 2010 Studies with White Sturgeon ELS to Investigate Sediment Related Toxicity.

Order	Parameter	Goal	Test Conditions	Measurement	Recommendation
1	Flow condition	Establish parameters and operational conditions that enable the maintenance of homogenous flow conditions in the test system.	Initial flow rate of 19 L/min, with incremental changes of +/- 2 L/min to achieve desired end state	Video record of fluorescein dye movement	Initial flow rate of 20 L/min to accommodate low flow requirement for yolksac larvae, and then increase flow rates to 25 L/min around the time when larvae initiate exogenous feeding
2	Gravel volume and distributions	Establish optimum density of gravel to create pseudo-hyporheic zone	Gravel: 0, 3, 7, 10 and 13 stones per 100 cm_2	Conductivity measurements	4 stones per 100 cm^2
3	Porewater sampling	Establish porewater sampling method	Airstone suction device in different depths of sediment using variable strength and duration of suction (via manual use of syringe). Initial volume to be collected 30 mL, with incremental changes of +/- 5 mL to obtain sufficient sample volume.	Only porewater is collected with no overlying water in the sample • Dye concentration measurements.	12 ports, with a volume of 8-10 mL each; no ports within the first and last 4 inches of the fluvial chamber.
4	Sediment depth	Establish optimum depth of sediment for ELS sturgeon and to maximize porewater collection	Initial depth at 2 inches, with trials of 3 and 4 inches	Porewater sampling at 0.5 and 1 inch and overlying water sampling within the 1 cm of water overlying the sediment • Dye concentration measurements.	Two (2) inches of sediment, with airstones positioned on top of 0.5 inches and below 1.5 inches of sediment

Table 1. (cont.)

Order	Parameter	Goal	Test Conditions	Measurement	Recommendation
5	Gradients between pore- and overlying water	Establish operational conditions that minimize gradients in water quality parameters between pore- and overlying water.	Each flow/sediment depth combination that is tested.	Time-resolved measurements of: • Dye concentration • Conductivity • DOC • pH	Flow-rates between 17 and 25L are appropriate as they do not affect gradients. Porewater sampling depth between 1 and 1.5 inches recommended due to observed gradients. Short time-dependency of gradients between overlying water and porewater indicates that a reduced equilibration time of 4 to 7 days prior to introduction of fish is sufficient.
6	Time to steady-state	Establish operational conditions that minimize time to steady-state.	Characterize time to steady-state between pore- and overlying water after establishing optimal flow and gravel conditions.	Time-resolved measurements of: • Alkalinity • Ammonia • Conductivity • DO • DOC • Hardness • pH	48 hours is sufficient for all parameters, with the exception of DOC which may not reach steady state
7	Cleaning methods	Establish most efficient method for cleaning	Introduce food 3X daily and scrape tanks at days 2, 3, 4 and 5.	Measure turbidity of samples using light scattering methods	Modified pipette, with spatula used to remove biofilm, if necessary

Order	Parameter	Goal	Test Conditions	Measurement	Recommendation
8	Laboratory control sediment	Define clean sediment with characteristics similar to UCR sediments	Research lab controls used in other bioassays Create sediment from clean silica sand and/or granite with grain size 0.5 to 2 mm and preference to dark color	Measure grain size and color	Control sediment: Hagen Geosystem Black Fine Gravel (ART #12648) is sandy, with all analytes below screening ecological values (SEVs). Acceptable for use. Reference sediments from Genelle Eddy and Lower Arrow Lake are gravelly sand, with all analytes below screening ecological values (SEVs). Acceptable for use.

APPENDIX

Sturgeon Test Methods

Appendix A Data summary reports for:

Order #5: Gradient Study

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Summary Data Report

Experiment #: 5 **Date:** 5/20/-7/04/10 **Expt. Leader:** DV/JD/MH

Title: Gradients

Goal:

Evaluate potential gradients between porewater and overlying water under different hydrological conditions (e.g., flow velocity).

Experimental Design:

Gradients in conductivity, pH and dissolved organic carbon (DOC) between porewater and overlying water were measured by means of suction devices that were installed at 10.2 cm intervals along the entire length of the centre of the sediment exposure chamber. Suction devices were buried at different depths to enable sampling of porewater in the top 2.5 cm of sediment and in the sediment-surface water transitional zone (pseudo hyporheic area with 4 rocks per 100 cm^2 for habitat enrichment as described in Order 2). Experiments without rocks for habitat enrichment were excluded as it was decided based on the findings from Order 2 that rocks were to be used in subsequent sturgeon experiments. Parameters that were used to assess potential gradients between porewater and overlying water were conductivity, DOC and pH. Measurements were made 24, 48, and 96 hr after initiation of the experiment. Dye was not used in these experiments since it was discovered during studies for Orders 3 and 4 that dye would not readily seep into the sediment without being physically pulled through. Flows that were tested ranged from greater (25 L/min) to lesser flow rates (17 L/min). These flow-rates were deemed appropriate for maintaining conditions appropriate for white sturgeon ELS culture.

Decision Criteria:

The goal of this experiment was to establish conditions under which the gradient between porewater and overlying water in the pseudo-hyporheic area is minimal while maintaining conditions appropriate for sturgeon ELS culture.

Results:

There were significant differences between overlying water and porewater for a number of parameters. These differences were most prominent for conductivity where significant greater values were recorded in porewater samples regardless of depth and time of sampling (Figure 1). There were differences in conductivity between porewater at different greater depths in the sediment. However, the differences were less than those between overlying water and porewater. Also in the reference sediment treatment group (Genelle sediment) statistically significant increases in conductivity in porewater were observed between the 24 and 96 hr at the greatest sampling depth. No such differences occurred in the experiment with Deadman's Eddy

(DE) sediment. Flow rate did not have an effect on conductivity in any of the matrices analyzed.

In the reference sediment experiment there was a statistically significant decrease in pH of porewater from both depths relative to that in overlying water. No such difference was observed in the DE sediment test group. In fact, pH was not different among sampling times or depths in this group.

In general, DOC concentrations were highly variable in porewater when measured 24h after initiation of the experiment. It is assumed that these differences between the early (24h) and later measurements are due to the fact that the DME substrate tested was of a dry nature prior to submersion in the test systems, and therefore, at 24h there were still significant dissolution processes ongoing. Similarly, the reference sediment (saturated with water during storage) used was mixed and introduced into the test system just prior to t=0, likely resulting in a very different initial porewater composition that slowly mixed with overlying water until a certain degree of steady-state was reached. It is assumed that after 48h this dissolution or exchange between overlying and porewater was mostly completed or had stabilized. While the artificial substrate group showed no further change in porewater DOC concentrations after 48h, there was still an apparent decrease in DOC concentrations in the DME sediments after 96h. It is not possible, however, to extrapolate from this observation to riverine sediments because the DME substrate was dry (collected above the water line from a beach/gravel bar). It can be assumed that water saturated sediments will behave very differently due to the lack of initial dissolution processes. This also may explain the differences observed between the DME and reference substrate. Depth of porewater sampling did not have a marked effect on DOC patterns.

Conclusions:

There were gradients among measurement parameters between overlying water and porewater. These appeared, however, to not be influenced by flow-rate or duration with the exception of a small difference in the reference sediment at the greatest porewater sampling depth. This also indicates - with the exception of some sediments at greater sampling depth - that gradients were relatively stable and do not change over time under constant flow-conditions. Also, the time-depended increase in conductivity at greater sampling depth as observed for the reference sediment could be indicative of shallower sediment horizons reaching steady-state more quickly. The reason why this only occurred for the reference substratum could be due to the fact that the DE sediment was collected from the gravel bar above the water line, and thus, may contain lesser amounts of fines. This could result in a lesser porous structure of the reference sediment causing more resistance in the flow of porewater between sediment horizons. Furthermore, sediment-sampling depth had a significant influence on conductivity but not pH or DOC. Based on this result and the findings from Orders 3 and 4, to enable sampling of sufficient volumes while reducing differences between overlying water and porewater sampling ports at shallower sampling depths between 2.5 and 3.4 cm is recommended. Also, considering the lack of time-dependency of gradients between overlying water and porewater indicating rapid establishment of steady-state after initiation of the experiments is in favor of reducing the equilibration time prior to introduction of test organisms in the definite exposure studies.

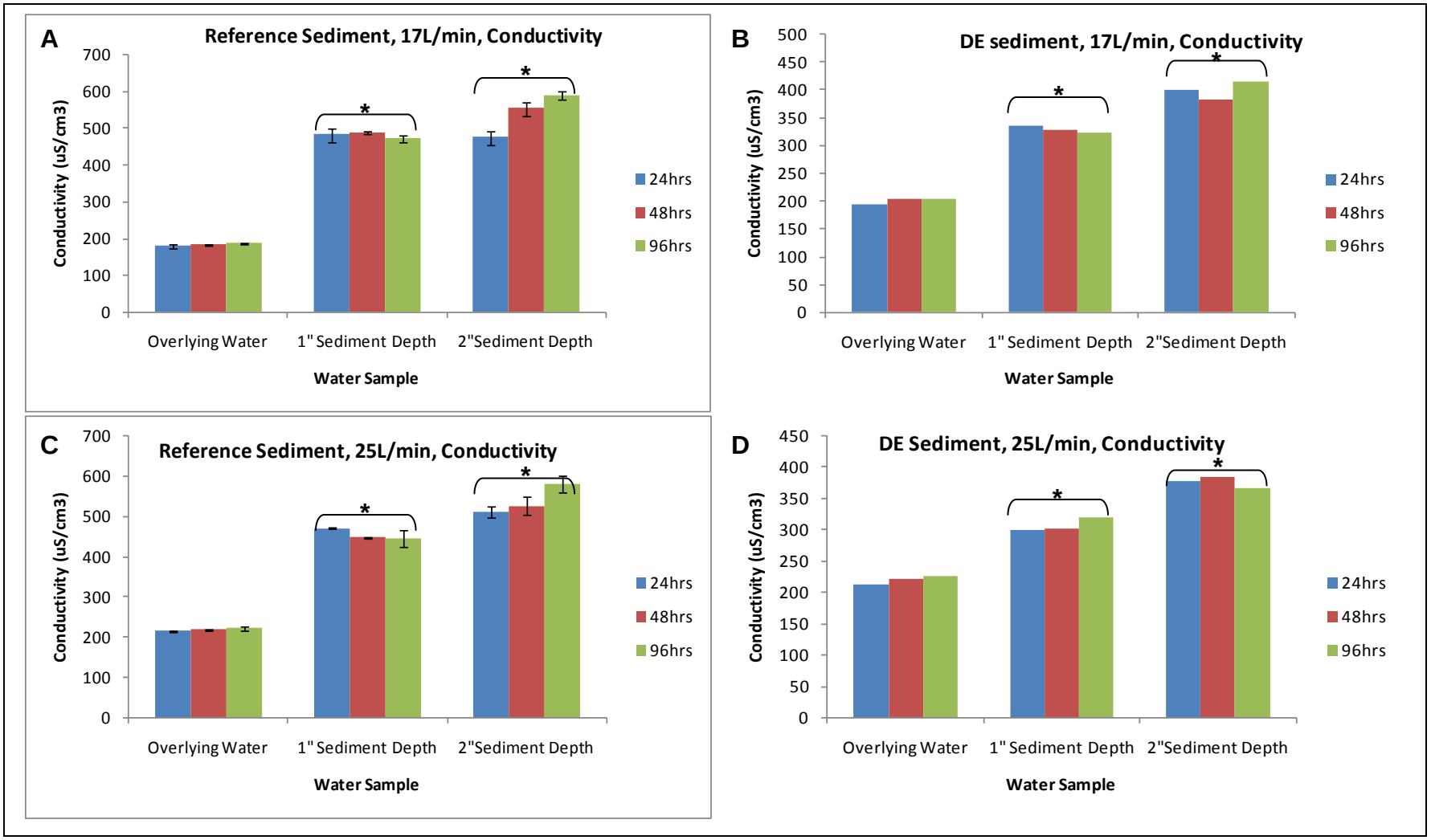


Figure 1: *Mean conductivity in overlying water, and porewater at flow-rates of 17 (A&B) and 25 (C&D) L/min. Overlying and porewaters were sampled at depths of 1 (1") and 2 (2") inches at 24, 48 and 96 h after initiation of experiment. Sediment types tested were reference sediment and sand bar substrate collected at Genelle (A&C) and Deadman's Eddy (B&C). Asterisks indicate significant difference from mean response in overlying water measured at the same time ($p<0.05$; Student's t-test).*

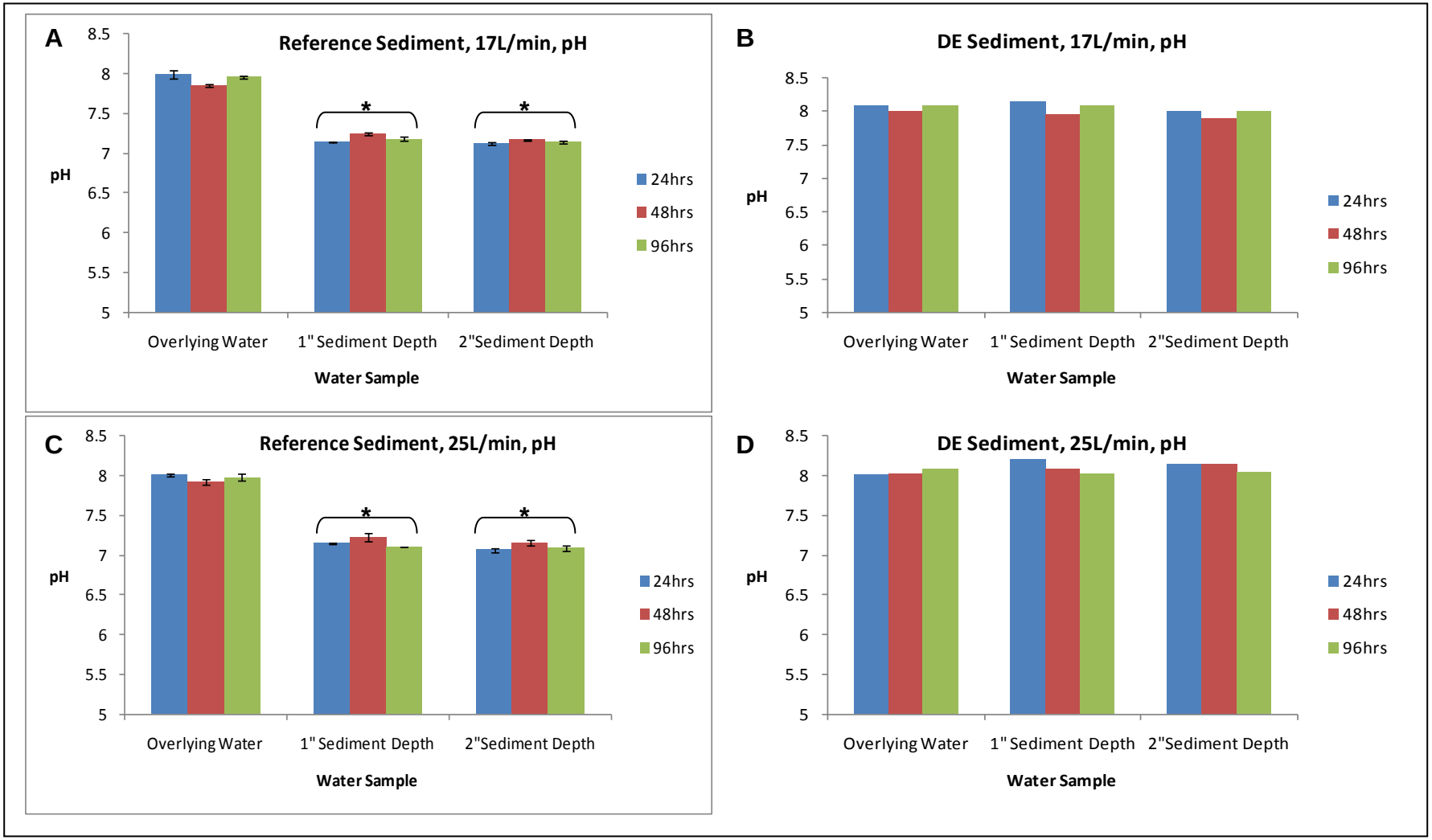


Figure 2: *Mean pH in overlying water, and porewater at flow-rates of 17 (A&B) and 25 (C&D) L/min. Overlying and porewaters were sampled at depths of 1 (1") and 2 (2") inches at 24, 48 and 96 h after initiation of experiment. Sediment types tested were reference sediment and sand bar substrate collected at Genelle (A&C) and Deadman's Eddy (B&C). Asterisks indicate significant difference from mean response in overlying water measured at the same time ($p<0.05$; Student's t-test).*

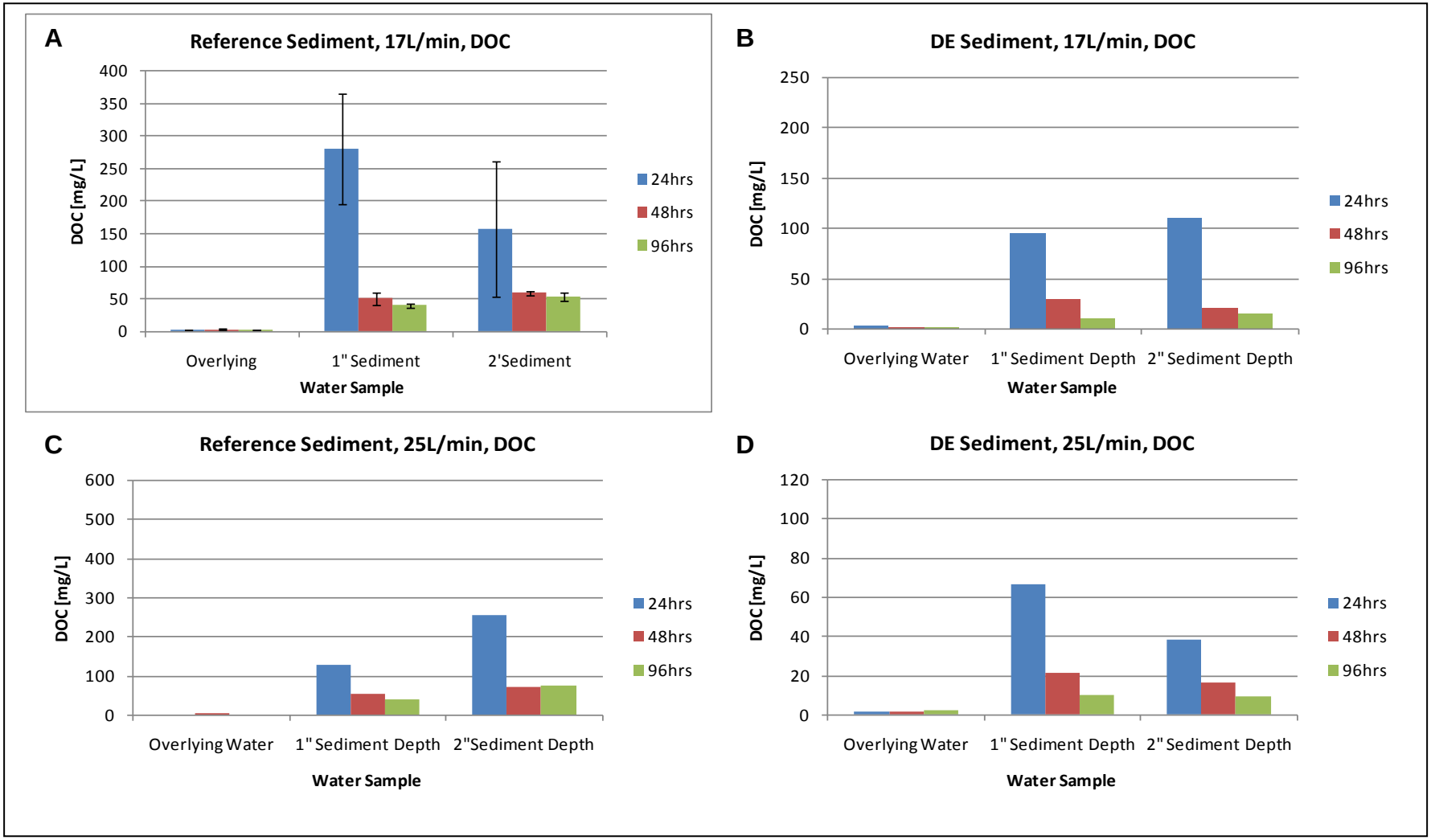


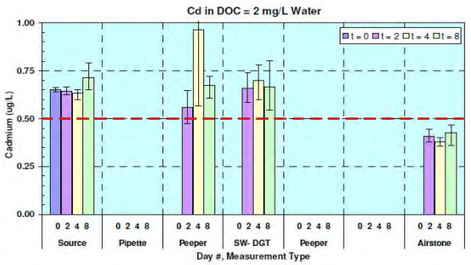
Figure 3: *Mean DOC [mg/L] in overlying water, and porewater at flow-rates of 17 (A&B) and 25 (C&D) L/min. Overlying and porewaters were sampled at depths of 1 (1") and 2 (2") inches at 24, 48 and 96 h after initiation of experiment. Sediment types tested were reference sediment and sand bar substrate collected at Genelle (A&C) and Deadman's Eddy (B&C). Asterisks indicate significant difference from mean response in overlying water measured at the same time ($p<0.05$; Student's t-test).*

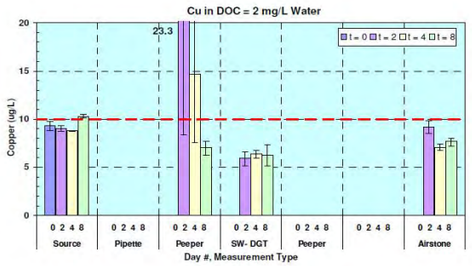
APPENDIX E

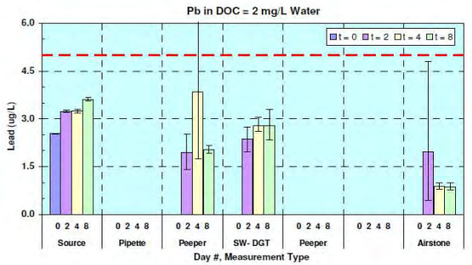
WHITE STURGEON METHODS DEVELOPMENT WORK EVALUATION AND COMPARISON OF POREWATER, SEDIMENT-INTERFACE WATER SAMPLING DEVICES - PRELIMINARY DATA FOR DAYS 0, 2, 4, AND 8

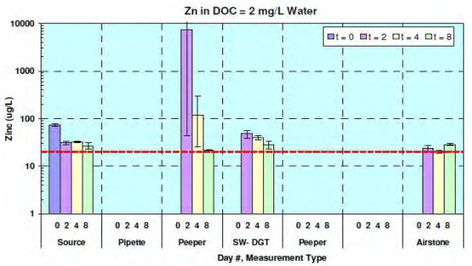
			Cadmium			Copper			Lead			Zinc		
Sample	Type	Day	Mean	SD	CV	Mean	SD	CV	Mean	SD	CV	Mean	SD	CV
Ctrl														
	Source	0	0.59	0.022	0.038	9.0	0.055	0.006	2.2	0.010	0.004	122	1.0	0.008
		2	0.55	0.061	0.110	8.1	0.48	0.059	2.5	0.075	0.030	26.3	0.67	0.025
		4	0.56	0.014	0.026	7.9	0.19	0.024	2.7	0.078	0.029	26.1	2.1	0.080
		8	0.57	0.06	0.10	9.58	0.24	0.03	3.06	0.06	0.02	24.87	1.86	0.07
	Grab	2	0.54	0.022	0.040	8.2	0.22	0.027	2.5	0.026	0.011	27.1	0.90	0.033
		4	0.53	0.021	0.039	7.8	0.055	0.007	2.5	0.040	0.016	41.0	2.9	0.071
		8	0.50	0.04	0.09	9.3	0.125	0.013	2.9	0.066	0.022	37.5	1.9	0.050
	Airstone	2	0.02	0.0055	0.312	2.2	0.57	0.258	0.18	0.12	0.689	8.8	9.1	1.037
		4	0.01	0.0050	0.521	1.0	0.078	0.076	0.047	0.029	0.609	5.3	2.5	0.476
		8	0.03	0.0000	0.000	1.1	0.210	0.200	0.052	0.015	0.287	3.6	0.8	0.222
	Peeper, Above	2	0.65	0.34	0.520	45	53	1.160	3.6	3.5	0.989	8905	14546	1.633
		4	0.66	0.042	0.064	9.8	4.1	0.420	1.3	0.62	0.466	159	170	1.068
		8	0.37	0.16	0.43	7.0	2.3	0.327	0.7	0.70	0.969	55	43	0.795
	Peeper, Below	2	0.24	0.076	0.313	8.8	2.5	0.287	0.46	0.24	0.523	1081	1749	1.617
		4	0.60	0.87	1.443	12	9.8	0.790	1.3	1.6	1.293	434	469	1.081
		8	0.18	0.08	0.431	3.19	1.14	0.358	0.373	0.207	0.554	15.67	4.88	0.312
	DGT, Sediment	2	3.15	0.17	0.055	35.9	3.4	0.095	15.8	1.6	0.098	378	43.0	0.114
		4	4.83	0.22	0.046	58.5	5.6	0.095	26.9	3.1	0.115	417.3	38.6	0.092
		8	9.44	2.54	0.269	102.7	21.6	0.210	52.37	10.9	0.208	539.3	110.4	0.205
	DGT, Water	2	2.09	0.18	0.087	26.7	2.5	0.095	8.8	0.363	0.041	228	65	0.285
		4	0.97	0.43	0.440	21.2	3.3	0.156	4.5	1.4	0.308	86	12	0.134
		8	0.98	0.05	0.055	22.5	0.7	0.031	5.1	0.8	0.160	72	10	0.144
DE														
	Source	0	0.04	0.016	0.375	4.0	0.090	0.023	0.14	0.011	0.079	94	0.70	0.007
		2	0.03	0.0070	0.224	2.2	0.13	0.061	0.068	0.0012	0.017	22	5.6	0.260
		4	0.03	0.0042	0.142	2.4	0.94	0.397	0.056	0.010	0.186	27	19.1	0.714
		8	0.04	0.012	0.320	2.0	0.2	0.1	0.1	0.0	0.1	11.0	4.9	0.4
	Grab	2	0.04	0.0076	0.194	2.2	0.061	0.028	0.064	0.0040	0.063	18	0.46	0.025
		4	0.04	0.0097	0.247	1.9	0.098	0.051	0.064	0.016	0.241	26	12.2	0.478
		8	0.04	0.007	0.192	2.0	0.229	0.116	0.075	0.024	0.324	25	8.5	0.338
	Airstone	2	0.09	0.023	0.270	18	5.1	0.283	0.46	0.042	0.090	13	0.81	0.062
		4	0.08	0.0040	0.053	16	8.9	0.555	0.15	0.021	0.144	19	8.8	0.464
		8	0.13	0.0484	0.360	15	4.3	0.291	0.13	0.038	0.283	15	3.0	0.196
	Peeper, Above	2	0.39	0.37	0.953	6.5	5.7	0.872	0.28	0.32	1.121	307	479	1.559
		4	0.37	0.098	0.262	9.5	2.6	0.274	0.41	0.096	0.233	598	633	1.059
		8	0.10	0.00	0.00	1.03	0.31	0.30	0.10	0.00	0.00	6.33	0.32	0.05
	Peeper, Below	2	0.35	0.21	0.604	9.8	1.1	0.116	0.26	0.11	0.414	66	31.9	0.484
		4	0.27	0.18	0.686	13	12	0.888	0.40	0.29	0.713	954	1091	1.143
		8	0.10	0.000	0.000	3	1	0.190	0.25	0.25	1.026	10	6	0.586
	DGT,Sediment	2	0.78	0.26	0.340	31.6	1.4	0.044	0.60	0.05	0.078	209	18	0.088
		4	1.40	0.14	0.097	62.8	5.9	0.094	0.67	0.08	0.112	370	21	0.057
		8	1.82	0.25	0.137	78.8	3.5	0.045	0.99	0.29	0.296	497	162	0.326
	DGT,Water	2	0.43	0.05	0.125	14.3	1.6	0.112	0.56	0.03	0.057	365	1	0.003

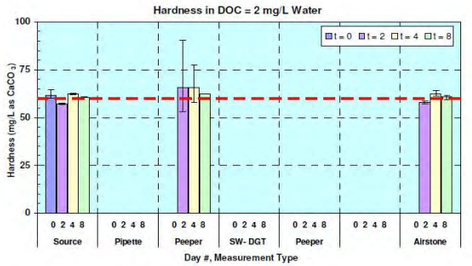
			Cadmium			Copper			Lead			Zinc		
Sample	Type	Day	Mean	SD	CV	Mean	SD	CV	Mean	SD	CV	Mean	SD	CV
		4	0.44	0.12	0.263	19.7	6.9	0.348	0.64	0.30	0.473	340	39	0.115
		8	0.51	0.21	0.423	28.2	3.0	0.106	0.59	0.16	0.278	457	60	0.132
H2O@2														
	Source	0	0.65	0.012	0.018	9.4	0.51	0.055	2.5	0.015	0.006	73	4.3	0.059
		2	0.64	0.022	0.034	9.1	0.26	0.029	3.2	0.042	0.013	31	2.6	0.082
		4	0.63	0.030	0.047	8.8	0.055	0.006	3.2	0.050	0.016	33	1.0	0.031
		8	0.71	0.071	0.100	10.2	0.231	0.023	3.6	0.061	0.017	26	4.4	0.168
	Airstone	2	0.41	0.034	0.085	9.2	0.67	0.073	2.0	2.4	1.245	24	3.8	0.160
		4	0.38	0.023	0.060	7.1	0.34	0.047	0.88	0.10	0.119	20	1.1	0.053
		8	0.43	0.058	0.136	7.7	0.42	0.054	0.85	0.12	0.146	28	1.7	0.061
	Peeper	2	0.56	0.086	0.153	23	24	1.035	2.0	0.56	0.285	7432	12789	1.721
		4	0.96	0.50	0.514	15	11	0.756	3.9	3.4	0.885	118	152	1.283
		8	0.67	0.1	0.090	7.0	0.731	0.104	2.0	0.1	0.061	22	0	0.012
	DGT,Water	2	3.91	0.36	0.093	36	3.65	0.102	18.5	2.0	0.110	285	35	0.123
		4	8.28	0.79	0.095	77	4.05	0.052	43.7	2.8	0.065	469	37	0.079
		8	15.77	2.505	0.159	150.50	22.59	0.150	86.8	12.0	0.138	656	96	0.146
H2O@5														
	Source	0	0.63	0.042	0.068	9.2	0.30	0.032	2.8	0.038	0.013	24	0.35	0.014
		2	0.72	0.018	0.025	10	0.20	0.020	3.4	0.010	0.003	26	2.8	0.104
		4	0.70	0.050	0.072	9.9	0.38	0.039	3.4	0.046	0.014	40	8.4	0.210
		8	0.66	0.1	0.085	10.8	1.37	0.127	3.3	0.221	0.066	30	4.4	0.149
	Airstone	2	0.52	0.040	0.077	11	1.6	0.148	1.2	0.46	0.394	21	0.99	0.048
		4	0.45	0.036	0.081	9.9	1.2	0.126	0.98	0.14	0.138	29	1.8	0.063
		8	0.51	0.094	0.186	10.1	0.2	0.015	0.93	0.08	0.085	36	9.1	0.254
	Peeper	2	0.75	0.13	0.172	11	2.2	0.201	2.0	0.075	0.037	56	45.2	0.808
		4	0.88	0.08	0.091	16	6.6	0.409	2.4	0.723	0.302	363	283.2	0.780
		8	0.70	0.04	0.059	9.0	0.955	0.107	6.90	6.49	0.941	23	0.2	0.010
	DGT,Water	2	4.04	0.32	0.080	40	2.9	0.071	21.7	1.706	0.079	143	10.6	0.074
		4	7.01	0.66	0.093	71	6.0	0.085	41.4	3.840	0.093	243	22.9	0.094
		8	15.83	2.13	0.134	151	17.7	0.117	89.8	10.938	0.122	510	59.1	0.116

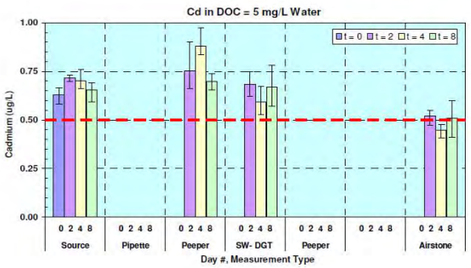

Cd in DOC = 2 mg/L Water
Cadmium (ug/L)
t = 0 t = 2 t = 4 t = 8
Source
Pipette
Peeper
SW- DGT
Peeper
Airstone
Day #, Measurement Type

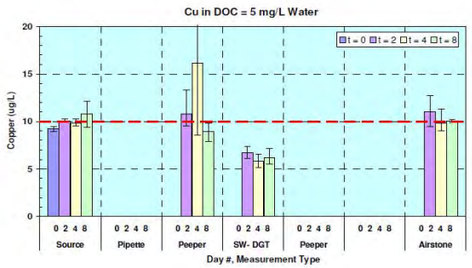

Cu in DOC = 2 mg/L Water
23.3
Copper (ug/L)
t = 0 t = 2 t = 4 t = 8
Source
Pipette
Peeper
SW- DGT
Peeper
Airstone
Day #, Measurement Type

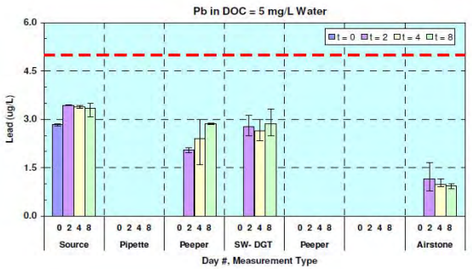

Pb in DOC = 2 mg/L Water
Lead (ug/L)
t = 0 t = 2 t = 4 t = 8
Source
Pipette
Peeper
SW- DGT
Peeper
Airstone
Day #, Measurement Type

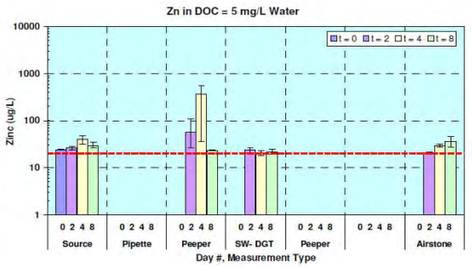

Zn in DOC = 2 mg/L Water
Zinc (ug/L)
t = 0 t = 2 t = 4 t = 8
Source
Pipette
Peeper
SW- DGT
Peeper
Airstone
Day #, Measurement Type

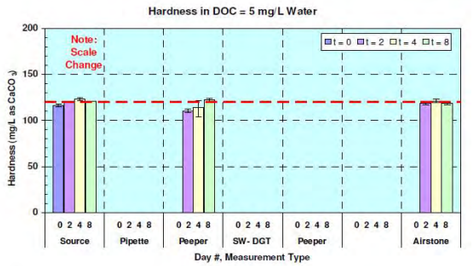

Hardness in DOC = 2 mg/L Water
Hardness (mg/L as CaCO 3)
t = 0 t = 2 t = 4 t = 8
Source
Pipette
Peeper
SW- DGT
Peeper
Airstone
Day #, Measurement Type

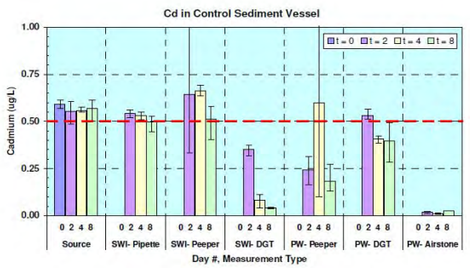

Cd in DOC = 5 mg/L Water
Cadmium (ug/L)
t = 0 t = 2 t = 4 t = 8
Source
Pipette
Peeper
SW- DGT
Peeper
Airstone
Day #, Measurement Type

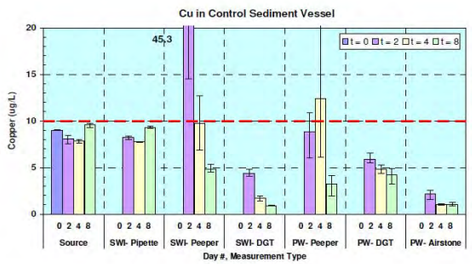

Cu in DOC = 5 mg/L Water
Copper (ug/L)
t = 0 t = 2 t = 4 t = 8
Source
Pipette
Peeper
SW- DGT
Peeper
Airstone
Day #, Measurement Type

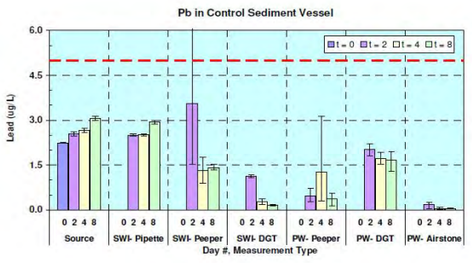

Pb in DOC = 5 mg/L Water
Lead (ug/L)
t = 0 t = 2 t = 4 t = 8
Source
Pipette
Peeper
SW- DGT
Peeper
Airstone
Day #, Measurement Type

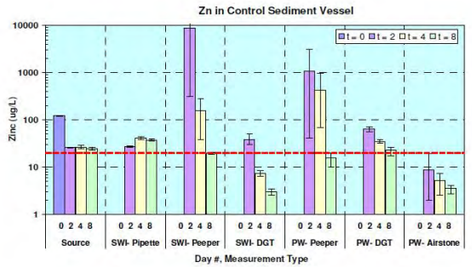

Zn in DOC = 5 mg/L Water
Zinc (ug/L)
t = 0 t = 2 t = 4 t = 8
Source
Pipette
Peeper
SW- DGT
Peeper
Airstone
Day #, Measurement Type

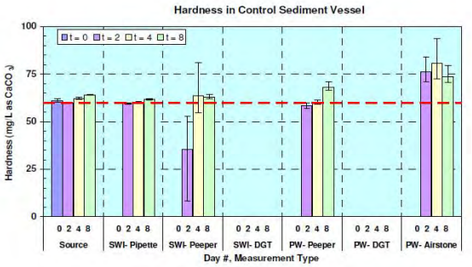

Hardness in DOC = 5 mg/L Water
Note:
Scale
Change
Hardness (mg/L as CaCO 3)
t = 0 t = 2 t = 4 t = 8
Source
Pipette
Peeper
SW- DGT
Peeper
Airstone
Day #, Measurement Type

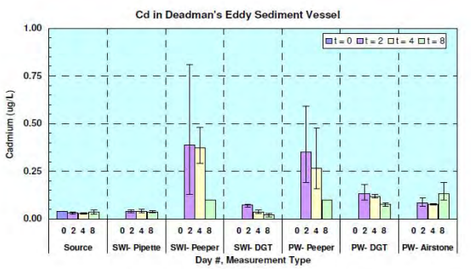

Cd in Control Sediment Vessel
Cadmium (ug/L)
t = 0 t = 2 t = 4 t = 8
Source
SWI- Pipette
SWI- Peeper
SWI- DGT
PW- Peeper
PW- DGT
PW- Airstone
Day #, Measurement Type

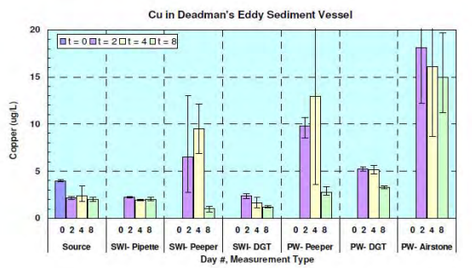

Cu in Control Sediment Vessel
45.3
Copper (ug/L)
t = 0 t = 2 t = 4 t = 8
Source
SWI- Pipette
SWI- Peeper
SWI- DGT
PW- Peeper
PW- DGT
PW- Airstone
Day #, Measurement Type

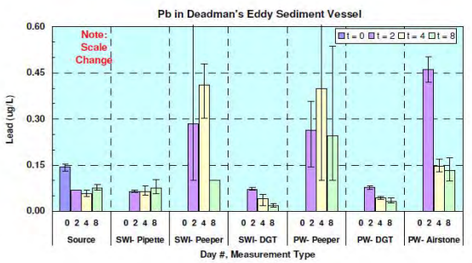

Pb in Control Sediment Vessel
Lead (ug/L)
t = 0 t = 2 t = 4 t = 8
Source
SWI- Pipette
SWI- Peeper
SWI- DGT
PW- Peeper
PW- DGT
PW- Airstone
Day #, Measurement Type

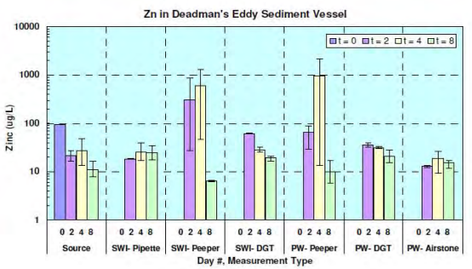

Zn in Control Sediment Vessel
Zinc (ug/L)
t = 0 t = 2 t = 4 t = 8
Source
SWI- Pipette
SWI- Peeper
SWI- DGT
PW- Peeper
PW- DGT
PW- Airstone
Day #, Measurement Type

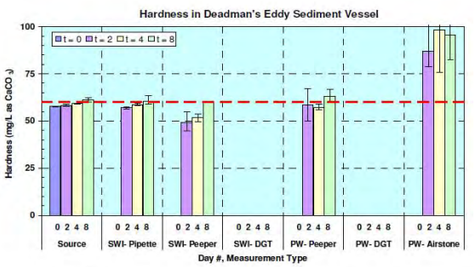

Hardness in Control Sediment Vessel
Hardness (mg/L as CaCO 3)
t = 0 t = 2 t = 4 t = 8
Source
SWI- Pipette
SWI- Peeper
SWI- DGT
PW- Peeper
PW- DGT
PW- Airstone
Day #, Measurement Type

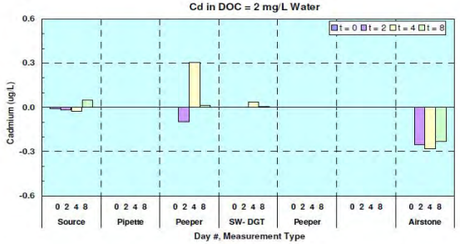

Cd in Deadman's Eddy Sediment Vessel
Cadmium (ug/L)
t = 0 t = 2 t = 4 t = 8
Source
SWI- Pipette
SWI- Peeper
SWI- DGT
PW- Peeper
PW- DGT
PW- Airstone
Day #, Measurement Type

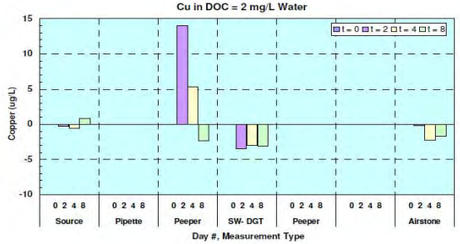

Cu in Deadman's Eddy Sediment Vessel
Copper (ug/L)
t = 0 t = 2 t = 4 t = 8
Source
SWI- Pipette
SWI- Peeper
SWI- DGT
PW- Peeper
PW- DGT
PW- Airstone
Day #, Measurement Type

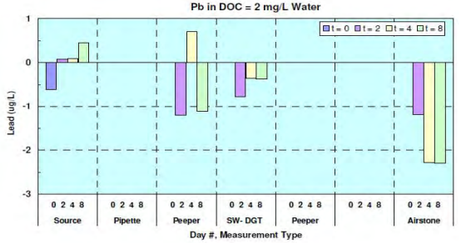

Pb in Deadman's Eddy Sediment Vessel
Note:
Scale
Change
Lead (ug/L)
t = 0 t = 2 t = 4 t = 8
Source
SWI- Pipette
SWI- Peeper
SWI- DGT
PW- Peeper
PW- DGT
PW- Airstone
Day #, Measurement Type

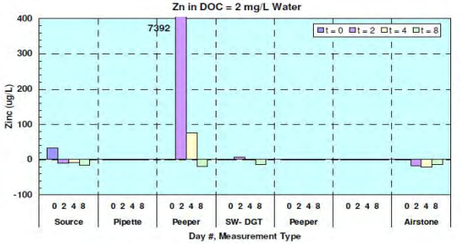

Zn in Deadman's Eddy Sediment Vessel
Zinc (ug/L)
t = 0 t = 2 t = 4 t = 8
Source
SWI- Pipette
SWI- Peeper
SWI- DGT
PW- Peeper
PW- DGT
PW- Airstone
Day #, Measurement Type

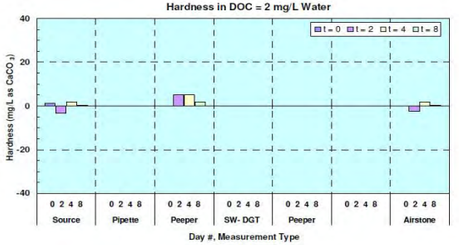

Hardness in Deadman's Eddy Sediment Vessel
Hardness (mg/L as CaCO 3)
t = 0 t = 2 t = 4 t = 8
Source
SWI- Pipette
SWI- Peeper
SWI- DGT
PW- Peeper
PW- DGT
PW- Airstone
Day #, Measurement Type

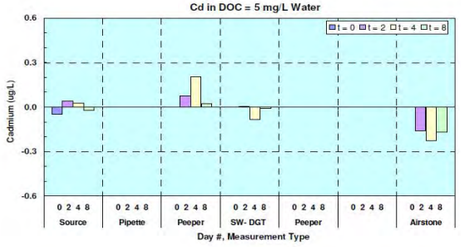

Cd in DOC = 2 mg/L Water
Cadmium (ug/L)
t = 0 t = 2 t = 4 t = 8
0.6
0.3
0.0
-0.3
-0.6
0 2 4 8
Source
Pipette
Peeper
SW- DGT
Peeper
Airstone
Day #, Measurement Type

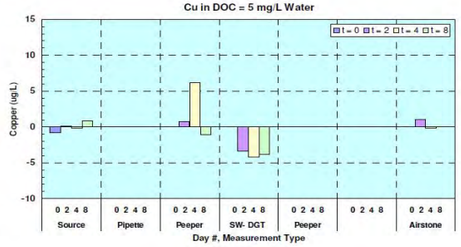

Cu in DOC = 2 mg/L Water
Copper (ug/L)
t = 0 t = 2 t = 4 t = 8
15
10
5
0
-5
-10
0 2 4 8
Source
Pipette
Peeper
SW- DGT
Peeper
Airstone
Day #, Measurement Type

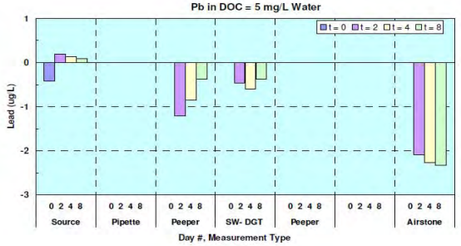

Pb in DOC = 2 mg/L Water
Lead (ug/L)
t = 0 t = 2 t = 4 t = 8
1
0
-1
-2
-3
0 2 4 8
Source
Pipette
Peeper
SW- DGT
Peeper
Airstone
Day #, Measurement Type

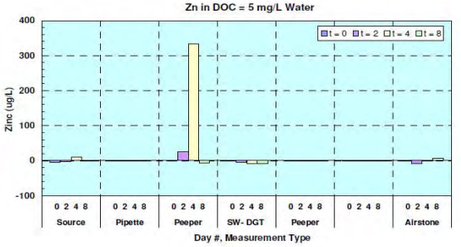

Zn in DOC = 2 mg/L Water
7392
Zinc (ug/L)
t = 0 t = 2 t = 4 t = 8
400
300
200
100
0
-100
0 2 4 8
Source
Pipette
Peeper
SW- DGT
Peeper
Airstone
Day #, Measurement Type

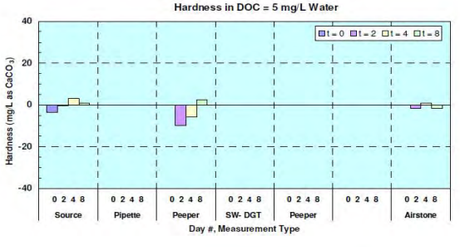

Hardness in DOC = 2 mg/L Water
Hardness (mg/L as CaCO3)
t = 0 t = 2 t = 4 t = 8
40
20
0
-20
-40
0 2 4 8
Source
Pipette
Peeper
SW- DGT
Peeper
Airstone
Day #, Measurement Type

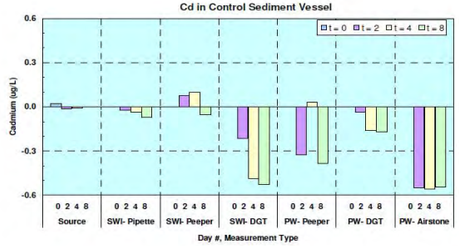

Cd in DOC = 5 mg/L Water
Cadmium (ug/L)
t = 0 t = 2 t = 4 t = 8
0.6
0.3
0.0
-0.3
-0.6
0 2 4 8
Source
Pipette
Peeper
SW- DGT
Peeper
Airstone
Day #, Measurement Type

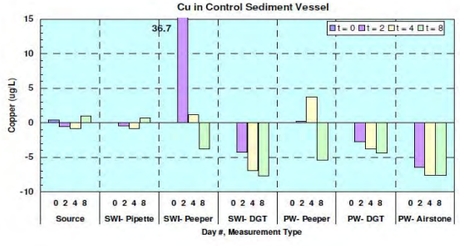

Cu in DOC = 5 mg/L Water
Copper (ug/L)
t = 0 t = 2 t = 4 t = 8
15
10
5
0
-5
-10
0 2 4 8
Source
Pipette
Peeper
SW- DGT
Peeper
Airstone
Day #, Measurement Type

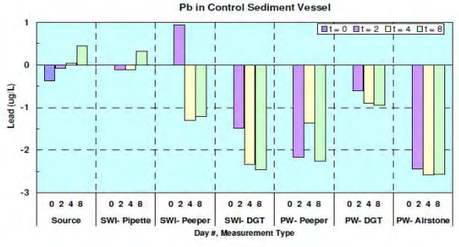

Pb in DOC = 5 mg/L Water
Lead (ug/L)
t = 0 t = 2 t = 4 t = 8
1
0
-1
-2
-3
0 2 4 8
Source
Pipette
Peeper
SW- DGT
Peeper
Airstone
Day #, Measurement Type

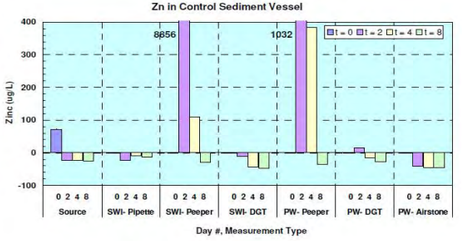

Zn in DOC = 5 mg/L Water
Zinc (ug/L)
t = 0 t = 2 t = 4 t = 8
400
300
200
100
0
-100
0 2 4 8
Source
Pipette
Peeper
SW- DGT
Peeper
Airstone
Day #, Measurement Type

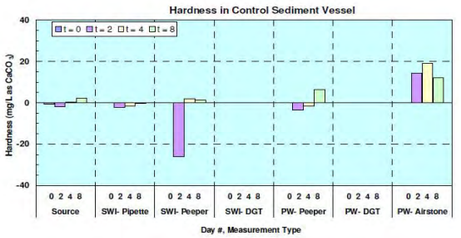

Hardness in DOC = 5 mg/L Water
Hardness (mg/L as CaCO3)
t = 0 t = 2 t = 4 t = 8
40
20
0
-20
-40
0 2 4 8
Source
Pipette
Peeper
SW- DGT
Peeper
Airstone
Day #, Measurement Type

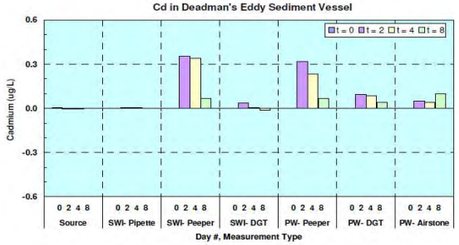

Cd in Control Sediment Vessel
Cadmium (ug/L)
t = 0 t = 2 t = 4 t = 8
0.6
0.3
0.0
-0.3
-0.6
0 2 4 8
Source
SWI- Pipette
SWI- Peeper
SWI- DGT
PW- Peeper
PW- DGT
PW- Airstone
Day #, Measurement Type

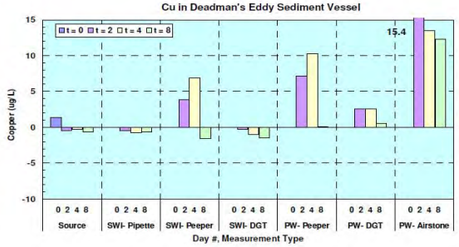

Cu in Control Sediment Vessel
36.7
Copper (ug/L)
t = 0 t = 2 t = 4 t = 8
15
10
5
0
-5
-10
0 2 4 8
Source
SWI- Pipette
SWI- Peeper
SWI- DGT
PW- Peeper
PW- DGT
PW- Airstone
Day #, Measurement Type

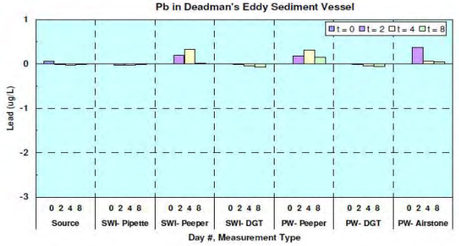

Pb in Control Sediment Vessel
Lead (ug/L)
t = 0 t = 2 t = 4 t = 8
1
0
-1
-2
-3
0 2 4 8
Source
SWI- Pipette
SWI- Peeper
SWI- DGT
PW- Peeper
PW- DGT
PW- Airstone
Day #, Measurement Type

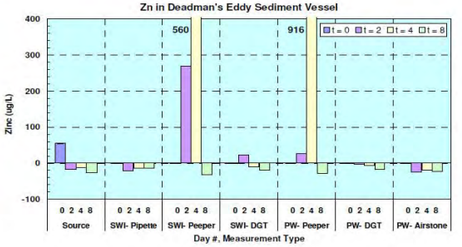

Zn in Control Sediment Vessel
8856
1032
Zinc (ug/L)
t = 0 t = 2 t = 4 t = 8
400
300
200
100
0
-100
0 2 4 8
Source
SWI- Pipette
SWI- Peeper
SWI- DGT
PW- Peeper
PW- DGT
PW- Airstone
Day #, Measurement Type

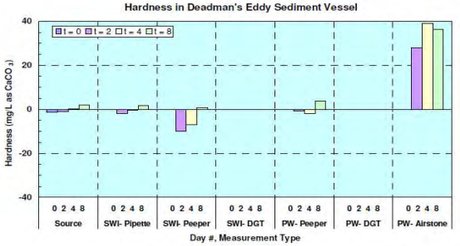

Hardness in Control Sediment Vessel
Hardness (mg/L as CaCO3)
t = 0 t = 2 t = 4 t = 8
40
20
0
-20
-40
0 2 4 8
Source
SWI- Pipette
SWI- Peeper
SWI- DGT
PW- Peeper
PW- DGT
PW- Airstone
Day #, Measurement Type


Cd in Deadman's Eddy Sediment Vessel
Cadmium (ug/L)
t = 0 t = 2 t = 4 t = 8
0.6
0.3
0.0
-0.3
-0.6
0 2 4 8
Source
SWI- Pipette
SWI- Peeper
SWI- DGT
PW- Peeper
PW- DGT
PW- Airstone
Day #, Measurement Type


Cu in Deadman's Eddy Sediment Vessel
15.4
Copper (ug/L)
t = 0 t = 2 t = 4 t = 8
15
10
5
0
-5
-10
0 2 4 8
Source
SWI- Pipette
SWI- Peeper
SWI- DGT
PW- Peeper
PW- DGT
PW- Airstone
Day #, Measurement Type


Pb in Deadman's Eddy Sediment Vessel
Lead (ug/L)
t = 0 t = 2 t = 4 t = 8
1
0
-1
-2
-3
0 2 4 8
Source
SWI- Pipette
SWI- Peeper
SWI- DGT
PW- Peeper
PW- DGT
PW- Airstone
Day #, Measurement Type


Zn in Deadman's Eddy Sediment Vessel
560
916
Zinc (ug/L)
t = 0 t = 2 t = 4 t = 8
400
300
200
100
0
-100
0 2 4 8
Source
SWI- Pipette
SWI- Peeper
SWI- DGT
PW- Peeper
PW- DGT
PW- Airstone
Day #, Measurement Type


Hardness in Deadman's Eddy Sediment Vessel
Hardness (mg/L as CaCO3)
t = 0 t = 2 t = 4 t = 8
40
20
0
-20
-40
0 2 4 8
Source
SWI- Pipette
SWI- Peeper
SWI- DGT
PW- Peeper
PW- DGT
PW- Airstone
Day #, Measurement Type

APPENDIX B

ACUTE WATER EXPOSURES OF TWO EARLY LIFE-STAGES OF WHITE STURGEON (*ACIPENSER TRANSMONTANUS*) AND RAINBOW TROUT (*ONCORHYNCHUS MYKISS*) TO COPPER

UPPER COLUMBIA RIVER

Appendix B
Acute Water Exposures of Two Early Life-Stages of White Sturgeon (*Acipenser transmontanus*) and Rainbow Trout (*Oncorhynchus mykiss*) to Copper

Prepared for:

Teck American Incorporated

P.O. Box 3087

Spokane, Washington 99220, USA

Prepared by:

Cardno ENTRIX

HDR | HydroQual, Inc.

In Cooperation with:

The University of Saskatchewan, Aquatic Toxicity Research Facility

Exponent, Inc.

Parametrix, Inc.

May 2018

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ACRONYMS AND ABBREVIATIONS

ASTM	American Society for Testing and Materials
ATRF	Aquatic Toxicity Research Facility
BLM	Biotic Ligand Model
Ca^{2+}	calcium ion
CAS	Columbia Analytical Services
CERC	Columbia Environmental Research Center
Cl^-	chloride ion
DO	dissolved oxygen
DOC	dissolved organic carbon
DQO	data quality objective
ELS	early life stages
EPA	U.S. Environmental Protection Agency
ESI	Environmental Standards, Inc.
K^+	potassium ion
LA50	biotic ligand associated with 50 percent mortality
LC50	lethal copper concentration where 50 percent mortality is observed
MDL	method detection limit
Mg^{2+}	magnesium ion
Na^+	sodium ion
NAWQC	National Ambient Water Quality Criterion
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
RL	reporting limit
SDG	sample delivery group
SO_4^{2-}	sulfate ion
U of S	University of Saskatchewan
USGS	U.S. Geological Survey

UNITS OF MEASURE

dph	days post hatch
hr(s)	hour(s)
°C	degrees Celsius
mg/L as $CaCO_3$	milligrams per liter as calcium carbonate
mg/L	milligrams per liter
µg/L	micrograms per liter
L	liter
µm	micrometers
µS/cm	microSiemens per centimeter
g	grams
mm	millimeter
µg Cu/L	micrograms of copper per liter

1 PURPOSE AND OBJECTIVES

As outlined within the Quality Assurance Project Plan (QAPP; TAI 2010a,b,c) a limited number of water-borne acute 96-hour (hr) toxicity tests were completed during the 2010 white sturgeon sediment toxicity study. These acute tests were intended to supplement parallel acute toxicity tests being performed by the U.S. Geological Survey, Columbia Environmental Research Center (USGS, CERC) on behalf of the U.S. Environmental Protection Agency (EPA); and evaluate the relative sensitivity of white sturgeon (USGS 2010).

Acute toxicity tests performed at the University of Saskatchewan, Aquatic Toxicity Research Facility (U of S, ATRF) were completed using white sturgeon at 16 days post hatch (dph) and 45 dph. To evaluate the relative sensitivity of white sturgeon, acute toxicity tests were also conducted using the standard test species rainbow trout (*Oncorhynchus mykiss*) at comparable life-stages. To identify specific data needs and to establish decision rules for the collection of data, the EPA data quality objective (DQO) process (USEPA 2006) was used. As an outcome of the DQO process, the purpose of this work and primary DQO was (under laboratory controlled conditions) to assess acute toxicity of white sturgeon (*Acipenser transmontanus*) at two early life stages (ELS[1]) to water-borne copper. Specific DQOs addressed included:

1. What concentrations of copper are acutely toxic to ELS of white sturgeon and rainbow trout as determined using standard 96-hr toxicity tests?
2. What is the relative sensitivity of white sturgeon and rainbow trout to copper at the tested life stages?

1.1 REPORT ORGANIZATION

This report is organized into the following sections:

- Section 1 – Purpose and Objectives. This section describes the purpose and objectives of the acute toxicity tests to ELS of white sturgeon and rainbow trout.
- Section 2 – Methods. This section provides an overview of the Study, including laboratory exposure design, hatchery collection, and laboratory analyses.
- Section 3 – Quality Assurance Project Plan Deviations and Modifications. This section discusses any modifications and deviations from the QAPP; and potential uncertainties associated with the Study.
- Section 4 – Validation Assessment. This section provides an overview of the validation assessment conducted on analytical data.
- Section 5 – Data Summary and Evaluation. This section presents a summary of data, integrating and interpreting the results relative to the primary study question(s).

[1] For purposes of this Study, early life stages are defined as 16- and 45-dph.

- Section 6 – Discussion and Recommendations. This section presents a summary of the results in terms of data gaps and provides recommendations.
- Section 7 – References. This section presents bibliographic information for documents cited herein.

2 METHODS

A summary of study design, sampling methods, and analytical procedures used to assess acute toxicity of ELS, of white sturgeon (*A. transmontanus*) and rainbow trout (*O. mykiss*) to copper is presented below.

2.1 TEST SPECIES AND SOURCE

2.1.1 White Sturgeon (*A. transmontanus*)

Fertilized white sturgeon eggs were obtained from the Kootenay Trout Hatchery located in Fort Steele, British Columbia on July 7, 2010. During the July 7, 2010, fertilization event, hatchery staff collected eggs from three females and sperm from four male adult white sturgeon captured in the Columbia River near the U.S.-Canada border (Ron Ek 2010, pers. comm.; FFSBC 2011). Fertilization of eggs was harmonized in the hatchery by injecting the mature sturgeon with a gonadotropin analog on two subsequent days. Embryos were transported in oxygenated bags and received at the U of S, ATRF within 12 hrs of fertilization.

Upon receipt at the U of S, ATRF white sturgeon embryos were acclimated to test waters[2] for 1 hr before being incubated in McDonald-type hatching jars for 72 hrs until neurulation occurred. After 72 hrs, flow conditions were increased to gently agitate the embryos and mitigate the potential for fungus development. Hatching jars were inspected daily, and infertile, damaged or fungus-infected embryos removed. Hatching began and ended on the 18th and 24th of July, respectively. During this time, sturgeon larvae were transferred from hatching jars to culturing tanks until hatching was complete.

Before the swim-up stage (approximately 7 dph), food was introduced *ad libitum* into the culturing tanks at a frequency of three to four times a day. The food source consisted of live artemia (*Artemia salina*), and a semimoist diet of Argent CYCLOP-EEZE® (freeze dried bloodworm, brine shrimp, shrimp, and tubifex worm) fish food. Culturing tanks were cleaned daily removing any uneaten food and waste.

2.1.2 Rainbow Trout (*O. mykiss*)

Fertilized rainbow trout eggs were purchased from Troutlodge, Inc. Eyed eggs were received on June 24, 2010. Upon arrival at the U of S, ATRF, eggs were acclimated to a water temperature of 12 °C for 1 hr prior to being incubated in McDonald-type hatching jars under flow-through conditions. Hatching jars were inspected daily, and infertile, damaged or fungus-infected embryos removed. Hatching was complete on July 1, 2010. Rainbow trout

[2] Test water used during the Study was intended have a target water hardness of 60 mg/L as $CaCO_3$, and consisted of a 1:1 mixture of dechlorinated City of Saskatoon water and ATRF reverse osmosis water.

fry were transferred into culturing tanks until hatching was complete. Food was introduced *ad libitum* into the culturing tanks at a frequency of three to four times a day. Unlike white sturgeon, rainbow trout were fed Aqua-Balance Trout Starter #0 and #2 crumble fish food. Culturing tanks were cleaned daily removing any uneaten food and waste.

2.2 TEST SOLUTIONS AND EXPOSURE METHODS

Stock solutions were prepared using copper (II) sulfate pentahydrate (Chemical Abstracts Service No. 7758-99-8; purity 99.995 percent), as obtained from Sigma-Aldrich. Consistent with the QAPP (TAI 2010a), target concentrations were formulated by mixing the copper (II) sulfate pentahydrate with test waters. As noted within Section 2.1, test waters consisted of a 1:1 mixture of dechlorinated City of Saskatoon water and ATRF reverse osmosis water with a targeted water hardness of approximately 60 mg/L as $CaCO_3$ and a dissolved organic carbon (DOC) concentration ranging from 1.5 to 2.5 mg/L. Formulated stock solutions were targeted to have final dissolved copper concentrations of 0, 2, 4, 8, 16, 32, and 64 µg/L. Stock solutions for the above-listed treatment concentrations were prepared a minimum of 72 hrs prior to use in acute toxicity tests.

Per the American Society for Testing and Materials (ASTM) guidelines for testing ELS of fish (ASTM 2009, E1241-05; ASTM 2007, E729-96), acute toxicity tests were conducted under static renewal conditions. Exposures initiated at 16 dph for white sturgeon and at 17 dph for rainbow trout were completed in 0.5-L polypropylene containers; while tests conducted at 45 dph (white sturgeon) and 48 dph (rainbow trout) were completed in 20-L polypropylene containers. As outlined within ASTM guidelines, 50 percent of the test solution was replaced every 12 hrs for each life-stage tested. Exposures at all targeted copper concentrations were conducted at a target water temperature of 16 ± 1°C (white sturgeon) and 12 ± 1°C (rainbow trout), and an illumination cycle of 16 light:8 dark (16:8) hrs.

2.3 SAMPLING METHODS AND ANALYSES

To ensure that toxicity tests were performed within design constraints specified by ASTM guidelines, general water quality parameters were routinely monitored in-house by laboratory personal at the U of S, ATRF. Specifically, temperature, pH, dissolved oxygen (DO), and conductivity were monitored daily using respective YSI probes; while alkalinity, inorganic nitrogen (e.g., ammonia and nitrate), and hardness were monitored at the beginning and end of the tests using LaMotte Company colorimetric and titration test kits (TAI 2010a).

In addition, water samples were collected at the beginning and end of the tests for chemical analyses as performed by Columbia Analytical Services (CAS). Samples submitted for chemical analysis by CAS were analyzed for dissolved copper, major cations/anions[3],

[3] Major cations/anions as defined for this Study include calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^{+}), sodium (Na^{+}), sulfate (SO_4^{2-}), and chloride (Cl^{-}).

alkalinity, hardness, and DOC. With the exception of dissolved fractions (i.e., copper and organic carbon), samples were collected into prepreserved sampling containers, and transported at approximately 4°C to CAS. Samples in which analyses required the dissolved fraction were filtered through a 0.45-µm polycarbonate filter before being transferred into prepreserved sampling containers and submitted for chemical analysis. A summary of the analytical methods employed for both in-house (U of S, ATRF) and off-site (CAS) water quality parameters are presented in Table B2-1.

Table B2-1. Analytical Methods and Associated Detection Limits

Parameter	Unit	Analytical Method	MDL
Analyses Performed by U of S, ATRF			
Temperature	˚C	YSI Probe	NA
pH	s.u.	YSI Probe	NA
Dissolved oxygen	mg/L	YSI Probe	2
Conductivity	µS/cm	YSI Probe	1
Alkalinity	mg/L as $CaCO_3$	LaMotte Kit 4491-DR	20
Hardness	mg/L as $CaCO_3$	LaMotte Kit 4824-DR-LT	20
Ammonia-Nitrogen	mg/L	LaMotte Kit 3304	0.02
Nitrate	mg/L	LaMotte Kit 3319	0.25
Nitrite	mg/L	LaMotte Kit 7674	0.02
Analyses Performed by Columbia Analytical Services			
Hardness	mg/L as $CaCO_3$	SM2340C	0.8
Alkalinity	mg/L as $CaCO_3$	SM2320B	1.0
Dissolved organic carbon	mg/L	SM5310C	0.07
Copper	µg/L	EPA6020	0.02[a]
Calcium	µg/L	EPA6010B	6
Magnesium	µg/L	EPA6010B	0.3-2.0
Sodium	µg/L	EPA6010B	20
Potassium	µg/L	EPA6010B	40-50
Sulfate	µg/L	EPA300.0	0.01-0.1
Chloride	µg/L	EPA300.0	0.06-0.1

Notes:
MDL – Method Detection Limit
NA – Not Available

In addition to the above-mentioned water quality measurements made during the course of the 96-hr toxicity tests, observations of mortalities were also recorded. The frequency of such measurements was at the start of the test, and at 6, 12, 24, 48, 72, and 96 hrs thereafter. Following the 96-hr exposure period, surviving fish were euthanized with Tricaine®-S, blotted dry, weighed and measured to the nearest 0.001 g and 0.01 mm, respectively; and preserved in 10 percent formalin for a period of 24 hrs. At the end of the 24 hr preservation period, the formalin was replaced with 70 percent ethanol for long-term storage.

3 QUALITY ASSURANCE PROJECT PLAN DEVIATIONS AND MODIFICATIONS

This section provides a discussion of deviations or modifications to methods outlined within the QAPP (TAI 2010a,b,c).

3.1 CHANGE ORDERS

During the course of this Study, one change request form was submitted and approved by EPA. As noted within Section 1.1 and detailed in the QAPP (TAI 2010a), the acute 96-hr toxicity tests were intended to supplement parallel testing being performed by the USGS, CERC on behalf of the EPA; and to provide an interlaboratory comparison of white sturgeon strain sensitivities (i.e., Sherman Creek Hatchery and Kootenay Trout Hatchery strains). As a result, acute toxicity tests conducted at the U of S, ATRF were to be performed using white sturgeon eggs supplied by the USGS, CERC as obtained from the Sherman Creek Hatchery. Unfortunately the USGS, CERC could not supply the U of S, ATRF with sturgeon eggs as obtained from the Sherman Creek Hatchery. As a result, acute toxicity tests conducted at the U of S, ATRF were completed using sturgeon eggs obtained from the Kootenay Trout Hatchery, refer to Section 2.1 herein.

In light of the fact that sturgeon eggs could not be made available to the U of S, ATRF from the Sherman Creek Hatchery and as detailed within the change request form, it was concluded that additional interlaboratory comparisons of strain sensitivities was not a high priority, and that normalization using the Biotic Ligand Model (BLM) was sufficient. A copy of the EPA-approved change request form No. 1 and associated technical justification is provided in Attachment B-1.

3.2 DEVIATION / CORRECTIVE ACTION REPORTS

In addition to the above-listed change order, one deviation/corrective action report (i.e., Form No. 09) was recorded during acute toxicity testing. The purpose of this deviation / corrective action report was to ensure that parallel acute toxicity tests being conducted at the U of S, ATRF and the USGS, CERC were harmonized to the maximum extent possible. As a result, rather than initiating acute toxicity tests on 15 dph as outlined within the QAPP (TAI 2010a), acute toxicity tests were initiated on 16 dph. As detailed within the deviation/corrective action report (see Attachment B1), this deviation is not anticipated to adversely affect data quality or Study objectives.

Although the above-mentioned change order and deviation/corrective action reports are not anticipated to adversely affect data quality or Study objectives, it is worthwhile recalling a finding from the internal peer review as conducted by EPA's Office of Research and Development.

Although the primary focus of the peer review for work completed at the U of S, ATRF was on the assessment of sediment toxicity to white sturgeon, their general observation of control survival remains applicable. As noted by peer reviewers "control survival is very important in evaluating the reliability of the results from a toxicity study. It is the key determinant assessing the health of the test organisms and the viability of the test design and exposure system (page 3 of 9)." Based on white sturgeon control survivals observed within both laboratories (U of S, ATRF and USGS, CERC) peer reviewers "believe that toxicity testing of the organisms was undertaken before successful baseline culturing techniques were established for this species, especially during transition to exogenous feeding (page 7 of 9)."

4 VALIDATION ASSESSMENT

Environmental Standards Inc. (ESI) performed the independent quality assurance and data validation review of the 2010 white sturgeon acute toxicity data produced by CAS of Kelso, Washington. The review was performed in accordance with requirements specified in the QAPP (TAI 2010a,c), and the following guidance:

- "Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use" (EPA-540-R08-005) (USEPA 2009)
- "U.S. EPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review" (EPA/540/R-04-004) (USEPA 2004)

Data were examined to determine the usability of the analytical results and compliance relative to the requirements specified above and the analytical methods. In addition, deliverables were evaluated for completeness and accuracy. Qualifier codes have been placed next to results on data tables to enable the data user to quickly assess the qualitative and/or quantitative reliability of any result based on the criteria evaluated. EPA's quality assurance/quality control (QA/QC) chemist reviewed the draft data and data validation reports. Issues were resolved and EPA approved the data for public use on October 17, 2011. Data validation reports are available on the "Downloads" page of the project database (http://teck-ucr.exponent.com). The following sections summarize results of the independent validation. It should be noted that consistent with the QAPP (TAI 2010a), general in-house water quality parameters monitored (e.g., temperature, pH, DO, conductivity, and inorganic nitrogen) during the tests were not validated. These routine water quality parameters were monitored to ensure that toxicity tests were within design constraints at the time of testing.

4.1 OVERALL DATA QUALITY

The majority of the data are useable, with qualifications presented in the validation reports, and included in the Project Database. Only useable data were included in this report (all data are in the Project Database). Qualifiers were applied to data by the laboratory and validators to indicate when data were out of calibration range (i.e., below or above levels of quantitation); where contaminated blanks compromised data interpretability; or if matrix spikes, internal standards or other quality control metrics were exceeded. Table B4-1 summarizes the number of samples with each type of data qualifier[4], by analyte; there were no rejected results. Information regarding how data qualifiers should be used is presented within the Draft Upper Columbia River RI/FS Data Management Plan Amendment No. 1 (TAI 2010d).

[4] Data qualifiers are defined within the footnotes of Table B4-1.

Table B4-1. 2010 Acute White Sturgeon Toxicity Summary of Data Qualifiers

Lab	Analyte Name	Number of Samples Analyzed	Reject Results	Accepted Results	Count of Results with No Flags	Count of Accepted Results Laboratory Flags				Count of Accepted Results Validator (ESI) Flags			Laboratory Flags, % of Accepted Results				Validator (ESI) Flags, % of Accepted Results		
						*	<	J	U	J	U	U*	*	<	J	U	J	U	U*
CAS	Alkalinity	161	0 (0%)	161 (100%)	160	0	0	0	0	0	0	1	0	0	0	0	0	0	0.6
CAS	Fluoride	161	0 (0%)	161 (100%)	1	0	0	160	0	154	0	6	0	0	99.4	0	95.7	0	3.7
CAS	Hardness as $CaCO_3$	140	0 (0%)	140 (100%)	140	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CAS	Organic carbon	161	0 (0%)	161 (100%)	58	0	0	0	1	71	1	31	0	0	0	0.6	44.1	0.6	19.3
CAS	Sulfate	161	0 (0%)	161 (100%)	129	0	0	0	0	32	0	0	0	0	0	0	19.9	0	0
CAS	Calcium	140	0 (0%)	140 (100%)	140	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CAS	Chloride ion	161	0 (0%)	161 (100%)	161	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CAS	Copper	140	0 (0%)	140 (100%)	138	0	0	0	0	0	0	2	0	0	0	0	0	0	1.4
CAS	Magnesium	140	0 (0%)	140 (100%)	140	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CAS	Potassium	140	0 (0%)	140 (100%)	140	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CAS	Sodium	140	0 (0%)	140 (100%)	140	0	0	0	0	0	0	0	0	0	0	0	0	0	0
U of S	Alkalinity	248	0 (0%)	248 (100%)	248	0	0	0	0	NA	NA	NA	0	0	0	0	NA	NA	NA
U of S	Conductivity	550	0 (0%)	550 (100%)	550	0	0	0	0	NA	NA	NA	0	0	0	0	NA	NA	NA
U of S	Dissolved oxygen	550	0 (0%)	550 (100%)	550	0	0	0	0	NA	NA	NA	0	0	0	0	NA	NA	NA
U of S	Hardness	248	0 (0%)	248 (100%)	248	0	0	0	0	NA	NA	NA	0	0	0	0	NA	NA	NA
U of S	pH	550	0 (0%)	550 (100%)	550	0	0	0	0	NA	NA	NA	0	0	0	0	NA	NA	NA
U of S	Chloride ion	197	0 (0%)	197 (100%)	0	0	197	0	0	NA	NA	NA	0	100	0	0	NA	NA	NA
U of S	Ammonia as Nitrogen	248	0 (0%)	248 (100%)	88	0	160	0	0	NA	NA	NA	0	64.5	0	0	NA	NA	NA
U of S	Nitrate	248	0 (0%)	248 (100%)	43	0	205	0	0	NA	NA	NA	0	82.7	0	0	NA	NA	NA
U of S	Nitrite	248	0 (0%)	248 (100%)	0	0	248	0	0	NA	NA	NA	0	100	0	0	NA	NA	NA
U of S	Temperature	550	0 (0%)	550 (100%)	550	0	0	0	0	NA	NA	NA	0	0	0	0	NA	NA	NA

Notes:

Data excludes lab replicates and QC sample data.

ESI

J Quantitation is approximate due to limitations identified during the QA review (data validation).
U This analyte was not detected at or above the associated detection limit.
U* This analyte should be considered "not-detected" because it was detected in an associated blank at a similar level.
UJ This analyte was not detected, but the detection limit is probably higher due to a low bias identified during the QA review.

CAS

J The result is an estimated value that was detected outside the quantitation range.
U The analyte was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL.

University of Saskatchewan

< Less than
NA Consistent with the QAPP (TAI 2010a), in-house water quality parameters monitored (e.g., temperature, pH, DO, conductivity, and inorganic nitrogen) during the tests at the U of S, ATRF were not validated by ESI. These routine water quality parameters were monitored to ensure that toxicity tests were within design constraints at the time of testing.

4.2 SAMPLE TRANSPORT AND HOLDING TIMES

As identified within the QAPP (i.e., Table B-3), aqueous samples should be preserved at 4° ± 2°C. Most samples received by the laboratory were within the required preservation temperature range. In cases where the sample receipt temperature was outside of the study-required range and the associated analytical method did not specify preservation criteria, data were not qualified. Results for several sulfate and organic carbon samples in sample delivery group (SDG) K1007776 were qualified as estimated due to a receipt temperature above the study and method-specified range.

Due to limited sample volume, the laboratory was unable perform pH determinations for some of the metals samples. According to Table B-3 of the QAPP, aqueous samples for metals analysis should be preserved to pH < 2 standard units. The validator was unable to verify that the affected samples were properly preserved. Data were not qualified due to this issue.

No transport holding times were exceeded.

4.2.1 Equipment Rinse Blanks

Equipment rinse blanks were included with the samples in SDGs K1008585, K1008730, and K1008731. Due to their presence in the associated rinse blanks at similar concentrations, results for copper and/or organic carbon in one or more samples in these SDGs were qualified as "not-detected".

4.2.2 Laboratory Holding Times

Laboratory holding times were not exceeded for any analyte in any of the samples.

4.3 INORGANICS

Inorganic analyses were conducted by CAS of Kelso, Washington. The majority of the data reviewed are useable with the qualifications presented in the validation reports and database.

4.3.1 Calibration

The analysis for calcium in one SDG K1008731 sample was qualified as unusable due to a very low recovery (< 50 percent) in the associated reporting limit (RL) standard analysis. Similarly, calcium in one SDG K1008585 sample was qualified as estimated due to a low recovery (< 70 percent) in the associated RL standard analysis; and sodium in one SDG K1008731 sample was also qualified as estimated due to a low recovery (< 70 percent) in the associated RL standard analysis.

According to project-specific reporting requirements, any reported positive results between the method detection limit (MDL) and the RL were qualified as estimated.

4.3.2 Blanks

Due to their presence in the associated laboratory blanks at similar concentrations, results for copper, fluoride, and/or alkalinity in one or more SDGs K1008585, K1008731, K1009220, K1010079, and K1010090 samples were qualified as "not-detected".

4.3.3 Surrogate Recovery

There were no surrogate analytes included in the inorganic analyses performed.

4.3.4 Matrix Spike

Results for organic carbon in several SDG K1009214 and SDG K1010079 samples were qualified as estimated due to high recoveries (greater than laboratory acceptance limits) in the associated matrix spike analyses.

4.3.5 Laboratory Control Samples and Standard Reference Material

All laboratory control sample and standard reference material results were within acceptance limits and qualification of data was not warranted.

5 DATA SUMMARY AND EVALUATION

5.1 EXPOSURE CONCENTRATION VERIFICATION

Formulated stock solutions to be evaluated for both white sturgeon and rainbow trout were targeted to have dissolved copper concentrations of 0, 2, 4, 8, 16, 32, and 64 µg/L. A summary of actual dissolved copper concentrations tested during this Study are presented within Table B5-1.

Table B5-1. Dissolved Copper Concentrations Evaluated during Acute Toxicity Tests

Treatment Number	Targeted Copper Concentration (µg/L)	Mean ± (standard deviation) Dissolved Copper Concentrations (µg/L)			
		White Sturgeon		Rainbow Trout	
		16 dph	45 dph	17 dph	48 dph
0	0	0.37 (±0.04)	0.36 (±0.03)	0.39 (±0.15)	0.76 (±0.71)
1	2	2.9 (±0.18)	2.0 (±0.08)	2.1 (±0.25)	2.6 (±0.19)
2	4	4.6 (±0.25)	3.6 (±0.16)	3.9 (±0.12)	4.0 (±0.05)
3	8	8.4 (±0.10)	7.4 (±0.15)	7.6 (±0.15)	8.2 (±0.37)
4	16	20 (±1.2)	15 (±0.27)	15 (±0.30)	15 (±0.52)
5	32	30 (±0.61)	29 (±0.28)	29 (±0.53)	30 (±0.63)
6	64	49 (±12)	57 (±2.7)	59 (±1.1)	61 (±3.0)

Notes:
For all tests, the number of copper measurements per treatment was five.

As indicated within Table B5-1, average dissolved copper concentrations employed during acute toxicity tests for both test species were in good agreement with targeted concentrations. The gradient of dissolved copper concentrations evaluated in this Study is illustrated within Figure B5-1. It should be noted that the solid green line within Figure B5-1, represents the above-listed overall mean, with treatment replicate concentrations illustrated by the smaller diameter blue dots, and treatment means represented by the larger diameter red dots.

Based on the observed copper concentrations (refer to Table B5-1 and Figure B5-1), it is anticipated that the range of dissolved copper concentrations tested will enable the evaluation of acutely toxic concentrations to ELS of white sturgeon and rainbow trout; and the evaluation of their relative sensitivities.

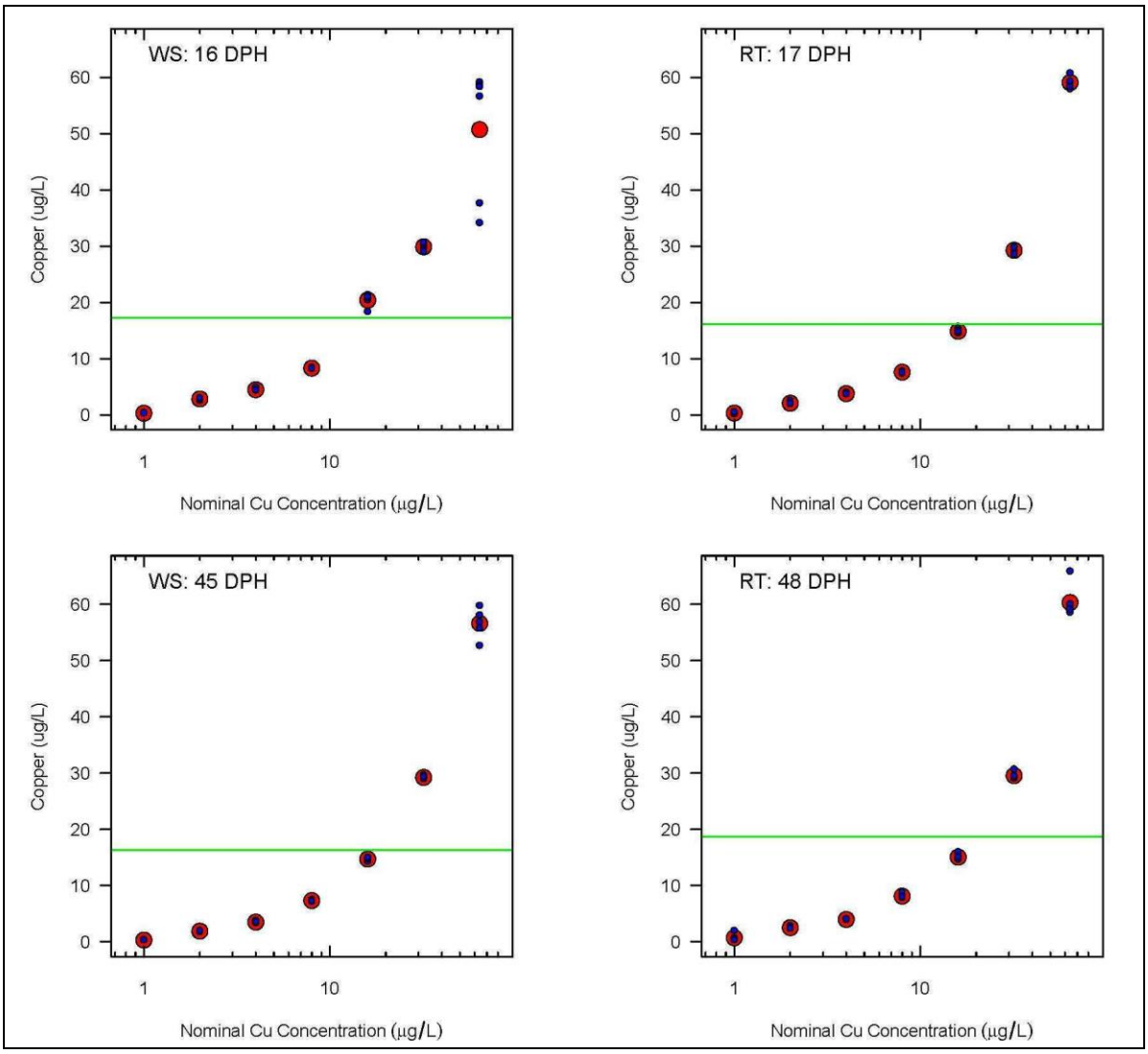

Figure B5-1. Plots of dissolved copper concentrations tested during 96-hr toxicity tests

Note: The solid green line represents the overall mean copper concentration, while respective treatment averages are depicted with a large diameter red dot; with replicate concentrations depicted using small diameter blue dots. Abbreviations are as follows: white sturgeon (WS), rainbow trout (RT), and days post hatch (DPH).

5.2 WATER QUALITY

To ensure that toxicity tests were performed within design constraints and that ambient water conditions did not confound test results, general water quality parameters were routinely monitored within the U of S, ATRF. As noted in Section 2.3, routine measurements included daily temperature, pH, DO, and conductivity; while inorganic nitrogen (i.e., ammonia, nitrate, and nitrite), alkalinity, and hardness were monitored at the beginning and end of the tests. A summary of average general water quality parameters observed during the tests is presented within Table B5-2, with individual measurements graphically illustrated for all replicates in Attachment B2-A.

As illustrated within Table B5-2, the average daily temperature recorded within white sturgeon acute exposures was 15.1°C, which is within the test acceptance criteria of 16 ± 1°C; and instantaneous temperatures were within ± 3°C of 16°C (TAI 2010a). Similarly, DO concentrations within white sturgeon exposures were maintained above the minimum test acceptability requirement of 70 percent of saturation; while all other water quality parameters did not vary by more than 50 percent. Therefore, routine water quality parameters measured within all white sturgeon exposures met minimum test acceptability criteria throughout the duration of the Study. Similarly, the average daily temperature recorded within rainbow trout acute exposures ranged from 11.5 ± 0.2°C to 13± 0.6°C (average of 12.25°C),which is within the test acceptance criteria of 12 ± 1°C (TAI 2010a). Similarly, DO concentrations within rainbow trout exposures were maintained above the minimum test acceptability requirement of 70 percent of saturation; while all other water quality parameters did not vary by more than 50 percent. Therefore, routine water quality parameters measured within all rainbow trout exposures also met minimum test acceptability criteria.

In addition to the above-mentioned routine water quality measurements and dissolved copper concentrations, water chemistry within respective treatments was determined to help interpret biological responses via the BLM. Specifically, concentrations of major cations/anions, alkalinity, hardness, and DOC were determined for each treatment by CAS. A summary of mean concentrations ± one standard deviation for respective treatments is presented in Table B5-3, with individual measurements graphically illustrated for all replicates in Attachment B2-B. For the purpose of interpreting biological responses with the BLM, DOC concentrations were not blank corrected. Blank-correcting DOC concentrations in this context (i.e., where the BLM is calibrated to these data) would increase the BLM-derived critical accumulation, making white sturgeon appear less sensitive. The approach taken in the current study represents a conservative evaluation of white sturgeon sensitivity to copper.

5.3 BIOLOGICAL MEASUREMENTS

Average control survival rates of white sturgeon in acute exposures conducted at 16 dph and 45 dph was 89.7 percent and 97.5 percent, respectively. These survival rates are greater than the acceptance criteria of ≥ 80 percent defined within the QAPP (TAI 2010a). No control mortality was observed in rainbow trout acute exposures. A summary of mortality rates recorded for both test species (white sturgeon and rainbow trout) for all treatment groups is presented within Table B5-4.

As illustrated within Table B5-4, mortality rates for both test species were observed to markedly increase at the forth treatment level (i.e., a target copper concentration of 16 µg/L).

Additional biological measurements recorded at Study termination included weight and length of individual fish. A summary of the average (± one standard deviation) weight and length recorded for both test species is presented within Table B5-5.

Table B5-2. Routine Water Quality Parameters Monitored during Acute Exposures

		Water Quality Parameter									
Test Species	No. of Measurements	Temperature (°C)	pH (su)	Dissolved Oxygen (%)	Conductivity (µS/cm)	No. of Measurements	Ammonia (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Alkalinity (mg/L as $CaCO_3$)	Hardness (mg/L as $CaCO_3$)
		Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	n	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
WS @ 16 dph	98	15.1 ± 0.1	7.7 ± 0.2	83.0 ± 2.1	185.0 ± 19.7	51	0.01 ± 0	0.13 ± 0	0.01 ± 0	42.7 ± 2.7	60.3 ± 1.8
WS @ 45 dph	151	15.1 ± 0.1	7.2 ± 0.2	85.1 ± 3.4	168.0 ± 8.5	57	0.01 ± 0	0.13 ± 0	0.01 ± 0	42.1 ± 4.1	56.6 ± 2.2
RT @ 17 dph	128	11.5 ± 0.2	7.4 ± 0.3	76.7 ± 3.9	163.1 ± 14.7	56	0.04 ± 0.03	0.14 ± 0.04	0.01 ± 0	37.2 ± 3.4	55.2 ± 7.8
RT @ 48 dph	166	13.0 ± 0.6	7.4 ± 0.1	81.0 ± 6.8	182.1 ± 12.0	56	0.04 ± 0.12	0.19 ± 0.06	0.01 ± 0	38.6 ± 2.7	58.1 ± 2.5

Notes:

SD – standard deviation
WS – white sturgeon
RT – rainbow trout

Table B5-3. Analytical Results Measured during Acute Exposures

	Water Quality Parameter								
Test Species	Alkalinity (mg/L as $CaCO_3$)	Hardness (mg/L as $CaCO_3$)	DOC (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Sulfate (mg/L)	Chloride (mg/L)
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
WS @ 16 dph	38.49 ± 3.67	63.99 ± 4.21	1.72 ± 0.35	12.14 ± 0.84	8.18 ± 0.62	13.70 ± 1.07	1.59 ± 0.12	43.53 ± 12.70	7.13 ± 2.86
WS @ 45 dph	36.60 ± 2.20	60.45 ± 2.93	2.26 ± 0.41	10.67 ± 1.08	8.21 ± 0.17	13.94 ± 0.32	1.67 ± 0.04	49.57 ± 3.16	5.78 ± 0.20
RT @ 17 dph	32.75 ± 3.89	53.08 ± 4.73	2.02 ± 0.34	9.60 ± 1.11	7.08 ± 0.51	11.09 ± 0.68	1.38 ± 0.11	40.70 ± 4.79	7.42 ± 2.94
RT @ 48 dph	37.59 ± 5.23	62.53 ± 3.67	1.57 ± 0.36	11.50 ± 1.16	8.20 ± 0.32	13.72 ± 0.65	1.64 ± 0.12	45.74 ± 3.27	6.70 ± 2.01

Notes:

SD – standard deviation
WS – white sturgeon
RT – rainbow trout

Table B5-4. Average Observed Mortalities for White Sturgeon and Rainbow Trout as a Function of Treatment. Mortalities are expressed as percent's (± one standard deviation).

	White Sturgeon (% mortality)		Rainbow Trout (% mortality)	
Treatment [a]	16 dph	45 dph	17 dph	48 dph
0	10.3 (± 8.2)	2.5 (± 5)	0 (± 0)	0 (± 0)
1	7.5 (± 5)	5 (± 5.8)	0 (± 0)	0 (± 0)
2	7.5 (± 9.6)	5 (± 10)	0 (± 0)	0 (± 0)
3	17.5 (± 9.6)	15 (± 5.8)	0 (± 0)	0 (± 0)
4	90 (± 11.5)	35 (± 17.3)	15.4 (± 10.2)	20.5 (± 9.6)
5	100 (± 0)	67.5 (± 15)	87.5 (± 9.6)	92.5 (± 5)
6	100 (± 0)	100 (± 0)	97.5 (± 5.0)	75 (± 20.8)

Notes:
dph – days post hatch
[a] Treatments are defined within Table B5-1.

Table B5-5. Average Length and Weight of White Sturgeon and Rainbow Trout at Study Termination. Results are expressed as the mean (± one standard deviation) for respective treatments.

	White Sturgeon		Rainbow Trout	
Treatment [a]	16 dph	45 dph	17 dph	48 dph
Weight (g)				
0	0.050 (± 0.003)	0.202 (± 0.015)	0.202 (± 0.006)	0.688 (± 0.015)
1	0.047 (± 0.001)	0.197 (± 0.007)	0.198 (± 0.003)	0.670 (± 0.025)
2	0.046 (± 0.004)	0.195 (± 0.014)	0.197 (± 0.012)	0.720 (± 0.023)
3	0.046 (± 0.002)	0.189 (± 0.004)	0.213 (± 0.006)	0.674 (± 0.042)
4	0.054 (± 0.004)	0.180 (± 0.023)	0.212 (± 0.007)	0.740 (± 0.056)
5	0.057 (± 0.003)	0.197 (± 0.006)	0.235 (± 0.012)	0.779 (± 0.028)
6	0.070 (± 0.011)	0.226 (± 0.021)	0.239 (± 0.016)	0.765 (± 0.041)
Length (mm)				
0	21.2 (± 0.25)	34.1 (± 1.37)	31.0 (± 0.33)	43.2 (± 0.62)
1	21.2 (± 0.25)	33.5 (± 0.68)	32.2 (± 3.21)	42.9 (± 0.29)
2	21.1 (± 0.34)	33.5 (± 0.92)	30.8 (± 0.51)	43.6 (± 0.46)
3	21.2 (± 0.08)	33.9 (± 0.37)	31.4 (± 0.77)	43.2 (± 0.88)
4	20.8 (± 0.57)	33.5 (± 2.07)	30.6 (± 0.24)	43.9 (± 0.79)
5	20.6 (± 0.37)	32.1 (± 2.32)	29.0 (± 0.79)	43.3 (± 0.36)
6	21.2 (± 0.37)	31.8 (± 0.77)	29.3 (± 0.96)	43.1 (± 0.80)

Notes:
dph – days post hatch
[a] Treatments are defined within Table B5-1.

Although both species were tested at comparable life-stages (e.g., white sturgeon @ 16 dph; rainbow trout @ 17 dph), there are significant differences in the weight of the test species. As illustrated within Table B5-5, rainbow trout @ 17 dph have an average body mass 4 times greater than that of white sturgeon @ 16 dph, regardless of treatment (dissolved copper concentration); while their difference in body length is marginal. A similar relationship is

observed at 48 dph (rainbow trout) and 45 dph (white sturgeon); with rainbow trout having an average body mass 3.6 times greater than that of white sturgeon; while their difference in length remains comparable to that observed at 16 and 17 dph.

5.4 BIOTIC LIGAND MODEL

Based on the above-mentioned water quality data, dissolved metal concentrations, and associated biological responses, the BLM (HydroQual 2007; Di Toro et al. 2001; and Santore et al. 2001, 2002) was used to normalize dose-response relationships. The BLM is a mechanistic model that explains how water chemistry of different exposure scenarios affects metal toxicity (i.e., metal bioavailability). The purpose of this calibration was to develop parameter files to calculate BLM-normalized acute effect copper concentrations for white sturgeon and rainbow trout. This normalization enables the translation of these effects from laboratory conditions to a wider variety of exposure scenarios where factors such as pH, DOC, hardness, and alkalinity may vary.

To perform the calibration, the BLM was run with measured (pH, DOC, temperature, chloride, sulfate, hardness, alkalinity, calcium, magnesium, potassium, sodium) water quality parameters. Concentration-response relationships between dissolved metal (copper) and observed mortalities for white sturgeon at 16 dph and 45 dph are illustrated within Figure B5-2.

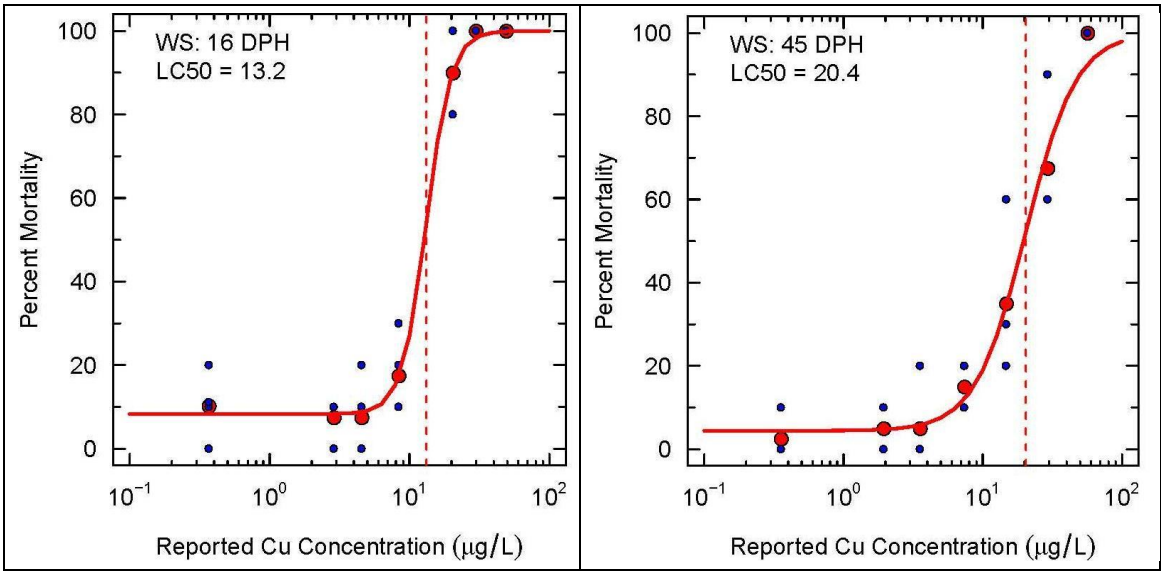

Figure B5-2. Plots of dissolved copper concentrations tested during acute toxicity tests with early life stages of white sturgeon

Note: Average copper concentrations within respective treatments are depicted with a large diameter red dot; with replicate concentrations depicted using small diameter blue dots. Test age of white sturgeon (WS) as determined days post hatch (DPH) are reported in the top left-hand corner of respective concentration-response relationships, along with the lethal concentration where 50 percent (LC50) mortality is observed.

As illustrated within Figure B5-2, white sturgeon at 16 dph have a lethal copper concentration where 50 percent mortality is observed (LC50) of 13.2 µg Cu/L; while at 45 dph the LC50 is 20.4 µg Cu/L. As a result, it would appear that white sturgeon at 16 dph

are more sensitive to dissolved copper than at 45 dph. Similar concentration-response relationships for rainbow trout at 17 dph and 48 dph were also generated, see Figure B5-3.

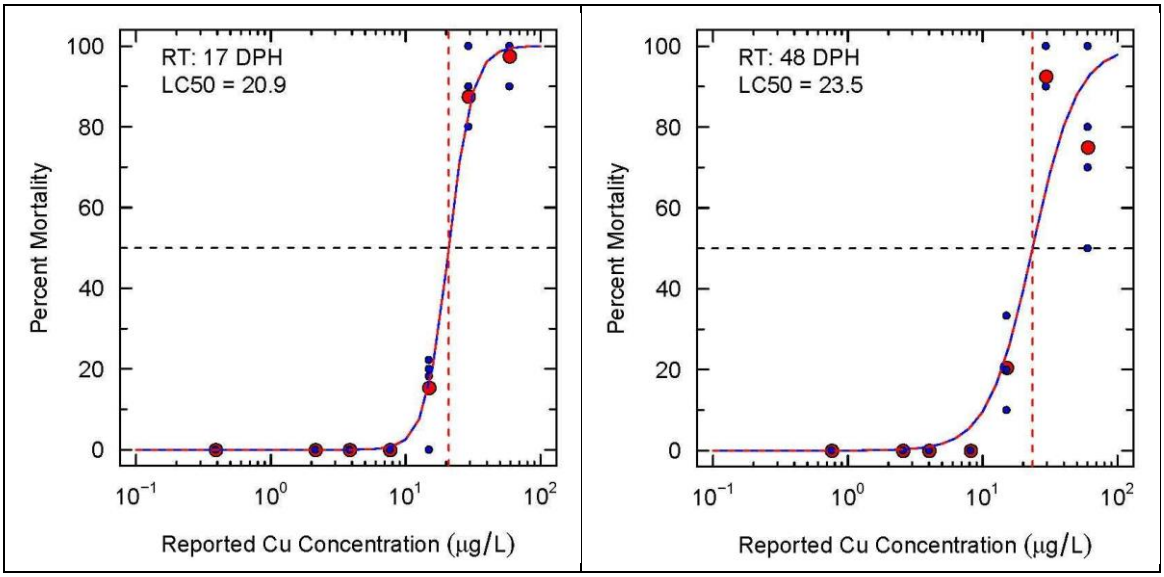

Figure B5-3. Plot of dissolved copper concentrations tested during acute toxicity tests with early life stages of rainbow trout

Note: Average copper concentrations within respective treatments are depicted with a large diameter red dot; with replicate concentrations depicted using small diameter blue dots. Test age of rainbow trout (RT) as determined days post hatch (DPH) are reported in the top left-hand corner of respective concentration-response relationships, along with the lethal concentration where 50 percent (LC50) mortality is observed.

As illustrated within Figure B5-3, rainbow trout at 17 dph were observed to have a LC50 of 20.9 µg Cu/L; while at 48 dph the LC50 was 23.5 µg Cu/L. As with white sturgeon; increased relative sensitivity to copper was observed at the earlier life-stage tested for rainbow trout (i.e., 17 dph).

In comparing the two species, it would appear that both are sensitive to dissolved copper concentrations, with white sturgeon being more slightly more sensitive under these test conditions. To better understand these relationships, data was normalized for bioavailability by considering accumulation on the biotic ligand. From the concentration-response on the biotic ligand, the critical accumulation associated with 50 percent mortality (LA50) can be estimated. Concentration-response relationships at the biotic ligand for both test species (white sturgeon and rainbow trout) at each life-stage are illustrated within Figure B5-4.

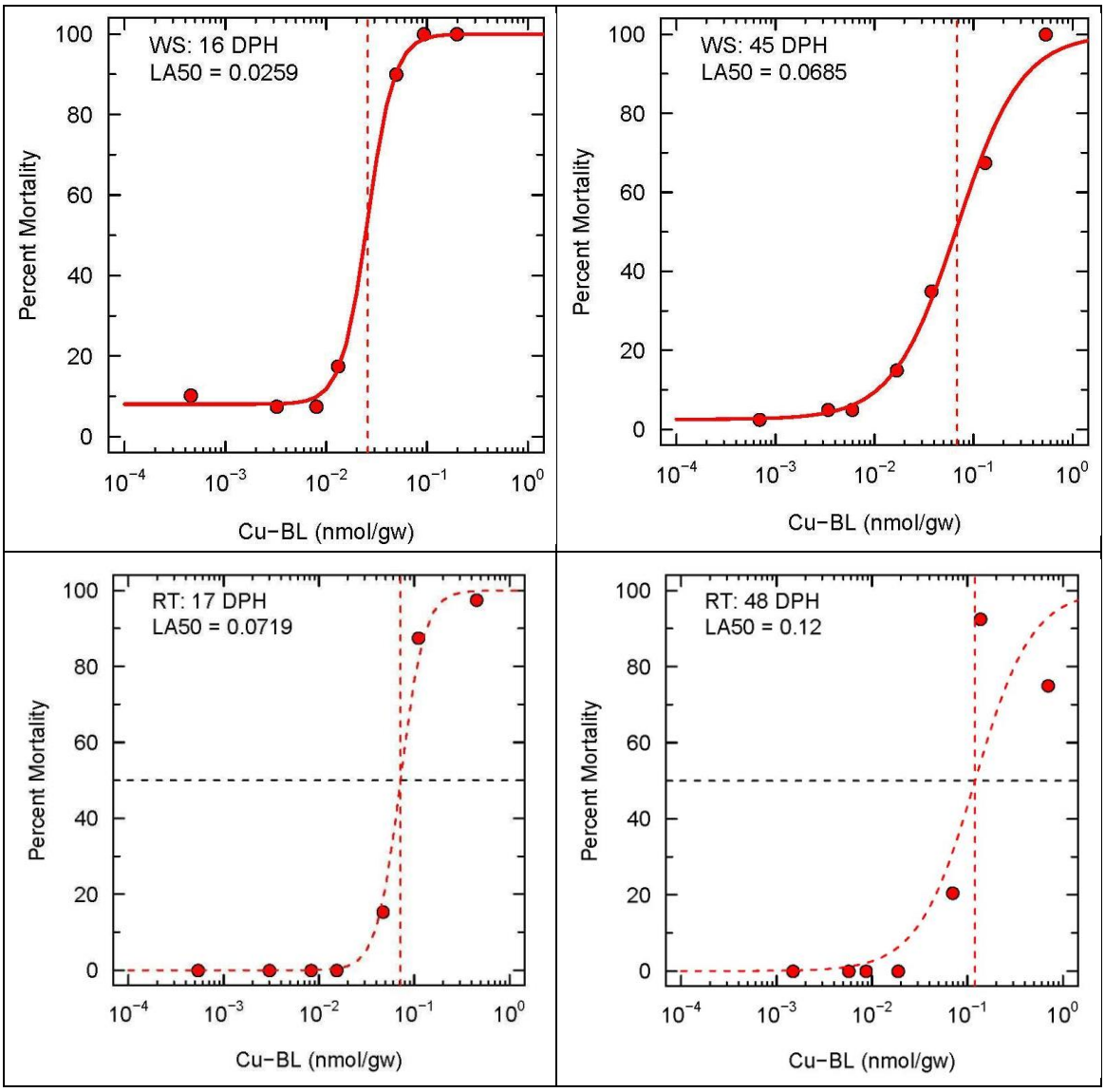

Figure B5-4. Plot of dissolved copper concentrations tested during acute toxicity tests with early life stages of white sturgeon and rainbow trout as evaluated at the biotic ligand

Note: Test age of white sturgeon (WS) and rainbow trout (RT) are determined from days post hatch (DPH) and are reported in the top left-hand corner of respective concentration-response relationships. In addition, the critical accumulation at the biotic ligand associated with 50 percent mortality (LA50) is also reported in the top left-hand corner of respective plots.

As illustrated within Figures B5-2 through B5-4, for the ELS evaluated and laboratory conditions tested herein, it appears that white sturgeon may be more sensitive to dissolved copper concentrations than rainbow trout. To place this into context for the purposes of an environmental risk assessment, values for acute water quality criteria as established within the State of Washington and the EPA National Ambient Water Quality Criterion (NAWQC) were calculated and compared to the normalized LC50s for white sturgeon and rainbow trout (Table B5-6).

Table B5-6. Acute Water Quality Criteria for Dissolved Copper in the State of Washington (WAC 173-201A-240) and the Contaminant Maximum Concentration; EPA NAWQC Relative to LC50s for Early Life-Stages of White Sturgeon and Rainbow Trout

Description	White Sturgeon		Rainbow Trout	
	16 dph	45 dph	17 dph	48 dph
Normalized LC50 (µg/L)	15.8	29.5	30.3	39.7
WA Acute Criterion (µg/L)	11.3	11.3	11.3	11.3
EPA NAWQC; CMC (µg/L)	9.6	9.6	9.6	9.6

Notes:

1. Acute criteria for the State of Washington (WA) were calculated based on an average water hardness of 64.5 mg/L as $CaCO_3$ as follows: WA Acute Criterion (µg/L) = 0.960 ($e^{(0.9422\ [\ln(\text{hardness})] - 1.464)}$).
2. EPA NAWQC; CMC were calculated using the BLM for Cu (USEPA 2007) based on the following average water quality inputs: pH = 7.94 s.u.; DOC = 1.59 mg/L and water hardness = 64.5 mg/L as $CaCO_3$.
3. NAWQC; CMC = National Ambient Water Quality Criterion; Contaminant Maximum Concentration (acute criterion).

As indicated within Table B5-6, normalized LC50s for both white sturgeon and rainbow trout at each life-stage tested are greater than state and national acute water quality criteria.

6 DISCUSSION AND RECOMMENDATIONS

The purpose of this Study was (under laboratory controlled conditions) to assess acute toxicity of white sturgeon (*A. transmontanus*) and rainbow trout (*O. mykiss*) at comparable early life-stages to water-borne copper. Specifically, this Study was intended to address the following:

1. What concentrations of copper are acutely toxic to ELS of white sturgeon and rainbow trout as determined using standard 96-hour toxicity tests?

2. What is the relative sensitivity of white sturgeon and rainbow trout to copper at the tested life stages?

Based on the work completed, BLM-normalized acute toxicities (i.e., LC50s) were determined for both species. Specifically, acute copper toxicities (LC50s) for white sturgeon were determined at 16 and 45 dph to be 15.8 μg Cu/L and 29.5 μg Cu/L, respectively. Similarly, rainbow trout LC50s at 17 and 48 dph were determined to be 30.3 μg Cu/L and 39.7 μg Cu/L, respectively. As indicated by the aforementioned LC50s and for the life-stages evaluated in this Study, it appears that white sturgeon may be more sensitive to dissolved copper than rainbow trout.

In consideration of the findings above and primary Study questions, no significant data gaps were identified that would require additional data collection at this time. It is also important to remember that additional life-stages for both species (white sturgeon and rainbow trout) were tested for water-borne copper toxicity at the USGS, CERC on behalf of the EPA (USGS 2010). As a result, the BLM calibrations performed to derive LA50s; will allow for a direct comparison of results between laboratories. Therefore, at this time no significant data gaps were identified that would require additional white sturgeon toxicity testing prior to conducting baseline ecological risk assessments. During that time and consistent with Guidance (USEPA 1997), should EPA determine that there is insufficient information to support informed risk-based management decisions, additional data may be needed.

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ATTACHMENT B1

CHANGE ORDER AND
DEVIATION/CORRECTIVE ACTION REPORTS

ATTACHMENT B1-1

CHANGE ORDER REQUEST FORMS
SIGNED

Change Request Form
Upper Columbia River (UCR) Sediment Study

Page 1 of 2

Change No. : 2 #1 MEA 07/06/10

CHANGE REQUEST: Acute water-only exposures to white sturgeon ELS using Kootenay Hatchery eggs

Applicable Reference: Quality Assurance Project Plan for the Assessment of Sediment Toxicity to White Sturgeon (*Acipenser transmontanus*)

Description of Change: Use of Kootenay Hatchery White Sturgeon for the Acute 96Hr LC50 Study (Appendix B)

Reason for Change: Due to unforeseen circumstances, white sturgeon eggs from the Washington State Hatchery (i.e., Sherman Creek) as obtained by the USGS-Columbia laboratory can not be shipped to the U of S laboratory as specified within Appendix B of the QAPP. As a result, white sturgeon eggs from the Kootenay Hatchery will be used in the acute 96 Hr. LC50 tests at the U of S.

Impact on Present and Completed Work: No impacts are anticipated, see attached.

Requested By: Markus Hecker (Scientist) Date: 6/29/2010

Acknowledged By: Jonathan Doering (Task Leader) Date: 6/29/2010

APPROVAL

Project Manager: Markus Hecker Date: 6/29/2010

Teck Project Manager: Date: 07/06/10

EPA Project Manager: Helen H. Bottcher Date: 7/10/2010

From:	Adzic Marko SPOK
To:	Anne Fairbrother
Subject:	FW: Recommendation to forgo further inter-laboratory sturgeon toxicity testing at USGS-Columbia and U of S
Date:	Monday, June 28, 2010 3:59:15 PM

From: Christopher G Ingersoll [mailto:cingersoll@usgs.gov]
Sent: Monday, June 28, 2010 10:04 AM
To: Bottcher.Helen@epamail.epa.gov
Cc: Duncan.Bruce@epamail.epa.gov; Greenberg.Marc@epamail.epa.gov; mesl@shaw.ca; Stephen E Cox; Adzic Marko SPOK; Paul Paquin; Robert Santore; MHecker@entrix.com; Edward E Little
Subject: Recommendation to forgo further inter-laboratory sturgeon toxicity testing at USGS-Columbia and U of S

Helen:

Ed Little and I participated on a call Friday afternoon with Marco Adzic, Ann Fairbrother, Markus Heck, Paul Paquin, and Bob Santore to discuss the utility of conducting additional inter-laboratory comparisons of sturgeon strain sensitivity between USGS-Columbia and U of S. The consensus on the call was that additional inter-laboratory comparisons of strain sensitivity are not a high priority.

This conclusion was based on the similar sensitivity of sturgeon in 96-h acute copper exposures conducted at the USGS-Columbia and at the U of S in different waters, with normalization using BLM modeling. Moreover, there is likely some differences in strain sensitivity between years based exposures conducted by USGS-Columbia between 2007 and 2009 which encompass the range of acute copper sensitivity observed between the USGS-Columbia and the U of S based on BLM modeling. In addition, the response of the genetically distinct Kootenai River white sturgeon was similar to that of the Columbia River population. Hence, the individuals on the call Friday concluded that inter-laboratory comparisons of strain sensitivity are not a high priority.

We will drop the paragraph on inter-laboratory testing from our USGS-Columbia QAPP. Please let us know if you would like to discuss this topic further.

Sincerely,

Ed Little and Chris Ingersoll

Chris Ingersoll
Columbia Environmental Research Center, U.S. Geological Survey
4200 New Haven Rd, Columbia, MO 65201
573/876-1819 (work), -1896 (fax)
cingersoll@usgs.gov, http://www.cerc.usgs.gov/

ATTACHMENT B1-2

DEVIATION/CORRECTIVE ACTION REPORT FORMS SIGNED

Deviation / Corrective Action Report Form
Sturgeon Early Life Stage Sediment Toxicity Test

Date: September 10, 2010 Deviation Number: 09

Applicable Reference: 2010 Quality Assurance Project Plan for the Assessment of Sediment Toxicity to White Sturgeon (*Acipenser transmontanus*)

Description of Change (what happened, when and why -- could include inadvertent deviation from QAPP, contradictory language in QAPP, unanticipated problems, schedule / time constraints):

Parallel acute toxicity tests (Appendix B of the QAPP) are being performed at the University of Saskatchewan's (U of S) Aquatic Toxicology Centre, and at the U.S. Geological Survey (USGS) Columbia Environmental Research Center (CERC). To ensure that these two studies are harmonized to the maximum extent possible, acute 96 hour (hr) toxicity tests (water-only exposures) were initiated on day 16 post hatch (16 dph); as opposed to 15 dph outlined within Appendix B of the QAPP. Similarly, additional acute 96 hr toxicity tests were performed on 45 dph due to logistical laboratory constraints.

Corrective Action (how the issue was addressed, any steps taken to ensure similar problems do not re-occur)

Regular communications (e.g., at a minimum bi-monthly) identified that acute 96 hr tests at the USGS CERC laboratory were initiated on 16 dph. As a result, to ensure harmonization between tests and laboratories, the U of S adjusted the initiation of their parallel acute water-only exposure toxicity tests. The two biological laboratories continue to maintain regular communications to ensure that any ongoing parallel tests continue to be harmonized to the maximum extent possible and practical.

Impact on Present and Completed Work (discuss magnitude of impact and bias of change if this can be anticipated)

No impact on the present or completed work is anticipated.

Recorded by: David Vardy Date: 09/10/2010

ACKNOWLEDGED BY

Task Manager: Dr. Markus Hecker Date: 09/10/2010

TAI Project Coordinator: Date: 09/15/10

EPA Project Coordinator: Helen H. Bottcher Date: 10/1/10

ATTACHMENT B2

SUMMARY PLOTS OF WATER QUALITY MEASUREMENTS RECORDED DURING ACUTE EXPOSURES TO EARLY LIFE STAGES OF WHITE STURGEON AND RAINBOW TROUT

ATTACHMENT B2-1

PLOTS OF ROUTINE WATER QUALITY MEASUREMENTS FOR ACUTE TOXICITY TESTS

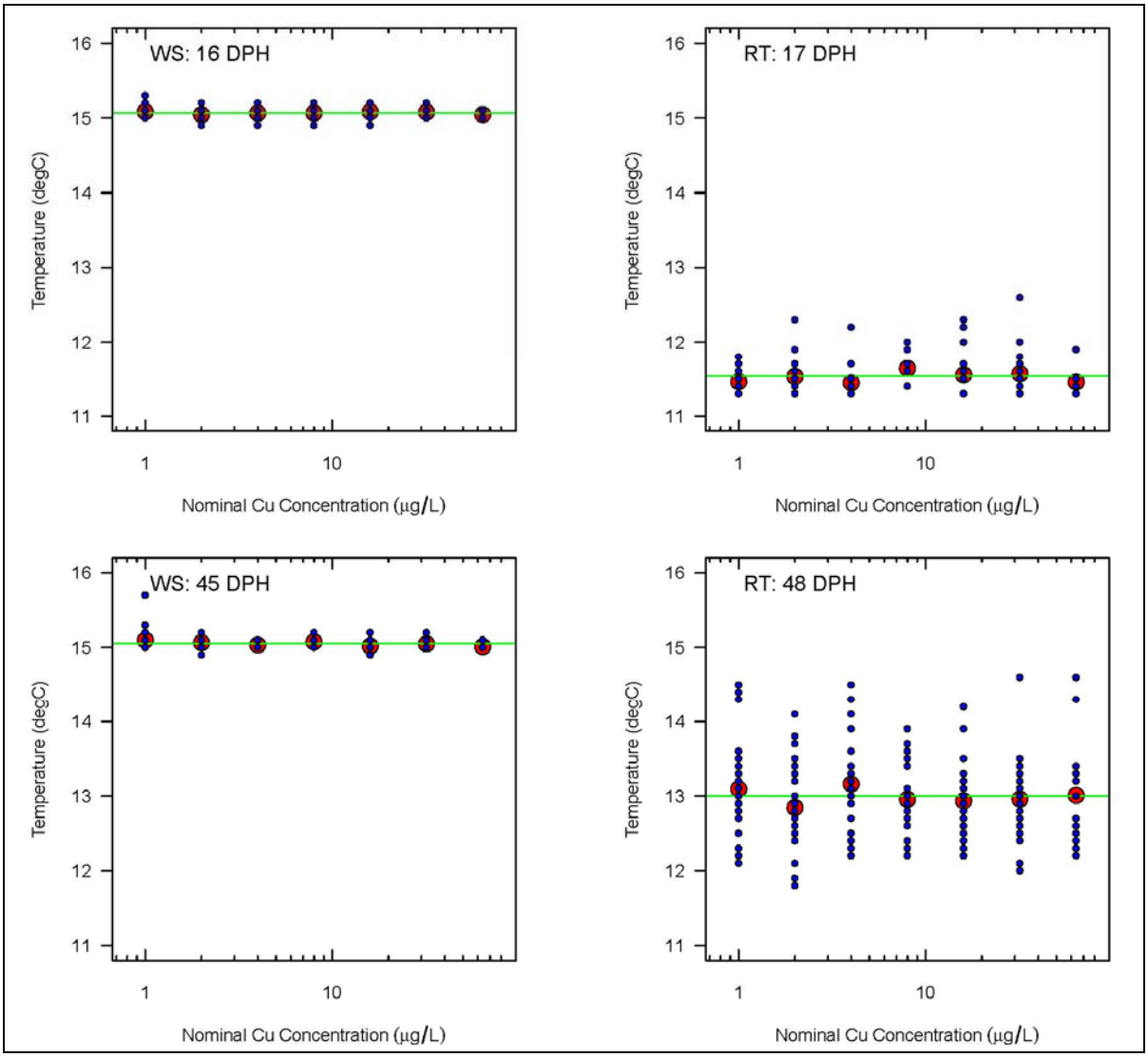

Figure B2-1a. Plot of water temperatures recorded during routine water quality measurements for white sturgeon (WS) and rainbow trout (RT) acute toxicity exposures at two different life stages as measured from days post hatch (DPH). The solid green line represents the average as calculated for respective test species and early life stage.

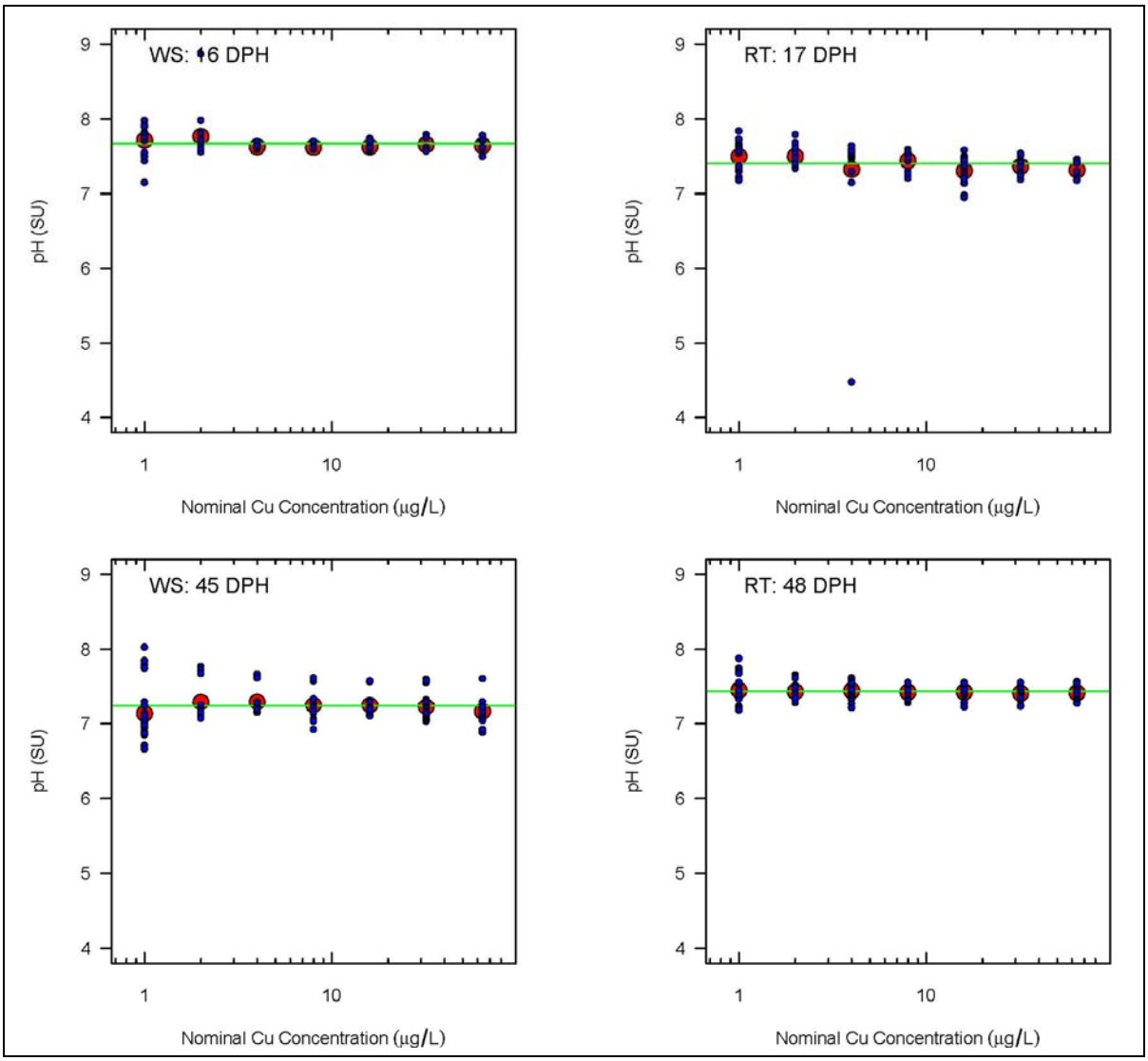

Figure B2-1b. Plot of water hydrogen ion activity (pH) recorded during routine water quality measurements for white sturgeon (WS) and rainbow trout (RT) acute toxicity exposures at two different life stages as measured from days post hatch (DPH). The solid green line represents the average as calculated for respective test species and early life stage.

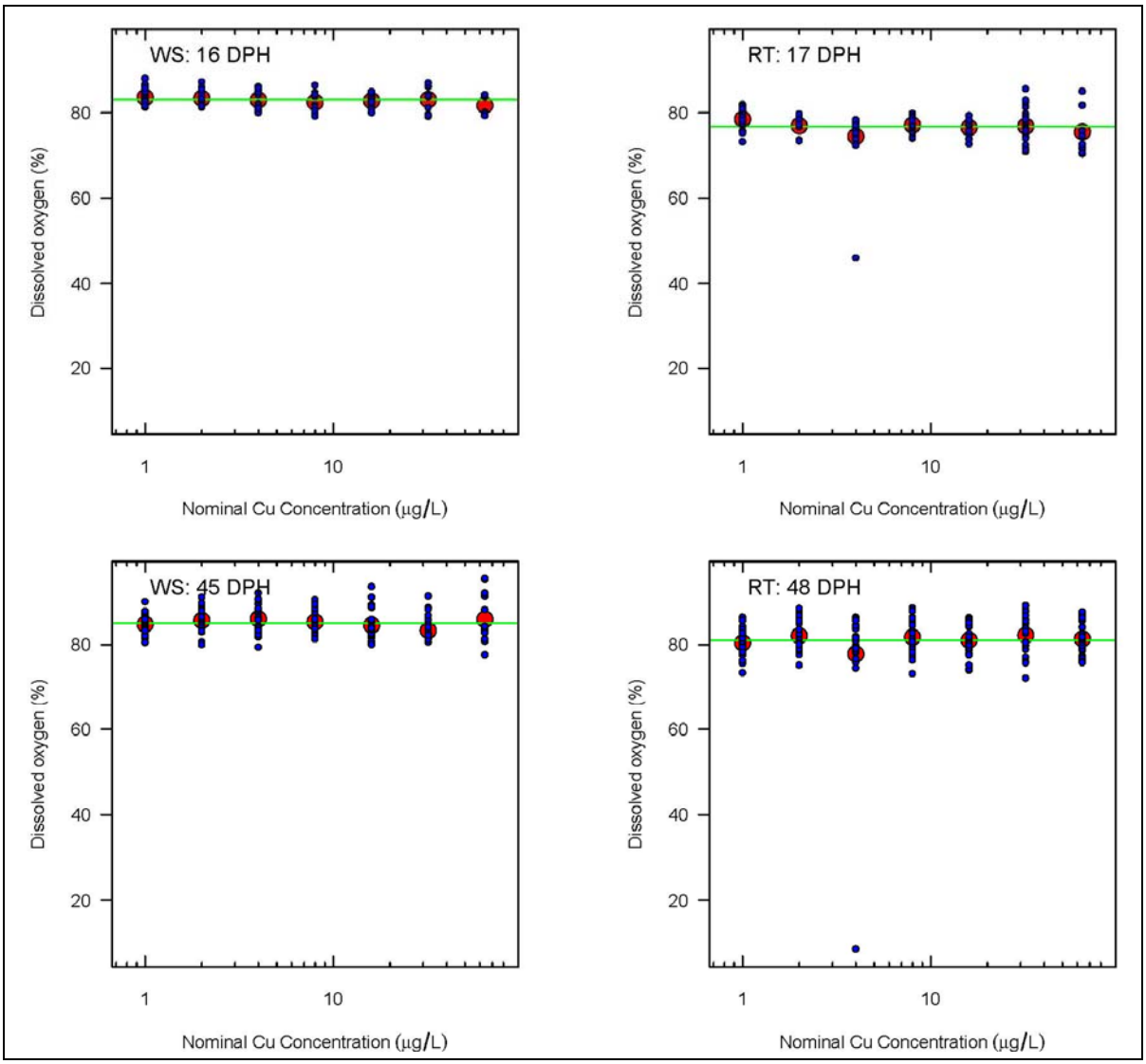

Figure B2-1c. Plot of dissolved oxygen recorded during routine water quality measurements for white sturgeon (WS) and rainbow trout (RT) acute toxicity exposures at two different life stages as measured from days post hatch (DPH). The solid green line represents the average as calculated for respective test species and early life stage.

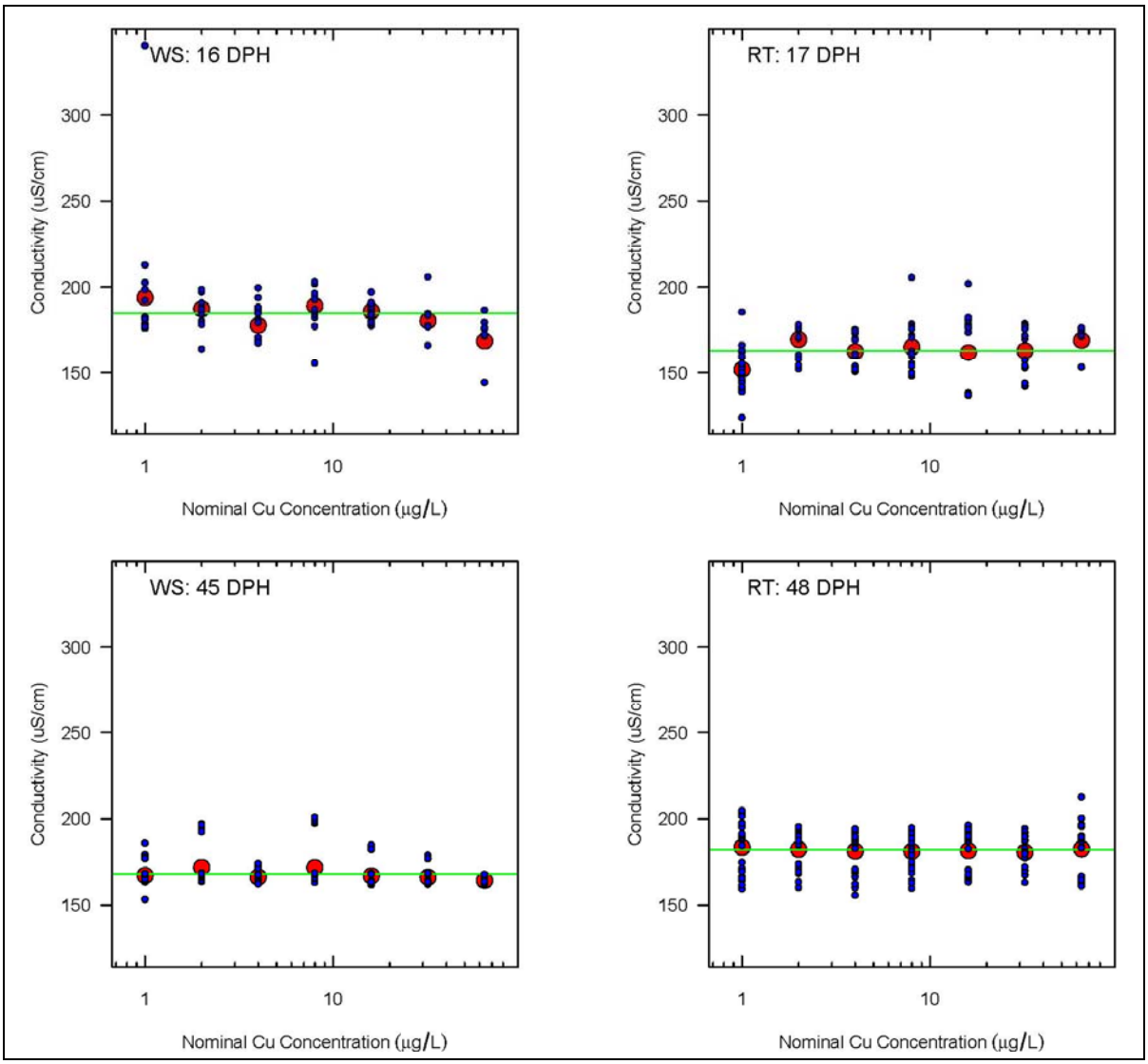

Figure B2-1d. Plot of conductivity recorded during routine water quality measurements for white sturgeon (WS) and rainbow trout (RT) acute toxicity exposures at two different life stages as measured from days post hatch (DPH). The solid green line represents the average as calculated for respective test species and early life stage.

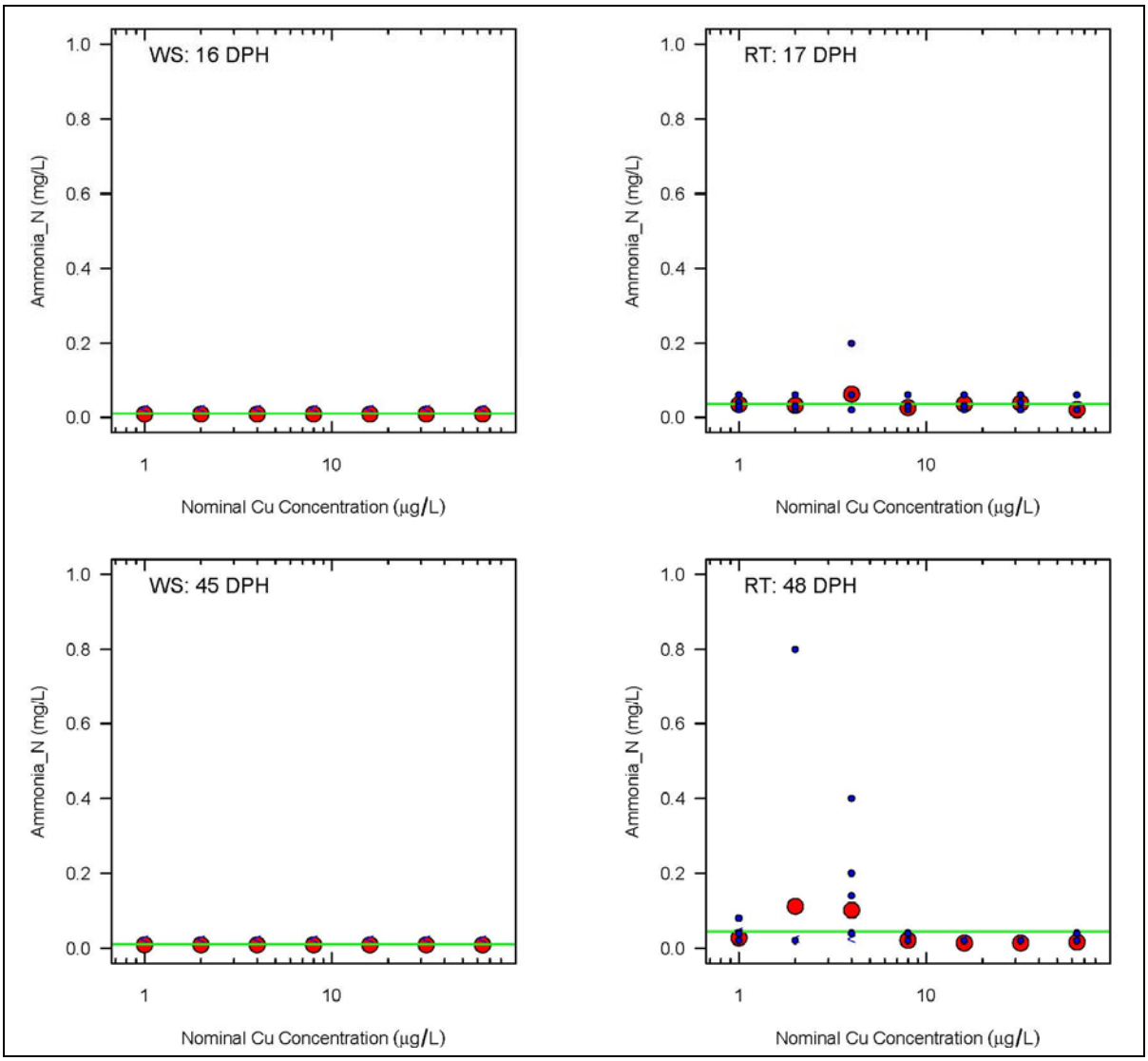

Figure B2-1e. Plot of ammonia recorded during routine water quality measurements for white sturgeon (WS) and rainbow trout (RT) acute toxicity exposures at two different life stages as measured from days post hatch (DPH). The solid green line represents the average as calculated for respective test species and early life stage. Non-detect concentrations are symbolized using "<".

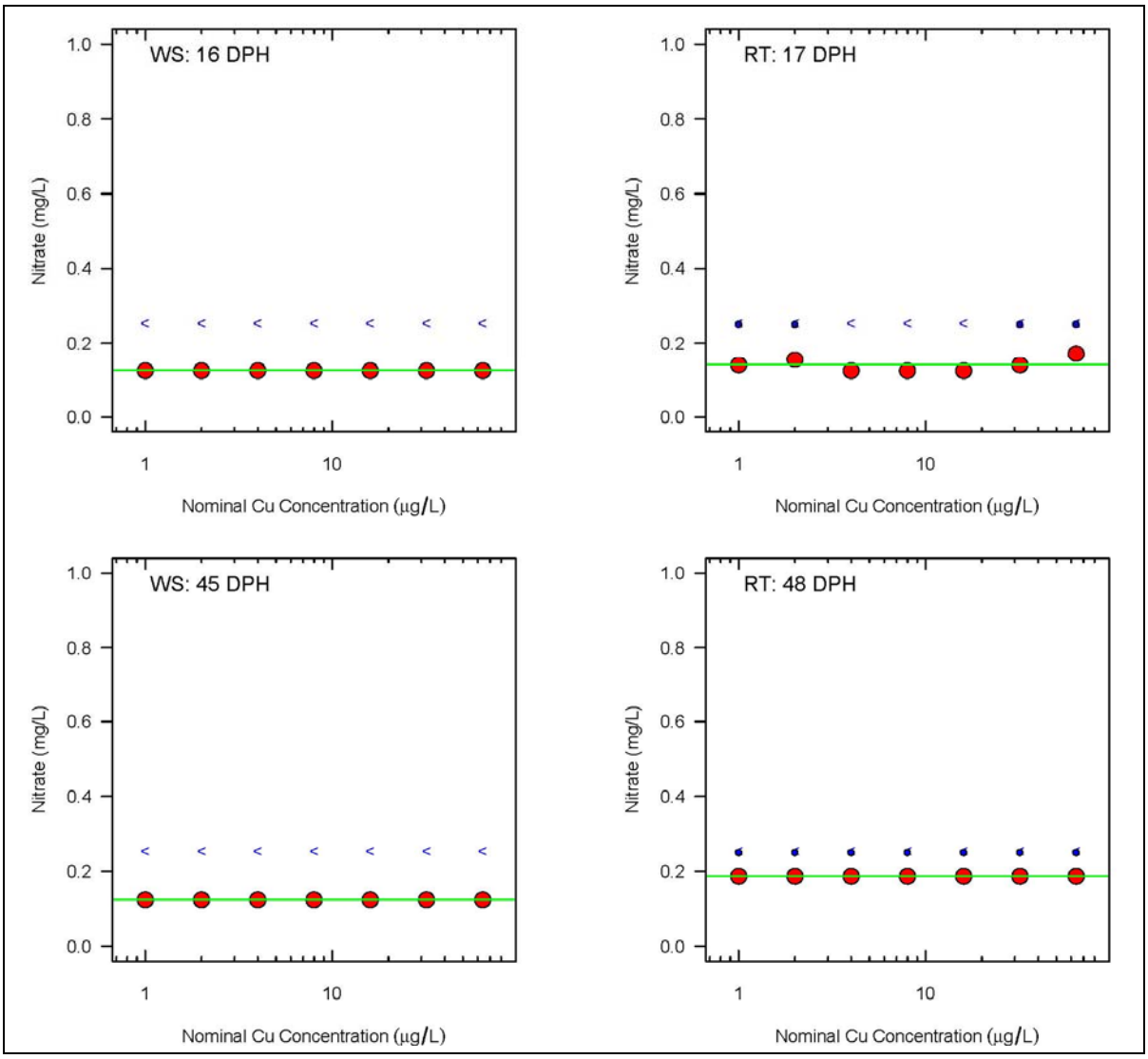

Figure B2-1f. Plot of nitrate recorded during routine water quality measurements for white sturgeon (WS) and rainbow trout (RT) acute toxicity exposures at two different life stages as measured from days post hatch (DPH). The solid green line represents the average as calculated for respective test species and early life stage. Non-detect concentrations are symbolized using "<".

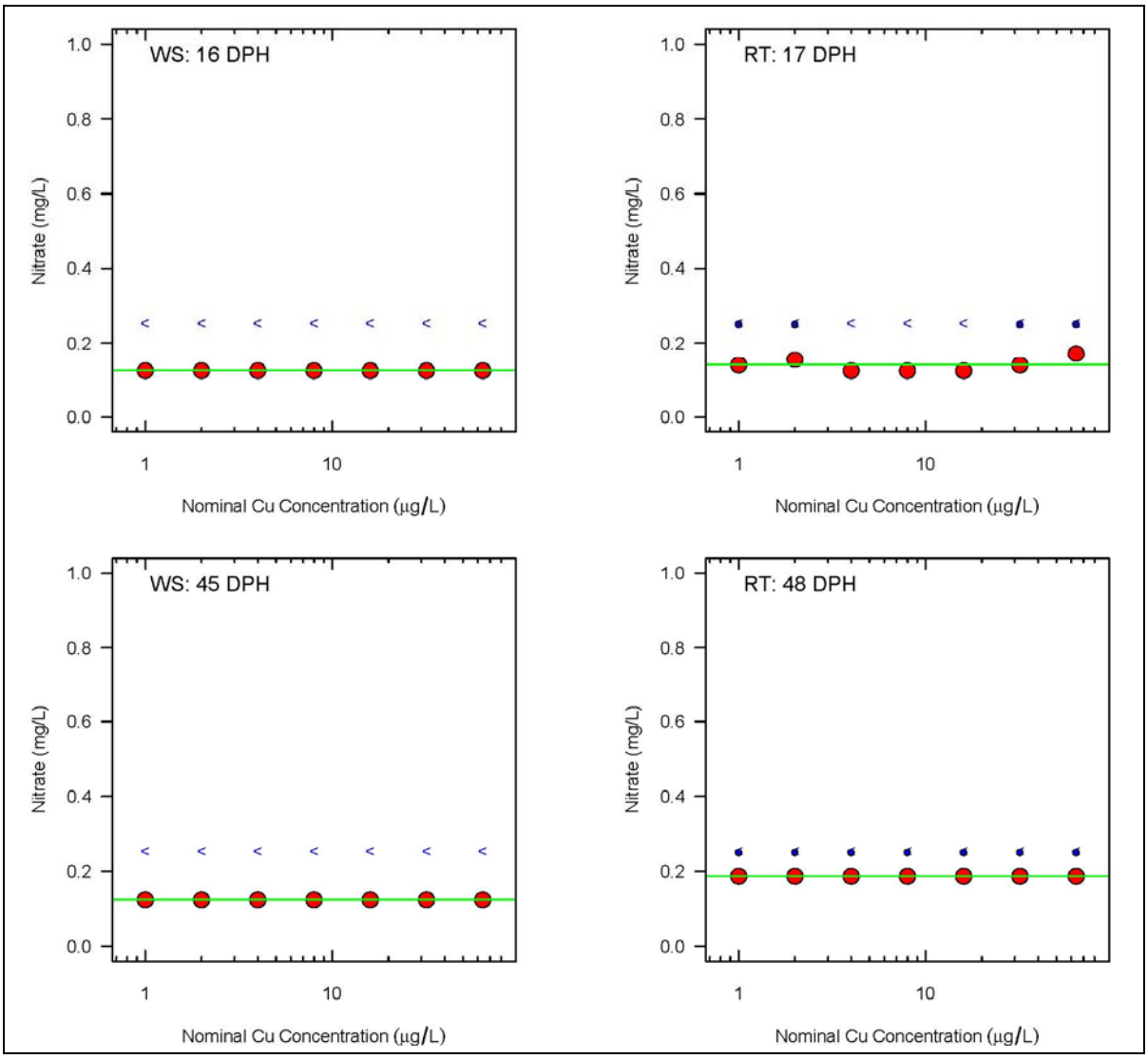

Figure B2-1g. Plot of nitrite recorded during routine water quality measurements for white sturgeon (WS) and rainbow trout (RT) acute toxicity exposures at two different life stages as measured from days post hatch (DPH). The solid green line represents the average as calculated for respective test species and early life stage.

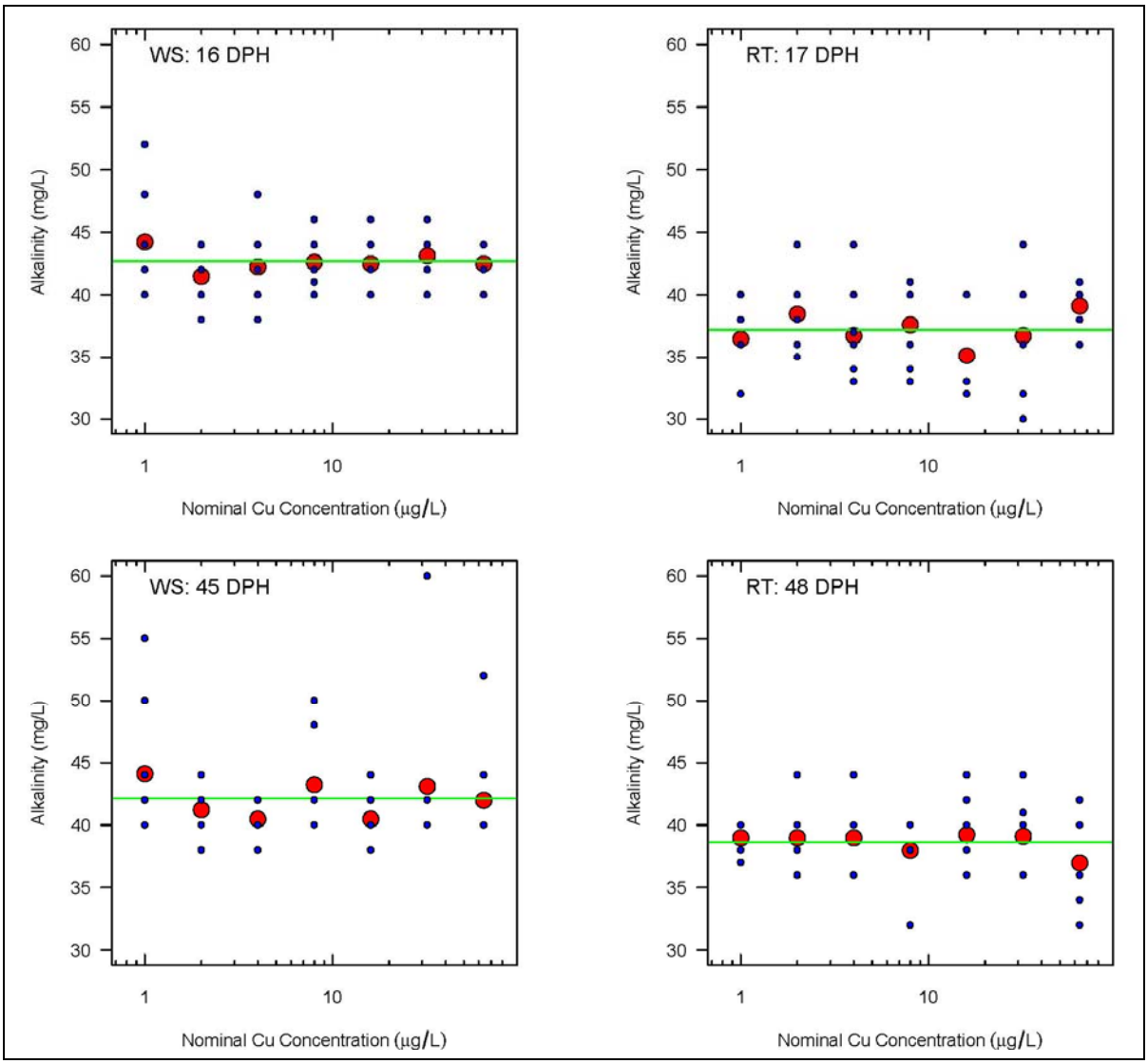

Figure B2-1h. Plot of alkalinity recorded during routine water quality measurements for white sturgeon (WS) and rainbow trout (RT) acute toxicity exposures at two different life stages as measured from days post hatch (DPH). The solid green line represents the average as calculated for respective test species and early life stage.

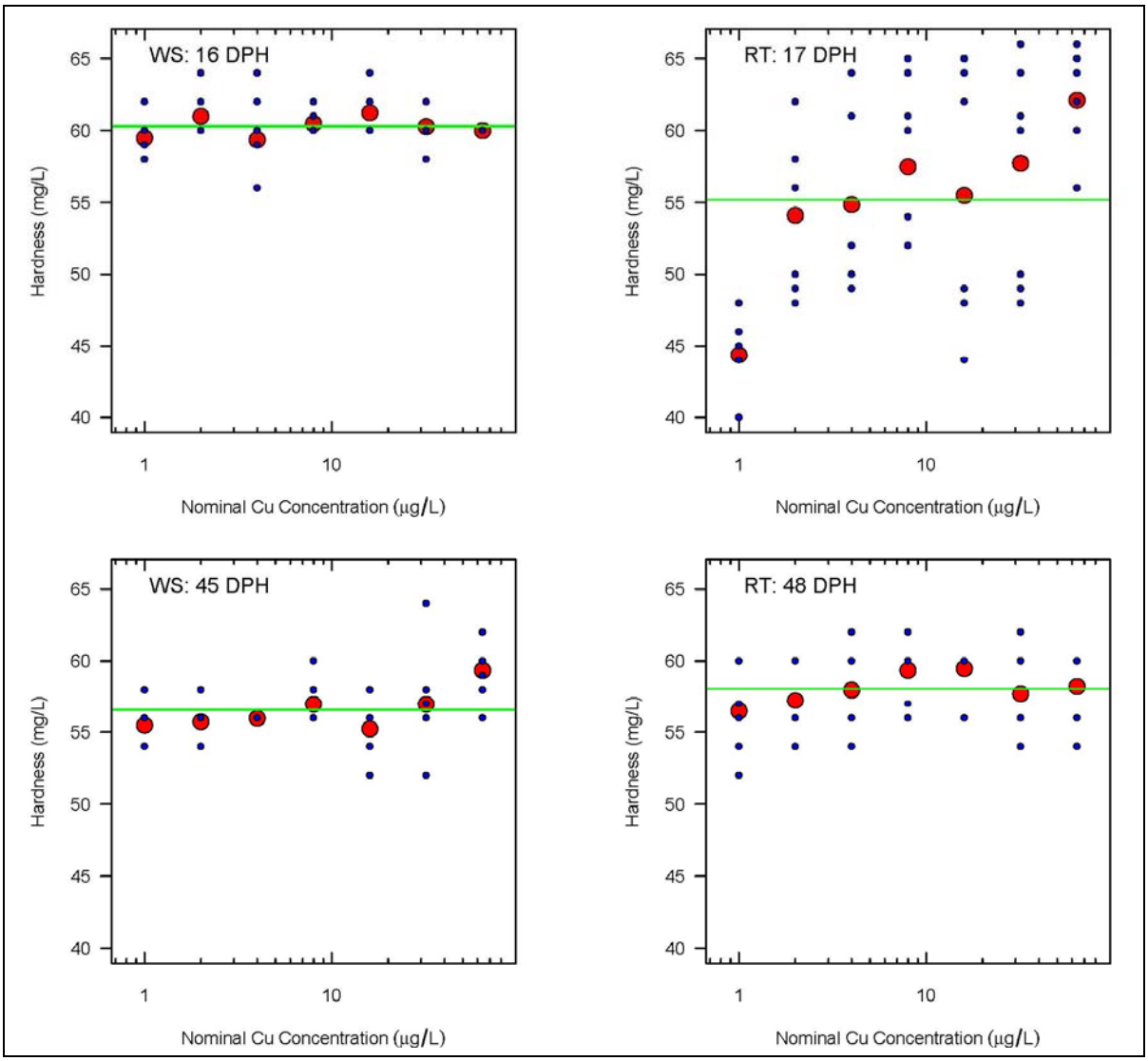

Figure B2-1i. Plot of hardness recorded during routine water quality measurements for white sturgeon (WS) and rainbow trout (RT) acute toxicity exposures at two different life stages as measured from days post hatch (DPH). The solid green line represents the average as calculated for respective test species and early life stage.

ATTACHMENT B2-2

PLOTS OF COLUMBIA ANALYTICAL SERVICES MEASUREMENTS FOR ACUTE TOXICITY TESTS

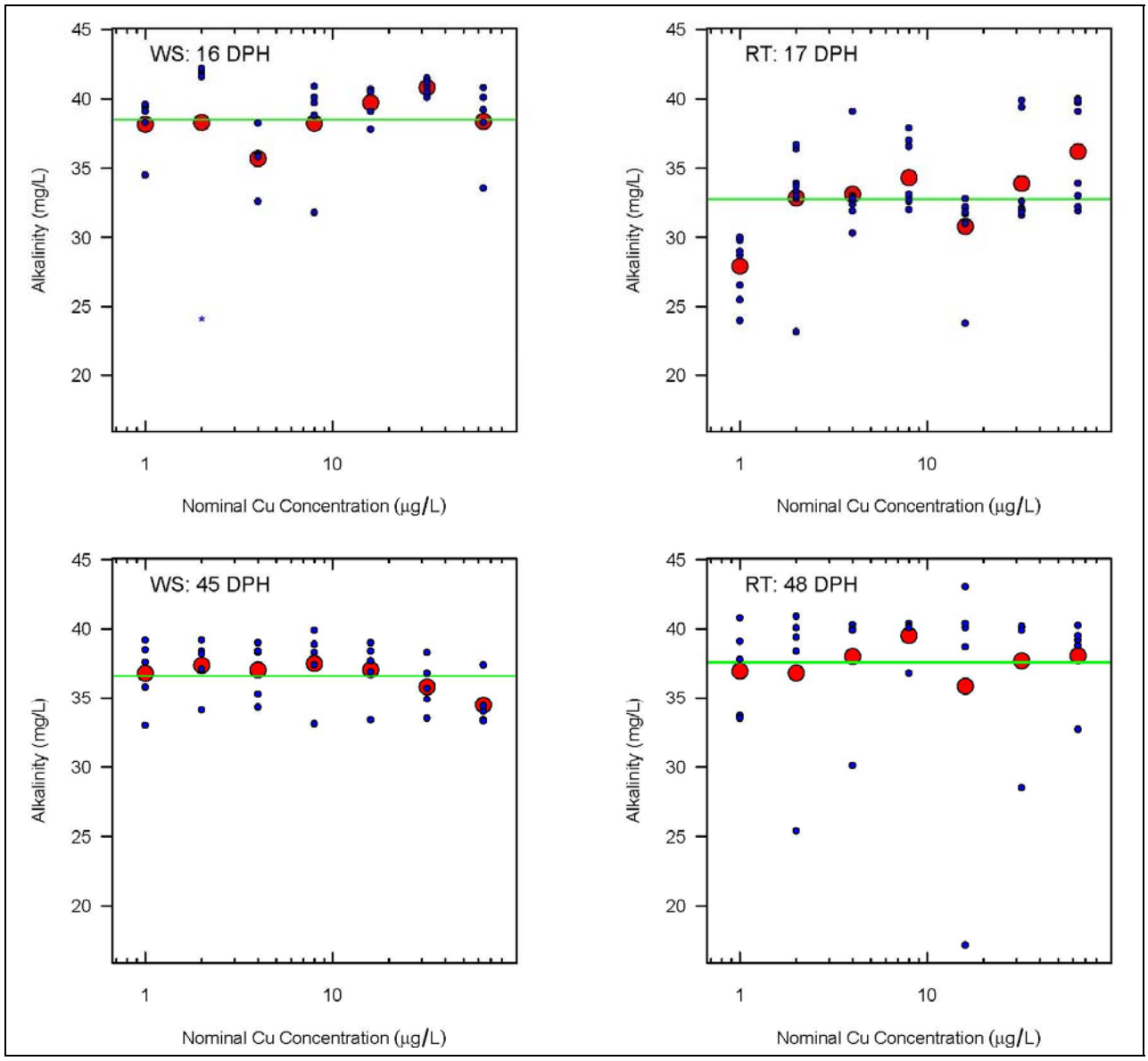

Figure B2-2a. Plot of alkalinity as determined by Columbia Analytical Services for white sturgeon (WS) and rainbow trout (RT) acute toxicity exposures at two different life stages as measured from days post hatch (DPH). The solid green line represents the average as calculated for respective test species and early life stage.

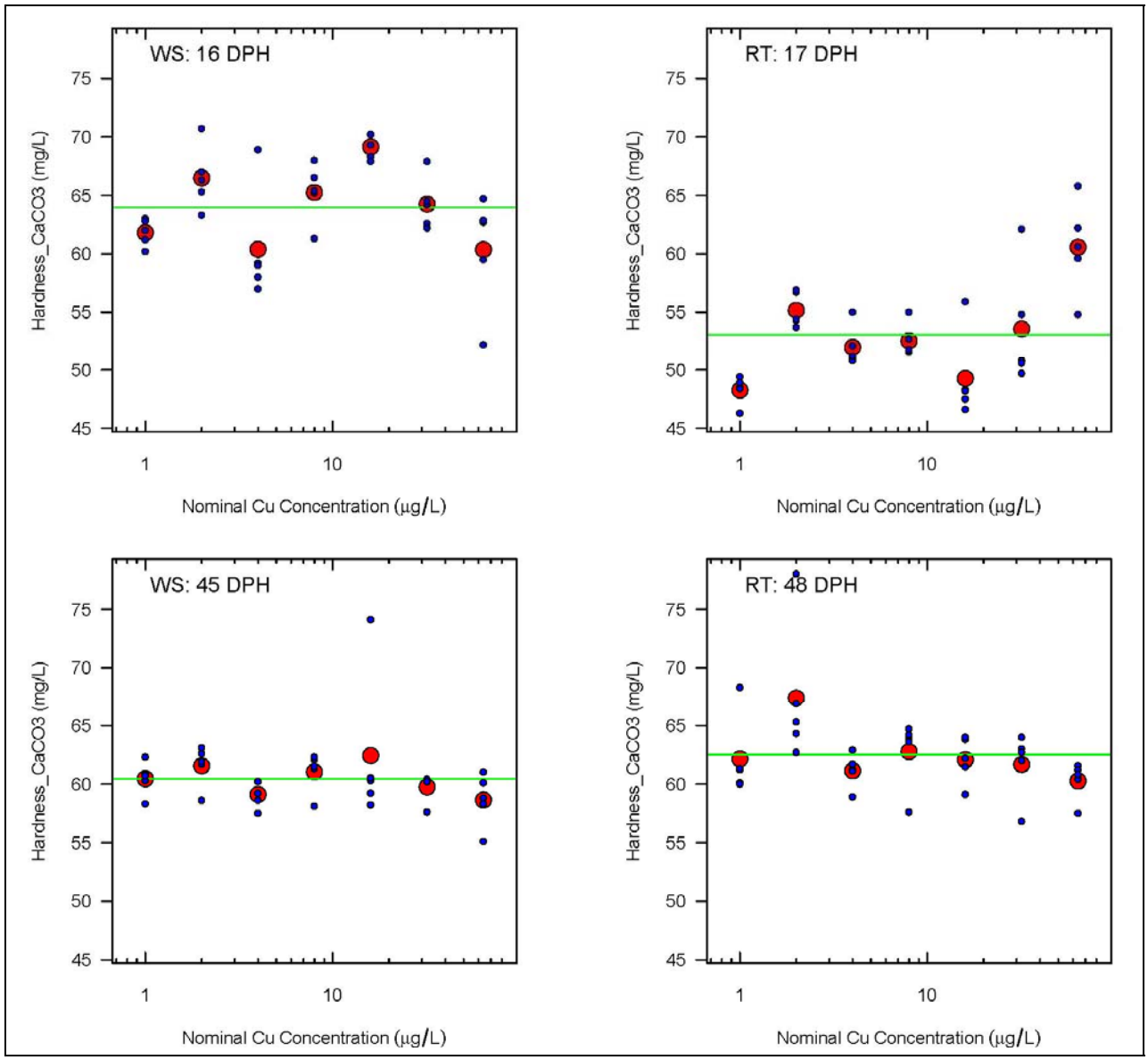

Figure B2-2b. Plot of hardness as determined by Columbia Analytical Services for white sturgeon (WS) and rainbow trout (RT) acute toxicity exposures at two different life stages as measured from days post hatch (DPH). The solid green line represents the average as calculated for respective test species and early life stage.

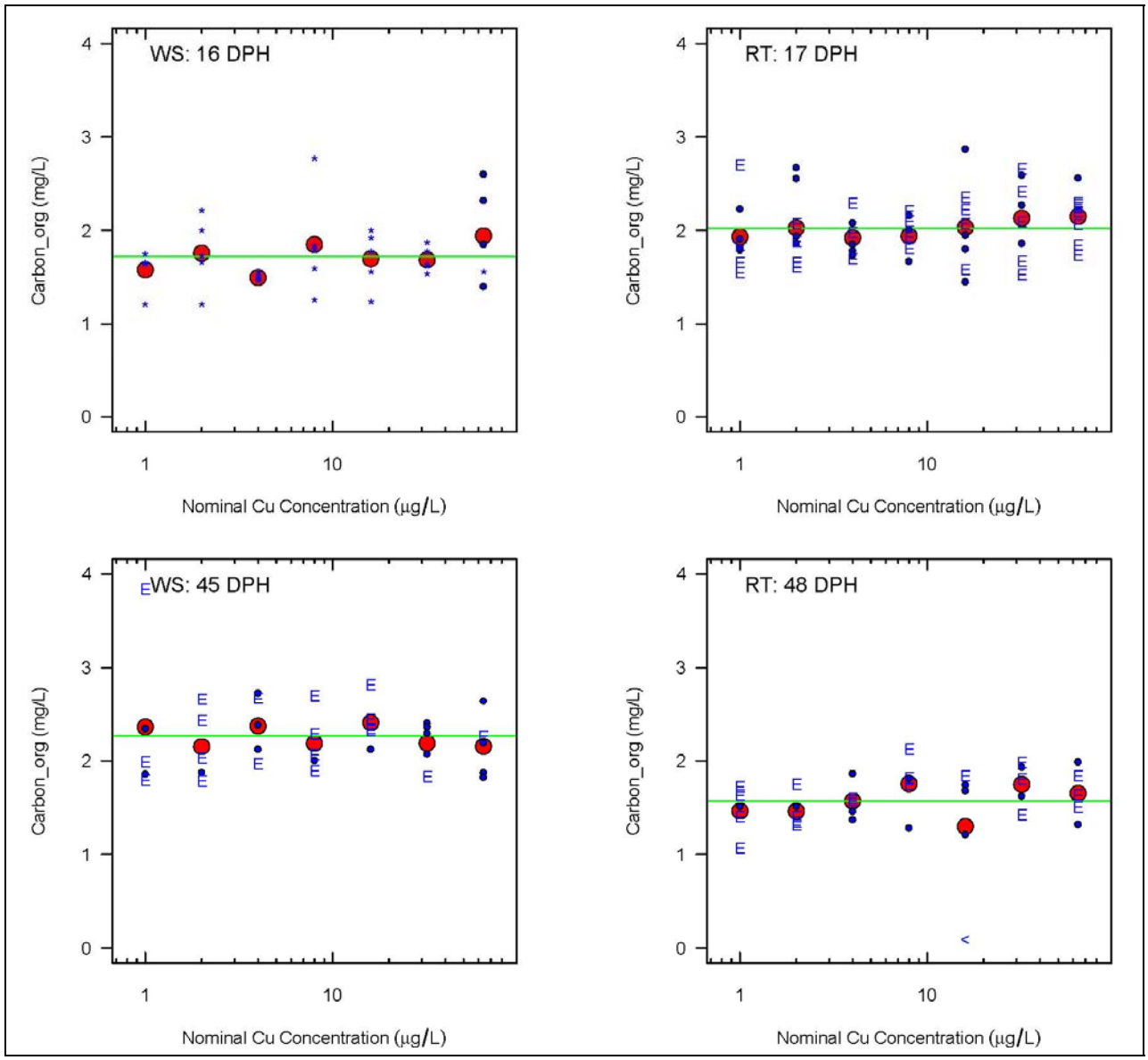

Figure B2-2c. Plot of dissolved organic carbon as determined by Columbia Analytical Services for white sturgeon (WS) and rainbow trout (RT) acute toxicity exposures at two different life stages as measured from days post hatch (DPH). The solid green line represents the average as calculated for respective test species and early life stage. Estimated and non-detect concentrations are symbolized using an "E" and "<", respectively.

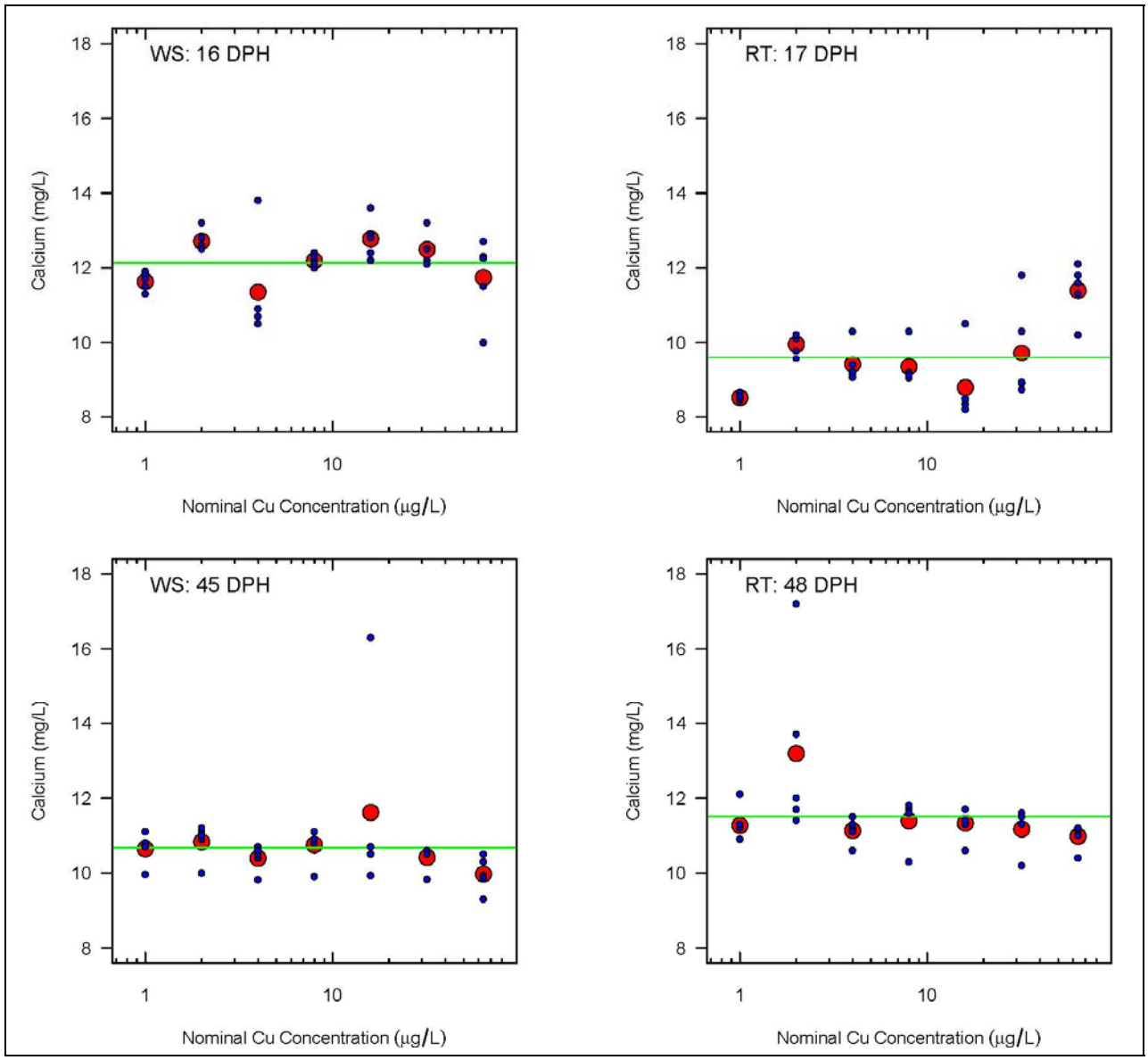

Figure B2-2d. Plot of calcium as determined by Columbia Analytical Services for white sturgeon (WS) and rainbow trout (RT) acute toxicity exposures at two different life stages as measured from days post hatch (DPH). The solid green line represents the average as calculated for respective test species and early life stage.

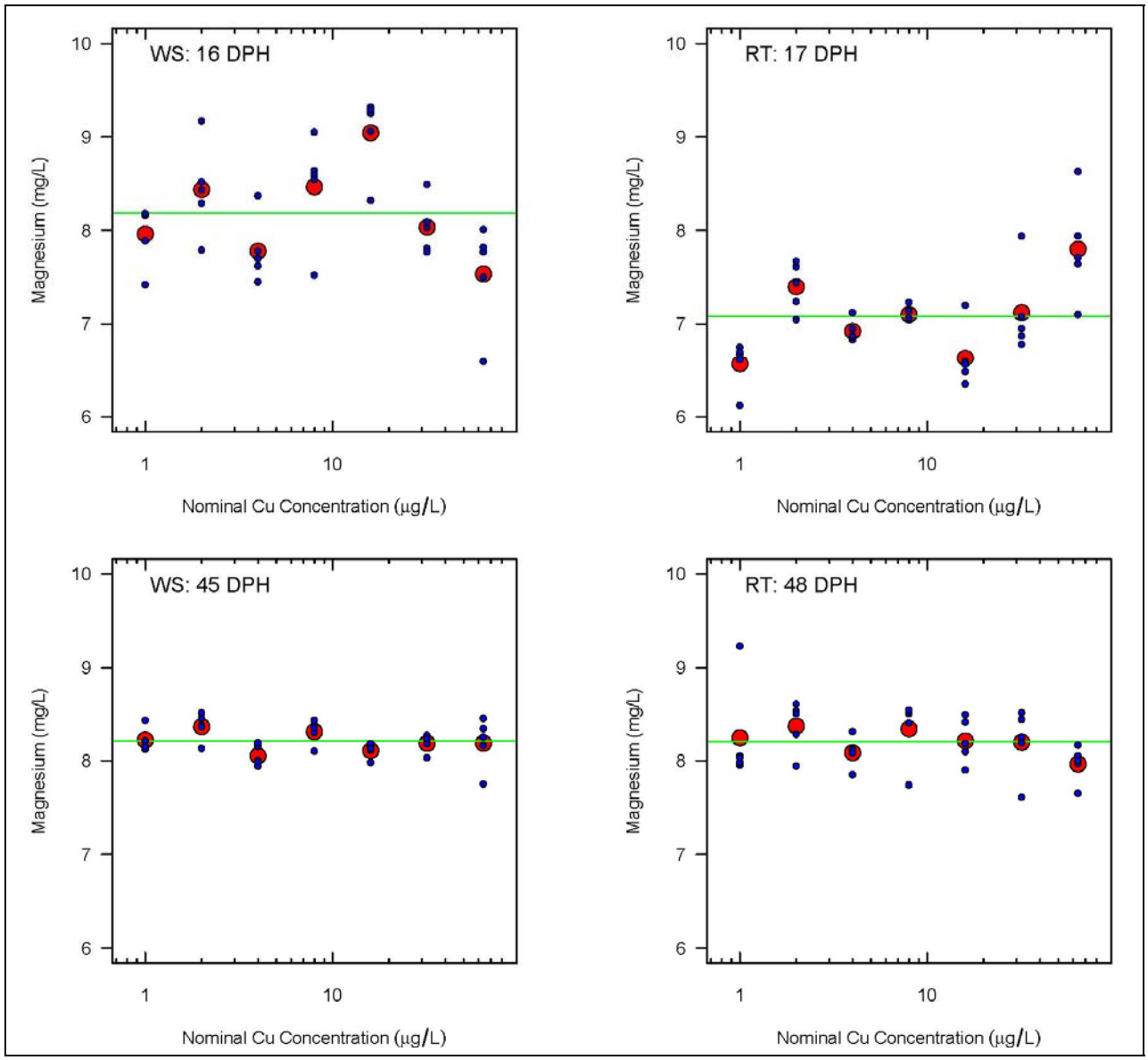

Figure B2-2e. Plot of magnesium as determined by Columbia Analytical Services for white sturgeon (WS) and rainbow trout (RT) acute toxicity exposures at two different life stages as measured from days post hatch (DPH). The solid green line represents the average as calculated for respective test species and early life stage.

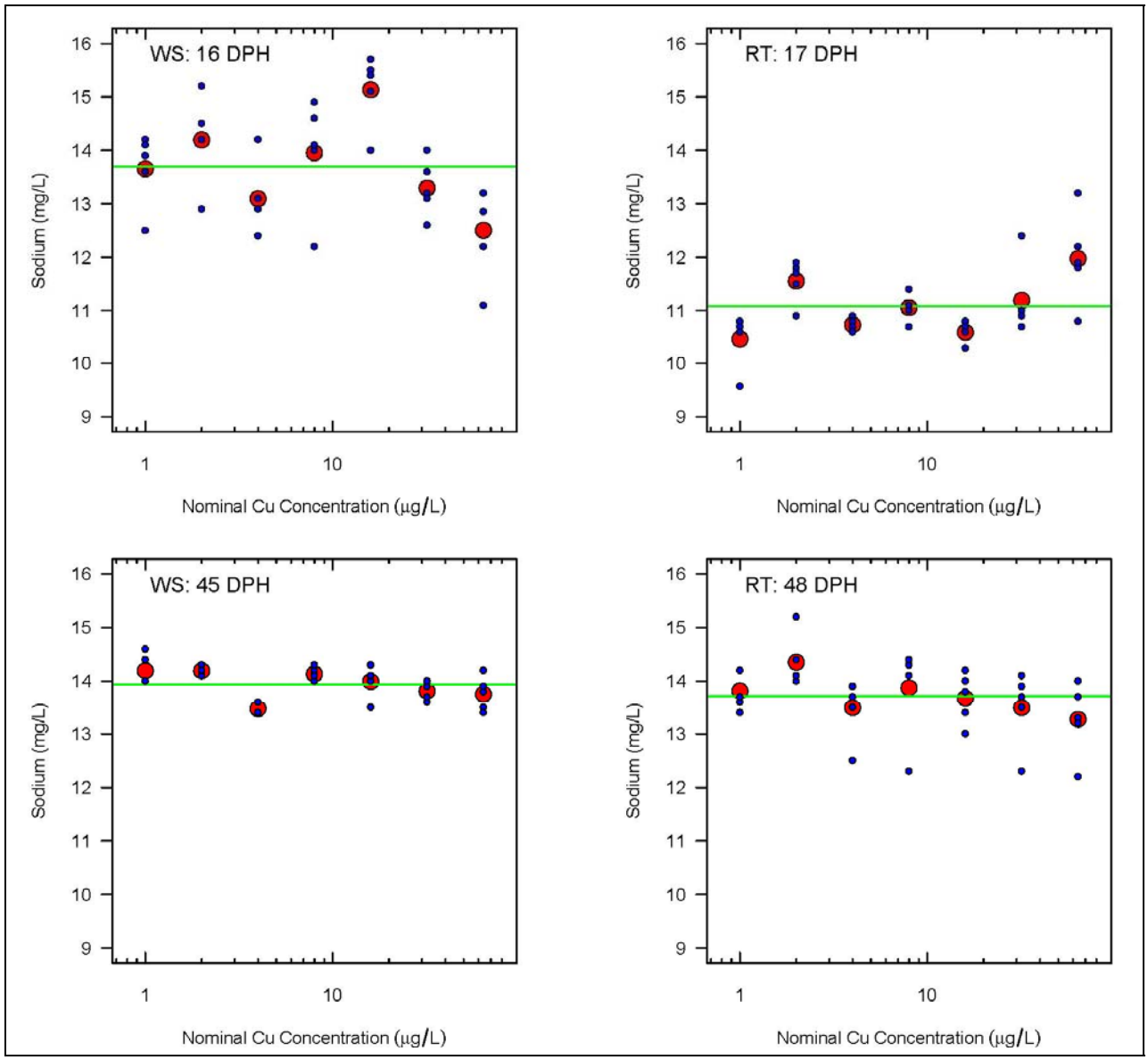

Figure B2-2f. Plot of sodium as determined by Columbia Analytical Services for white sturgeon (WS) and rainbow trout (RT) acute toxicity exposures at two different life stages as measured from days post hatch (DPH). The solid green line represents the average as calculated for respective test species and early life stage.

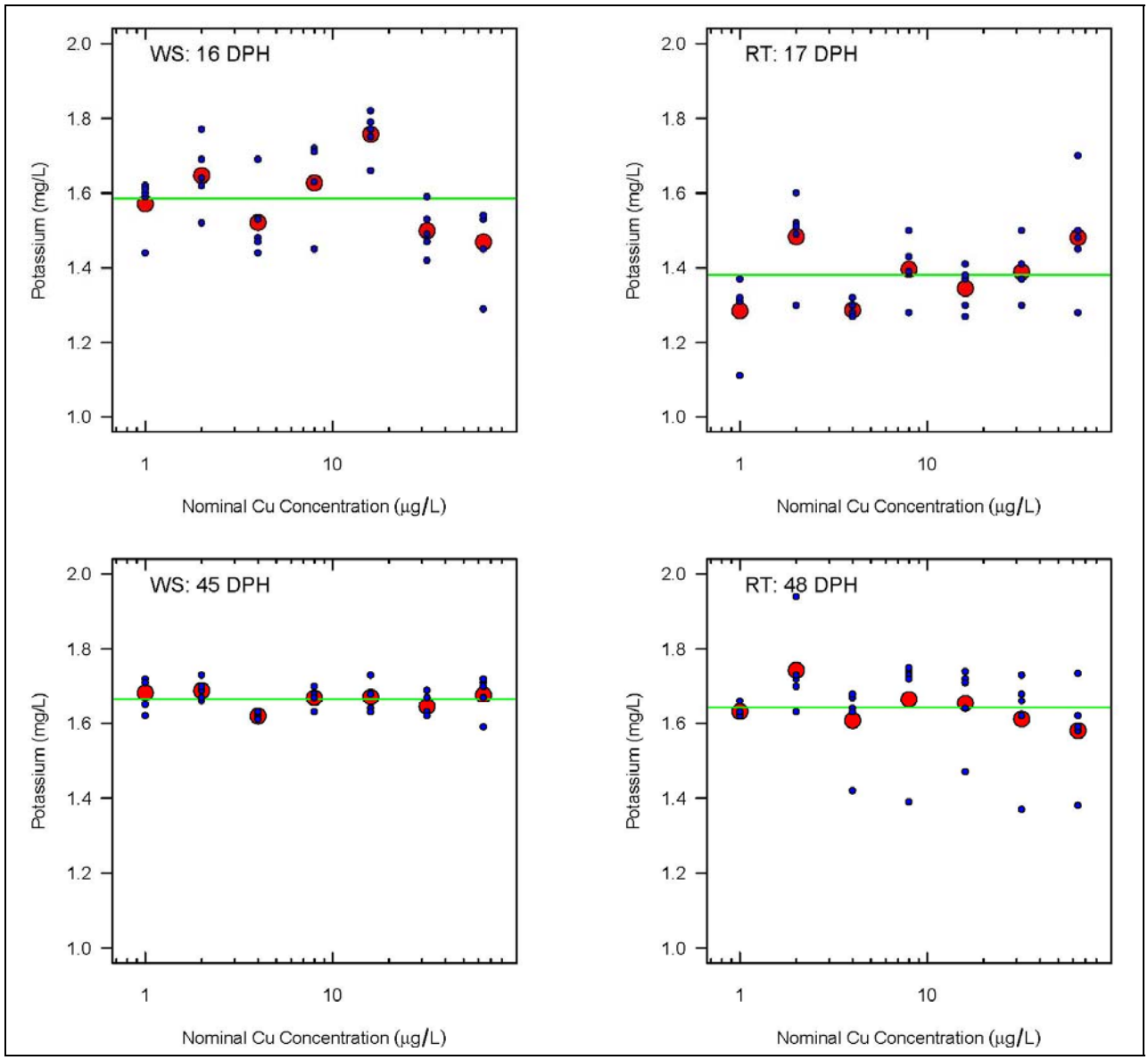

Figure B2-2g. Plot of potassium as determined by Columbia Analytical Services for white sturgeon (WS) and rainbow trout (RT) acute toxicity exposures at two different life stages as measured from days post hatch (DPH). The solid green line represents the average as calculated for respective test species and early life stage.

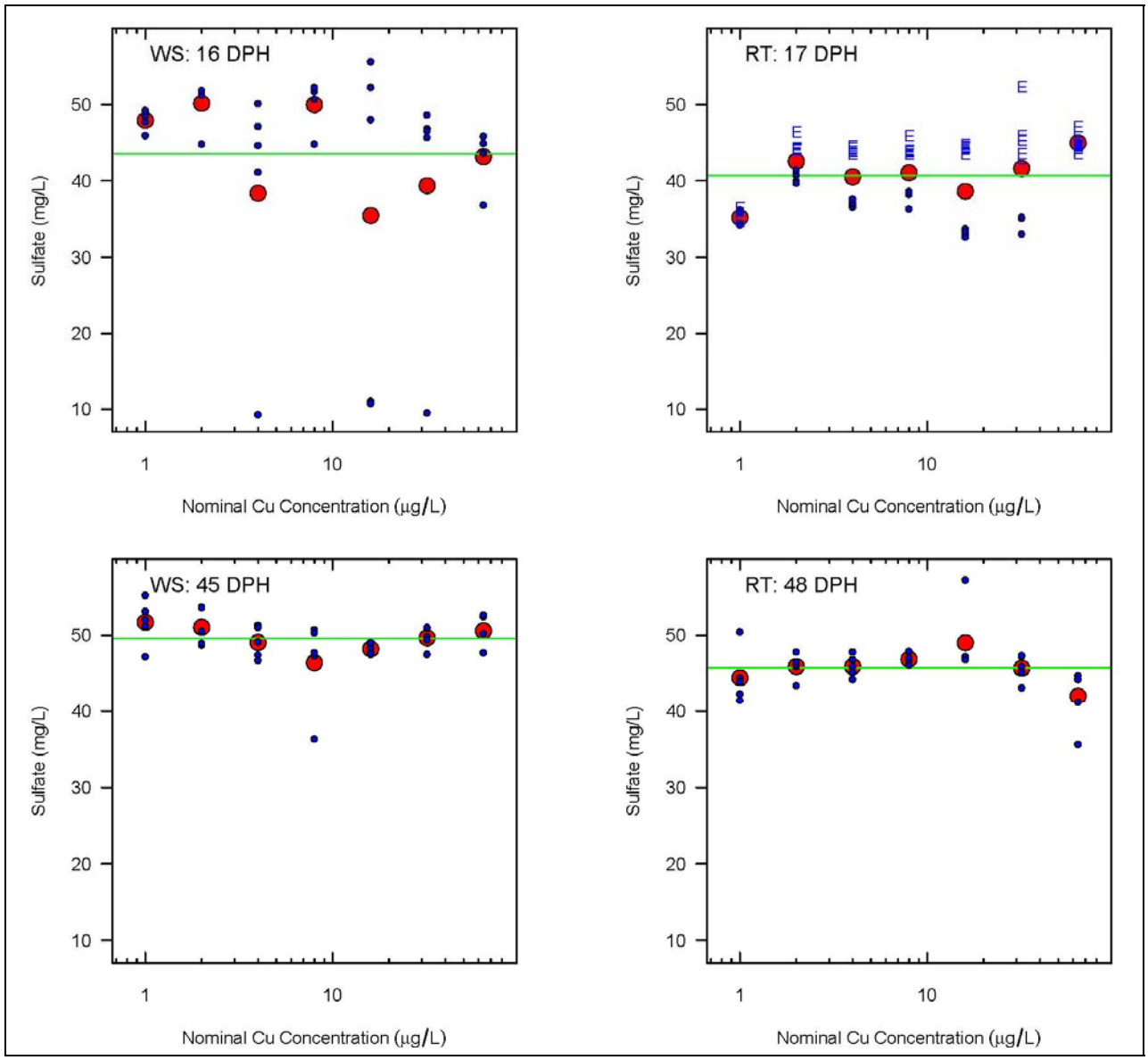

Figure B2-2h. Plot of sulfate as determined by Columbia Analytical Services for white sturgeon (WS) and rainbow trout (RT) acute toxicity exposures at two different life stages as measured from days post hatch (DPH). The solid green line represents the average as calculated for respective test species and early life stage. Estimated concentrations are symbolized using an "E".

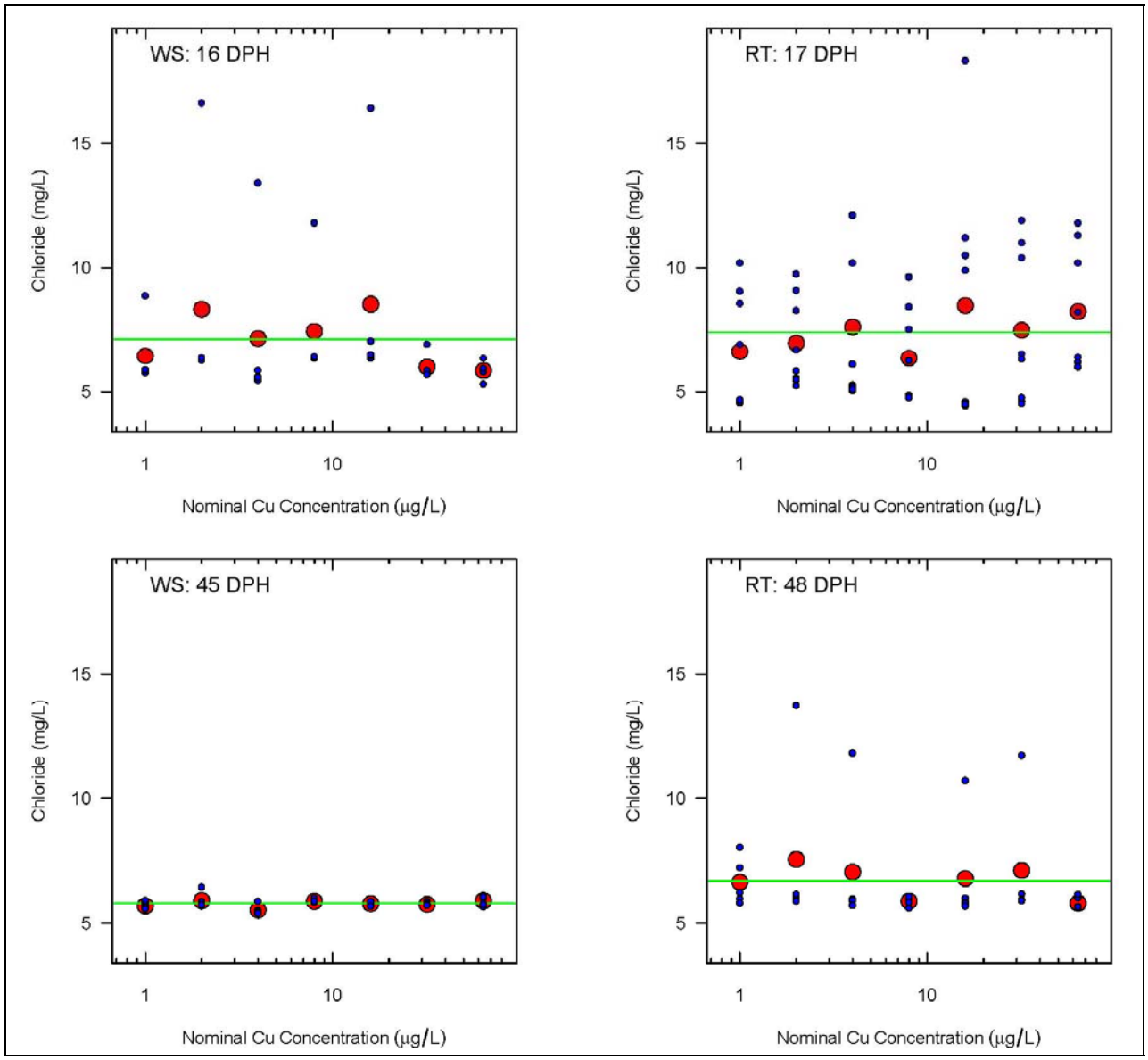

Figure B2-2i. Plot of chloride as determined by Columbia Analytical Services for white sturgeon (WS) and rainbow trout (RT) acute toxicity exposures at two different life stages as measured from days post hatch (DPH). The solid green line represents the average as calculated for respective test species and early life stage.